“Grow Dryland” by A2WH.com

Harvest water from air for desert planting and reversing desertification.

The A2WH Grow Dryland is designed to support seedlings in location too dry for them to survive otherwise.

Grow Dryland extracts water from the air and uses that water to keep seedlings alive in desert conditions where water and electricity are not available. Grow Dryland is powered entirely by solar energy which makes it ideal for remote and hard to access locations.

Grow Dryland delivers water directly to the root zone of the developing seedling to sustain the seedling through its early growth phases and root development. When used with a wick system, water collected by the A2WH unit can guide the seedling’s roots deep below the surface where soil moisture is sufficient for the seedling to continue to develop and thrive. Once the plant is large enough to grow on its own the Grow Dryland can be moved to support a new seedling. When combined with a bio-sponge and land profiling techniques the A2WH unit can support tree seedlings in the most hostile and desolate conditions.

The A2WH Grow Dryland delivers about 2 ounces of water per summer day directly to trees roots via a wick or tube and occupies about 2 square foot. Grow Dryland was invented as part of a program to try and restore foliage across massive deserts and decertified areas where a tree could survive if it got big enough but where the seedlings die of dehydration before they get big enough to reach the deeper moist soil.

The A2WH Grow Dryland is designed for use in desert conditions where severe degradation from desertification has made the land nearly barren. When combined with the rest of our program the A2WH units can help turn this land back into viable habitat and reduce hardships caused by drought. Our overall program is designed to support this while increasing local revenue and increased food security.

A2WH – Grow Dryland
Air to Water Harvest

Atmospheric Water Generator, Water from Air Device, Renewable water directly from solar energy.

Greening the Desert

Reverse Desertification

Support Trees in locations where it is otherwise infeasible.

Dramatically increase the survival rate of the trees.

Eliminates the need to install and maintain miles of pipe.

No Need to negotiate right away for infrastructure.

Easily supports very large scale distribution planting.

Grow Dryland uses:

- Start trees for to provide wind screens where irrigation unavailable.
- Start shade and fuel trees at remote locations like camping and recreation lots where there is no water available.
- Start perimeter privacy and wind screen trees on larger lots where Grow Dryland may be easier and less expensive than installing larger irrigation systems.
- Start forage trees needed to restore grazing lands before they severely degrade.
- Start trees to provide habitat and shelter to attract wildlife to barren desert lots.
- Start the process of revitalizing degraded and desertified lands by Start trees on that can hold water in the soil, reduce erosion, reduce runoff, reduce dust loads, and provide habitat and aid in returning the land to healthy state.
- Support growth of plants in areas where municipal watering restrictions would prohibit the same plant.
- Establish high nitrogen biomass trees on cheaper land where there are no irrigation rights available. The foliage can be used to produce traditional biomass for fuel or used to produce high nitrogen compost, which can deliver a higher profit margin.

- Produce income from desert land without increasing demand on groundwater.

Introduction:

The A2WH Grow Dryland is a small atmospheric water generator powered by solar energy, is approximately 2 square feet in size, and delivers enough water to keep a seeding alive in the middle of the Sahara desert. The cost of the Grow Dryland unit is under $200 USD (in quantities of 200) and will drop further in larger quantities.

Each Grow Dryland can start many trees over its useful life and when combined with wicking drill techniques it can guide seedling roots into deeper subsurface moisture so it can thrive even in the dry desert. When combined with land profiling, A2WH units help soils increase water retention, reduce structural loss, and provide more water available for volunteer plants. This it is enabled by the A2WH device which can be deployed in a distributed and incremental fashion and can and provide water to seedlings distributed over a very large area that would be economically infeasible using traditional infrastructure and pipe techniques. The core ability for A2WH to extract the essential water from the air using solar energy makes the otherwise nearly impossible both feasible and cost effective.

The A2WH device can reliably produce water in areas where there is little or no rain; in fact it will deliver the most water during the hottest driest parts of the year, which is when fragile seedlings need it the most. Other water and dew harvest devices may not have any water left during the critical part of the year and therefore A2WH units can significantly increase survival probability.

"Grow Dryland" was invented to reverse desertification worldwide. It is part of a larger program which makes it to possible rehabilitate large areas of degraded and desertified land. This plan centers around starting profitable trees because they can act as the anchor for a recovery oasis, we can start during the worst drought and this kind of planting can restore life and rehabilitate the land without increasing groundwater demand. It can work in many areas but it will be most beneficial in with low rainfall or common drought. Parts of our program can help restore groundwater in degraded areas which can help accelerate the recovery. Our assertion is that if you want people in desertified areas to plant, maintain and protect the trees needed to reclaim the land then they need to gain local benefits, income or food from those trees. We focus on plans which are synergistic with the needs of local farmers and local villagers who we believe will make the best long term stewards. All plans require money to get started but unlike many approaches our plan can deliver a profit so it is not entirely dependent on charity or government funding.

See Also: Grow Dryland reduces impact of drought on cattle ranching

Rest of the Planting Program:

There are many seedling tree planting programs but unfortunately many of these programs are one-shot affairs where over 70% of the trees die within the first year. Our goal is different. We want to create an economic system where local farmers can use the trees to build their income.

Wicking root Drill – guides roots to naturally available water where they may never have otherwise reached.

Bio-Sponge – Stores water from rainfall so the tree has a local reserve while providing naturally decomposing nutrition.

Micro Land profiling – (Micro Catchment) Guides water to the Bio-sponge for storage, reduces evaporative losses and helps eliminate soil erosion.

Food and Foliage – Reduces drought related food famine.

Nitrogen rich compost – The nitrogen rich leaves can be composted for nutritional fertilizer that holds moisture.

Bio-Fuel trimming – Use careful pruning to guide the tree's growth. Can also utilize timings for bio-fuel or wood fuel.

Harvesting – Some desert trees have wood that is highly prized for furniture and can be sold. The best trees will regrow from the stump and grow faster the second time.

Other parts of the planting regime:

Our focus on very dry and degraded land habitat foliage restoration requires a little more process than planting a seedling in the ground utilizing traditional methods. But with the little extra effort our systems can dramatically increase the bio-production of the land.

Bio-Sponge: We are focusing on hostile desert and severely degraded land habitats, which experience deep droughts and where deep sand is common. Moisture holding capacity of sand is very low and so even following rain events there is usually too little moisture retained in surface areas to support seedling vegetation. Creating a bio-sponge around the seedling trees, which is enriched with biological components that hold water and release nutrients as they decay, is essential to helping seedlings reach their full development which, in turn, is essential for carbon up take, biomatter production and maximizing revenue at harvest. Our general recommendation, if practical, is that a dirt column be placed at the planting area which is a minimum of 1.5 foot in diameter by 3 foot deep mixed 50% by weight with bio-degradable matter, such as leaves, to provide superior results. Ideally this bio-sponge would be 3 foot in diameter by 6 foot deep with an effective 50 to 150 gallon storage capacity before it reaches a waterlogged state. This level of storage capacity is much more important for supporting adult tree growth than not disturbing the natural capillary function of the original soil.

No Fog or Rain needed:

A2WH makes the most water on the hottest sunniest day when no rain and not fog is available.

Other tree devices rely on rain capture or harvesting atmospheric dew, or fog, and will typically fail during droughts and very dry periods. We like these devices for locations only where there is consistent rain with low risk of drought.

A2WH units are developed especially for use in areas too dry and too severe for other devices and we believe our units will deliver consistently better performance at these locations.

Wicking Root drill: The Wicking root drill is well-established art and is pre-published in agro-forestry. Any device, which delivers drip feed water to a wick that extends downward far enough to reach the area where moist dirt is consistently available, will carry that water down through the root zone to the deeper moist soil. The seedling's roots will follow this wick downward since it contains supporting moisture and will eventually reach the deeper moist dirt.

