Integration of Renewable Energy, Desalination, Agriculture, and Aquaculture

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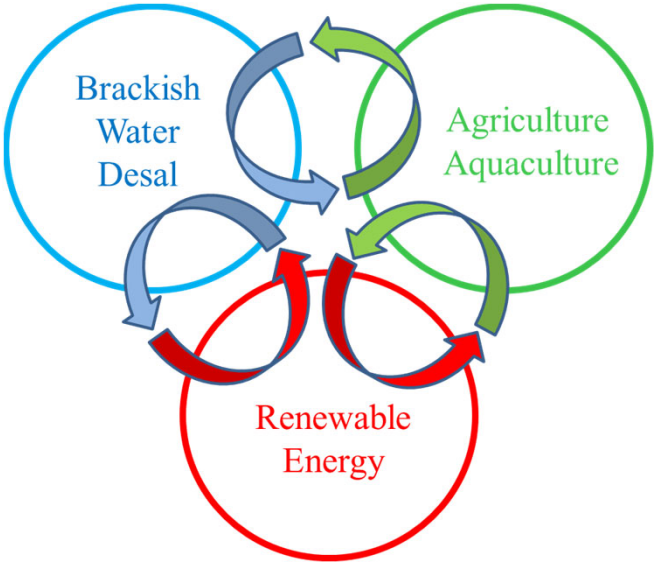
Projects and Motivation

- Bureau of Reclamation P2P: Pilot Evaluation (just ended)
  - University of North Texas (UNT)
  - New Mexico State University (NMSU)
- National Science Foundation (NSF) INFEWS (2019-2024)
  - University of North Texas (UNT)
  - New Mexico State University (NMSU)
  - Colorado State University (CSU)
- CNPq, National Council for Scientific and Technological Development, Brazil: Aquaculture (started 2019)
  - University of North Texas (UNT)
  - Federal University Parana, Brazil (UFPR)

Food-Energy-Water



Renewable Power System: Hybrid

Why hybrid? For off-grid applications, flexible and complementary.

