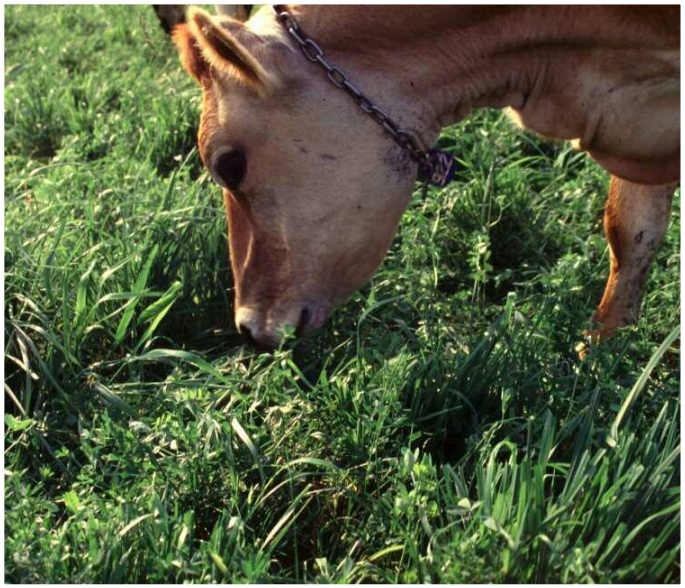
Forage Response to Defoliation – Basic Principles and Application



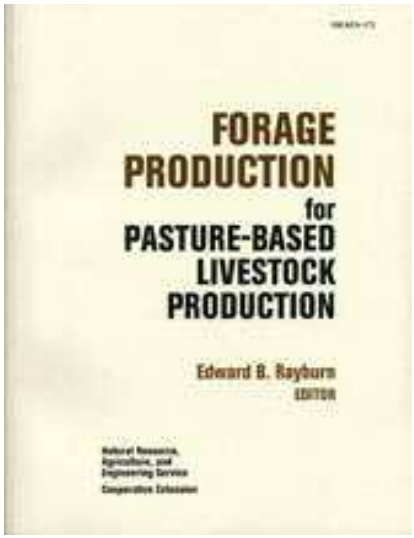
Presented by:
Sid Bosworth
Extension Forage Agronomist
University of Vermont

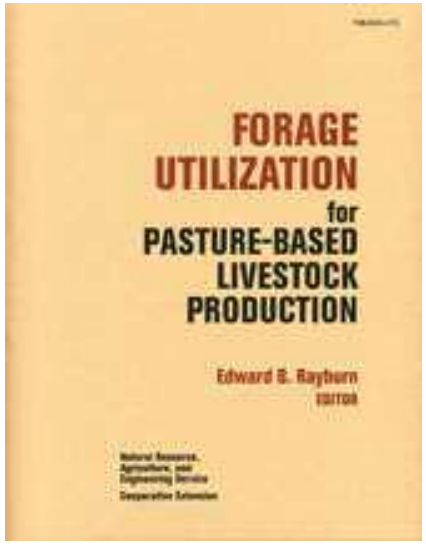
NORTHEAST SARE
Sustainable Agriculture Research & Education
Professional Development Program

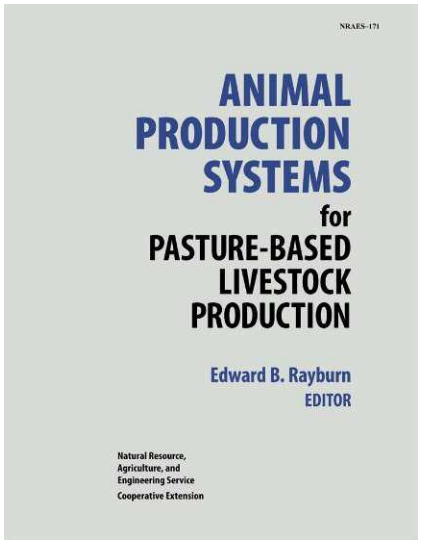
New England Forage & Weed ID and Management Training Project

Resources

PALS PLANT AND LIFE SCIENCES PUBLISHING
FORMERLY NRAES



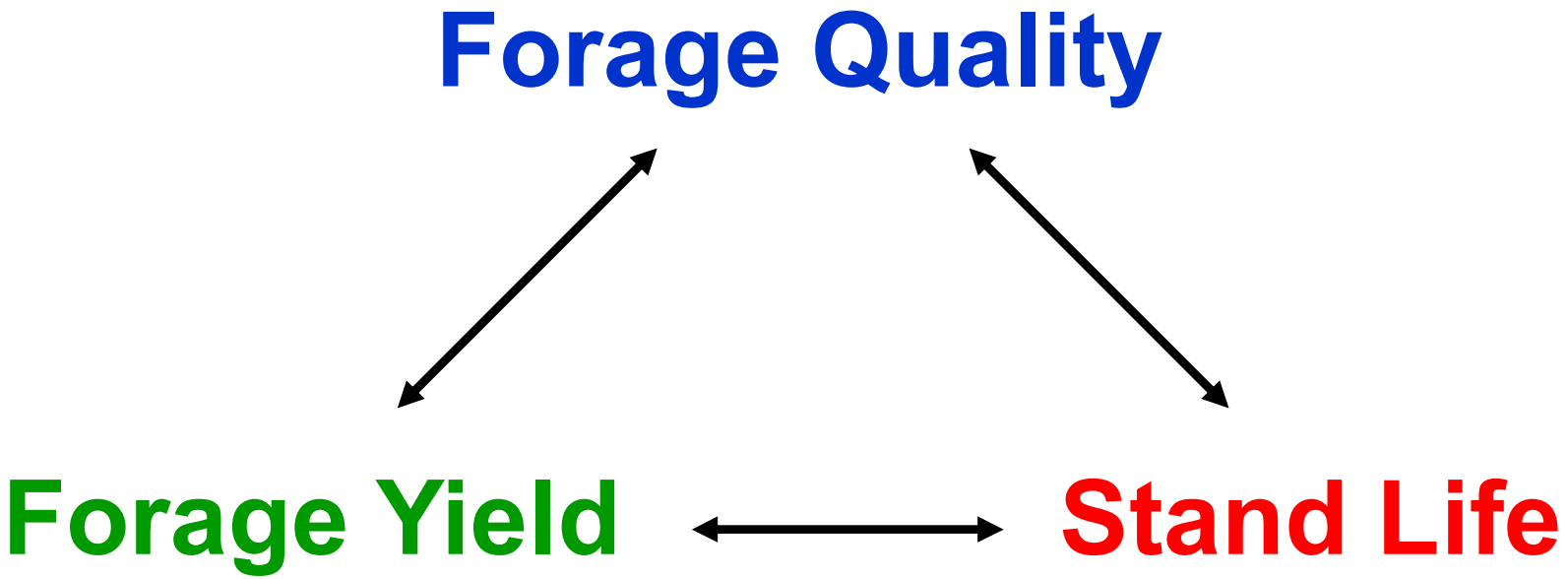




http://palspublishing.cals.cornell.edu/nra_order.taf

Our PDP website: http://pss.uvm.edu/pdpforage/

Importance of Defoliation Management

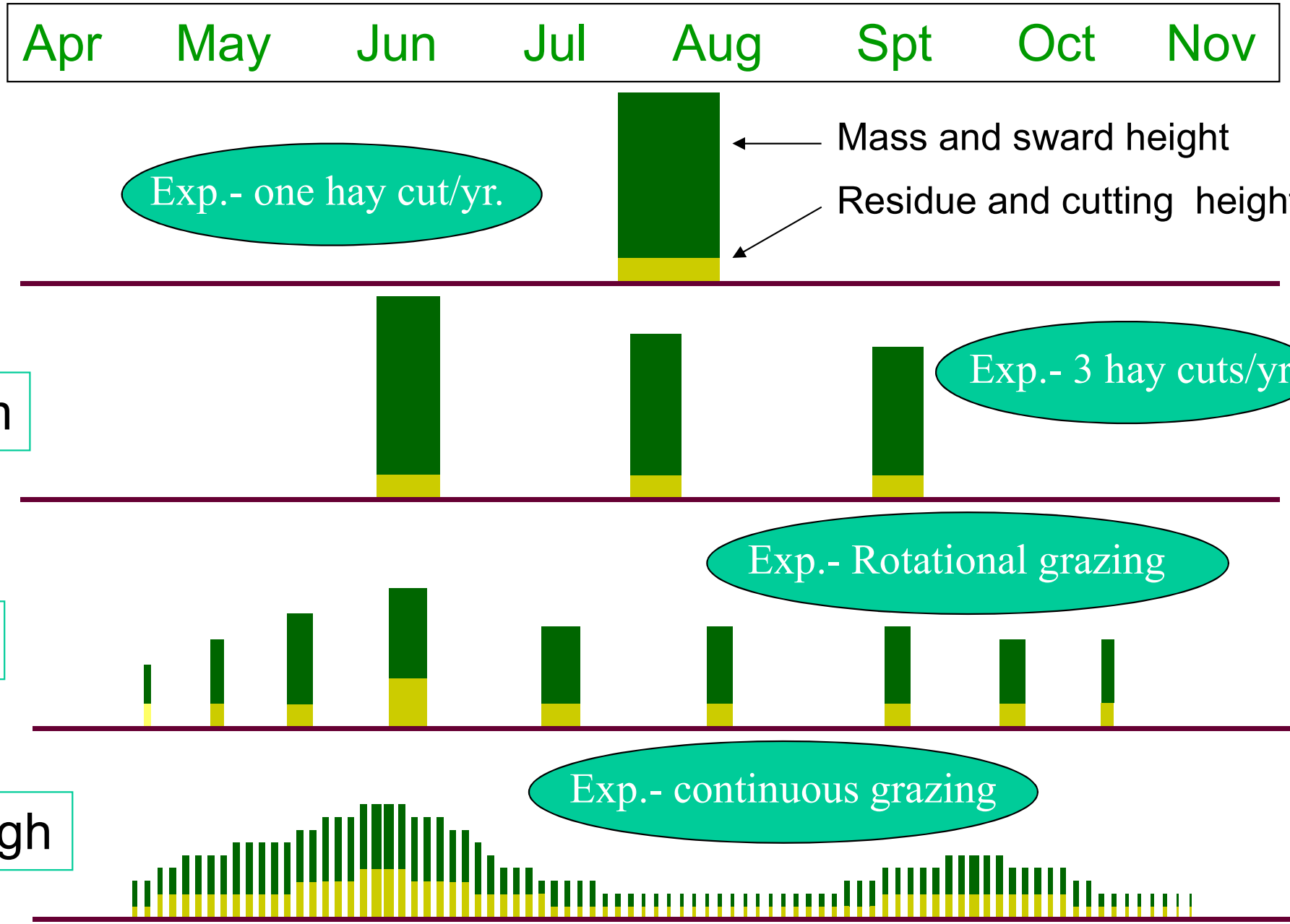


An important goal in most forage programs is to maximize economic yield of nutrients while insuring stand persistence.

Elements of Defoliation

- Timing of first harvest in a season
- Frequency of harvest (time interval)
- Timing of the last harvest
- Number of harvests per year
- Defoliation height
  - Sward height or mass
  - Stubble or cutting height or residue

Defoliation Intensity



Defoliation Intensity

What is the affect of defoliation intensity on:

- Growth Rate and Yield
- Seasonal distribution
- Forage Quality
- Stand persistence

What is the plant response to defoliation intensity?

Plant Response to Defoliation

The plant response to defoliation depends on many variables:

The physiological, morphological and anatomical characteristics of each forage

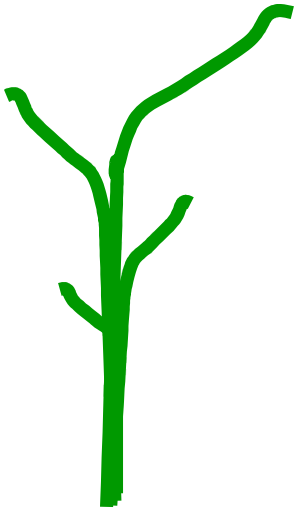
The botanical composition of the forage stand (if a mixed stand)

The environmental conditions in which forage plants are growing

Physiological Characteristics - Energy

Plants require energy for growth and maintenance.

Photosynthesis (PSN) is the primary source of plant energy in the form of carbohydrates.

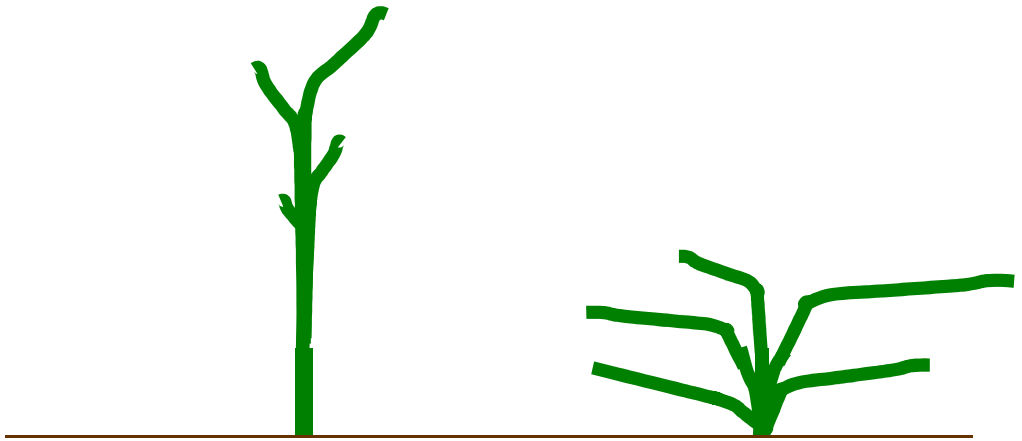


Food reserves are usually stored in roots or basal portions of perennial forages and are an important source of energy for 1) over wintering, 2) initial spring growth, and 3) regrowth after defoliation.

Photo-synthesis → **Energy for respiration and growth** ← **Food Reserves**

Morphological Characteristics

Plant Shape and Height

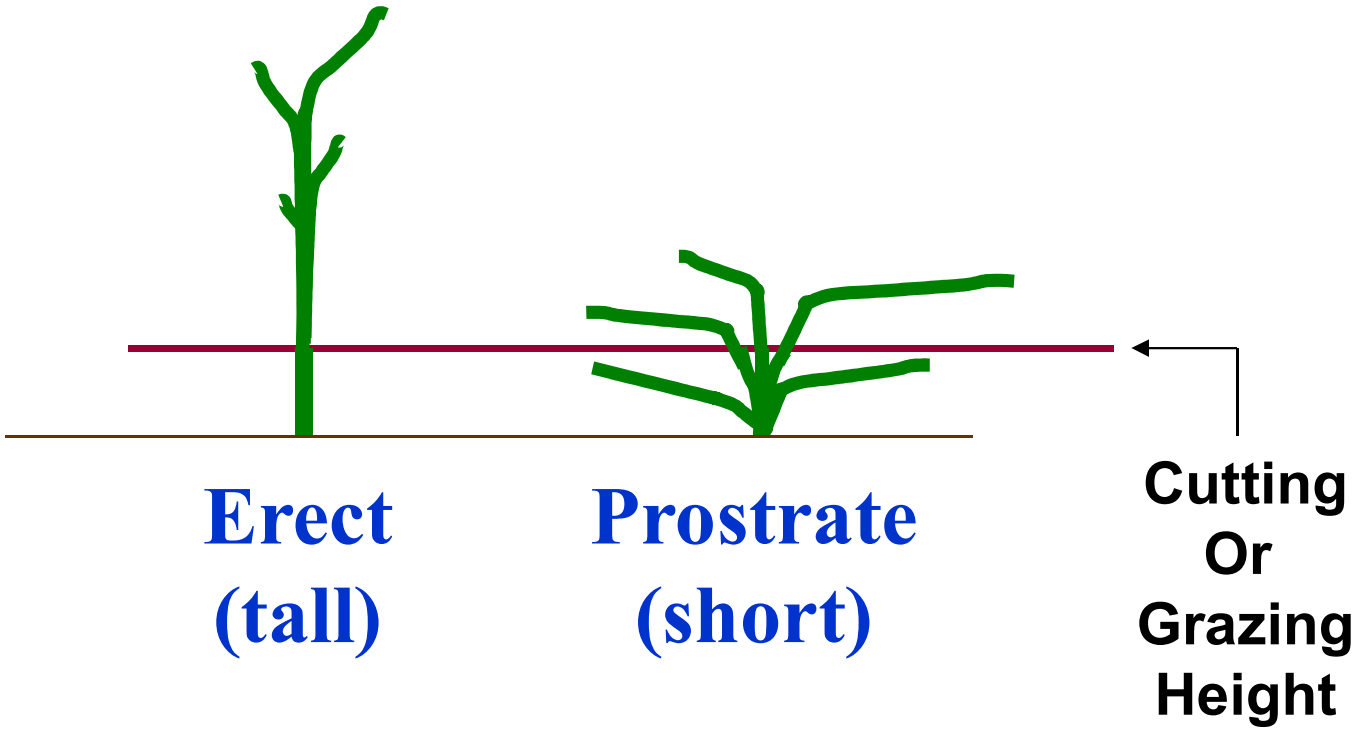


Erect (tall)

Prostrate (short)

