The Overstory agroforestry ejournal

hosted by agroforestry.net

Wick irrigation can greatly increase water use efficiency, which is especially needed in regions with severe water scarcity. In this photo, different wicking materials are evaluated for capillary rise, gravity flow and wetting rates.

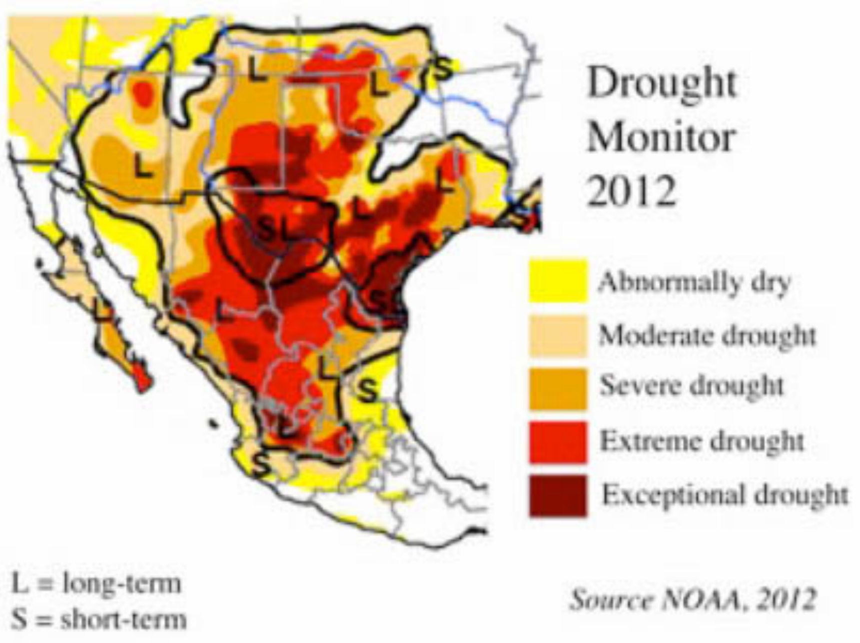
The Overstory #249

Wick Irrigation for Tree Establishment

by David A. Bainbridge

September 17, 2012

The world's 500 million resource-limited farmers are facing ever more difficult challenges in growing sufficient food and products for sale with inadequate water supplies (Hazell et al., 2007). These farmers face difficulties in locations where the climate is moderate but rainfall is seasonal, and endure far more severe problems in arid and semi-arid regions where rainfall is scarce and unpredictable. Climate change, including increased climate variability, is expected to worsen the problems these farmers and gardeners face by raising the temperature and reducing rainfall. The severe 2011-12 drought in Mexico illustrates what we may expect in the future (Figure 1, NOAA, 2012). The global maps of predicted chances are equally daunting.



Source NOAA, 2012

Figure 1

Figure 1. Mexico drought – a view of the future.

These small farmers urgently need to increase water use efficiency. Despite the need for low cost, simple, improved irrigation systems that could increase yields, scientific research and international development programs have largely neglected this challenge. This is primarily due to the lack of money in these resource-limited communities. Even with increased water use efficiency, many farmers will still struggle to meet their basic food needs. Deep pipe (Bainbridge, 2006), buried clay pot (Bainbridge, 2001) and other traditional systems work well but are often too expensive.

Wick irrigation is a low cost alternative that may help many of these small farmers. A wettable fabric or rope is used to carry water from a reservoir or pipe to the roots of the plant. In its simplest form it can be done with rags and recycled bottles at almost no cost. Cotton wicks were traditionally used in conjunction with buried clay pot irrigation in India (Mari Gowda, 1974). The wicks help move the water further from the clay pot to encourage greater root development (Bainbridge, 2002). Subsequent tests and research have demonstrated the value of wicks for irrigation even in very severe environments. These wicks can be gravity flow down (fast), capillary flow up (slow), or a hybrid (Figure 2).

