Artemisia tridentata Mesocosm: Annual Water Usage and Water Balance

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Abstract

Native plants in the Great Basin such as big sagebrush (*Artemisia tridentata* L.) do not receive supplemental irrigation and must rely on water storage within the soil from snowmelt and rainfall. With changing climate likely to produce prolonged dry periods, detailed information on soil water storage and water use by sagebrush tends to be lacking. The objective of this study was to measure variations in soil water storage and water use by sagebrush. Changes in water storage were monitored by depth with an AquaPro capacitance-type water content sensor in an established sagebrush stand. Litterfall mass was measured using screen-type litterfall collectors. Nitrogen content of sagebrush leaves and litter was measured with a combustion analyzer. Precipitation accounts for a large portion of the water used by sagebrush during wet years such as 2011. In dry years such as 2013, sagebrush must absorb more water from soil storage to meet plant demand. Moreover, when the aridity index (P/ET) of the soil is low, sagebrush must use significant amounts of water stored within the soil. Water distribution in the soil reaches a minimum during the late summer to fall (August-November). Nitrogen concentration in leaf tissue and litter is affected by water availability and storage. There is less leaching of NO_3 in dry years. Solutes including NO_3 become concentrated in lower water content volume providing higher concentrations for root interception. Roots exploit the soil profile to find H_2O, encountering more nutrients such as N. In wet years, primary production is greater than in dry years. The higher N content of 2014 leaf litter is contributed by the higher N in 2013 leaf litterfall. It is necessary to follow water balance and nutritional composition of sagebrush in wet and dry years to determine the dynamics that might be attributed to climate change.

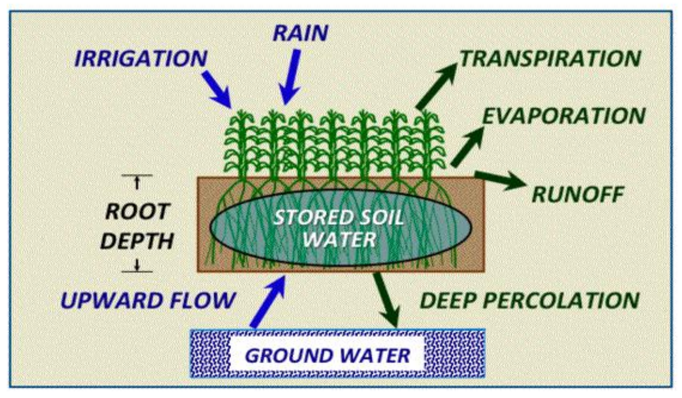
Introduction

Big sagebrush (ARTR) of the Great Basin relies on precipitation and water storage for plant biomass production. The major objective of studying sagebrush water balance is to explain water use, nutrient availability, and how it might be controlled by climate change.

Objectives:

- Quantify climate—soil –plant community interactions.
- Assess status and trend of soil water content.
- Assess ARTR mesocosm water balance.
- Assess changes in plant tissue composition.

Soil Water Balance



- Runoff = zero.
- Deep percolation = Assumed to be zero during growing season.
- Irrigation = zero.
- ET > Precipitation

Methods

Methods to Assess Water Usage and Water Balance in Big Sagebrush:

Big Sagebrush (ARTR) soil water content data collection and analysis:

- Five years of soil water content data were collected from a mature big sagebrush (ARTR) stand (Logan Forestry Sciences Lab) at 11 sample points, using an AquaPro capacitance-type water content sensor.
- Data were compiled and water use was calculated and graphed.
- Precipitation (P) and evapotranspiration (ET) data for USU, were obtained from the USU Climate Center.

Big Sagebrush (ARTR) litterfall and leaf tissue sampling and analysis:

- Annual leaf litter was collected on screen-type litterfall collectors from a mature big sagebrush (ARTR) stand at 11 sample points and placed into labeled paper bags in November.
- Samples were air-dried, weighed, and ground to a fine powder with the use of a digital plant tissue grinder.
- Leaf tissue samples were collected in July, oven-dried at 60 °C, and ground in a Wiley mill. Leaf tissues was analyzed for N content using a Leco Combustion Analyzer.

