Nature-Based, Unconventional, and Innovative Water Management Solutions for Sustainable Agriculture

USDA | FAO | WASAG

By: THE INTERNATIONAL CLIMATE HUB

USDA

Food and Agriculture Organization of the United Nations

Nature-Based Solutions

Sun and Water

An Overview of Small Scale Solar Powered Water Management Systems

Jon Fripp PE,
Co-Director, National Design, Construction, and Soil Mechanics Center, Natural Resources Conservation Service, USDA.

Vignette Overview

- The problem of water
- How solar pumping can help
- Overview of solar pump design
- Drawbacks and concerns

Water is not uniformly distributed

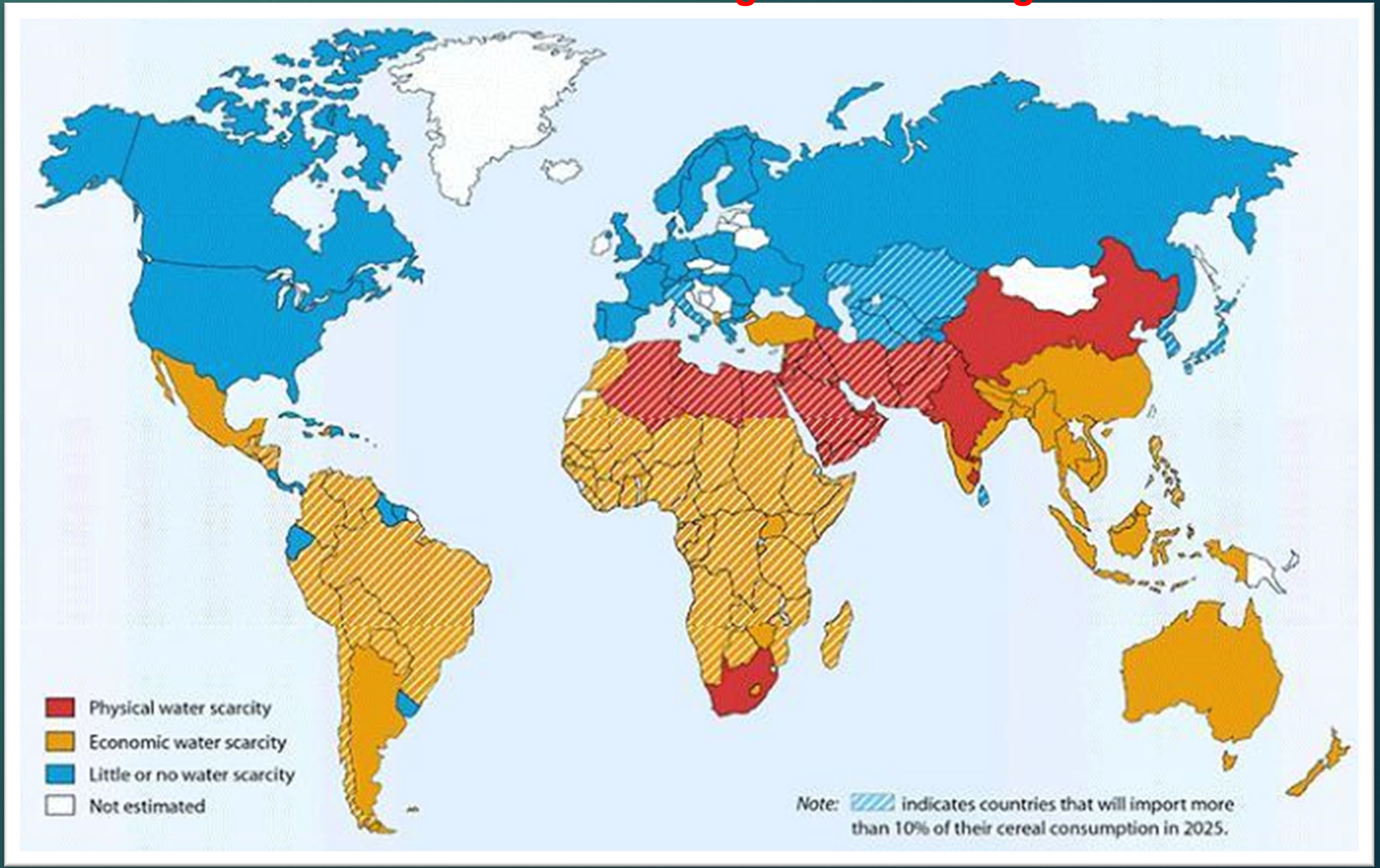
Sources:

- Groundwater
- Surface Water

Water usage:

- 70% agriculture
  - *Water shortages constrain food production*
- 19% industrial
- 11% domestic

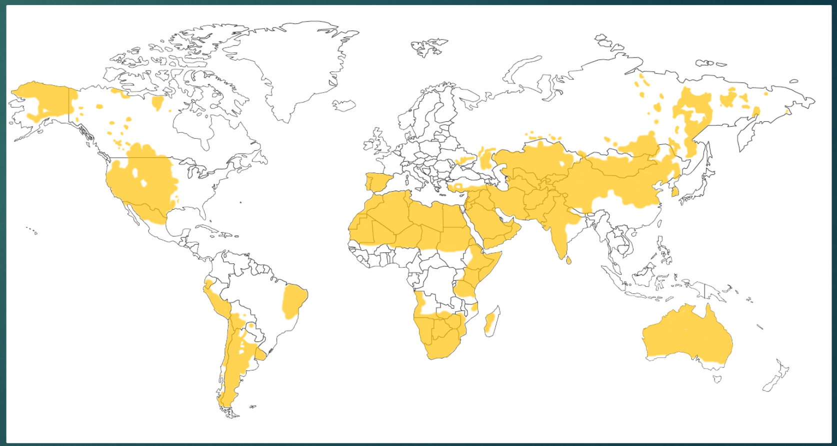
40% of worlds population live in areas suffering water shortages.



Surface Water Use Problems

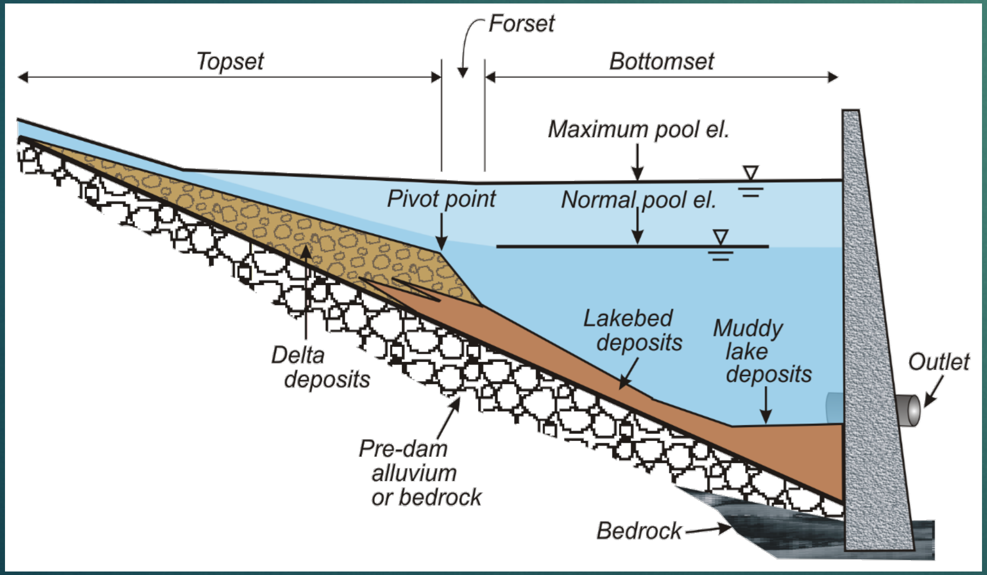
- Rain is variable. Rivers are variable.
- Therefore, we need something to store water – **DAMS and Reservoirs**
- Hydrologic variability and longer multiple year droughts result in carry over storage needed
- Reliable water requires large storage (>3x annual flow)
- Large storage requires big dams and run of river structures
- 1/4th of all sediment in rivers deposits in reservoirs

Regions where multiple year droughts are common

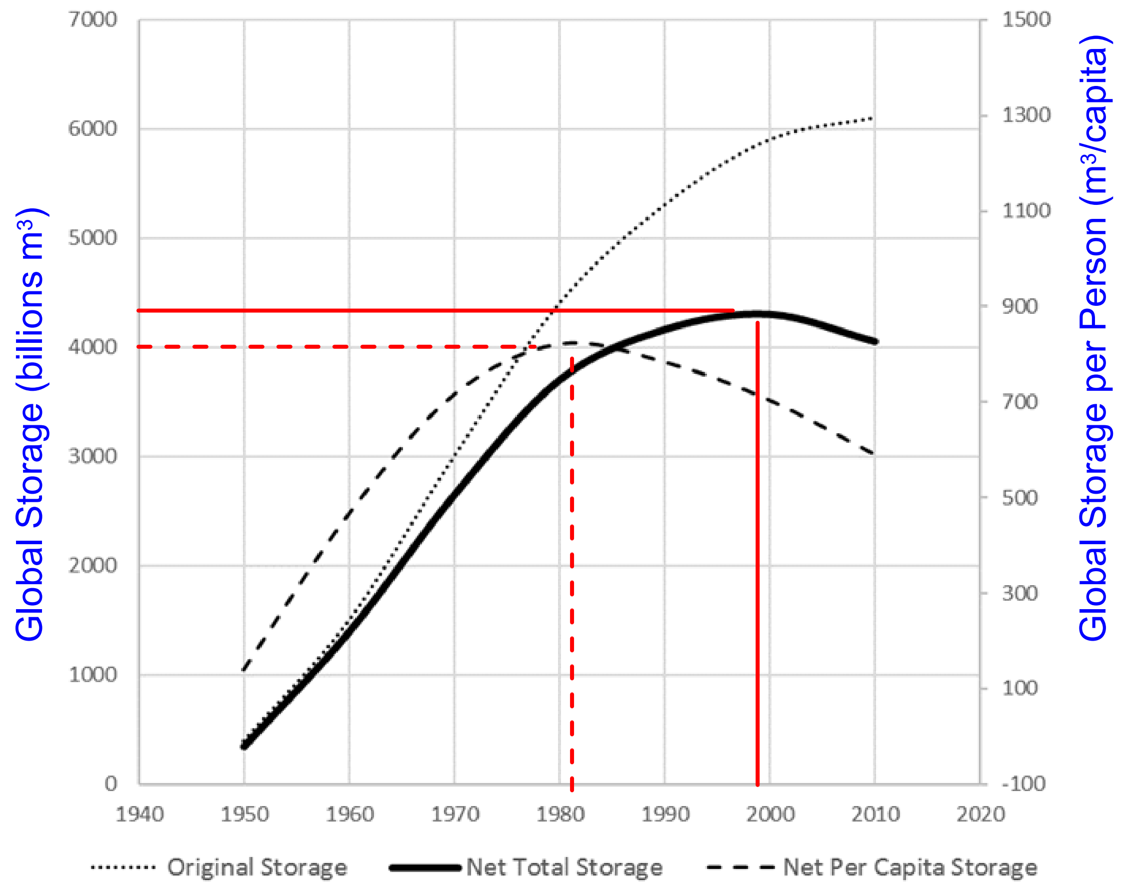


Reservoir Sedimentation - An international problem….

On a world-wide average, the rate of reservoir storage being lost to sedimentation is greater than the rate of storage being added by construction. World-wide reservoir storage per capita peaked several decades ago. It is now back to 1965 levels due to sedimentation.



