LAND STEWARDSHIP GUIDE

Reducing Runoff and Increasing Infiltration in the Mediterranean Climate of Northern California

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Introduction

Since European arrival, many past and current land-use practices have altered the way that winter rains are absorbed and infiltrated into our surrounding landscape. Water quickly drains off of the land from semi-impermeable surfaces (driveways, roads, landings, etc.) and also by compaction of soils caused by heavy equipment, overgrazing, and development. These unnaturally high rates of runoff cause erosion that delivers sediment and other pollutants to streams, and forms ruts and gullies that further drain the land and lower the water table.

The impacts of global climate change will likely continue to alter the patterns of rainfall distribution, storm intensity, and summer temperatures in our region; resulting in more intense winter storms, and longer, hotter dry seasons. As landowners and stewards we have the potential to restore the land's natural ability to capture, infiltrate, and store winter rains to increase the health and yield of our springs, wells, streams, and rivers during the dry season.

Planting the Rain:
Methods to Capture and Store Water in the Soil

The most cost-effective way to store water is in the ground. By restoring and enhancing the land's soil "sponge" we can increase underground water storage potential. For instance, for every 1 inch of rain that falls on 1 acre there are approximately 27,000 gallons of water available to be captured and stored in the soil.

Countless methods of harvesting rainwater have been developed and practiced around the world for millennia. Some of these ancient methods, as well as more modern designs, are being implemented in Northern California to combat drought by infiltrating winter rains into the soil. The techniques that follow are all designed to slow the rate at which water flows off of the land and result in more water being available for longer into the dry season. Many of these projects can be done with simple hand tools and do not require heavy equipment or lots of money.

Planning for Success: Seven Water Harvesting Principles

1) Practice thoughtful and long-term observation *before* making any serious changes to the land.

2) Seek the advice and knowledge of others. "Many eyes make for less surprise."

3) Get out during storm events and observe: Where is storm water flowing, concentrating, or ponding on the land? What areas are eroding, or seem vulnerable? What areas are functioning well during heavy rain events? Are there stable places where one could collect and store water in the ground safely? How are the roads and driveways handling heavy rains?

4) When designing potential projects, start at the top of your land where the volume of water is less concentrated. Future rainwater harvesting projects can be added downslope over time.

5) Start small and expand on what works. "Least change for greatest effect."

6) Integrate rather than segregate; try to link and group water harvesting projects on the landscape to increase their overall effectiveness.

7) Reassess and revisit your projects over time (especially during storm events.) What is working, what is not, and how can we build on past successes?

Getting Your Feet Wet: Project Design & Implementation

Swales (Berms and Basins)

One method of collecting and infiltrating excess runoff from winter storms is in swales, also called "berms and basins." Swales are shallow trenches (1-3' deep x 2-6' wide) built on-contour (level) with the slope. They can be of any length, from just a few feet to several meters long and are best built on gently-to-moderately sloping land (less than a 3:1 pitch).

In our region, swales are most effective when designed to capture runoff from semi-impermeable surfaces such as roads, landings, driveways, parking areas, overgrazed areas, etc. They are also used to collect and infiltrate excess water from roofs and greenhouses. Vegetated swales are very effective in preventing nutrient and sediment runoff when placed downslope of cultivation sites or livestock areas.

Swale Construction

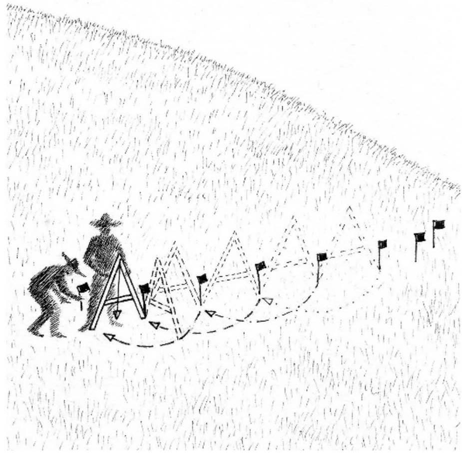
Swales can be constructed using simple, level-seeking devices such as an A-frame level and hand tools. They are always designed with safe overflow routes to handle large storm events. The overflow should be armored with rock. Ideally, swales should be situated so that the overflow is captured by others swales placed downslope to maximize infiltration potential. The berms can be planted and can also serve as pathways. Swales function best when covered in living vegetation.

Swales should not be built on steep or unstable slopes, or across stream channels.

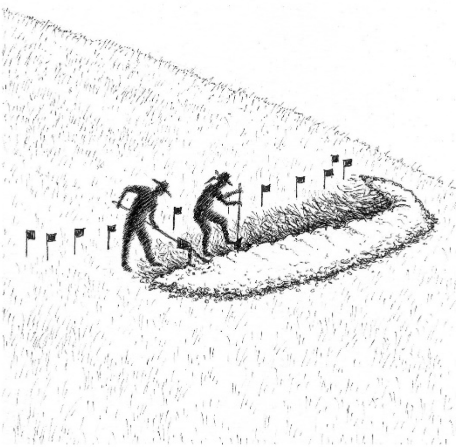
Swales may need maintenance over time. In areas with gophers, the berms should be thicker-walled and thoroughly compacted. Swales are spaced depending on the concentration of water that they will be receiving. The more water (resulting from compacted soils, driveways, clearings, etc.) the more closely spaced they should be. A general rule of thumb is, 10-15' between swales on heavily compacted soils, and wider spacing (15-30') when surface water concentrations are less.

