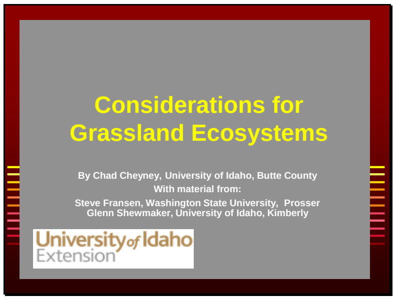
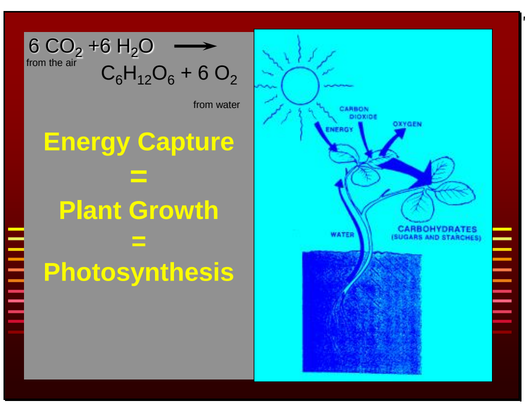


Today we want to review the principles of the ranching business. Look at the laws of thermodynamics and see how they apply to agriculture, and then related the ranching business and physics to grass land ecology. We will review grass anatomy and physiology and its relationship to ranching and ecosystems and then summarize with some principles for grazing management

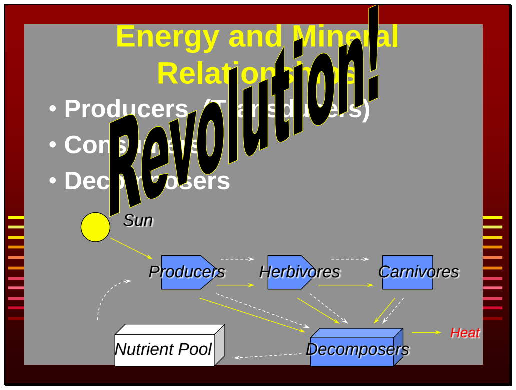
If use a lot of energy in farming and ranching. Most of this is ancient flows of solar energy captured in fossil fuels. If we agree that farming and ranching is the ENERGY business, then grass farming **IS** the SOLAR ENERGY businesses. In order to be successful in the solar energy business we have to understand the mechanics of HOW we capture, convert and sell the energy. In order to be effective as grass farmers we must capture solar energy in plants through photosynthesis, convert this energy into animal products through grazing and sell the animal products at a profit.

While no operator can maximize all the factors required, by understanding the mechanisms and the principles, we can judge how good a job of grass farming we ARE doing and make adjustments so that we can do a better job in the future.

Since plants are our energy collectors and soil is not, is imperative to minimize the amount of time bare soil is exposed to the sun. While the soil surface is covered with green plants we need to optimize the conditions that permit plant to grow as rapidly as possible through effective irrigation, fertilization and the timing and severity of defoliation that we permit. Finally we must convert the standing forage into animal product. If we keep the quality of the forage high, we increase the effectiveness of energy transfer from plants to other forms of life, which we can harvest.



The basis for energy flow in ecosystems is the capture of solar energy in the bonds between carbon atoms in glucose. This process occurs INSIDE the leaf. When the stomata, special openings in the surface of the leaf, are open to permit water to exit, carbon dioxide can enter the leaf in response to gradients. Using a very complex series of chemical reactions, the solar energy is used to connect carbon dioxide molecules into glucose molecules, releasing oxygen into the atmosphere. If the stomata close, because the plant has wilted, the process cannot go forward and energy capture stops.

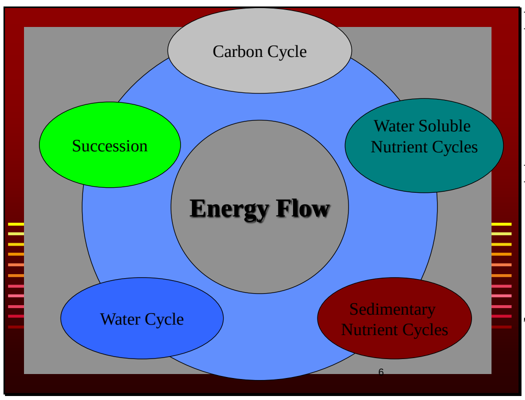


Ecosystems are divided into "levels". The primary level is the producers. These are the green plants, which change solar energy into chemical energy stored in glucose. This level and all the other levels break these carbon bonds, in the process of respiration, to get the energy back to maintain and grow their bodies.

The second level is the herbivores. This is the first group of organisms to feed on the producers. The third level is the carnivores which eat only (primarily) the bodies of the herbivores. At all levels, waste products are produced that are eventually stripped of the last bits of useful energy by the decomposers. Any energy not stored in the bodies in the system is released as heat, and lost to heating the universe.

Nutrients on the other hand move from some pool through the system and back to the pool. How large the pool is, where it is located, how fast it revolves all determine how effective energy capture and transfer between levels is. Very little (less than 10%) of the nutrients consumed by animals are actually removed or moved when the animals are consumed.

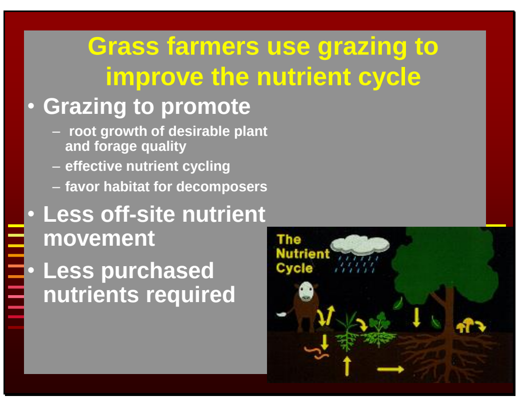
The concept of effective energy capture and transfer, and the rate of nutrient cycling are important concepts that can guide the ranch or farm practices and business to greater ecological and economic efficiency. When you begin to look at what you do in your business in these terms I believe it will revolutionize the way you think and work.