Results: Water Supply & Demand & N content of ARTR

- As shown in Figs 1 & 3, precipitation accounts for about 20-50% of the water needed for ARTR growth seasonally or annually, respectively.
- Figs 2 & 4 compare wet and dry years 2011 through 2015 seasonally or annually, respectively. 2011 was a wet year whereas 2013 was a dry year.
- Since 2011 was a wet year, less soil water storage was needed by sagebrush (15% usage, Fig 5). Since 2013 was a dry year, more soil water storage was needed by big sagebrush (35% usage, Fig 5).
- Changes in soil water storage are related to the AI (Fig 6).
- Figs 7-10 show soil profile water content for the wettest and driest years as examples.
- Leaf N was highest in the dry year of 2013 because (Fig 11):
  - Less leaching of NO_3.
  - Greater solute concentration including NO_3 in a smaller volume of water.
  - Greater root interception of solutes and water.
- Higher N concentration in 2014 litter is from higher N in 2013 leaf tissue. (Fig 12)

Conclusion

To predict sagebrush response to climate change such as a drier climate, it is necessary to measure sagebrush water use and nutrient content in both wet and dry years. AI can be used to predict change in soil water storage (Fig 6).

Sagebrush Water Supply and Demand

Fig 1. Precipitation vs ET

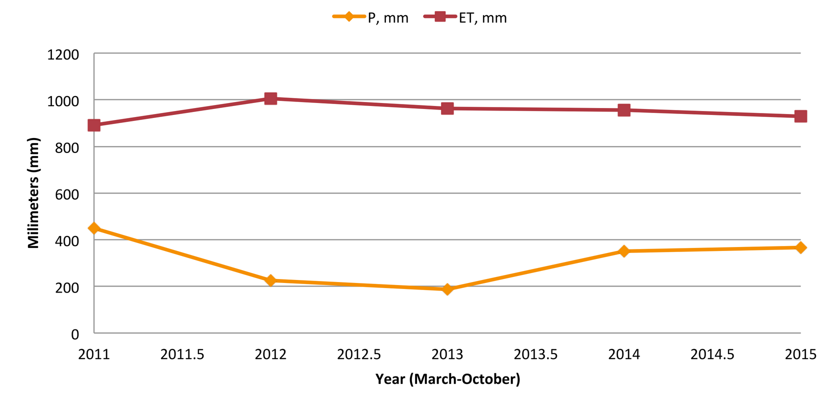


Fig 3. Precipitation vs ET

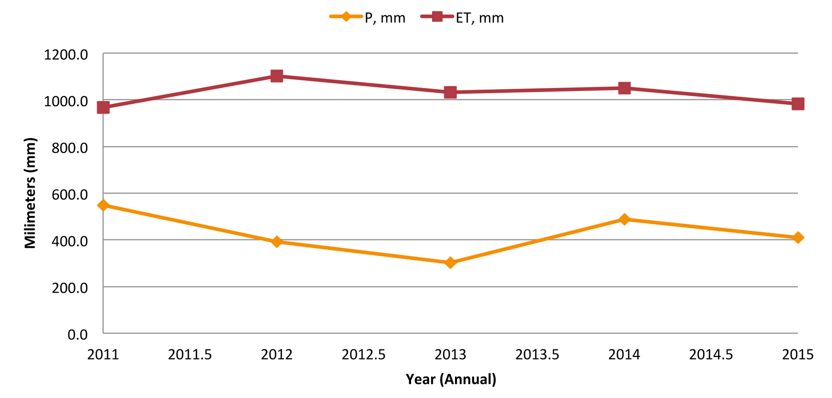


Fig 2. Aridity Index (P/ET)

