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Agricultural Research Service

Agricultural Research Service Area Organization

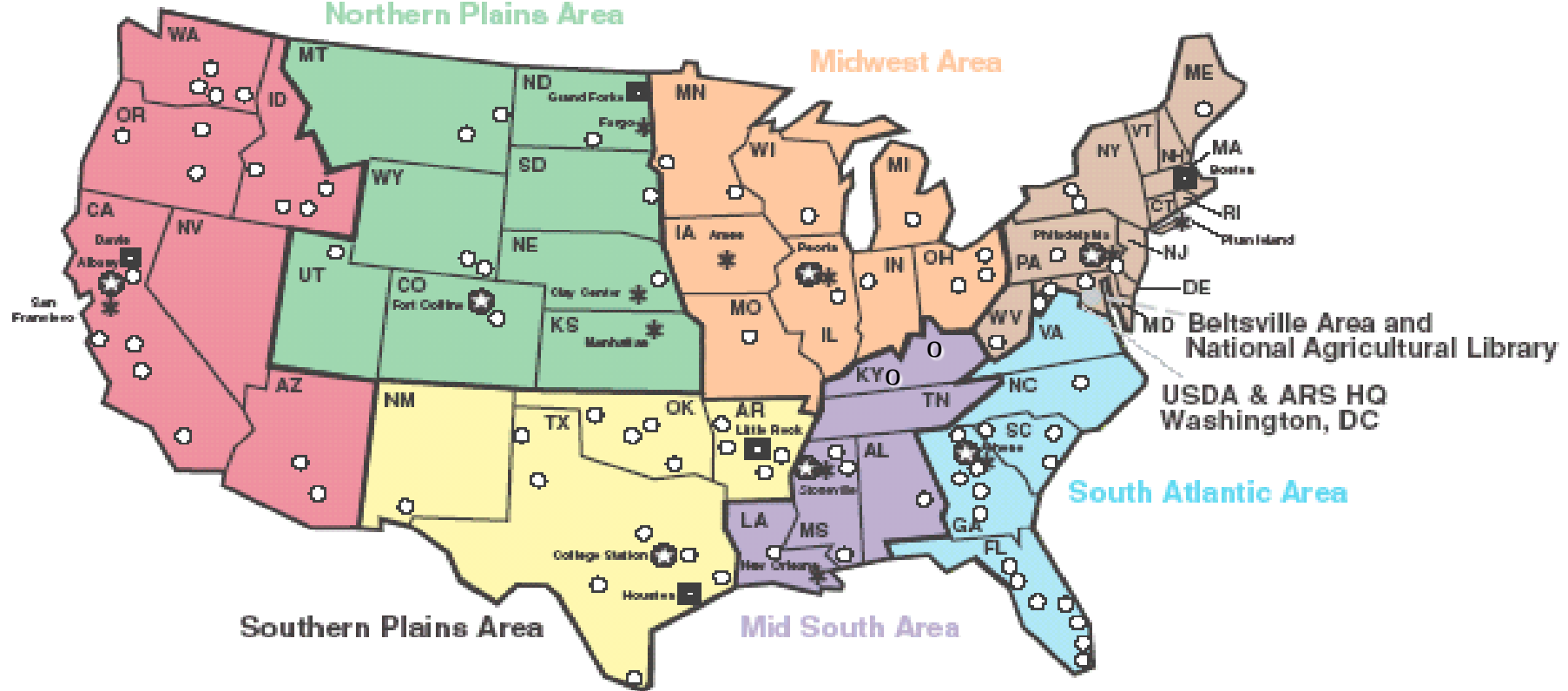
- **100 Research Locations**
- **2100 Scientists**
- **1000 Research Projects**
- **22 National Programs**

Pacific West Area

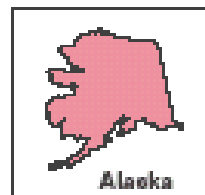
Northern Plains Area

North Atlantic Area

Midwest Area



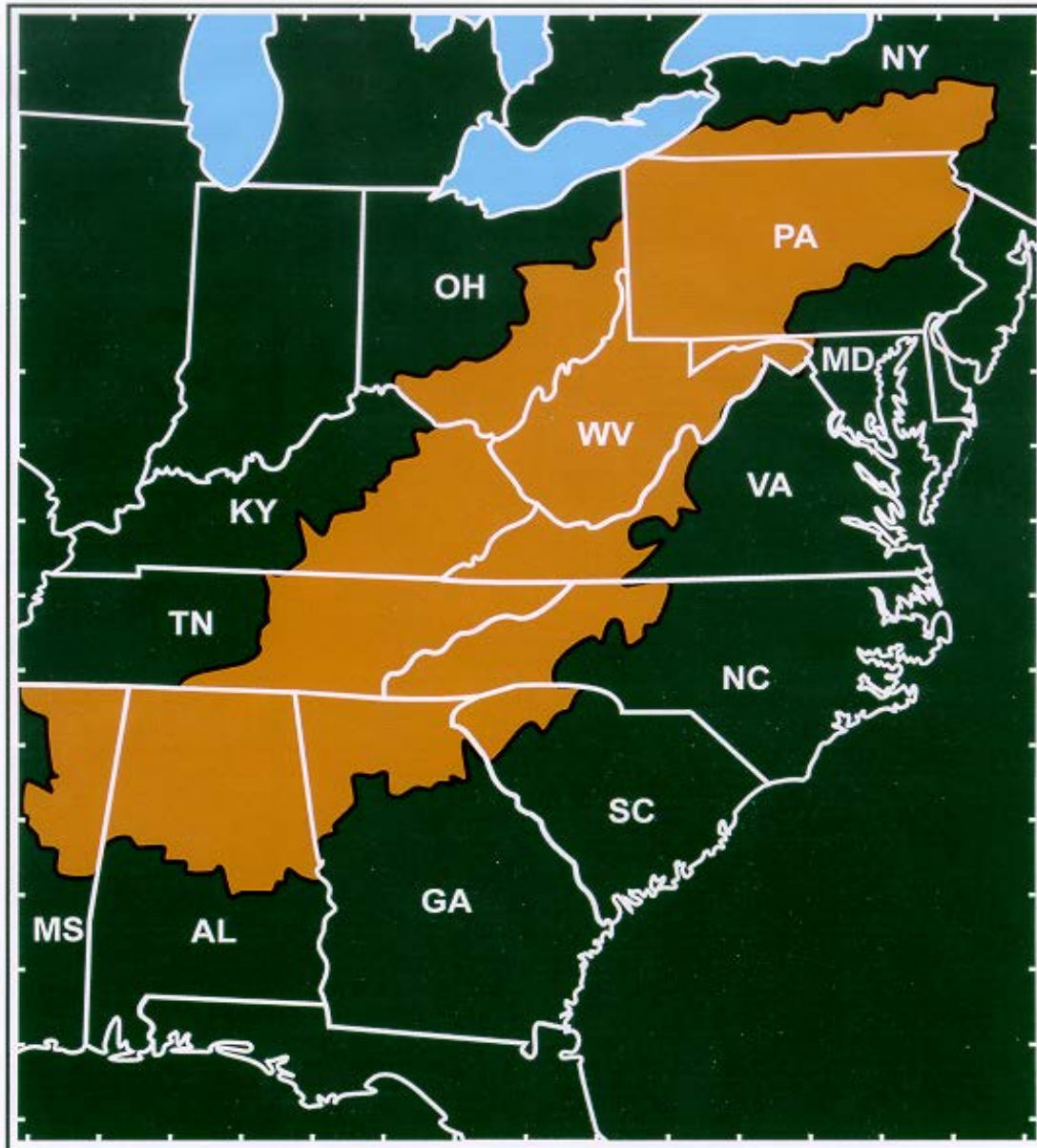
- ⊕ Area Offices
- * Research Centers
- Human Nutrition Centers
- Research Locations



