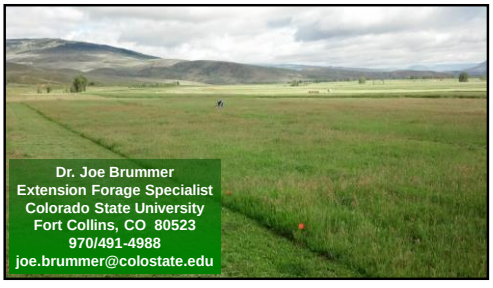
Mountain Meadow Management
Fertility, Irrigation, and Rotational Dry Up



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Why Fertilize?

- Increase forage yield
  - Do you need more hay or pasture to meet the livestock demands of your own operation?
  - Do you have a market for any extra hay that you produce?

Soil Fertility

- Must be considered in overall management plan
- All meadows should be periodically soil tested to determine nutrient status
- Generally, nitrogen and phosphorus are the only nutrients of concern for meadows

Nitrogen
General Considerations

- Virtually all meadows are nitrogen deficient and will respond to N fertilization
- All plants use nitrogen
  - Legumes fix N from the air
  - Grasses are heavy users and need additional N to be productive, also become extremely competitive
- Need to test soil phosphorus levels
  - N response can be limited by inadequate P

Drawbacks to
Nitrogen Fertilization

- Must be applied annually
- Potential for runoff, leaching, or volatilization if not properly applied
- System can crash if N fertilization is discontinued??

Nitrogen Sources

- Most common
  - Urea (46% N)
  - Urea-Ammonium Nitrate solution (28-32% N)
- A pound of N is a pound of N
  - Given that the N actually reaches the plant in an available form

Problem with Urea

- Susceptible to ammonia volatilization
  - Higher the temperature + the longer the fertilizer lays on the surface = greater losses
  - Leads to inconsistent yield responses from year-to-year
  - Must pay attention to management to minimize losses

Mountain Meadow Fertility/Interseeding Trial

- Blue Valley Ranch
  - South of Kremmling, Colorado
- Plots established in May 2011
- Interseeding Treatments:
  - Alfalfa
  - Birdsfoot Trefoil
  - Mix of Mammoth Red (3.5 lbs) and Alsike Clover (2.5 lbs)
  - Seeded with John Deere Powr-till drill at 6 lbs PLS/acre, May 2011

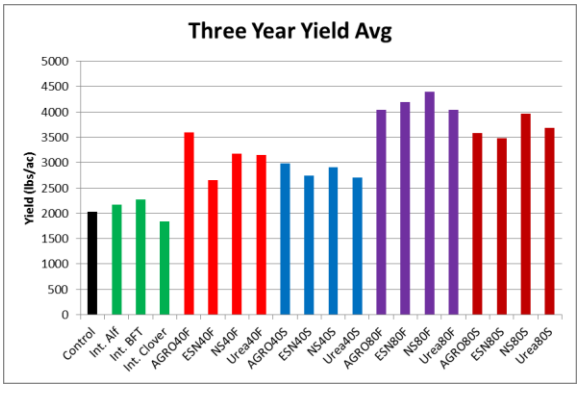
Mountain Meadow Fertility/Interseeding Trial

- Fertilizer Treatments:
  - Fertilizers:
    - Urea (Uncoated)
    - ESN polymer coated urea
    - Nutrisphere-N coated urea
      - Urease + nitrification inhibitor
    - Agrotain coated urea
      - Urease inhibitor
  - Rates:
    - 40 or 80 lbs N/acre
  - Timing of Application:
    - Fall and Spring

Year Main Effect

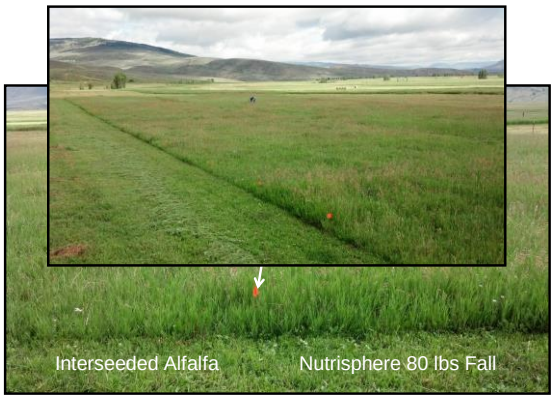
2011 = 3700 lbs/acre
2012 = 2340 lbs/acre
2013 = 4090 lbs/acre
Avg. = 3380 lbs/acre