Swale Construction

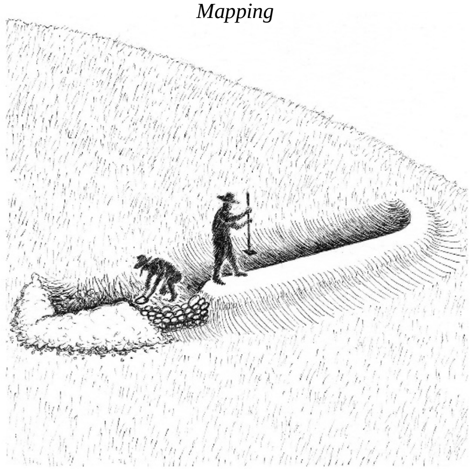
Observation



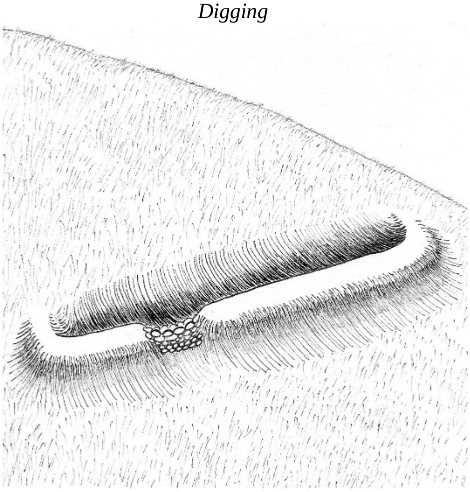
Mapping



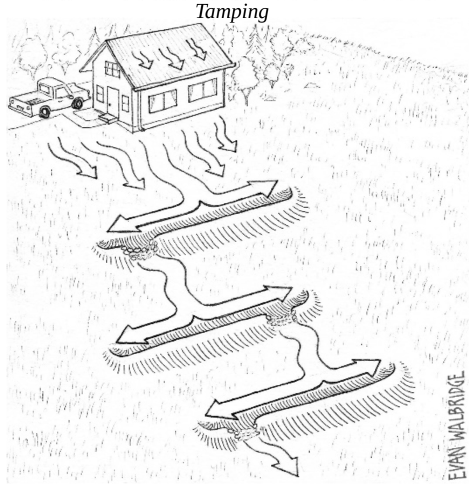
Digging



Tamping



Completed Swale



Series of Swales

Step 1: Practice long-term and thoughtful observation *before* constructing your project. Some questions to ask: where is the water coming from and where is the highest point on the land that we can catch it? Where will the overflow drain to in large storm events? Can we fit multiple swales into this area to create a more synergistic effect?

Step 2: Use an A-frame level, water level, or laser level to find the land's contour. Flag out a contour line. If you plan to build multiple swales, mark them all out so you can integrate them. (After flagging the contour lines you might want to stop and observe the area for some days, weeks, or months, to decide if the location will suit your project goals.)

Step 3: Excavate soil from upslope (1-3' deep x 2-6' wide) along the length of the contour line. Mound soil below to create an earthen berm. Excavate enough soil to make the berm sturdy and thick-walled.

Step 4: Shape and smooth out the basin to lessen steep sides. The bottom should be flat and wide. Compact, shape, and level the berm with a soil tamper.

Step 5: Create an overflow route. The overflow area should be approximately 2/3 of the berm height to allow water to escape during storms. It can be 2-4' wide. Rock the overflow area to prevent erosion.

Step 6: Seed, mulch and plant the swale. Trees and shrubs planted on or below the berm benefit from the water stored in swale.

Protecting the Water Cycle

In recent years, outbreaks of blue-green algae (cyanobacteria) have been documented in mainstem rivers along the north coast. The combination of warm, shallow water and nutrient pollution from agricultural runoff may be increasing the incidence of toxic algal blooms. Preventing nutrient pollution from entering watercourses keeps our rivers clean and safe to swim in during summer months.

Retain Your Fertilizer Investment

Fertilizers can often be applied *below* the suggested application rates and provide similar results. Maintaining a healthy soil ecology by applying living compost and/or actively aerated compost teas can help your plants to efficiently absorb available nutrients. Compost can also provide most of the essential nutrients needed by plants to grow and produce a yield—without using concentrated fertilizers. Avoid using chemical fertilizers.

Planting cover and catch crops in the fall helps capture and retain leftover fertilizers, preventing them from being leached away by winter rains. They also help to protect the soil from erosion, while building soil carbon. Planting a mix works best: fava beans, vetch, bell beans, Austrian field peas, etc. Winter rye is also a great “nutrient catch crop” to add into your mix. Winter rye grows fast in cool weather, absorbing leftover nutrients in the soil and storing them in their plant tissue until the following spring. Both cover and catch crops are tilled into the soil 3-6 weeks before planting your next crop.

**Cover crop mixes can be hard to find in local garden stores when needed in the fall. Try preordering in bulk ahead of time. See resources section for cover crop suppliers.*

Used or bulk potting soil should be covered with a tarp or stored in a covered area during winter months to prevent leaching of nutrients. Keep stored fertilizers in sealed containers and in a dry area protected from rain. Disconnect garden sites from water courses by directing runoff into vegetated swales, filter strips, or vegetated earthen basins. If no other route for water exists, try using straw bales, wood chips, or straw wattles to help slow and filter fine sediment and/or fertilizers before entering stream courses. Keep all exposed soil on your land armored with vegetation or mulch during all four seasons.

Note: Current Humboldt County regulations require that agricultural areas be set back 100' from perennial streams, springs, and wetlands, and 50' from ephemeral (seasonal) waterways.

Minimizing Nutrient Runoff from Livestock and Poultry:

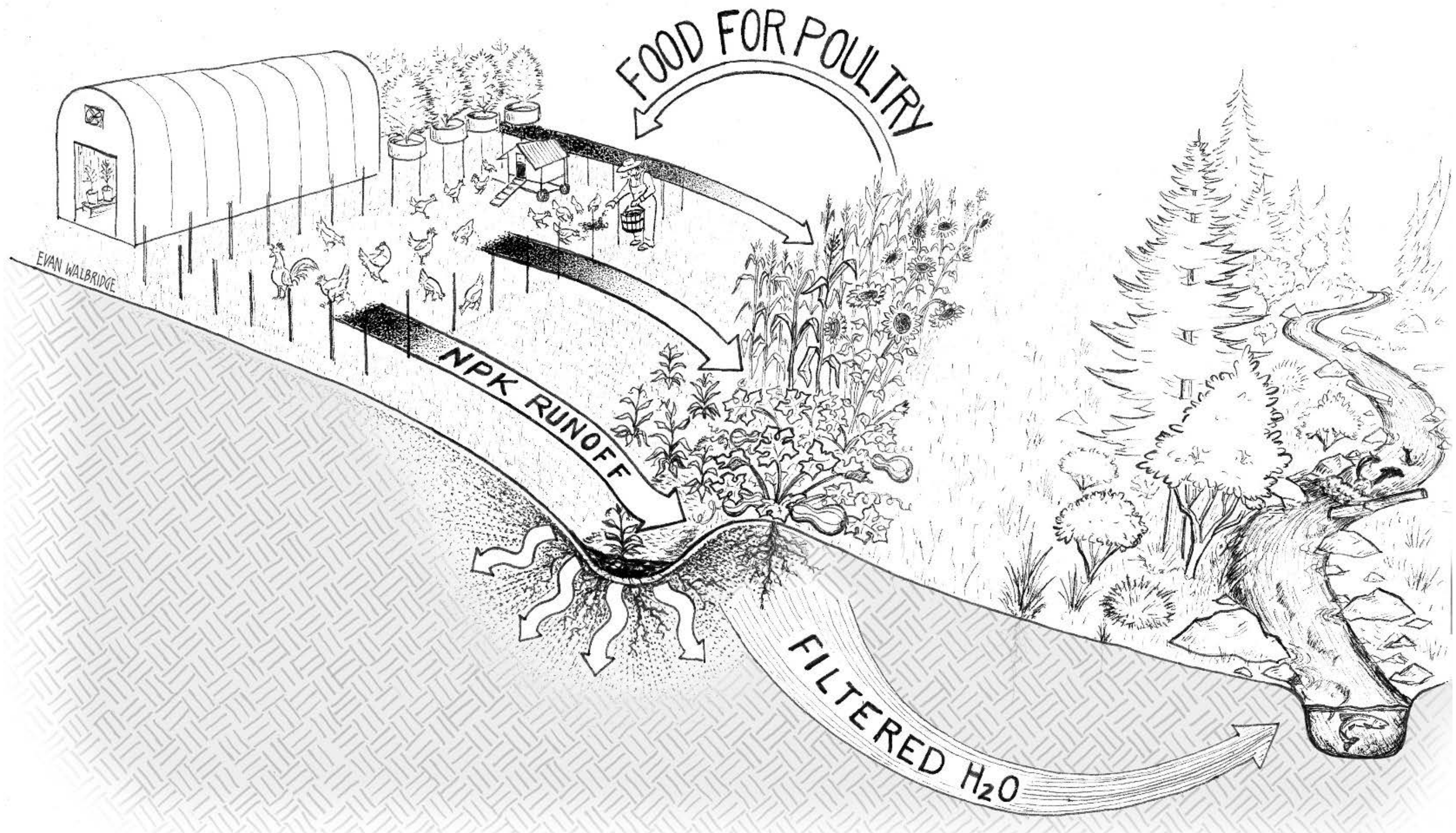
Animals that are confined to a single foraging area can leave soil bare and compacted, causing increased runoff during heavy rains. This can hasten the transport of sediment and nutrients (animal manures) into nearby watercourses.

If possible, rotate grazing livestock and poultry and avoid confining animals to one area. Portable electric fencing is an economical and efficient way to rotate livestock and poultry. If you are unable to maintain adequate soil cover (grasses and forbs) in your pastures, the number of animals is either too high, or they are not being rotated frequently enough. Livestock should be excluded from all riparian zones.

**See resources section for electric fencing suppliers.*

Swales can be built below livestock areas to help capture and retain sediment and nutrients. These areas can be planted with fruits or vegetables that consume excess fertilizer runoff with the co-benefit of providing a yield—food. Plants that readily absorb excess nutrients such as comfrey, field corn and sunflowers can be fed back to poultry in a closed-loop system.

During winter months piles of animal manures should be covered to retain nutrients and prevent leaching. Additionally, gutters can be installed on the roofs of barns, paddocks, and chicken coops to direct clean rainwater away from accumulated animal manures. Always maintain a minimum 50’ non-grazed vegetation buffer between animal confinement areas and watercourses to help prevent nutrients and/or sediment from entering the water sources.



Cross-section of swale constructed below garden/poultry site capturing nutrient runoff.
Swale is planted with field corn, sunflowers, sorghum, Russian comfrey and squash to provide food for chickens.

Human Waste and the Carbon Cycle

Septic Tank Considerations:

Septic systems are cited as one of the most common sources of groundwater contamination in the United States.[3] Improperly designed, located, or maintained septic tanks and leach fields can be a major source of pollution to surface and groundwater supplies. Always consult a professional and obtain the necessary permits before installing septic systems.

Save Water and Prevent Nutrient Pollution by Utilizing a Dry Composting Toilet:

Removing human urine and feces from the water cycle and keeping them in the carbon cycle is a simple solution that protects water supplies and creates a new source of nutrient rich material for the land. Several commercial and homemade design options for dry composting toilets are available.

**See resource section for more info.*

Note: Humboldt County is currently in the process of changing and updating its waterless toilet regulations.

Raising the Water Table: Gully Repair

Gullies dehydrate the adjacent landscape by draining "daylighting" shallow groundwater to their low points. Thus, a six foot-deep gully has the potential to lower the surrounding water table by six feet. Gullies can rush water off the land 10 to 1,000,000 times faster than natural drainage rates.[4] Most gullies are formed by roads (old or new) that capture and unnaturally concentrate water into areas or drainages that are not adapted to carry this increased surface flow.

Before beginning any gully restoration project, follow it upslope to find the source of water (points of diversion) which caused the gully. If the gully has just recently been formed, water may be able to be directed out of the eroding area into its original channel. A more common scenario is needing to divert water in several locations upslope (usually on a road) to reduce the concentration of water coming to the gully. If the gully is old, you may want to allow water to flow in the gully and use brush projects described below to capture and build-up sediment for some years before diverting water out of the gully into its original channel.

Note: Diverting water from a gully back into its original channel (especially if it is old) may require collaboration with neighbors. Be sure to follow the original channel downslope to make sure that it is fully intact and stable enough to receive water.