**USDA
Agricultural Research Service
Appalachian Farming Systems Research Center
Beaver, WV**



Appalachian Region



Then the Grazinglands Research Laboratory... a 7000-acre laboratory







GRL's Animal Research Facilities After 2011 Tornado



Today – Animal Research Facilities



Calan Gate Barn

Scale House



Growsafe Barn (expected to be completed in 2016)

Today – Feed Mixing Facility



New Feed Mixing Facility



Agricultural History

<u>Year</u>	<u>Total U.S. Population</u>	<u>% Farmers</u>
1790	3,929,214	90
1840	17,069,453	69
1860	31,443,321	58
1890	62,941,714	43
1900	75,994,266	38
1920	105,719,620	27
1950	151,132,000	12.2
1970	204,335,000	4.6
1980	227,020,000	3.4
1990	246,081,000	2.6
2000	281,421,906	1.9
2010	310,233 000	1.6
2012	312,780,968	1
2016	324,756,892	< 1 ?

Finishing Goats and Lambs on Pasture



Meat Goat Finishing Trial 2005-2007

- Alfalfa (*Medicago sativa* L.) pasture
- Red Clover (*Trifolium pratense* L.) pasture
- Orchardgrass (*Dactylis glomerata* L.) pasture
- Three 0.5-acre strips each
- Each strip divided into 10 paddocks
- Rotational Stocking with targeted 4-d stay
- Animals dewormed every 28 d (monthly) plus FAMACHA© every 14 d.





Seasonal mean of average daily gain (ADG) when goat wethers were finished on alfalfa (ALF), red clover (RCL), or orchardgrass (OGR) pastures in 2005-2007.

Item	ALF	RCL	OGR	P level
2005				
ADG, lb/d	0.18a	0.19a	0.11b	<0.001
2006				
ADG, lb/d	0.10a	0.07a,b	0.06b	=0.05
2007				
ADG, lb/d	0.22a	0.15b	0.13b	<0.001

Turner, Cassida, and Zajac. 2013. Grass and Forage Science.

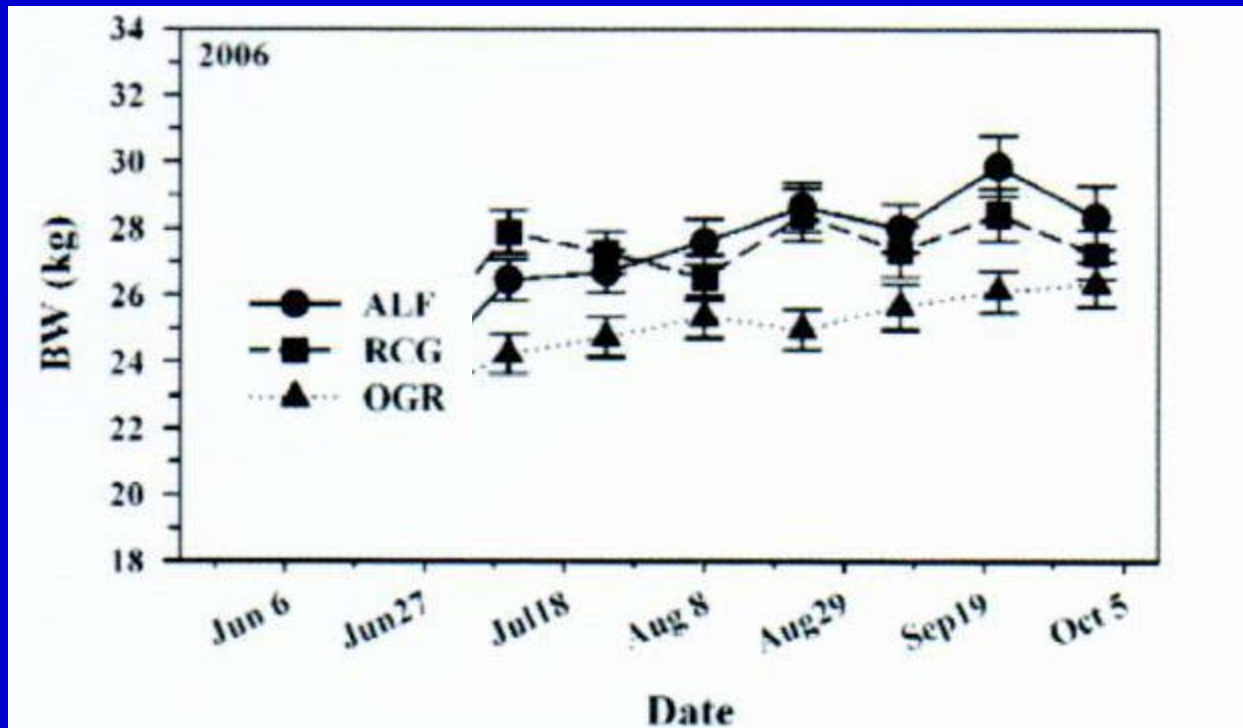


Figure 5 Cumulative BW change over the 2005–2007 grazing seasons when meat goats were finished on alfalfa (ALF), red clover + grass (RCG) and orchardgrass (OGR) pastures. Data are mean $\pm$ 1 s.e.m.

	ALF	RCG	OGR
BW, lbs	64	59	54

Goats-Alfalfa or Red Clover or Orchardgrass

Table 1 System productivity of alfalfa (ALF), red clover plus grass (RCG) and orchardgrass (OGR) pastures in 2005–2007. Data are mean $\pm$ 1 s.e.m.

Item	Year	ALF	RCG	OGR	<i>P</i> value
ADG (g d ⁻¹)	2005	82 $\pm$ 5 ^a	91 $\pm$ 4 ^a	50 $\pm$ 4 ^b	<0.001
	2006	45 $\pm$ 6 ^a	32 $\pm$ 6 ^{ab}	27 $\pm$ 3 ^b	=0.06
	2007	100 $\pm$ 6 ^a	77 $\pm$ 4 ^b	50 $\pm$ 5 ^c	<0.001
Gain per animal (kg*)	2005	10 $\pm$ 0.6 ^a	11 $\pm$ 0.5 ^a	6 $\pm$ 0.5 ^b	<0.001
	2006	5 $\pm$ 0.7 ^a	4 $\pm$ 0.7 ^{ab}	3 $\pm$ 0.4 ^b	=0.06
	2007	9 $\pm$ 0.6 ^a	7 $\pm$ 0.3 ^b	5 $\pm$ 0.5 ^c	<0.001
Gain per ha (kg†)	2005	197 $\pm$ 11.3	219 $\pm$ 10.4	202 $\pm$ 17.5	>0.10
	2006	138 $\pm$ 19.3	94 $\pm$ 18.0	128 $\pm$ 15.9	>0.10
	2007	245 $\pm$ 14.7 ^a	188 $\pm$ 9.2 ^b	179 $\pm$ 18.9 ^b	<0.01

Within rows, means without a common superscript differ at the *P* value listed. *Duration of grazing season was 121, 119 and 90 d in 2005, 2006 and 2007 respectively. †Land base was 0.2 ha for OGR in all years; 0.4 ha for ALF and RCG in 2005; and 0.3 ha for ALF and RCG in 2006 and 2007.

