Effects of Grazing on Grass

C. A. Matney, Ph.D.
School of Natural Resources and Extension
University of Alaska Fairbanks

What is Grazing?

- Consumption of herbaceous vegetation by herbivores
  - Non-woody plants
  - Forbs
  - Sedges
  - Rushes
  - Grasses
- Browsing = consumption of woody plants
  - Trees
  - Shrubs
- Cattle are predominately grazers

How well do you know grasses?

- Monocotyledons
- Herbaceous parallel veined plant with hollow stems and nodes….

So, What Happens to Grasses When Grazed?

- This is a long answer….
- In order to answer this question, we need to know:
- How grasses work
  - Plant parts and some physiology
  - Annual patterns of growth
- Then we can have an idea of what may happen with grazing

Annual Grasses

Fast growing

Mine resources

Seeds

Perennial Grasses

Slower growing

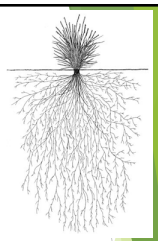
Conserve resources

Roots and Propagules

Perennial Grass Roots

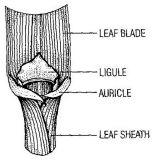
Rhizomes

Stolons

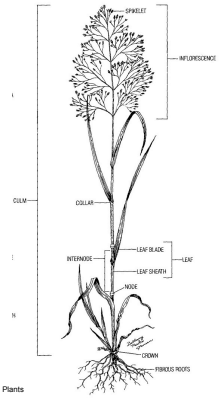


Bunchgrass

Grass Plant Characteristics



ENLARGEMENT OF THE JUNCTION OF THE BLADE AND SHEATH WITH ASSOCIATED PARTS



Stubbendieck et al. 1992. North American Range Plants

Grass Characteristics

Infloresence aka Seed Head

Wind Pollinated

Grass Characteristics

Stem ~ Culm

Leaf Collar

Leaf Sheath

Leaf

Grass Characteristics

Node

Grass Plant Characteristics -Shoot Development

- **Phytomer:** basic unit of shoot growth in grass
  - Leaf blade
  - Leaf sheath
  - Internode
  - Auxiliary bud
  - Intercalary meristem
  - Node

Grass Plant Characteristics -Phytomer Organization

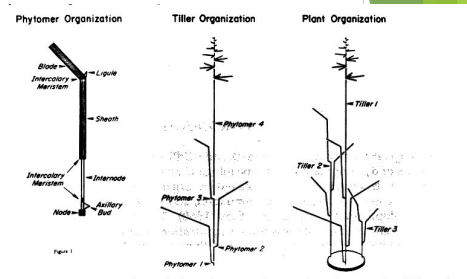
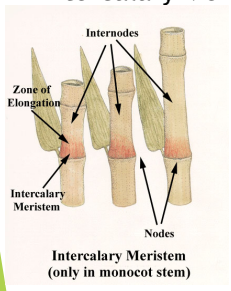


Figure 4.1. The developmental morphology of grasses originates from the successive differentiation of phytomers from the apical meristem of individual tillers. Individual plants are composed of an assemblage of tillers originating from axillary buds of previous tiller generations (adapted from Etter 1951).

Grass Plant Characteristics -Intercalary Meristems



Intercalary meristem is meristem at the base of the internode in monocot stems (particularly grass stems). If the tip of the stem is removed, the uppermost intact intercalary meristem becomes the apical meristem and starts intercalary growth.

http://www.puc.edu/Faculty/Gilbert_Muth/botglosi.htm

Grass Plant Characteristics -Crown

- 2. Crown
  - Stem tissue comprised of compressed nodes and internodes
  - Located at the base of the plant, just above the roots
  - Lower portion of the crown gives rise to the roots, the upper to the stems
  - Buds give rise to tillers

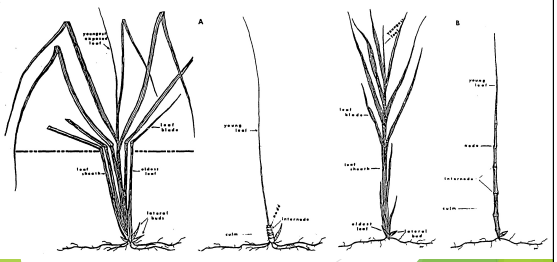
Grass Plant Characteristics -Tillering depends on

- Resource availability
  - Moisture
  - Temperature
  - Nutrients
  - Plant Age
  - Root Biomass
- Red:far-red radiation ratio (shaded or not)
- Rate of tillering has an effect on the response to defoliation

Apical or Terminal Bud Location

Arrangement of Leaves

Figure 5. Vegetative shoots of (A) sea oats producing primarily short shoots and (B) bitter panicum producing primarily long shoots.