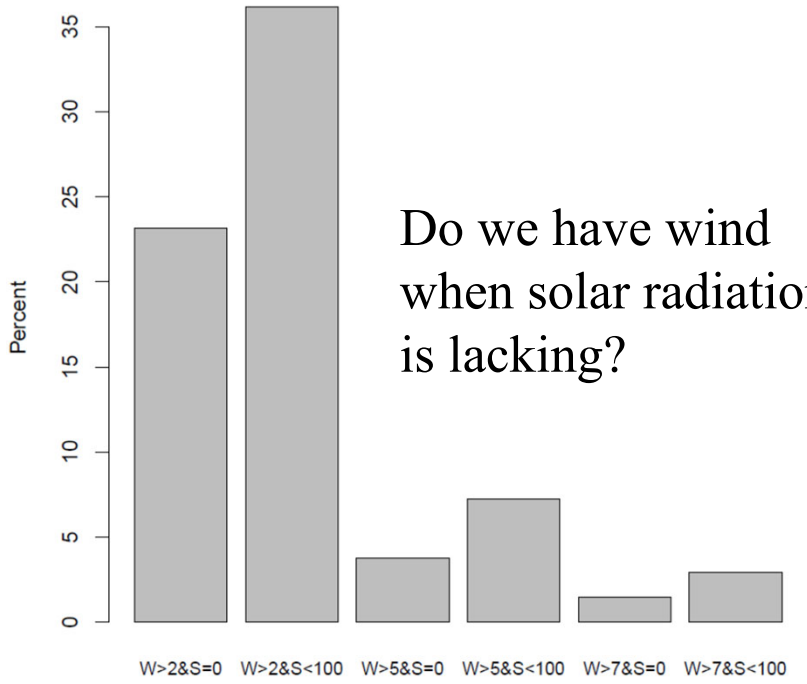
For example

- Solar: no production at night
- Wind: possible production at night

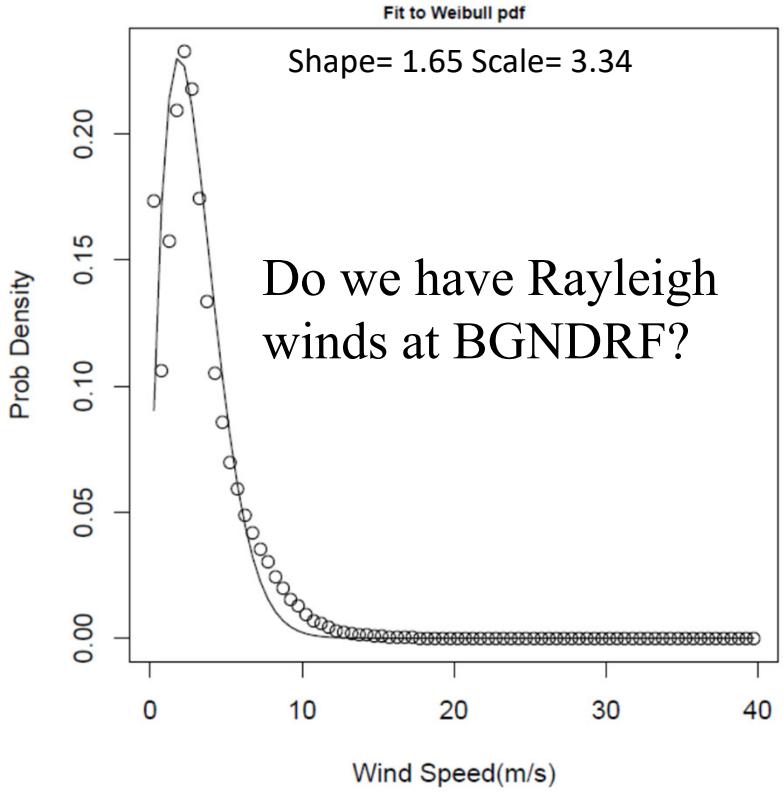
- Wind 1.6 kW
- Solar 1.3 kW
- CF=0.7
- 50kWh/d

Wind and solar resources at BGNDRF

- Measuring since May 2017, now 236,000 observations at 5-min
- Characterize solar and wind resources for electricity production

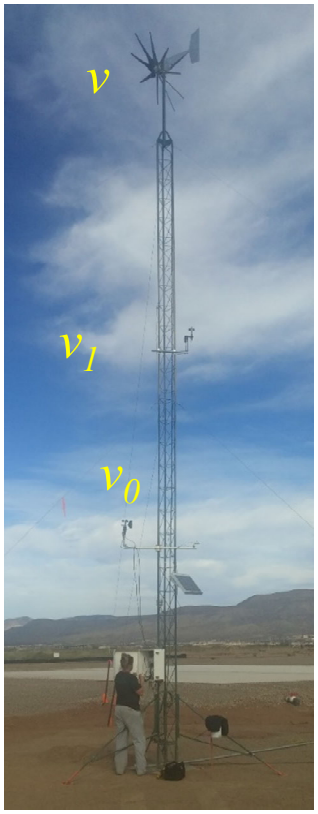


Do we have wind when solar radiation is lacking?



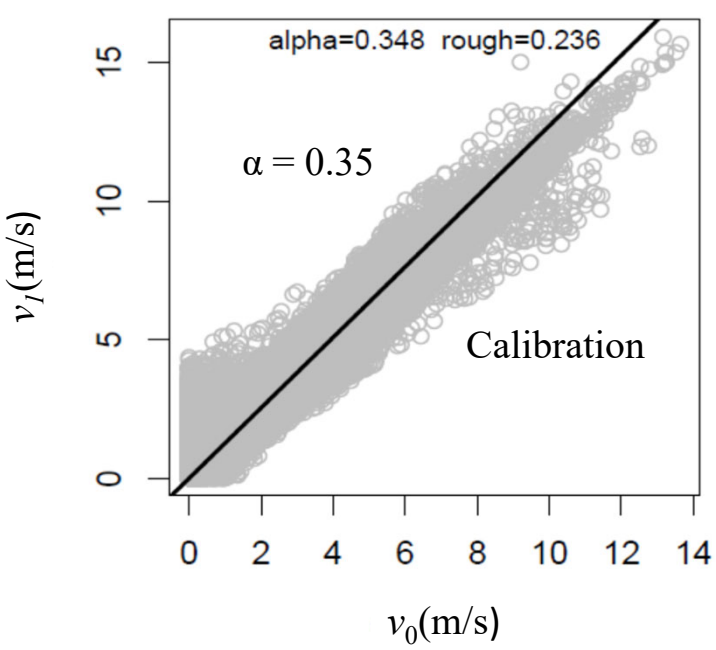
Do we have Rayleigh winds at BGNDRF?