This can be as simple as a nylon rope inserted down a 6-foot deep hole 1" in diameter and hooked to the outlet tube of the A2WH device so that it is kept continually damp. We cannot claim credit for this work but we think it is an essential component of helping trees reach their full potential in desert conditions.

Micro Land Profiling / (Microcatchments): The areas where we focus quite often have very low rainfall - less than 6 inches per year. With this little rain it is essential to redirect as much of the water that does fall as possible into the bio-sponge which can retain much of the water until the tree needs it. This is also important because it reduces the amount of water lost to evaporation. We recommend micro profiling where the profile is designed to deliver water to the tree from an area equal to 70% to 200% the size of the adult umbrella depending on local climate conditions. At the most simple level this can be thought of as a shallow bowl a few inches deep that slopes to the bio-sponge where the seedling is planted so that any free water that is available collects over the sponge and soaks in. An overflow allows any extra water to flow to the next seedling or tree. This can be augmented in very sandy soils by adding a 2" thick layer of rocks over a ½" layer of impermeable clay so that the water rapidly runs through the rocks and along the top of the clay until it reaches the bio-sponge, which reduces the losses to evaporation and maximizes the water available to the tree. Plastic, newspaper or anything less permeable than the sand can replace the clay and on sloped or hilly land and can quite often be achieved with a small number of rocks used to guide the water over the bio-sponge before it is lost to adjacent areas. We believe micro profiling is far less expensive, less time consuming, and more feasible in than large-scale land modification required by many permaculture approaches. And it can be used on land with terrain unsuitable for normal permaculture.

A secondary benefit of micro profiling is that with this kind of adaption a majority of the water, which falls on the land, is retained on the land and soaks in to recharge the soil moisture that is critical to support volunteer plants. By retaining this water it radically reduces runoff, which has many benefits including reduction of soil erosion via silt loads to river systems and reservoirs. In desert conditions, with less than 20 inches of rainfall per year, profiling the land to encourage water to run towards the tree before soaking into the bio-sponge around the tree will dramatically improve residual soil moisture available for the tree.

Utilizing bio-sponge and micro land profiling techniques, it is quite likely to be able to dramatically accelerate seedling growth from year 3 through maturity, which means more carbon uptake and larger trees at harvest.

Is A2WH Cost effective?

It may be a better question to ask whether one can obtain a positive return on their investment when using A2WH.

There are conditions where A2WH makes it feasible to bring low-value land into production that would have simply been idle or contributing to erosion, silt loads and dust storms. If you spend $75 to plant a tree and then end up harvesting an average of $25 per year worth of fodder per year for the next 30 years then you earn $750; 10 times return on your money. If you then sell the lumber at the end for another $500 then you have a total of $1250 for 1667% increase on your money. If you are able plant shade trees, which increases the value of your property and helps make the hot summer season more pleasant, then it can make your investment in the entire parcel enjoyable and worthwhile.

One of the side effects of a designing entirely for renewable energy is that there is a minimum complexity and minimum number of parts which drive the ultimate cost. At its current price A2WH is very cost effective when compared to alternatives that generally includes transporting water each week or installing large-scale deep wells and water distribution infrastructure. As discussed above, at its current cost points, A2WH could enable businesses which could deliver many times the original investment. Our studies currently indicate that the ability to re-habilitate degraded land will yield a positive return on investment in nearly every circumstance.

The net effect of this program when deployed in the very large scale is that it can dramatically reduce the negative effects of desertification while providing revenue and food security. If you put a value on this then A2WH is quite inexpensive. We have done studies for farmers in Jordan where they are fortunate to net $500 per year and it appears that this program could more than double their income while reducing their risk of going further into debt when the next drought occurs. Farmers in this area have experienced several years of drought over the last 7 years and A2WH could have helped them avoid descending further into debt.

A2WH Grow Dryland is ideal for areas where repeated droughts are devastating the finances of farmers depending on rain fed crops since it increases the probability of them receiving a crop of foliage able to support their animals during years when traditional food is not available. We believe the A2WH Grow Dryland could be the very best and most cost effective way to protect their ability to live successfully on their farms and avoid being forced to relocate to populated urban or city alternatives.

One of the side effects of this program is that it can significantly reduce surface soils displaced by wind. If you consider the associated economic costs of not taking soil stabilizing actions (which means wind storms will continue and the cost burden realized by urban communities, potentially miles away, which are directly and adversely impacted by substantial amounts of airborne sediments will continue) then A2WH utilization can offer a positive rates of return (ROI) even before the wood is harvested and may be the most a cost effective way to take action against the problem.

A2WH Difference to Fog or Dew / condensate capture systems:

Dew harvest systems work by chilling their surface at night using night radiant chilling, which is similar to how your car roof can feel cooler than the air around it especially in the desert.

We like this technology and built several early devices that used night radiant chilling. Unfortunately we found that as you reach the parts of the year, like the hottest portions of the summer and fall when water is desperately needed, the humidity drops enough that the night radiant chilling is insufficient to chill the air enough to reach the dew point. As a result these devices stopped working when the water was most needed.

We designed A2WH to deliver the most water in the hottest driest parts of the year when water is most critical and least available. This requires that A2WH uses entirely different physics but we think the result has been well worth the extra years of research it required.

How A2WH works:

A2WH absorbs water from the air at night when the air is the coldest and then uses solar heat the next day to convert water it absorbed the prior night into liquid water. The collected water is directed via tube and wick system that runs vertically down from the plant and root structures.

Absorbing the water at night is important because that is when the relative humidity is the highest which allows our chemical desiccant to absorb the greatest amount of water from the air and this allows more water to be absorbed with less fan energy and also allows more absolute water to be absorbed. After a night of absorption the system ends up heavier by the amount of water absorbed.

Because we only need to pull the night air past our desiccant matrix the energy cost is as low as simply running a fan, which pulls the night air through the system. The next morning the system converts to a sealed operating mode that makes it air tight so any water that evaporates from the matrix under solar heat is captured where it can condense on the cooler outer skin of the A2WH unit. A small micro-controller senses day and night and automatically changes modes as needed. The same micro-controller senses heat, charging energy, battery voltages, and adjusts operation of the system accordingly for optimal production.

A2WH Difference to Electric Refrigeration systems:

Electric refrigeration systems work by cooling the ambient air until it reaches the dew point which allows some of the water to condense on a chilled surface of metal condenser.

This chilling energy is delivered by an electric heat pump similar to a window air conditioner. These units work well in some conditions and are very common for replacing bottled water but a side effect of their design is that they must chill large amounts of air to get the water, which consumes a large amount of electricity. When compared to the cost of transporting bottled water we believe these units provide a valuable service because even 3,000 watts is less pollution than having a large truck transport by 2 or three times a week.

As the humidity drops the refrigeration units must cool more and more air by a larger increment of degrees, which increases the energy costs. It is not uncommon for these units to stop delivering water when humidity drops below 50%.

We have receive calls from customers who are reporting that their units are consuming over 3,000 watts to produce 1 gallon, which in remote locations is very expensive since the power is generated from diesel and/or gasoline.

In contrast, A2WH units use a low powered DC fan to draw relatively humid night air that is then absorbed by desiccant. The next day solar heat is used to separate the water absorbed by the desiccant and converted it to usable liquid water. This allows A2WH to use cheap solar heat in rather than expensive electricity to obtain 98% of its energy.

We do not believe the electric systems can be used cost effectively or reliably in the locations where the A2WH planting system is intended to be used.