Reductions in Global Reservoir Storage



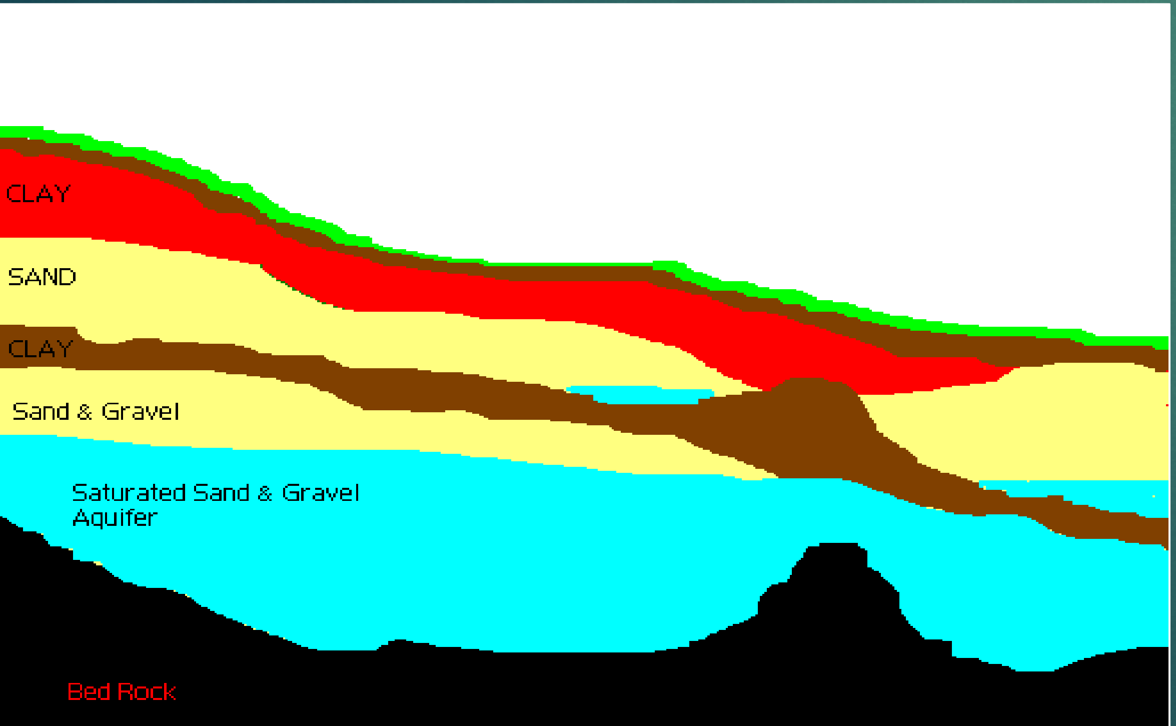
George Annandale, 2013

2/3rds of reservoir uses are entirely dependent on storage…and Pakistan loses an average of 1% per year

Groundwater

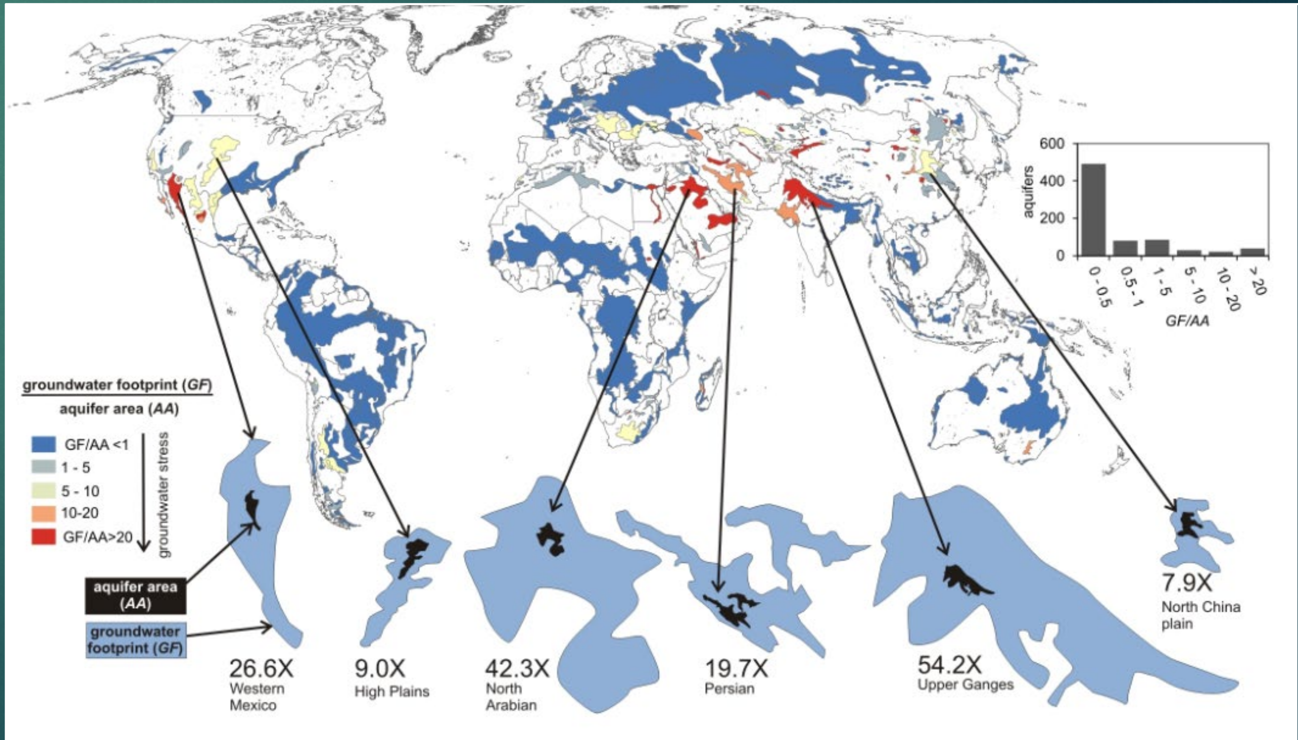
<u>Advantages of Wells:</u>

- Resistant to weather effects
- Accessible technology to extract
- Local control
- Local use



Ground Water Use Problems

- ***Some areas are using groundwater at a non sustainable rate***
- ***Worldwide, we use 3.5 times more groundwater than what is replenished***
- **Groundwater is being exhausted**



- **Average residence time: 1,400 years**

Residence time – take away all groundwater, it would take 1400 years to replenish.

- ***The Upper Ganges aquifer has a footprint of 54.***

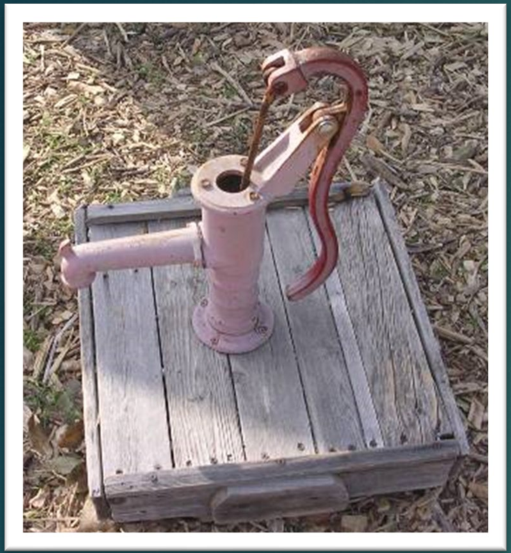
This means that 54 times more water is removed from the aquifer than what is replenished. *The area would have to be 54 times larger to capture the precipitation needed to sustain current groundwater extraction*

Ground Water Use Problems

- *Need to get water from where it is to where we need it*
- Pumps generally need power
- Grid based electric power can be unreliable
- Diesel or gas supplied power can be expensive
- If the power fails, the pumps do not operate
- If the pumps do not operate, water is not moved to where it is needed
- Without timely water, crops and livestock can be impacted

Pumps

How is the water going to get to the surface?



Is the pump sustainable?

- **Hand pumps**
- **Powered pumps**
- **Windmill pumps**
- **Solar pumps**
- **others**

Why Solar?

- Solar energy can provide the power needed for pumps
- Solar is reliable and has lower maintenance
- Systems cost more than diesel/gas powered pumps, but once installed, they "work" for free for several years
- Ultimately Solar is cheaper

BUT… a solar based pumping system requires:

- *Appropriate planning*
- *Good design*
- *Good installation*
- *Knowledgeable operation*
- *Maintenance*

Solar powered pump systems - *Keep it simple*

Simple system – no battery storage

Basic Components:

- PV solar panels
- Pump
- Delivery *(the load)*

How to design a balanced solar system – for pumping (no battery)

Step 1: How much water is needed – <u>the Load</u>

Step 2: How much pump is needed – <u>the Pump</u>

Step 3: How much electrical production is needed - <u>PV Solar Panels</u>

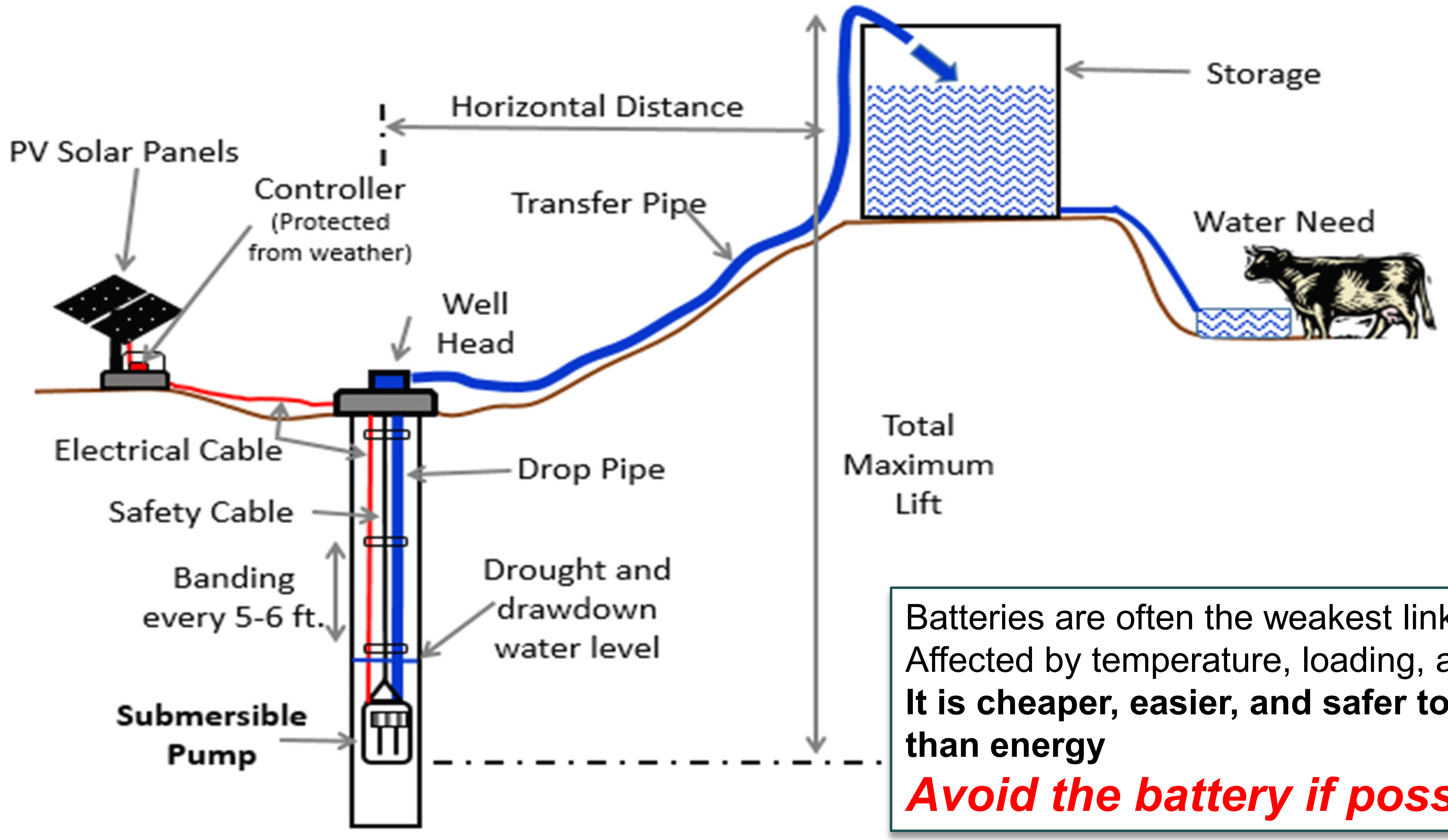
The size of the load drives the

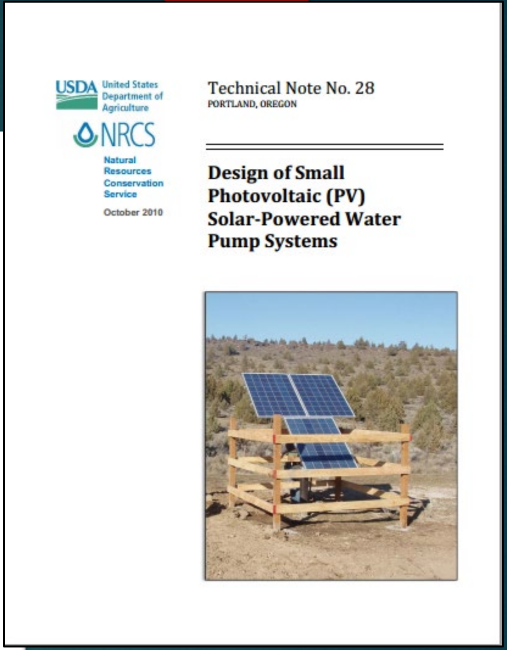
size of the pump which determines the

size of the solar panels

This is the same approach as used when designing a lighting system

System Layout Example




USDA United States Department of Agriculture
NRCS Natural Resources Conservation Service
October 2010