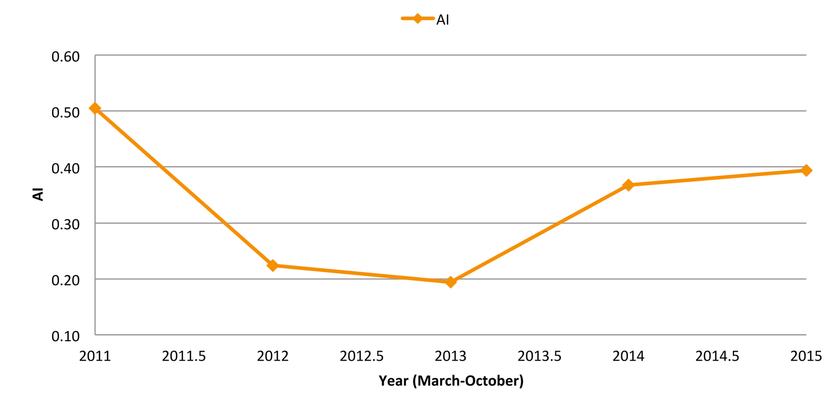


Fig 4. Aridity Index (P/ET)

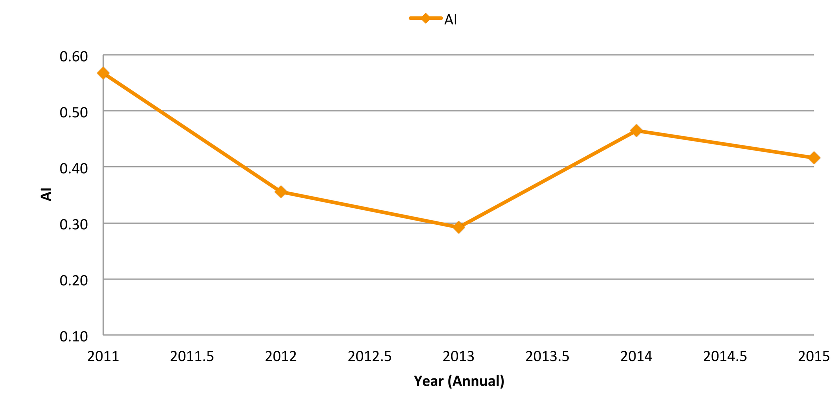


Fig 5. Mean Difference between wettest & driest soil profile water content

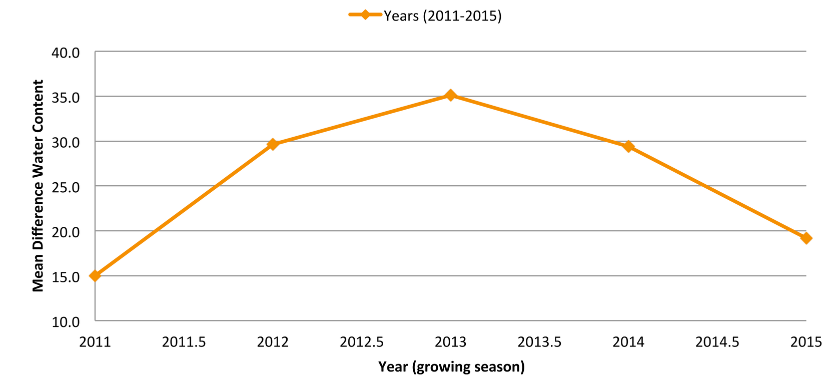
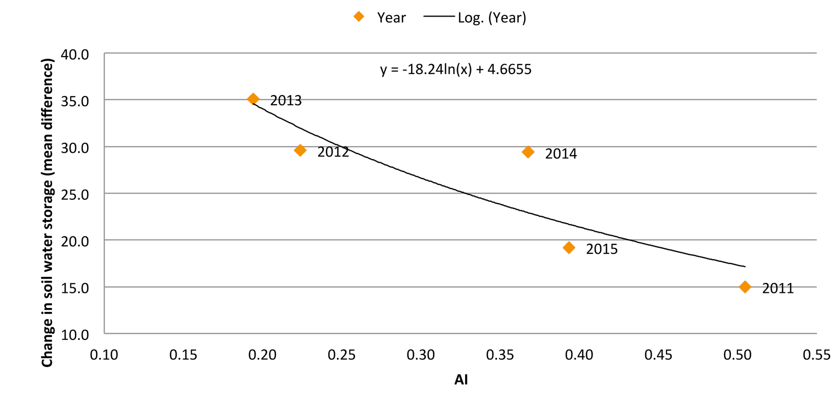


Fig 6. ARTR Water Usage & Water Balance



- ET is the plant demand, P is the supply.
- Aridity index (AI) = P/ET
- Mean difference is between the wettest and driest soil profile within a growing season.