Chemical Desiccant choices and Safety:

A2WH made an early design and marketing decision, which was not to use desiccant chemicals unsafe for direct human contact. Since then we have taken that decision even further and limited our use desiccants to only those already used in commercial food preparation (one of our most common chemicals is actually used in pickles and as a replacement for table salt). This important choice is in contrast to other desiccant systems that require dangerous refrigerants that can be toxic if leaked. For example, the USA military uses chemicals to produce water from air for ships and mobile armor that are so toxic that a few drops can kill a person. Certainly, it required many extra months for us to confirm appropriate ways that we could use human-safe chemicals and still deliver an efficient and cost effective product. We continue believe that this is the best decision to help avoid accidental harm to humans, plants, and animals by keeping dangerous chemicals completely out of our system.

Questions and Answers (FAQ)

It seems like the entire planting process could cost over $75 per tree with the labor to make the bio-sponge, planting wick and micro forming the land. How can this be viable for larger scale plantations?

The important aspect here is that we are focusing on planting trees where the tree would not have been able to survive without A2WH. This allows less expensive land to be used which makes things viable which would normally not be considered useful for agriculture. Depending on the assumptions used the cost could be between $5.00 to $125 a lot depends on the cost of labor and the assumed cost for access to machinery. We work from an assertion that most farms already have tractors with 24" drills or back hoes available so you are only paying for the per hour operating costs and that this work is done by people already working the land in their spare time so our USA estimates are $35 per tree. Our primary focus is on the 3rd world where labor costs are closer to $150 per month per person and we are looking mostly at stewardship approaches where the person doing the planting is also the person getting the benefit so this would largely be taken out of their discretionary time. It is really a ROI question. If you can spend $35 to plant a tree and then receive $30 worth of fuel wood and or fodder for the next 50 years then it is a very good payback. If you spend $200 to plant a tree but it makes provides shade which makes staying on your vacation land in your $80,000 mobile home then it is a judgment call.

How long does the unit need to stay with the tree?

This depends on many factors such as the time between rain fall, The natural soil moisture, The tree chosen, Time of year planted and how much of the planting process you implemented. In ideal scenarios it could be as short as 1 summer or about 4 months. In the more hostile locations with lower natural soil moisture and those areas with long periods between rain you would want to leave the unit for 2 full years or until you see a major growth spurt out of the tree which normally indicates it has reached a source of moisture that can provide more water.

How long does one tree require the exclusive need of the wetting device?

This depends on the tree, how deep the deeper soil moisture is, The annual rain fall. The average time between rain fall and whether bio-sponge was implemented. The short answer is 1 to 2 years and you should see a growth spurt as the tree reaches the deeper soil moisture. It could take longer in very hostile climates. It will definitely take longer if the bio-sponge, root wick guide and micro-forming are not included.

What does each unit cost?

The costs vary with time as our parts and labor costs change. At the time of writing this we plan to make some units available in As of Aug-2013 it is available in the USA via Ebay with a buy-it-now price of $350. When land owners buy hundreds or thousands of units the cost can drop substantially because it allows us to buy the materials in larger quantizes which gives us substantial discounts. Our ultimate goal is to make these units inexpensive enough to make it attractive for use in large scale desertification.

Question: Is 2 oz. of water per day is sufficient to nourish our tree?

This will depend on the tree and the size of the tree when planted. We obtained the 1.5 ounce figure from multiple external articles but are just starting the process of testing it. We increased the minimum goal from 1.5 ounces to 2 ounces to provide some margins and then over-sized the A2WH unit so it produces closer to 3 to 4 ounces on an average sunny summer day in a hot desert climate.

We recommend starting with small seedlings less than 1 foot tall so their initial water needs should be met. One of the things we want to test is how long it takes to guide the roots of a tree that is this small down to the deeper soil moisture and whether the amount of water we deliver is adequate to give the tree sufficient energy to reach this goal. If we find during these tests that more water substantially accelerates how fast the tree can reach the deep water then we will adjust the product specification as needed. It will always be a balancing act between driving costs down and delivering enough water.

In some instances we will install 2 or 3 of the A2WH units to see if the tree with the larger number of units reaches the deeper water a lot faster it may be worth increasing the size and cost of the A2WH unit to deliver the greater amount of water.

I think this will require some experimentation as we want to have the smallest cheapest unit that can reach the end goal.

Question: Should the application require all that is suggested under the Micro Land Profiling plan the cost and effort would be considerable.

Answer: We agree there is no free lunch. What this plan and the A2WH technology does is allow you do plant a valuable crop on land that is essentially worthless. The ability to use this cheaper land can pay for a lot of labor and investment in improving the land. In a era where many experts acknowledge that availability of fresh water will be a limiting factor in our ability to feed the world's population this plan provides a solution to put a lot of land into profitable use without increasing our demands on traditional freshwater supplies. We think the benefits outweigh the costs. Our original goal was to provide a way to tackle desertification in countries where it is killing the ability of small rural farmers to stay on their lands. It took centuries to degrade this land and it will take investment and cost to reclaim the land. It is not easy and it is not free but it does provide a profitable way to approach the problem that can be applied by individual farmers or could be applied to millions of square miles.

One of the things we are in the process of testing in this stage is to measure the tree health, growth rates and survival rates when we use various combinations of the full planting system. Ultimately we may only need a fraction of the planting system in a given location or climate while we may need all of it in other climates. One of our goals is to be able to better predict how much of the planting process will be needed in various climates.

Do you may have more technical info?

We have quite a bit of information available but a lot of it needs to be confirmed by on the ground tests. We also have to be careful to avoid including so much detail that we bore readers to sleep. As such we can never publish all the detail we have available. I am more than willing to answer specific questions.

What does Micro Forming mean?

Answer: This basically means adjusting the terrain around the tree to guide water which falls in the area that may be the size from ½ to 3 times it's adult umbrella size so that most of the water which falls in this area is guided to an area directly around the tree where the soil has been amended to hold more water than sandy desert soil can normally hold. This is a form of Microcatchments which has been used for millennia. In the simplest context this can a simple grade leading in a shallow bowl shape to the tree. Depending on the soil composition it may be necessary to add a clay or plastic lining covered by rocks, gravel, bark or sand which provides a barrier to prevent the water from soaking through so the water runs along the liner and into the bio-sponge. We never want more than a couple inches of water standing over the bio-sponge so the profile must allow any excess to drain off but in most instances this creates a favorable condition where the water once the sponge is fully saturated soaks out into the deeper sand surrounding the sponge which in effect creates a secondary saturated sponge area that encourages the tree to extend it's roots deeper as it follows this water downward. We actually prefer to do the planting on hills because the micro forming can be as simple as piling rocks to guide the runoff to the tree and a few more rocks to hold the water over the bio-sponge before it is allowed to continue down the hill. This provides a secondary benefit of holding water on the land where it soaks in which helps recharge the ground water table rather than allowing it to run off carrying away the valuable top soil and eroding the land.

What about pests such as Rabbits?

Answer: There is a risk that rodents or bugs could eat the tree. In addition some animals may simply chew holes in the A2WH unit. To minimize this risk we suggest forming a small enclosure out of light weight chicken wire or machine wire small enough to keep the rodents out. We will still lose some trees if the rodents dig under the wire but this is the same risk farmers have been dealing with for centuries and the techniques for control are well understood.

Where did you obtain information about Root guide wicking?

We found this in a very good article published by Agro forestry. "Overstory #249 Wick Irrigation for Tree Establishment by David A. Bainbridge September 17, 2012" Once we had the terms then there where hundreds of additional references available in Google. Government studies have tested this technique and have confirmed that it can help trees find deeper soil moisture they would otherwise never have found. This ability to guide the roots to deeper water can make the difference between trees that end up dead or stunted and trees which thrive.