Energy flows through ecosystems, and is used to maintain the integrity and function of the system. All energy is eventually converted to waste heat. In thermodynamics we say that "all systems move to higher levels of entropy" (disorganization) if not continually supplied with energy.

Matter or nutrients on the other hand are (except in relativity) neither created nor destroyed, but changed from one form to another. These changes we often refer to as "cycles". If these cycles are not operating effectively, it reduces the ability of the ecosystem to capture and store energy.

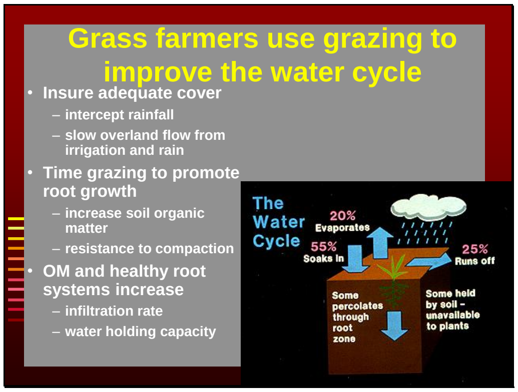
The various cycles and processes are really "windows" into how effective the energy flow in an ecosystem is. If one or more of the cycles is not operating effectively, the energy will not be captured, or at a much reduced rate.



According to the laws of thermodynamics, nutrients are not created or destroyed, but only changed from one form or place to another. The forms and rates that these elements go through in our ecosystem are called nutrient cycles. The most easily and rapidly manipulated cycle is the Nitrogen Cycle, where nutrients can literally be reused in days. Other systems include mineralization of the nutrient from the parent material, for example phosphorus, and are called sedimentary cycles and can be very long taking many years. Notwithstanding, grazers who effectively manage root grow and forage quality can increase the rate at which nutrients become available for reuse in the systems that they manage.

Off-site movement of nutrients to ground and surface water is an issue. Poor management of purchased fertilizer products, excessive rainfall or irrigation and poor management of plant cover which permits surface flows and erosion all contribute to loss of nutrients from agricultural ecosystems, with resulting problems elsewhere. Since animals excrete more than 90% of the nutrients they ingest and the rate that these nutrients become available in the ecosystem are influenced by feed quality, managing feed quality, animal movement and locations are important aspects of minimizing the loss of nutrient to off-site movements.

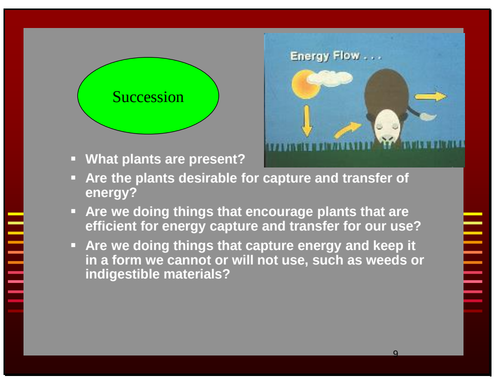
Because we are generally pretty poor managers of the various nutrient cycles, we are addicted to purchasing mineral nutrients from out fertilizer dealer. If we manage grazing to promote root growth and rapid decomposition of plant and animal materials on site, we can cycle those nutrients more quickly and reduce our dependence on purchased fertilizer inputs. This improves both our profitability and our environmental stewardship.



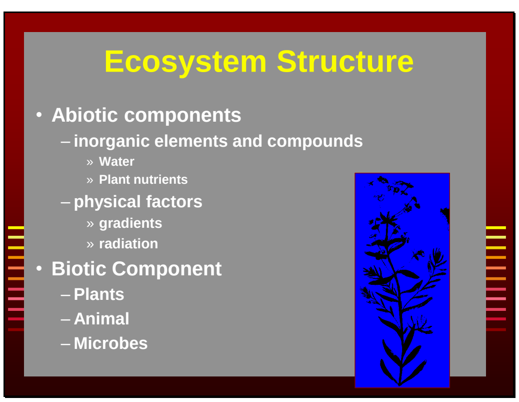
As we indicated before the various ecosystem processes that we can manage are all windows into how effective our energy capture process is.

Water is imperative to the energy capture process. Without adequate soil moisture, carbon cannot get into the plant, and energy cannot be captured between the carbon bonds. When plants wilt, or even when it becomes more difficult for them to move water from the soil to the leaves, photosynthesis slows or stops.

The water cycle in the largest sense is global, and some aspects are out of our immediate control. On the other hand by managing the amount and timing of irrigation water having adequate plant residual to reduce overland flows and increase water penetration, by managing grazing to promote root growth and consequently the depth and volume of the root zone, we can increase the effectiveness of the amount of water that is provided by nature or we distribute though irrigation. Management that over or under applies water or reduced the effective root zone reduces the effectiveness of energy capture either

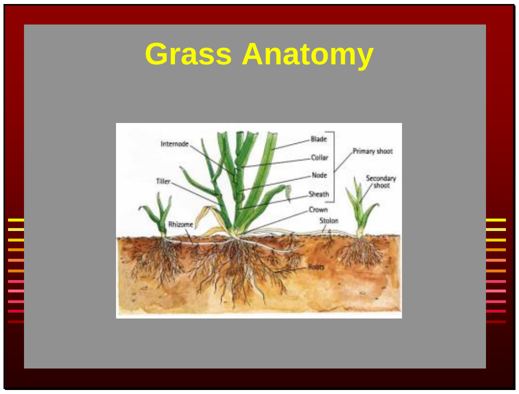


The way we are going to look at energy flow today is from the perspective succession. What plants are present? Are they desirable from the perspective of capturing and transferring energy? This is what we are doing when we do a pasture trend and condition evaluation.