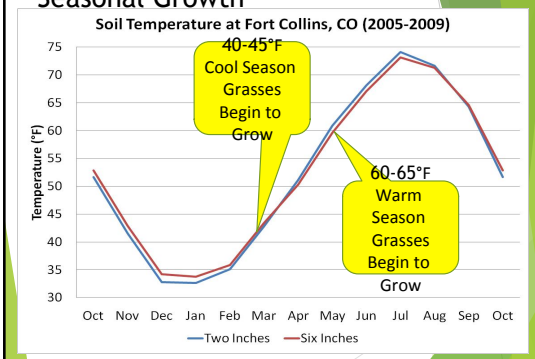


For More Information
Grass Plant Morphology

Developmental Morphology and Physiology of Grasses

- Chapter 4
- In Grazing Management, an Ecological Perspective
- D.D. Briske
- http://cnrit.tamu.edu/rlem/textbook/textbook-fr.html

Seasonal Growth



- Cool Season vs. Warm Season

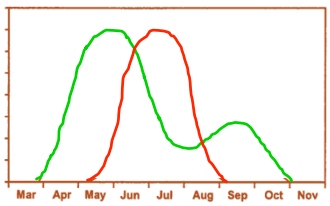
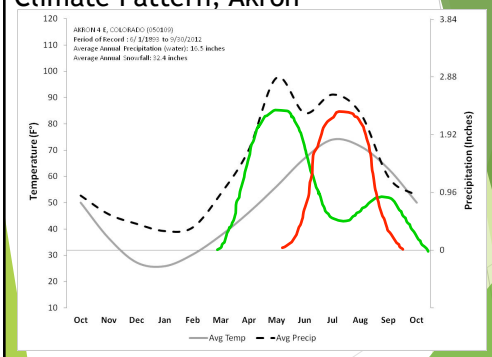
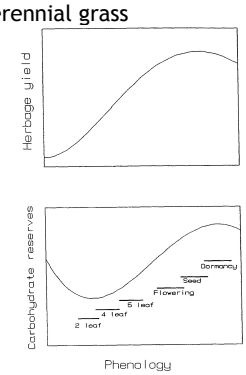


Figure 1. Seasonal growth distribution of cool- and warm-season grasses.

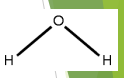
Climate Pattern, Akron



Annual growth curve and carb cycle for a cool season perennial grass



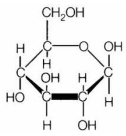
Plant Physiology



- Plants make their own food
  - Utilize photons from the sun
  - Take in CO_2 from the atmosphere
- Plants uptake water and minerals from the soil as building blocks (not food)
- Minerals/Nutrients
  - Nitrogen[1] (N), Phosphorus[1] (P), Potassium[1] (K), Calcium[2] (Ca), Sulfur[2] (S), Magnesium[2] (Mg), Silicon (Si), Boron (B), Chlorine (Cl), Manganese (Mn), Iron (Fe), Zinc (Zn), Copper (Cu), Molybdenum (Mo), Nickel (Ni), Selenium (Se), and Sodium (Na)

Plant Physiology

- Plants make their own food
  - Sugars, starches, and fat
  - Using nutrients/minerals from the soil they synthesize proteins, vitamins, and other important biological compounds



Sugar

Plant Physiology

- Important Physiological Processes that occur in the plant
  - Bud formation
  - Root replacement
  - Regeneration of leaves and stems after dormancy
  - Regrowth after defoliation (herbivory)
  - Respiration during dormancy

Plant Physiology

- Factors affecting how much food the plant can make (rate of photosynthesis)
  - Intensity and quality of light (PAR)
  - Leaf Area
  - CO2 available in atmosphere
  - Physiological efficiency of the plant species
  - Water supply
  - Temperature
  - Nutrient levels in soil
  - Overall individual plant health (stress level, age, and etc…)