Brush Packing:

The majority of gullies can be stabilized and repaired using materials sourced onsite. Brush (fir branches, coyote brush, etc.) can be used to pack gullies to help slow the transport of water and sediment. To be successful, it is best to mindfully place the brush in the gully with the top of the brush facing uphill and the butts facing downhill. The butts of the brush can be pushed into the soil to help keep it in place.

It is important that the material is packed densely enough (stomped) so that it is compressed against the walls and bottom of the gully. This helps reduce voids that may concentrate water in areas, potentially undermining your structure. Using fresh material works best, since the decaying leaves help to fill the spaces in between the branches over time. If older, leafless brush is used, forest duff and/or straw, grass, wood chips, or sawdust can be spread in the gully to help fill the gaps. The end result should be a dense matrix of brush that allows water to pass through—while capturing soil particles and organic matter.

The brush packing method works best in forested areas where surrounding tree roots can grow into and stabilize the fertile soil and organic matter captured by the gully restoration project. Like all restoration projects, it is important to monitor the results and add or remove brush as needed over time.

Brush Check-Dams:

Brush check-dams can also be built in gullies to slow the erosive force of water and to catch sediment. While they require more effort and design than brush packing, they are very effective in capturing fine sediment and raising surrounding ground water levels. Depending on the materials being used, they can last for several years.

Like most restoration projects, it is best to start with building a few check-dams in the safest looking areas first and see how they respond to storm events. Observe your sites and make adjustments if needed. More check-dams can be built in time.

The method described below will work for gullies up to about 5' deep and 10-12' wide.

1) Lay back sides of gully if too steep. Throw dirt upstream of the site back into gully.

2) Select and cut wooden posts (redwood, fir, cedar, etc.) 3-5' long and 2-4" in diameter. Sharpen one end of posts. Space roughly 2' apart perpendicular to flow and drive in at least 1' deep with a sledgehammer. Spread a 4” layer of forest duff, straw, sawdust, etc., in between posts, on sides of gully and up to 3' below the dam.

3) Lay and pack brush (dense fir boughs, coyote brush, huckleberry, etc.) in between posts with butts facing upstream. Butts should extend 1' upstream from the posts. Tops of brush should lay 3-4' downstream from posts forming an apron to dissipate the energy of water flowing over the dam. Continue packing brush densely in between posts. Fill approximately 1-2' above posts.

4) Stand on top of material and compact it while cinching down with cross-braces (fir poles, or branches.) Brush should compact down to just below posts. Make sure that cross-braces are placed so that they are lower in the center of the gully to encourage water to overflow in the middle of the dam. Cross braces are woven, wired, or tied to posts to keep brush cinched down. **The finished dam should be at least 1-2' below the top of the gully to ensure that water is not diverted out of its channel, potentially causing a new gully.**

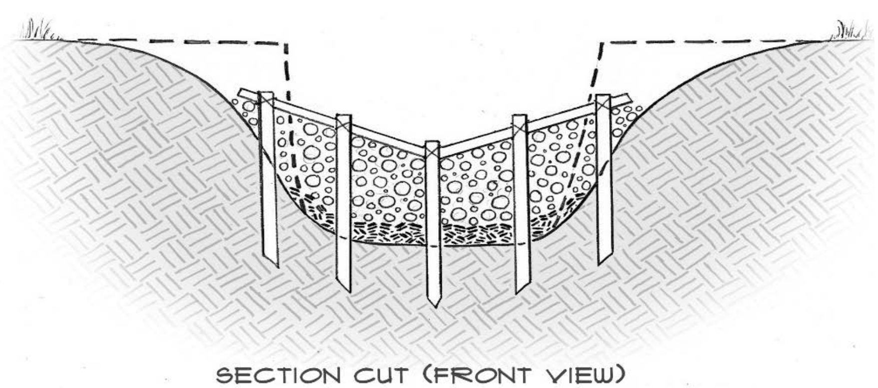
5) Spread a thick layer of forest duff, straw, moss, etc., on upstream side of dam. Be sure to fill in all spaces between the butts of brush. The idea is to create a filter that allows water to slowly pass through, while capturing and storing sediment above the dam.

Over time, new stakes can be driven to raise the height of the dams as they back-fill with sediment. Brush can be woven in between posts as needed. Mature check-dams can also be stabilized with Juncus species (a native rush also known as wiregrass) in wetter areas, or with native perennial bunch grasses in drier areas. In time, as the bottom level of the gully is raised to a height that is acceptable, rocks can also be used to permanently stabilize the sequestered sediment behind the check-dams.

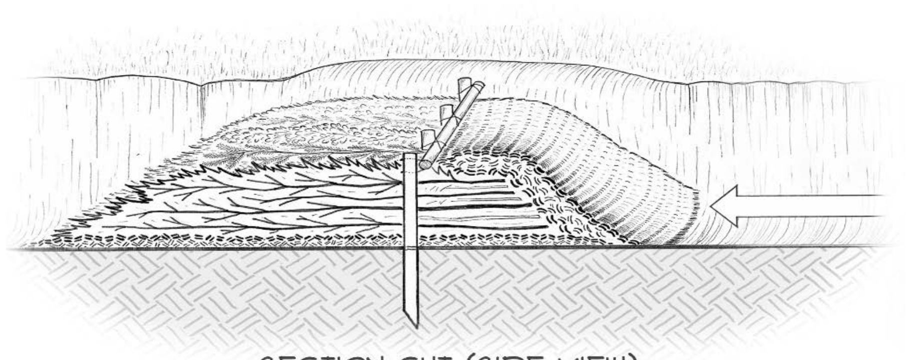
Living check-dams can also be built out of willow if the site is wet (high water table.) Willow posts are best cut and planted in the beginning of their dormancy in the fall. Be sure to drive the willow posts in right-side-up, so they sprout.

Note: Be sure to monitor your check-dams during the first few storms. Pack and fill any gaps that may be diverting water around or under your structures with forest duff, moss, or another suitable material.