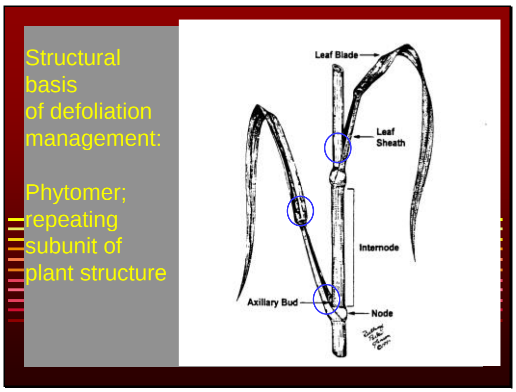


Different plants “prefer” different environmental conditions. Succession is affected by physical features of the environment. These include such things as moisture, nutrients, toxins, soil physical constituents, particle size and structure, as well as physical factors such as gradients. Gradients are indications of the differences in amount of a feature across space. We say the gradient is greater when two places close together have very big differences in a features, such as temperature.

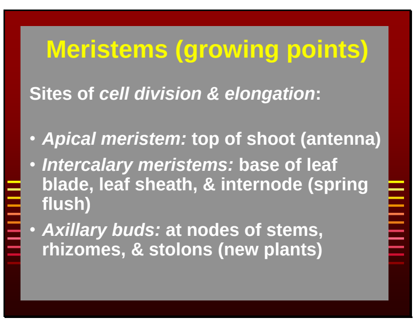
The biotic components include the plants, animals and microbes that are capturing and utilizing energy. Which organisms are present and in what concentration, can have a huge impact on energy capture and transfer within the system. Sometimes energy flow and transfer is very high, but not in components of the ecosystem that are useful to Man.



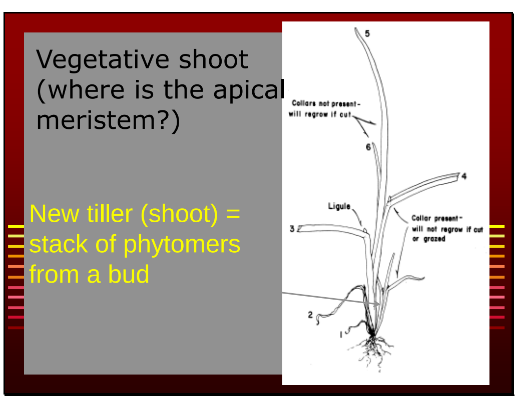
Here are the generalized parts of a grass plant.
Leaves – the blade and the sheath are separated by the collar
Nodes – this is where the leave attaches to the stem, buds (meristems) are found at nodes
Internodes –is the tissue between stems. This can be highly compressed—stacked like a deck of cards or it can elongate quickly to push the inflorescence above the canopy.
Phytomer- the phytomer is the unit of grass, a node, internode and leaf
Buds - are found in various places, including the apical bud, axillary and intercalary bud
Shoots – are the collection of leaves and stems
Roots –are structures underground that collect water and nutrients
Rhizomes are horizontal underground stem, while
Stolons are horizontal above ground stems. Al stems are composed of phyotomers, and where ever there is a axillary bud either a leaf or a root may form, depending on the conditions.
Tiller is another shoot that has formed from an axillary bud



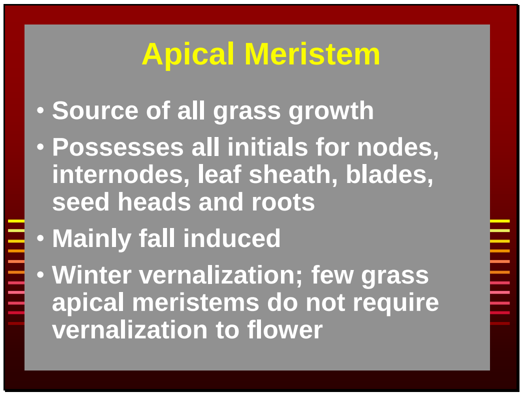
The phytomer is the repeating unit of the grass plant. It is composed of a bud, node, internode and leaf. When the grass is vegetative, the internode is extremely short. If the apical meristem has been induced to form a flower, then the internodes will elongate rapidly, raising the apical meristem in the canopy. Once this happens that stem cannot produce more leaves.
New shoots and new leaves, which we want for livestock feed, are generated from axillary buds (meristems) buried in the crown of the plant. As long as the apical bud has not been induced to flower, it will continue to produce additional leaves.
Some species of grasses have inflorescences once a year, eg. Orchard grass. Others have and inflorescence on every shoot that come up.



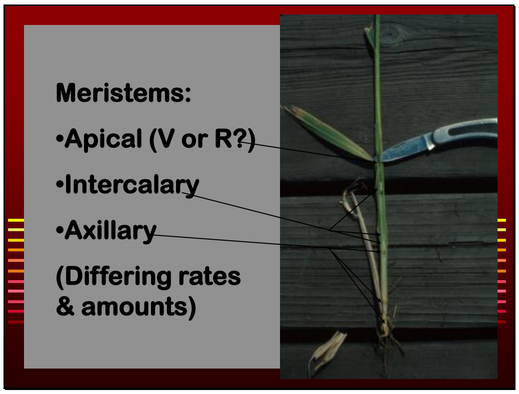
Meristems are sites of cell division.
Apical meristems can be induced to become flowers
Intercallary meristems are found in the body of the leaf and permit rapid expansion and growth, eg. orchard grass
Axillary buds are found in the axil of the bud, between the leaf and the node. They can produce additional Phytomers piled on top of each other leading to a new shoot. The creation of the potential for a new shoot only occurs once a year!