Can it work in areas where there is simply not enough water like Southern Nevada?

Southern Nevada type climates are very interesting because there is a lot of relatively inexpensive land that is essentially unused. It also provides a lot of sun with a long growing season so if the water issue can be overcome it opens a new section of land that can deliver a lot of food and fuel. We are currently working to establish test sites to prove our assertions but we believe that we while our planting density will be low in this area that the full process can produce full sized adult forage or bio-mass trees limited mostly by growing season and available sun.

Parts of Nevada only receive 3 to 4 inches of rain per year but can receive a lot more water. Our core idea is to profile the land to guide water from ½ to 2 times the adult umbrella into a bio-sponge in which the soil has been amended to dramatically increase its water holding capacity. This reduces the amount of water lost as it runs through and dissipates into the sandy soil below the root zone. The bio-sponge holds the water where the tree can easily access it and combined with the good sun it becomes available to generate the biomass.

As described below we take the 3 to 4 inches of rainfall and assume that it falls in 10 to 16 storms which each drop a minimum of 0.2 inches of rain. This gives us 10 separate events where the bio-sponge is changed with about 100 gallons of usable water or 1,000 gallons of usable water which is retained for the use of the tree. By adjusting the capture area and bio-sponge size this could be increased as needed to meet the needs of the tree. One challenge we have is that normal watering guides do not assume the water is held in this form where the tree can easily access it so they tend specify a larger amount of water but a large portion of this drains right through the root zone and is not available to the tree. It should be obvious that we must design the capture and sponge capacity to reflect the minimum survival requirement during the longest period we expect to go without rain during an average year which means it will have excess water available for many parts of the year which will help spur growth and maximize bio-mass production.

We target a minimum of 24% water retention by weight in the bio-sponge. A 4' x 4' X 4' bio sponge occupies 64 cubic foot or 478 gallons. At 20% retention it should be able to store approximately 96 gallons of water which the tree lives on until the next storm plus whatever it can obtain from the nearby soil. A single storm which dumps ¼ inch of rain over a 40' x 40' foot area will deliver 249 gallons of water part of which would be lost immediately due to surface evaporation but a majority will flow to the bio-sponge which will fully charge the sponge and provide enough left over to dampen the surrounding sand. This is probably overkill depending on the amount of water dropped by the average small rainstorm so the sponge could be enlarged or the capture area could be reduced. The actual capture size and bio-sponge size can be adjusted to best fit the local environment.

Southern Nevada occasionally experiences a 18 month drought which may exceed the drought capability of our favorite trees even with the bio-sponge. Since this occurs very seldom we treat it as an exception process. The small A2WH unit used to start the tree will not provide sufficient water to support the adult tree but we can produce larger units that can do so if the tree is delivering adequate value to justify the investment. In reality the bio-sponge makes it feasible to haul in water via truck which is used to refill the sponges and which can then carry even the adult tree for several months. The amount of water required is a direct function of the adult tree size so larger trees which are producing more bio-mass value and delivering more revenue will need more water.

Isn't it better to re-establish native species?

We support people who link revitalizing land with re-establishing native species and establishing local preserves that restore native habitat as part of restoring water sheds. We think these are valuable efforts and believe that our "Grow Dryland" product can help in these endeavors. Wherever it is possible to obtain sufficient funding to take this approach we think it has strong merit. We do not believe it is the only way to revitalize degraded land and do not believe it will always be the most successful strategy.

The main challenge with the native restoration is that some of the implementations have taken hundreds to thousands of acres that local farmers have historically used for grazing completely out of use for a number of years. When you attempt to take land that has been contributing to the living of a farmer who is struggling

to provide a viable living for their family away they are likely to ignore or fight the new limitations. The long term good is simply less important to many people trying to support their family today so it is normal human nature for them to ignore the new regulations. We think that allowing local villagers and farmers to control pieces of land where they receive the benefits from improvements is one of the best ways to create long term stewards who will enthusiastically support revitalization programs.

We believe it is normal human interest to think first about the welfare on one's family. To accommodate this we prefer strategies that allow enlightened self-interest to guide decisions that benefit the farmer and their family first but which naturally benefit the ecosystem and the community as a side effect. We prefer minor changes which do not reduce the number of animals they can support and which will rapidly increase the amount of forage food available especially during drought years.

There is a good argument that plants which already live in an area are well adapted to the needs of that area in ways that imported species can not duplicate. This is very true and we always prefer local species when they can support the rest of the program goals. There is a unfortunate reality that Humans and our associated animals place new demands on plants and a native plant that could thrive without humans and our associated animals doesn't have the characteristics necessary to continue to thrive in anything except protected reserves. As such planting the imported species trees which can maximize delivery of income, forage may be a better choice especially for bottom up projects.

What about areas where the ultra-poor do not own the land?

This is a major problem since people who have no vested interest in the land are unlikely to make an investment in that land. If you do not own the land then planting even single seasons crops is risky. The A2WH Grow Dryland process requires multiple years to begin producing desired results so the local farmer needs to be assured of the ability to access and protect the land for at least 7 to 10 years to make the investment worthwhile. We feel land control needs to reside at the family or small village level for our program to deliver the greatest value but there are options even when they do not. In the short and medium term we will focus on markets where land ownership is not a problem.

In the longer term there are several groups working on this issue but it will take time, energy and a lot of money. It can require changing both the local laws and culture on a country by country basis while many government managers living in comfortable city locations will not experience a direct benefit from making the necessary changes. Each country's government should focus on this as a major short term issue because it looks like mass hunger, famine and migrations are an effective way to make governments collapse. If they do not want to experience massive turmoil in their country then they need to solve the land ownership and land access problems ASAP. Hopefully US Aid and other major aid providers such as the World Bank and the United Nations will force this change in the countries receiving aid because it is essential to long term success.

One possible solution is that as we demonstrate how the A2WH Grow Dryland solution works to increase land value we partner with the wealthy people in each country so they purchase or lease large tracts of degraded or abandoned land and then have them partner with local villagers who act as the local farmers and stewards who do all of the field work. This is predicated on the wealthy and powerful in the country understanding the local laws well enough to gain control of the required lands. The local villagers benefit in the short and medium term with improved food supplies while they split the revenue from bio-fuel and timber harvest in the long term. In an ideal scenario the land ownership transitions to the people actually working the land after the 3rd lumber harvest or a 300% profit has been accrued by the land owner, whichever comes first. Even if the wealthy land owners will not agree to ownership transition we feel it is still better to put this land back into productive use than allowing it to sit barren and idle. This is clearly not ideal but it may be one of the faster ways to use natural human greed to solve the property access problem across many cultures. There are other options for how to approach this problem many of which may be superior.

The Icrisat (International Crops Research Institute) has been working to form associations that give women rights to control land they rehabilitate. They are targeting access to village wasteland in regions where women do not have property rights. The are teaching these women how to use Zai pits which are small pits enriched with compost to plant drought tolerant trees or to create semi-permanent planting basins to harvest rainwater and concentrate nutrients. Even with A2WH it is critical to ensure that people who make the investment in the land can reap the rewards from that investment so land rights will represent a significant contribution to any solution. We would prefer to see the property rights be available to these women but if it comes to a tradeoff between waiting for a perfect solution or starting with what works to improve food supply then food must win.