Effect of height on wind at BGNDRF

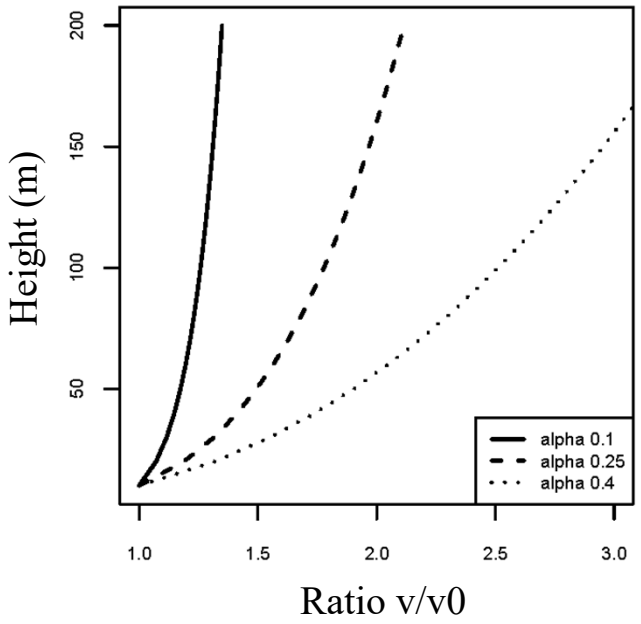


Wind speed increases with height!
Power ~ cube of wind speed!!

$$\frac{P}{P_0} = \left(\frac{v}{v_0}\right)^3$$



α = effect of friction



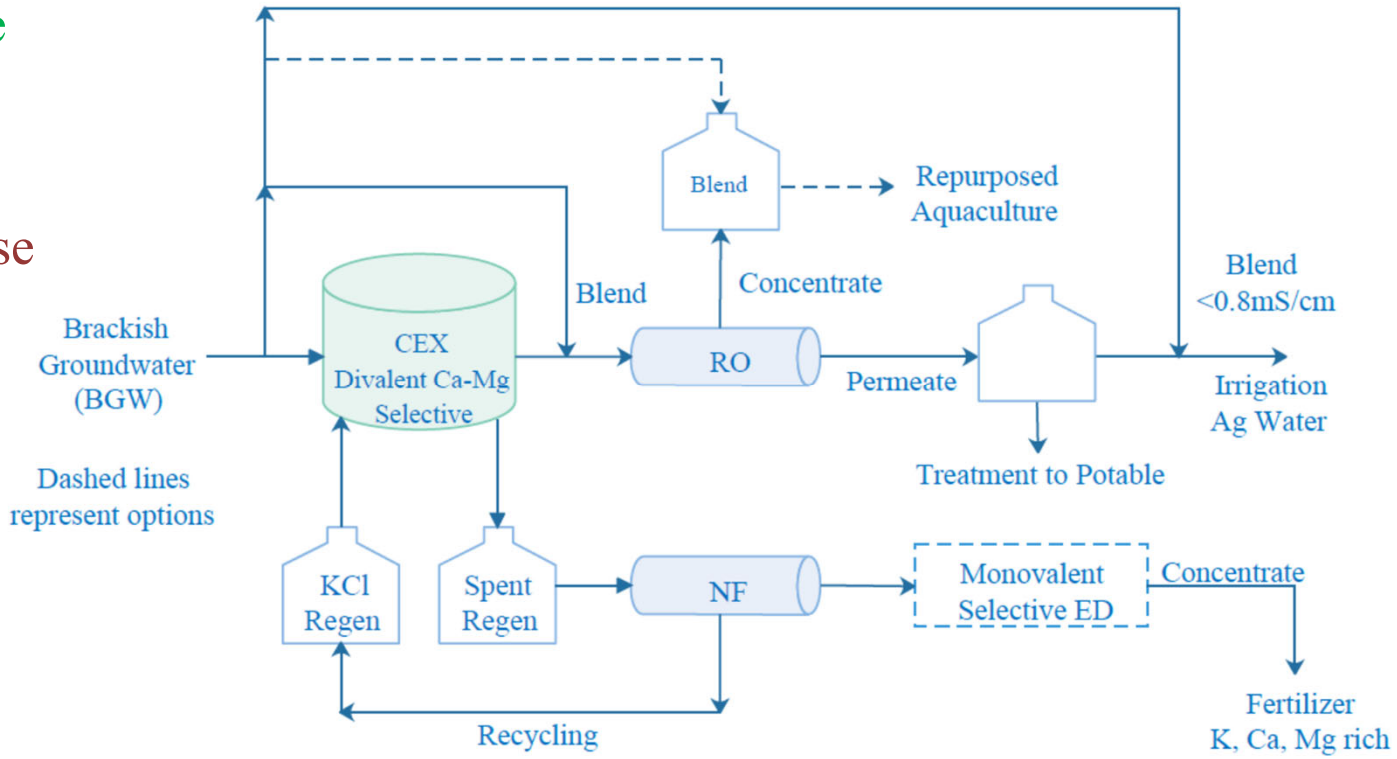
$$\frac{v}{v_0} = \left(\frac{H}{H_0}\right)^{\alpha}$$