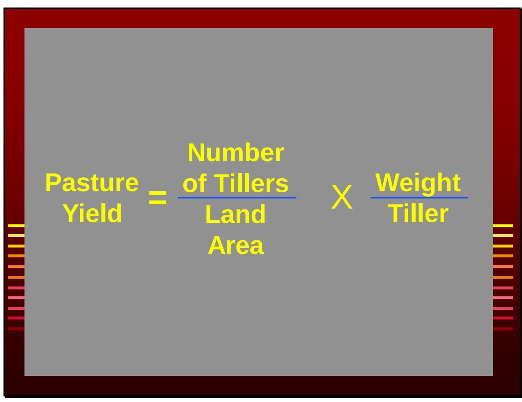


Where do new shoots come from? The come from a axillary bud in the crown, that develops a new stack of Phytomers ready to turn into a shoot of grass…..Vegetative shoots keep their apical meristems low in the canopy and continue to produce additional leaves

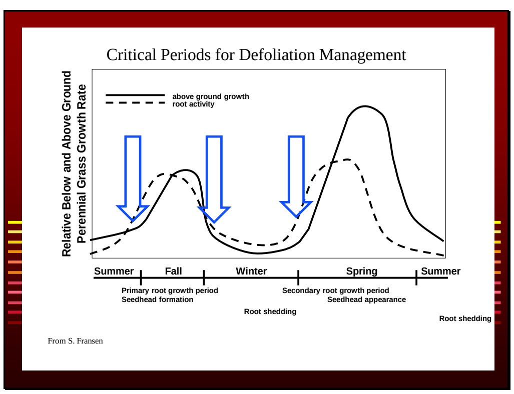


The creation of new buds for new shoots occurs only in the fall! This means that plants that do not have adequate energy or nutrients will not produce as many buds and their potential to produce shoots the following year will be reduced. Every new bud comes with the potential for a new root, this too happens primarily in the fall





Your pasture yield is the product of the number of tills produced and the weight of each tiller….

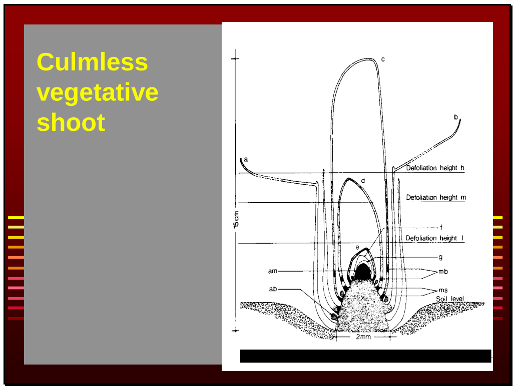


Notice that root growth always precedes above ground growth.

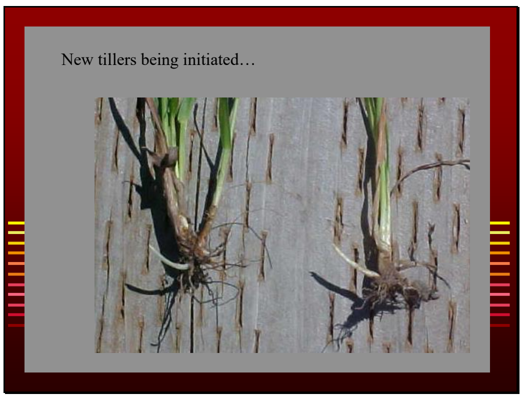
In the late summer and early fall, meristems in the base of the plant are triggered to divide and form additional meristems, each of which represents a potential tiller for next years grass grow. In addition, the primary root growth for the next 6 months is initiated and may be completed. Failure to have adequate energy available for this process in the fall, means there will be fewer tillers and a more limited root system for the next year.

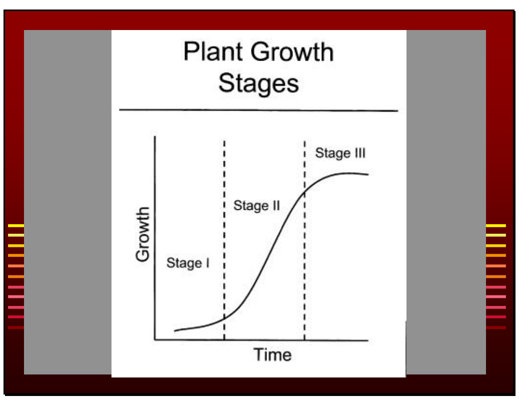
Unlike perennial forbs like alfalfa, grass plants store very little energy in their root system,. During the winter the grass plants live off of the NSC which are stored in the bottom 3-4 inches of the plant stems. If the lower parts of the shoots are removed, there in insufficient energy for the newly initiated tillers to survive until spring. During this time, some of the meristems are triggered to become reproductive.

In the spring there is another smaller expansion of the root system, initiated the previous fall, before the spring flush of growth. During the summer roots are shed. The more severe the grazing, with inadequate rest, the more severe the root shedding will be, and the poorer the NSC reserves in the leaf bases will be, leading to reduced initiating of new tillers and roots for the following year.



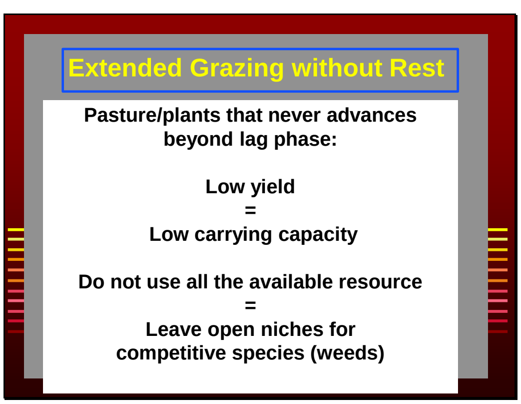
He is a diagram of the vegetative apical meristem.
AM- apical meristem
AB- axillary meristem
MB & MS intercalary meristems