2011 – Cool, wet spring, slow growth
2012 – Hot, dry, drought, 3 short irrigations
2013 – Normal growing conditions/irrigation



Fertilizer Main Effect

Type	2011	2012	2013	Avg
Control	2330	1490	2250	2020
Agrotain	NA	2310	4790	3550
ESN	3730	2240	3830	3270
Nutrisphere	3860	2720	4250	3610
Urea	3840	2320	4010	3390



Rate Main Effect

Rate	2011	2012	2013	Avg
0	2330	1490	2250	2020
40	3330	2090	3560	2990
80	4290	2710	4880	3960

Average efficiency
25 lbs forage/lb N in 2011 at both rates
15 lbs forage/lb N in 2012 at both rates
33 lbs forage/lb N in 2013 at both rates

Timing Main Effect

Timing	2011	2012	2013	Avg
Control	2330	1490	2250	2020
Fall	3940	2810	4580	3780
Spring	3680	2600	3860	3380

Breakeven Yield Increases

- Assumptions:
  - Additive adds from $0.05 to $0.12 per lb N
    - Agrotain the cheapest, ESN most expensive
    - At 80 lbs N/ac, costs additional $4.00 to $9.60/ac
  - Current price of mountain meadow hay
    - $125/ton or $0.0625/lb
- Breakeven for 80 lb N application rate
  - 64 lbs additional hay/ac for Agrotain
  - 154 lbs additional hay/ac for ESN

Take-Home Messages

- Yield responses were consistently higher when fertilizer was applied in the **fall**
- On average, nitrogen use efficiency was similar between 40 and 80 lb rate
  - Significantly affected by growing conditions
  - 15 to 33 lbs of forage per lb of N applied
- Nutrisphere and Agrotain both showed positive yield benefits compared to straight urea, especially when applied in the fall
  - Response affected by growing conditions
  - Need minimal yield increases to pay added expense
    - 64 to 90 lbs additional forage per acre
- ESN releases too slow, not worth the expense

Potential Advantages of Early Season Irrigation

Potential Advantages of Early Season Irrigation

- What happens when water is spread in a thin layer across the soil surface?
  - Acts like a lens
  - Quickly warms
  - Starts to raise soil temp
    - Irrigate frost out of the ground!!
- What happens at night as that water continues to flow across the surface?
  - Stays above freezing
  - Insulates soil and plants
  - Keeps soil surface from freezing and having to thaw the next day

Potential Advantages of Early Season Irrigation

- What is the end result?
  - Can jump start growth by 2 weeks or more
  - Earlier spring grazing
  - Earlier haying
    - More fall regrowth for grazing

Agronomic Responses of Grass Hayfields to No Irrigation as Part of a Potential Colorado Western Slope Water Bank

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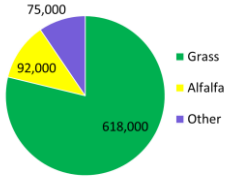
- Reduced water supply
- Increasing demand
- Colorado River Compact- 7 states
  - Upper Basin: Colorado, Wyoming, Utah, New Mexico
  - Lower Basin: Arizona, California, Nevada
  - If flows fall below 75 MAF in any rolling 10-year period (annual average of 7.5 MAF), water curtailments will be imposed on upper basin states
- Primary water use - irrigated agriculture

Western Slope Water Bank

- Owners of pre-compact water rights temporarily lease water
- Irrigators compensated to reduce irrigation use
- Saved water is available to the water bank
  - Meet compact obligations
  - Municipal, industrial, or other agricultural uses
- Minimize economic and environmental impacts
  - Short-term
  - Done on a rotational basis
  - Crop selection

Acres of Major Irrigated Crops on the West Slope



- Forage crops may be ideal for inclusion in a water banking system
  - Availability
    - Over 90% of irrigated crops
  - Primary user of water
    - Grass CU = 1,069,759 AF/yr
    - Alfalfa CU = 178,750 AF/yr
  - Tolerance to reduced irrigation

Objectives

- Purpose:
  - Assess the agronomic feasibility of withholding irrigation for one season on grass hayfields in support of a Western Slope Water Bank
  - Provide adequate information for hay producers as well as proponents of water banking to confirm if this approach is worth pursing as a method to free up water to meet compact obligations and/or other uses
- Objectives:
  - Determine the impacts of reduced irrigation to forage yield and quality and associated recovery period of grass hayfields in different regions of Western Colorado