	ALF	RCG	OGR
ADG, lb/d	0.16	0.14	0.09

Turner, Cassida, and Zajac. 2013. Grass and Forage Science.

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Amy Radunz
The Ohio State University
Meat Sciences



Carcass data of goat wethers finished on alfalfa (ALF), red clover (RCL), or orchardgrass (OGR) pastures in 2007.

Item	ALF	RCL	OGR	P level
Final BW, lb.	63.7a	59.9a	54.8b	<0.001
Carcass Wt., lb.	29.6a	26.5b	23.7c	<0.001
Dressing %	46.4a	44.2b	43.0b	<0.001
REA, sq. in.	1.40a	1.23b	1.13b	<0.001
BF, in.	0.07a	0.06b	0.05b	<0.01
Leg Score	10.4a	10.2a	9.6b	<0.001
Lean Score	11.0a	11.3a,b	10.7b	<0.05
Conformation Score	10.7a	10.5a	10.0b	<0.01

	ALF	RCG	OGR
Carcass, lbs	31.6a	30.9a	27.1b
Dressing, %	52a	51.8a,b	50b
REA, sq. cm	7.4a	7.0a	6.5b
BackFat, mm	1.5a	1.3a,b	1.2b
Body Wall, cm	0.96a	0.90a,b	0.83b

Turner, Cassida, and Zerby. 2014. Meat Science.

Meat-*Longissimus* sample

Ash, %	4.3	4.2	4.3
IM Fat, %	1.7	1.4	1.5
Protein, %	20	20.5	20.3

Fatty Acid Profiles

DFA, mg/100g	1077	1158	1229
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Desirable FA = 18:0 + PUFA +MUFA

DFA, Omega-3, Omega-6 and ratio were similar.

Chevon is a low fat, red meat option with high DFA for human diets and health.

Meat Goat Wethers 2007

Rotational Stocking (Paddock System)

Forage TDN (%)

ALF	RCL	OGR
70.9	67.5	65.4

Forage CP (%)

ALF	OGR	RCL
23.1	17.6	17.4

Forage TDN:CP Ratio

ALF	OGR	RCL
3.1	3.7	3.9

Goat (Optimum in Diet)
TDN:CP Ratio
5.8 – 6.0

Goat kid ADG (lb/d)

ALF	RCL	OGR
0.22	0.17	0.11

BUN (mg/dl)

ALF	OGR	RCL
24	23.6	20.7

Dietary TDN:CP Ratio < 5
Wasting Forage Protein
(Beef Cattle)

Supplemental Energy Needed
Readily available carbohydrate
such as cracked Corn??
Soy Hulls?? Economics??

2007 Meat Goat Wethers

ADG (lb/d)

ALF	RCL	OGR
0.22	0.17	0.11

Forage TDN (%)

ALF	RCL	OGR
70.9	67.5	65.4

Forage CP (%)

ALF	RCL	OGR
23.1	17.4	17.6

ALF goat kids able to tolerate
spike in FEC (GI Parasites) and
still gain weight

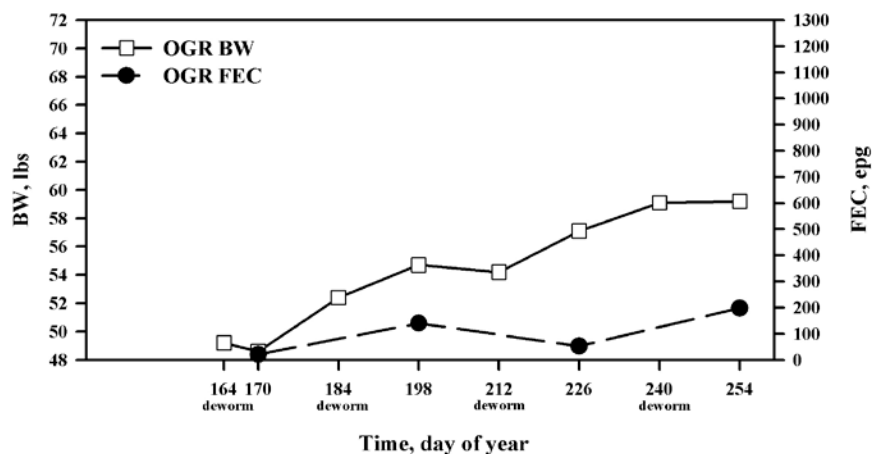
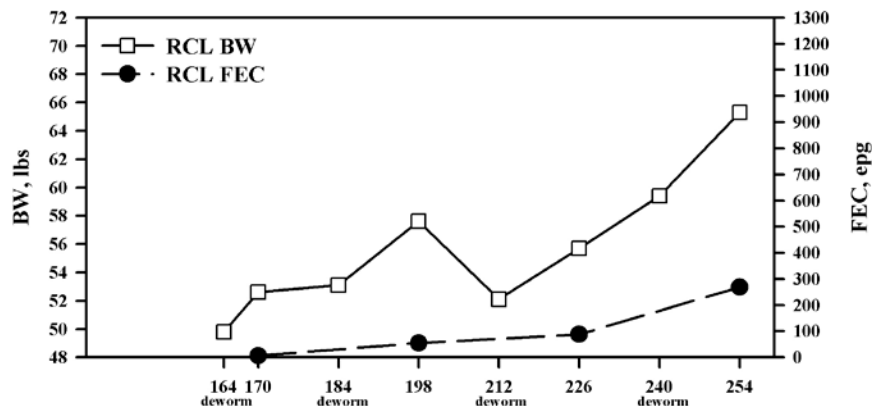
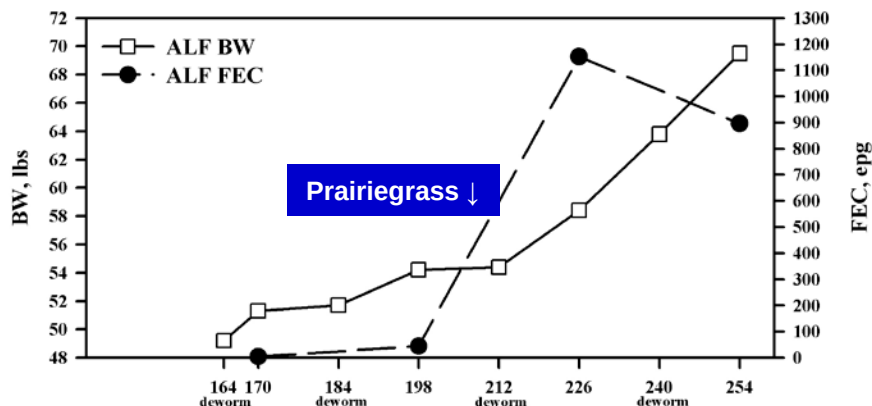
Resilience