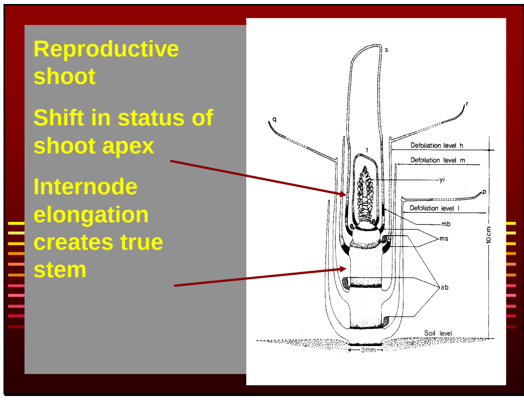




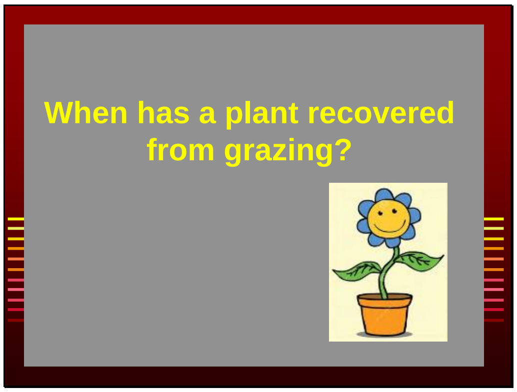
We often say that pastures go through 3 growth phases. The same is true for individual plants. It is a logarithmic curve. The first stage is a "lag" phase while the plant utilize existing reserves to grow leaves. Once the leaves are in place, the plants begin the second phase or "log" phase where growth is rapid, because it is supported by current energy capture from photosynthesis. Finally the plants enter the 3rd phase, another lag where the existing growth has become decadent and is becoming parasitic on the rest of the plant.

Plants can be pushed into phase one by environmental conditions, or they may be defoliated into this condition and kept there by continuous remove of new growth.





During the summer some apical meristems are vernalized and converted to potential flowers. These stems will elongate there internodes and elevate the growing point into the "defoliation zone". If the apical meristem of either a vegetative or reproductive stem is removed the tiller stops growing and producing leaves and another shoot must come from the crown.

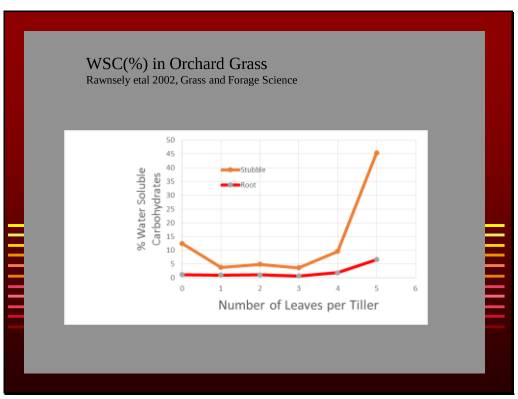


WSC (%) in Orchardgrass

Rawnsley etal. 2002 Grass and Forage Sci.

Leaves/tiller	Stubble	Root
0	12.5	1.2
1	3.8	1.01
2	4.9	1.09
3	3.7	0.73
4	9.6	1.92
5	45.3	6.64
LSD 0.05	17.7	3.30

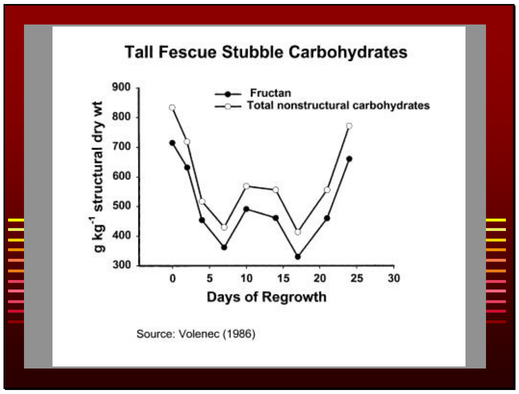
Here is data from defoliation of vegetative orchard grass stems. The residual, the lower 4 inches of the plant was destructively sampled at the time indicated by the number of fully collared (mature leaves) showing.



Here is the same data presented graphically. Notice

- The level of NSC in the roots hardly varies at all
- It takes until the 5th leaf is fully collared for the NSC concentration to become elevated.

Now---when do you think that this plant has recovered fully recovered from being grazed?



Here is similar data for tall fescue, only the x axis is represented with time. It looks to me like it take at least 23 -25 days for vegetative plants to recover. That 25 days is the amount of REST needed to keep that plant in good condition. If we graze that plant is phase I, it will take LONGER than 25 days for it to recover. If we keep that plant in phase I, it may NEVER recover!

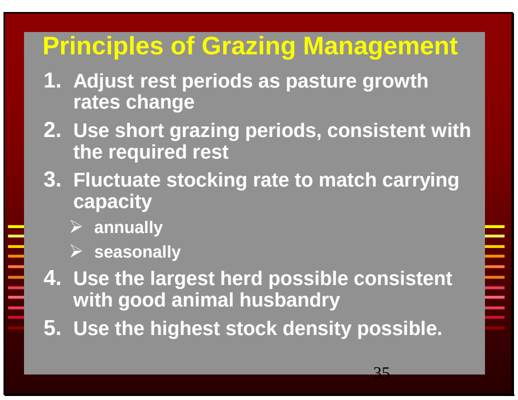
Let's look at the effect of REST

Outside of the enclosure the pasture is receiving NO rest.

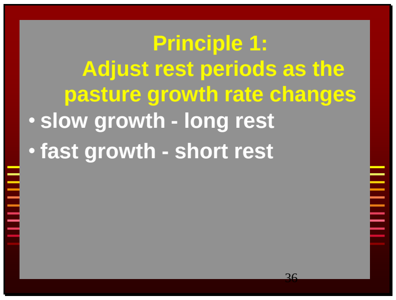
After 21 day of REST there is significant more grass.

