UNDERSTANDING GROWTH DYNAMICS OF RANGELAND SPECIES UNDER UNLIMITED WATER AND RAINFED CONDITIONS

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ABSTRACT
This experiment was conducted to determine the maximum potential yield of native plant species when maintained in an unlimited water and natural rainfed environments to support the PHYGROW forage production model. Samples of the dominant rangeland plant species found in Central Texas were collected eight times during a 365 day period in 1995-96. Weight per unit basal area, and canopy area increased significantly throughout the growing season in bunchgrasses and sod/rhizomatous grasses, respectively, in water unlimited plots. Individual plant weight of forbs increased with irrigation, although it was only significant for the legume, Texas Bluebonnet. Woody plants exhibited little response to supplemental irrigation. All species exhibited unique patterns of growth depending on plant architecture and successional status.

KEYWORDS
Growth, modeling, rangeland, evapotransitation, forage production

INTRODUCTION
The emergence of spatially referenced multiple species plant growth models such as PHYGROW (Ranching Systems Group 1995), has driven the need to develop information on maximum potential yield of major forage species in a region (Stuth 1996). Generally, these data are derived through extrapolation from prior research or estimates from knowledgeable experts. Subsequently resource managers and planners would benefit if potential forage yields could be determined for individual plant species within natural communities, where moisture is unlimited, and under rainfed conditions. This research seeks to establish plant growth dynamics from easily measured attributes of species common to much of Central Texas.

METHODS
The experiment was conducted in 1995 and 1996 at Brownwood, Texas (31° 43'N, 98° 59'W, 437 m elevation) on a Speck-Tarrant soil association (Lithic Argiustolls and thermic Lithic Calciustolls, respectively). There were six plots randomly assigned one of two treatments (three supplemental irrigation, three natural rainfall). To insure water was not limiting the three irrigated plots had supplemental water added using a portable pump and sprinkler system to maintain daily soil moisture above -1.0 bars. Plants sampled were placed in one of four categories; bunchgrass, sod or rhizomatous grass, annual forb, and woody. The selected species were sampled on eight dates corresponding to major annual production stages throughout the year. Seven randomly selected plants were collected in each of the three replications of the two moisture regimes. Plant material was oven dried at 60°C for 72 hours after clipping and weighed to determine weight on a dry matter basis.

Bunchgrasses were sampled by clipping the entire plant at ground level, and measuring basal diameter to determine weight per basal diameter. These species included; sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.), silver bluestem (*Bothriochloa saccharoides* (Sw.)), Texas wintergrass (*Stipa leucotricha* Trin. & Rupr.), purple threeawn (*Artistida purpurea* Nutt.), Texas cupgrass (*Eriochloa sericea* (Scheele) Munro.), Texas grama (*Bouteloua rigidiseta* (Steud.) A.S. Hitchc.). Sodgrasses and grasses originating from rhizomes were clipped in a 10cm x 10cm quadrant to determine weight per unit area. Grasses sampled in this method included; curly mesquite (*Halaria belangeri* (Steud.) Nash), vine-mesquite (*Panicum obtusum* Kunth in H.B.K.), and buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.). Dominant forbs were identified and collected individually during their annual growth cycle to determine weight per individual plant. These include; bluebonnets (*Lupinus texensis* Hook), Texas star (*Lindheimera texana* Gray & Engelm.), and Indian blanket (*Gaillardia pulchella* Foug.). Woody species total dimensions was determined using the conic frustrum dimensional model. A representative branch was clipped as a reference unit to count the number of reference units present within the plants canopy. Current year's growth was then removed from the reference unit to determine weight per volume. Woody species included; liveoak (*Quercus virginiana* Mill), cedar elm (*Ulmus crassifolia* Nutt.), elbow bush (*Foresteria pubescens* Nutt.), and skunkbush (*Rhus aromatica* Ait.).

Soil moisture was measured at two depths (18cm, 45cm) by two methods, gravimetrically on each of the eight sampling dates and weekly using electrical resistance gypsum blocks. Rainfall for the study area was monitored using conventional rain gauges. Additional weather information was received from the National Weather Service reporting station located 0.8km from the study site.

RESULTS
The results of this research demonstrates that available soil moisture is an important factor in forage production. Plants in the unlimited water plots had a higher maximum production level (standing crop) than those receiving natural rainfall. This was the case even with rainfall being above average for all months except; June 95, October 95, December 95, January 96, and February 96, (only one during peak production).