Brush Check Dam



SECTION CUT (FRONT VIEW)



SECTION CUT (SIDE VIEW)

Brush Check Dam - Perspective

Restoring the Sponge

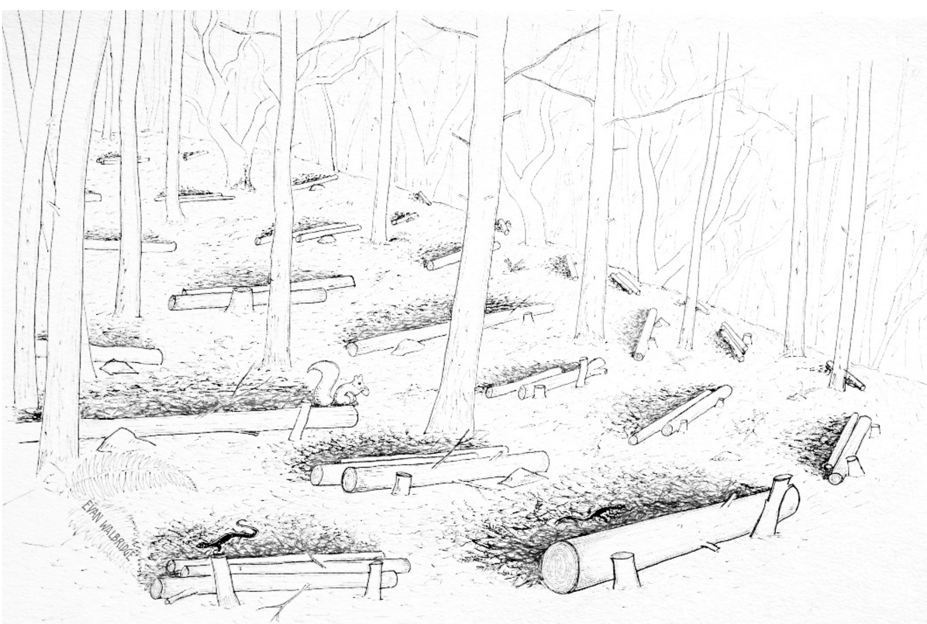
Forest Thinning & Fuels Reduction to Enhance Groundwater

Due to past industrial logging practices and a history of fire suppression, our forests are now more densely populated with brush and young trees than ever before. Recent scientific research, as well as local observation, suggests that these young, crowded forests have high evapotranspiration rates which are negatively affecting summer stream flows.[1] Reducing understory brush and small-diameter Douglas fir trees may help reduce the demand on shallow groundwater levels, while also increasing the ability of precipitation to reach the forest floor–where it can readily be absorbed. Fuels reduction also helps to prevent catastrophic wildfires, which can have large scale impacts on the health and function of our watersheds.

Fire hazard reduction can fit beautifully with gully restoration. Before burning slash piles, take a walk around your land and see if the brush can be used to heal gullies, laid on-contour across slopes, or placed on exposed soil.

Lay Logs On-Contour to Slow and Infiltrate Water:

When doing fire hazard reduction work, small diameter logs (3-8”) can be laid on-contour (perpendicular to the slope) to help slow, spread, and sink water into the ground. Logs and brush can be laid cross-slope on old logging roads and disturbed areas to help reduce runoff velocities and to repair compacted soils. As the logs catch leaf litter and debris and begin to rot, they increase the permeability of soils—enhancing infiltration. The decaying organic matter also offers habitat to soil life and amphibians, as well as providing nutrients to the surrounding forest.



Logs laid on-contour

Meadowlands and Prairies: Native Perennial Bunch Grass

Before European settlement, north coast grasslands were mostly graced by long-lived, perennial bunch grasses.[5] Overgrazing, fire suppression, and the introduction of exotic annual grasses from Europe and other countries have altered the plant communities that once existed in our meadows.

Non-native, annual grasses have shallow root systems (6”- 2' deep) and their foliage dries out quickly during the summer season. They add little organic matter to the soil, do not offer late summer forage to wildlife or livestock, and their dry leaves increase the fire danger during summer months.

Conversely, native perennial bunch grasses stay green much longer into the dry season and have long, fibrous root systems that can penetrate deep into the soil layers. These roots build and store soil carbon (humus) that serves as a sponge, absorbing and holding large amounts of water in the soil. The roots themselves provide a preferential flow-path, coaxing water to infiltrate and percolate deep into the earth. Some species are extremely long lived. Purple Needle Grass (*Stipa pulcra*), a native to our area, has an average life expectancy of 20-200 years.[2] Thus, we can view native perennial bunch grasses as being the “old growth” of our meadows.

By identifying native grasses on your land you can help protect and expand them by clearing away encroaching vegetation such as young Douglas fir, scotch broom and coyote brush. Native grass seed can be collected during the summer months, or can be sourced from the Mattole Restoration Council if you are interested in planting your own. Most perennial bunch grasses do best when transplanted from plugs, or as starts. Plugs or seeds are most successful when planted at the beginning of the rainy season so roots can become established before summer.

**For more info on native bunch grasses, check the resources section in the Appendix.*

Heavy Equipment/ Earth Moving

Before Using Heavy Equipment: Some Questions to Ask

Can the project be accomplished with handwork vs. heavy equipment? Is the potential project on steep or unstable soils, or close to a watercourse? Will the perceived benefits of the project outweigh the potential risks (erosion, soil compaction, increased runoff, habitat fragmentation, etc.?) Are the soils too wet or too dry do the work? Do I have a plan for reducing runoff and sedimentation from the site? Do I have all of the materials needed (straw bales, wood chips, native grass seed, etc.) to armor the soil when the project is completed? Am I, or the hired person, qualified to do the best job possible? Do I need permits or a licensed engineer?

If Heavy Equipment is Required

Larger projects often require heavy equipment to do the job. But our fragile north coast geology is exceptionally vulnerable to erosion. Poor planning and design and unskilled operators using earth moving machines can create legacy impacts that alter the way water flows on the land for generations to come.

Have a well-thought-out plan and design *before* using earth moving machines. When in doubt, seek the advice of a professional. Avoid driving heavy equipment on undeveloped areas, especially when soils are wet. Limit the footprint of disturbed areas. Have a spill kit onsite in case of a hydraulic fluid, or oil spill. In the winter months, only conduct earth moving projects during extended dry periods. After completing a project, seed and armor all exposed soil with rice straw, wood chips, or another seedless mulch. Get out and observe your projects during the first rains.