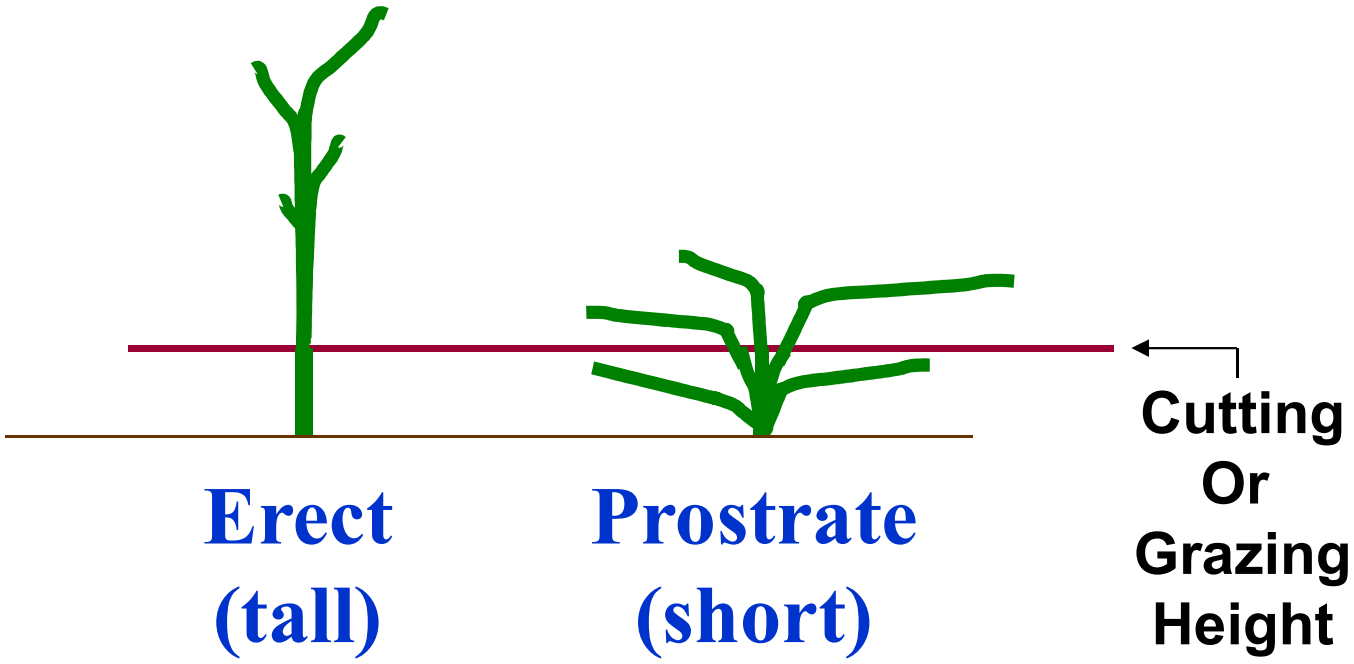
Morphological Characteristics

Plant Shape and Height

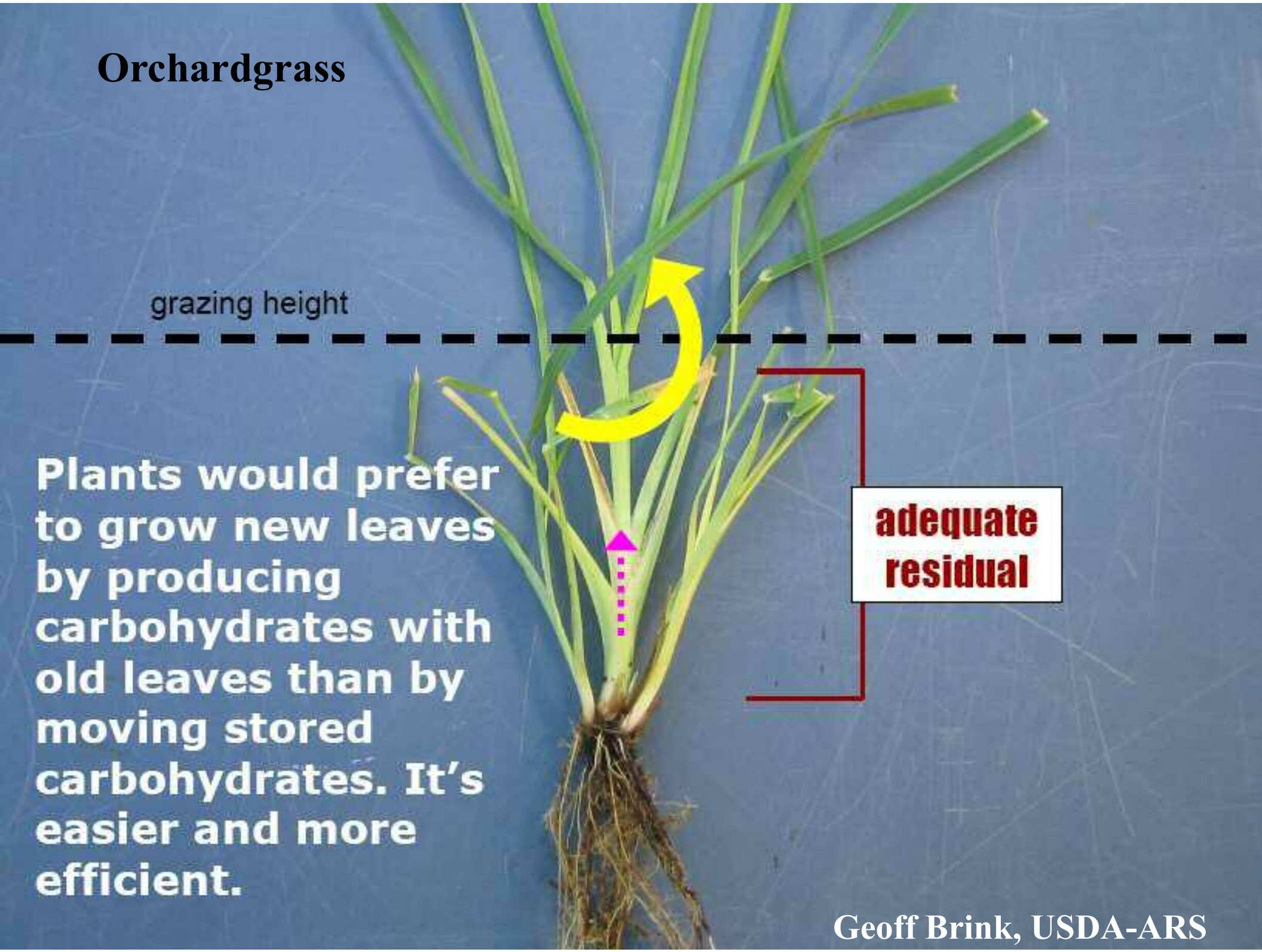


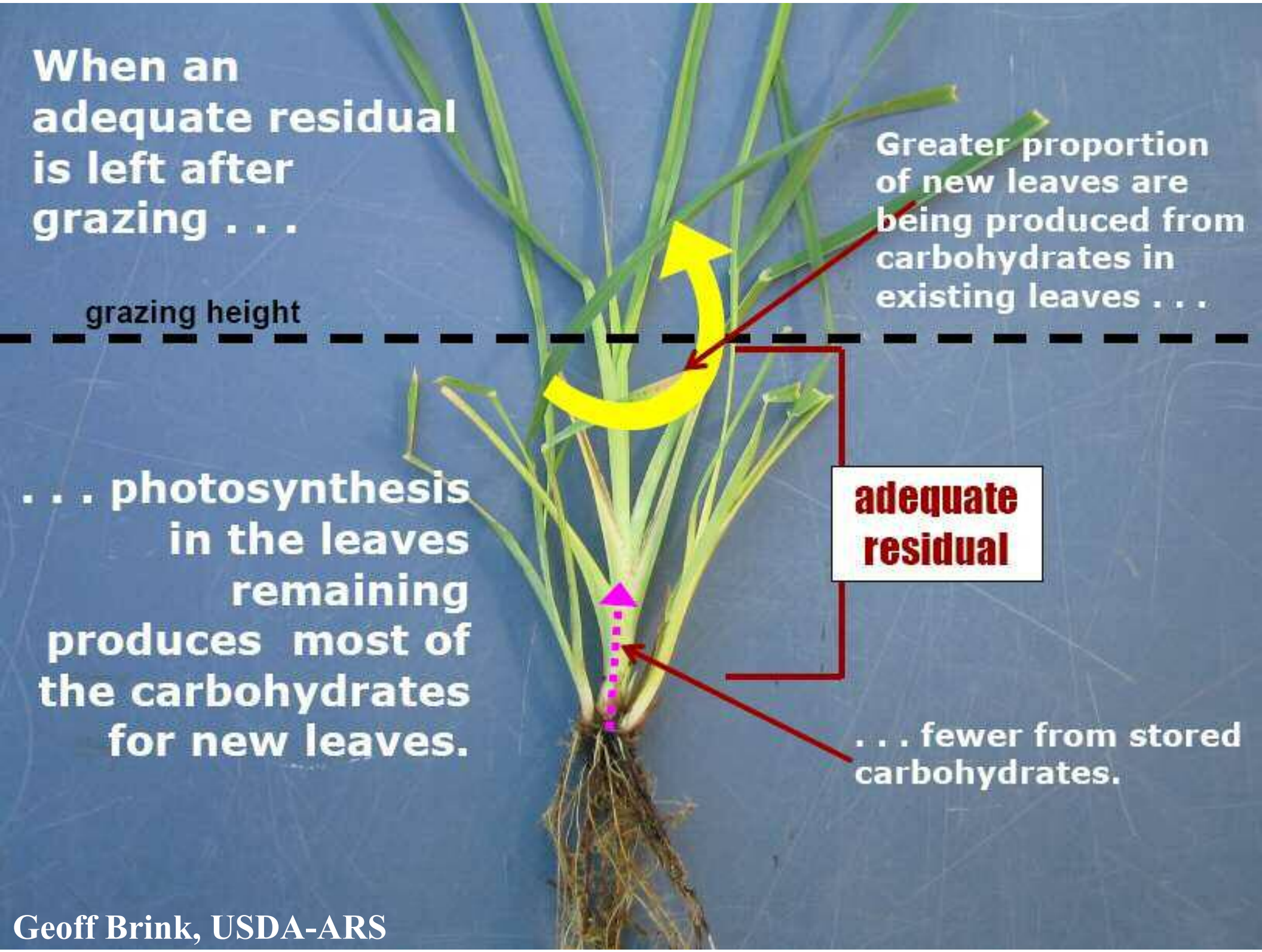
Morphological Characteristics

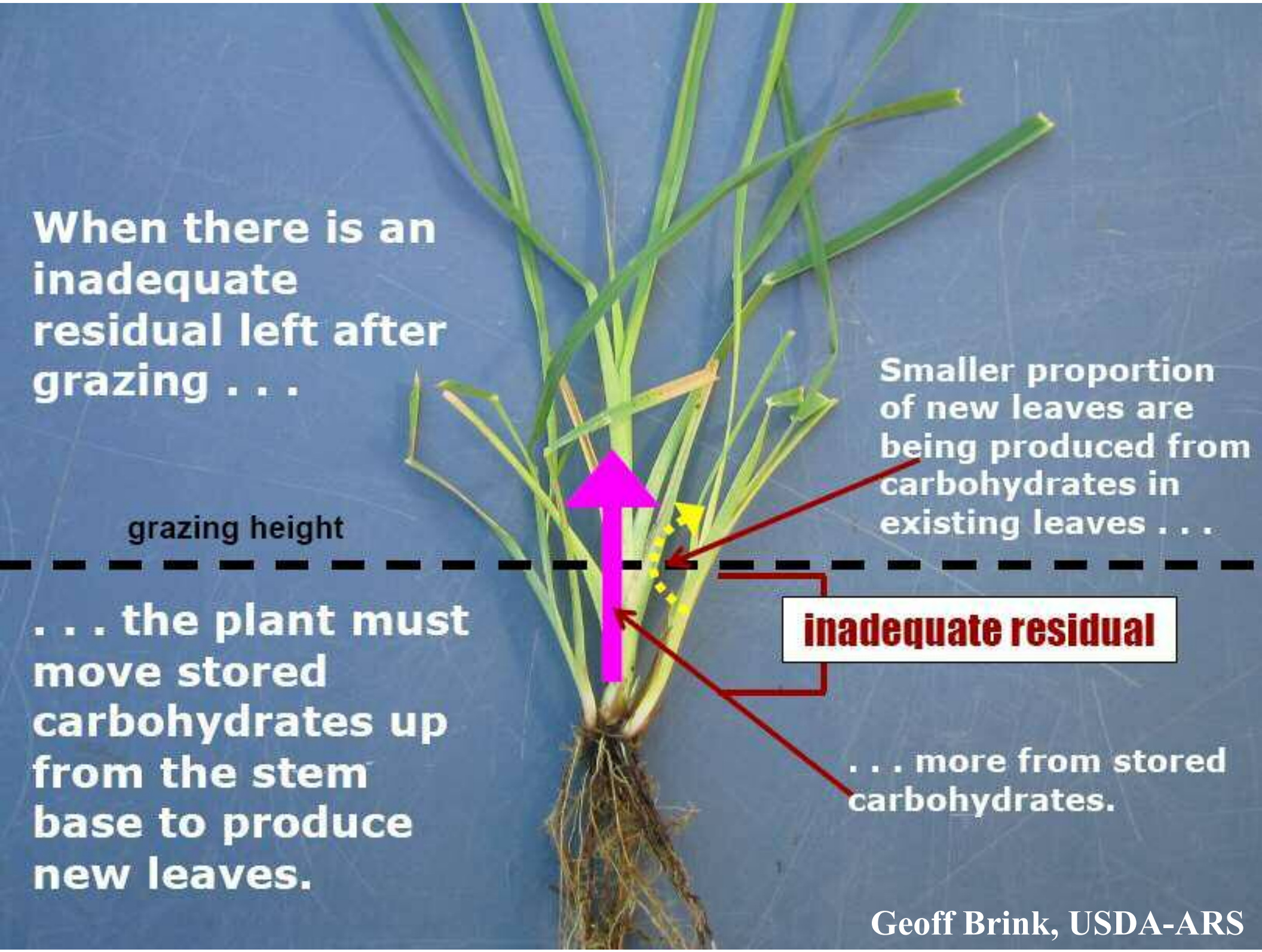
Plant Shape and Height



Upright or tall growing species must rely almost entirely on stored energy for new growth whereas short or prostrate species can utilize photosynthesis of low growing leaves for energy.


Orchardgrass
grazing height
Plants would prefer to grow new leaves by producing carbohydrates with old leaves than by moving stored carbohydrates. It's easier and more efficient.
adequate residual
Geoff Brink, USDA-ARS


When an adequate residual is left after grazing . . .
grazing height
Greater proportion of new leaves are being produced from carbohydrates in existing leaves . . .
. . . photosynthesis in the leaves remaining produces most of the carbohydrates for new leaves.
adequate residual
. . . fewer from stored carbohydrates.
Geoff Brink, USDA-ARS


When there is an inadequate residual left after grazing . . .
Smaller proportion of new leaves are being produced from carbohydrates in existing leaves . . .
grazing height
inadequate residual
. . . the plant must move stored carbohydrates up from the stem base to produce new leaves.
. . . more from stored carbohydrates.
Geoff Brink, USDA-ARS

Morphological Characteristics

Tall Species

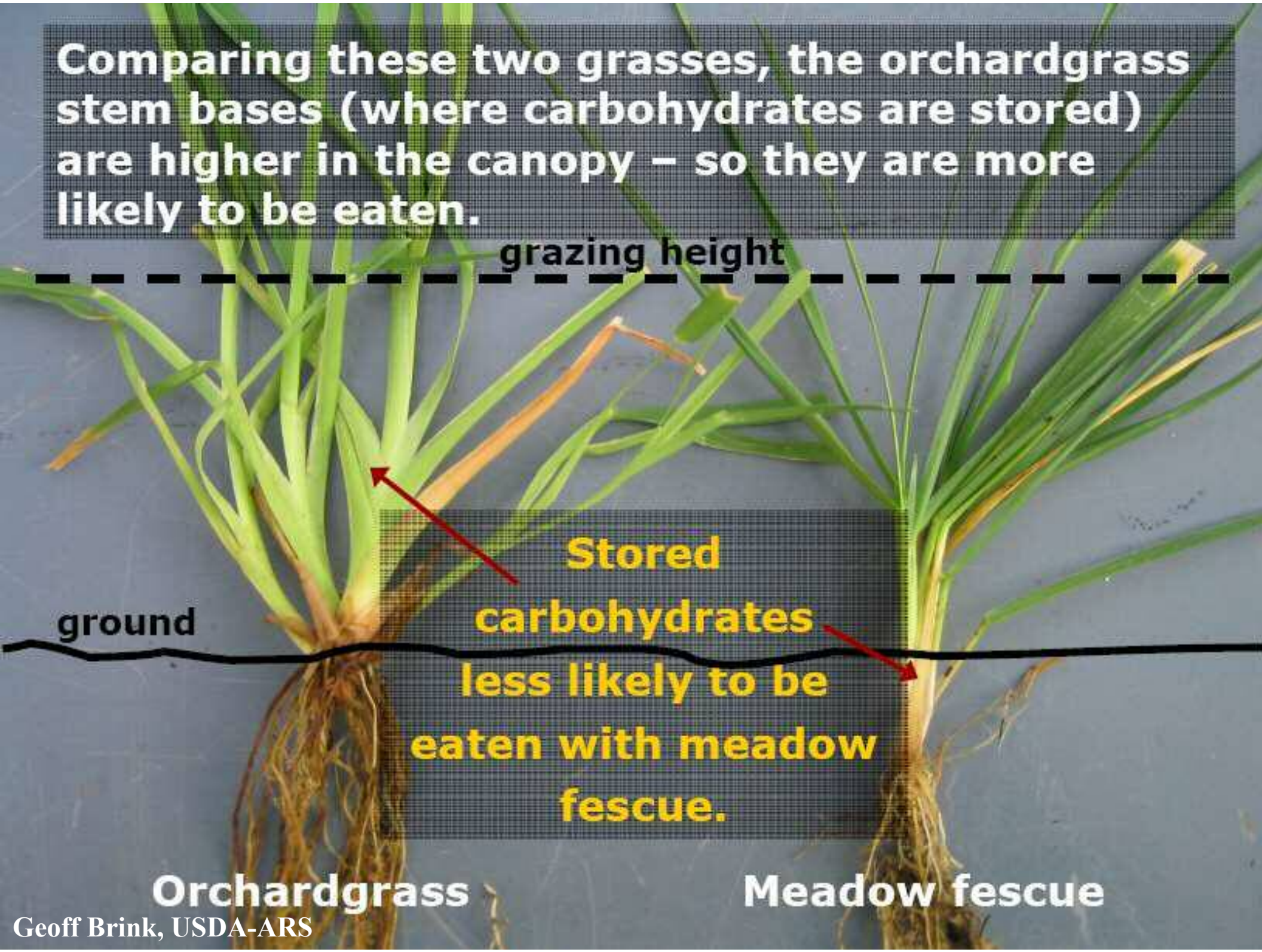
- Alfalfa
- Red clover
- Upright varieties of birdsfoot trefoil
- Alsike clover
- Timothy
- Smooth bromegrass
- Orchardgrass
- Tall fescue
- Reed canarygrass

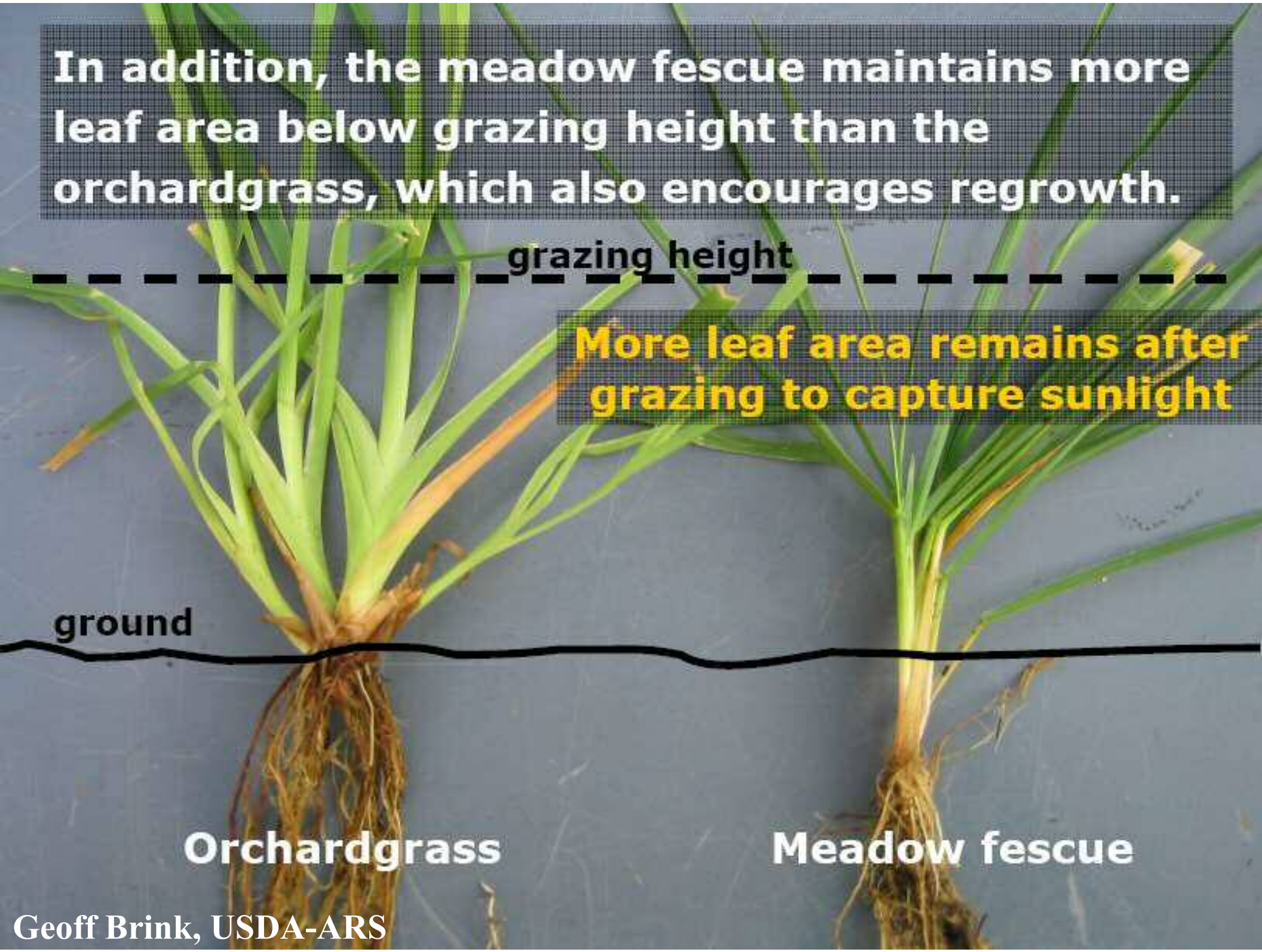
Intermediate Species

- Intermediate varieties of birdsfoot trefoil
- Ladino type of white clover
- Tetraploid Per. Ryegrass
- Meadow fescue

Short Species

- 'Empire' type varieties of birdsfoot trefoil
- Common and Dutch varieties of white clover
- Kentucky bluegrass
- Some diploid per. ryegrasses


Comparing these two grasses, the orchardgrass stem bases (where carbohydrates are stored) are higher in the canopy – so they are more likely to be eaten.
grazing height
Stored carbohydrates less likely to be eaten with meadow fescue.
ground
Orchardgrass
Meadow fescue
Geoff Brink, USDA-ARS

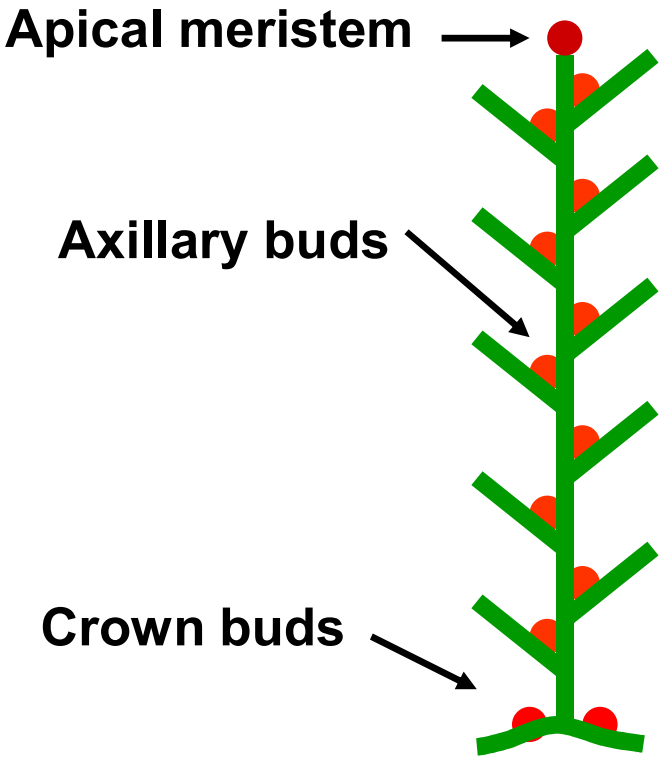

In addition, the meadow fescue maintains more leaf area below grazing height than the orchardgrass, which also encourages regrowth.
grazing height
More leaf area remains after grazing to capture sunlight
ground
Orchardgrass
Meadow fescue
Geoff Brink, USDA-ARS

Cultivars can also vary in their morphology and response to defoliation. Newer, lower growing orchardgrass varieties will persist better under more frequent and shorter residual height grazing.