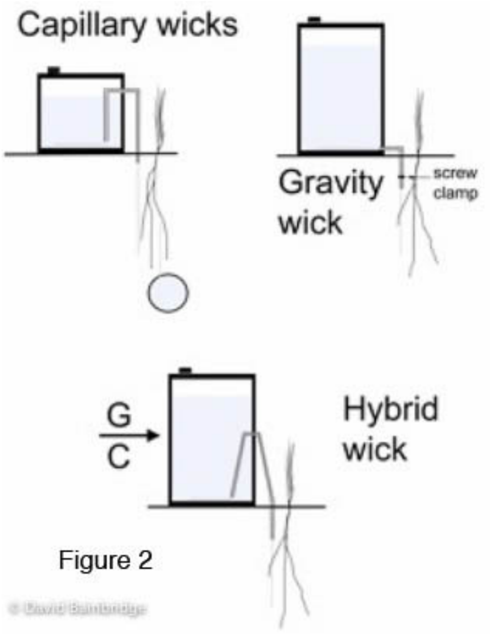


Figure 2

Figure 3

Figure 2. Wick styles – capillary, gravity, hybrid. Figure 3. Travertine capillary wick installation

Capillary mats are now widely used in greenhouses and plant propagation (Neal and Henley, 1992). Wicks have also been used for watering plants in containers for decades (Editor, 1955). A well-developed wick system for irrigating window boxes is also sold in commercial kits (e.g., Wickinator™ and Groasis Waterboxx) (Editor, 2010).

Wicks for field use are less well studied. To explore their potential for agroforestry, trials of wick irrigated tree seedlings were conducted in the greenhouse at University of California, Riverside. The 6 mm nylon wick was threaded through the bottom of the plant container with capillary rise providing water from a reservoir below. A very young palo verde (Parkinsonia floridum) seedling about 8 cm tall in 16 grit silica sand was growing and exhibited no sign of water stress after one month with water consumption of just 20-30 ml/day in a very dry greenhouse environment. This result is promising for agroforestry and environmental restoration.

An initial field test was installed on a very dry, east facing slope at a borrow pit restoration site in California's Coachella Valley in 1988. This site has an average rainfall of just 6.7 cm (2.6") and pan evaporation of 267.5 cm (105"). The tree seedlings were fed by 5 mm cotton capillary wicking from a 2 liter bottle with the wick rising from the reservoir through a plastic tube with the exposed end of the wick placed with the seedling roots (Figure 3). The water moved by capillary action and wicking up and across the arched tubing to the seedling. Prosopis glandulosa (mesquite) seedlings with wicks grew and survived better than surface watered plant receiving more water, although algae/mold/scum built up on the wicks and appeared to reduce water transfer.

The next test used capillary nylon wicks wetted from below by a buried pipe on a landscape restoration project along highway 86 also in Coachella Valley. Here the wicks were wetted by a buried 10 cm diameter pipe reservoir that was refilled periodically (Figure 4). The 8 mm nylon wicks worked better than cotton, but the small wicks and capillary rise did not promote growth and survival as well as buried clay pot, porous capsule or deep pipe irrigation (Bainbridge, 2002).

To better understand wick irrigation, a series of lab tests have been done using water with dilute food coloring to evaluate capillary rise, gravity flow and wetting rates in wick materials (Figure 5). These showed significant differences in capillary rise depending on material and weave. Most materials tested achieved a capillary rise of at least 25 cm and some passed 50 cm. The 11 mm (7/16") detergent washed solid braid nylon exhibited the best capillary rise, reaching 25 cm in 100 minutes and 55 cm in 20 hours. Other wicks including polyester yarn and 11 mm double braid polyester rope performed almost as well. Gravity flow rates also vary widely but are generally related to capillary rise. With new 11 mm solid braided nylon rope washed once with hot water and detergent (to remove lubricants used in weaving) the mean flow rate of gravity wicks in a snug fitting plastic tube was 0.6 ml/second (n=11). With a hose clamp tightened one turn past snug the mean flow dropped to 0.2 ml/second and the clamp could easily be tightened enough to stop the flow. Flow studies showed that water in an 11 mm unconstricted gravity nylon wick would reach 4 meters down a vertical wick in 15 minutes.