FAMACHA® Score

ALF	RCL	OGR
1.8	1.8	1.7

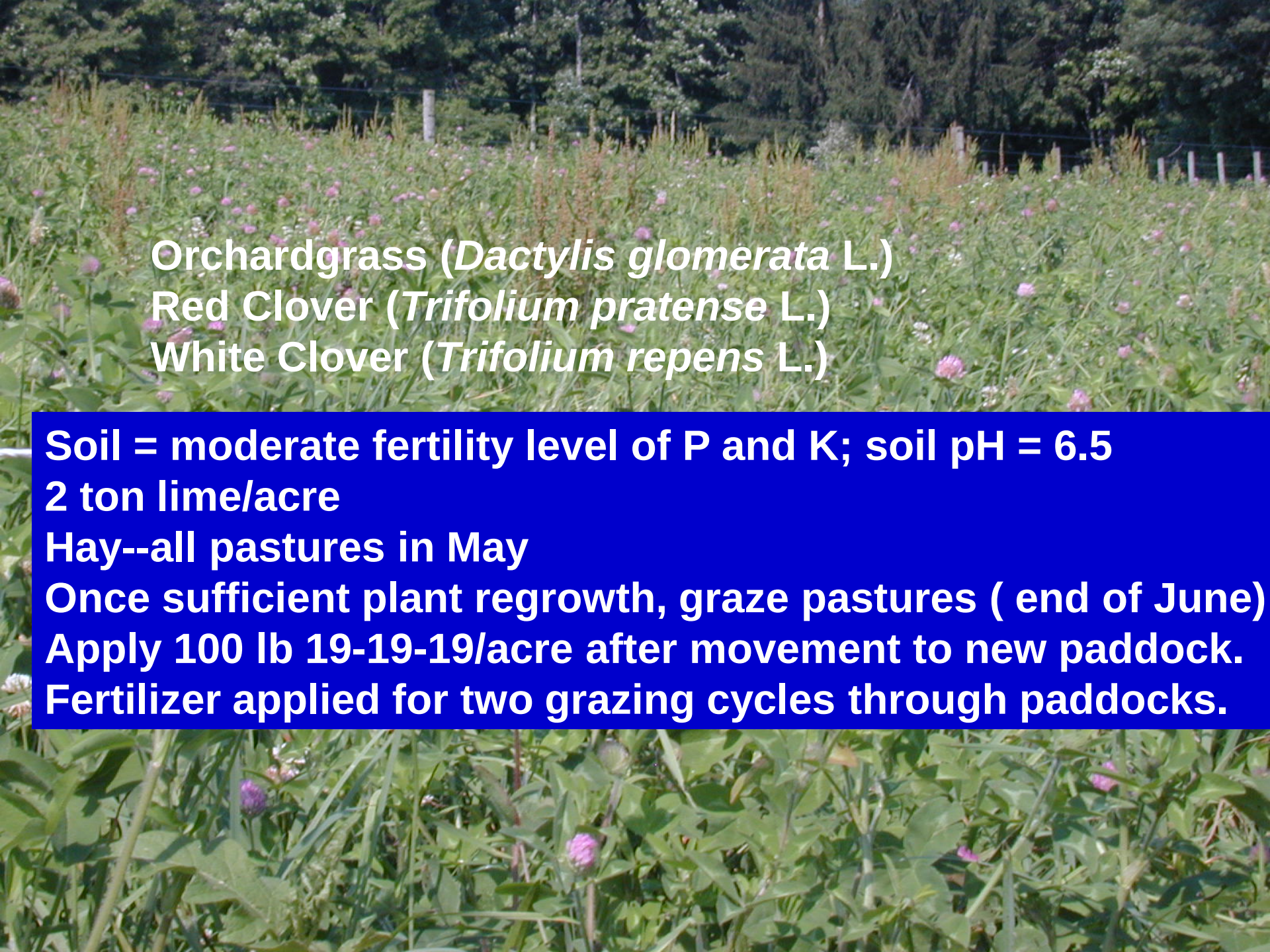
Blood PCV (%)

ALF	RCL	OGR
31.8	33.7	30.5



Sheep and Goat Finishing Study 2006-2008

- **Suffolk crossbred lambs**
- **Katahdin lambs**
- **Boer goats with Kiko influence**
- **All animals born: March 15 - 31, 2006
 March 1 - 15, 2007
 March 1 - 15, 2008**
- **Monitored weight gain, carcass parameters, meat quality**
- **All pastures were hayed before grazing**
- **Deworming based on FAMACHA© Score 3 or greater**
- **FAMACHA© and FEC every 14 d; PCV every 28 d**



Orchardgrass (*Dactylis glomerata* L.)

Red Clover (*Trifolium pratense* L.)

White Clover (*Trifolium repens* L.)

Soil = moderate fertility level of P and K; soil pH = 6.5

2 ton lime/acre

Hay--all pastures in May

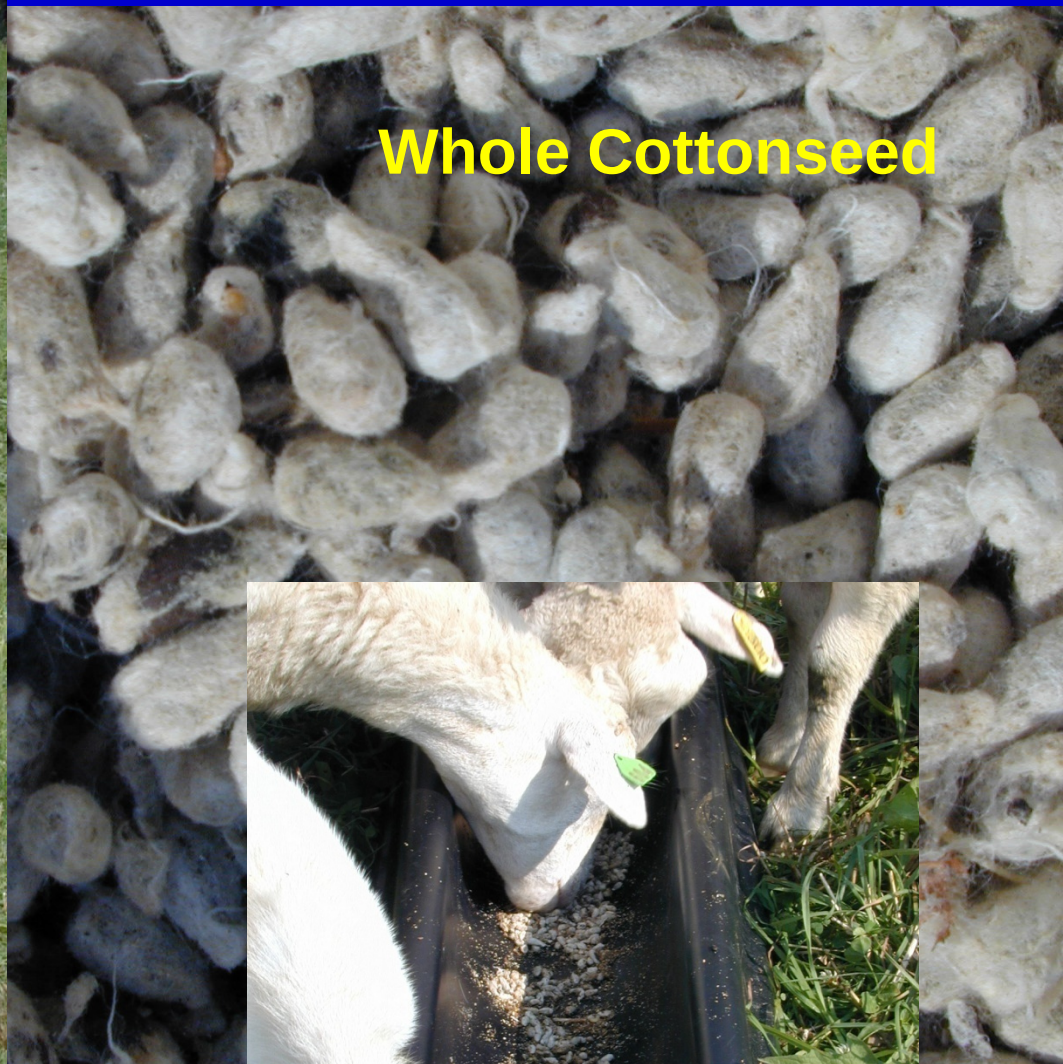
Once sufficient plant regrowth, graze pastures (end of June)

Apply 100 lb 19-19-19/acre after movement to new paddock.