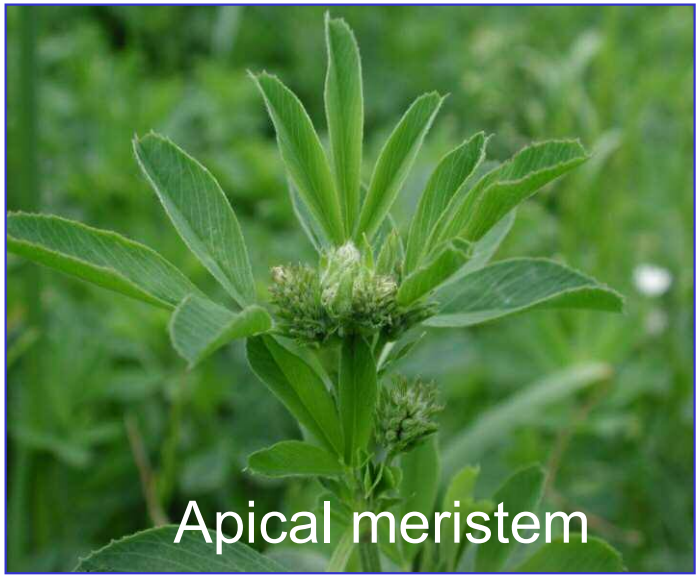
http://www.persistorchardgrass.com/testimonials.htm

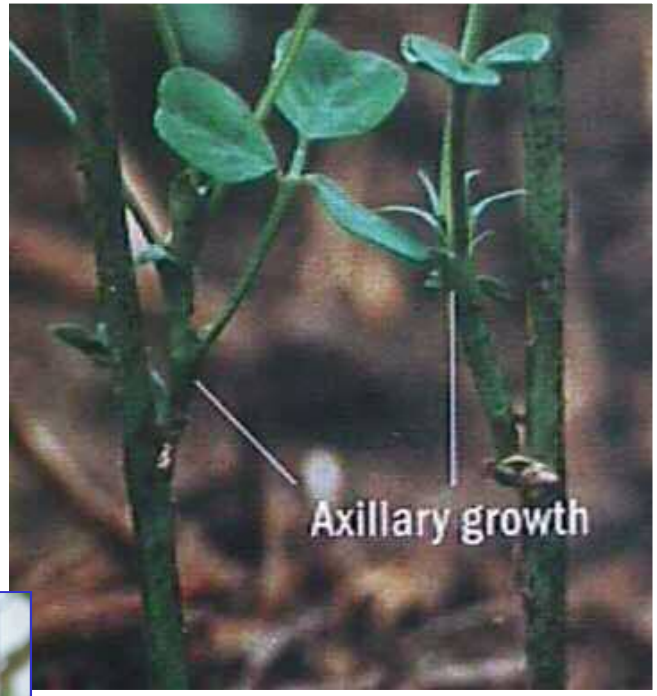
Anatomical Characteristics

Location of Growing Points



Legume Plants

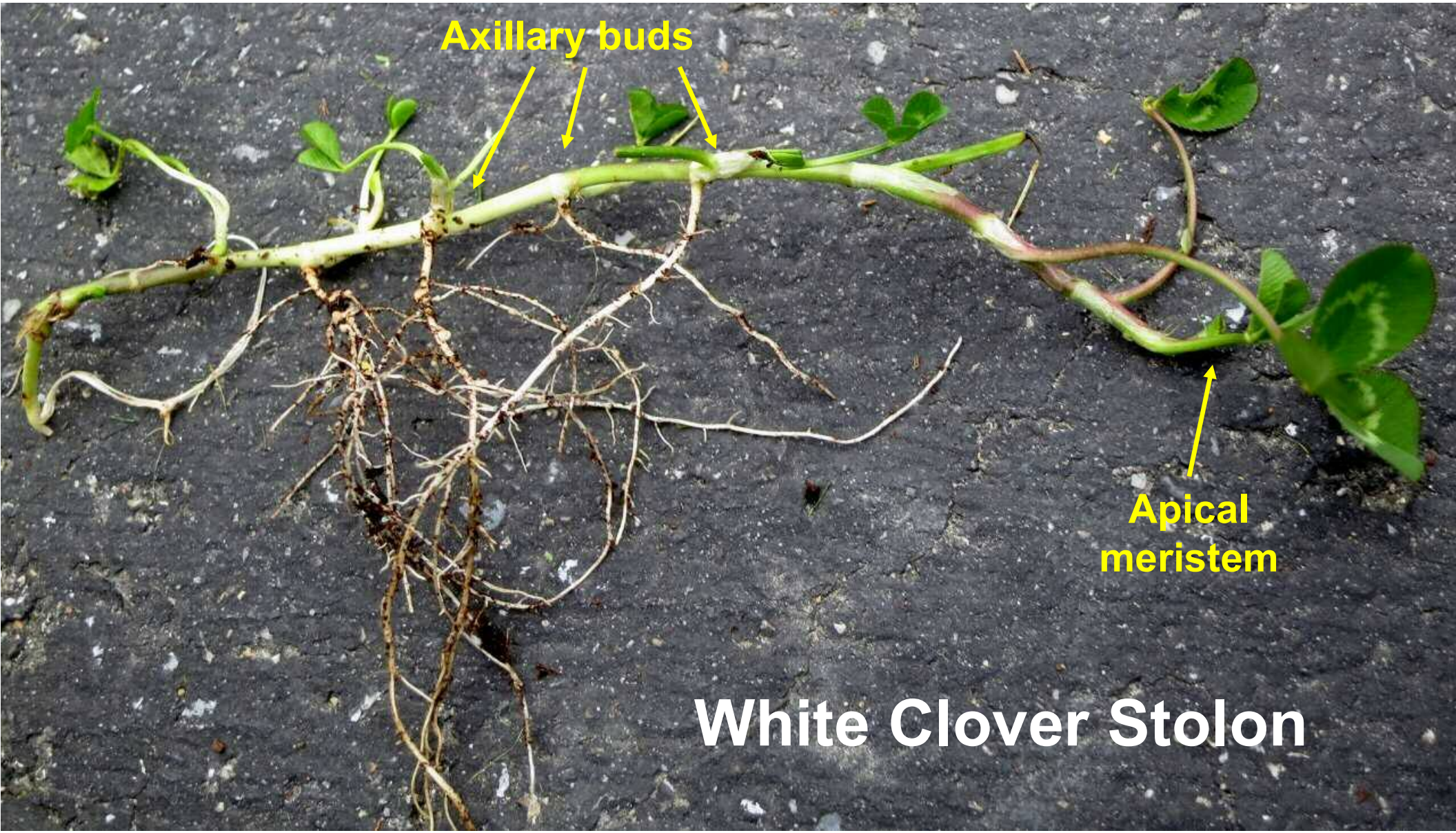




Plant Response to Defoliation

Anatomical Characteristics

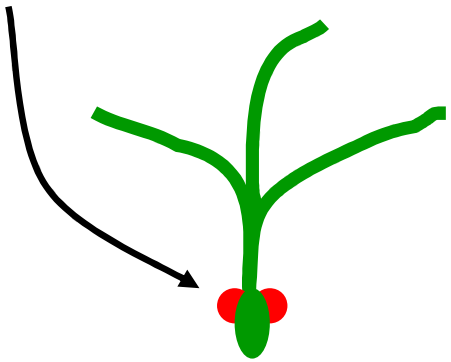
Location of Growing Points



Anatomical Characteristics

Location of Growing Points

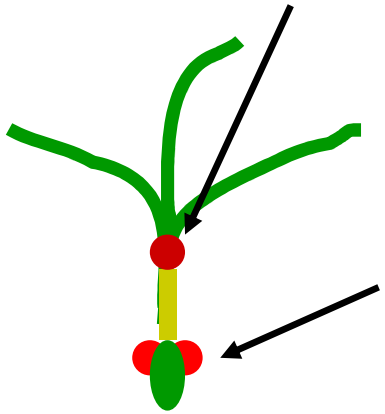
Apical meristem, axillary buds, and crown buds are all compressed at the crown



Non-jointing grasses

Axillary bud with short stem

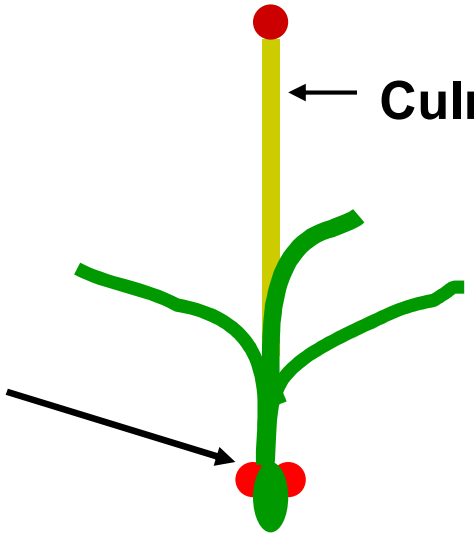
Crown buds



Jointing grasses

Apical meristem

Culm



Reproductive grass tiller

Vegetative grass tillers

Anatomical Characteristics

- Jointing grasses:

  (GP elevates at regrowth)

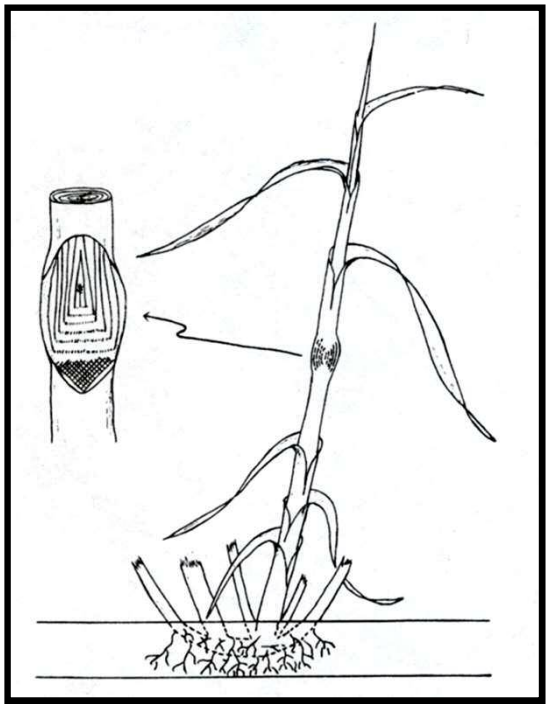
  – Timothy
  – Smooth bromegrass
  – Reed canarygrass

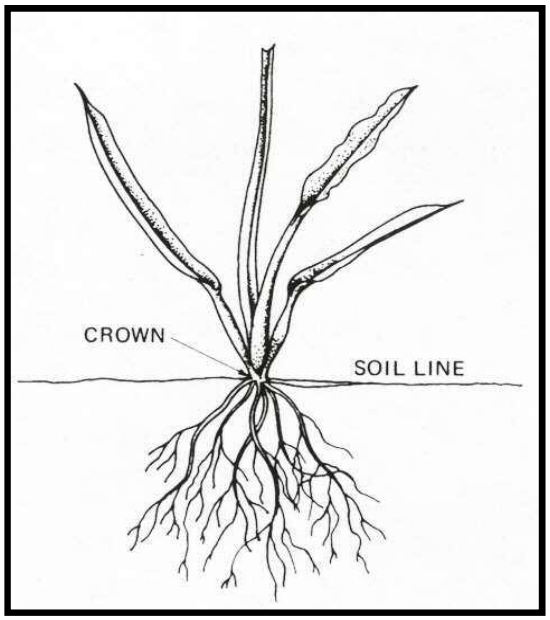
- Non-jointing grasses

  (GP stays at crown)

  – Orchardgrass
  – Tall and meadow fescue
  – Perennial ryegrass
  – Ky. bluegrass

Grass Types





Plant Response to Defoliation Intensity

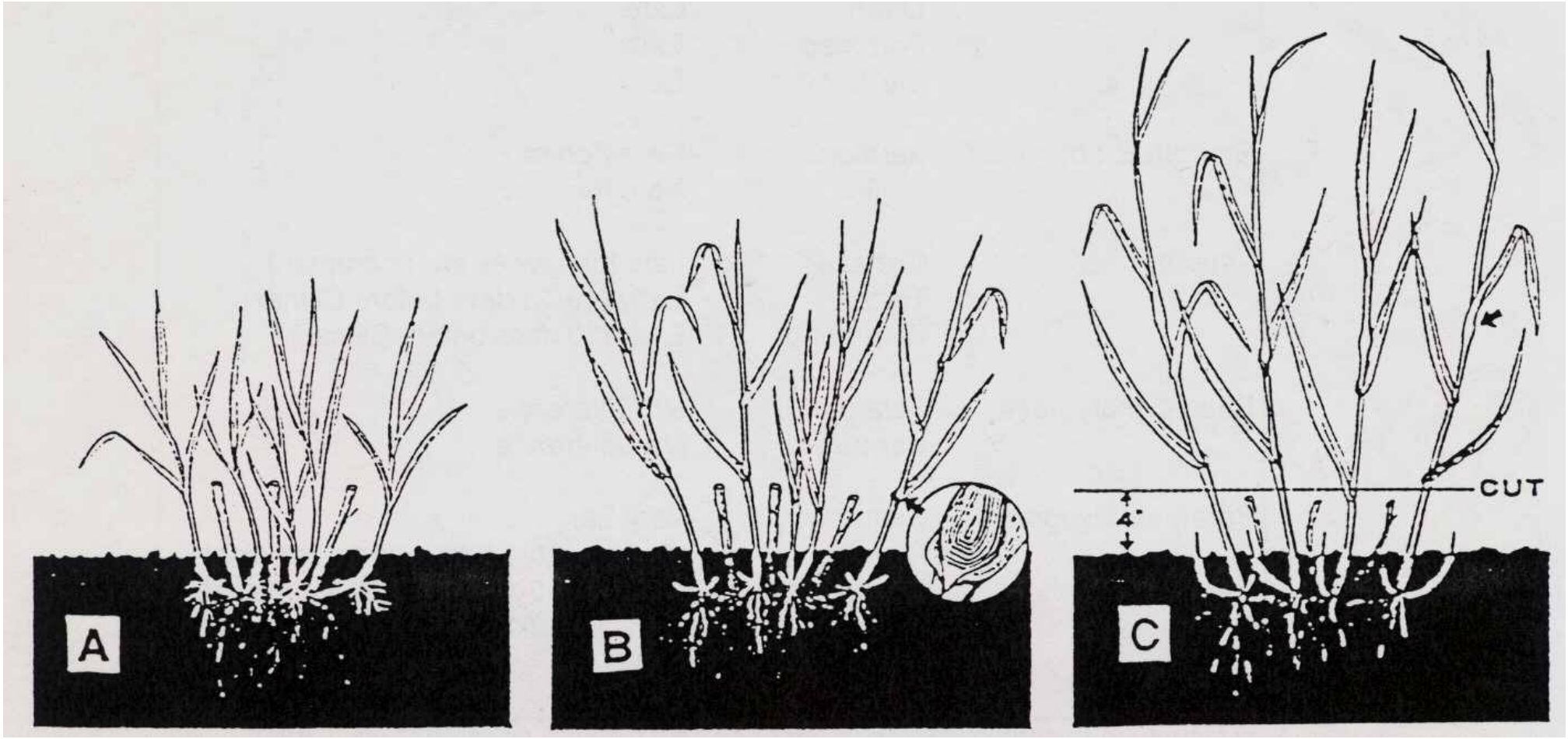
Location of Growing Points

- Non-jointed, bunch grasses (like orchardgrass, tall fescue, perennial ryegrass) can recover from defoliation quite rapidly since the growing point is below the cutting height and developing leaves never stop growing.
- Legumes and jointed grasses are slower to recover since new growth must be initiated from either crown buds or axillary buds on stems close to the ground and rely on stored energy for initial growth.

Plant Response to Defoliation Intensity

Smooth Bromegrass Aftermath Growth

(Timothy has similar response)

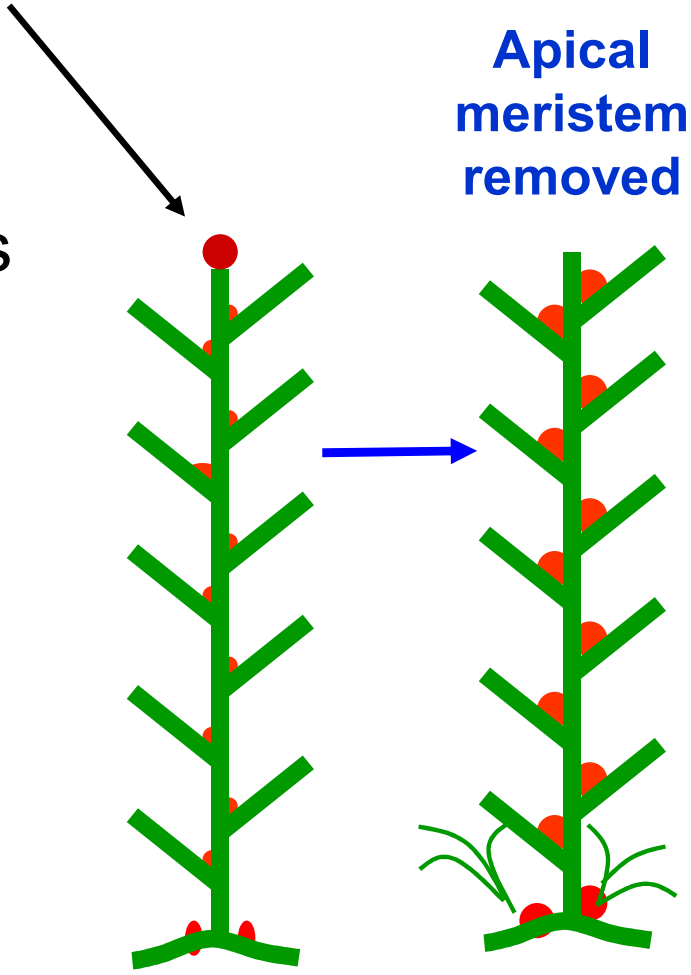


Early Regrowth **Danger Period** **Time to cut**

Plant Response to Defoliation Intensity

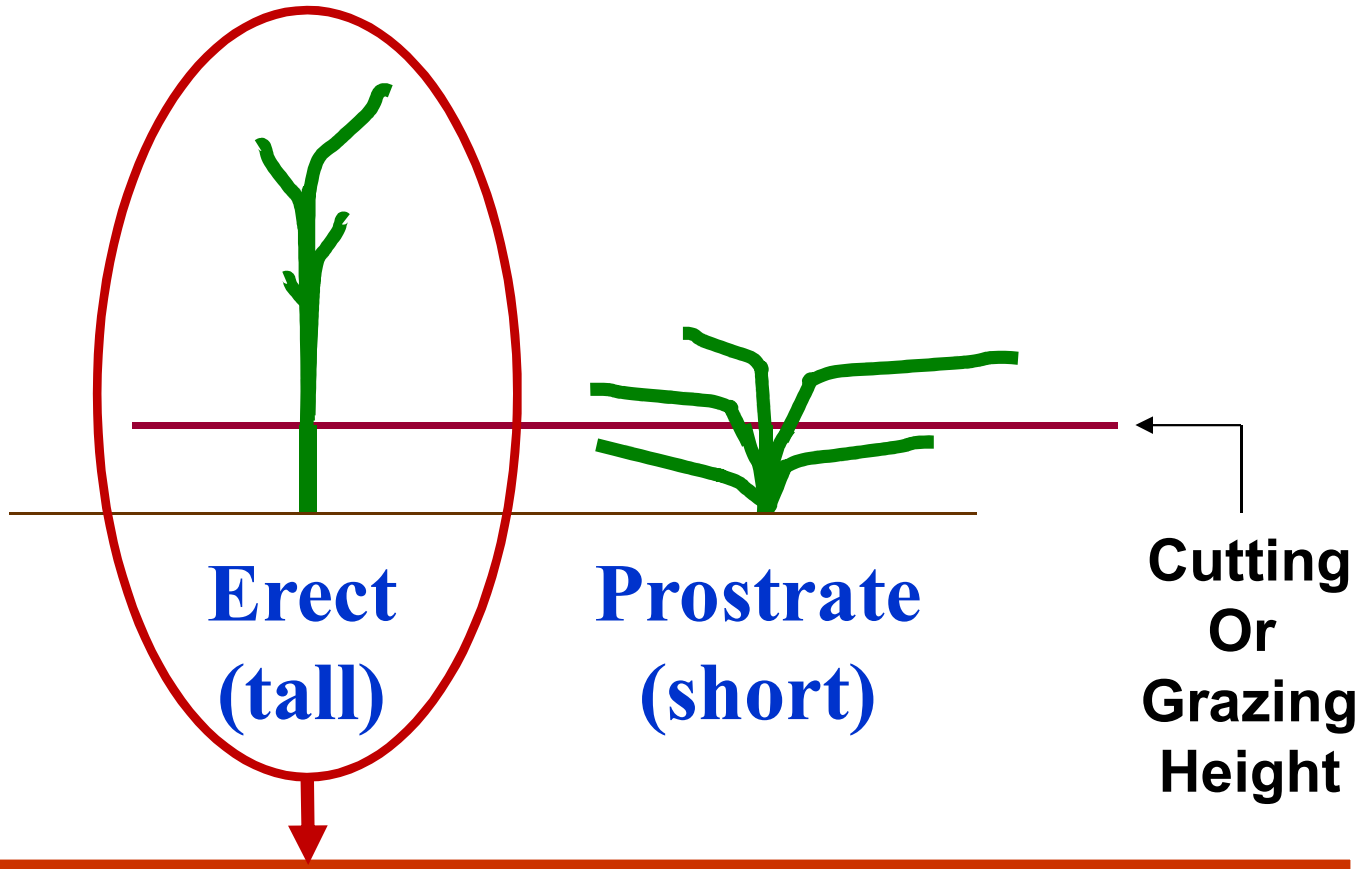
Apical Dominance

- Many species have strong apical dominance (alfalfa, red clover, timothy and smooth bromegrass) which means axil and crown bud development is inhibited until the apical meristem is removed.
- Other species such as orchardgrass express very little apical dominance (they continue to tiller and produce basil leaves even as the reproductive stem elongates).