Plant Physiology

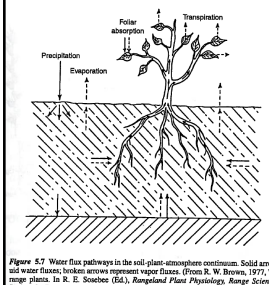
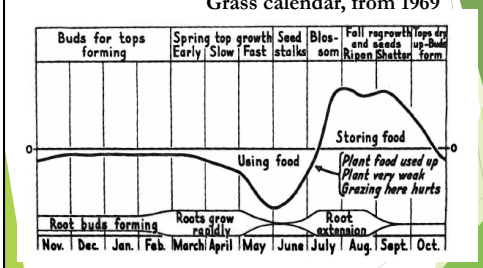


Figure 5.7 Water flux pathways in the soil-plant-atmosphere continuum. Solid arrows represent liquid water fluxes; broken arrows represent vapor fluxes. (From R. W. Brown, 1977, Water relations of range plants. In R. E. Sosebee (Ed.), *Rangeland Plant Physiology, Range Science Series, No. 4.* Society for Range Management, Denver, CO.)

Water is always on the move

Plant Physiology

Grass calendar, from 1969



Carbohydrate Allocation Patterns Depend On

- Age of the plant
- Herbivore/Plant Interactions
- At the Leaf Level (Approximate Growth)
  - 0 - ½: leaf extensions by importing carbohydrates (Carbs)
  - ½ - ¾: self maintenance
  - ¾ - full: exporting Carbs to other parts of plant

Carb Allocation Priorities

- First: leaf tissue and root elongation (water exploration) for photosynthesis and respiration
- Second: Increase in dry weight and internode elongation
- Third: Reserves (storage and reproduction for next year) - lowest priority

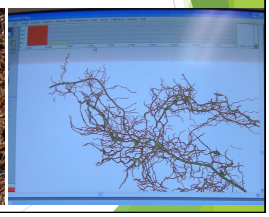
If you dip into reserves, you change plant vigor (the ability to handle stressors). Reserves are very similar to a savings account

Carbohydrate Allocation

- Lower leaves export Carbs downward toward the roots
- Middle leaves export Carbs both up and down
- Upper leaves export Carbs upward toward new plant tissue
- Most active growing areas tend to have more Carbs allocated to them

Water Stress Effects on Carb Allocation

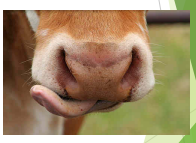
- Water stress tends to shift allocation to below ground production



What Happens with Grazing (Defoliation)?

Grazing

On taller grasses, cattle rip down to a height of 3 inches on average



Grazing

On shorter grasses, they take bites and rip down to ¾ of inch from ground

Plant Physiology and Grazing

- Grazing Resistance
  - Avoid being eaten……
  - or……..
  - Tolerate being eaten

Plant Physiology and Grazing

- Avoidance
  - Structural avoidance
  - or……..
  - Chemical avoidance!

Plant Physiology and Grazing

- Tolerance
  - Morphological
  - or……..
  - Physiological!

Plant Physiology and Grazing

Genetic Potential
+
Growth Promoting Features
-
Detrimental Impacts
+/-
Environmental Constraints
=
Plant Performance

Detrimental Impacts
1. Removal of Photosynthetic Tissue
2. Reduced Carbohydrate Storage
3. Reduction of Root Growth
4. Reduction of Seed Production

Growth Promoting Features
1. Increased Photosynthesis
2. Increased Tillering
3. Reduced Shading
4. Reduced Transpiration
5. Growth Promoting Substances

Measuring plant response

After tissue removal, what happens?