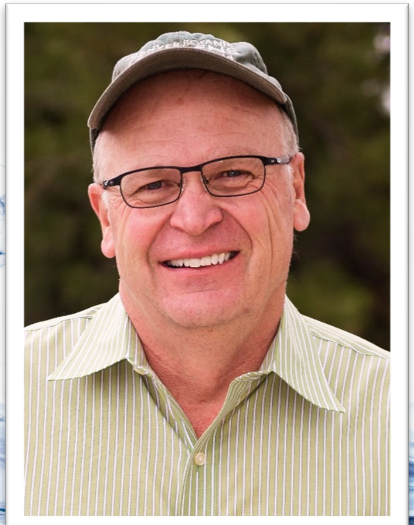
Technical Note No. 28
PORTLAND, OREGON

Design of Small Photovoltaic (PV) Solar-Powered Water Pump Systems

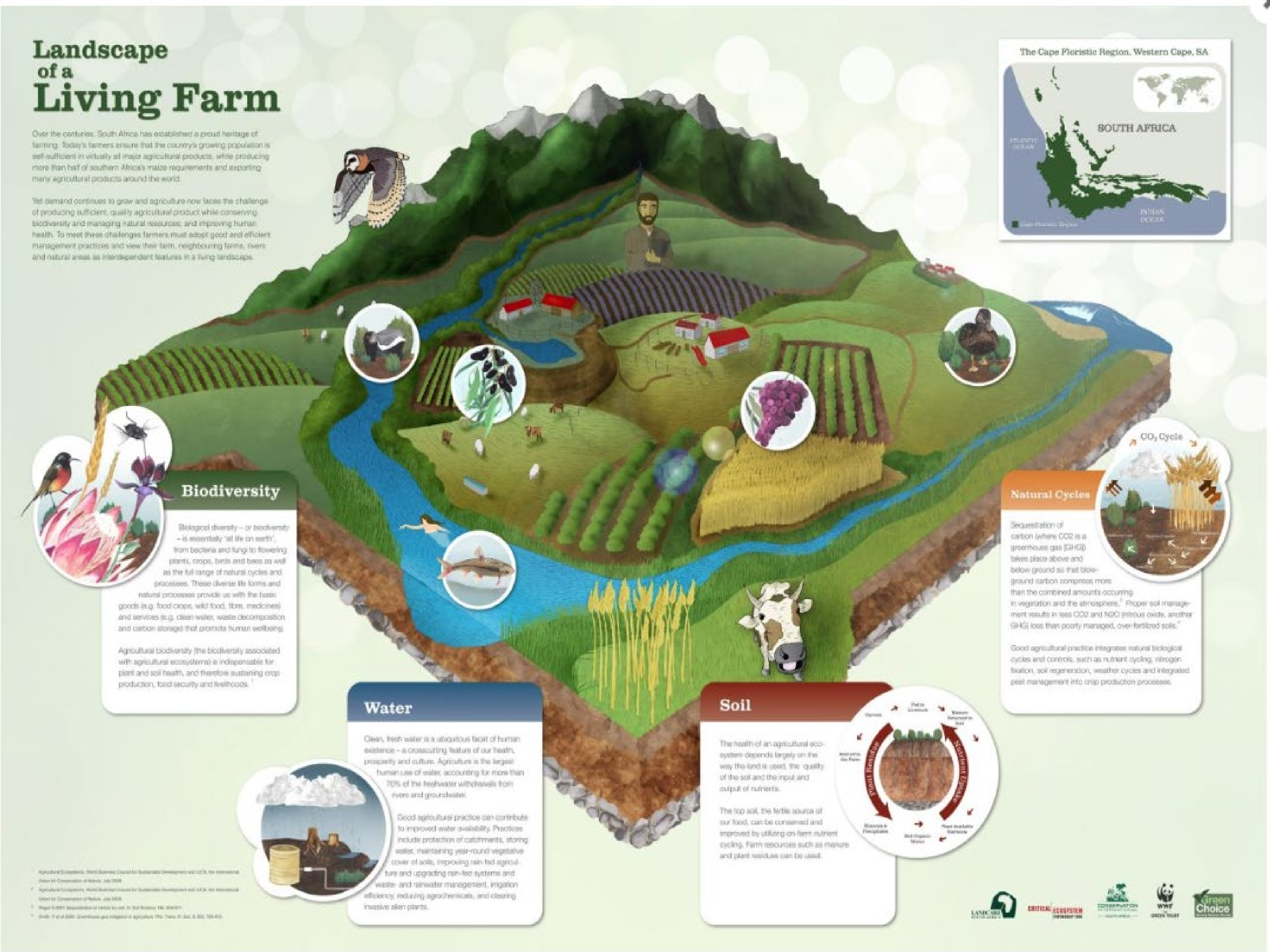
Batteries are often the weakest link in a PV system
Affected by temperature, loading, and cycles
It is cheaper, easier, and safer to store water rather than energy
Avoid the battery if possible

Rebecca Hufft & Larry Vickerman

- Bringing Together Restoration and Sustainable Agriculture Practices for Improvements in Soil Health, Biodiversity, and Wildlife Habitat

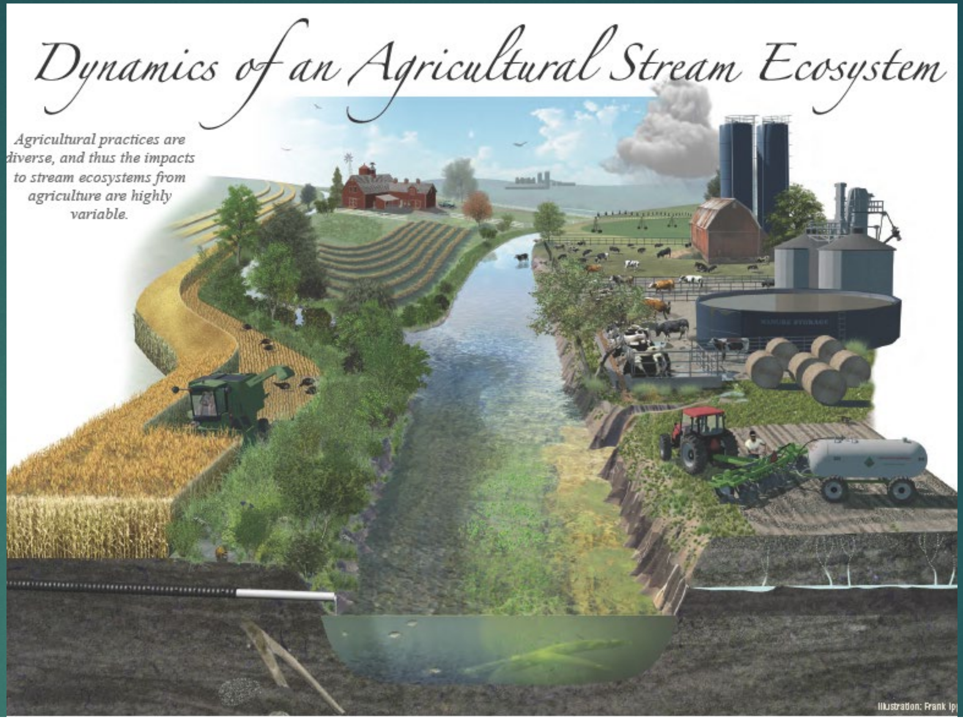


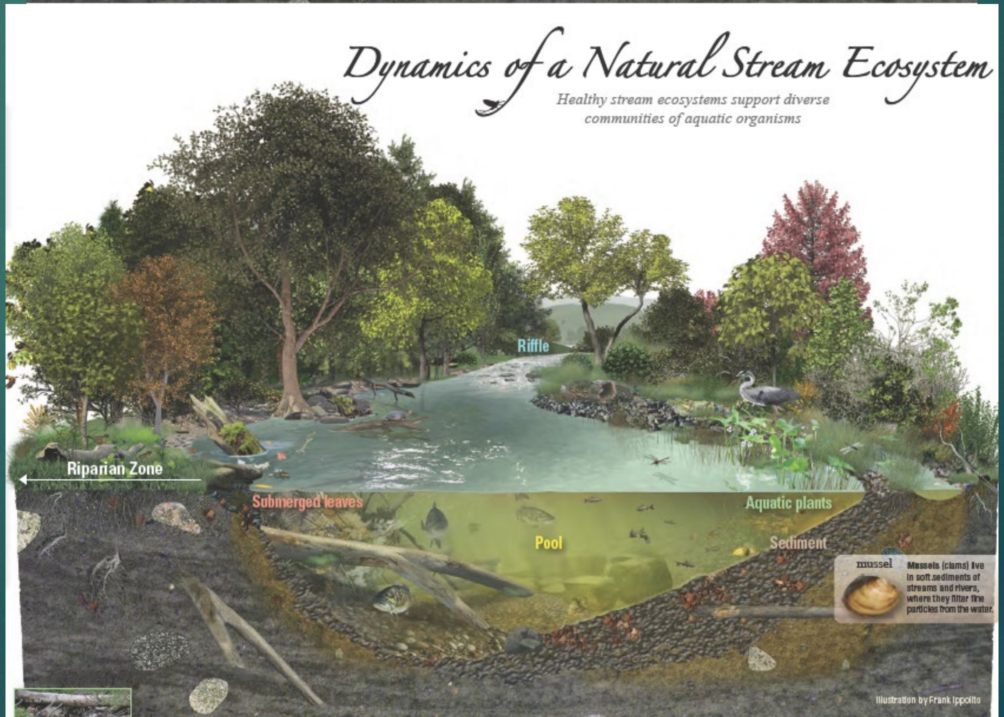
DENVER BOTANIC GARDENS



Landscape of a Living Farm
Over the centuries, South Africa has established a proud heritage of farming. Today's farmers ensure that the country's growing population is self-sufficient in virtually all major agricultural products, while producing more than half of southern Africa's maize requirements and exporting many agricultural products around the world.
Yet demand continues to grow and agriculture now faces the challenge of producing sufficient, quality agricultural product while conserving biodiversity and managing natural resources; and improving human health. To meet these challenges farmers must adopt good and efficient management practices and view their farm, neighbouring farms, rivers and natural areas as interdependent features in a living landscape.
The Cape Floristic Region, Western Cape, SA
SOUTH AFRICA
Biodiversity
Biological diversity – or biodiversity – is essentially 'all life on earth', from bacteria and fungi to flowering plants, crops, birds and bees as well as the full range of natural cycles and processes. These diverse life forms and natural processes provide us with the basic goods (e.g. food crops, wild food, fibre, medicines) and services (e.g. clean water, waste decomposition and carbon storage) that promote human wellbeing.
Agricultural biodiversity (the biodiversity associated with agricultural ecosystems) is indispensable for plant and soil health, and therefore sustaining crop production, food security and livelihoods.[1]
Water
Clean, fresh water is a ubiquitous facet of human existence – a crosscutting feature of our health, prosperity and culture. Agriculture is the largest human use of water, accounting for more than 70% of the freshwater withdrawals from rivers and groundwater.
Good agricultural practice can contribute to improved water availability. Practices include protection of catchments, storing water, maintaining year-round vegetative cover of soils, improving rain-fed agriculture and upgrading rain-fed systems and waste- and rainwater management, irrigation efficiency, reducing agrochemicals, and clearing invasive alien plants.
Soil
The health of an agricultural ecosystem depends largely on the way the land is used, the quality of the soil and the input and output of nutrients.
The top soil, the fertile source of our food, can be conserved and improved by utilizing on-farm nutrient cycling. Farm resources such as manure and plant residues can be used.
Plant Residue
Nutrient Uptake
Natural Cycles
CO_2 Cycle
Sequestration of carbon (where CO2 is a greenhouse gas (GHG)) takes place above and below ground so that below-ground carbon comprises more than the combined amounts occurring in vegetation and the atmosphere. Proper soil management results in less CO2 and N2O (nitrous oxide, another GHG) loss than poorly managed, over-fertilized soils.
Good agricultural practice integrates natural biological cycles and controls, such as nutrient cycling, nitrogen fixation, soil regeneration, weather cycles and integrated pest management into crop production processes.