Morphological Characteristics

Plant Shape and Height

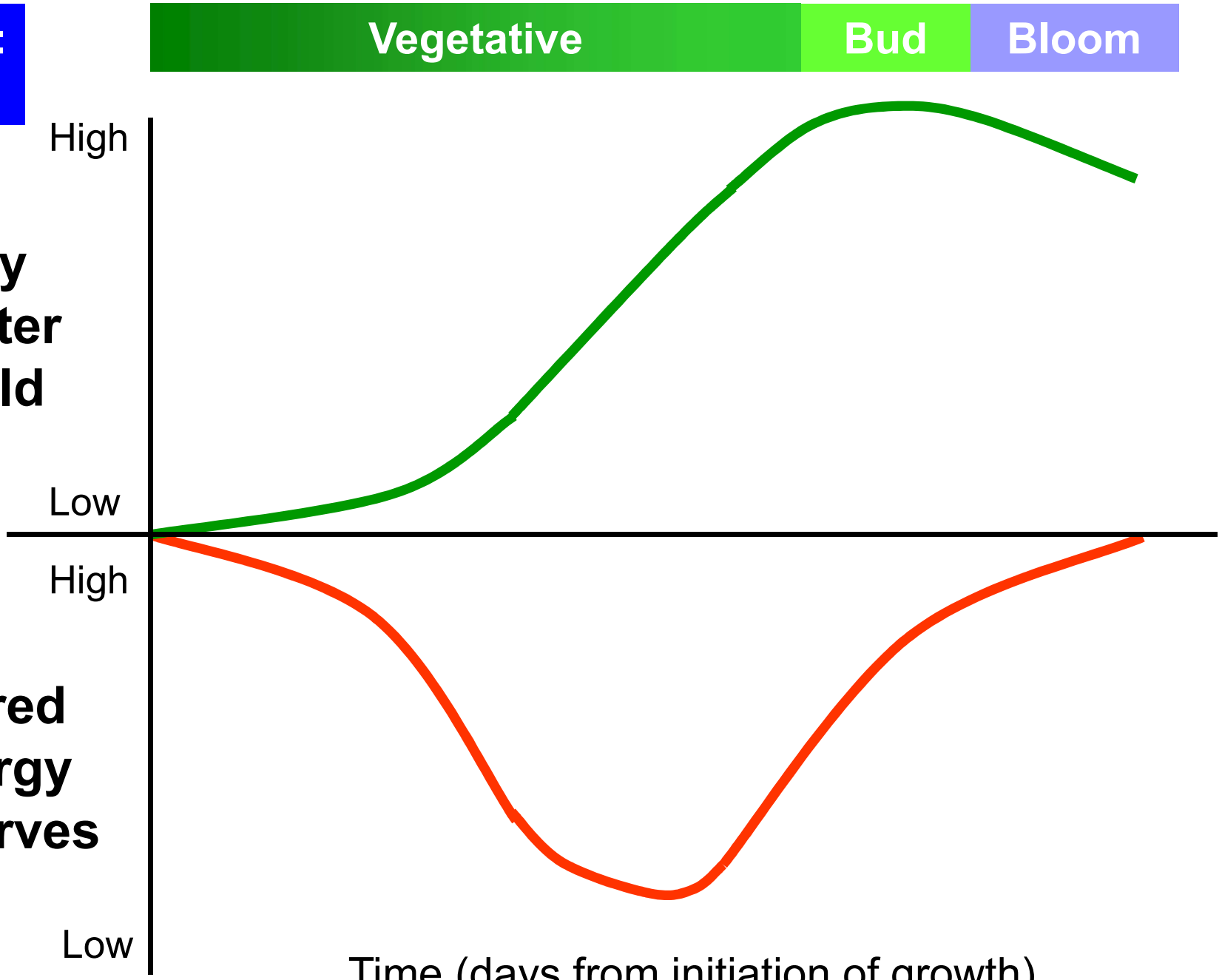


Upright or tall growing species or species with strong apical dominance must rely almost entirely on stored energy for that initial new growth

Plant Response to Defoliation

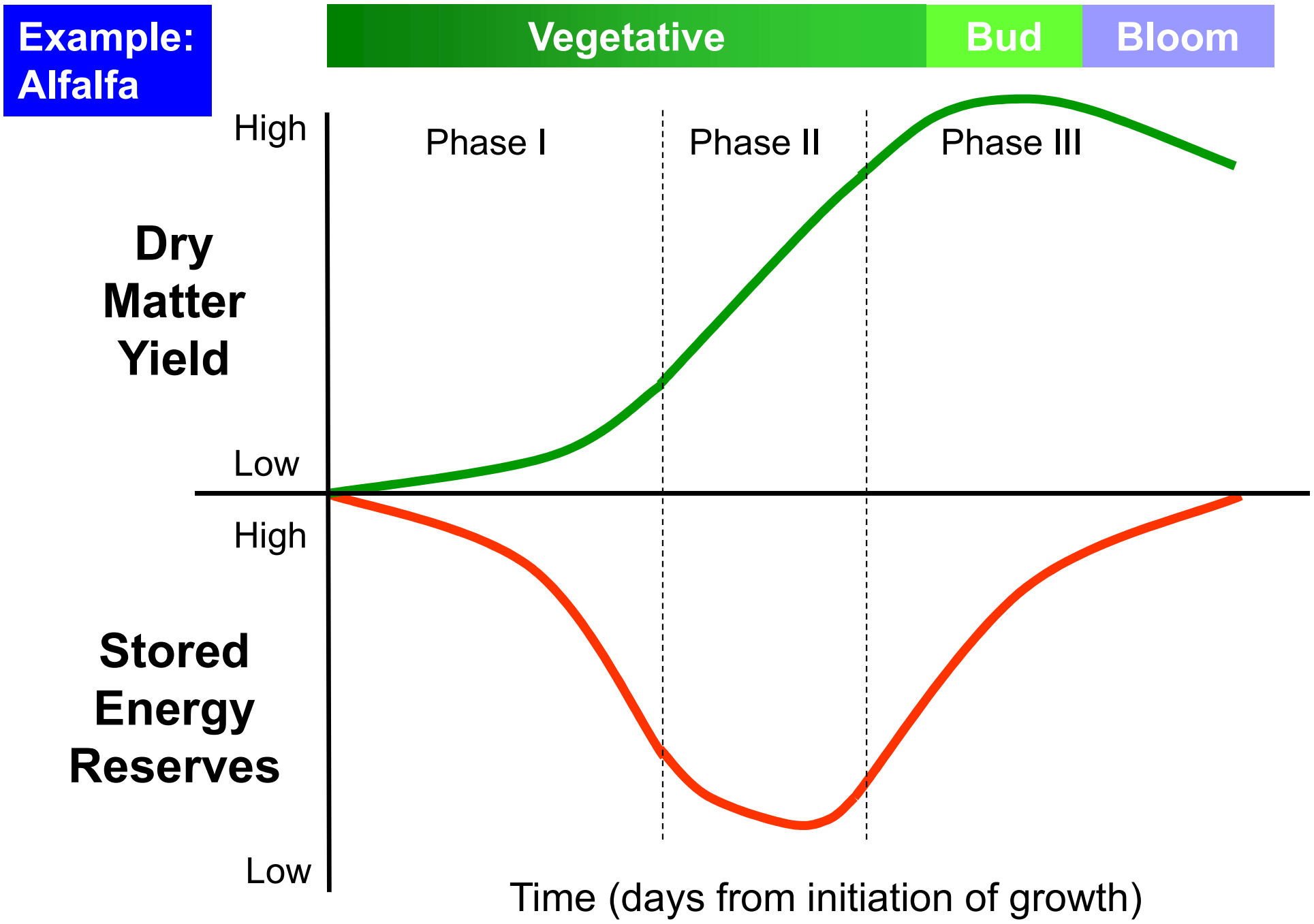
Physiological Characteristics - Stored Energy

Example: Alfalfa



Plant Response to Defoliation

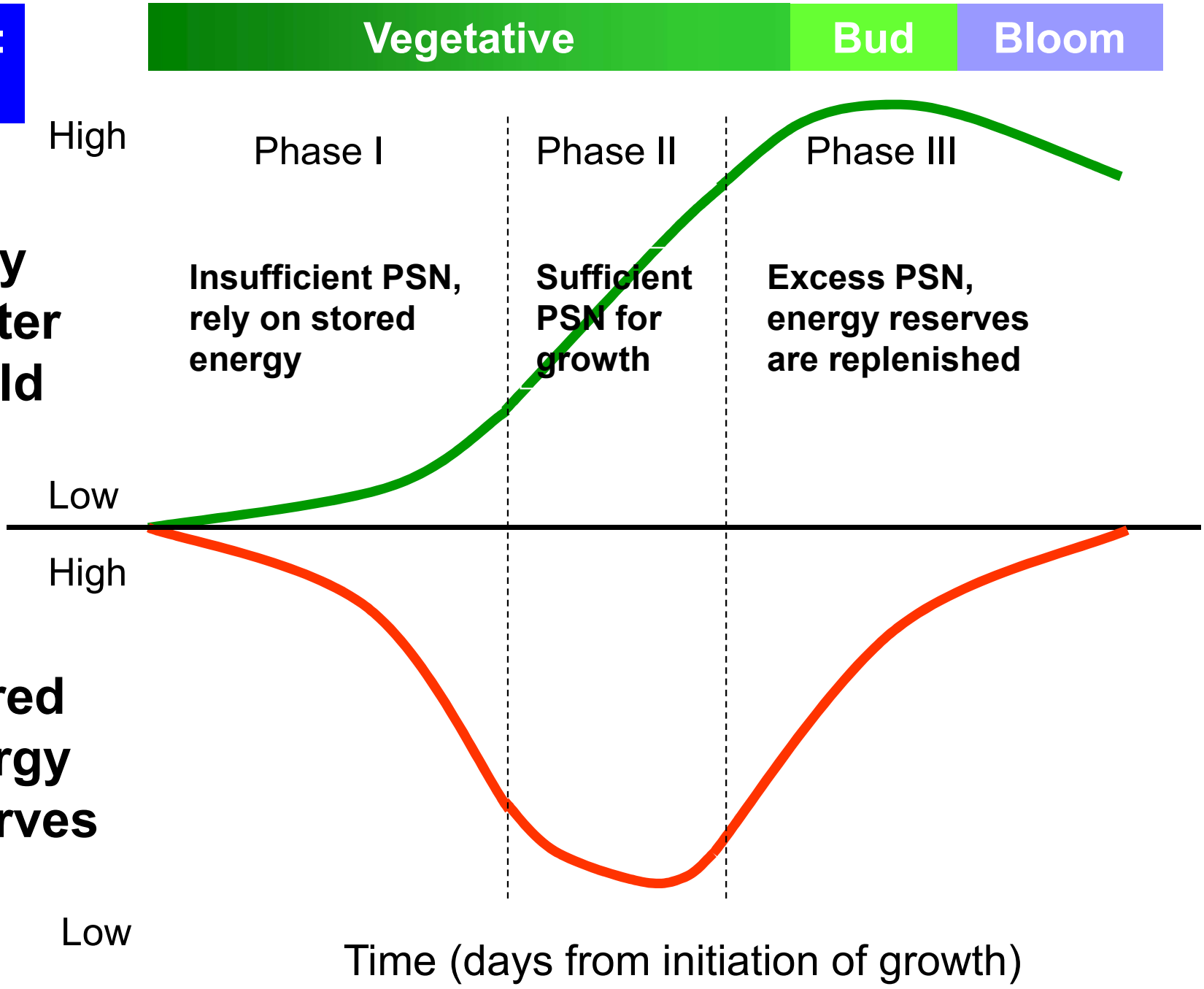
Physiological Characteristics - Stored Energy



Plant Response to Defoliation

Physiological Characteristics - Stored Energy

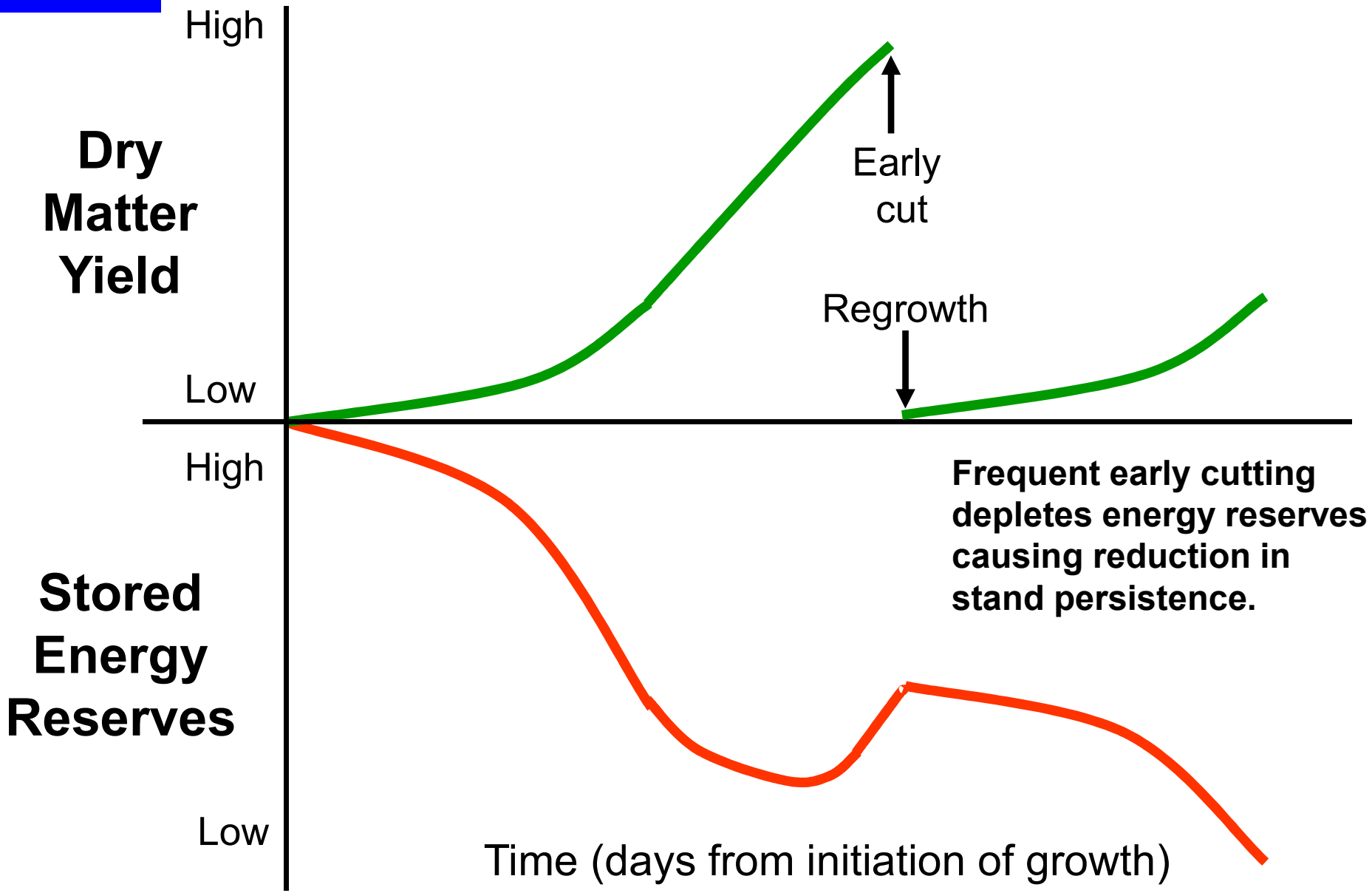
Example: Alfalfa



Plant Response to Defoliation

Physiological Characteristics - Stored Energy

Example: Alfalfa



Forage Cutting Height

- Lower cutting results in more yield from that harvest
  - 0.5 t/a per year for each inch of alfalfa
- Lower cutting height reduces forage quality
  - 5 points Relative Feed Value per inch cutting height
- Lower cutting height shortens stand life of grasses
  - Especially smooth bromegrass, orchardgrass, timothy
- Lower cutting height increases ash with disc mowers
- Best compromise is generally 3 to 4 inches cutting height

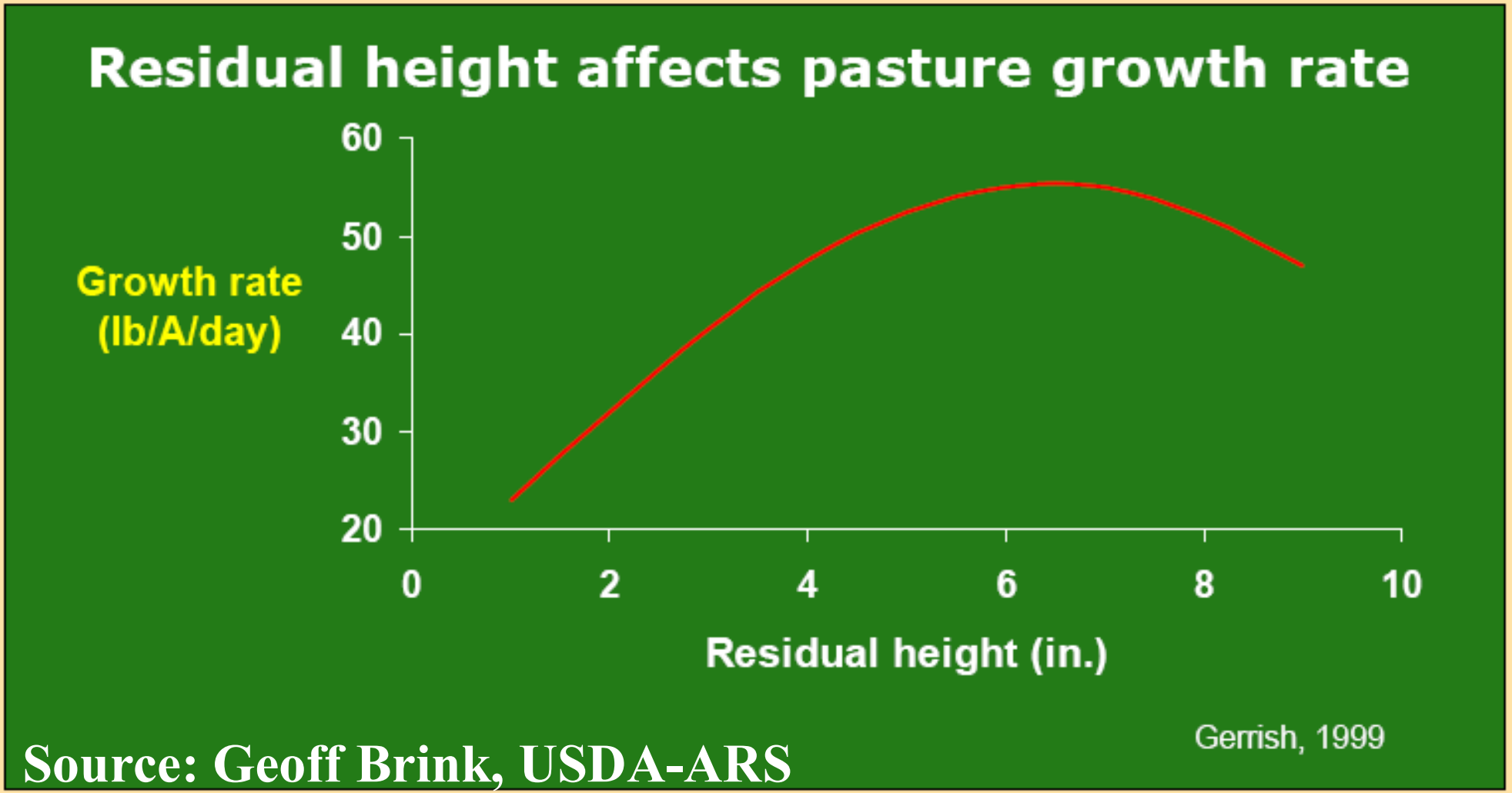
USDA-Dairy/Forage Research Lab 2010

Orchardgrass after two years of being cut with a 2-inch stubble.