Reference:

Drought and Desertification

- Global water stress interactive map
- Tackling Land Degradation and Desertification a DEF-IFAD partnership – 1035 million hectares affected by human induced soil degradation 45% by water erosion due to uncontrolled runoff. 12 million hectares are lost to deserts per year which is enough to grow 20 million tonnes of grain. From 1957 to 1990 the area of arable land lost was equal to all the crop land in Denmark, Fran, Germany and the Netherlands combined.
- Drought Covers One-Third Of U.S. Counties, The Largest Agricultural Disaster Area Ever Declared – Drought is a fact of life. Our A2WH device with the full planting process can make land and farmers more resilient to drought while improving the ability of their land to hold water and recharge the ground water table when there is rain.
- Desertification of the American Southwest: An analysis of Population, Climate, and Water Management. Includes a nice map showing the counties by county desertification in the America southwest.
- Desertification in an Arid Shrubland in the Southwestern United States: Process Modeling and Validation – Great explanation of the desertification process and causes. Talks a lot about Salinization which our process can help naturally reverse by allowing natural rainfall patterns to drive the growth on the land reducing the salt load received from imported water.
- DESERTIFICATION OF ARID LANDS By H. E. Dregne – Great set of links to organizations focusing on this topic.
- Soil, Desertification, Farm Bill Hotlist – A good set of links.
- Green Gold documentary by John D. Liu – good video showing impact of desertification. I think his approach has a lot of merit but I think it could go even faster with the support of A2WH and our planting program to create the mini life oasis which can act as the nucleus of a larger recovery.
- Desertification why most solutions fail
- Desertification: A review of the concept
- Trying to green the Gobi desert
- Climate information – resource conservation – sustainable management of land Climate and Land Degradation by World Meteorological Organization - Climate exerts a strong influence over dryland vegetation type, biomass and diversity. Precipitation and temperature determine the potential distribution of terrestrial vegetation and constitute the principal factors in the genesis and evolution of soil. – Very good overview that clearly explains effects of wind and drought on degradation.
- Water scarcity in Africa and the Middle East: A nice map shows where water scarcity has highest impact.
- Desertification and Misuse of Water Resources in Syria – Drought and desertification displaced 50,000 families who migrate to urban centers in search of work. human beings also can contribute to desertification by over-taxing water and soil resources.
- California Desertification: Too Dry or Not Too Dry -
- Desertification by excessive pumping in the Messara valley, Greece - Messara Valley located in the Geropotamou basin is threatened with desertification. A dramatic drop of about 20 m in the mean annual groundwater level during the last 30 years due to uncontrolled use reduced the available water
- Desertification in the Mediterranean - Earthy high mountains, that in the past carried tall forest and large pastures, have become rocky lands and look like the bones of a sick body... In the past rain water was utilized and did not run on the barren land to the sea as it does now. It infiltrated and was stored into the soil and it was distributed in springs, fountains and river streams".
- Desertification as usual: groundwater management under the Inyo-LA Long Term Water Agreement - Pumping had dried springs and seeps in the area and lowered water tables beyond 8 feet. Thus, human activity had converted biologically diverse native meadow to of opportunistic species, a process termed "desertification" in the scientific literature.
- That Sinking Feeling About Groundwater in Texas Posted by Sandra Postel of National Geographic's Freshwater Initiative in Water Currents on July 19, 2012 - Besides setting the stage for a record-breaking fire season, the drought forced farmers to pump more groundwater to make up for the rainfall deficit. Without the extra pumping, the drought would have decimated their crops. Ogallala. Water table in the region has dropped 100-150 feet in sizeable areas. As droughts become more frequent, particularly in arid crop-producing regions, groundwater reserves will be depleted even faster than in recent decades, threatening not only water but food supplies.
- U.S.In Drought, Water War in Calif. Fought Underground FRESNO, Calif. September 7, 2013 (AP) - Throughout the Central Valley — one of the world's most productive agricultural regions — farmers, residents and cities have seen their wells go dry. Those who can afford it have drilled deeper wells that can cost hundreds of thousands of dollars.

Economic impact of drought, desertification and Climate Change

- UN introduction to Desertification and Degradation – 52% of land used for agriculture is moderately or severely affected by soil degradation. 12 million hectares lost per year which is equivalent to 20 million tons of grain. 50 million people at risk of displacement in next 10 years. Overgrazing and water draw are primary contributors to degradation.
- UNCCD brochure on desertification and land degradation – 1.9 billion hectares of land worldwide. 24 billion tons of fertile soil disappears per year. Risk of 12% drop in food production and 30% increase in food prices due to desertification. Water scarcity at risk of displacing 700 million people by 2030.
- Desertification costs $42 billion per year – 20% of world's populations is threatened by global desertification. Over 4 billion hectares or 30% of earth's surface at risk. Six million hectares lost per year. Cost of inaction is estimated at 1% to 3% of GDP in developing countries. 135 million people at risk of being displaced by desertification. Over 60 million people will need to move from desertified areas of Sub-Saharan Africa toward Northern Africa and Europe by 2020. Recurrent droughts in Peru have forced 20% of farmers to move from rural locations into towns. In Mexico 47% of land is affected by desertification and contributed to mass migration towards United States.
- Desertification: How to stop the shifting sands - CNN.com – Costing the Chinese economy $6.5 billion per year. Estimated to cost Spain $200 million per year.
- USGS Desertification – Over 100,000 people and 12 million cattle dead from Sahelian drought in 1968, Rio Puerco Basin of central New Mexico one of the most eroded river basins of the American West.
- Global Desertification Dimensions and Costs – ciesien.org – 42 billion estimated in 1990 dollars but this may substantially understated as they are only showing $250 per hectare reduction for irrigated crops and $38 reduction per hectare for rain fed crops. Reversing a $38 loss for with moderate desertification yields $152 total crop per hectare. My recent contacts with farmers in Texas, California and Louisiana show much higher gross sales than $152 per hectare which implies that land degradation has a higher cost per acre than this white paper acknowledges.
- Desertification of the American Southwest An analysis of Population, Climate, and Water Management
- Desertification and Migration Mexico and the United States
- U.N. Desertification crisis affecting 168 countries worldwide, Severe land degradation affecting 168 countries and land degradation is costing the USA $490 billion per year and wiping out an area three times the size of Switzerland on an annual basis. Expert panel estimates 4% to 12% reduction in GDP for countries on Africa Continent.
- USDA Land Degradation Overview – Estimate $400 billion per year loss worldwide due to soil degradation. Nice chart showing degradation by continent in percent and total amount of millions of square kilometers degraded. Absence of land tenure and the resulting lack of stewardship is a major issue in some countries. Food security, environmental balance, and land degradation are strongly inter-linked and each must be addressed in the context of the other to have measurable impact. Land degradation is as much a socioeconomic problem as it is a biophysical problem. Land degradation and economic growth or lack of it (poverty) are intractably linked; (people living in the lower part of the poverty spiral are in a weak position to provide the stewardship necessary to sustain the resource base. As a consequence, they move further down the poverty spiral—a vicious cycle is set in motion) Also incudes a great set of reference links.
- ASSESSING THE EXTENT, COST AND IMPACT OF LAND DEGRADATION AT THE NATIONAL LEVEL – Shows China with 7.76 billion in direct costs and 31 billion indirect or about 4% of GDP. There is a 2 billion per year investment in response. The interesting thing about this number is that the indirect costs which are seldom shown in many studies are 400% the direct impact. It is unclear if the risk of mass migration is covered under the indirect costs.
- UNCCD - The Economics of Desertification, Land Degradation and Drought: Methodologies and Analysis for Decision-Making – Claims 6% to 24% reduction in GDP for South American countries due to Desertification. About 42 per cent of the poor around the world depend on degraded and marginal
- areas for their livelihoods. Once land degradation has occurred it generates negative feedback loops influencing wider natural processes.
- Economics of Land Degradation the costs of Action versus Inaction by International Food Policy Research Institute 2011. – In recent years prices of agricultural land have increased quickly and have tripled in many parts of the word. Persuading land users to adopt the land remediation strategies has been a problem. I think this is because in many cases the plans would reduce the economic or food output of the land in the short term negatively impacting the local famers. I believe any viable plan must give them short term benefits that actually increase their food production or income. . Land-tenure policies that give formal or perceived tenure security also enhance long-term investment in land improvement.
- Desertification crisis affecting 168 countries worldwide, severe land degradation is now affecting 168 countries across the world, according to new research released by the UN. Desertification / Land degradation is now costing $490 billion per year and wiping out an area three times the size of Switzerland every year. UNCCD 4-12% lost agricultural GDP in Africa is contributing to hunger and conflict on the continent.