Brackish Water Desalination

Recycle

Blend

Repurpose



11 m^3/d water at ~80% recovery

Tested with BGNDRF water from wells #1, #3, and #4

Water Quality Results: Example Well #4

	Ground Water	RO Permeate	RO Concentrate	Irrigation
Conductivity, mS/cm	4.5	0.15	16.7	0.5
Sodium, mg/L	436	28	1697	49
Potassium, mg/L	35	1	182	5
Magnesium, mg/L	269	1	1139	16
Calcium, mg/L	557	1	2523	30
Chloride, mg/L	673	32	4275	71
Sulfate, mg/L	1908	4.6	10999	105
SAR	3.8	4.8	7.1	1.8

Regenerative Agriculture at BGNDRF

- Johnson-Su composting bioreactor
  - Inoculation soil microbial community
- Full factorial:
  - Ag Water (A), Well Water (W)
  - Inoculation (I), No-Inoculation (N)
  - Four replicates, Latin Squares
- Cover Crops

Buckwheat

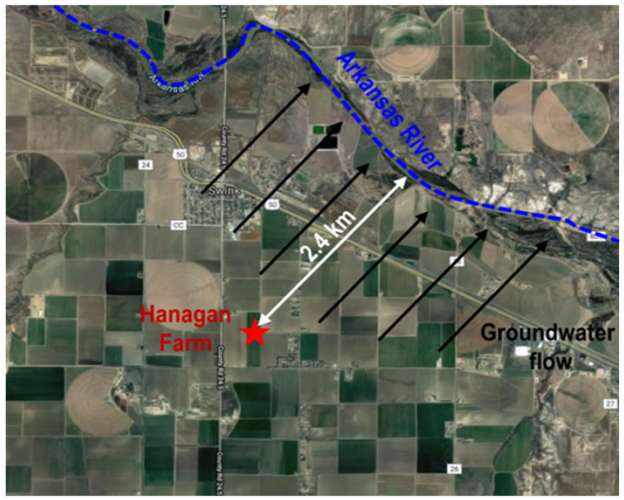
Clover

Sesbania

A-I	W-I	A-N	W-N
W-N	A-I	W-I	A-N
A-N	W-N	A-I	W-I
W-I	A-N	W-N	A-I

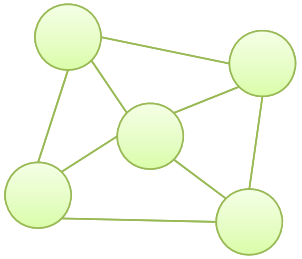
Regenerative Agriculture: Farm Level

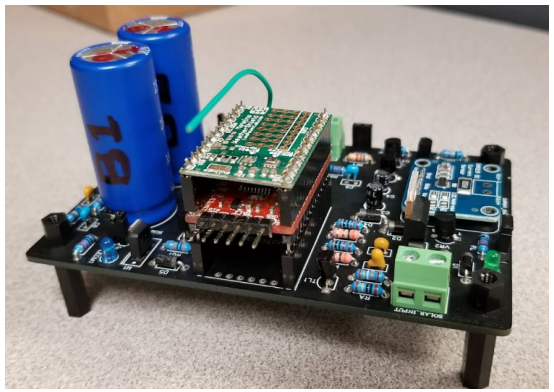
- Lower Arkansas River Valley, Colorado
  - CSU study area
  - Increased soil and water salinity
  - Decreased crop yield
- Hanagan Farms
  - Experimental plots
  - Treatments as in BGNDRF