Figure 4. Capillary wick from buried pipe

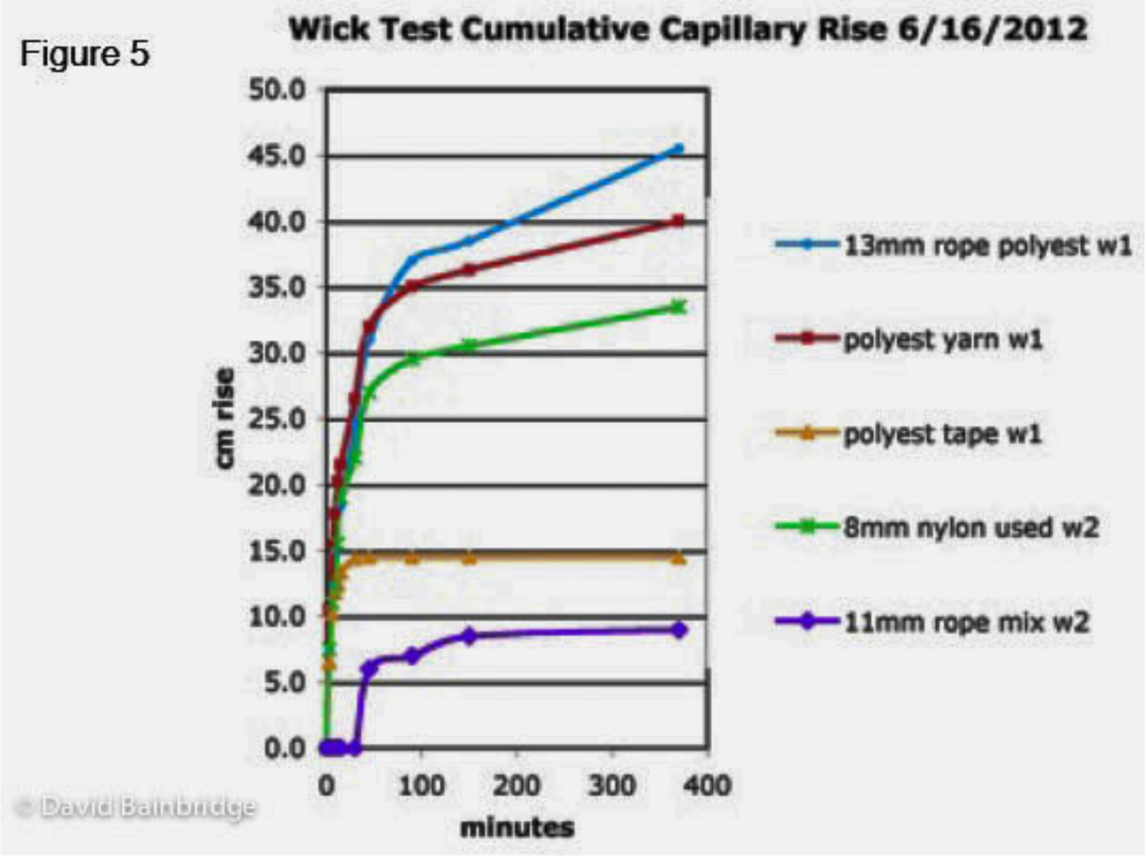


Figure 5. Capillary rise comparison

With a better understanding of the opportunities for wick irrigation, a group of five barely alive (plant health rating 2 on a scale of 0=dead–5=excellent) orphan mesquite seedlings left over from field projects were pruned and planted near the Salton Sea in California's low desert in 2009. The wicks used in this trial were 50 cm (20") long made with 11 mm washed solid braid nylon rope with 8 liter (2 gallon) reservoirs (Figure 6). Thread to barb fittings were screwed and glued into a hole drilled in the bottom of the reservoir to attach clear 12 mm (1/2") inside diameter vinyl tubing. A hose clamp near the end of the plastic tubing was used to adjust the flow to the fully buried wick. All planted mesquite seedlings received a tree shelter (Bainbridge, 1994). Reservoirs were refilled when possible, about every 30 days for the start of the first growing season, or about 250 ml/day. All plants revived well. After 631 days the mean plant health rating of the survivors was 3.6 out of 4. As the polyethylene 8 liter bottles broke down in the sun after more than a year, they were replaced with recycled 20 l containers made with PETE. These were filled twice the second year. After receiving a total of less than 120 liters of water and less than 7.5 cm of rain, all remained alive and well after three years. Previous irrigation studies in this area would suggest survival rates of 0-2% with surface irrigation, 25% with drip, and 80-90% with buried clay pots or deep pipes. Wicks appear to be as good as the best and use less water and cost less to install.