Orchardgrass after two years of being cut with a 4-inch stubble.

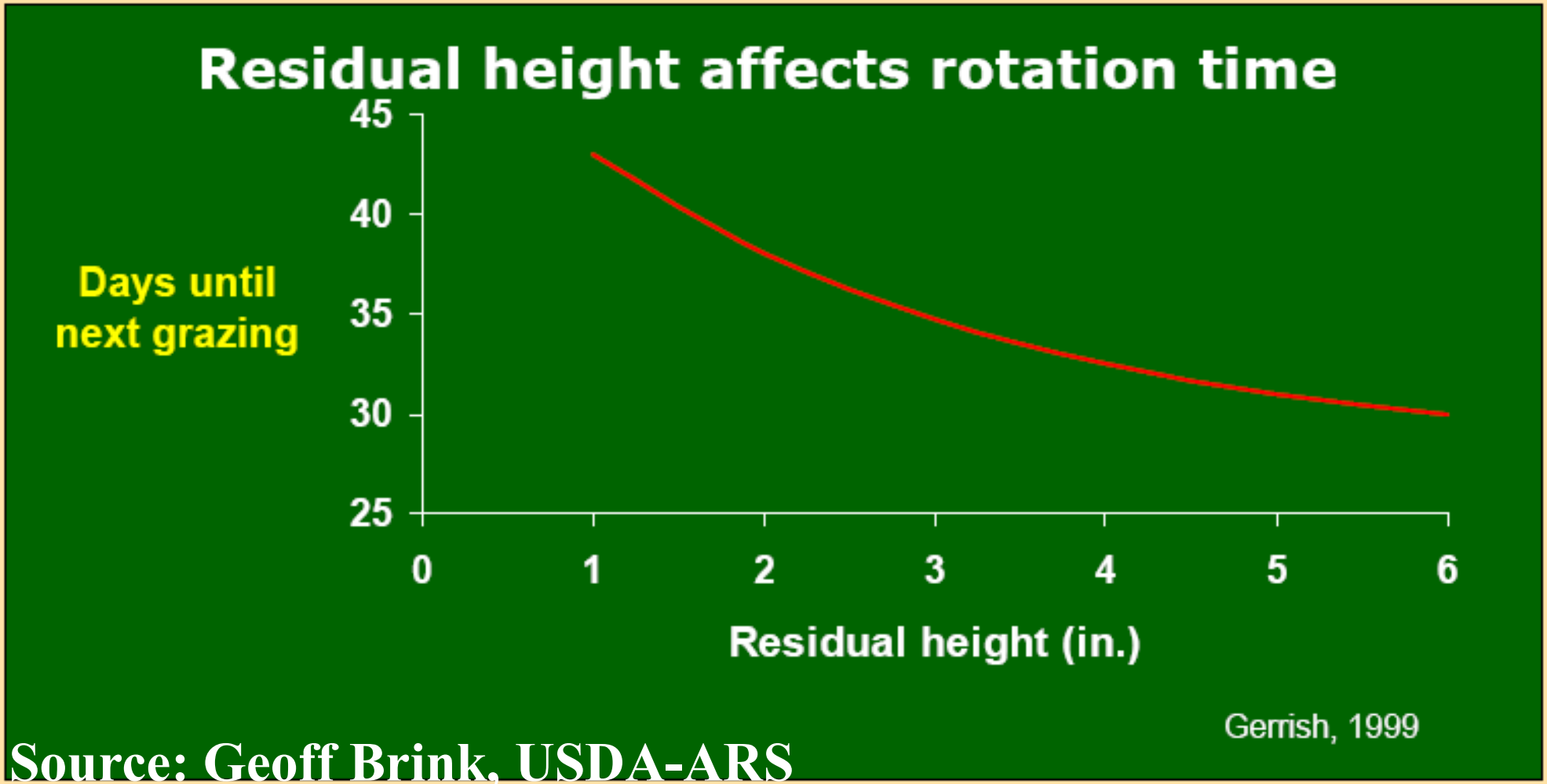

What is the impact of overgrazing?

This graph shows the rate at which grass grows depending on the residual height. The rate increases as residual increases – until the grass is long enough to start shading the underside of the plant and slowing down the growth.



Source: Geoff Brink, USDA-ARS

An adequate residual height, which promotes quicker regrowth, also shortens the length of time before cattle can graze in the same pasture again.



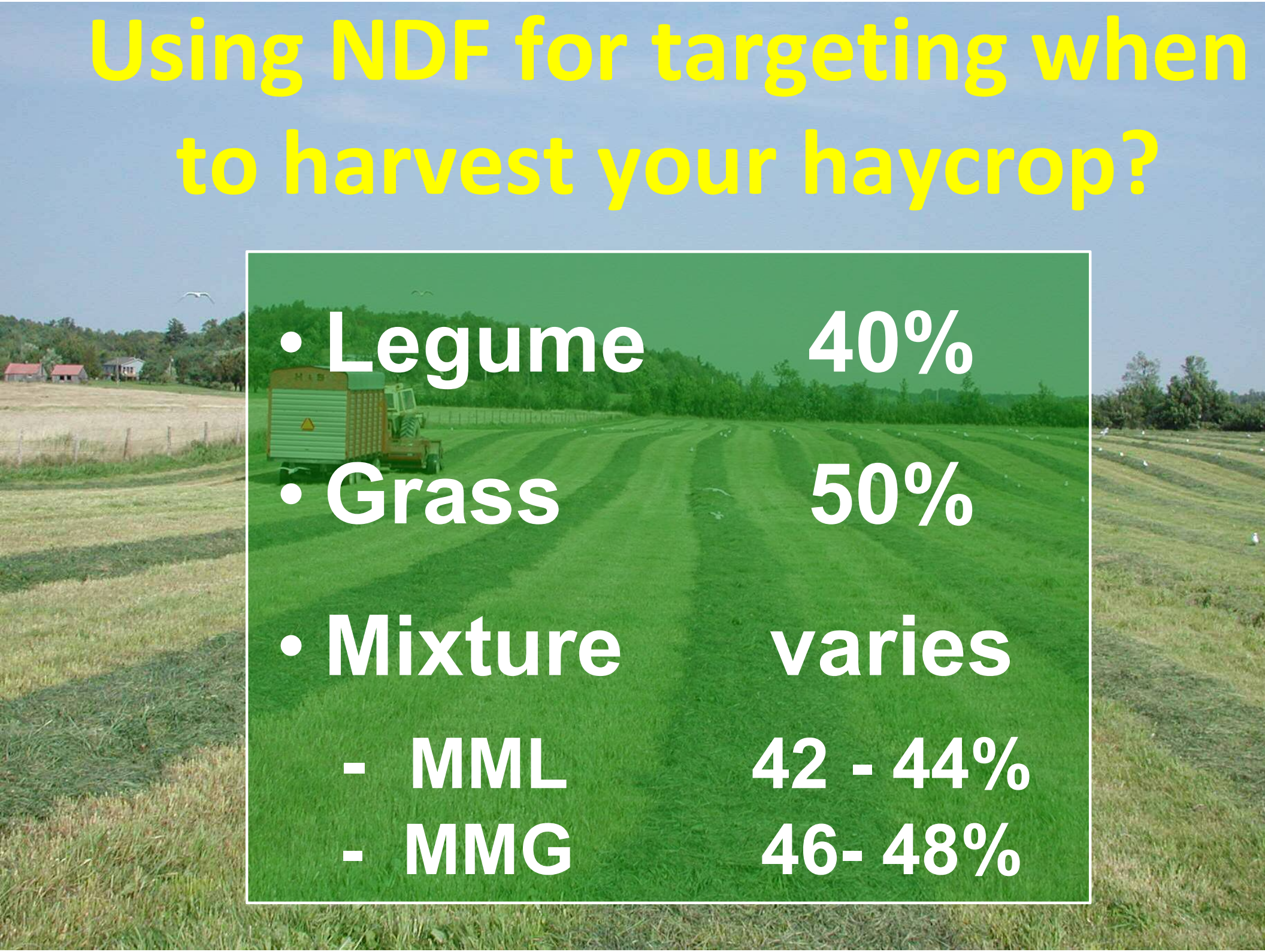
Source: Geoff Brink, USDA-ARS

Plant Response to Defoliation Intensity

Impact on Forage Quality

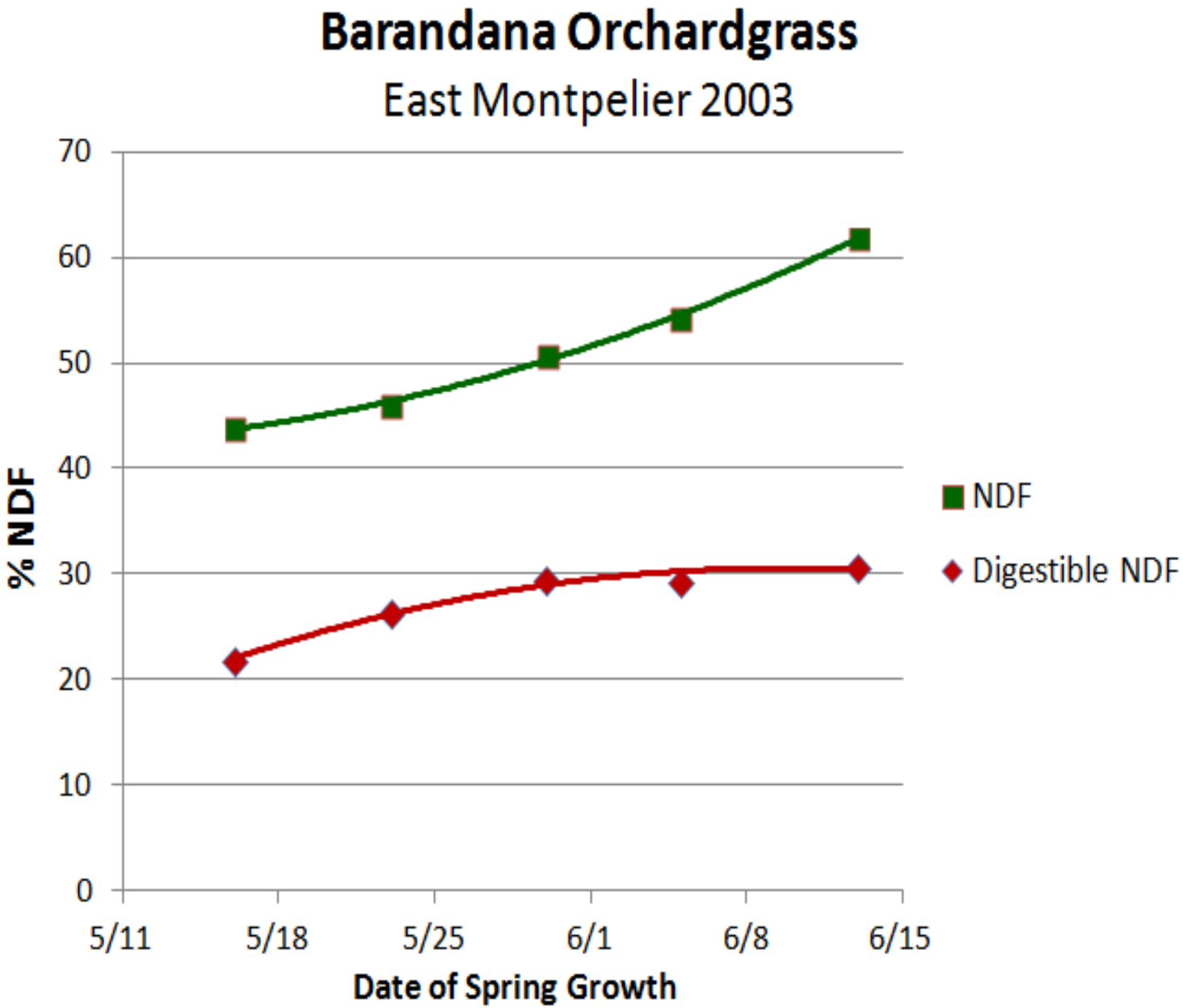
NORTHEAST SARE
Sustainable Agriculture Research & Education
Professional Development Program

Using NDF for targeting when to harvest your haycrop?

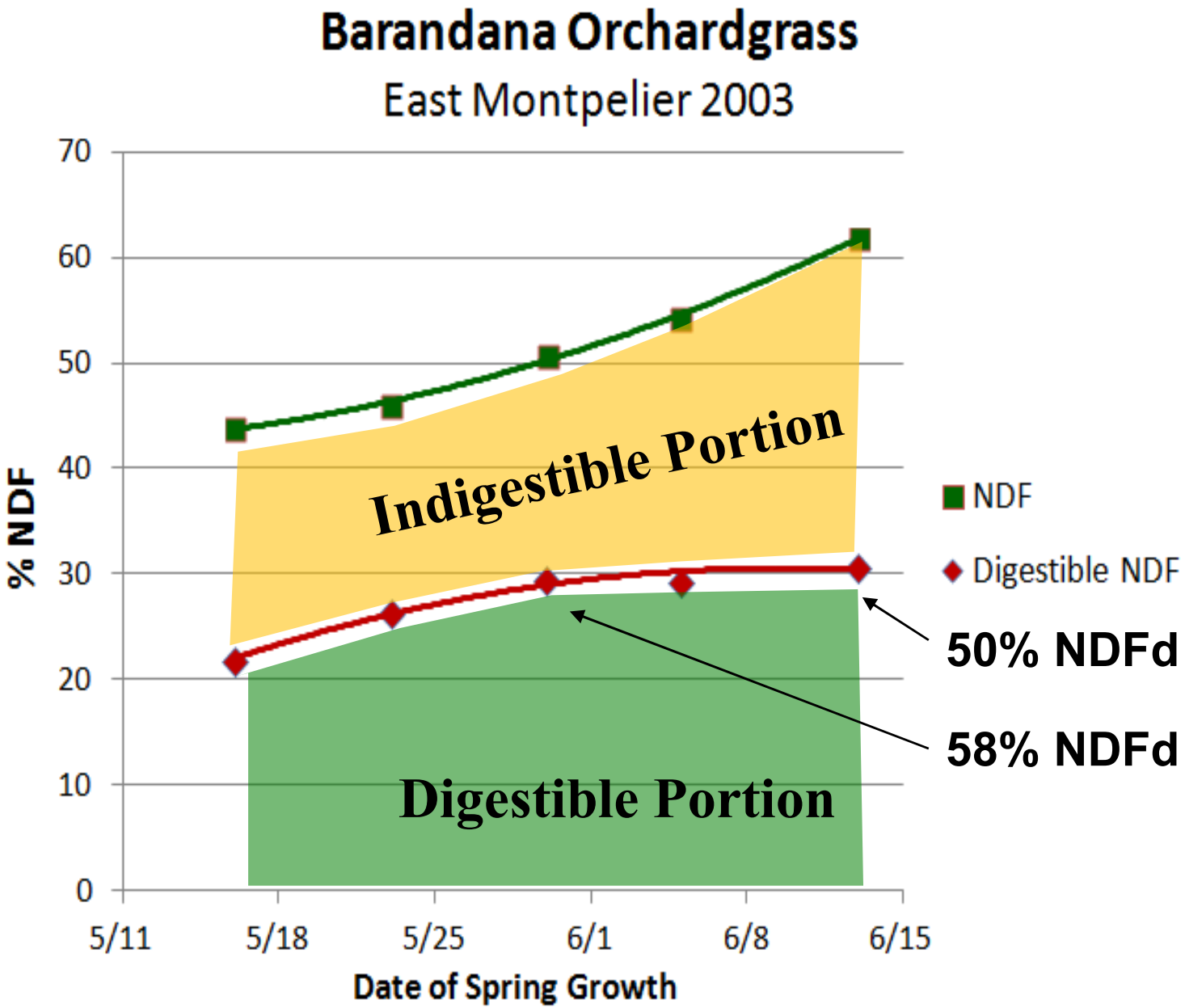


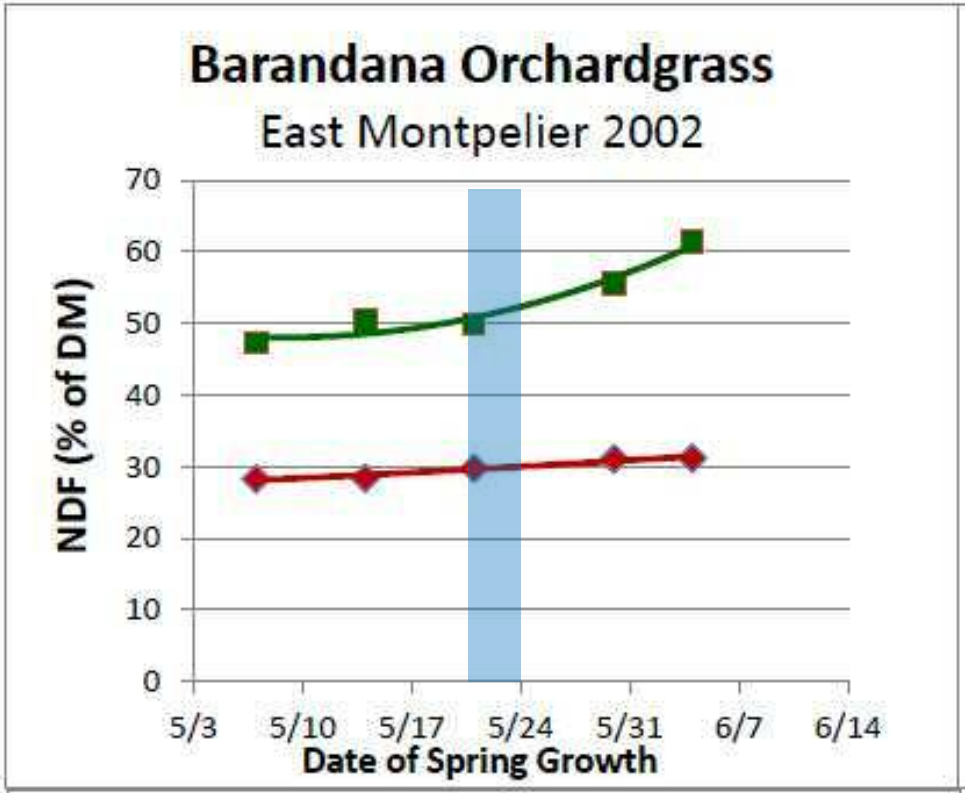
- Legume 40%
- Grass 50%
- Mixture varies
  - MML 42 - 44%
  - MMG 46- 48%