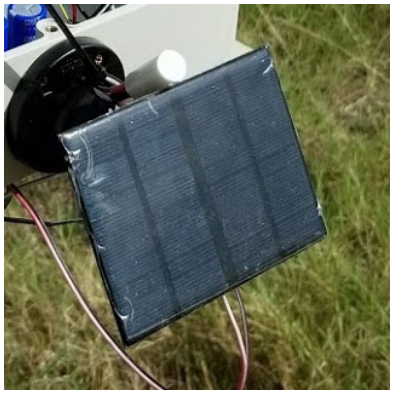


Cyberinfrastructure for Agriculture

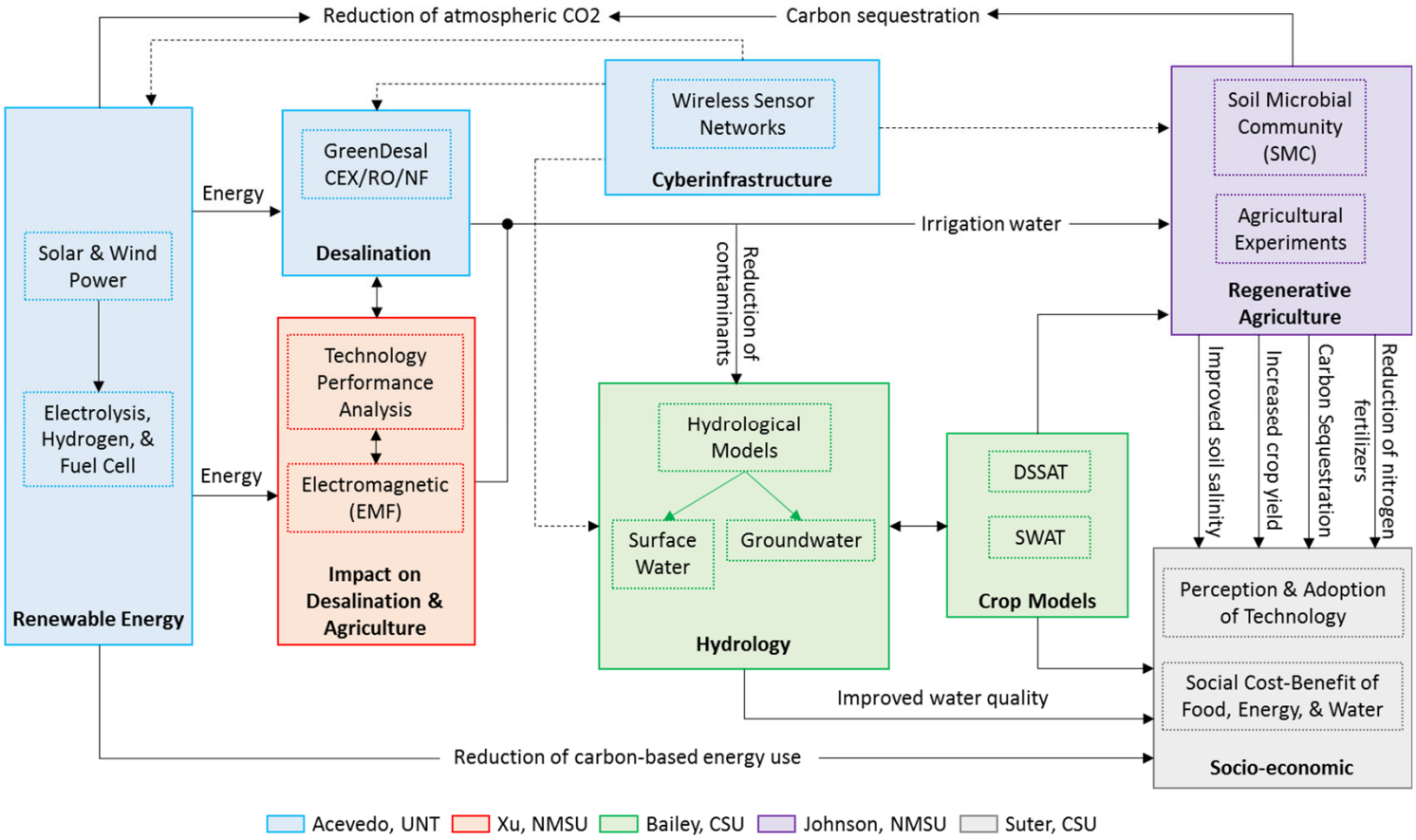
- Wireless Sensor Networks
- Battery-less nodes to monitor soil moisture and crop parameters
- Control of irrigation
- Inform the hydrological and crop models
- Distributed in agricultural field