Note: Armoring all exposed areas with mulch not only helps prevent soil erosion. Covering bare earth protects it from direct exposure to sunlight. Soil temperatures above 80° F can oxidize soil carbon (humus), reducing its capacity to store water.

Recharge Ponds: Design and Considerations

Natural, earthen (unlined) ponds that are carefully designed and placed in the right locations can contribute to groundwater recharge and enhancing stream flows. But not all ponds are beneficial to our watersheds. Poor pond placement and design can lead to catastrophic failures, resulting in large-scale erosion events. Ponds may also serve as habitat for detrimental non-native species, such as bullfrogs.

Location: *Ponds must always be situated in stable areas.* This often requires the advice of an engineering geologist to determine the safest location. Grassland slopes that exhibit slow soil creep (earth flows) are especially vulnerable to failure. Always plan a safe overflow route for water leaving a pond.

In some site-specific cases, ponds are built in seasonal, Class III streams. These ponds are designed for streamflow/wildlife enhancement purposes only (not for domestic use) and require the appropriate permits. Class III streams are generally defined as watercourses that are intermittent and dry up in the summer, but have the potential to deliver sediment to perennial flowing Class I or II streams.

Ponds constructed in sheltered locations help to reduce evaporation from wind and excessive sun exposure. Ponds built upslope from homesteads and garden sites provide gravity flow. Unlined ponds can be used to increase groundwater levels; when located nearby to garden and orchard sites they can provide subsurface water to adjacent plants and trees, reducing irrigation needs.

Size and Shape: The size and shape of a pond can influence many factors, including: stability, effectiveness in collecting, holding and storing water, evaporation rates, natural circulation of water within the pond, water temperature, etc.

A pond that is wide and shallow (larger surface to volume ratio) will evaporate faster than a pond that is narrow and deep. Also, a series of small ponds may fit better into an existing landscape than one large pond. Smaller ponds grouped together can act synergistically to create larger connected subsurface groundwater storage areas. Solar pumps can be used to move or circulate water between ponds. A pond built with various depths and shapes can help to circulate water naturally by creating warmer and cooler areas within the pond. Ponds designed this way are also safer for children and offer more habitat value to wildlife.

Water Sources for Ponds: Consider the sources of water filling the pond. Will it be road runoff, water from the roofs of buildings or greenhouses, falling rain, surface runoff, etc.? If road runoff will be used, consider placing a sediment retention pond or basin above the primary pond. This will help to catch and settle sediment delivered from the road. An armored overflow is recommended below the retention pond to further prevent erosion. The retention pond can be cleaned out periodically during the dry season to maintain its holding capacity.

Pond Overflow: The outlet and overflow of a pond must be armored sufficiently with rock to reduce the risk of erosion-causing failure of the pond. A full or half-round culvert can also be used to direct overflow into a stable, rock-armored area. Designing the shape of the pond to reduce the amount of fill required to build the dam (or dike) is also a safer option.

Natural Clay, Bentonite Clay, and Liners: The soil type, location, and intended purpose of the pond will determine which method of sealing (or not sealing) a pond is best. In sites where natural clay is found, a pond may require no extra measures to seal it other than soil compaction. Some soils are too porous to hold water and require the addition of bentonite clay to seal the pond. Sediment retention ponds are usually not sealed.

Lined Ponds: A lined pond is most effective for storing water for fire protection and irrigation, but does not allow water to percolate into the soil for groundwater recharge purposes. Lined ponds also degrade over time, are prone to trapping animals, and can be dangerous to small children due to their slippery sides. When designing a lined pond, an earthen bench (or a series of benches) can be built around the perimeter of the pond 2-4' below the high water mark prior to installing the pond liner. These benches can have rocks placed on them after the liner is installed to help offer an escape route. Old carpet can be draped over the side of the pond to provide traction. Secure fencing around lined ponds will help keep out large animals and children.

Never introduce non-native fish or other aquatic plants or animals into ponds that may escape into nearby streams or rivers. Invasive bullfrog and fish populations can be managed by allowing the pond to dry out, or draining it late in the fall. (Bullfrogs need a full year to complete their life cycle.)

Note: All ponds should be designed by a licensed engineer and constructed by an experienced heavy equipment operator. Diverting surface water into ponds requires a permit from the Division of Water Rights and CDFW.

Rural Dirt Roads

Roads can act like gutters, rushing surface and subsurface water off the landscape. Roads also increase the flooding of streams and rivers, can cause gullies and landslides, and transport sediment and other forms of pollution into watercourses. A well-designed, built and maintained road can reduce many of these problems, saving money and time in the long run.

When considering groundwater recharge and reducing sediment pollution, the main goal of road design and maintenance is to focus on breaking up the concentration of water in as many places as possible. This means directing water from roads into stable vegetated areas where it can slow down and infiltrate into the soil before entering a watercourse.

10 Basic Rural Road Guidelines and Principles

1) Avoid building new roads. If possible, focus money and resources into upgrading and maintaining existing road networks.

2) Reduce the concentration of water on your roads by out-sloping, constructing rolling dips, adding more culverts, and by building and maintaining properly sized water bars. The goal is to disperse water off of the road in as many places as possible, thereby allowing more water to soak into the ground.

3) Do not direct water from roads onto gullies, slips, slides, or other unstable areas. Avoid directing runoff from roads carrying fine sediment directly into watercourses. If no other route exists, consider using straw bales, straw wattles, or brush dams to help filter water before entering streams.

4) In stable areas with a lower gradient, water from roads can be directed into shallow retention ponds, swales, vegetated flats, or basins, to encourage infiltration.

5) Keep your active road surfaces rocked and maintained to prevent excess erosion caused by road runoff.

6) Culverts should be appropriately sized to handle 100-year storm events, placed on grade with the watercourse, and the inlets and outlets armored with rock.

"Critical-dips" should be installed at all culverted stream crossings to prevent water from over-topping and flowing out of its natural drainage.