- This will be the Arab world's next battle Population growth and water supply are on a collision course. **Hunger is set to become the main issue**. – Saudi aquifer is large depleted and they will be phasing out wheat production and is largely dependent on imported wheat. Saudis leasing land in Ethiopia to produce food. Ground water in Yemen is dropping 2 meters per year and in the capital city tap water is only available once every 4 days and in some cities once every 20 day. Grain harvest has shrunk by 33% over the last 40 years while demand continues to rise. Syria grain harvest has fallen 20% since 2001 while Iraq has fallen by 25% since 2002. Because of the failure of governments to mesh population and water policies, each day now brings 10,000 more people to feed, and less irrigation water with which to feed them.
- More than 30 million climate migrants in Asia in 2010 - Numbers of people displaced by environmental and weather-related disasters likely to increase. Warning by Asian Development Bank The Asian Development Bank warned that governments must start to make preparations now, to be ready for the multiplying threats, and because more extreme weather has already started to take effect, though changes so far have not been dramatic in their impact. "The number of extreme weather events is increasing and Asia and the Pacific is the region at the epicenter of weather disasters,"
- Peak soil: industrial civilization is on the verge of eating itself - Imminent global food crisis without urgent action. Approximately 20% of worlds cultivated land is degraded. Within 12 years high water stress will affect food basket regions. In 1950 2.5 calories of food produced per calorie of fossil fuel. Now it takes 10 calories of fossil fuel to produce 1 calorie of food.
- World Scientists Define United Approach to Tackling Food Insecurity - It's past time to realize that farms of every size all over the world are fundamental to human nutrition and economic well-being, We must redirect public subsidies to promote economically and environmentally sound farming practices that conserve finite natural resources
- Food Security: Near Future Projections of the Impact of Drought in Asia –
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Climate Change

- Poisonous trees planted in desert could mitigate climate change. Intensive carbon farming could absorb all the CO2 produced by vehicles in Germany over two decades. The Jatropha plant is a poisonous tree, able to withstand arid conditions and can be used to produce fuel oil. By Nilima Choudhary
- Climate change linked to 2011 East Africa drought – UK's Met Office thinks long dry periods similar to 2012 where more likely to occur as a result of man's activities.
- Africa: Desert Plantations Could Help Capture Carbon - Claims Jatropha Curcas trees in large plantations can capture carbon $56 to $84 per tonne which they claim is competitive with high tech means. They claim desalination and treated sewage would be good water source and that soil moisture has risen from 0.2 percent to three percent. See the full report:
- Climate change 'will make hundreds of millions homeless' Carbon dioxide levels indicate rise in temperatures that could lead agriculture to fail on entire continents. Climate change is amplifying risks from drought, floods, storm and rising seas. "Hundreds of millions of people will be forced to leave their homelands because their crops and animals will have died. The trouble will come when they try to migrate into new lands, however. That will bring them into armed conflict with people already living there.

Restoring Desertified and degraded Lands

- We must make up ground on the battle against desertification - Icrisat (International Crops Research Institute) has been working to form associations that give women rights to control land they rehabilitate. They are targeting access to village wasteland in regions where women do not have property rights. Using Zai pits small pits enriches with compost to plant drought tolerant trees to create semi-permanent planting basins to harvest rainwater and concentrate nutrients. Even with A2WH it is critical to ensure that people who make the investment in the land can reap the rewards from that investment so land rights will represent a significant contribution to any solution.
- Saving US grasslands: a bid to turn back the clock on desertification This article highlights the flood damage caused by degrading lands. Their technique is complementary to ours and both can dramatically reduce the flood damage and silt load while increasing the carry capacity of the land. Also mentions a consulting company specializing in HM (Holistic Management) and Department of agriculture grant supporting training in that art.
- How Korean organizations are combating desertification in Mongolia – working in the worlds coldest desert. They are using both trees and grasses. The grasses work in dried up lakes where there is enough water for them to survive without needing to import more water.
- Restoring "Desertified" Land – Interesting piece on how reducing over grazing can help restore land. The challenge is that once the land reaches a certain level of degradation those people grazing herds on it are faced with economic problems that are exaggerated if they cannot graze those lands. One of

our benefits is that we create drought resistant forage in areas where it could not otherwise be supported. As a result the herds have nonnative foliage available so the people have the choice of reducing their grazing on the affected lands. In addition our trees create shade zones and natural nitrogen rich bio-matter than can help the native plants recover by holding more moisture in the surface soil.

- Allan Savory: How to fight desertification and reverse climate change - Entertaining but controversial approach for treating degraded soil. His approach has been used for decades by American ranchers who move animals to new grazing areas seasonally but he extends this by ensuring that the duration of the animal herd is short enough in time to avoid too much damage. The general topic area is known as "Holistic Management" Allan endorses rotational grazing where he is using animals to create footprints which help concentrate water and create protected pockets for plants to sprout. The animals also spread seeds and natural fertilizer. Allan favors bunched and moving animals. A key aspect is to avoid leaving animals in one place for too long where overgrazing can destroy the underlying roots. Alan's process is synergistic with the "A2WH Grow Dryland" process. We focus on providing alternate forage supply during dry periods when damage from overgrazing is at highest risk and the highest temptation for local farmers. The extra Grow Dryland forage makes it feasible to move the animals after they have made their positive contribution but before they over graze. I am seeking collaboration to test our "A2WH Grow Dryland" planting process on land where trees are desired but where there is currently no water available to support the seedlings and where the seedlings normally die of thirst before their roots mature enough to allow them to continue to thrive on their own. We believe the "A2WH Grow Dryland" process will provide the greatest value for wind screen trees, ridge line trees and property line trees in dry grazing areas where additional edible foliage would be advantageous but no water is available to get them started.
- The National Strategy, Action Programme and Integrated Financing Strategy to Combat Desertification in the Occupied Palestinian Territory Over grazing of rangelands, Over pumping of ground water, Improper farming and irrigation practices and systems, Excessive application of fertilizers and chemicals, Deforestation, forest fires and fire wood collection, Urbanization, mining and change in land use patterns
- Can Desertification Trends be Reversed in West Asia and North Africa? Adel El-Beltagy The International Center for Agricultural Research in the Dry Areas (ICARDA) Aleppo, Syria. - The threat of desertification is greatest in the zone lying approximately between the 100 and 400 mm rainfall isohyets. This area represents about 80% of the land area outside the hyper-arid desert environments of WANA

Sustainable Dryland Farming

- Cape Verde farmer $1,000 per month from 0.2 hectares - During 1999 a 0.2 hectares plots provides farmers with monthly revenue of $1,000 by shifting to extreme water conservation drip systems and switching to high return horticultural crops.
- Dry Farming vineyards in Northern California
- Growing veggies in the desert no longer a mirage – Interesting use of drip irrigation combined with sub surface use of salt water.
- Keyline Plowing: What is it? Does it work? – claims to build 8 inches of topsoil per year.
- DRYLAND FARMING: CROPS & TECHNIQUES FOR ARID REGIONS BY RANDY C RESWELL & DR. FRANKLIN W. MARTIN Published 1993; Revised 1998 by ECHO Staff
- More efficient irrigation systems for desert and dryland restoration
- IAEA-TECDOC-1468 Nutrient and water management practices for increasing crop production in rainfed arid/semi-arid areas Proceedings of a coordinated research project
- Dryland Farming System WIDTSOE 488 pages
- Arid Agriculture - Buffum
- Dry-Farming University of California

Wicking root guide

- Wick Irrigation for Tree Establishment by David A. Bainbridge September 17, 2012 – Great introduction of using Wicking materials combined with drip feed to guide a tree's roots deep into the ground. Shows the downward wicking characteristics of a variety of materials. Has been demonstrated near Salton sea in California to dramatically increase tree health and survival rates and to help the trees discover deeper soil moisture they would not have found without the guide.
- Microcatchment Water Harvesting for Desert Revegetation - 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.