Fertilizer applied for two grazing cycles through paddocks.

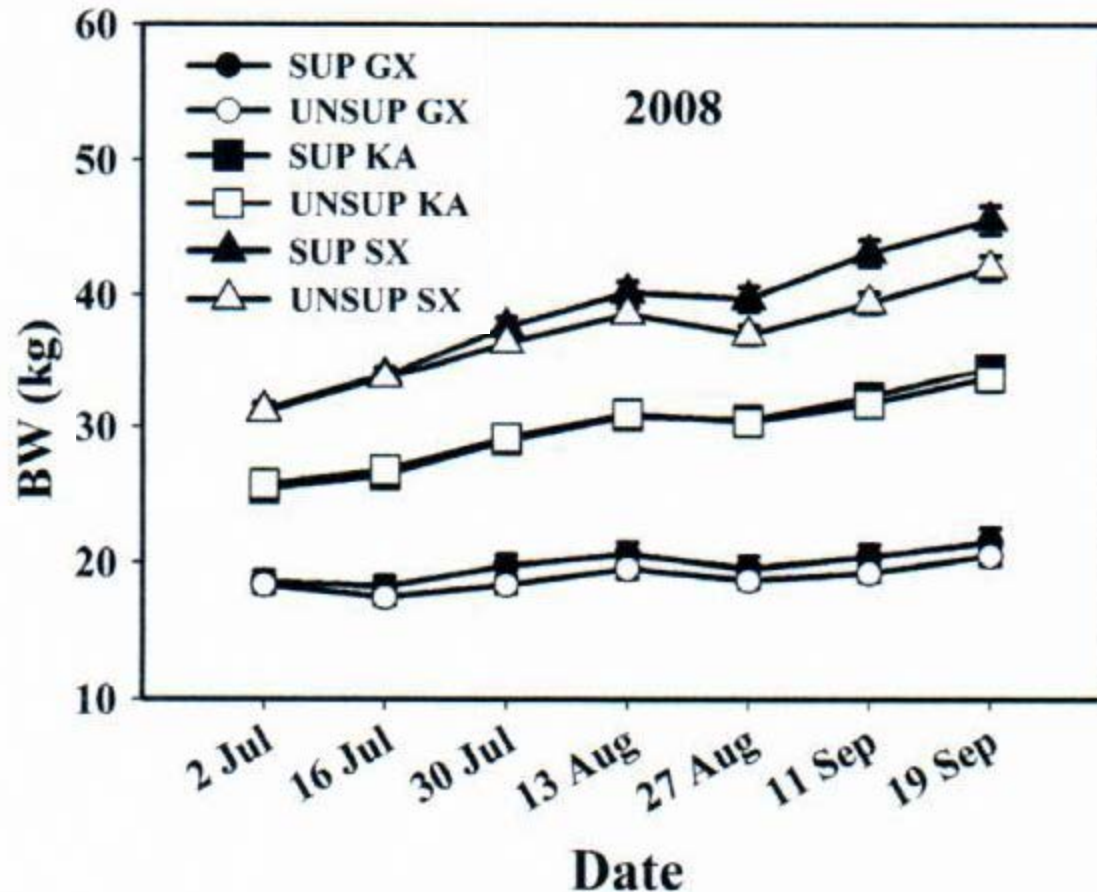


**Six grazing groups;
Each group of 18 animals (six of each breed)
managed with rotational stocking;
Graze 1.5 acres divided into three paddocks
(each 0.5-acres); 21-d period of stay;
Three groups- no supplement
Three groups-WCS supplement at 0.5%BW**



Whole Cottonseed

Turner, Belesky, Zajac, and Dowd.
2015. Grass and Forage Science.



Lamb and Kid ADG (lb/d)

	UnSupplemented			Supplemented		
<u>Year</u>	<u>SX</u>	<u>KA</u>	<u>GX</u>	<u>SX</u>	<u>KA</u>	<u>GX</u>
2006	0.39	0.29	0.11	0.45	0.35	0.15
2007	0.28	0.25	0.10	0.36	0.24	0.13
2008	0.31	0.22	0.06	0.40	0.25	0.08
Mean	0.33	0.25	0.09	0.40	0.28	0.12

SX = Suffolk Sheep Crossbred

KA = Katahdin Sheep

GX = Goat Crossbred

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Performance and carcass data of Suffolk (SX) lambs, Katahdin (KA) lambs, and goat kid (GX) wethers finished on pastures with and without whole cottonseed supplement in 2007.

	-NO SUPPLEMENT-			---SUPPLEMENT---		
Item	SX	KA	GX	SX	KA	GX
Begin BW, lbs	58.3	54.8	33.9	57.0	53.5	32.2
Final BW, lbs*	76.5	71.2	40.5	85.3	71.7	42.5
ADG, lb/d*	0.28	0.25	0.10	0.36	0.24	0.13
Carcass Wt., lbs	39.6	38.4	19.0	42.7	36.5	20.6
Dressing %	51.7	54.0	47.0	49.9	50.9	48.5
REA, sq. in.	1.92	1.72	0.97	1.97	1.70	0.99
BF, in.	0.05	0.10	0.03	0.06	0.09	0.03
Leg Score	11.4	12.3	9.8	12.0	11.9	9.7
Lean Score	12.3	12.3	10.7	12.4	12.7	10.7
Conform Score	11.3	12.1	9.8	11.9	11.8	9.7

Turner, Belesky, Cassida, and Zerby. 2014. Meat Science.

Meat, %

	SX	KA	GX
Ash	4.3b	4b	4.5a
IM Fat	2.2b	3.3a	1.8b
Protein	21.8	22.7	22.5

Fatty acids, g/100g

Omega-6	12.6a	7.7b	12.2a
Omega-3	5.7a	4.1b	4.3b
Ratio	2.3b	2.0b	3.1a
DFA	74.2	74	73.4

Desirable FA = 18:0 + PUFA + MUFA

Turner, Belesky, Cassida, and Zerby. 2014. Meat Science.

Overall

Katahdin lambs and meat-goat kids finished on pasture with and without WCS supplement produced desirable final BWs and carcass weights for most niche markets in the USA.

Suffolk lambs may be better suited for the traditional lamb markets in the USA.

Overall, FA profiles among Suffolk lambs, Katahdin lambs, and meat-goat kids were different.

WCS supplement (0.5% BW) decreased Omega-3 FA and increased Omega-6:Omega-3 ratio in lamb meat and chevon.

This ratio and PUFA:SFA ratio in lamb meat and chevon were within the guidelines for meats than can aid improvements to human diets and health.