Keep culverts clear of debris. To help prevent culverts from plugging, a sturdy metal post can be embedded (pounded) into the center of the stream channel the distance of the diameter of the culvert directly upstream of the culvert inlet.

**See Upgraded Road drawing for more details.*

7) Put on rain gear, grab a shovel, and get out on the road during storm events. Many serious problems can be avoided before they occur by using hand tools and allowing flowing water to help you do the work.

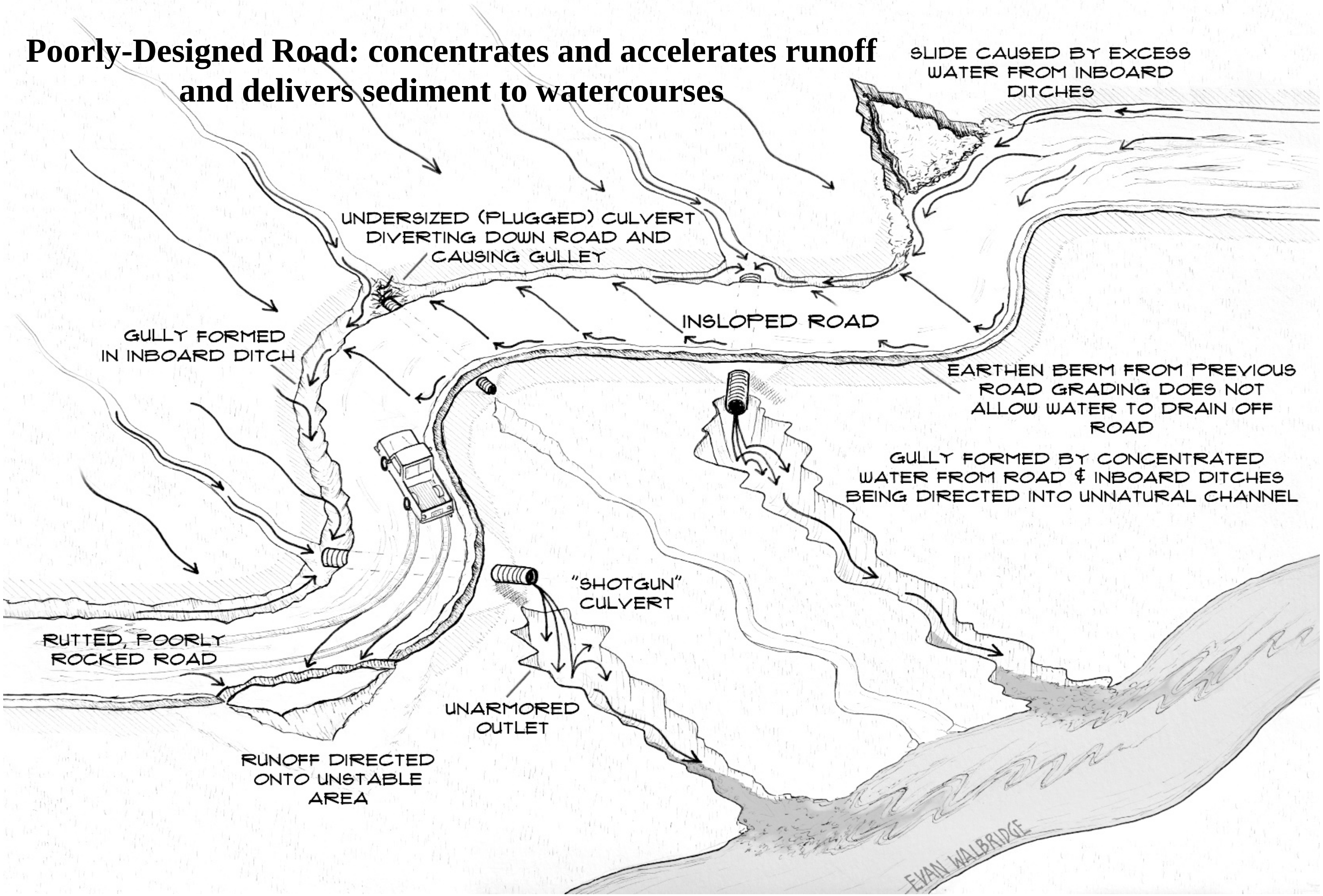
8) Schedule grading or excavation projects only during extended dry periods of weather. Use seasonal roads only during the dry season to eliminate rutting and erosion.

9) When in doubt, consult an engineering geologist or qualified restorationist before building or upgrading a road. Acquire the proper permits from CDFW before working in, or next to a stream.

