TECHNICAL NOTES

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HOW COOL SEASON GRASSES GROW AND PLANT NEEDS

by

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A. Grass Parts (Figure 1)

1. Leaves (Flowers)
2. Stems (Rhizomes and Stolons)
3. Roots

B. Plants Must Have Adequate:

1. Space
   a. Soil depth.
      * Water holding capacity.
      * Fertility storage capacity.
   b. Sufficient sunlight to meet their needs.
   c. Plant numbers.
      * Too many may stunt growth.
      * Too few or inadequate top growth allows weed invasion.

2. Water and Nutrients
   a. Function of water - actively growing grasses are 75% to 90% water.
      * Necessary for photosynthesis.
      * Minerals must be dissolved in water before they are taken up by the roots.
      * Plant cooling agent.

* Water is the major limiting factor to rangeland plants.

* Adequate moisture during the last half of the growing season will not compensate for an inadequate moisture supply during the first half.

b. Nutrients

* From air: carbon dioxide.

* Carbon dioxide is second to water as a leading element for grass growth.

* Of the elements required for grass growth about 95% are taken from the air and only 5% from the soil (if water is not included).

* Plants use phosphorous, nitrogen, potash, calcium, magnesium, and sulfur in large quantities to manufacture their food. They use other minerals such as iron, copper, boron, manganese, molybdenum, and zinc in small quantities but must have them for good plant growth.

* Sources of nitrogen on rangeland:

  - Rain
  - Decomposition of grass roots and shoots
  - Animal excretion
  - Some legumes such as lupine and vetch

3. Root System

a. Functions of the older portion of root system:

* Anchors the plant.

* Binds the soil.

b. Functions of new portion of root system:

* Extracts mineral elements and water from soil particles.

* Replaces the older roots that become inactive.

c. Root Replacement

* Each year a portion of a grass plant's roots die and are replaced.

* Amount of annual replacement ranges from 20-50% of the total root system.

* Growing roots require food from the leaves and water from the soil.

4. Top Growth

a. The leaves and stems are where plants make their own food.

b. Stems are the support structure for the plant and transport water and nutrients to and from the above ground portion and the roots.

c. The amount of top growth directly affects the plants total water absorption and transpiration.

d. Nutrient storage.

5. Relationship between top growth and root system. (Figure 2)

   a. Vigorous top growth is essential in order to maintain a healthy root system which in turn results in a grass plant that produces abundant forage and is more tolerant of drought and other stresses.

   b. A small top growth can only support a small root system.

C. Plants Make Their Own Food Through A Process Called PHOTOSYNTHESIS. (Figure 3)

1. Photosynthesis is an energy-capturing process.

2. In the presence of sunlight, a simple sugar, glucose, is formed when water and carbon dioxide are fixed in chlorophyll, the green tissue of the plants (carbon fixation).

3. The sugars then combine with the minerals elements from the soil to make proteins, plant oils, and fats that the plant needs to grow and reproduce itself.

4. Photosynthesis is limited to periods when plants have green leaves, stems or both and favorable water and temperature conditions.

   a. Cool season plants.

   b. Warm season plants.

D. Food Storage

1. Location

   a. Lower stem bases for most grasses.

   b. Rhizomes (examples - saltgrass, smooth brome, reed canarygrass).

   c. Seeds for annuals (example - cheatgrass).

   d. Roots in forbs (example - legumes).

   e. Branches and roots (shrubs and trees).

2. Uses

   a. To support tiller recruitment and growth after defoliation when photosynthesis is low.

   b. To develop heat and cold resistance.

   c. To support metabolism during periods of dormancy.

   d. To promote flower and seed formation

E. Tillers Are The Basic Unit Of Grasses (Figure 4)

1. Tillers and Bunchgrasses

   a. Tillers are composed of growing points, stems, leaves, nodes and dormant buds (Figures 5 and 6)

   b. Individual grass plants are composed of several tillers which originated from axillary buds of older parental tillers.

c. Each tiller establishes a shoot and root system to acquire resources.

d. A bunchgrass is a collection of individual tillers with some shared facilities. The analogy would be an apartment house of clones. A study by Olson and Richards (1988) showed that an ungrazed tiller does not enhance the growth potential of an unrelated heavily grazed tiller on the same plant. Food is not transferred through the root and crown system to needy tillers. A parent tiller will support a daughter tiller.

e. Generally tillers have: an emerging leaf, an immature leaf, a mature leaf and a senescing leaf.

2. Tiller Recruitment

a. Tiller recruitment occurs mostly in the spring and fall. Thus, the fall green up is not free forage but is the basis for next year's production. Fall recruitment of tillers only occurs if there is sufficient moisture available.

b. Fall or early spring initiated tillers provide the most production because they have a longer period for growth and development. The number of tillers in a plant determines the potential for the total production within the constraints of resource availability.

3. Intercalary Meristems

a. Intercalary meristems (areas of cell division or growth) are located at the base of the leaf blade and sheath, and at the internode.

b. Result in the growth of the leaf blades, sheath and internode.

c. The growth of the leaf blade and sheath stop when the ligule is fully developed.

d. The basal location of the intercalary meristem within the blade and sheath explain why leaf growth can occur following defoliation as long as the leaf has not matured.

e. Internode elongation is dependent upon species and phenology. Generally, it occurs as the apical meristem becomes reproductive but in some grasses it occurs in the vegetative stage of the plant. When internode elongation occurs it raises the apical meristem above ground level.