Wick irrigation has been demonstrated to work well and should be considered for field planting of trees and shrubs in agroforestry system establishment and environmental restoration. It can provide critically needed water while plants get established in micro catchments or runoff watering systems (Cohen, 2002; Evenari et al., 1982). It seems unlikely that one wick would be able to provide enough water to maintain a larger shrub or tree (1 m tall or more depending on water demand). Future tests will help clarify this and should suggest how many wicks might be needed for larger plants and trees of differing species. Wicks may also be used to help reduce the vulnerability of drip systems to clogging and blockage (Figure 7).

Figure 6. Mesquite gravity wick details

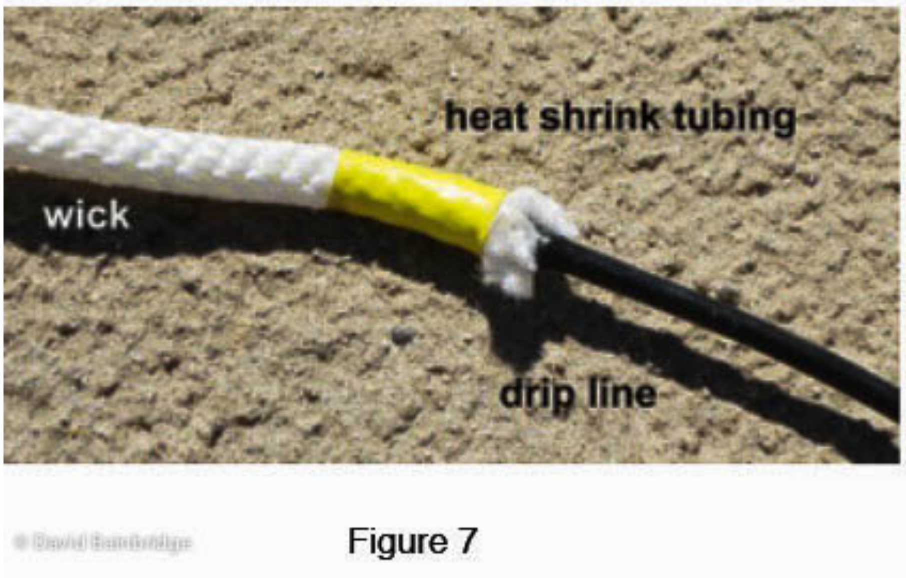


Figure 7. Wick slid over drip tubing

The rapid flow rates in gravity wicks also offer a great opportunity for establishing trees where groundwater is within 5 meters of the surface. A hole can be drilled to groundwater using a hand or powered auger and a wick can be pushed down to the water table. The gravity feed from above will enable the root to extend downward to reach the capillary rise from the water table (Figure 8). This could make it possible to grow trees in areas where the roots would otherwise fail to reach groundwater. In hot climates this could be rapid for some species. Under favorable conditions mesquite roots can grow rapidly, up to 4 mm/hour (Cannon, 1917). If the groundwater rise in the wick is 1 m, and the roots grow just 1 mm an hour they could reach groundwater in about two weeks. Without the wicks, developing this ground water connection can take several years (pers. obs.).