After 42 days of rest there is significantly more than after 21 days

Look at the difference in the plants that received 5 continuous weeks of grazing (no rest). They have no vigor, not new roots and not reserves (last 3-4 inches of the shoot). Compare to the plant that was defoliate and then received 6 weeks of rest. Look at the size of the leaves, the new white roots forming and the mass of the crown.
(new axillary buds and potential tillers)

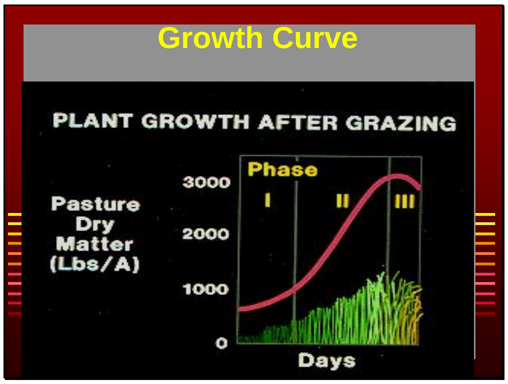


These are the “five principles” of grazing management. They apply in every grazing system in every grazing ecosystem. However, the implementation of these principles may vary considerably between ecosystems because of scale and environment.
One: Adjust the rest period as the pasture grow rate changes
Two: Use the shortest grazing period possible consistent with the required rest
Three: Adjust stocking rate to match carrying capacity between and during the year
Four: Use the largest herd possible consistent with good animal husbandry practices.
Five: Use the highest stock density possible consistent with good animal husbandry practices
Correct implementation of these principles will result in improved energy flow, and better nutrient and water cycles

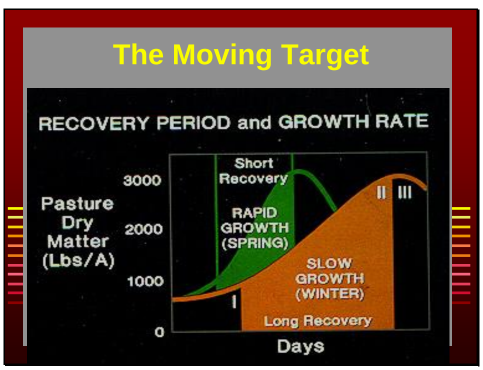


Principle 1: Adjust rest periods as the pasture growth rate changes

Pasture growth rate varies with season, temperature, moisture and nutrient levels. Although it may seem obvious, slower growing plants require more time to recover from grazing than do rapidly growing plants. In the spring, new tillers my begin to emerge, and be available to be grazed in as little as 3-4 days, but the plant will not have recovered from the impacts of the previous defoliation for several weeks.

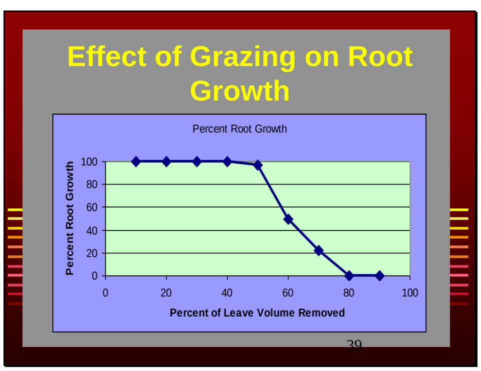


We can divide the plant grow into 3 periods or phases. Phase I is when plants have been severely defoliated. During Phase I growth depends on leaf base reserves, rather than on photosynthesis. Grow rate is very low, the quantity of growth is low, but since it is tender and high in protein and soluble sugars it is of very high quality, and is highly palatable to the animals. Phase II occurs when enough new leaves have developed that the new growth can be supported by the photosynthesis carried on in the leaves and does not depend on using plant reserves. During Phase two, growth rate is as rapid as possible, and the quality of the forage is still very good, and lots of high quality forage is produced in a relatively short period of time, and plant reserves are replenished. Eventually, as herbage mass accumulates, it begins to become lignified and less digestible, the newer leaves begin to shade the older leaves that begin to die. Growth rate diminishes or retreats and forage quality begins to drop. This is phase III, when we would normally harvest hay at the beginning of Phase III. Phase III has lots for herbage mass but it is of reduced quality.



Unfortunately, the optimum amount and timing of rest is a moving target. The time of year, the amount of soil moisture, the amount of soil nutrient, the previous level of defoliation, and physiological state of the plants all affect the re-growth rate. Managing the timing and amount of defoliation to optimize energy capture to meet our production and ecological objectives is our job.

While severe defoliation is not over-grazing, it significantly extends the necessary recovery period to prevent over-grazing, and opens the door for subsequent over-grazing.

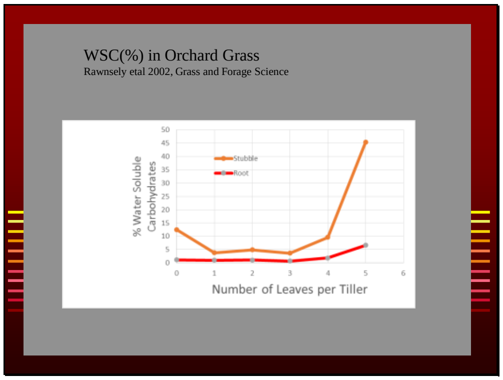


Let us look at the impact of defoliation on root growth. Here we have data from a study where the plants were defoliated, and the amount of root growth in the following period was compared to the defoliated control. You can see that when we remove 50% of the top growth, we begin to severely impact the rate of root grow, and by the time we have reached 80% defoliation, we have completely stopped root growth. This is the basis of the old saw of "take half, leave half", which works pretty well in systems with a single grazing.

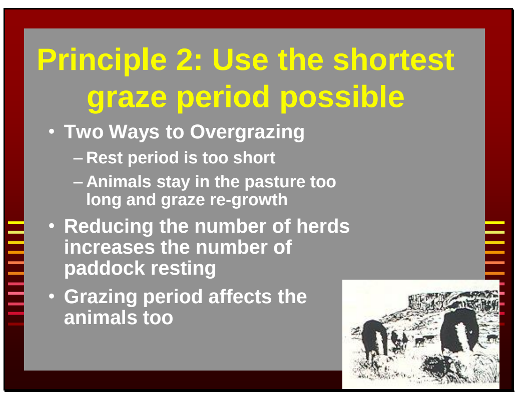
When we exceed 50% defilation, the new top grow has to come from energy reserves in the plant, from the roots or leaf bases. While this varies somewhat from specie to specie, lets think about the impact of this over time. Re-grazing the plant before it has had time to replace normal root replacement and the impacts of the current defoliation on root mass, reduces its root volume and depth making it harder for it to gather soil nutrients and moisture. As a result, the plant grows more slowly, and is re-grazed again before it has had time to recover. The downward spiral continues until the plant dies. That's overgrazing!