4. Axillary Buds

a. The apical meristem produces axillary buds at the nodes of the grass plant.

b. If the apical meristem is removed the axillary bud will produce a new tiller if there is adequate moisture.

5. Leaf Replacement Potential

a. The rate at which the leaf area is regrown following defoliation is a function of the number, source and location of meristems within the plant.

b. Growth will occur most rapidly from immature intercalary meristems (blade, sheath) and least rapidly from newly initiated axillary buds.

c. When the apical meristem becomes reproductive or is removed by grazing, leaf replacement must originate from axillary buds which require the greatest amount of time for regrowth. This is why grasses that have a high ratio of reproductive or culmed vegetative tillers (jointed grasses) are best suited to intermittent grazing.

F. Longevity Of Perennial Grasses Depend On The Successive Production Of Short Lived Tillers.

1. The dead centers of many perennial grasses are a natural development rather than a negative response to stress.
2. Tiller longevity in perennial grasses is usually less than 1 year.
3. Grasses must have more than a 1:1 ratio of tiller replacement to increase in size.
4. If tiller recruitment was stopped for the time equal to the life of the existing tillers, the plant would loose its growing points and die.
5. Changes in tiller density occurs when tiller recruitment lags behind or exceeds tiller mortality. (Figure 7)
6. Reproductive tiller development terminates with seed maturity; vegetative tiller mortality is the consequence of shading of smaller tillers, and less carbon allocation to young tillers from parental tillers may be more important. (Figure 8)

G. Axillary Buds And Growing Points Give Rise To and Regulate All Growth.

1. With the right conditions axillary buds start growth in the fall, although in spring also for many species.
2. Apical meristem (Figures 5, 6, and 8).

   a. Controls the growth of the tillers and all growth initially originates from the apical meristem.

   b. Continues to grow (produce intercalary meristems) as long as the apical meristem is in the vegetative state.

   c. The apical meristem produces the seedhead. (Figure 8)

   d. Once the apical meristem becomes reproductive (in the boot stage) the plant is committed to reproduction and its ability to produce new phytomers and leaves specifically is at a low level and declining. **This is the most critical period for the grass (boot stage through soft dough stage).**

   e. When the apical meristem becomes reproductive or is removed by defoliation - Vegetative growth can only occur from immature intercalary meristems (leaf blade and sheath) or from axillary buds. Axillary bud development is dependent on soil moisture so there may not be adequate soil moisture for regrowth.

   f. The type of grass determines when the apical meristem is elevated. Once the apical meristem is elevated it is susceptible to removal by grazing or mowing. If the growing point is removed, that tiller cannot grow and new growth must come from axillary buds which reduces next years crop.

H. **Growth Cycle (Figures 9 and 10)**

(Growth from inception to maturity is quite similar in all grasses.)

1. Fall/Winter

   a. If there is adequate moisture new tillers start in the fall from axillary buds.

   b. These tillers overwinter in the 1-3 leaf stage.

2. Spring Vegetative Growth

   a. Expanding young leaves use most of the carbohydrates they produce and also import some carbon from older leaves that are mature or draw on carbohydrate pools.

   b. Photosynthesis from fall initiated tillers is generally adequate to meet the needs of the plants for initiation of spring growth.

   c. Only a small portion of the stored carbohydrates is used for the start of spring growth.

   d. As spring growth begins, the apical meristem (growing point) is inside the stem, near the base of the plant. Whether or not the apical meristem is elevated during the growing season depends on the type of grass plant and stage of growth.

   e. The phenology (state of development) of a plant is primarily dependent upon air temperature which is expressed as growing degrees.

3. Late Spring/Summer Reproductive Growth

   a. Fall initiated tillers have the greatest chance of becoming reproductive, thus tillers initiated in the spring generally will not flower.

   b. Most cool-season grasses (almost all of the native range grasses in Eastern Washington), require tiller initiation in the fall and exposure to cold temperature for formation of reproductive structures.

   c. During stem elongation (reproductive growth) the apical meristem is already forming an inflorescence and elevates above the ground, becoming susceptible to removal.

4. Regrowth

   a. Within 2 days following defoliation, photosynthesis provides from 88% to 90% of the regrowth in bluebunch wheatgrass; the remainder is supplied from carbohydrate pools stored food). The carbohydrate pools should be considered small buffers for regrowth, not large reserves.

   b. The most critical factor affecting regrowth is the amount of green leaf and stem tissue remaining after defoliation. The more green leaf area remaining after a grazing period, the greater the potential for regrowth. Favorable growing conditions are required.

c. Under range conditions there may not be enough moisture for axillary buds; the quickest regrowth comes from leaves and stems on existing tillers; we just cannot expect a lot of regrowth under range conditions.

I. Establishment of Seedlings

1. Plants may reproduce by tillering, rhizomes and stolons, or seeds.

2. Reproduction by seed is the most common method among the higher plants and the only method of many perennials and all annuals.

3. The seedling depends on the rapid development of its own roots to supply it with moisture. In drought years, the seed may not germinate or the seedling may die before it can send its roots down to the moist subsoils. Annuals such as cheatgrass are serious competitors to young perennial plants because of its rapid root growth and the early initiation of growth.

4. Shrub or forb seeds can remain for a period of 5-10 years, some much longer, allowing the plant to survive prolonged drought periods or other disturbances.