NSF INFEWS Project Diagram

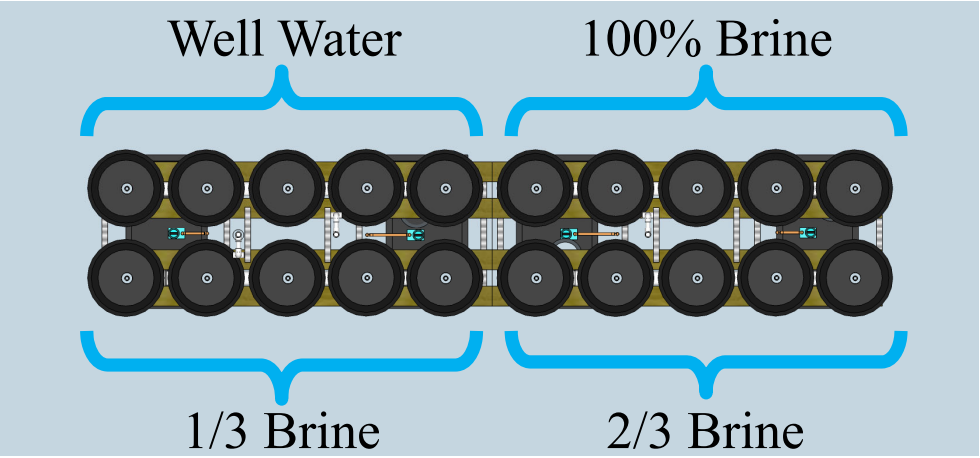


Aquaculture

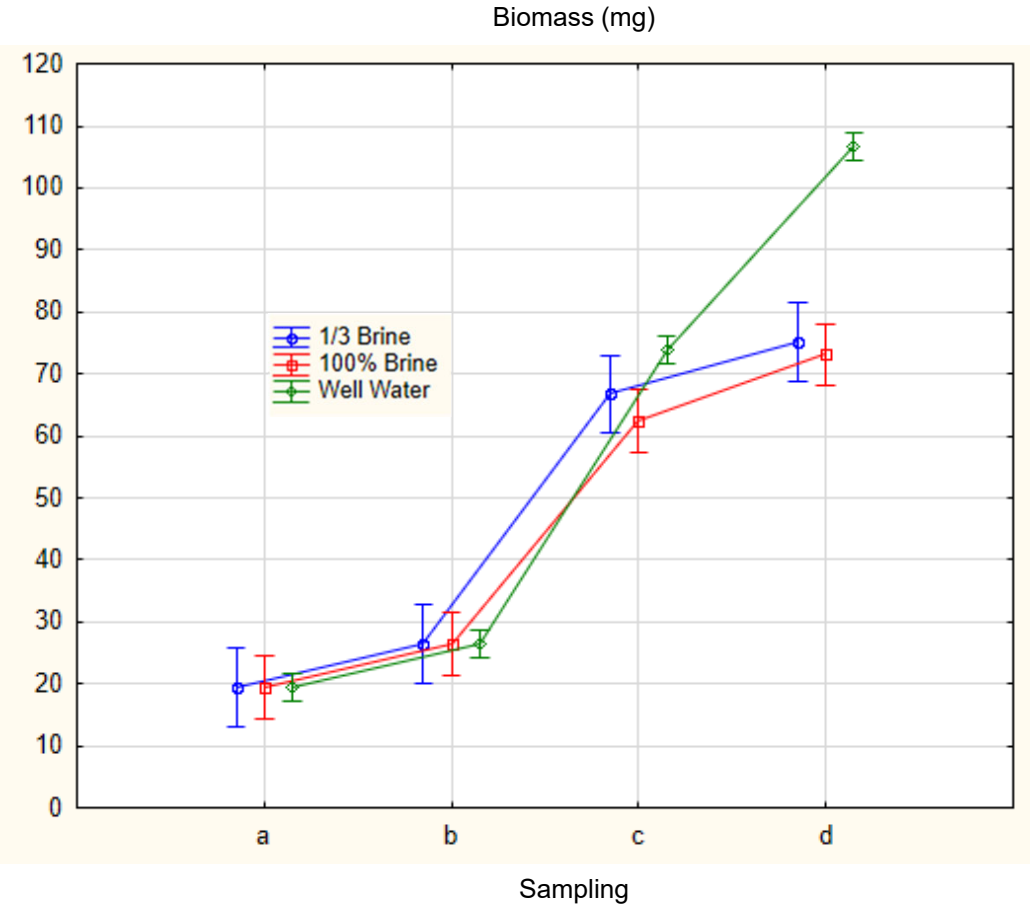
Could RO concentrate be used for food production?