Chatfield Farms
Creek Restoration
Active Beavers
Grassland Restoration
Google Earth
©2017 Google
N
1000 ft


Dynamics of an Agricultural Stream Ecosystem
Agricultural practices are diverse, and thus the impacts to stream ecosystems from agriculture are highly variable.
Illustration: Frank Ip

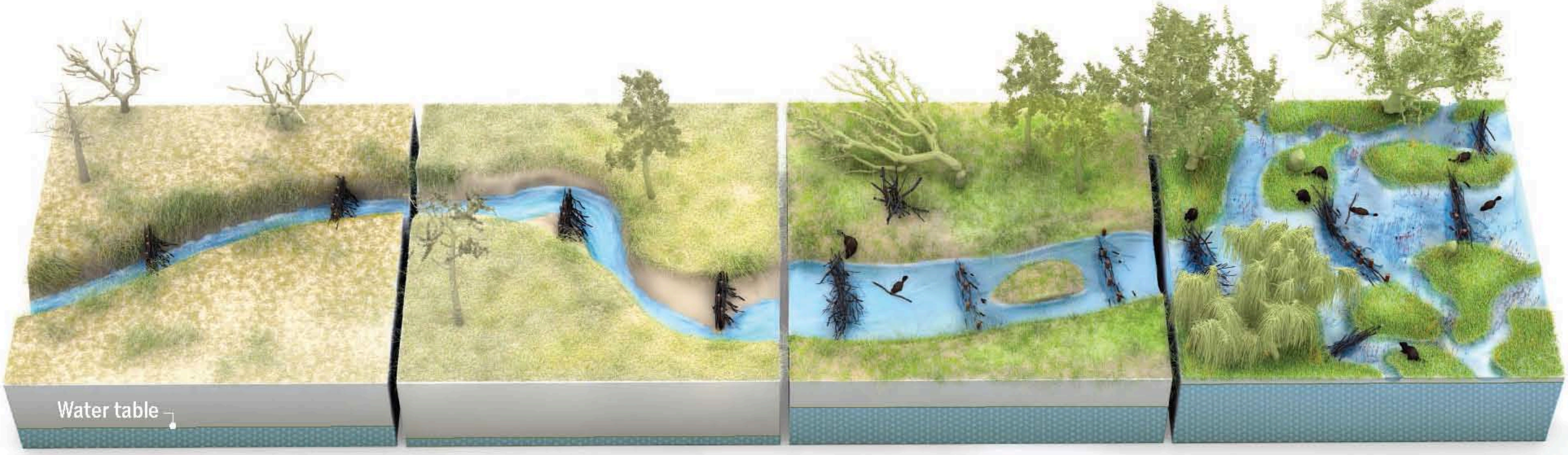

Dynamics of a Natural Stream Ecosystem
Healthy stream ecosystems support diverse communities of aquatic organisms
Riffle
Riparian Zone
Submerged leaves
Aquatic plants
Pool
Sediment
mussel
Mussels (clams) live in soft sediments of streams and rivers, where they filter fine particles from the water.
Illustration by Frank Ippolito

A stream comes back to life

Across the U.S. West, scientists and land managers are using beaver dam analogs (BDAs) to heal damaged streams, re-establish beaver populations, and aid wildlife. In some cases, researchers have seen positive changes in just 1 to 3 years.


Incised stream


Restored stream



Adding dams
Beaver trapping and overgrazing have caused countless creeks to cut deep trenches and water tables to drop, drying floodplains. Installing BDAs can help.

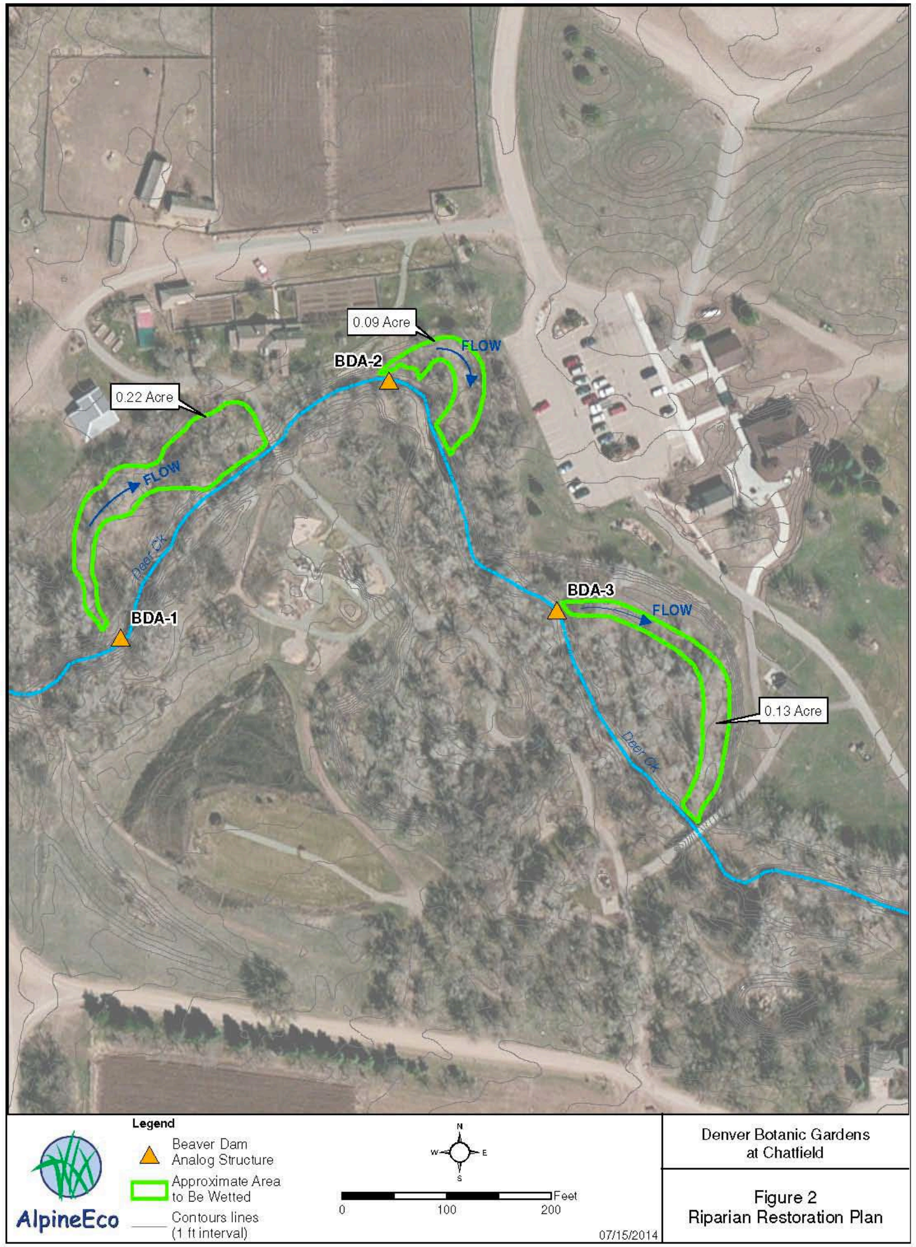
Widening the trench
BDAs divert flows, causing streams to cut into banks, widening the incised channel, and creating a supply of sediment that helps raise the stream bed.

Beavers return
As BDAs trap sediment, the stream bed rebuilds and forces water onto the floodplain, recharging groundwater. Slower flows allow beavers to recolonize.

A complex haven
Re-established beavers raise water tables, irrigate new stands of willow and alder, and create a maze of pools and side channels for fish and wildlife.

Goldfarb B. 2018. Science 360 (6393): 1058-1061

Ecosystem Engineers

0.09 Acre
FLOW
BDA-2
0.22 Acre
FLOW
Deer Ck
BDA-1
BDA-3
FLOW
0.13 Acre
Deer Ck
Legend
Beaver Dam Analog Structure
Approximate Area to Be Wetted
Contours lines (1 ft interval)
AlpineEco
N
W
E
S
0
100
200
Feet
07/15/2014
Denver Botanic Gardens at Chatfield
Figure 2
Riparian Restoration Plan




Seed Sourcing and Local adaptation

Moisture manipulation
Watering regime

Temperature manipulation
Aquarium gravel

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Chatfield Farms

Soils and Water Efficient Agriculture

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Water placement method is primary way to increase water efficiency

-Drip irrigation vs. overhead sprinkler saved 36% of total water used

-Use of remay covers to protect new seedlings and lessen evaporation

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Utilizing plastic mulch

- -Can increase water savings an additional 10-15%
- -Reduces evaporation and competition from weeds
- -Warms the soil for quicker plant growth in the Spring and enhances yield

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Chatfield Farms

Floating Row Covers

- -reduce evaporation
- -Increase temperature and humidity around crop
- -Gain 2-6 degrees F frost protection
- -Provide insect protection

Micro-sprayers

- -Can deliver from 0.88 g.p.m. to 3.30 g.p.m. (3.33 to 12.5 LPM) with a low-profile spray pattern
- -Less issues with overspray and wind disruption
- -We use a 1.54 g.p.m. (5.8 LPM) head for germinating and growing out seeded crops such as beets, carrots, leafy greens and cover crops

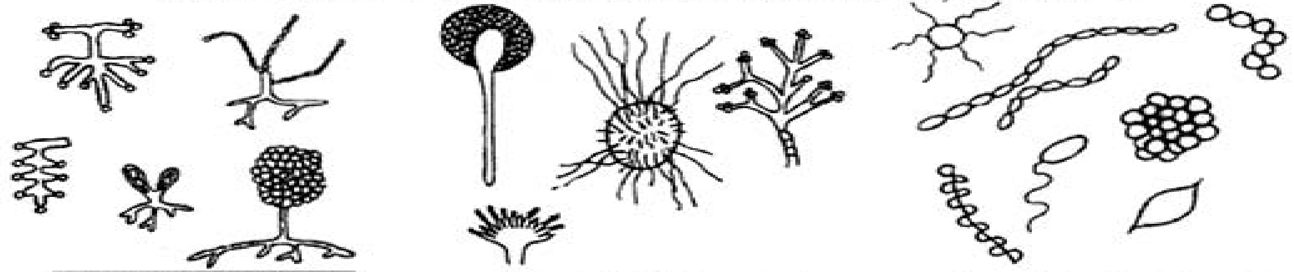
DENVER BOTANIC GARDENS
Chatfield Farms

Addition of compost

- -Improve water and oxygen infiltration into the soil
- -Dr. Whendee Silver, UC Berkeley, documented an additional 900 lbs. of carbon sequestered in an acre of pasture land by top-dressing with ½ inch of compost and then grazing.
- -The compost improved grass growth 25-50% and ***improved water retention an average of 2,800 gallons per acre.***

Figure 3.3

COMPOST MICROORGANISMS MAGNIFIED 1,000 TIMES



Actinomycetes	**Fungi**	**Bacteria**
100 thousand - 100 million per gram of compost	10 thousand - 1 million per gram of compost	100 million - 1 billion per gram of compost

Reproduced with permission from On-Farm Composting Handbook. NRAES-54, published by NRAES, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, New York 14853-5701. (607) 255-7654. Quantities of microorganisms from: Sterritt, Robert M. (1988). Microbiology for Environmental and Public Health Engineers. p. 200. E. & F. N. Spon Ltd., New York, NY 10001 USA.