The most desirable plant growth from the perspective of the grazing animal is the new tender shoots that re-grow, and not the old rank leaves or seed heads. If animals are permitted to return and re-graze the new growth, root reserves are depleted, root growth is restricted or stops, the root zone diminishes, and the PLANT eventually dies. This happens first to the most palatable plants in the pasture, and proceeds down the order of animal preference.

This slide demonstrates the difference in root growth associated with repeated close defoliation. The plant on the right has continually been clipped to a height of 1 inch whenever an inch of growth had occurred. Notice that there are practically no roots, the leaves are narrow and the individual plants are distinct, exposing bare soil. An inch of grow was removed from the plant 2nd plant from the left whenever it reached a height of 6 inches. Notice that it has nearly the same root volume and depth as the unmolested plant on the far left.



We have seen this data before…it is telling us that vegetative plants need to have 4-5 collared leaves before they have "recovered"

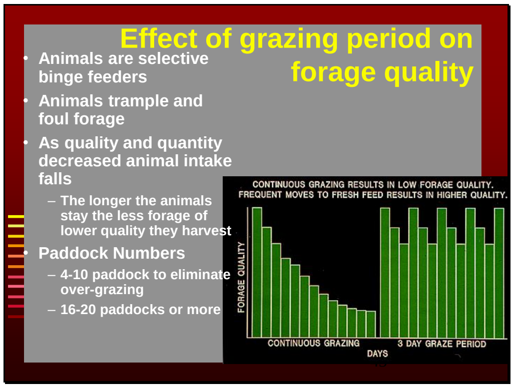


Principle 2: Use the shortest grazing period possible.

There are two ways to overgraze. One, if the plants do not have adequate rest to recover from grazing before the next grazing episode Or, two, if the animals stay in the pasture too long and can graze re-growth. When the first situation exists, often most of the plants in the pasture will suffer together. When the second situation exists, usually the most desirable plants will be affected. By keeping grazing periods short, we can prevent overgrazing by not permitting animals to graze re-growth, and by permitting adequate recovery or rest for **all** the plants in the pasture. In the spring, grazing periods should be limited to 3-4 days, the time required for new tillers to begin to form, and later in the year this may be extended to 7-10 days depending on the situation.

Whenever we can reduce the number of herds that we are managing, we can generally increase the amount of entire pasture area that is receiving rest.

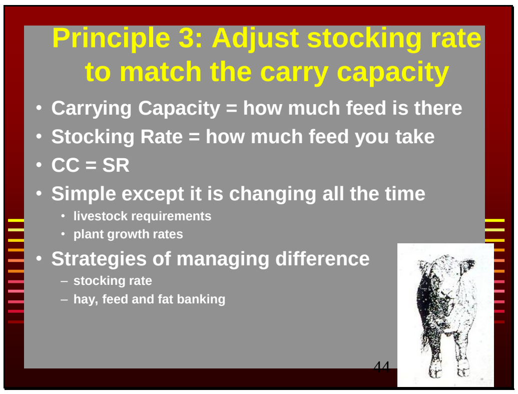
The grazing period also affects the performance of the livestock. Short periods improve livestock performance. There is a lot of truth to the old saw, "they eat the best, and tread on the rest".



Animals are binge eaters. When first turned into a new paddock, feed quality is high and the eat all of the very best parts of the best quality plants they can consume. After they fill up they rest, ruminate, trample, defecate and urinate, reducing the quality and acceptability of the rest of the forage in the paddock. As the feed quality decreases, so does their feed intake, and consequently their performance as well.

Reducing the grazing period for the paddock as much as feasible, reduces negative quality influence and results in higher feed quality, intake and animal performance.

So how man paddocks does one need. Over grazing can usually be stopped with 4-10 paddocks…usually 8 is suggested. However, if you need to get superior performance from growing animals you will want more paddocks so that feed intake and quality remain high.



Principle #3 is to adjust the stocking rate to the carrying capacity.

We can think of carrying capacity as the amount of feed that is available over a given period of time, and we can thing of stocking rate as the amount of feed needed to meet the nutritional demands of the livestock we want to pasture. If we expect our animals to grow or perform in other ways, our available forage needs to meet or exceed our animal demand. This does not sound like too big a problem, but it is more complicated that it seems. Herbage grow rates vary with season and year, and stocking rate changes with class of animal, reproductive status and absolute growth! Matching these two factors a a continuous juggling act!

Sometimes we either are not very effective a matching these two factors or we have period of slow or no-growth that we have to deal with. Strategies for dealing with this issue include:

Changing animal demand by changing stocking rate or season of use, eg. Changing the calving season.

Store energy as hay or silage-the "hay bank" Varying the stocking rate

Store energy in the field—the "feed bank".

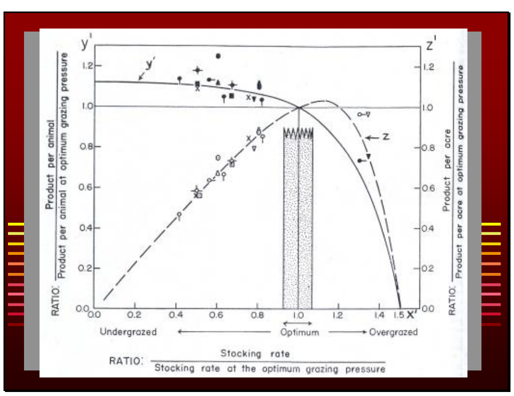
Store energy as animals reserves –the "fat bank"

Principle 3

Change your stocking rate to match what you have -- simple right?