5. Grass seeds are viable for only 1-2 years; there is not a soil bank of grass seeds; in good years grasses must produce seed and then the next year must germinate and recruit seedlings.

J. Types of Grasses (Figure 12)

1. Bunchgrasses or Jointed Grasses (bluebunch wheatgrass, Idaho Fescue, crested wheatgrass, etc.)

   a. Have a high ratio of reproductive or culmed vegetative tillers.

   b. Internode elongation elevates the apical meristem above the ground surface where it can be removed by defoliation.

2. Sodforming or non-jointed grasses (orchardgrass, tall fescue, Kentucky bluegrass, etc.

   a. Less than 10% of the stems are jointed and produce seedheads.

   b. The growing point on the other stems remain close to the ground during the growing season. The leaves and tillers can continue to elongate even though a portion of the leaves have been removed by grazing or mowing.

   c. Forage production comes from continued leaf growth at the junction of the blade and collar and base of sheath (intercalary meristem). If the intercalary meristem is not removed, the leaf will continue to grow as long as there is adequate moisture.

   d. If the intercalary meristem is allowed to grow too high it can be removed. Once the intercalary meristem is removed the growth stops because the source of regrowth is gone. New growth must come from axillary buds which take time to start growing.

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PARTS of GRASS PLANTS

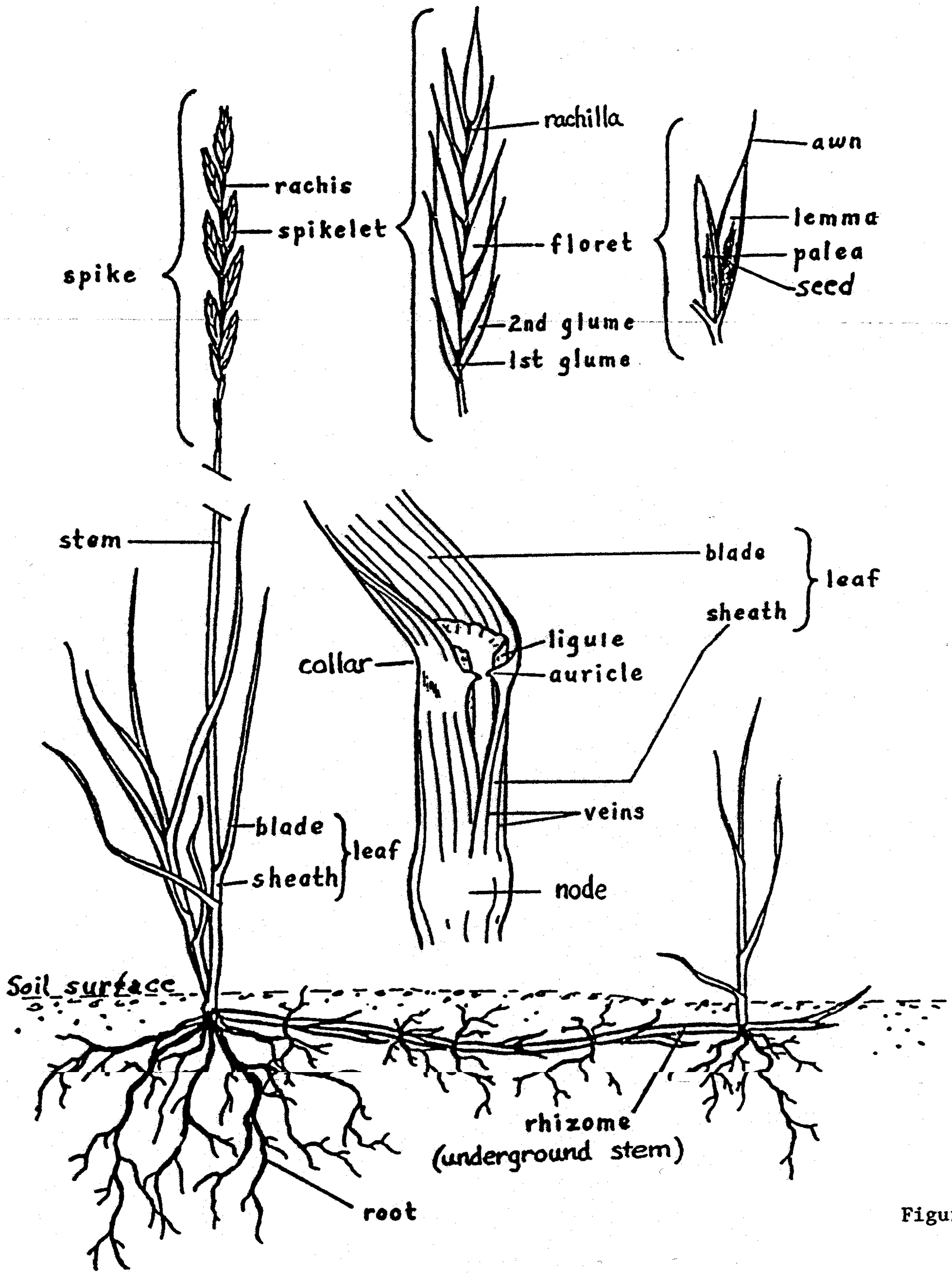
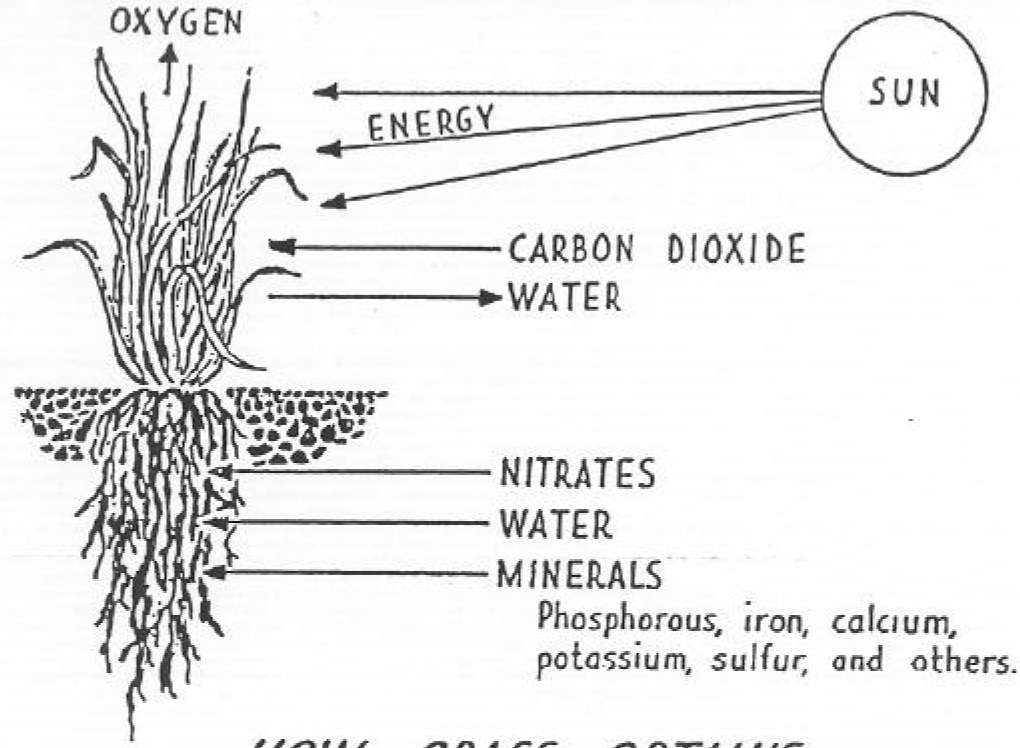