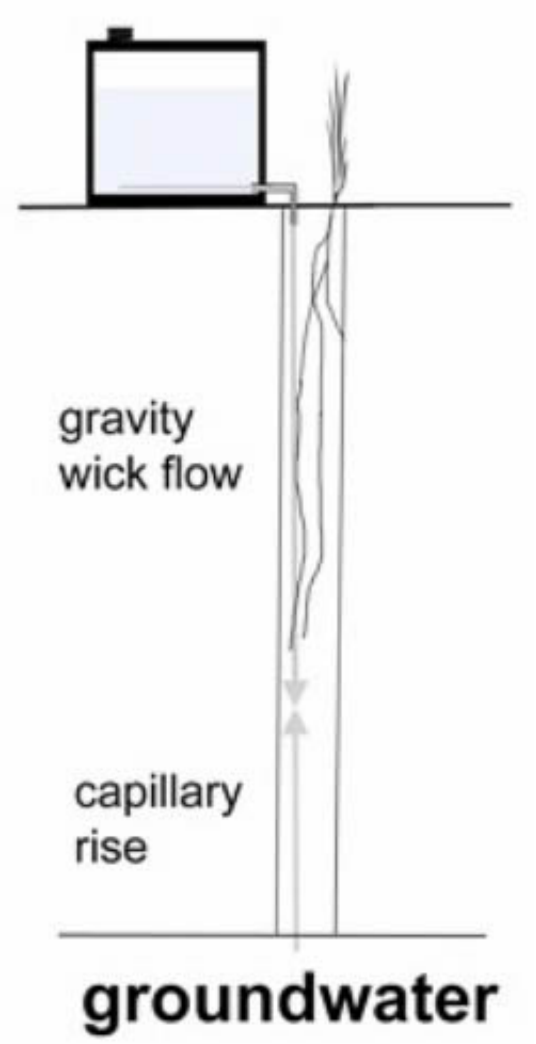
Wicks may also prove useful in planting cuttings and poles. A wick (for cuttings) or several wicks (for pole planting) could be loosely tied to the cutting to provide moisture for root establishment. The wick could again be extended to groundwater to improve long-term survival.

Wicks are robust, low cost and offer a long refill interval. This can make them a good candidate for agroforestry in many areas of the world. With global climate change increasing the challenges of developing sustainable agro-ecosystems, wick irrigation may be a valuable addition to the tool kit of small scale irrigation systems (deep pipe, clay pot, porous pipe and porous capsule) suited for small, resource-limited farmers. It can help with the key challenges of establishing needed trees and conserving water (Chambers et al., 1991).

Additional research on wick material and wick preparation is well suited for school and university class projects. Demonstration projects are urgently needed (Bainbridge, 2012). Tests of wicks in different configurations for gardens and greenhouses are also needed.

Wicks for starting trees or shrubs

Tree or shrub wicks can be made with nothing more than a larger plastic bottle or pail, some solid braid nylon rope (7/16 inch works well) and a razor knife. Wash the rope with detergent or soap, rinse and let dry. Hang in the sun for a week or two if possible. Trim the fuzz from one end of the nylon rope and using a flame melt the nylon end, then with a gloved hand or stick shape the tip into a point (care is needed, as the hot melted nylon can easily cause burns). For a regular bottle, cut or punch a hole smaller than the rope near the bottom, and for a sports type drinking bottle, cut out the web (the small crossed plastic piece) in the bottle valve and cut a flap in the bottom of the bottle for refilling. Pull the rope through until 30-40 cm (14-16 inches) are left exposed and then tie a knot and cut the pointed end free to go on the next bottle. For a hybrid wick system that adds advantages of capillary and gravity wicking insert the wick about halfway up the bottle in a plastic tube. It will act as a gravity wick at first, then as the water level drops it will transition into a capillary wick.



© David Bainbridge Figure 8

Plant the seedling and wick together. If it is a taproot type plant and the soil is soft, one can push the wick deep into the soil with a metal needle. The wick should be exposed to the roots of the shrub or tree as it comes out of the container. Multiple wicks can also be used from one reservoir to guide root development to improve wind firmness. Wick placement may also be used to reduce tree root/annual crop interference. After planting add a tree shelter, cage, sticks, branches, rock mulch or other protection from wind, sun and browsing animals.