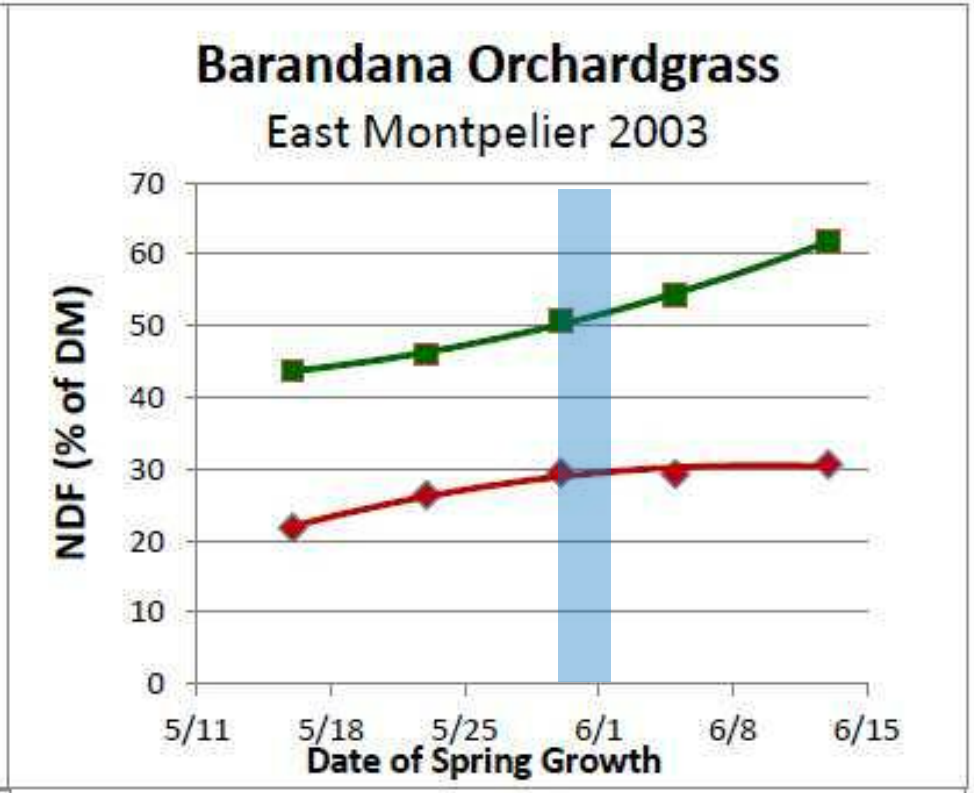
NDF and Digestible NDF

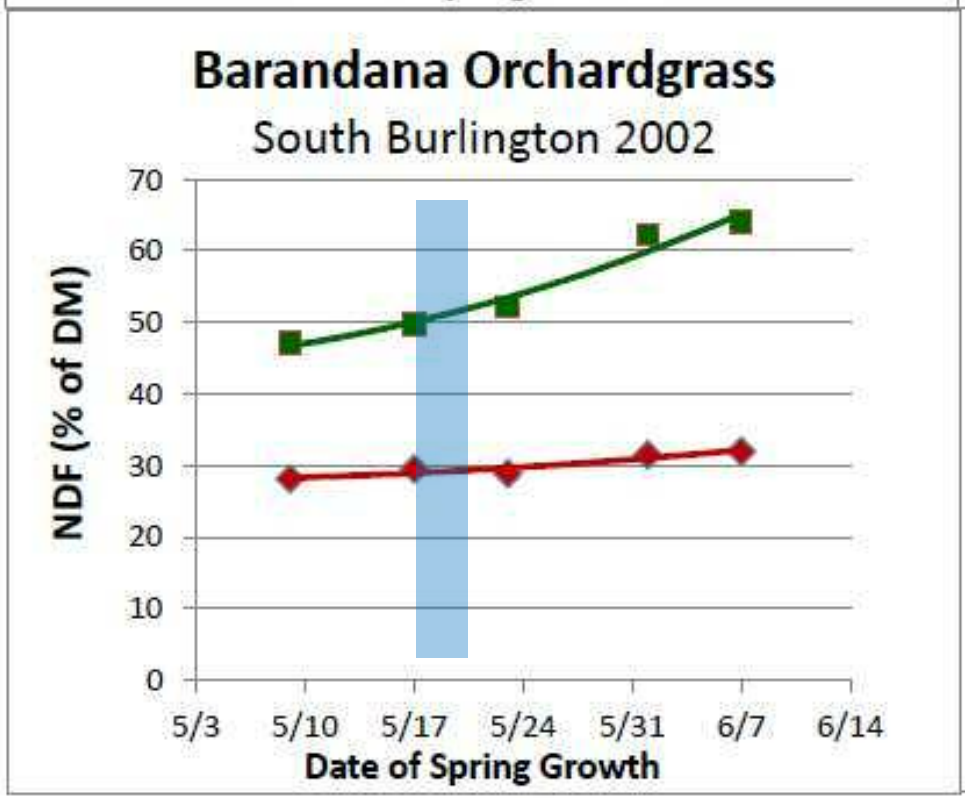


NDF and Digestible NDF




Barandana Orchardgrass
East Montpelier 2002
NDF (% of DM)
70
60
50
40
30
20
10
0
5/3
5/10
5/17
5/24
5/31
6/7
6/14
Date of Spring Growth


Barandana Orchardgrass
East Montpelier 2003
NDF (% of DM)
70
60
50
40
30
20
10
0
5/11
5/18
5/25
6/1
6/8
6/15
Date of Spring Growth


Barandana Orchardgrass
South Burlington 2002
NDF (% of DM)
70
60
50
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0
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5/10
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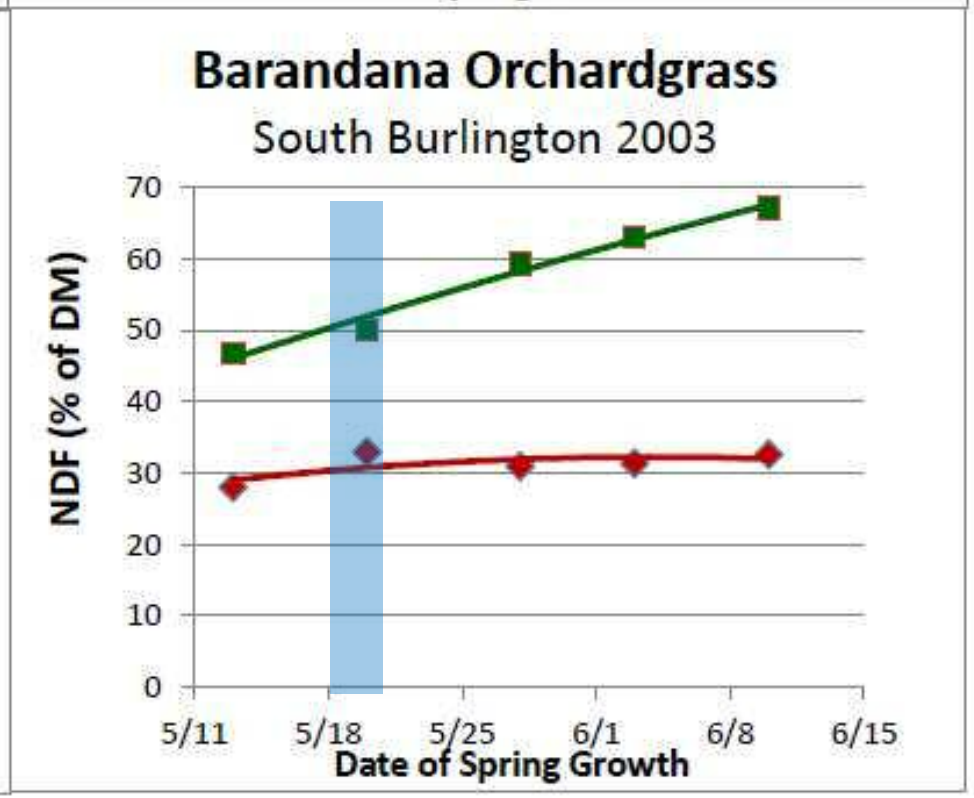
5/24
5/31
6/7
6/14
Date of Spring Growth


Barandana Orchardgrass
South Burlington 2003
NDF (% of DM)
70
60
50
40
30
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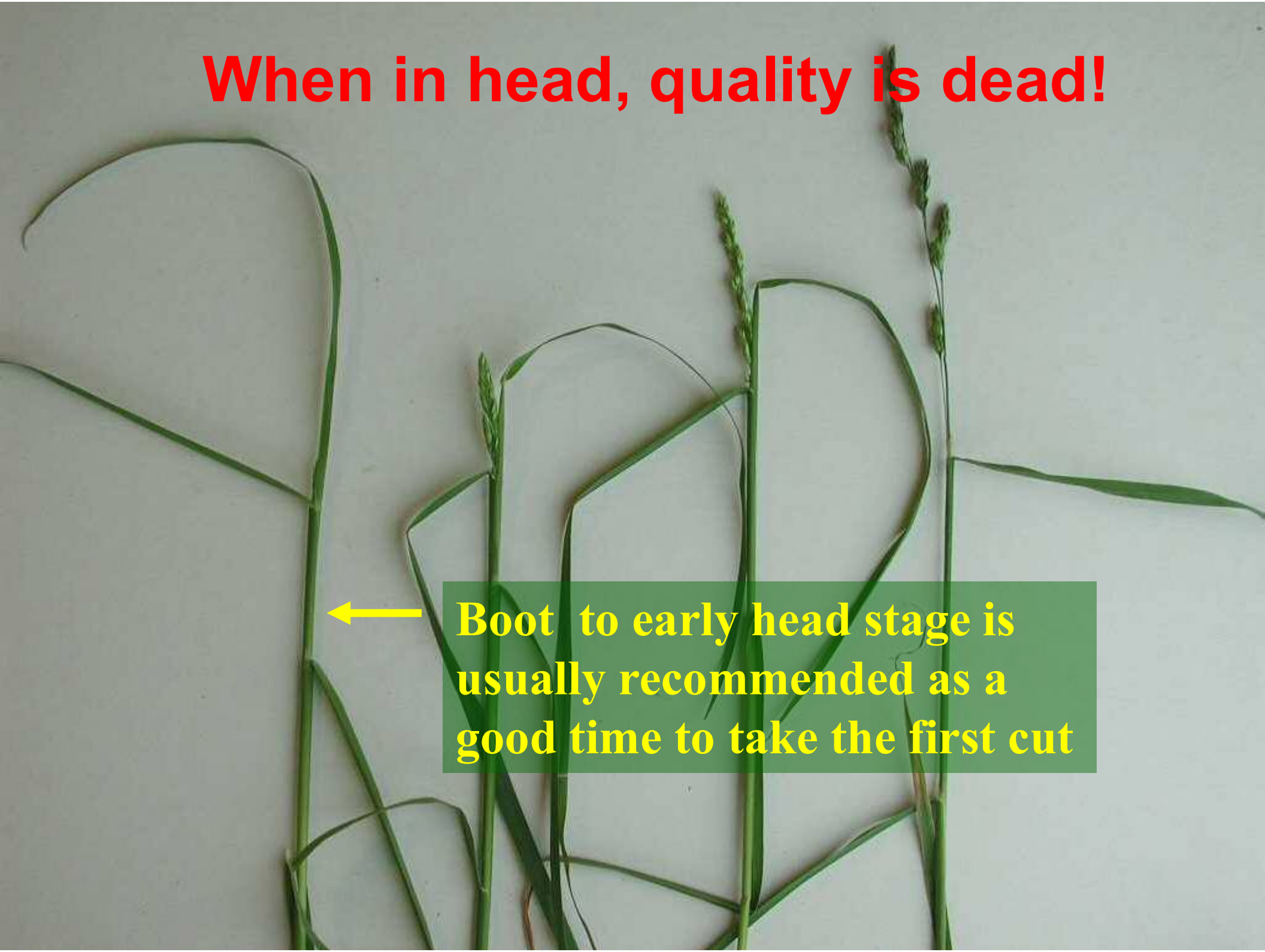
0
5/11
5/18
5/25
6/1
6/8
6/15
Date of Spring Growth

When in head, quality is dead!



Boot to early head stage is usually recommended as a good time to take the first cut

Grasses and Forage Quality

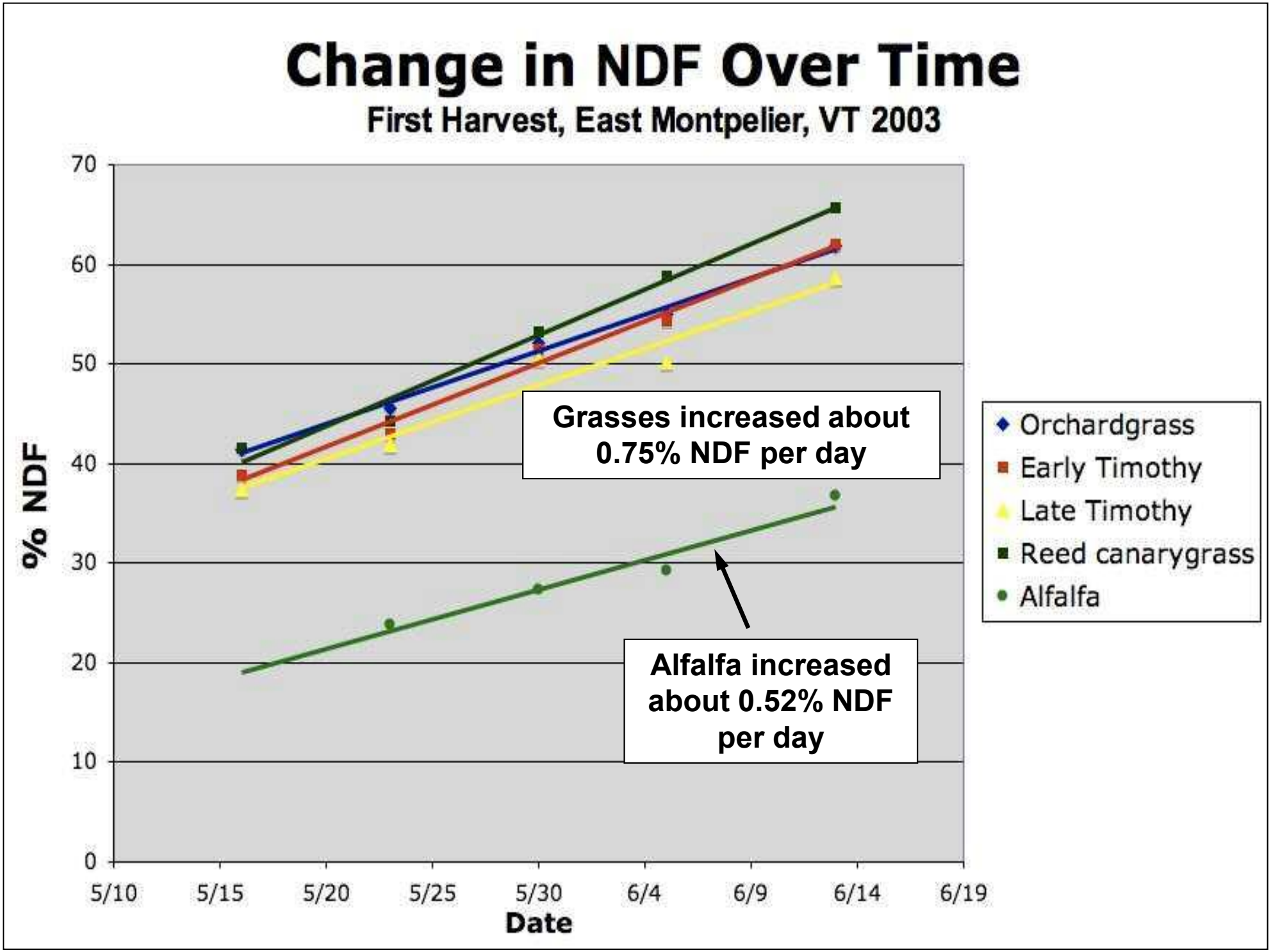
Two locations (E. Montpelier, S. Burlington)
Two years (2002, 2003)
Three grasses:
- Orchardgrass (three cultivars)
- Timothy (two cultivars)
- Reed canarygrass (one cultivar)

Alfalfa (pure and in mixture with each grass)

Dates when first 5% of tillers in each stand reached boot/early head stage

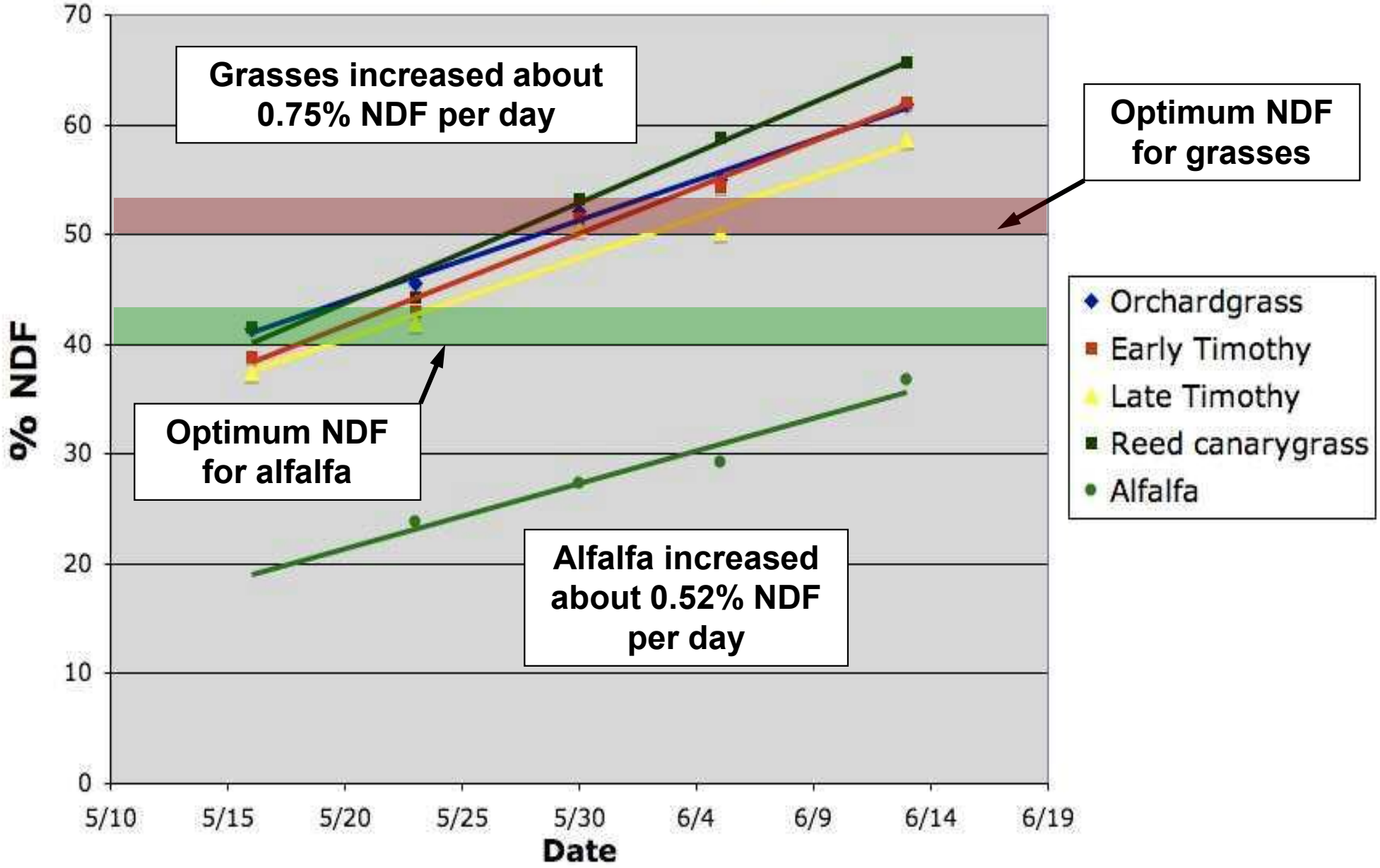
(East Montpelier, VT)

Treatment	2002	2003
Pizza OG	6/3	6/4
Barindana OG	6/3	6/4
Pennlate OG	5/29	5/29
Sunrise Tim	6/10	6/12
Sunset Tim	6/14	6/18
Palaton RCG	6/10	6/12


Change in NDF Over Time
First Harvest, East Montpelier, VT 2003
% NDF
70
60
50
40
30
20
10
0
5/10
5/15
5/20
5/25
5/30
6/4
6/9
6/14
6/19
Date
Grasses increased about 0.75% NDF per day
Alfalfa increased about 0.52% NDF per day
Orchardgrass
Early Timothy
Late Timothy
Reed canarygrass
Alfalfa