- Irrigation for Remote Sites by SERG – Soil Ecology and Restoration Group – discusses micro catchments, wicks, clay pots, deep pipes and tree shelters. Confirms that 20ml can be enough to start trees and have them show no water stress when using the wicking water delivery.
- Restoration of the Salton Sea -
- Wick irrigation involves using "ropes as wicks to supply water to plant roots"
- Wicking Irrigation for Tree Establishment blog also talks about deep pipes as alternatives.
- More efficient alternate irrigation systems – discusses clay pot and deep pipe irrigation. Claims mesquite trees where started with a total of 5 gallons the first year. Also claims some trees only need 20 ml of water per day when water this way. Discusses microcatchments which is similar to micro forming the land we recommend .
- Criteria and options for appropriate irrigation methods by FAO – Nicely written with simple easy to understand pictures. Did cover the clay pots but missed micro catchments and the proper use of the wicking system.
- More efficient irrigation systems for desert and dryland restoration – discusses clay pot seeping water out to support acacia and eucalyptus trees in areas with 200mm of precipitation. Demonstrated 20% taller growth with improved survival rates. Also mentions using the wick in conjunction with the clay pot.

Trees people may want to consider.

These links cover a broad range of information including trees from the deep desert in the USA through tropical trees. We include links which show how the trees grew, how they affected the land and can act as pioneers for other species. We see many groups become completely fixated on one tree which they believe is the super tree that will solve all problems. We also like nitrogen fixing trees and we prefer trees that produce large amounts of bio-mass with a special focus on trees which produce edible green foliage that can be directly consumed by agricultural animals. With that said the real requirement for sustainable success is that the trees used provide benefits to local farmers who can derive both a short term economic value and a long term economic value. Our believe is that humans will tend to act in their own self-interest first and in the best interest of their community second if we recognize this facet of human behavior and build our programs and strategies around it then it will maximize long term success hence the reason we like trees which provide the greatest benefit to local farmers who are striving to survive on the land. With this said trees are unique in farming because the farmer must wait for years to obtain the maximum return on their investment which extends their risk of financial loss over a greater period of time. One of the best ways to ensure catastrophic loss in the long term is to plant a mono crop which is likely to succumb to the same disease or pest simultaneously and cause a loss of all or a majority of the farmer's long term crop. To avoid simultaneous failure of the entire investment a planting strategy that includes a number of species is recommended even if it reduces short term yields. We strongly recommend that where possibly you consider the use of native trees provided they can meet your other goals.

- Albizia lebbeck - a Promising Forage Tree for Semiarid Regions - J.B. Lowry, J.H. Prinsen and D.M. Burrows. The Albizia also known as Sirus and East Indian walnut is a nitrogen fixing tree which produces foliage which can be used to feed Rabbits, Goat, Cattle and Sheep. It grows fast and can tolerate drought. Occurs naturally in areas with as low as 400mm of rain and as high as 1,600 Meters. We believe with the combination of "Dryland Grow", micro catchment, bio-sponge and wicking water feeds that it can be successfully grown in areas with rainfall under 200mm per year. This tree will not tolerate waterlogged soils and will die if the roots are submerged for extended periods. Leaf drop occurs during dry part of year. Under ideal conditions can grow 5 meters per year. Each adult tree yields 100 to 120kg per year of edible dry matter. Leaves and flowers are good as supplement to poor quality grass. I appears to enhance pasture grass supporting both greater mass and higher quality grasses while study in Queensland showed higher quality grasses for 2 months longer into the dry season. Light transmission is 40 to 50% compared to 80% for Australian eucalypt is only 50% so animals in need of shade gain more benefits from Sirus trees. Tree regrows from stump after lumber harvest but grows to maturity faster due to larger starting root mass. Lumber has specific gravity of 0.55 to 0.60 and is under high demand for fine furniture and cabinets.
    - Effect of Albizzia lebbeck plantation on the nutrient cycling in a semi-arid grazingland MEENAKSHI SUNDARAVALLI V. & KAILASH PALIWAL Department of Plant Sciences, School of Biological Sciences, Madurai Kamaraj University Madurai – 625021, India – Substantial increase of soil moisture under Albizzia trees in open grassland. Albizia trees increase nutrient content of understory due to rapid leaf turnover.
    - Effect of green manure on rice production by Scherchan, D.P. SAAR workshop 1989. Application of Albizia Lebbek as green manure increased yield of rice grown on loamy acidic soil by 17% while Adhatoda vasica increased yield by 23%.