Table 3.6

MICROORGANISMS IN COMPOST

Actinomycetes	Fungi	Bacteria
Actinobifida chromogena	*Aspergillus fumigatus*	*Alcaligenes faecalis*
Microbispora bispora	*Humicola grisea*	*Bacillus brevis*
Micropolyspora faeni	*H. insolens*	*B. circulans complex*
Nocardia sp.	*H. lanuginosa*	*B. coagulans type A*
Pseudocardia thermophilia	*Malbranchea pulchella*	*B. coagulans type B*
Streptomyces rectus	*Myriococcum themophilum*	*B. licheniformis*
S. thermofuscus	*Paecilomyces variotti*	*B. megaterium*
S. thermoviolaceus	*Papulaspora thermophila*	*B. pumilus*
S. thermovulgaris	*Scytalidium thermophilim*	*B. sphaericus*
S. violaceus-ruber	*Sporotrichum thermophile*	*B. stearothermophilus*
Thermoactinomyces sacchari		*B. subtilis*
T. vulgaris		*Clostridium thermocellum*
Thermomonospora curvata		*Escherichia coli*
T. viridis		*Flavobacterium sp.*
		Pseudomonas sp.
		Serratia sp.
		Thermus sp.

Source: Palmisano, Anna C. and Barlaz, Morton A. (Eds.) (1996). Microbiology of Solid Waste. Pp. 125-127. CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, FL 33431 USA.

DENVER BOTANIC GARDENS
Chatfield Farms

Composting and cover cropping has raised our S.O.M. from 1.5% to 5-7%

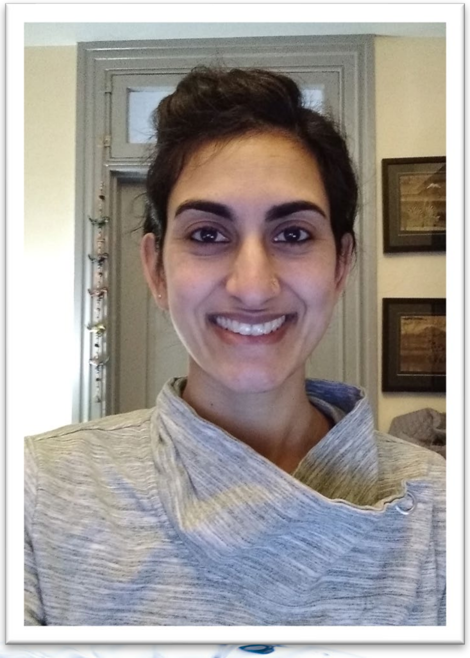
Plant-microbe bridge

- Compost inoculates soils with bacteria, fungi and actinomycetes
- Microbial activity drives the process of aggregation and enhancing soil structural stability
- Some carbon fixed by plants during photosynthesis is exuded by roots to feed soil microbes

Unconventional & Innovative Solutions

Produce Safety Rule

Kruti Ravaliya
Consumer Safety Officer – US FDA, CFSAN



U.S. FOOD & DRUG ADMINISTRATION

Food Safety Modernization Act (FSMA)

7 Foundational Rules

- Foreign Supplier Verification Programs
- Produce Safety Rule
- Preventive Controls for Human Food
- Preventive Controls for Food for Animals
- Third Party Accreditation
- Intentional Adulteration
- Sanitary Transportation of food

Produce Safety Rule

- Science-based minimum standards for the safe growing, harvesting, packing, and holding of fruits and vegetables.
- Focuses on biological hazards related to growing, harvesting, packing and holding produce
- If you are a covered farm, you must comply with the PSR

FDA

Standards for the Produce Safety Rule

- Subpart A (§112.1-112.7): General provisions
- Subpart C (§112.21-112.30): Personnel Qualifications and Training
- Subpart D (§112.31-112.33): Health and Hygiene
- **Subpart E (§112.41-112.50): Agricultural Water**
- Subpart F (§112.51-112.60): Biological Soil Amendments of Animal Origin and Human Waste
- Subpart I (§112.81-112.84): Domesticated and Wild Animals
- Subpart K (§112.111-112.116): Growing, Harvesting, Packing and Holding Activities
- Subpart L (§112.121-112.140): Equipment, Tools, Buildings and Sanitation
- Subpart O (§112.161-112.167): Records

Definition of Ag Water in the Produce Safety Rule

Agricultural water - Water used in covered activities on covered produce where water is intended to, or is likely to, contact covered produce or food contact surfaces. Includes water used for hand washing.

- **Pre-harvest ag water** – Water used during growing activities (including irrigation using direct water application methods and water used for preparing crop sprays).
- **Harvest, post-harvest ag water (H/PH)** - Water used in harvesting, packing, and holding activities (including water used for washing or cooling harvested produce, making ice and water used for preventing dehydration).

Sources of Agricultural Water

- Surface Water - all water open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water
- Ground Water - supply of fresh water found beneath the Earth's surface, usually in aquifers, which supply wells and springs
- Other – public water systems, **reuse**

Water Reuse

- Water reuse is the practice of reclaiming water from a variety of sources, treating it, and reusing it for beneficial purposes[1]
- No prohibition of reuse in produce production, **as long as** the water does not introduce hazards into or onto covered produce and food contact surfaces

1 - https://www.epa.gov/waterreuse

Proposal Overview – Preharvest water

FDA

- Definitions:
  - “agricultural water assessment” and “agricultural water system”
- Agricultural water assessments:
  - conducted once annually, and whenever a significant change occurs
- Outcomes:
  - Farms would be required to evaluate factors and determine which corrective or mitigation measures might need to be implemented
  - Includes expedited mitigation measures that would be required, if finalized, for hazards related to certain activities associated with adjacent and nearby lands

Foreign Supplier Verification Program

- Compliance with FSVP provide adequate assurances that:
  - Foreign suppliers produce food using processes and procedures providing same level of public health protection as FSMA Preventive Controls (21 CFR 117, 21 CFR 507) or Produce Safety Rule (21 CFR 112) provisions
  - Food is not adulterated or misbranded (as it relates to allergen labeling)
- FSVP creates a level of parity between U.S. food producers and foreign food producers

GUIDELINES FOR THE SAFE USE AND REUSE OF WATER IN FOOD PRODUCTION

- Eric L. Stevens, Ph D.
- Alternate Delegate CCFH

U.S. FOOD & DRUG ADMINISTRATION

Overview of the guidelines

- General Section
  - Covers general scope and definitions (including water fit-for-purpose) and other provisions/assessments/managements for the broad use of water use and reuse
  - CCFH53 (December 2022) forwarded proposed draft to Step 5/8 for CAC46 (November 2023)
- Annex 1 (Fresh Produce)
  - Clarifying index organisms for monitoring hazards in water used in fresh produce production
  - Examples of sampling frequency and other microbiological criteria
  - CCFH53 (December 2022) forwarded proposed draft to Step 5/8 for CAC46 (November 2023)
- Annex 2 (Fishery Products)
  - CCFH53 (December 2022) returned to Step2/3 for redrafting and circulation of comments (have had 2 rounds of EWGs)
- Annex 3 (Dairy Products)
  - CCFH53 (December 2022) initiated the development of an Annex and co-chaired by Chile, IDF, and EU

Accelerating Sustainable Agriculture

WATEREUSE

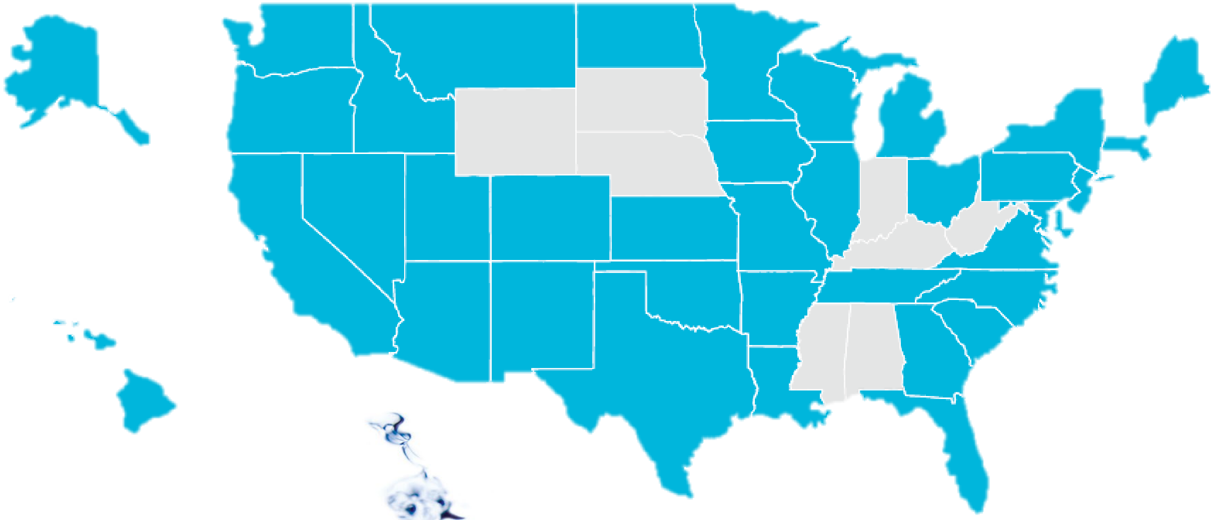
Greg Fogel
Director of Government Affairs and Policy
WateReuse Association

WateReuse Association

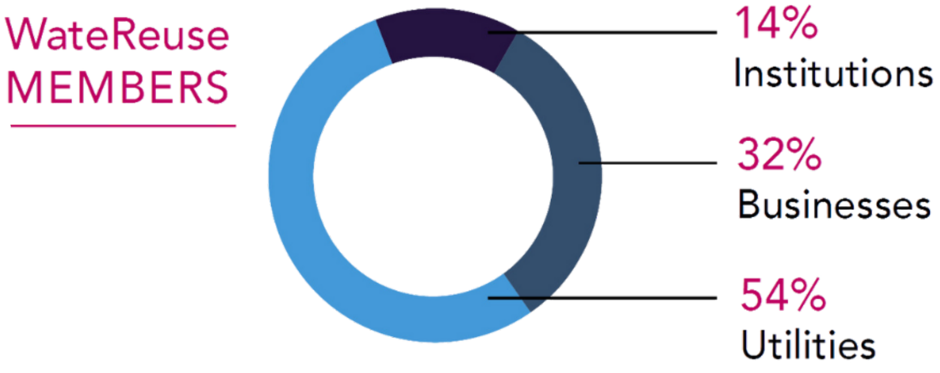
- Nation's only trade association solely dedicated to advancing laws, policy, funding, and public acceptance of recycled water

- Conferences
- Networking
- Membership
- National Advocacy
- State Support
- Communications

WateReuse Membership: Utilities, Business, Institutions



- WateReuse members in 38 states, operating across all 50 states.
- 10+ State and Regional Sections



What is Water Reuse?

The process of intentionally capturing a water source that is typically discarded (e.g. wastewater or stormwater) and cleaning it as needed for a designated beneficial freshwater purpose.

"Wasted water" is a valuable resource

Benefits of Water Reuse in Agriculture

In the United States, more water is used for agriculture than for any other purpose. The benefits of using recycled water to meet this critical demand include:

Resilience

Water recycling provides a reliable supply of freshwater that does not depend on environmental factors or conservation.

Local Control

Agricultural reuse creates a local water supply to offset the use of imported water in areas that depend on water transported from other regions.

Environmental Protection

Agricultural reuse saves water resources for environmental benefits such as aquatic habitat, reduces pollution to sensitive water bodies, and reduces energy use associated with pumping water long distances.

Examples of Water Reuse in Agriculture

Agricultural water reuse has a long history as a multi-benefit solution to address water supply challenges, water quality issues, environmental stresses, and food security risks.

Orange County, Florida

For over 30 years, a coalition that includes the City of Orlando, Orange County, and the region's agricultural community have worked cooperatively to irrigate up to 2,737 acres of citrus annually with recycled water.