2007 Grazing Season (Averaged over the season)

1 June – 15 Sept

	Suffolk		Katahdin		Goat	
	<u>FEC</u>	<u>ADG</u>	<u>FEC</u>	<u>ADG</u>	<u>FEC</u>	<u>ADG</u>
UnSup	955	0.28	508	0.25	627	0.10
Sup	1426	0.36	1281	0.24	702	0.13

2007 Grazing Season

(Average 1 June - 15 Sept)

- **FEC**

Unsupplemented	696 epg
Supplemented	1149 epg

- **ADG**

Unsupplemented	0.15 lb/d
Supplemented	0.21 lb/d

- **Resilience**

Supplemental Protein (and Energy) helps animals to tolerate higher levels of GI parasites and still be productive (gain weight) when grazing pasture.

Doses of Dewormer (1 June – 15 Sept)

					Mean
Tmt*	2006	2007	2008	Mean	Doses/ Animal
UnSup	75	104	79	86	1.6
Sup	61	98	73	77	1.4

* Tmt means each year not different, $P > 0.10$.

Theoretical dosing of 1 time per month = 3.5 Doses/Animal
(3.5-month study)

FAMACHA©

42% reduction in doses of dewormer administered

Doses of Dewormer (1 June – 15 Sept)

Breed	2006	2007	2008	Mean	Mean Doses/ Animal
Goat	109a	121a	71a	100	2.8
Suffolk	22b	50b	53a	42	1.2
Katahdin	5c	31c	28b	21	0.6

a,b,c Within a year, breed means differ $P < 0.001$.

BoKi goat = Boer x Kiko

Breeding for GI Parasite Resistance
(moderate to highly heritable trait in sheep)
Need more focus on Goats

Meat Goat Finishing Study 2009-2011

- **Red Clover (RCL) pasture (Polyphenol oxidase)**
- **Birdsfoot Trefoil (BFT) pasture (Condensed tannins)**
- **Chicory (CHIC) pasture (Sesquiterpene lactones)**
- **Three 0.5-acre strips of each pasture**
- **Each strip divided into 10 paddocks**
- **Rotational Stocking with targeted 4-d stay**
- **Deworming based on FAMACHA© Score 3 or greater**
- **FAMACHA© and FEC every 14 d; PCV every 28 d**
- **Monitor weight gain, carcass parameters, and meat quality**



Meat Goat Performance 2009 and 2010

Year	Item	RCL	BFT	CHIC	P level
2009	Start BW, lb	50.3	50.0	49.7	NS
	End BW, lb	67.5a	65.9a	60.6b	<0.02
	ADG, lb/d	0.14a	0.13a,b	0.08b	<0.06
2010	Start BW, lb	49.9	49.8	49.8	NS
	End BW, lb	70.8a	67.3a,b	62.7b	<0.03
	ADG, lb/d	0.18a	0.15a	0.11b	<0.01

a,b Means in the same row without a common letter are different at the P level listed.

NS = Not Significant; Means are not different; P level > 0.10.

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BioGraze 2009

Carcass

Item	RCL	BFT	CHIC	<i>P</i> level
Final BWt, lb	67.5a	65.9a	60.6b	< 0.02
Shrunk BWt, lb	63.3a	62.1a	56.3b	= 0.08
Carcass Wt., lb	34.0	32.4	30.6	NS
Dressing %	53.0a	51.9b	54.2a	= 0.08
REA, sq. in.	1.5	1.4	1.3	NS
REA to CWt Ratio	4.4	4.5	4.5	NS
BFat, in.	0.04	0.03	0.02	NS
IP Fat Score	3.2	2.7	2.5	NS
Leg Score	10.9	10.4	10.1	NS
Lean Score	9.9	10.7	10.8	= 0.09
Conform Score	10.7	10.4	10.1	NS

Turner, Cassida, Zerby, and Brown. 2015. Meat Science.

Table 3

Ash, crude protein (CP), and intramuscular fat (IMF) concentrations in *Longissimus* muscle samples collected from carcasses when meat-goat kids were finished on red clover (RCL), birdsfoot trefoil (BFT), or chicory (CHIC) pastures during the 2009 and 2010 growing seasons. Data are least square means $\pm$ standard error of the mean (SEM).

Item	RCL	BFT	CHIC	SEM	<i>P</i> level [†]
Ash, %	4.6	4.6	4.6	0.1	NS
CP, %	22.3 ^b	23.0 ^{a,b}	25.6 ^a	1.0	= 0.10
IMF, %	0.7	1.0	0.8	0.3	NS

^{a,b} Means within a row with unlike letters differ at the *P* level listed.

[†] Not significant, NS, *P* > 0.10.

Turner, Cassida, Zerby, and Brown. 2015. Meat Science.

Summary

SFAs	43.75	44.98	44.03	1.34	NS
MUFAs	41.51	40.17	38.40	1.81	NS
PUFAs	14.20 ^b	13.80 ^b	16.69 ^a	0.85	<0.10
Omega-6	10.68 ^{a,b}	9.81 ^b	12.12 ^a	0.68	<0.10
Omega-3	3.52 ^b	3.99 ^{a,b}	4.57 ^a	0.27	<0.10
DFAs	71.08	69.75	70.68	0.95	NS

Ratio

Omega-6:Omega-3	3.08	2.78	3.04	0.15	NS
PUFA:SFA	0.33 ^{a,b}	0.31 ^b	0.39 ^a	0.02	<0.10
MUFA:PUFA	3.18	3.24	2.61	0.27	NS

^{a,b} Means within a row with unlike letters differ at *P* value listed.

* Saturated fatty acids, SFAs; monounsaturated fatty acids, MUFAs; polyunsaturated fatty acids, PUFAs; omega-6 fatty acids, omega-6; omega-3 fatty acids, omega-3; desirable fatty acids, DFAs.

† Not significant, NS, *P* > 0.10.

Turner, Cassida, Zerby, and Brown. 2015. Meat Science.

Overall

Final BW and carcass weights RCL > BFT > CHIC.

When adjusted for carcass weights, carcass parameters were similar.

Meat samples

CP higher in CHIC vs RCL.

Omega-6 to Omega-3 ratio and Desirable FA were similar.