Figure 1



HOW GRASS OBTAINS MATERIALS FOR FOOD MANUFACTURE

Figure 2

A. Although you may think you see quite a bit of "daylight" between grass plants in even your best pastures, actually the plants are properly spaced. Notice how the roots intermingle and the leaf canopy prevents sunlight from reaching other plants such as weeds. B. Each year approximately 30 percent of each grass plant's root system must be replaced. What happens if you overgraze and the plant's root system not only can't expand, but can't replace that vital 30 percent natural loss? C. Weeds can take hold and grow where grass roots have been too severely weakened. Weedy pasture is less productive pasture.

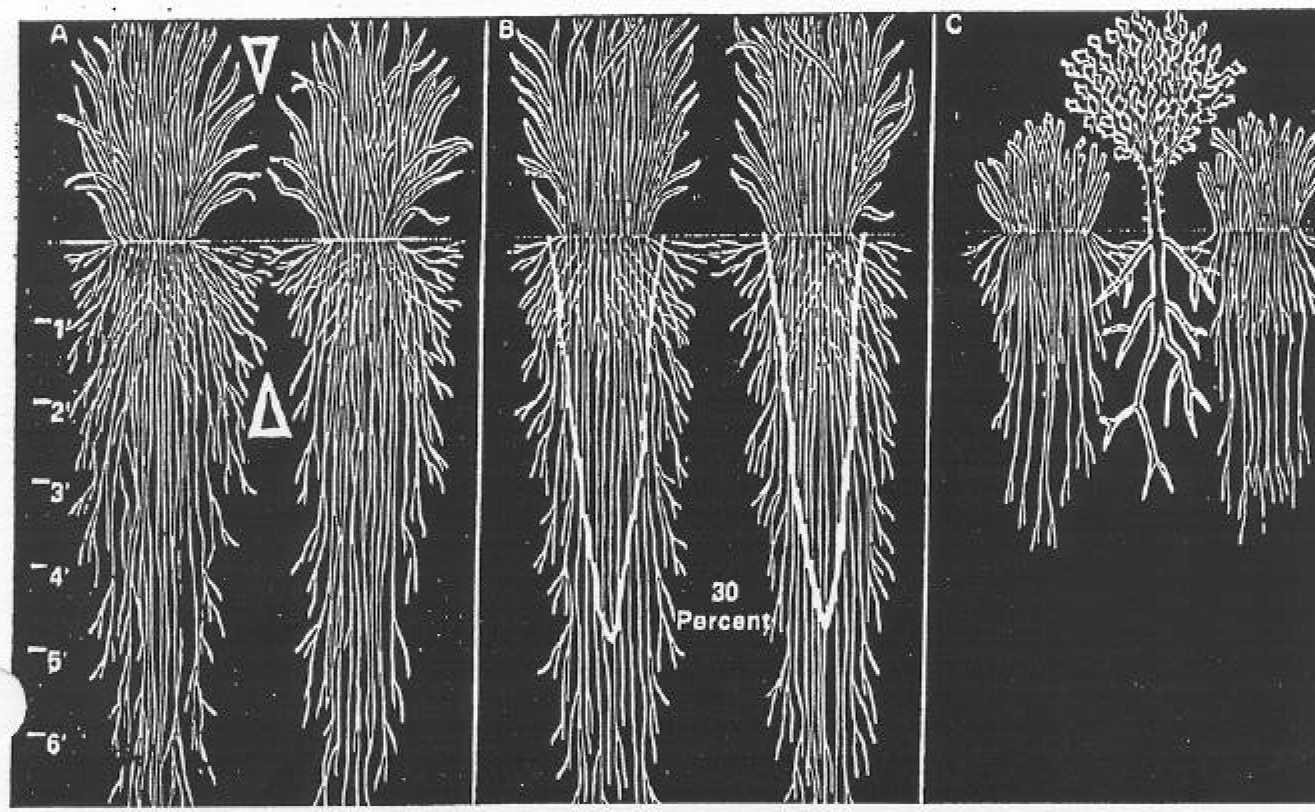


Figure 3

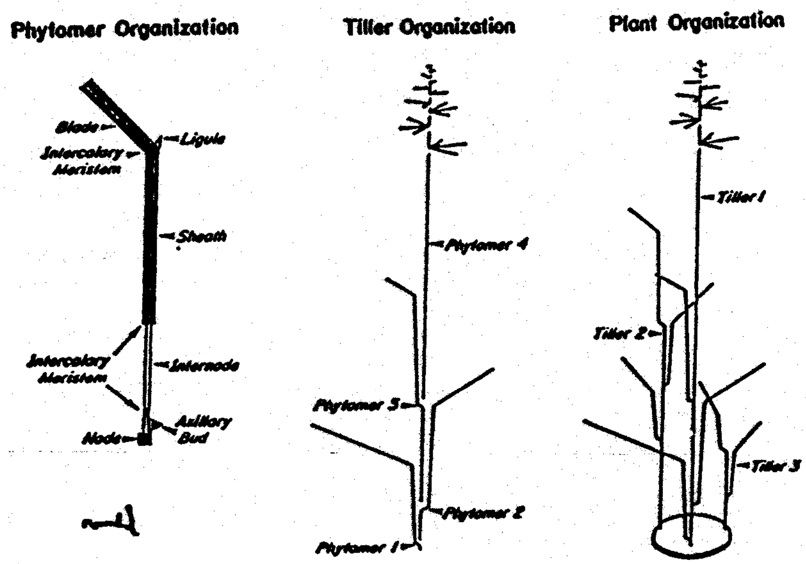


Figure 4

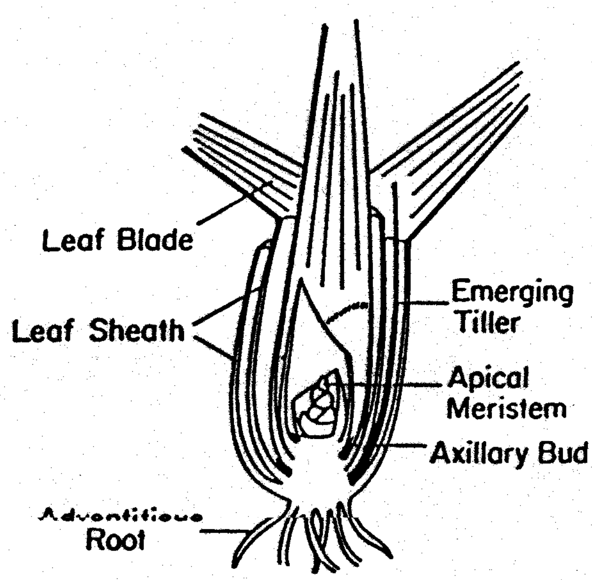


Figure 5 **Tiller initiation from axillary buds in the crown of a grass plant. Axillary buds contain single rudimentary apical meristems capable of differentiating a complete tiller (from Jewiss 1972).**