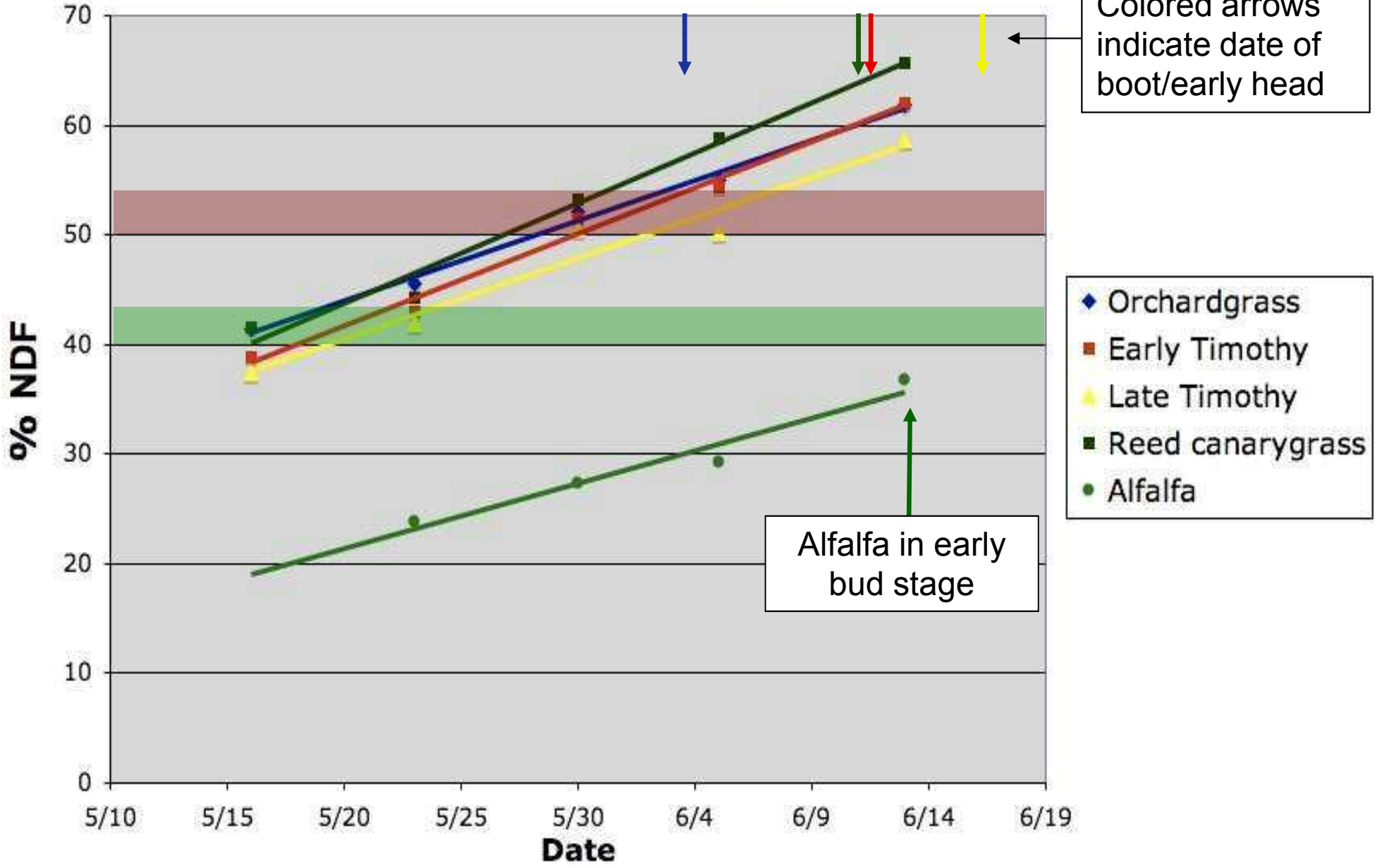
Change in NDF Over Time

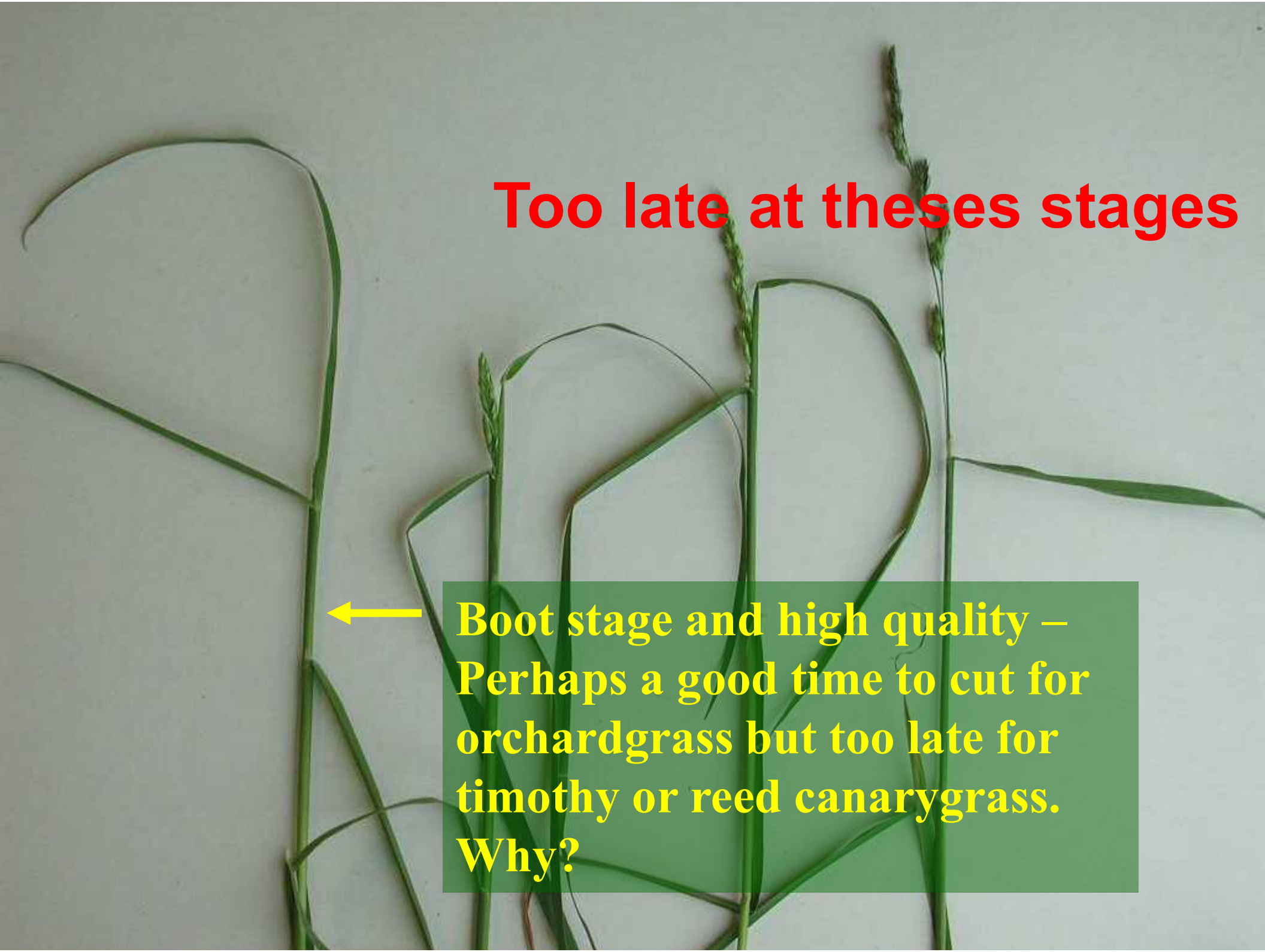
First Harvest, East Montpelier, VT 2003



Change in NDF Over Time

First Harvest, East Montpelier, VT 2003



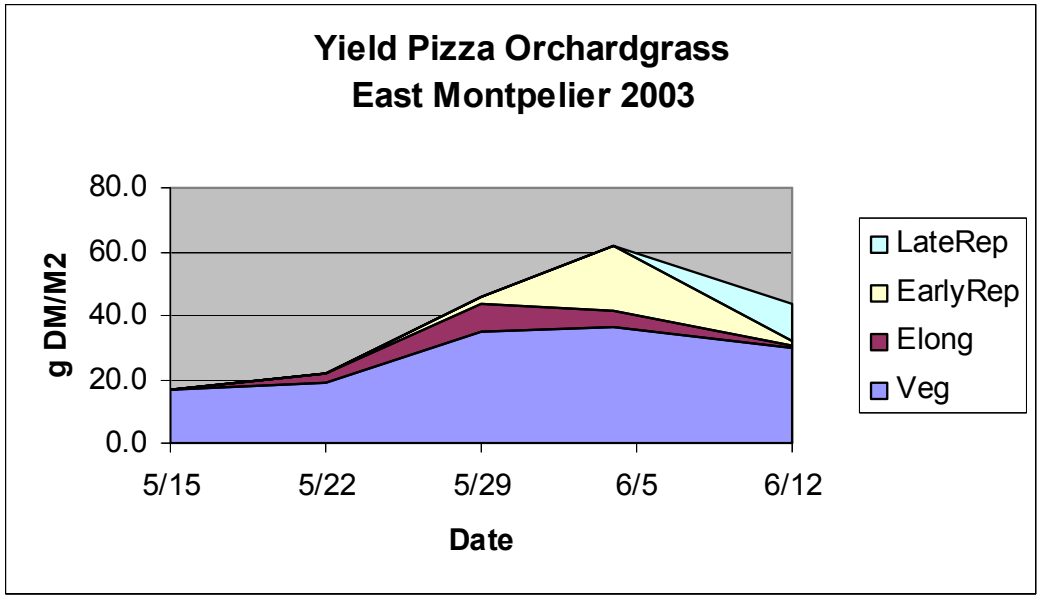

Too late at theses stages
Boot stage and high quality – Perhaps a good time to cut for orchardgrass but too late for timothy or reed canarygrass. Why?

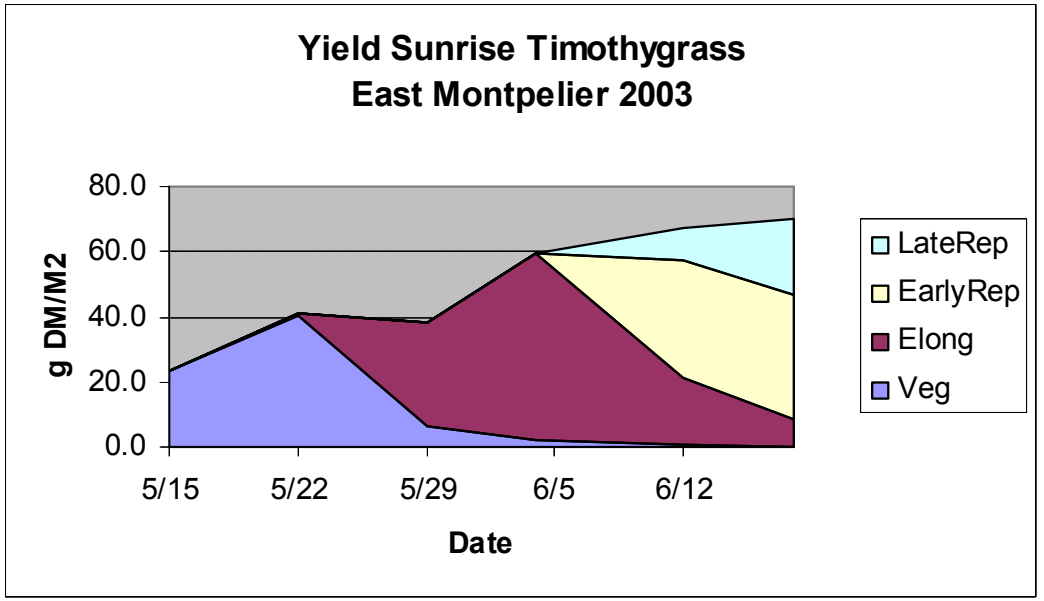
Staging Grasses

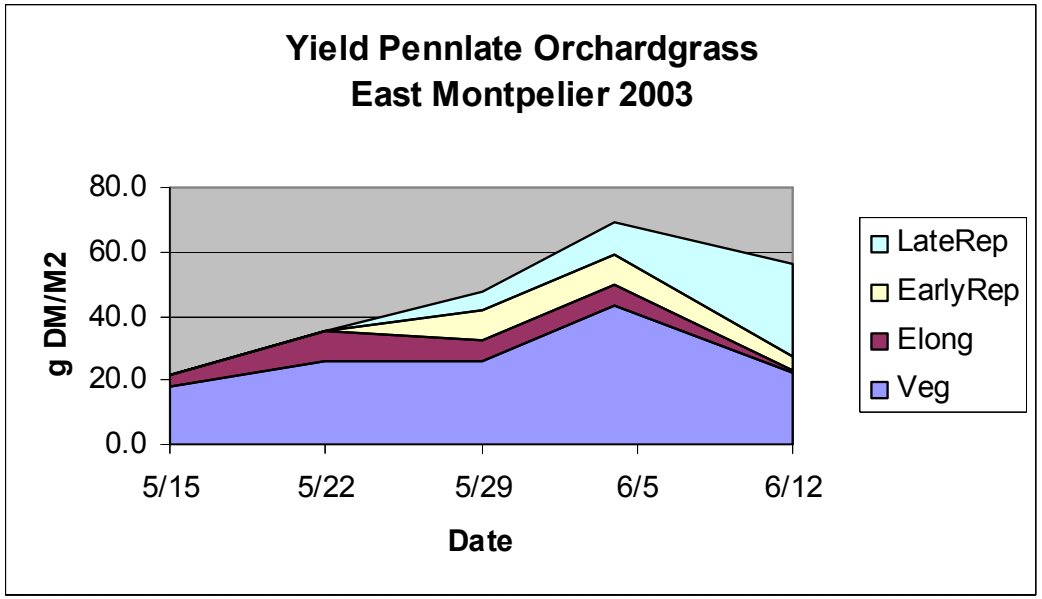
Vegetative Elongating Boot

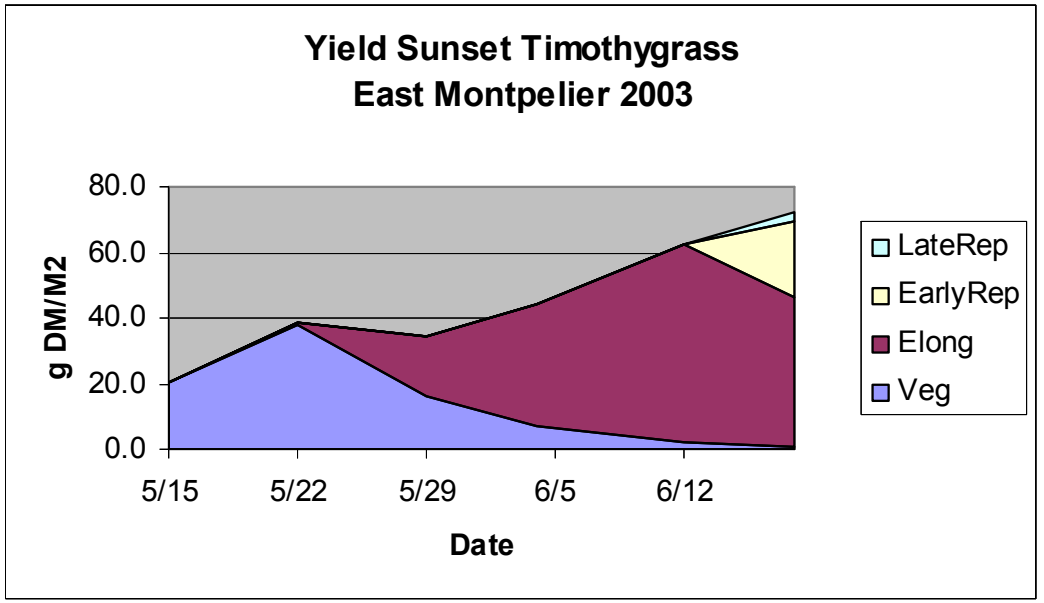
Heading

Tiller Stages of Grass Treatments



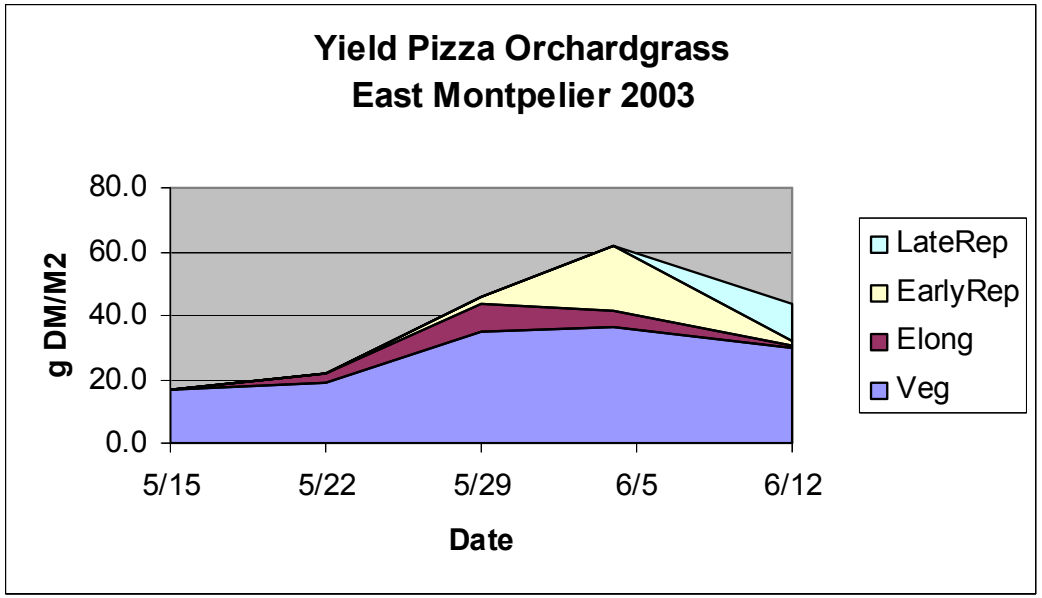


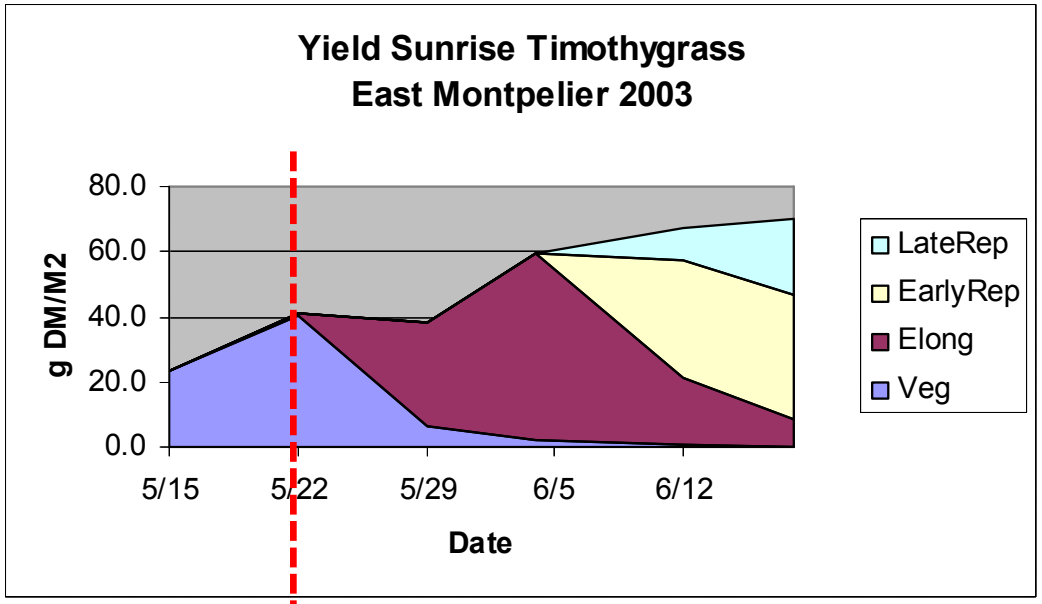


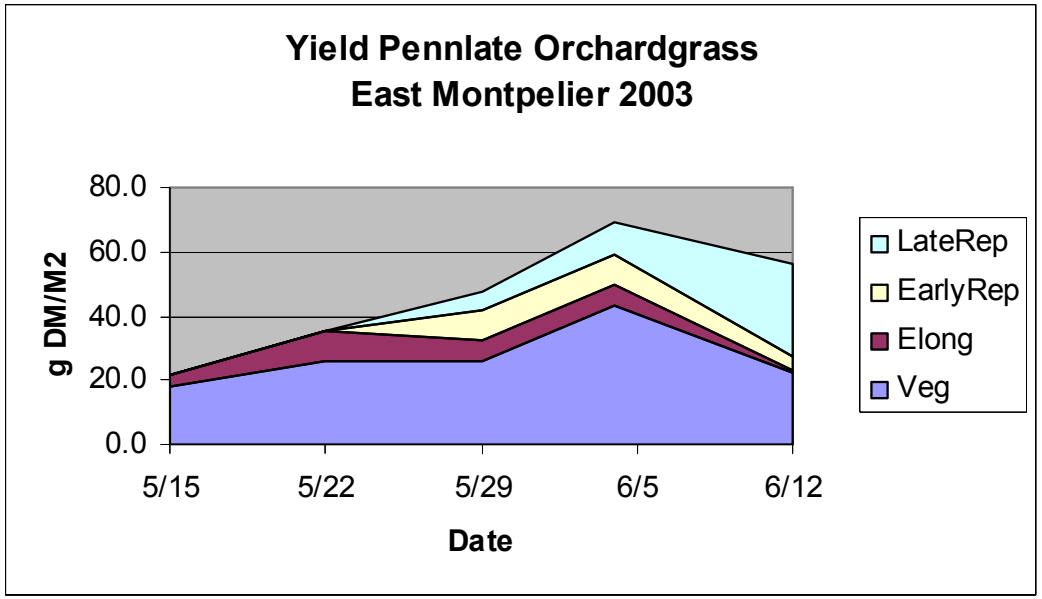


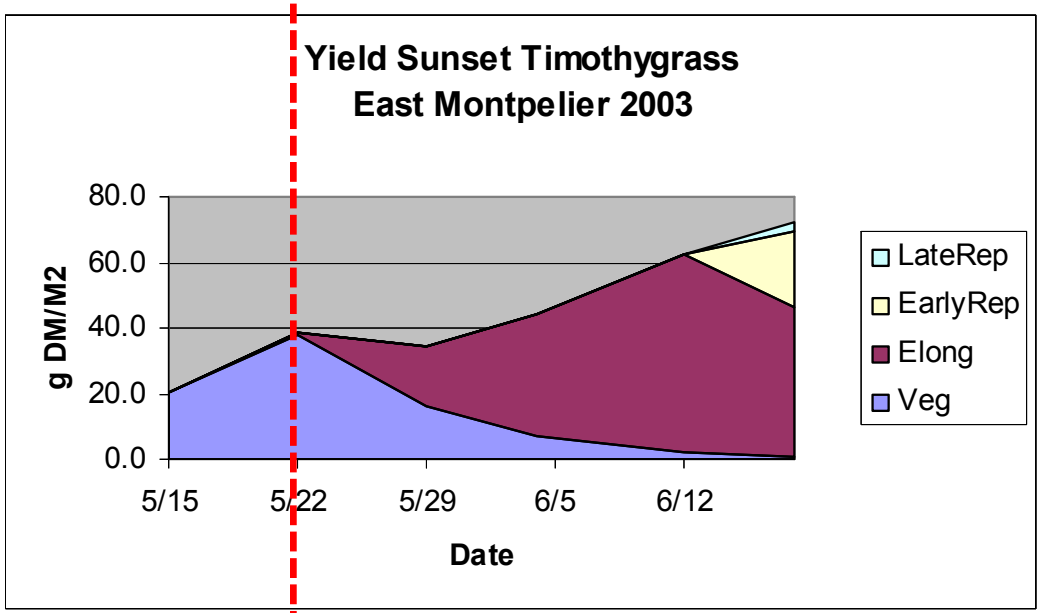
How does this affect forage quality of these grasses?