Table 1 provides the accumulated yield of all species for the 365 day period. All perennial grasses had significantly higher maximum production in unlimited water plots compared to rainfed only plants. The cool season grass, Texas wintergrass was less repressed in rainfed situation than other bunchgrasses. One of the major species, sideoats grama, was very sensitive to rainfall. The annual forb, Indian blanket, was rainfall insensitive once established, while the other forbs were more sensitive to rainfall, espesially bluebonnet. Bluebonnets were present and growing within unlimited water plots on all collection dates (mature plants seeded and disappeared in June 95, with new seedlings emerging in July 95). Crown volume weight of woody species did not exhibit strong response to supplemental water. Elbow bush had higher maximum herbaceous production in supplemental watered plots given their shallow root system, while cedar elm, liveoak, and skunkbush had higher maximum production in natural rainfed indicating deep root systems.

Change in standing crop reflects the net change in growth, senescence, and turnover. Table 2 provides seasonal changes in standing crop per unit area for all major species by successional response to grazing. Differences in architecture of several species resulted in large variation in response per unit of plant dimension. For instance, the increaser, silver bluestem has a very narrow base with large stems and tillers. However, sideoats grama, a decreaser had larger basal diameters relative to above ground biomass. These data provide the foundation to construct maximum potential yield of plant

communities by understanding basal area of grasses, canopy cover of sod grasses, forb plant density, and crown volume per area.

REFERENCES

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Table 1
Accumulated annual production of major species growing in rainfed and irrigated conditions, 1995 - 96

Species	Rainfed		Rainfed & Irrigation		Rainfed % of maximum yield
	Mean	SEMe	Mean	SEMe	
*BUNCHGRASSES					
silver bluestem	2.48	0.16	4.67	0.25	53.1
Texas cupgrass	1.87	0.08	3.16	0.19	59.2
purple threeawn	1.40	0.04	2.40	0.46	58.3
Texas wintergrass	1.49	0.16	2.01	0.24	74.1
Texas grama	0.78	0.09	1.76	0.03	44.3
sideoats grama	0.59	0.07	1.58	0.05	37.3
*SODGRASSES					
vinemesquite	0.36	0.03	1.03	0.02	35.0
curly mesquite	0.25	0.03	0.49	0.10	51.0
buffalograss	0.13	0.00	——	——	NA
**ANNUAL FORBS					
bluebonnet	5.46	0.14	19.46	0.56	28.1
indian blanket	3.03	0.06	3.35	0.52	90.4
Texas star	0.43	0.09	0.72	0.22	59.7
***WOODY					
liveoak	1074.6	59.5	880.2	76.0	>100
cedar elm	609.0	143.0	462.4	79.4	>100
elbow bush	325.7	67.6	404.0	123	80.6
skunkbush	611.0	129.0	217.5	15.8	>100

*g/cm^2
**g/individual
***g/m^3

Table 2
Means for maximum potiential standing crop of plants growing under water unlimited conditions, 1995 - 96

Species	Grazing response	wt/ unit							
*BUNCHGRASSES	(DATES)	3/24	5/13	6/23	8/11	10/09	11/10	12/21	02/17
sideoats grama	Dec	1.61	1.15	1.11	1.64	1.81	1.80	1.39	1.54
silver bluestem	Inc	2.99	3.30	3.16	5.17	7.55	7.85	6.50	5.25
purple threeawn	Inc	3.63	4.14	2.31	2.57	3.10	2.54	2.73	2.75
Texas cupgrass	Dec	2.33	1.96	2.17	2.45	3.79	4.45	3.72	3.09
Texas grama	Inv	1.02	1.23	.92	1.34	1.88	1.85	1.46	1.58
Texas wintergrass	Inc	1.17	1.88	1.08	1.05	.96	1.50	1.59	1.49
*SODGRASSES									
curly mesquite	Inc	.46	.25	.30	.50	.47	.54	.49	59
vinemesquite	Dec	.72	.42	.70	.93	1.13	1.06	1.00	1.10
**ANNUAL FORBS	(DATES)	3/24	4/15	5/13	8/11	10/9	11/10	12/21	2/17
bluebonnets	——	1.87	3.67	11.08	0.55	4.14	5.34	2.0\[1]	6.13
Indian blanket	——	.29	2.10	3.16	——	——	——	——	——
Texas star	——	.10	.25	.72	——	——	——	——	——
***WOODYS	(DATES)	3/24	4/15	5/13	6/23	8/11	10/9	11/10	12/21
elbow bush	Inc	130.8	257.1	396.9	359.9	359.9	236.0	10.2	0.00
cedar elm	Inc	173.8	308.5	461.7	410.8	410.8	344.1	109.7	0.00
liveoak	Inc	19.7	281.6	242.7	786.5	786.5	753.8	682.1	530.5
skunkbush	Inc	38.6	103.7	214.3	195.4	195.4	89.8	0.00	0.00

Inc = Increaser, Dec = Decreaser, Inv = Invader

*g/ cm^2
**g/ individual plant (only collected during growth cycle)
***g/m^3

\[1] N Heavy wildlife use