Monterey, California

Local utility Monterey One Water provides recycled water for the irrigation of more than 12,000 acres of conventional and organic food crops.

Hayden, Idaho

The Hayden Area Regional Sewer Board treats about 1.2 million gallons of wastewater each day, recycling as much as 100% of it to irrigate alfalfa and poplar trees.

Federal Programs to Support Water Reuse and Agriculture

Environmental Protection Agency

- Clean Water State Revolving Fund (CWSRF) and Drinking Water State Revolving Fund (DWSRF)
- Water Infrastructure Finance and Innovation Act (WIFIA)

U.S. Department of Agriculture

- Conservation Innovation Grant Program
- Regional Conservation Partnership Program
- Environmental Quality Incentives Program
- Rural Utility Service Loans and Grants

Bureau of Reclamation

- Title XVI Water Reclamation and Reuse Grants Program
- Large-scale Water Recycling Projects Grant Program

Other Federal Initiatives

National Water Reuse Action Plan (WRAP)

- **Relevant actions include**:
  - Address Barriers to Water Reuse in Agriculture Through Improved Communication and Partnerships
  - Leverage Existing U.S. Department of Agriculture Programs to Encourage Consideration and Integration of Agricultural Water Reuse
  - Facilitate U.S.-Israel Collaboration on Technology, Science, and Policy of Water Reuse

Water Reuse Regulations

- Water recycling projects must comply with the Clean Water Act, Safe Drinking Water Act, Food Safety Modernization Act, and other related laws; however…
  - Water recycling itself is regulated at the state level

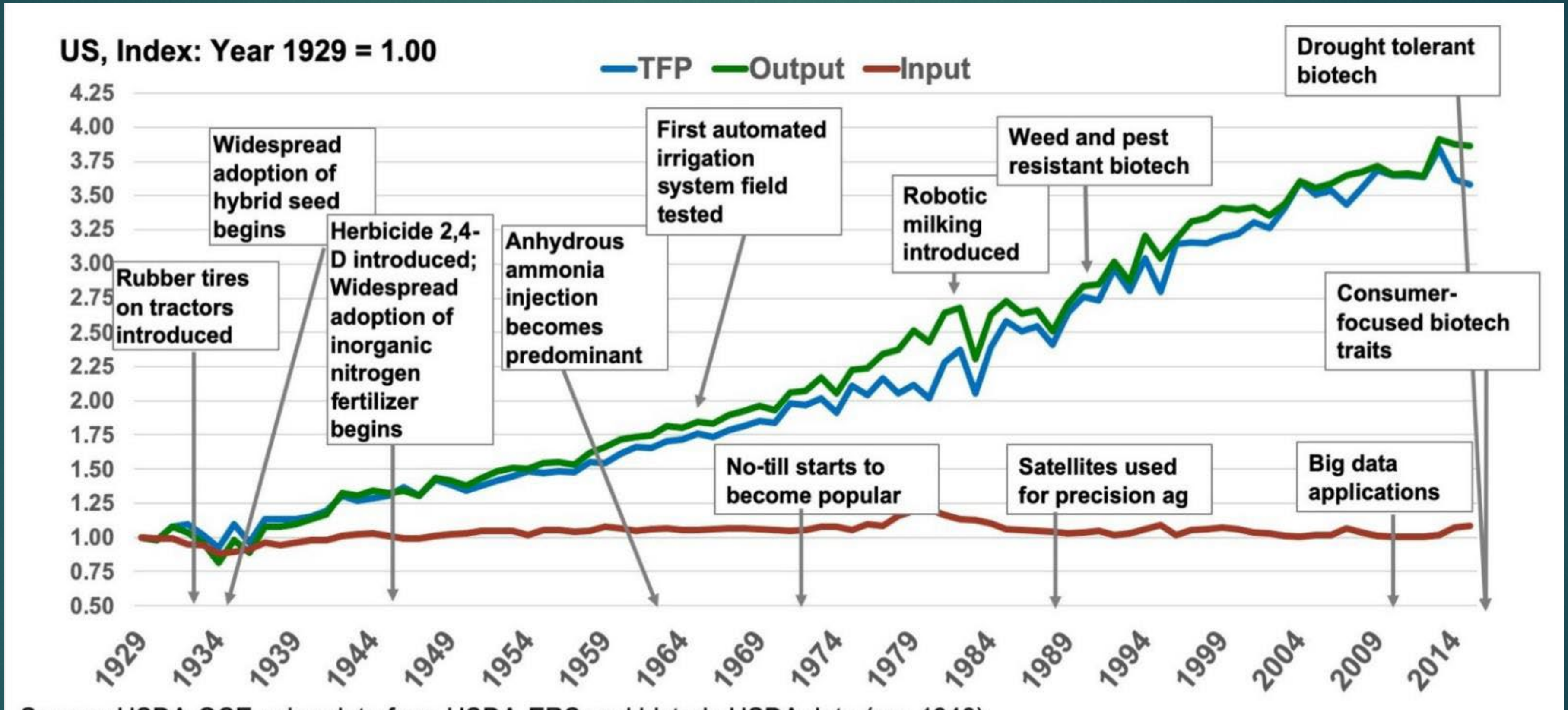
- 28 states have at least one regulation related to agricultural water reuse
  - see U.S. EPA's REUSExplorer Tool

USDA –
Natural Resources Conservation Service

Alan Gillespie, P.E.

National Water Management Engineer

Technological Innovations Improving Agricultural Productivity



Source: USDA-OCE using data from USDA-ERS and historic USDA data (pre-1948)

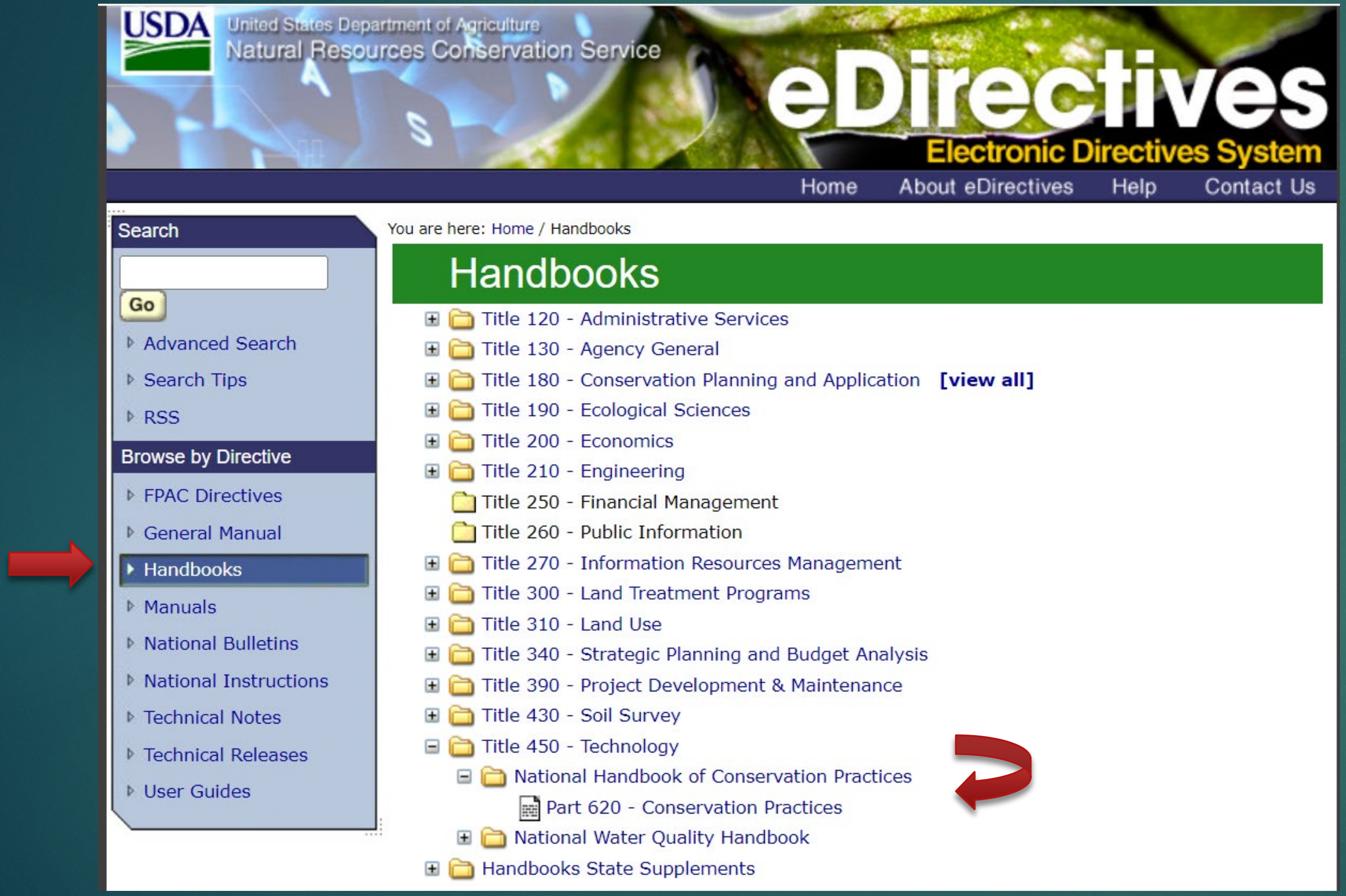
Our Mission

- We deliver conservation solutions so agricultural producers can protect natural resources and feed a growing world.

Our Vision

- A world of clean and abundant water, healthy soils, resilient landscapes, and thriving agricultural communities through voluntary conservation.

Publicly Available Directives



directives.sc.egov.usda.gov

1. Handbooks
2. Title 450 – Technology
3. Natl. Handbook Of CPs
4. Part 620 - CPs

Irrigation & Drainage Tailwater Recovery (Code 447)

A system in which all facilities utilized for the collection, storage, and transportation of irrigation tailwater, rainfall runoff, field drain water, or combo thereof for reuse are installed.

Purpose

- Improve irrigation water use efficiency
- Improve offsite water quality
- Reduce energy use

Application

- Tailwater Pit & Tailwater Recovery Structure

Roof Runoff Structures (Code 558) & Water Harvesting Catchment (Code 636)

Rainfall is piped from the gutter

Storage tanks with an overflow pipe

Purpose

- Protect surface water quality by excluding roof runoff from contaminated areas
- Prevent erosion from roof runoff
- Increase infiltration of roof runoff
- Capture roof runoff for onfarm use

Application

- Roof gutter, concrete curb, or trench drain

Purpose

- Provide water for livestock, fish, wildlife, of other conservation purpose where addition water is needed

Application

- Surface catchments and plastic tanks

On-Farm Recharge (Interim* Code 817)

The periodic application of surface or stormwater to cropland with connectivity to an unconfined aquifer.

Purpose

- To recharge a specific aquifer to reduce the risk of natural resource degradation, or limitation to land use caused by groundwater depletion

Application

- Managed Aquifer Recharge on Cropland

On-Farm Recharge (Interim* Code 817)

An off-channel impoundment or trench made by constructing an embankment, by excavating a dugout or ditch, or by a combination of both with a permeable base underlain by an unconfined aquifer.

Purpose

- To recharge a specific aquifer to reduce the risk of natural resource degradation, or limitation to land use caused by groundwater depletion

Application

- Recharge Basins & Excavated Recharge Trench

Conditions Where these Practices Apply

Adequate water supply
- On-farm water control and distribution structures

Adequate water conveyance
- Available stormwater runoff or surface water deliveries

Chemigation history
- History of groundwater friendly application

Soils & Vados Zone
- High vertical and horizontal hydraulic conductivity
- Connectivity to unconfined aquifer

Crops (for ICPS Code 817)
- History of groundwater friendly application

General Criteria for Code 817

Water Availability

- All necessary rights secured
- Hydrologic cycle

Siting Criteria

- Water table
- Infiltration, percolation, & hydraulic conductivity

Supporting Practices

- Measuring devices, pipelines, ditches, & pumps

Water Quality

- Pretreat water prior to entering recharge footprint

Instrumentation & Monitoring

- Install monitoring wells within or near the recharge footprint

Considerations and Maintenance

Clogging

- Deposition and accumulation of suspended solids, biofilms, and biomass.
- Fine-grained sediment

Cycle Time

- Fully drained within 24 – 48 hours.