Wettest vs Driest year

Fig 7. 2011 ARTR Soil Water Content

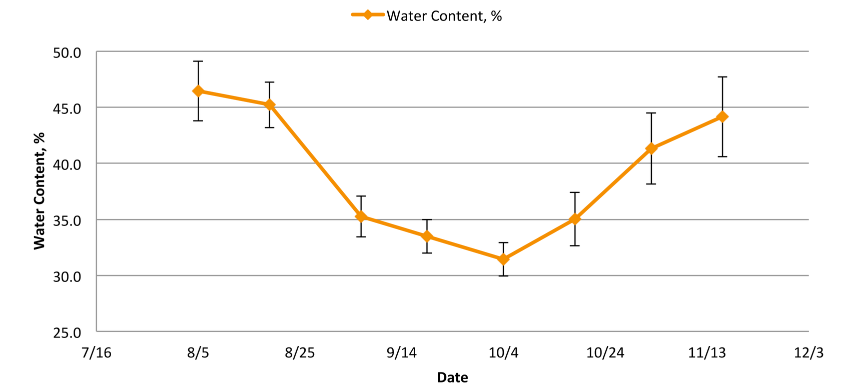


Fig 9. Soil Water Profile Comparison of 8/5/11 and 10/4/11

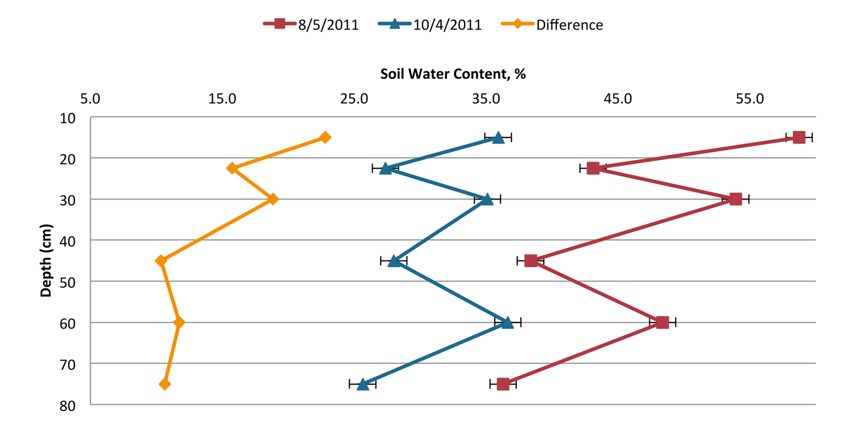


Fig 8. 2013 ARTR Soil Water Content

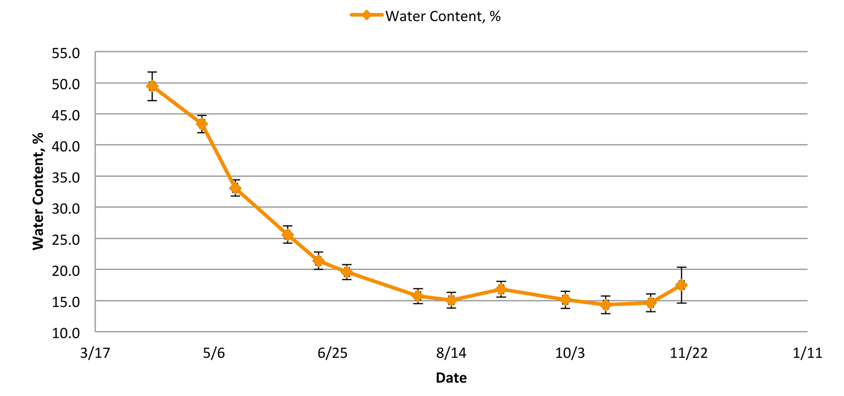
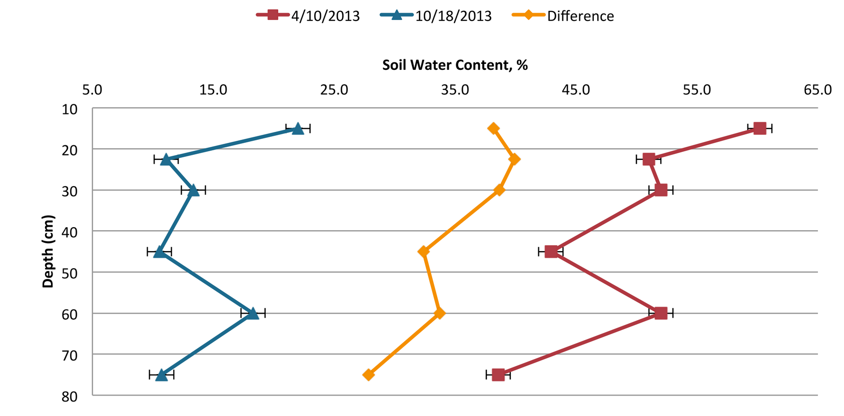