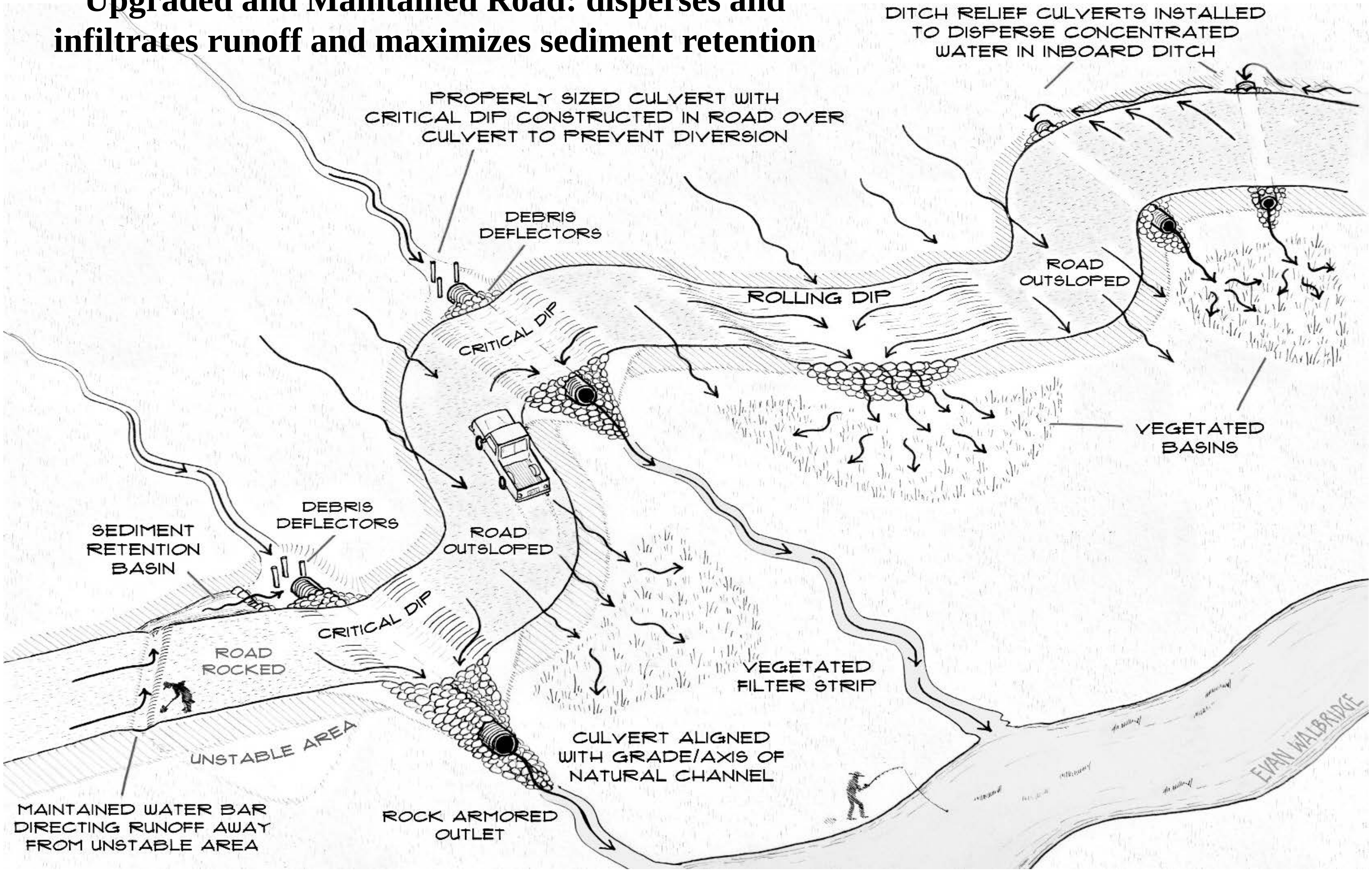
Note: A grading permit is required from the county for all earth moving projects that exceed 50 cubic yards of material.

10) Download a free copy of *Handbook for Forest, Ranch & Rural Roads* by the Pacific Watershed Associates: http://mcrcd.org. A hard copy can also be purchased by contacting the Mendocino Resource Conservation District: (707) 462-3664. This is the best book that exists related to designing and maintaining rural roads in our region.

Poorly-Designed Road: concentrates and accelerates runoff and delivers sediment to watercourses



Upgraded and Maintained Road: disperses and infiltrates runoff and maximizes sediment retention



Appendix – Technical Information & Resources

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Evan Walbridge: Website: http://www.evanwalbridge.com, Phone: (415) 328-9231
(Note: Technical drawings were designed in collaboration with Kyle Keegan)

Suggested Reading:

Permaculture design/ water conservation and rainwater harvesting: Gaia's Garden, Toby Hemenway, Chelsea Green Publishing, 2009
Rainwater Harvesting for Drylands and Beyond, Brad Lancaster, Chelsea Green Publishing
Best Management Practices for Cannabis Growers Guide (Mendocino RCD): http://mcrcd.org/

Compost Toilets:

The Humanure Handbook, Joseph Jenkins, Chelsea Green Publishing, 2005
Websites: http://greywateraction.org/contentabout-composting-toilets/
https://watershedmg.org/sites/default/files/newcontent/poo-to-peaches-early-draft-web.pdf

Pond Design, Siting and Maintenance:

Website: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_030362.pdf
Desert or Paradise: Restoring Endangered Landscapes Using Water Management, Including Lake and Pond Construction, Sepp Holzer, Chelsea Green Publishing, 2012

Native Grass Info, Identification, Seed and Plant Sources:

Mattole Restoration Council Native Plant Nursery (707) 629-3514
Website: http://www.mattole.org/resources/native-plants/
Kyle Keegan, The Fool's Farm, Salmon Creek, (707) 943-1504, email: owlsperch@asis.com
Cheryl Lisin, Lost Coast Interpretive Association, (707) 986-7138
California's Coastal Prairies: http://www.sonoma.edu/cei/prairie/

Portable Electric Fencing Supplies:

Premier 1 Supplies: https://www.premier1supplies.com/c/fencing/?gclid=Cj0KEQiA8orFBRCEpODivaOft_EBEiQAy3mlfQgzQuO9l-5rwOKkHScX5WpXCLqlK5MCTHezLSYqmAUaAiQC8P8HAQ

Bulk Cover Crop Seed Source Websites:

https://www.bountifulgardens.org/departments/316
https://www.fedcoseeds.com/ogs/search?listname=Cover%20Crop

Sources Cited:

1) Andrew Stubblefield, Max Kaufman, Greg Blomstrom, *Summer Water Use by Mixed Age and Young Forest Stands, Mattole River, Northern C.A., U.S.A*
https://www.fs.fed.us/psw/publications/documents/psw_gtr238/psw_gtr238_183.pdf
2) https://www.fs.fed.us/psw/publications/beyers/psw_2010_beyers(montalvo)_NativePlantRecomm.Nassella.pulchra.pdf
3) Joseph Jenkins, *The Humanure Handbook*, 3rd Edition, Chelsea Green Publishing, 2005
4) Leonard (Brad) Job, *Engineered Groundwater Recharge as Mitigation for Reduced Summer Flows in the Upper Mattole Watershed*, BLM, Arcata, CA
5) Thomas S. Keter, *Environmental History and Cultural Ecology of the N. Fork of the Eel River Basin, California*, Six Rivers National Forest, 1995
6) The term "Planting the Rain" was borrowed by Brad Lancaster from the book, *Rainwater Harvesting from Drylands and Beyond*