Remove Surface Crust

- Manually remove surface crusts from footprint when infiltration rate reduced 25 – 50%.

Annual Dry-down

- Dry recharge area annually for fine-grained sediment and organic decomposition.

THANK YOU FOR YOUR PARTNERSHIP!

Additional Information:

www.nrcs.usda.gov

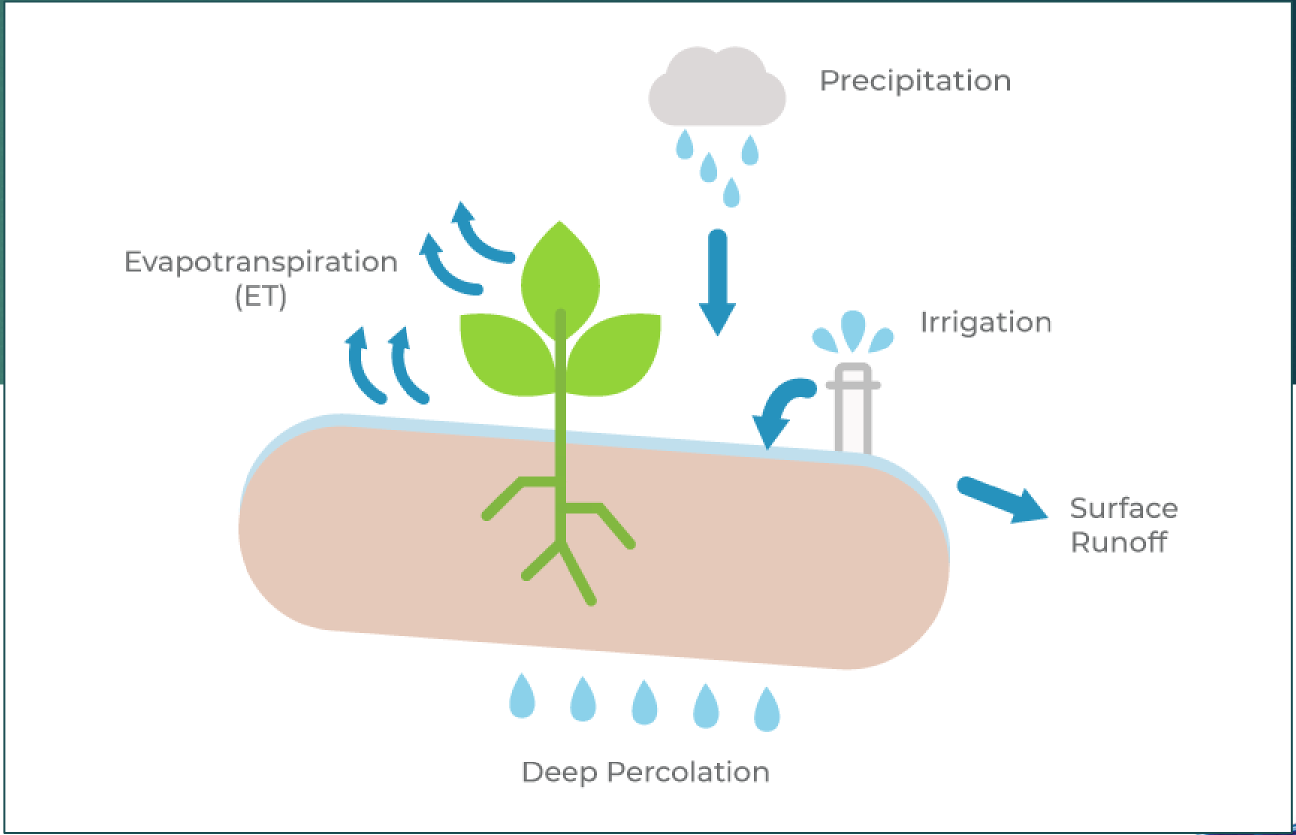
Drought Resistant Agriculture

Dr. Chris Peterson, USDA, Foreign Agricultural Service

New Technologies

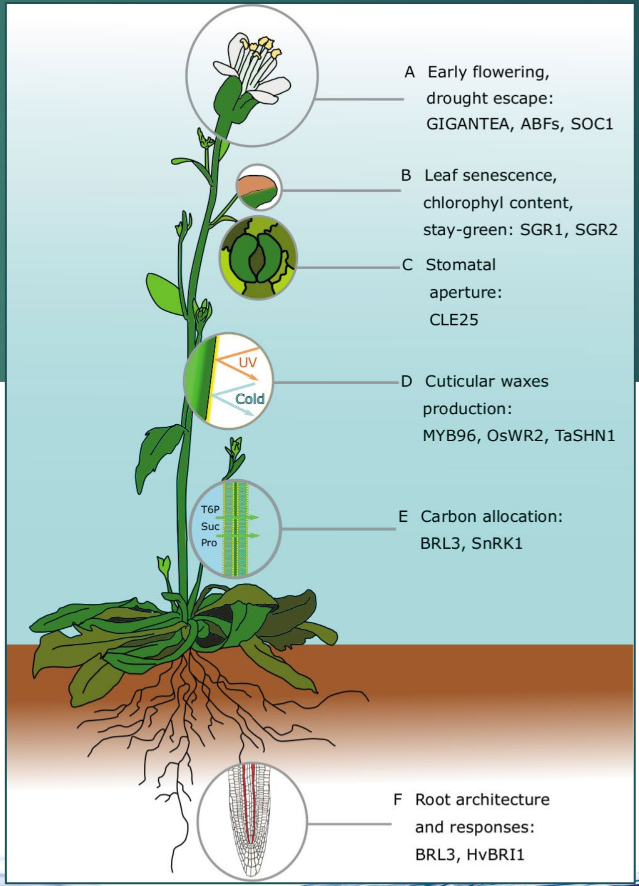
Increasing water supply is not always practical

- What if plants could be made to use available water more efficiently?
- Turns out they can!



Drought resistant plants conserve water

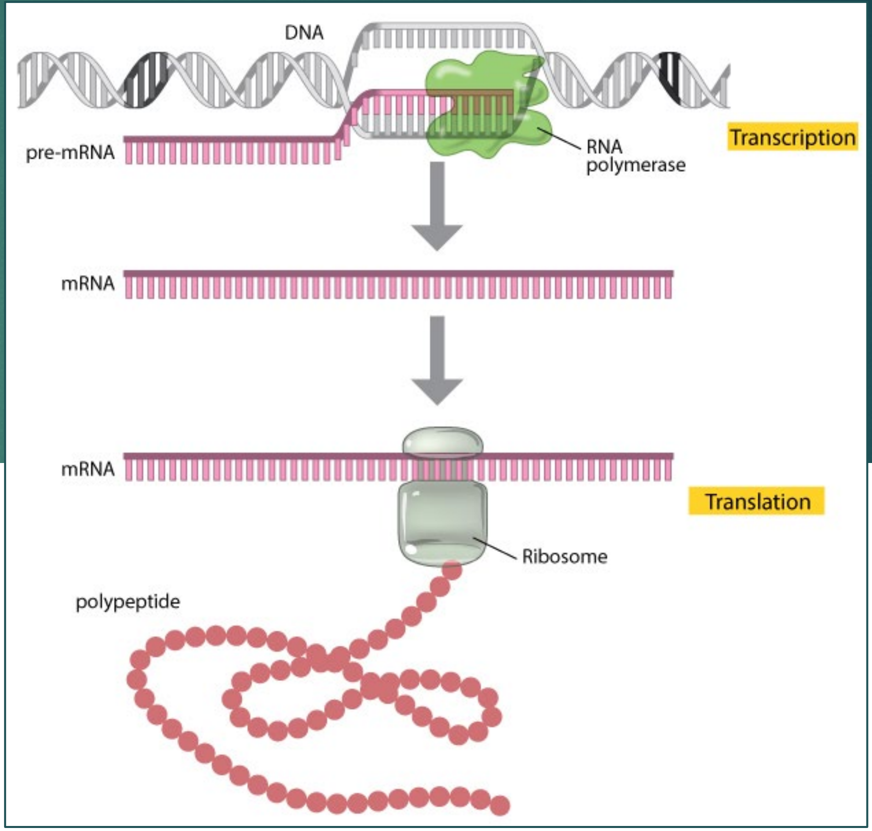
- Traits evolved to adapt to arid environments
- We can move these traits into crop plants through genetic engineering



Genuity® DroughtGard™ Corn

*Provided for example purposes and does not constitute an endorsement by USDA.

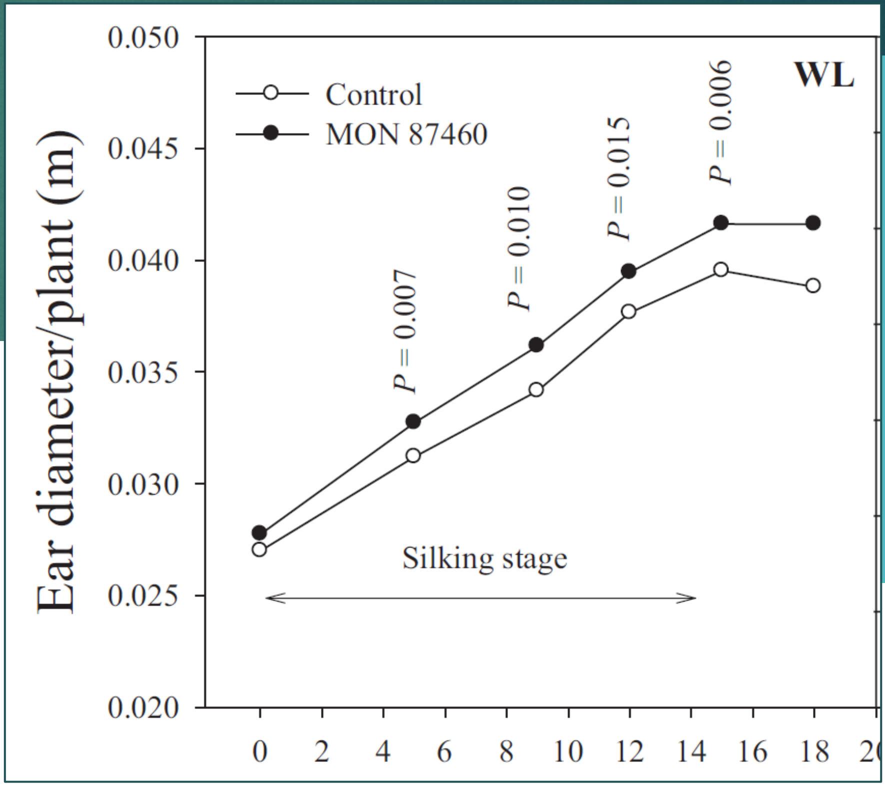
- Incorporates a gene from beneficial bacteria that protects plant processes from drought
- In short, allows the corn to grow normally with less water



Genuity® DroughtGard™ Corn

*Provided for example purposes and does not constitute an endorsement by USDA.