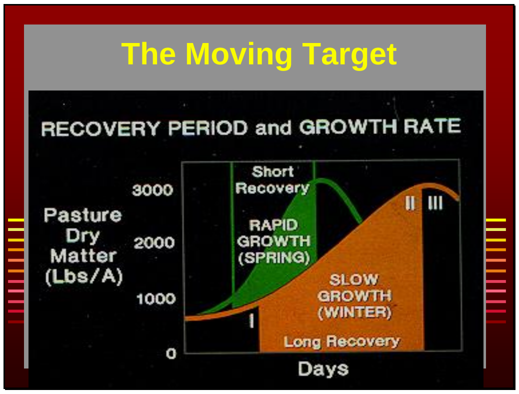
Sounds simple, but this too is a moving target, since the amount and quality of feed are changing, and the nutrient requirements of the livestock are changing as well

We need strategies or ways to deal with these differences between needs and availability. One way of course is to change the number of animals to meet the feed availability.



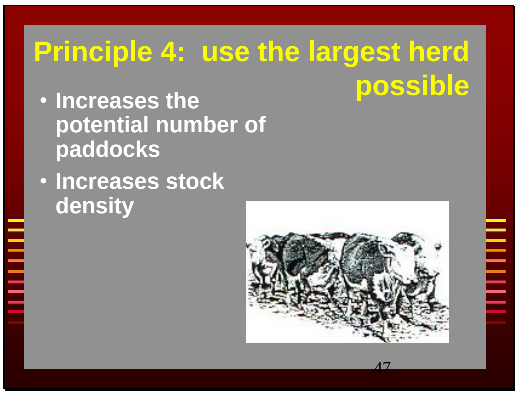
This is a Mott Curve, named for the man who invented it. The Mott Curve shows that when we put one animal in a pasture that they can "always" find a diet adequate for maximum animal performance, but the production per unit area is low. As we add more animals, the competition between animals lowers their individual performance, but the total per unit area is increase….UNTIL we exceed the "optimum. Then everything goes to heck in a handbasket…and in a big hurry.

The trouble with the Mott Curve is that there is one for every situation, and nobody really knows what it characteristics are until after…..



Unfortunately, the optimum amount and timing of rest is a moving target. The time of year, the amount of soil moisture, the amount of soil nutrient, the previous level of defoliation, and physiological state of the plants all affect the re-growth rate. Managing the timing and amount of defoliation to optimize energy capture to meet our production and ecological objectives is our job.

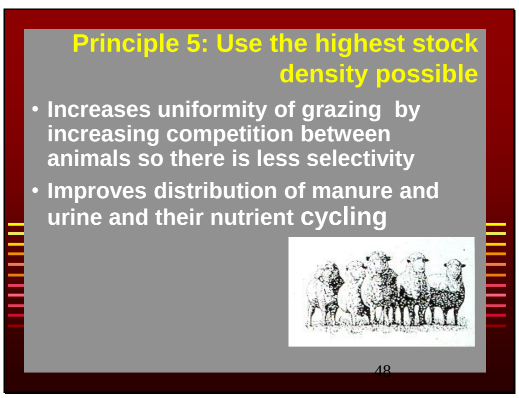
While severe defoliation is not over-grazing, it significantly extends the necessary recovery period to prevent over-grazing, and opens the door for subsequent over-grazing.



Principle 4: Use the largest herd possible consistent with good animal husbandry practice.

First of all, when we have several small herds, we tend to spread them out over the available area, just because it becomes hard to have enough paddocks to manage the pasture properly. This usually leads to a larger proportion of the pasture being exposed to grazing for longer periods of time, which impinges upon our second principle to keep the grazing period as short as possible.

Secondly, have large herds permits us to manage stock density to reach our grazing objectives more easily. We will discuss stock density with principle 5.



Principle 5: Use the highest stock density consistent with good animal husbandry and your objectives.

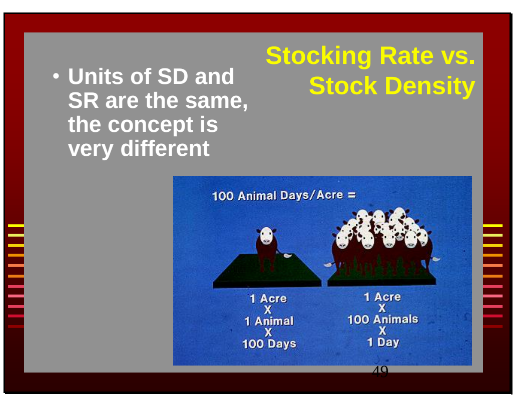
Higher stock densities increase competition between animals for forage. This results in less selectivity on the part of the animals and greater uniformity of pasture utilization. Higher stock density also increases the uniformity of redistribution of manure and urine, improving nutrient cycling.

The units of stock density, animals per acre or lbs of live weight per acre, are the same as the units of stocking rate. However, stocking rate and stock density are definitely different concepts!

Increases competition between animals so there is less selectivity therefore more uniform

Improves distribution of manure and there for nutrient cycling

SD is not the same as SR



Close your eyes and image two identical one acre pastures on the same day. In the first pasture you put one animal and you leave it for 100 days. In the second, you put 100 animals for one day. What will you find at the end of each of these grazing period?

If your experience and intuition is similar to mine, the one cow for 100 days will be patchy with short places and wolf plants, under and over grazing side by side. The 100 cows for 1 day will be grazed off pretty uniformly. You might find that it is severely grazed, but it will not be over grazed.

Both of these pastures will have experienced the same stocking rate—100 animal days per acre, but quite different stock densities.

Summary

- The business of ranching is capturing and selling solar energy
- Ranchers need to optimize the capture of solar energy by growing as much useful plant material as possible
- Energy flows through ecosystems while nutrients cycle
- Succession is one way to look at how effective energy capture is, and is affected by abiotic and biotic components of the ecosystem
- Grazing management impacts the effectiveness of energy capture by influencing the ability of plants to recover from grazing

Summary

- Tiller weight and numbers are the basis of yield and there are critical times during the year when initiation of tillers can be negatively impacted by management
- The bottom 3-4 inches of the grass plant belongs to the plant. This is were the grass plants energy reserves are for winter survival and tiller initiation.
- Plants that are kept in the lag phase of growth are low producing open the ecosystem to penetration by unwanted plants
- There are five principles that can be applied to grazing management that all stem from the fact that :