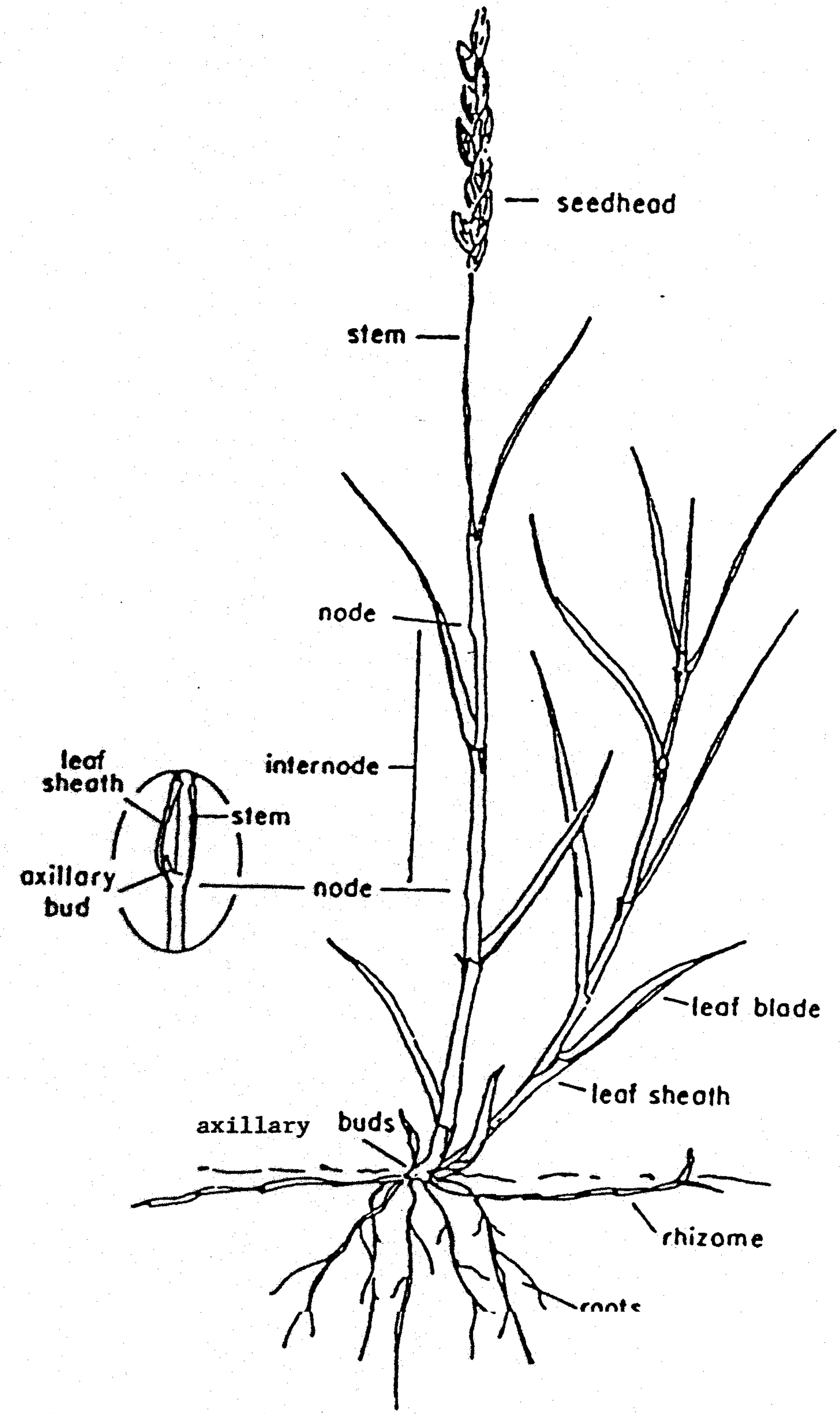


Figure 6 Structure of the grass plant and location of buds that can grow into tillers. The main growing point has matured into a seed head.

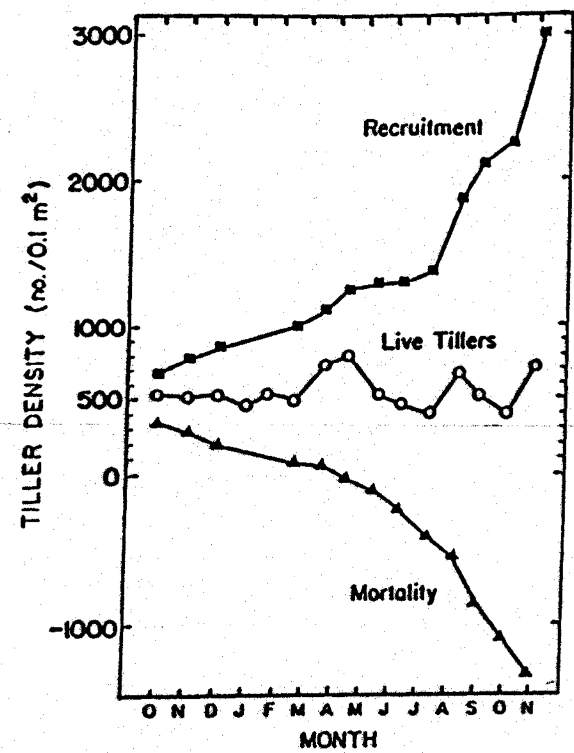


Figure 7 Live tiller density as a consequence of tiller recruitment and mortality within a population. Tiller density increases when recruitment exceeds mortality and decreases when recruitment lags behind mortality (from White 1980).

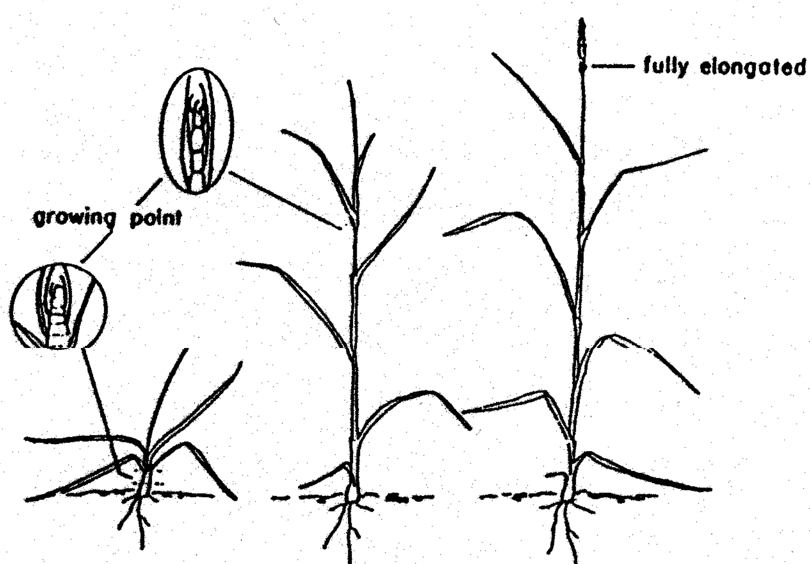


Figure 8 Developmental phases of a grass tiller.