Experiment:
Survival & growth of
Macrobrachium rosembergii
at BGNDRF

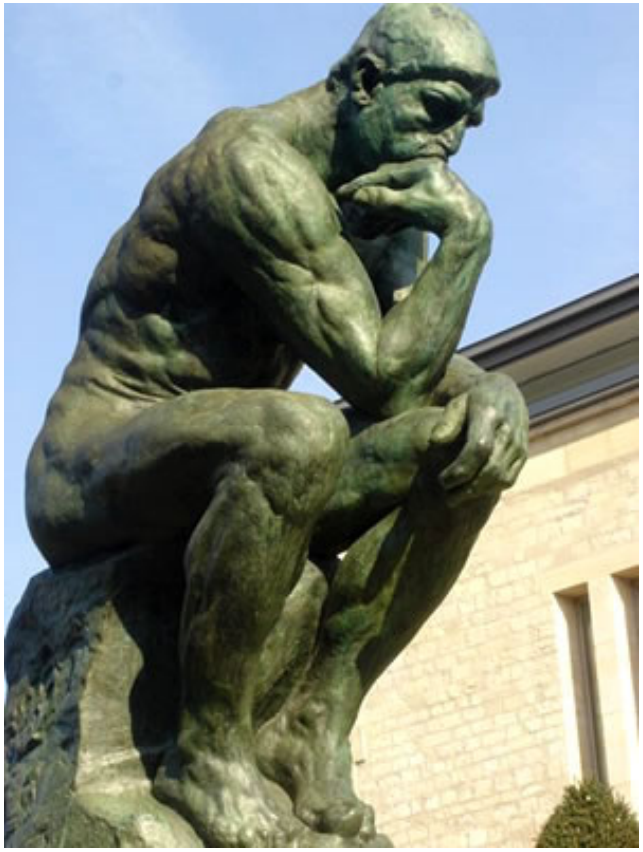
Experimental Design and Results



40 juveniles per tank



Why decreased growth?
Is there something in the brine?



Testing Antiscalant

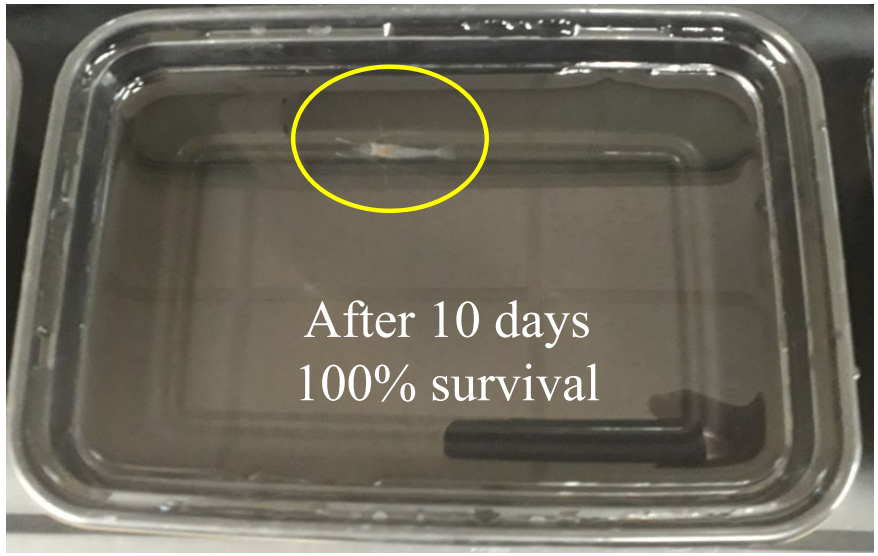
Increasing concentrations:

1.125 to 432 ml of 10% Antiscalant
in 15 liters of well water

Treatments bracket:

- 4.5 ml (equivalent to operational concentration)
- 108 ml (lethal concentration LC50)

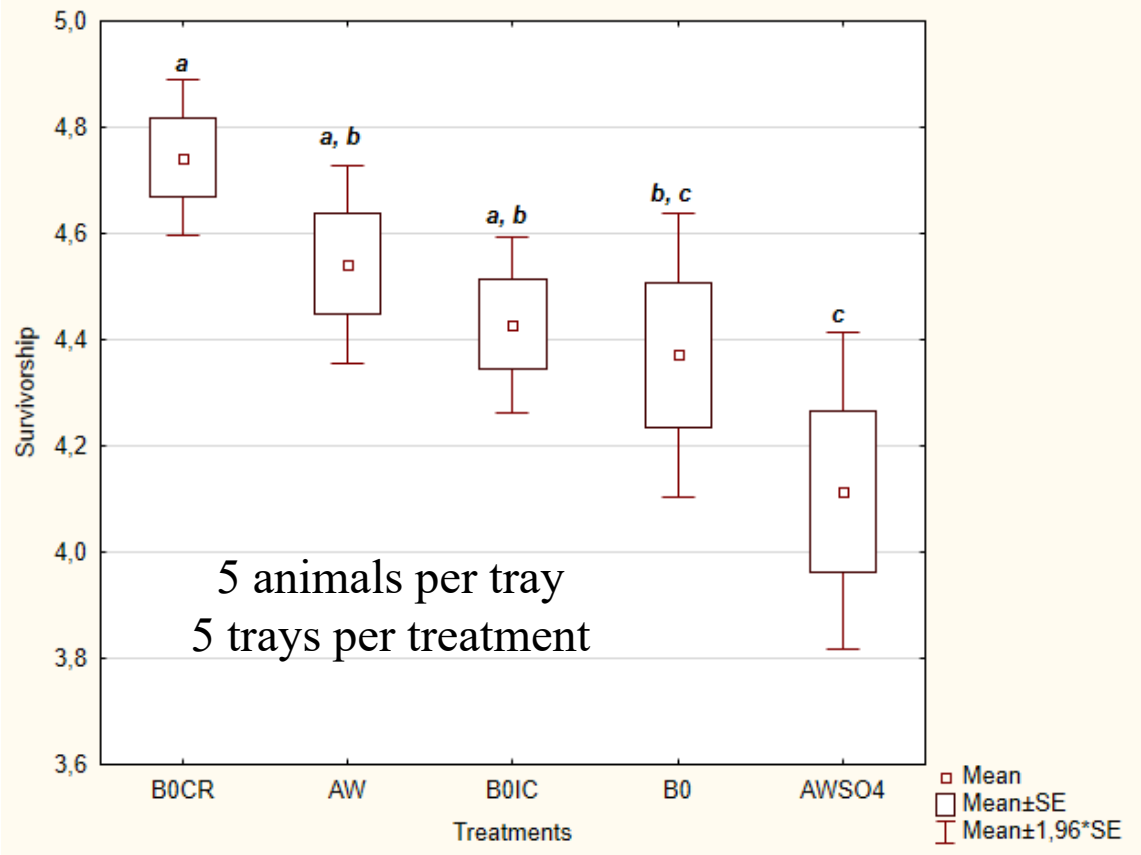
1 animal per tray
5 trays per treatment



Survival best after removing cooper

Treatments

- AW= artificial ocean water (10 SPU)
- AWSSO4= artificial ocean water (10 SPU) with SO_4
- B0= Pure brine
- B0CR= brine with copper removal
- B0IC= brine with corrected ion balance



Summary

- Motivated by Food-Energy-Water nexus
  - Integration
- Powered by hybrid wind and solar
  - Wind and solar resources characterization at BGNDRF
- Known and proven water treatment technologies
  - Blending water, recycling regenerant, and repurposing concentrate
- Agriculture: soil microbial community, soil and crop improvement, cyberinfrastructure, and modeling
  - Sites: New Mexico and Colorado
- Aquaculture
  - Growing shrimp in concentrate successful after removing copper

Acknowledgments

- BGNDRF
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