For a more adjustable wick system use a threaded to barbed plastic fitting (preferably nylon or polypropylene) and a piece of 12 mm (1/2”) inside diameter clear vinyl tubing. Drill a hole in the bottom edge of the reservoir with a drill bit the size of the diameter of the fitting at the valley at the bottom of the threads so the fitting will screw into the container. For flexible plastic the hole size can be even a little smaller. Then lay a bead of polyurethane glue (e.g., Gorilla glue) around the hole and screw in the fitting. Let dry. Cut a short length of tubing to carry the wick from the reservoir and down at least 5-10 cm (2-4”) into the soil. Slip a hose clamp over the tubing and then push the wick up into the tube several inches. Push the vinyl tube onto the barbed fitting and then tighten the hose clamp until the wick is securely fastened. For a project with many wicks test flow rates at different tightness to obtain an appropriate flow. Refill as needed. Adjust screw clamp to modulate flow rates.

Bainbridge, D. A. 2012. Restoration of arid and semi-arid lands. Chapter 10, Pp. 115-129 in J. van Andel and J. Aronson, Restoration Ecology: The New Frontier. Blackwell.

Bainbridge, D. A. 2007. A Guide for Desert and Dryland Restoration: New Hope for Arid Lands. Island Press, Washington, DC.

Bainbridge, D. A. 2006. Beyond drip irrigation – hyper efficient irrigation systems. Proceedings American Society of Agricultural and Biological Engineering Annual International Meeting, Portland, Oregon. ASABE #062073. St. Joseph, Michigan 10 p.

Bainbridge, D. A. 2002. Alternative irrigation systems. Ecological Restoration. 20(1):23-30.

Bainbridge, D. A. 2001. Buried clay pot irrigation. Agricultural Water Management 48(2):79-88.

Bainbridge, D. A. 1994. Treeshelters improve establishment on dry sites. Treeplanter's Notes. Winter 45(1):13-16.

Cannon, W. A. 1917. Relation of the rate of root growth in seedlings of Prosopis velutina to the temperature of the soil. Plant World 20:320-333.

Chambers, R., N. C. Saxena and T. Shah. 1991. To the Hands of the Poor. Intermediate Technology Publications, London, UK 273 p.

Cohen, M. E. 2002. Utilizing microcatchment systems to increase tree establishment rates in the Bolivian high plains. MS Thesis, Forestry. Michigan Technological University. Houghton, MI. http://forest.mtu.edu/pcforestry/people/1998/cohen.pdf Accessed June 18, 2012

Dai, A. 2010. Climate change: Drought may threaten much of the globe within decades. University Corporation for Atmospheric Research, National Center for Atmospheric Research, Boulder, CO. October 19, 2010. www2.ucar.edu/atmosnews/news/2904/climate-change-drought-may-threaten-much-globe-within-decades Accessed March 25, 2012.

Editor. 1955. New aids to living – Waterwick. Popular Science 167(4):170.

Editor. 2010. A 100 best innovations of 2010. Popular Science. www.popsci.com/technology/gallery/2010-12/gallery-looking-back-100-best-innovations-2010?image=46

Evenari, M., L. Shanan and N. H. Tadmor. 1982. The Negev: the challenge of a desert. Harvard University Press, Cambridge, MA.

Hazell, P., C. Poulton, S. Wiggins and A. Dorward. 2007. The Future of Small Farms for Poverty Reduction and Growth. 2020 Discussion Paper No. 42. International Food Policy Research Institute. Washington, D.C.

Mari Gowda, M. H. 1974. Dry orcharding. The Lal Baugh 19(1/2):1-85.

NOAA. 2012. North American Drought Monitor. www1.ncdc.noaa.gov/pub/data/cmb/drought/nadm/nadm-201201.pdf Accessed Feb 23, 2012

Neal, C. A. and R. W. Henley. 1992. Use and runoff comparisons of greenhouse irrigation systems. Proceedings Florida State Horticultural Society. 105:191-194.