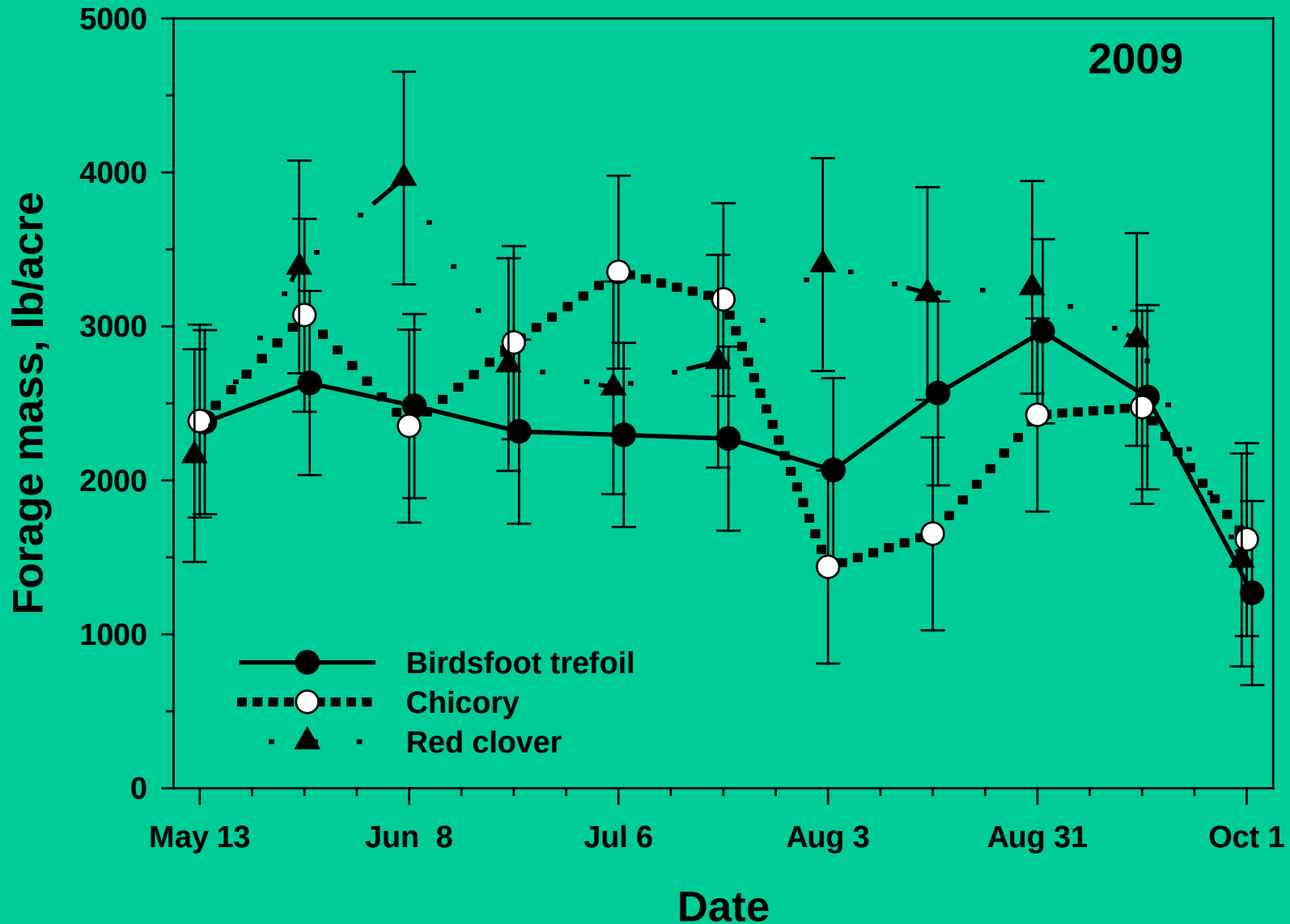
Meat Goat Performance 2009 and 2010

Year	Item	RCL	BFT	CHIC	P level
2009	Start BW, lb	50.3	50.0	49.7	NS
	End BW, lb	67.5a	65.9a	60.6b	<0.02
	ADG, lb/d	0.14a	0.13a,b	0.08b	<0.06
2010	Start BW, lb	49.9	49.8	49.8	NS
	End BW, lb	70.8a	67.3a,b	62.7b	<0.03
	ADG, lb/d	0.18a	0.15a	0.11b	<0.01

a,b Means in the same row without a common letter are different at the P level listed.

NS = Not Significant; Means are not different; P level > 0.10.

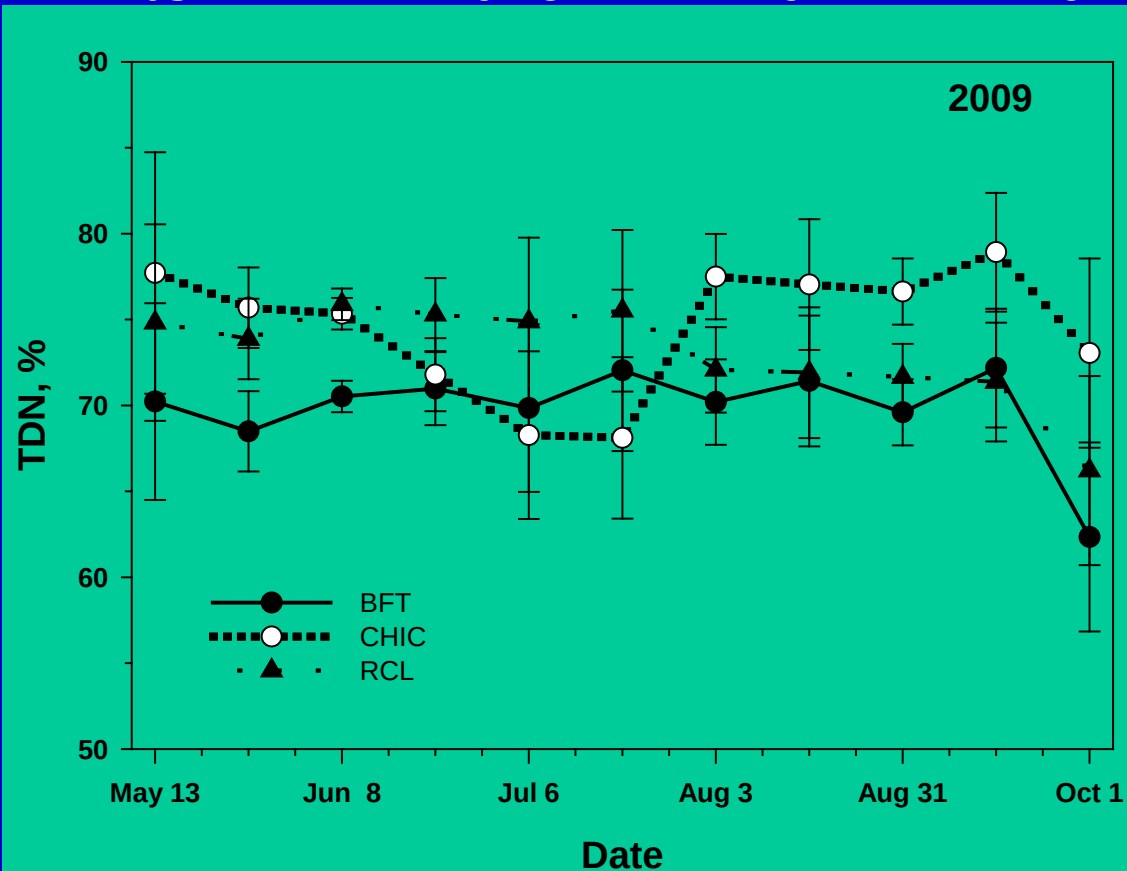
Forage mass in grazed pastures during the 2009 grazing season.