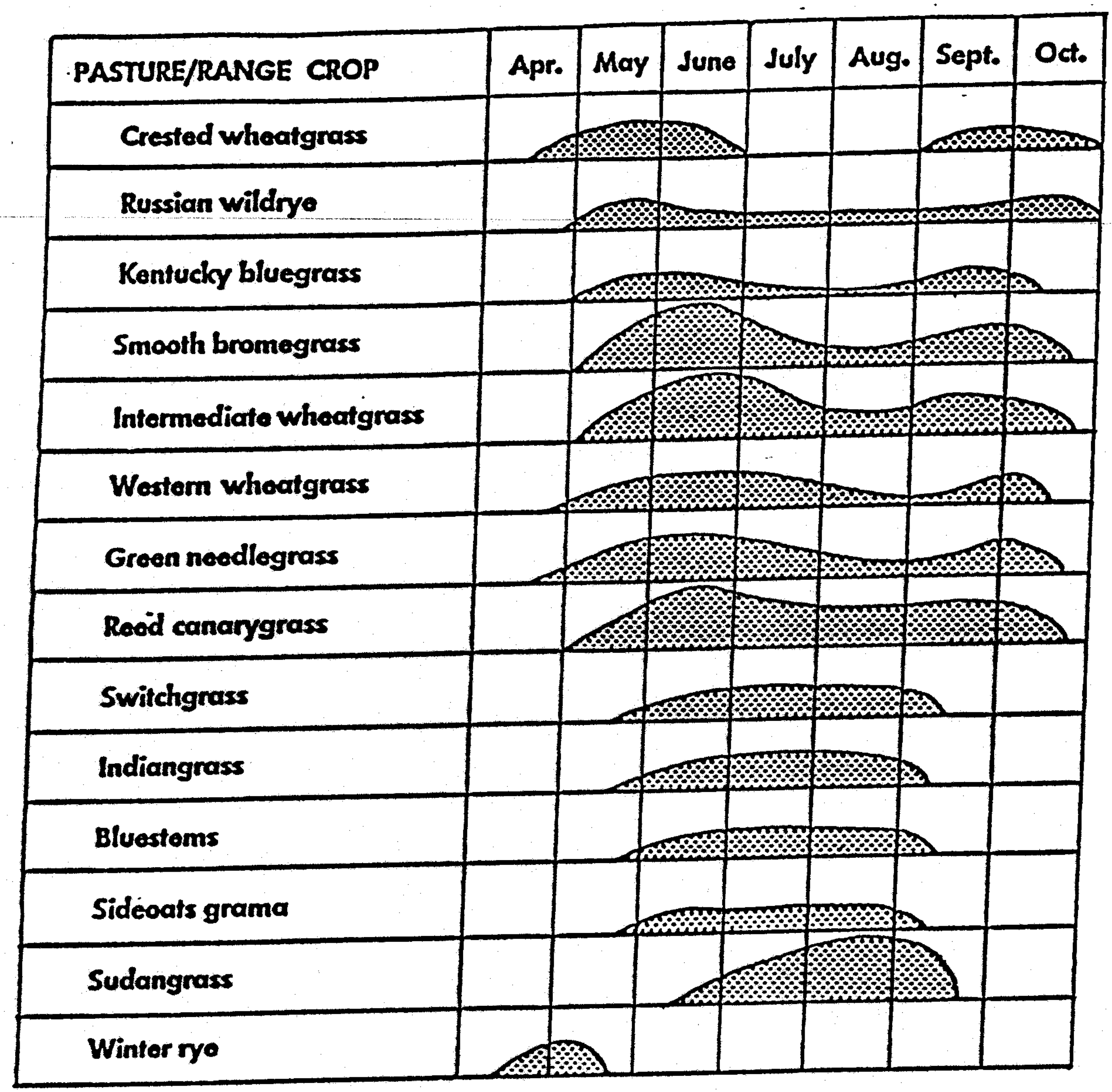

PASTURE/RANGE CROP
Apr.
May
June
July
Aug.
Sept.
Oct.
Crested wheatgrass
Russian wildrye
Kentucky bluegrass
Smooth bromegrass
Intermediate wheatgrass
Western wheatgrass
Green needlegrass
Reed canarygrass
Switchgrass
Indiangrass
Bluestems
Sideoats grama
Sudangrass
Winter rye