ORIGINAL SOURCE

Bainbridge, David A. 2012. Wick Irrigation for Tree Establishment. Permanent Agriculture Resources, Holualoa, Hawaii. http://www.overstory.org

---

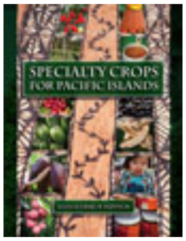
AUTHOR BIO

David Bainbridge is a restoration ecologist based in San Diego, California. He is currently working on a book, “Beyond Drip,” describing the many traditional irrigation systems that can be more efficient than drip and can be used by resource limited farmers. His work appeared in Overstory #175--Deep Pipe Irrigation in 2006. He can be contacted at: sustainabilityleader@gmail.com

---

RELATED EDITIONS OF THE OVERSTORY

The Overstory #209--Soil Compaction & Trees
The Overstory #175--Deep pipe irrigation
The Overstory #111 - Land Husbandry
The Overstory #104--Soil and Water Conservation
The Overstory #96--Sheet Mulch
<http://www.agroforestry.net/overstory/overstory96.html>
The Overstory #88--Revegetation Planning for Farm Forestry
<http://www.agroforestry.net/overstory/overstory88.html>
The Overstory #80--Forests and Water
<http://www.agroforestry.net/overstory/overstory80.html>
The Overstory #73--Buffers, Common-Sense Conservation
<http://www.agroforestry.net/overstory/overstory73.html>
The Overstory #45--Vegetative Erosion Barriers in Agroforestry
<http://www.agroforestry.net/overstory/overstory45.html>



By the publishers of *The Overstory*: From Bamboo to Black Pepper, Cacao to Coconut and Tea to Taro--*Specialty Crops for Pacific Islands* provides detailed cultivation, value-added, and marketing information for over two dozen of the most important specialty crops for the tropics. Order your copy.

Back in print: *The Overstory Book: Cultivating Connections with Trees, Second Edition*

Now available to order from Amazon.com:
http://www.amazon.com/Overstory-Book-Cultivating-Connections-Trees/dp/0970254431

Advanced study internship

The people who bring you *The Overstory* e-journal now offer an 8-week advanced study internship in tropical agroforestry: http://www.agroforestry.net/internship.

Article submissions

Have you written an article in the last 5 years on a topic that you think would interest other Overstory subscribers? Would you like it to be circulated in edited form to subscribers in 187 countries? Then submit it to the Overstory for consideration--it's that easy! Please read our submission criteria before sending us your submission: http://www.agroforestry.net/overstory/ovsubm.html.

Address changes

Please send e-mail address changes to overstory@agroforestry.net.

Publisher Notes

The Overstory is distributed by Agroforestry Net, Inc., P.O. Box 428, Holualoa, Hawaii 96725 USA; overstory@agroforestry.net; Web site: http://www.overstory.org

Agroforestry Net, Inc. is a 501(c)(3) nonprofit educational organization.

Editor: Craig Elevitch

Past editions of The Overstory: http://www.overstory.org

Support *The Overstory* by donation, sponsorship, or book purchase.

Thanks for reading!

The Overstory is for private, individual use for educational, non-commercial and informational purposes. Please read conditions for use before subscribing.

Click here to subscribe

or send an email to overstory@agroforestry.net with:

1) your name
2) e-mail address
3) organization or brief project description
4) your location (city, state, country)

To remove your name from our list, simply send an email with your the name and email address under which you are subscribed to overstory@agroforestry.net

We will never give, trade, sell or distribute your e-mail address or subscription information to anyone without your prior consent.

| Journal Home | Journal Previous Editions | Journal Submissions |

| Current Projects | Publications | About Us | Links |

Search

Agroforestry Net, Inc.
PO Box 428
Holualoa, Hawaii 96725 USA
Contact us: email@agroforestry.net

Site comments and suggestions

Page Last Updated: November 4, 2012