Energy and Protein Requirements

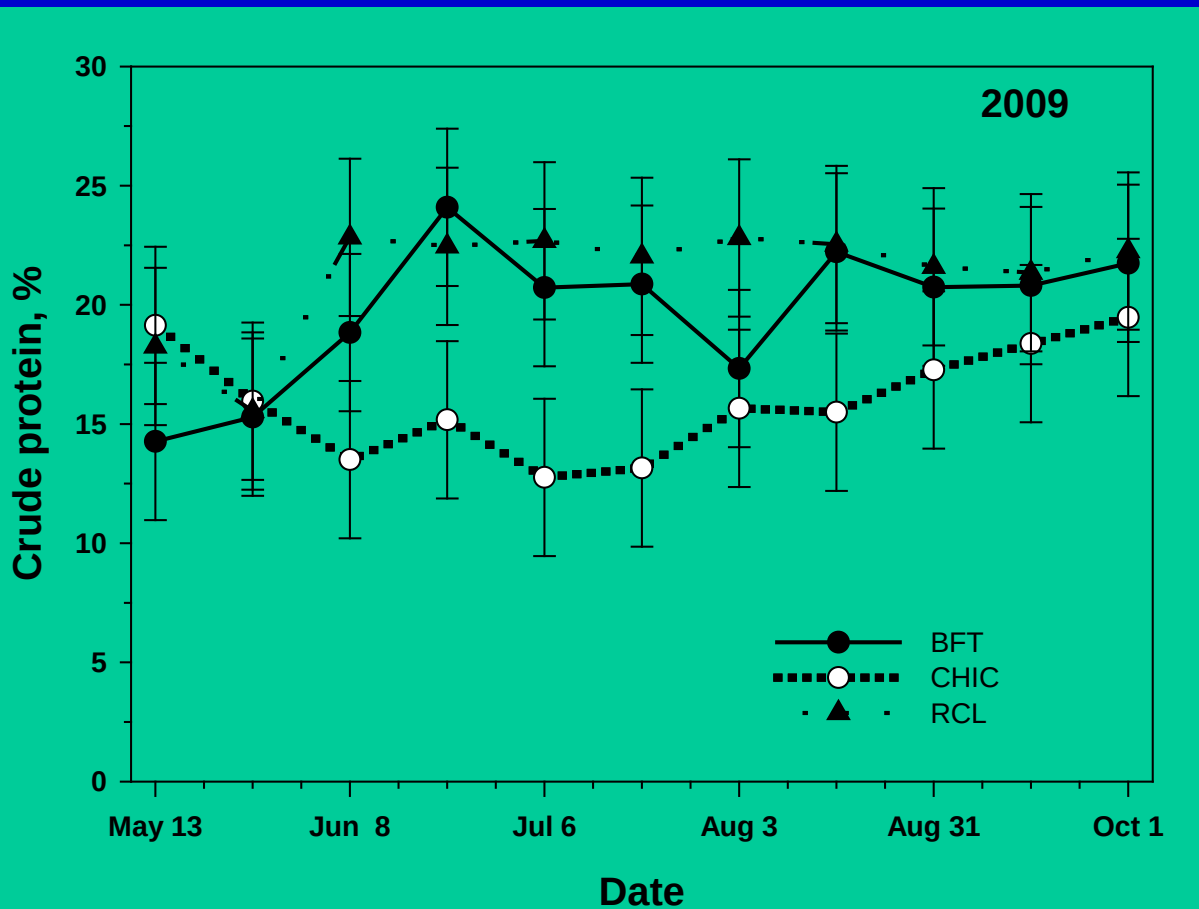
Meat Kids, Finishing (NRC, 2007)

<u>Body Weight</u>	<u>Gain, lb/d</u>	<u>TDN,%</u>	<u>CP,%</u>
44 lbs	0.22	68	15.3
44 lbs	0.45	89	23
77 lbs	0.22	48	10
77 lbs	0.45	67	16



Energy and Protein Requirements Meat Kids, Finishing (NRC, 2007)

Body Weight	Gain, lb/d	TDN,%	CP,%
44 lbs	0.22	68	15.3
44 lbs	0.45	89	23
77 lbs	0.22	48	10
77 lbs	0.45	67	16



Remote Sensing for Forage Nutritive Value

- Sensor development
- Generalized equation development
- Timing of protein supplementation
- Estimate forage intake
- Screening alfalfa collection



Grazinglands Research Laboratory-El Reno-OK

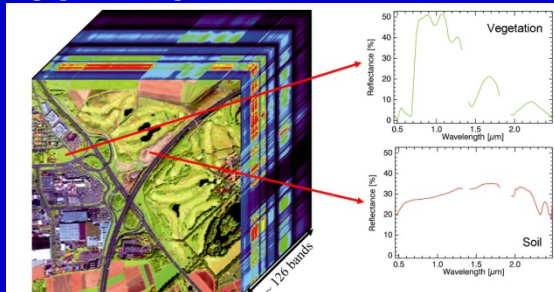
Grazinglands Research Laboratory-El Reno-OK

UAV-Remote Sensing (2016+)



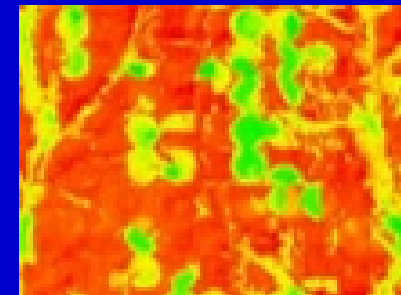
- Plant water use
- Forage quality
- Grazing patterns
- Animal management
- Pasture management
- Vegetation characterization

Image cube from a
Hyperspectral Camera



+ Thermal Camera + **LIDAR** = Plant water-use Map

Light **D**etection **A**nd **R**anging
Or
Light **I**maging, **D**etection, **A**nd **R**anging



Meat Goat FEC, PCV, and FAMACHA 2009 and 2010

Year	Item	RCL	BFT	CHIC	P level
2009	FEC, epg	1267b	1906b	2247a	<0.04
	PCV, %	30.6	28.4	27.1	NS
	FAMACHA [©]	2.6	2.8	2.9	NS
2010	FEC, epg	903	1177	2165	NS
	PCV, %	30.0a	27.3b	27.7b	<0.01
	FAMACHA [©]	2.9b	3.0a	3.0a	<0.05

a,b Means in the same row without a common letter are different at the P level listed.

NS = Not Significant; Means are not different; P level > 0.10.

Goat BioGraze 2009-2010

Year	Item	RCL	BFT	CHIC	<i>P</i> level
2009	Start BWt	50.3	50	49.7	NS
	End BWt	67.5a	65.9a	60.6b	<0.02
	ADG	0.14a	0.13a,b	0.08b	<0.06
	FAMACHA	2.6	2.8	2.9	NS
	PCV, %	30.6	28.4	27.1	NS
	FEC	1267b	1906b	2247a	<0.04
	Total Dosing Events of Dewormer	156	179	183	NS
2010	Start BWt	49.9	49.8	49.8	NS
	End BWt	70.8a	67.3a,b	62.7b	<0.03
	ADG	0.18a	0.15a	0.11b	<0.01
	FAMACHA	2.9b	3.1a	3.0a	<0.05
	PCV, %	30.0a	27.3b	27.7b	<0.01
	FEC	903	1177	2165	NS
	Total Dosing Events of Dewormer	154	161	162	NS

SPECIAL THANKS

USDA, ARS, AFSRC

Personnel

- John Snuffer
- Jeff Ellison
- Ken Harless
- Brody Meadows
- Carol McClung
- Dr. Kim Cassida (now MI State Univ.)
- Eddie Lester
- Sean Green
- Dr. David Belesky (now WVU)
- Joyce Ruckle
- Matt Huffman
- Mark Peele

VA-MD Regional Veterinary College, VA Tech

- Dr. Anne Zajac
- Parasitology Lab Staff and Students

West Virginia University

- Jim Pritchard
- Dr. Paul Lewis (now Retired)
- WV Small Ruminants Management Project

84 Packing Company

- Sandy Gregg
- Gary Gregg

Ohio State University

- Dr. Henry Zerby
- Amy Radunz
- Jill Gevin
- Megan Bishop

THANK YOU