    - Performance of Leucaena leucocephala and Albizia lebbeck trees under low irrigation water in the field Plant Production Department, College of Food Science and Agriculture, King Saud University – Great set of research links.
    - Influence of Intercrops on the biomass production of Albizia Lebbeck tree under rainfed and semi-arid conditions by Asia-Pacific Agroforestry newsletter. Compares to Azadirachta indica, Dalbergia Sissoo and Acacia nilotica. The other trees out performed the Albizia Lebbeck for total biomass but the Lebbeck was close to top in dry leaves weight. All trees gained more weight when intercropped with legumes.
    - Drought induced changes in growth – concludes the Lebbeck was superior for biomass production in semi-arid dry lands when compared to Cassia Siamea .
    - REVIEW ON ALBIZIA LEBBECK A POTENT HERBAL DRUG Mohammad Faisal *, Singh P P, Irch
    - Haiya R Institute of Pharmacy Bundelkhand University Kanpur Road Jhansi (U.P.) India
    - S. El-Hawary, K. El-Fouly, N.M. Sokkar and Z. Talaat, 2011. A Phytochemical Profile of Albizia lebbeck (L.) Benth. Cultivated in Egypt. Asian Journal of Biochemistry, 6: 122-141.
    - Growth of Albizia lebbeck (L.) Benth., in different soil compositions of Korangi and Landhi Industrial Areas of Karachi, Pakistan Atiq-ur-Rahman, S. (Government Degree Coll., Karachi (Pakistan). Dept. of Botany); Iqbal, M.Z. (Karachi Univ. (Pakistan). Dept. of Botany)
    - PRODUCTS FROM THE TREE LEGUME ALBIZIA LEBBECK As SUPPLEMENTS FOR SHEEP IN THE DRY TROPICS A.C. SCHLINK*, J.B. LOWRY* and D.S. GIBSON*
    - Specific leaf area and leaf dry matter content of plants growing in sand dunes Yulin LI1,*, Douglas A. JOHNSON2, Yongzhong SU1, Jianyuan CUI1, and Tonghui ZHANG1 Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, 260 Donggang West Road, Lanzhou, 730000, P.R. China 2USDA-ARS Forage and Range Research Laboratory, Utah State University, Logan, Utah 84322-6300, USA
    -
- Not all Nitrogen Fixers are created equal – explains the amount of nitrogen fixed for several species.
- Mentions red Alder for North America as a high nitrogen fixing tree. Leucaena leucocephala is great for warmer areas but is not cold resistant but where it will grow it will produce large amounts of biomass with fast growth. It also produce as excellent fodder for cattle but only grows well in humid climates. It also mentions the Russian olive which is an extremely hardy tree but is also highly allergenic and does not produce a valuable lumber.
- National scale biomass estimators for united states tree species Jennifer C. Jenkins – Estimating bio-mass production especially foliage biomass can be important when selecting trees to produce edible fodder or compost. Those which produce the highest mass of foliage will tend to produce more compost and a higher ROI in the short term but this can be offset by the value of the mature wood when harvested. Also be aware that some trees will restart from the original trunk and regrow to adult size much faster after the first wood harvest where others must be replanted. See also A comparative analysis of biomass production in five tropical tree species and Biomass production in the Central Great Plains USA under various coppice regimes
- Nitrogen fixing trees for fodder production - A Field Manual by Humanity Development Library 2.0
- Department of Forest Plantation program Southern Bhutan with RGOB and world bank funding. Shows a nice cost modeling sheet for forest planting.
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- The Framework Tree Species Method for Lowland Deciduous Forest in Northern Thailand -
- Low water trees by Arizona Municipal water users association. Some of our favorites from this list shown below. I chose the higher range on the hardiness numbers and I have personally seen some of these species survive lower temperatures than listed.
    - Eucalyptus Microtheca (collibah) a 35 foot tall tree with very low water requirements and fast growth hardy to 10F.
    - Afghan Pine (Pinus eldarica) a 50 foot tall tree with low water requirements fast growth and hardy to 10F.
    - Acacia stenophylla at 30 foot tall tree with very low water needs that grows fast and is hardy to 18F.
    - Texas Honey Mesquite (Prosopis Glandulosa V. Glandulosa) 30 foot tall tree with very low water requirements and fast growth. Hardy to 0F and thornless versions are available.
    - Chilean Mesquite (Prosopis species) a 30 foot tall tree with fast growth an very low water requirements ahrdy to 20F.
    - Sweet Acacia grows 20 foot tall with low water requirements hardy to 10F.
    - Willow Acacia a 30 foot tall tree with low water requirements and fast growth hardy to 20F.
    - Hybrid Palo Verde a 25 foot tall tree with very low water requirements hardy to 20F.
    - Blue Palo Verde a 30 foot tall tree with very low water requirements and fast growth,
    - Palo Brea a 25 foot tall tree with very low water requirements and fast growth hardy to 30F.
    - Desert Willow a 25 foot tall tree with low water requirements and hardy to 0F.
    - Indian Rosewood a 40 foot tall tree with moderate water requirements fast growth and hardy to 30F.

    - Live Oak (Quercus Virginiana) a 0 foot tall tree with moderate water requirements and hardy to 0F.
    - Evergreen Elm a 35 foot tall tree with moderate water requirements and fast growth. Hardy to 20F.
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- Desert trees from moon valley nurseries -
- Nitrogen Fixing trees – Old site but a great list that mentions many trees not on other lists. Mesquites, Honey mesquite, velvet mesquite which can support browsing animals. Paloverde, Desert Ironwood which produces high value hardwood
- Nitrogen Fixing Tree Paves the way for others – discusses the black locust (Robinia pseudoacacia) tree as an invasive tree that creates opportunity for other volunteers in the under forest. It shows that it has more than doubled the nitrogen content of the direct under the trees. In this context they felt this was undesirable supporting invasive species but in an area where we are looking at Dryland farming and land reclamation our first goal is to revitalize the soil, increase it's ability to support live, hold water and reduce erosion. In this context increasing the soil nitrogen level it is desirable. If you can obtain the same benefits from native species it is desirable but we work from the premise that local farmers will only support and protect the trees if they receive a direct beneficial output or income from the tree or the land it improves so I think it is better to focus first on this critical aspect because otherwise the land will remain in a degraded condition or will be allowed to degrade further both of which are worse than the risk from the invasive species.
- Nitrogen Fixing Tree Start-up Guide - Agroforestry Net provides a nice chart with tree height, soil requirements, water requirements and temperature tolerance.
- Nitrogen Fixers for Temperate Climate Permaculture Forest Gardens – Gray Alder, Black Locust, Japanese Pagoda Tree, Mountain Mahogany, Russion Olive, GoldenChain Tree
- Using neem trees to combat desertification – The Neem tree grows fast, has deep roots and is reputed to have many medicinal properties. It's fruit kernals generate oil that acts as natural mosquito repellent. It has been used to combat desertification in Peru's arid north. Has survived multi-month submersion and temperatures up to 50C. The Neem tree can not grow in areas that freeze. Endorsed by non-profit org "Plan Verde" or "Green Plan" which is ran by Elke Kruger. The German federal development agency (GIZ) is also planting these in West Africa. Neem trees do need some water to start so spreading into undesired areas when planting in severe desert is relatively low risk.
- Forage Tree Legumes in Tropical Agriculture Edited by Ross C. Gutteridge and H. Max Shelton Department of Agriculture The University of Queensland Queensland 4072, Australia – FAO.org – Leucaena leucecephala, gliricidia sepium, Perennial Sesbania, Calliandra calothyrsus, Albizia lebbeck, erythrina, Acacia Angustissima, Acacia Saligna, Codariocalyx gyroides, Desmanthus virgatus, Faidherbia albida, flemingia macrophylla,
- Castor Bean or Castor Oil Plant – An annual so normally would not consider but does grow up to 20 foot and has been known to survive mild frosts in southern England. Produces oil that can be directly used as motor lubricant and hand lamps.
- Firewood BTU comparison by tree species
- Samanea Saman (Rain Tree) Fabaceae (legume family) - Also known as Monkey pod, Tamalini tree. Great for warm pacific islands and other tropical locations. Nitrogen fixing Grows to 80 foot and is a great shade tree. Best under 1,000 foot and with rainfall between 500 and 3000mm. 5 year old tree can produce 1210 pounds of green forage. Drops leaves during dry periods. Produces a human edible fruit. This tree needs areas with over 24 inches of rain but in those areas it's yield of fodder can be several times higher than the Lebbeck tree. Timber is valued for Carvings, furniture paneling and boat framing and may be sellable as firewood. Naturally drops leaf and flower litter which makes excellent nitrogen source. Good for intercropping with Coffee, tea, cacao, nutmeg and vanilla.
- Community Participation in Saline Soil Restoration Using a Diverse Tree Planting Technique: A Case Study of Nongsim Sub district, Borabue, Mahasarakam, Thailand. Informative look at survival rates and growth rates of several species in salt contaminated soils. Includes the Lebbeck and several Acacia species. The Lebbeck and the Acacia Auriculiformis Cunn both delivered 100% survival rates but the Hibiscus tilaceus L and Casuarina Equisetifolia delivered much higher growth rates measured by change in height.
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To Classify

- http://www-pub.iaea.org/MTCD/publications/PDF/te_1468_web.pdf

Cattle & Drought

To avoid duplicate maintenance these links have been moved to the directly relevant document.

- Cattle Reference Links from A2WH Cattle herding Drought Resilience document

Background Formula

- Weights, Measures and Conversion Factors for Agricultural Commodities and their products USDA

To Categorize

- http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1165868.pdf
- http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/financial/cig/?cid=stelprdb1086053
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- http://southwestfarmpress.com/livestock/much-state-s-warm-season-grass-pastures-still-drought-damaged
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