- Reproductive allocation, growth allocation, maintenance allocation
  - Below ground biomass
  - Photosynthesis
  - Fruits and seeds
  - Above ground biomass

Plant Response to Grazing

- Defoliation/Herbivory
  - Response unique for each plant in each location
  - Generally, leaving more living material is better for the plant
  - Removing dead material is good for the plant in most cases (any idea why?)
  - LEAVE ENOUGH LEAF MATERIAL TO CONTINUE PHOTOSYSNTHESIS, IN ORDER TO RECOVER

Grazing, What to Keep in Mind

- Grazing will impact photosynthesis if it occurs during critical periods during the year
- Therefore, tight controls should be placed on grazing strategies to avoid damaging plant growth and production

Critical period in terms of defoliation: the point of maximum accumulation

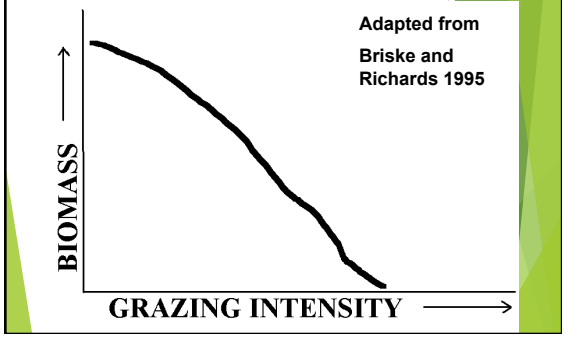
Defoliation and Plant Vigor

- Multiple events are much more stressful on plants than single events
- A safe time is when the environment can support plant regrowth
- Optimal defoliation is at peak of seed shatter (although forage quality may be low) or during winter

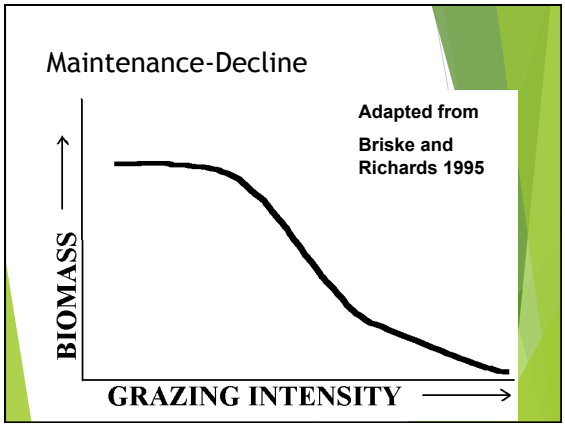
The Debate

- Choose your own defoliation response (which one is right?)
  - Decline (Reduced Growth)
  - Maintenance-Decline (Equal Growth)
  - Optimization (Increased Growth)

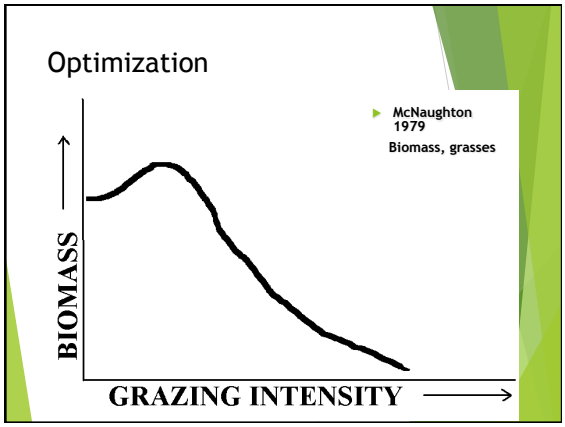
Decline



Maintenance-Decline



Optimization



Plant Physiology and Grazing

- You must control the four following factors
  - **Amount of leaf material removed (which parts are removed, what is left)**
  - Time of grazing
  - Number of times the pasture is grazed
  - Which plants are grazed (depends on herbivores used)

Bluebunch wheatgrass: 89% of carbon comes from remaining leaf area for regrowth, 1-9% comes from roots

Plant Physiology and Grazing

- **How Much Do I Leave?**
  - 50% or more of photosynthetically active leaf material during the growing season is a commonly accepted rule of thumb but….
  - Leave buds intact during the dormant season, also consider if you need to maintain a plant microclimate or winter litter
  - Early grazing, most chance for regrowth
  - Late grazing, least chance for regrowth

Plant Physiology and Grazing

- Improve the plants odds to recover from grazing by adding something
  - Maintain optimum soil nutrient levels (fertilize if warranted)
  - Extend growing season and plant ability to recover by irrigation