- 6% increase versus the non-GE variety during drought conditions
- No difference during normal conditions



Plant, Cell and Environment (2015) **38**, 1866–1880

HB4 Soybean and HB4 Wheat

- Incorporates a gene from sunflower that affects many processes to respond to water stress
- For example, the gene allows a longer period for seed setting during the plant's life cycle

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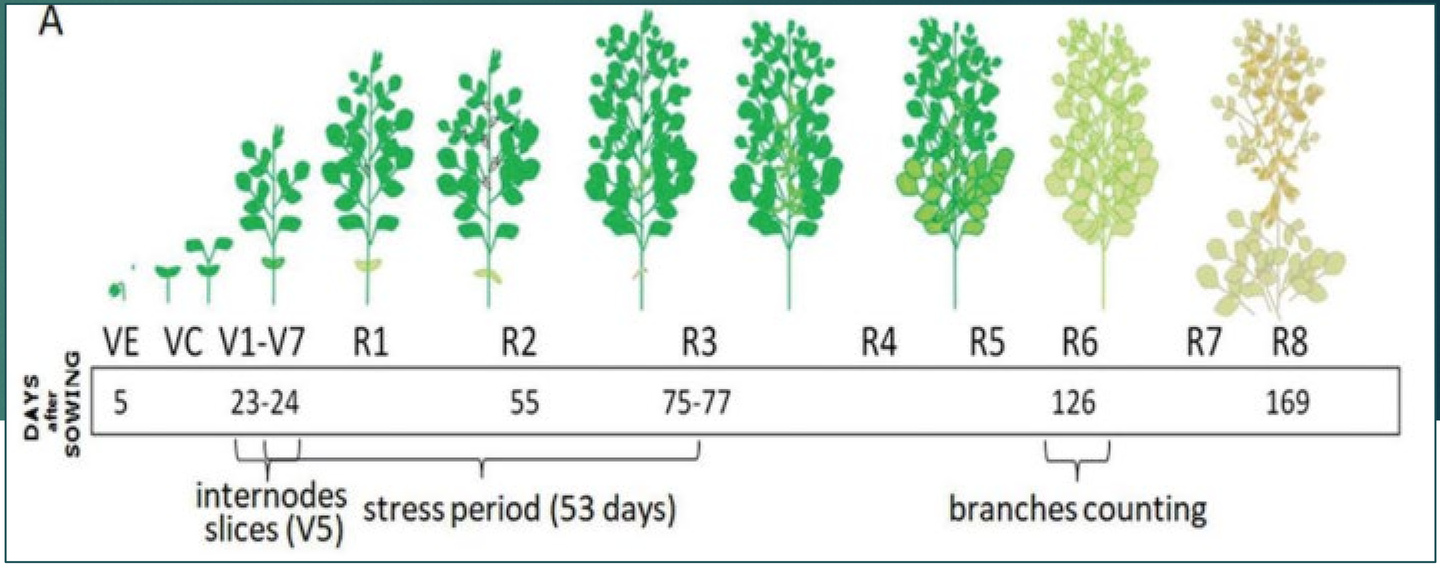
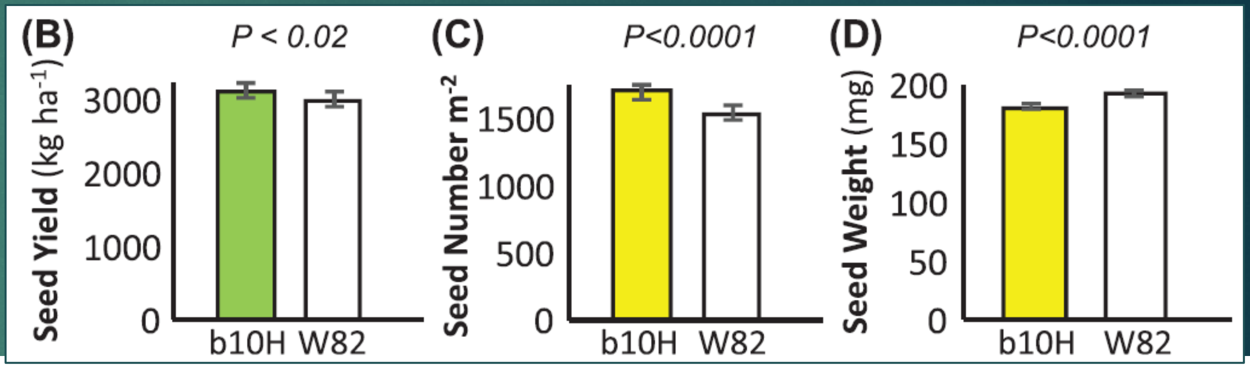


HB4 Soybean and HB4 Wheat

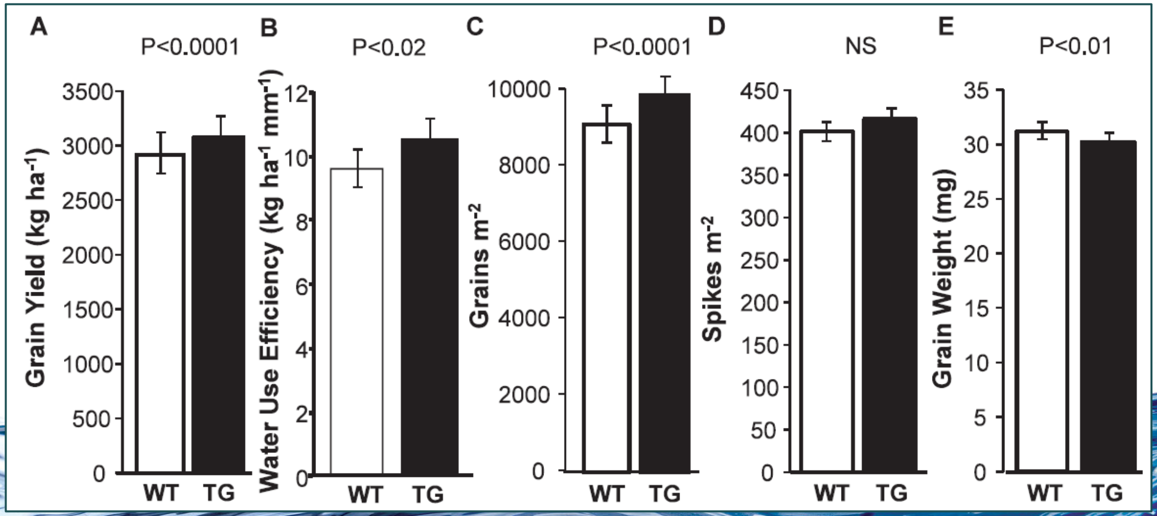
*Provided for example purposes and does not constitute an endorsement by USDA.

- Soybean: 4% increase in kg/ha across 27 field sites

- Wheat: 16% increase seeds/m2 during water stress



Journal of Experimental Botany, Vol. 71, No. 10 pp. 3142–3156, 2020



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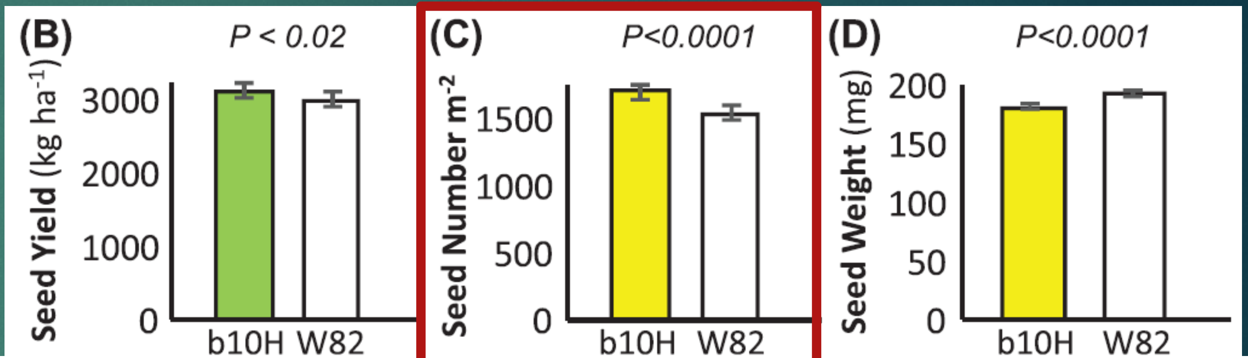

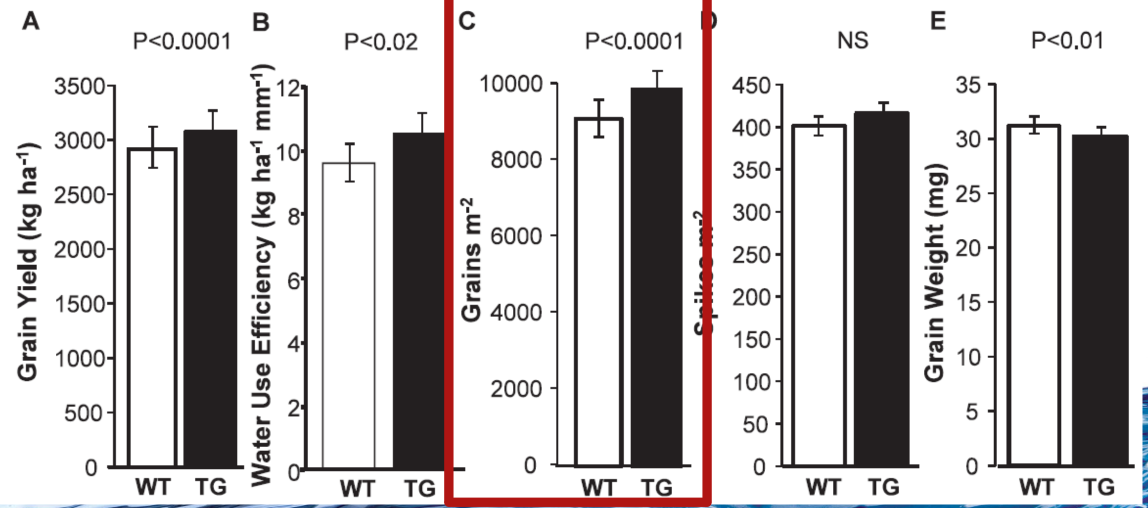

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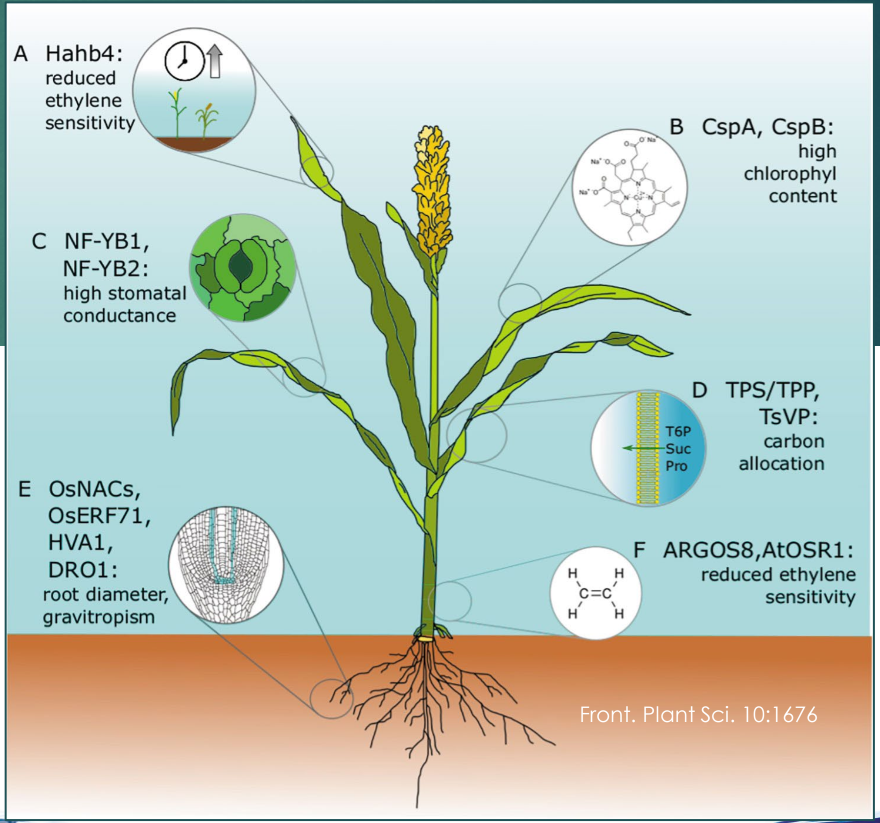
But there's a lot more we can do

- Plants have many ways to conserve water

- Research into drought tolerant crops is ongoing



Water Resources

- Federal Register :: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption
- FSMA Proposed rule on Agricultural Water
- FDA Proposes Compliance Date Extension for Pre-Harvest Agricultural Water Requirements | FDA
- Harvest and Post-harvest Agricultural Water Fact Sheet
- NRCS Directives
- Global Agricultural & Disaster Assessment System (GADAS)
- https://watereuse.org/educate/types-of-reuse/agricultural-reuse/
- https://watereuse.org/educate/water-reuse-101/agricultural-reuse/
- https://www.climatehubs.usda.gov/hubs/international/topics/Water
- Global Reservoirs and Lakes Monitor (G-REALM)
- Global Agricultural Monitoring (GLAM)