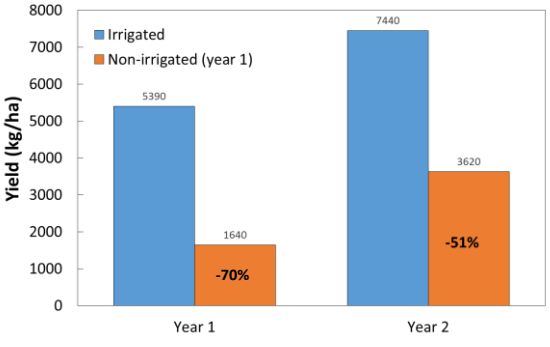
Grass Hayfields

- Hayden, CO
  - Carpenter Ranch – 6,340 ft
  - Upper Yampa
- Steamboat Lake, CO
  - Fetcher Ranch – 8,200 ft
  - Upper Yampa
- Kremmling, CO
  - Blue Valley Ranch – 7,365 ft
  - Upper Colorado
- Gunnison, CO
  - Trampe Ranch – 7,700 ft
  - Upper Gunnison
- Cimarron, CO
  - 6,900 ft
  - Gunnison
- Doyleville, CO
  - Razor Creek Ranch 7,600 ft
  - Upper Gunnison

Treatments and Measurements

- Side by side plots
- Year 1
  - Fully Irrigated (Contro
  - Not Irrigated
- Year 2
  - Both fully Irrigated
- Measurements
  - Yield
  - Quality
    - Crude protein (CP), neutral detergent fiber (NDF), and *in-vitro* true digestibility (IVTD)
  - Ground cover and species composition
  - ET, temperature, and precipitation

Grass Dry Matter Yield



Grass Forage Quality

Treatment	CP (%)	NDF (%)	IVTD (%)
Year 1			
Irrigated	7.6	54.9	73.5
Non-irrigated	10.8	51.9	75.4
Year 2			
Irrigated	8.6	58.0	74.7
Non-irrigated	8.0	53.3	74.4

Blue Valley Ranch

Fully Irrigated- Year 1

Fully Irrigated- Year 2

Non-irrigated- Year 1

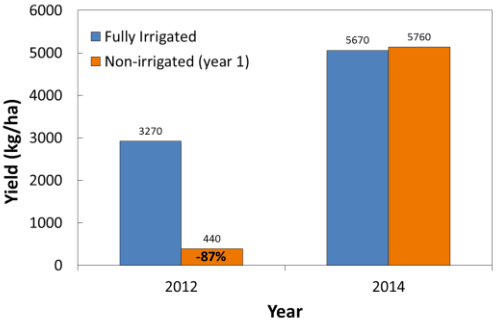
Returned to Irrigation- Year 2

	Year 1	Year 2
Treatment	--------kg/ha-------	
Fully Irrigated	7,310	8,550
Non-Irrigated (Year 1)	2,170	3,940
% Reduction	-70%	-54%

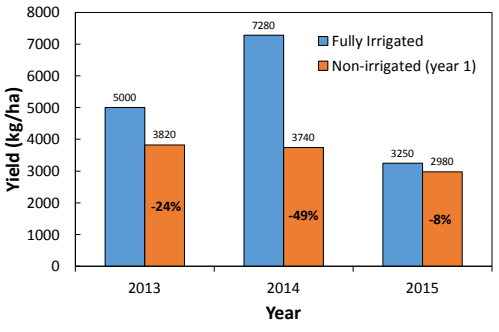
Razor Creek

- Data collected in 2012
  - Severe drought conditions resulted in producer withholding irrigation on half of the field
- Resampled in 2014 after 2 years of normal

Razor Creek Dry Matter Yield



Carpenter Ranch Dry Matter Yield



Conclusions - Grass Hayfields

- Withholding irrigation for one season on high-elevation grass hayfields:
  - Improved forage quality in year 1 (CP ↑ and NDF ↓)
  - Significantly reduced yields (average reduction of 70%)
  - Yields did not fully recover when returned to full irrigation the following season (average reduction of 50%)
  - The severity of yield reductions measured in this study may limit potential participation in a water bank program
  - Producers would need to be compensated for reduced yields the year of withholding irrigation and for at least the first recovery year
  - Based on limited data, it appears that yields will recover to near normal by the second year of full irrigation (within about 10%)