Defoliation

Case Studies

Defoliation and competition

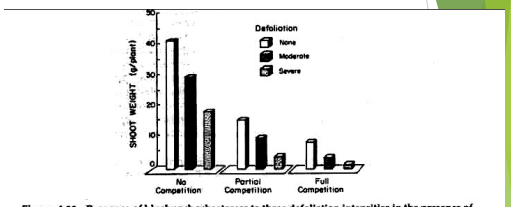
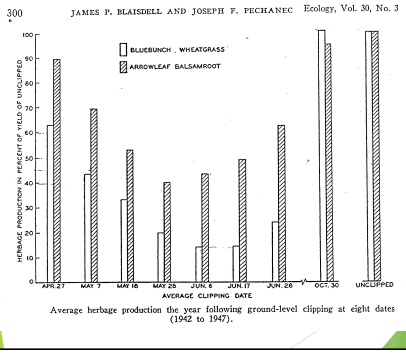


Figure 4.11. Response of bluebunch wheatgrass to three defoliation intensities in the presence of full, partial, or no competition from associated vegetation. Competition from associated species exerts a greater influence on growth following defoliation than defoliation intensity (adapted from Mueggler 1972).

Blaisdell and Pechanec



Average herbage production the year following ground-level clipping at eight dates (1942 to 1947).

Cook et al. 1958

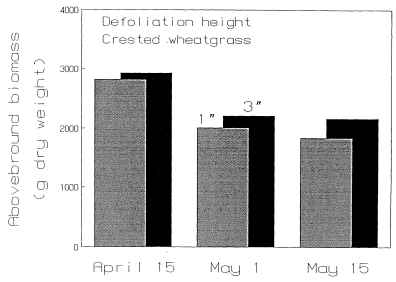


Figure 4 -- Influence of clipping height and season on aboveground biomass of crested wheatgrass. (From Cook et. al., 1958)

Cook et al.1958

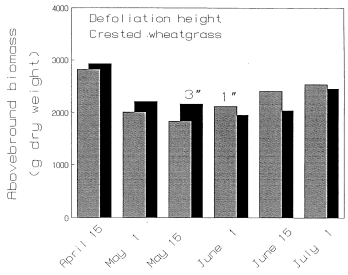


Figure 5 -- Influence of clipping height and season on aboveground biomass of crested wheatgrass. Note the influence of removing the apical meristem following the June 1 clipping treatment. (From Cook et. al., 1958)

Cook et al.1958

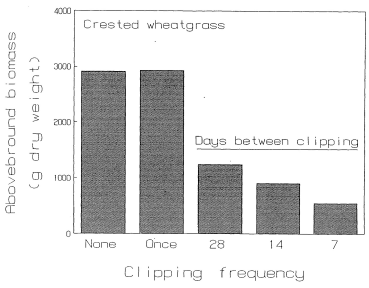


Figure 6 -- Influence of clipping frequency on aboveground biomass of crested wheatgrass. (From Cook et. al., 1958)

Info: Defoliation of Tufted Hairgrass

- Greenhouse study
  - Merril and Colberg 2003
  - Nitrogen (elk dung) amendment and water logging
    - Plants clipped 1 or 2 times (10 cm), 26 May and 2 July
    - 6 weeks waterlogging increased production and shoot nitrogen concentration
    - 10 weeks waterlogging loss root biomass, and shift to shallower root system with nitrogen amendment

Info: Defoliation of Tufted Hairgrass

- Field study
  - Pond 1961
    - 3 year study, only density measured
    - June 30 - Sept. 15
    - biweekly clipping at 2.5 and 7.5 cm, fall control clip
    - decrease of 11% on average at 2.5 cm
    - increase of 4% on average at 7.5 cm
    - control clip did not change density

Info: Defoliation of Tufted Hairgrass

- Turfgrass studies
  - Watkins 2004; 3 year study
    - 6.5 and 7.5 cm (occasionally & weekly through growing season, respectively)
    - "tolerant" but rust prevalent
  - Mintenko et al. 2002; 3 year study
    - 1.8, 2.5, and 7 cm (weekly through growing season)
    - "tolerant" but 2.5% loss foliar cover on average and rust was prevalent

Defoliation Studies

Clipping	Grazing
Uniform leaf area removed	Variable leaf area removed
Unselective removal	Palatability selected
Poor trampling effect	Trampling impacts
No pulling	Pulling of vegetation
No spit	Spit influence

Questions?