Fig 10. Soil Water Profile Comparison of 4/10/13 and 10/18/13



- 2011 was an overall wet year (Fig 7), where as 2013 was an overall dry year (Fig 8).
- During wet years the upper soil layers are saturated, lower layers unsaturated.

ARTR Litter-Nitrogen

Fig 11. Sagebrush Leaf Tissue

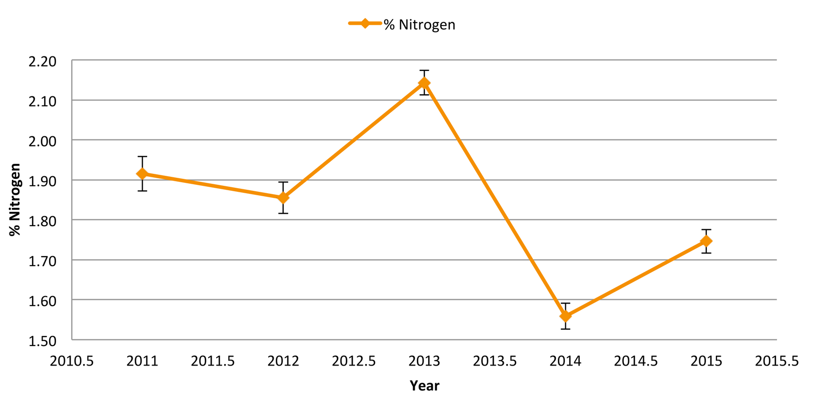
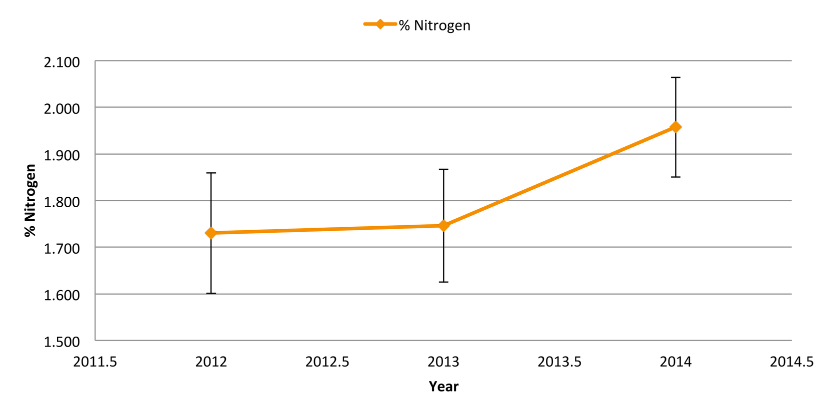


Fig 12. Sagebrush Litter



- Litter was collected annually in November, leaf tissue was sampled in July.
- Annual litterfall includes primary production from the previous growing season.

Acknowledgments

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References

USU Utah Climate Center, 2015. Accessed: 23 October 2015. https://climate.usurf.usu.edu/mapGUI/mapGUI.php