Figure 2

GROWTH CURVE OF BLUE BUNCH WHEATGRASS AT VARIOUS GROWTH STAGES

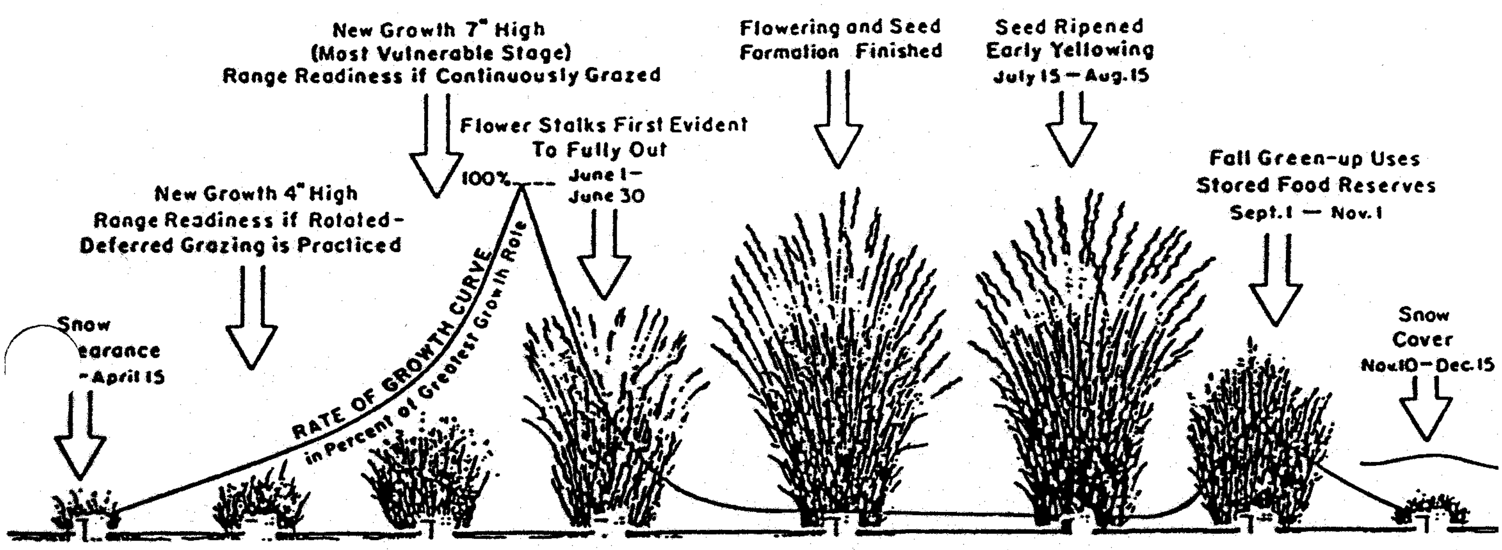


Figure 10

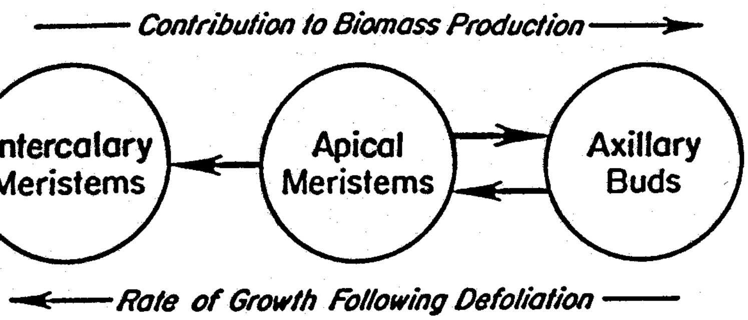


Figure 11 **Sources of meristematic activity in a grass plant. The relative growth rate from each source following defoliation is established by the extent to which tissue differentiation has previously occurred. Axillary buds confer perenniality to the plant while intercalary meristems are relatively short-lived (from Briske 1986).**

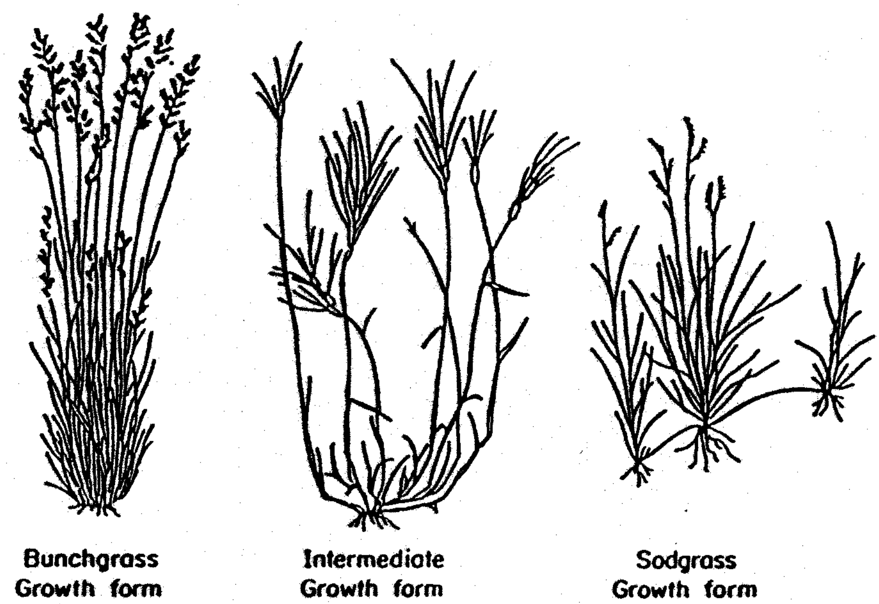


Figure 12 **Variation within the grass growth form originates from the pattern of tiller emergence expressed by various species groups. The bunchgrass growth form originates from intravaginal tiller development, while extravaginal tiller development contributes to a more diffuse tiller arrangement and serves as a prerequisite to the sodgrass growth form. Stolons or rhizomes further increase inter-tiller distances within plants.**