Tiller Stages of Grass Treatments







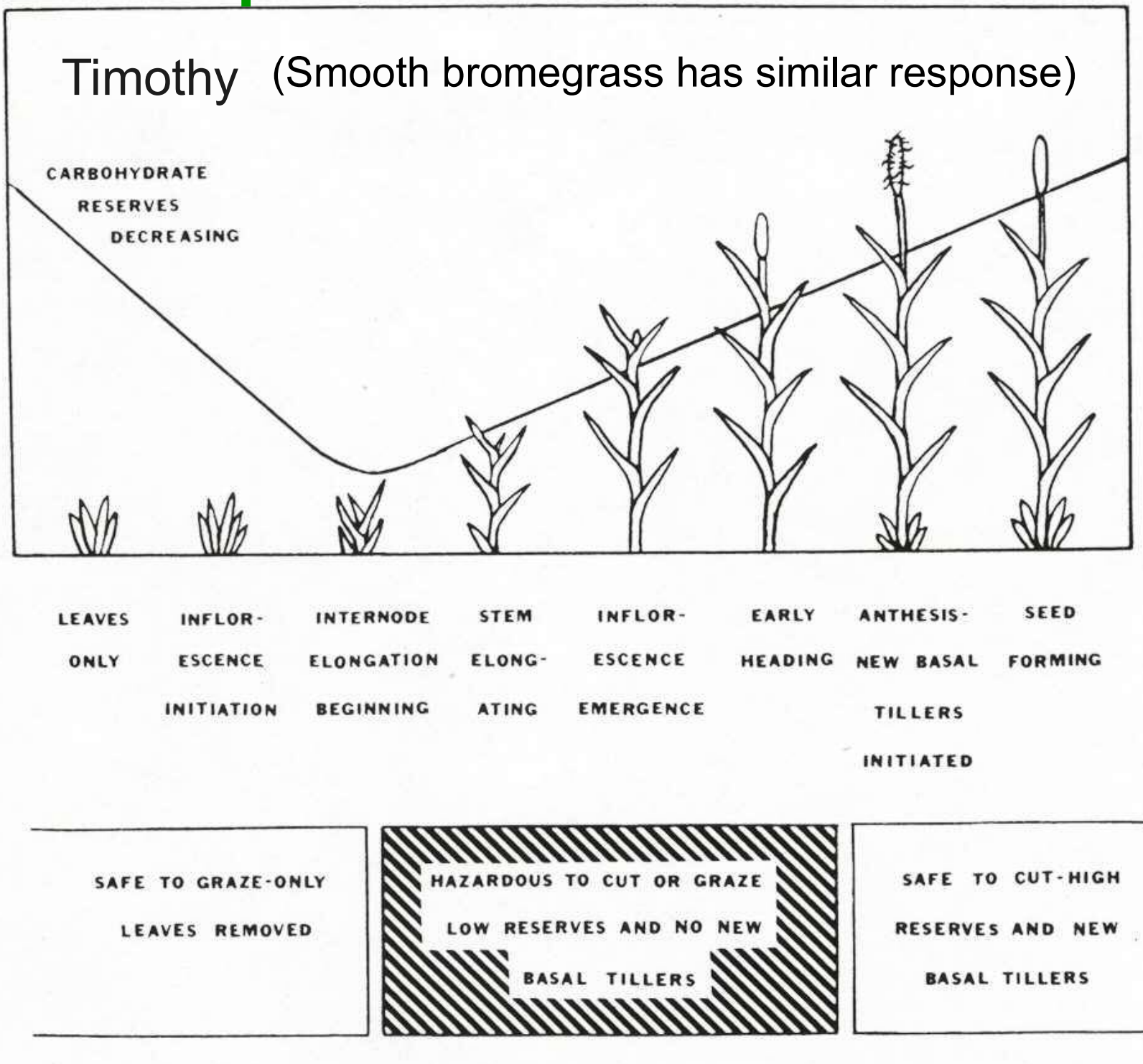


Can we cut the Timothy earlier to achieve higher quality?

Plant Response to Defoliation Intensity

- Intolerant of early first cut:
  - Smooth bromegrass
- Less tolerant of early first cut
  - Timothy (variety dependent)
- Tolerant of early first harvest:
  - Orchardgrass
  - Reed canarygrass
  - Tall fescue/meadow fescue
  - Perennial ryegrass

Plant Response to Defoliation Intensity



Plant Response to Defoliation

Environmental Interaction

Spring Growth

Summer Growth

Grass Quality

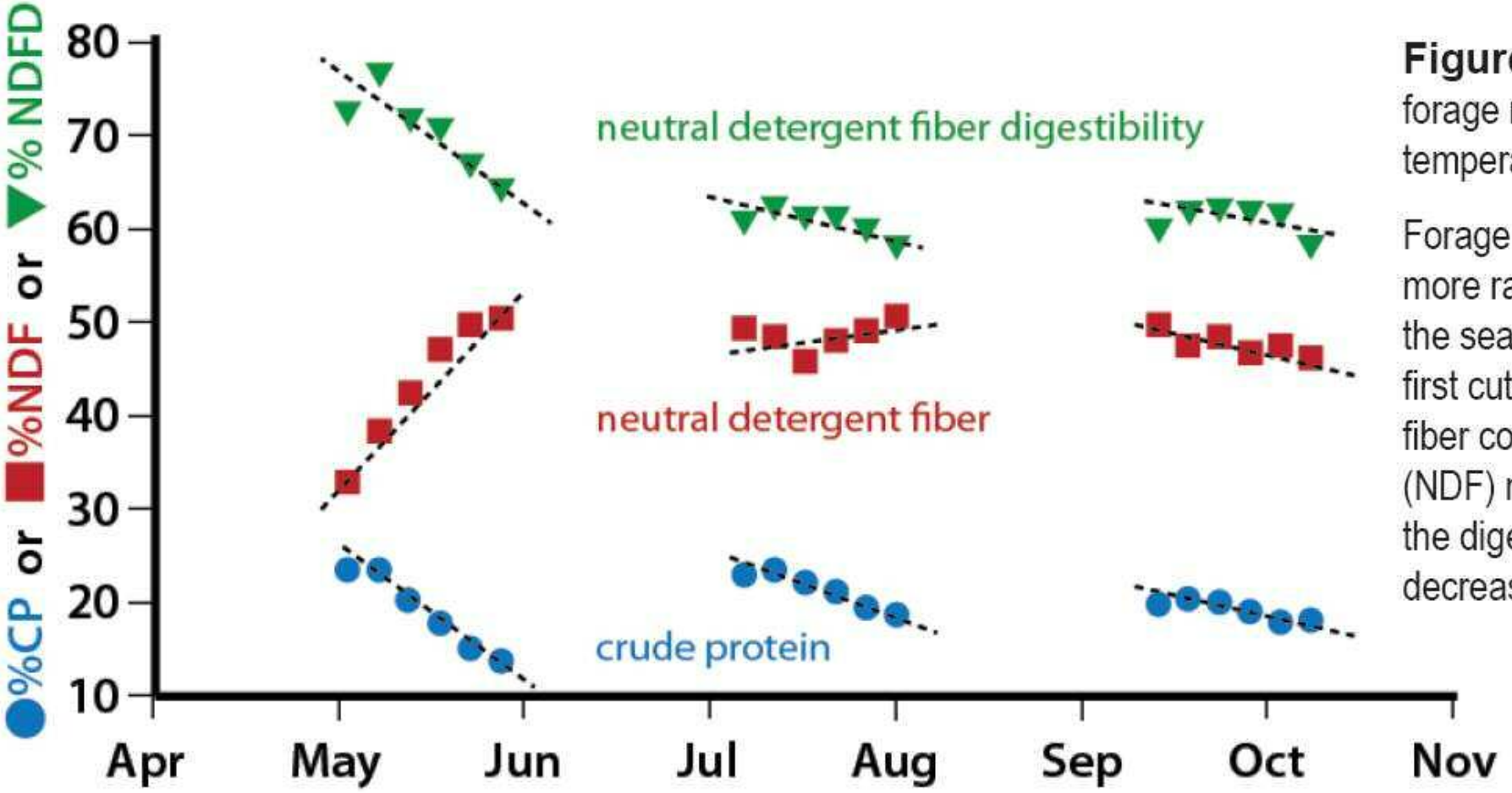
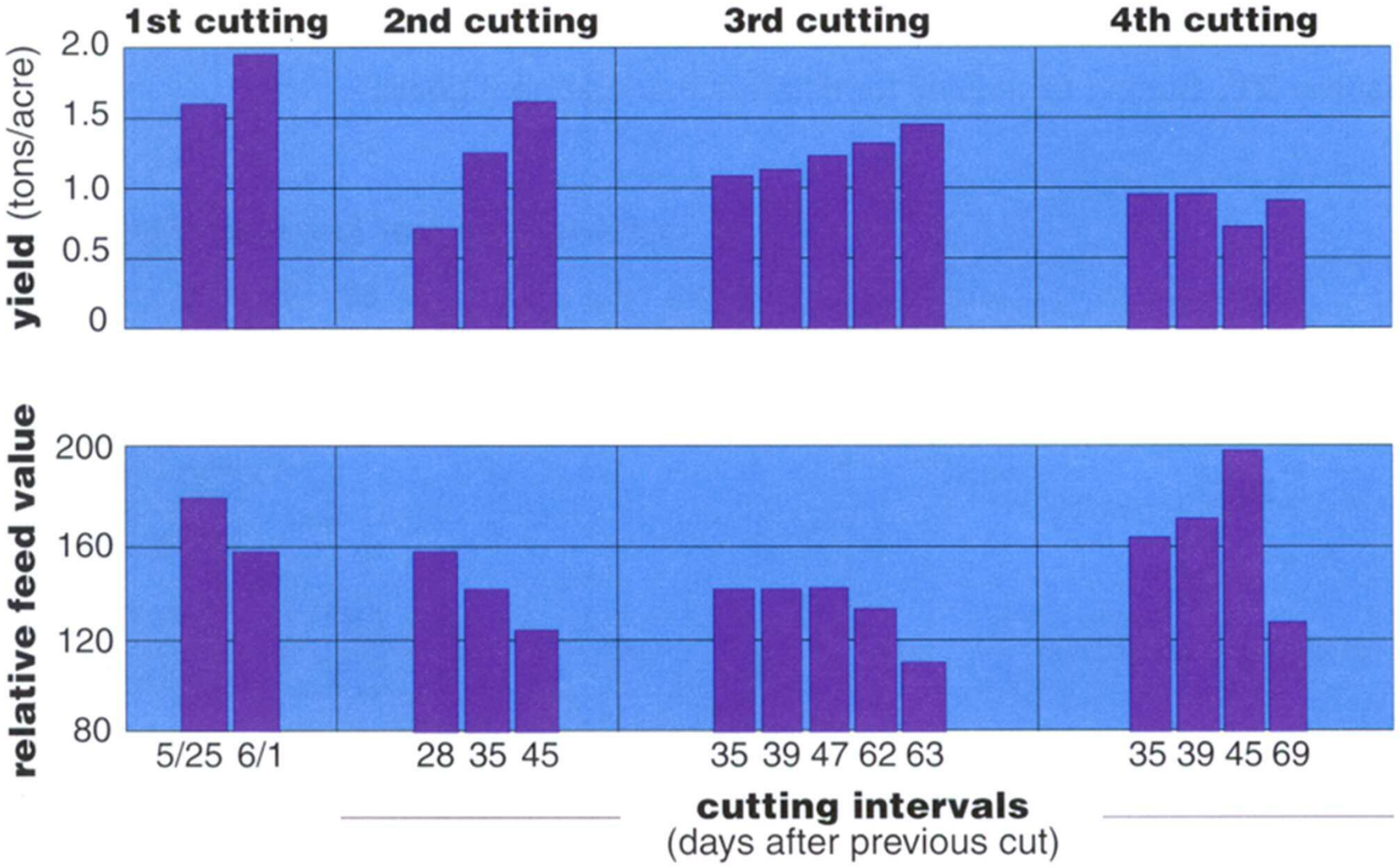


Figure 5: Change in forage nutritive value of temperate grasses.

Forage quality declines more rapidly early in the season, or with first cutting, as the fiber content increases (NDF) more rapidly and the digestibility quickly decreases (NDFD).

(Brink, USDA- Dairy/Forage Research Lab, 2010)

Alfalfa Quality and Yield



Source: Adapted from Brink and Marten, University of Minnesota, 1989

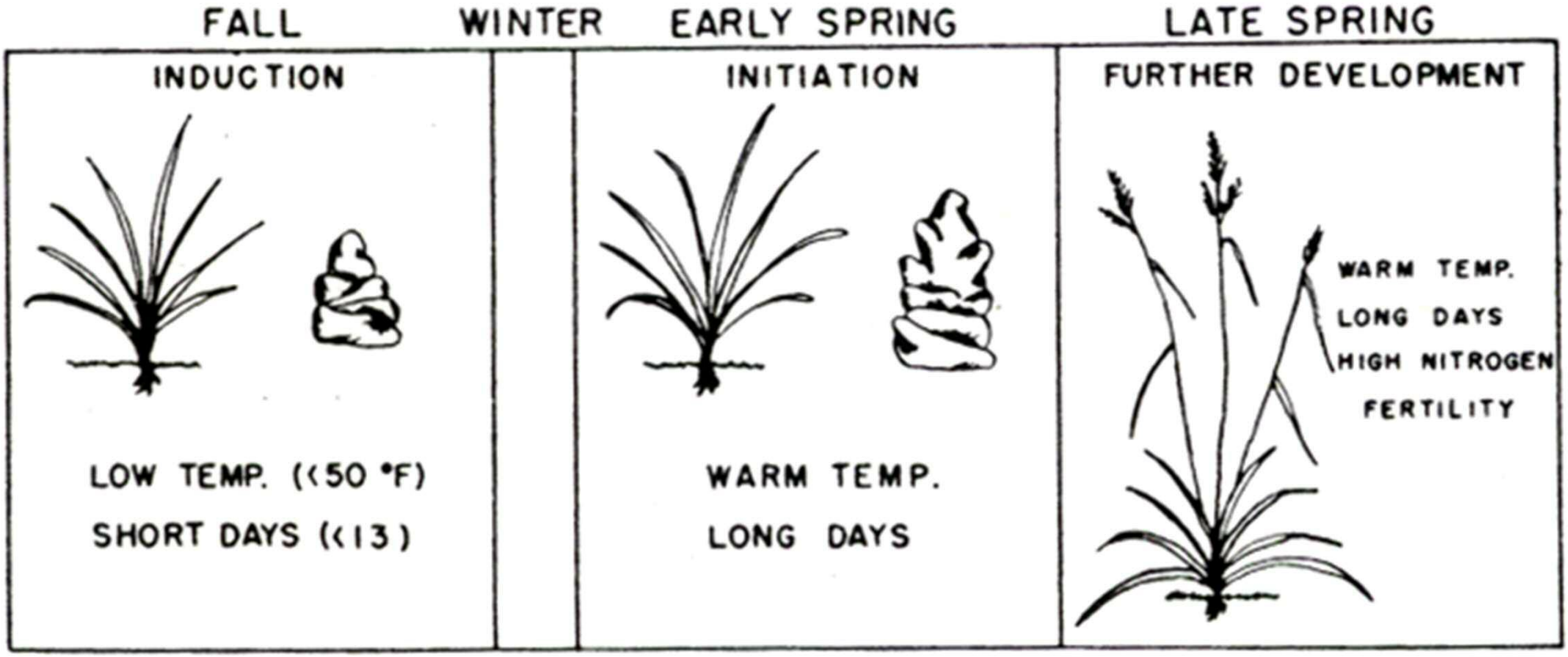
Environmental Interaction

Spring Growth

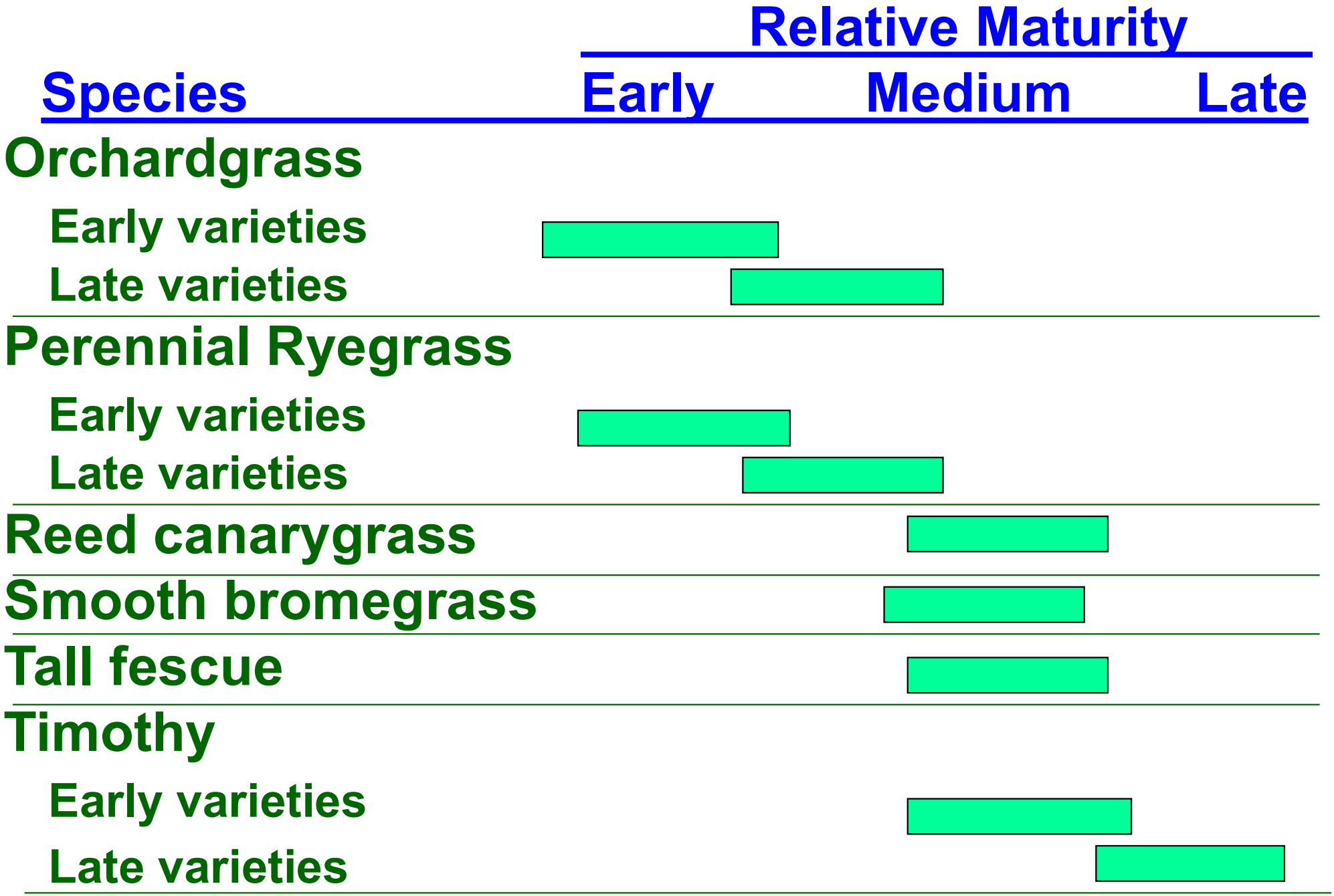
Summer Regrowth

Flowering Culm

Most cool season grasses have a winter requirement for floral induction that my include both short days and low temperatures (vernalization) although some only require one or the other. Timothy requires no winter induction only long days. The spring initiation phase is also referred to as secondary induction.



Relative Heading Date



Date of Grass Seedhead Development

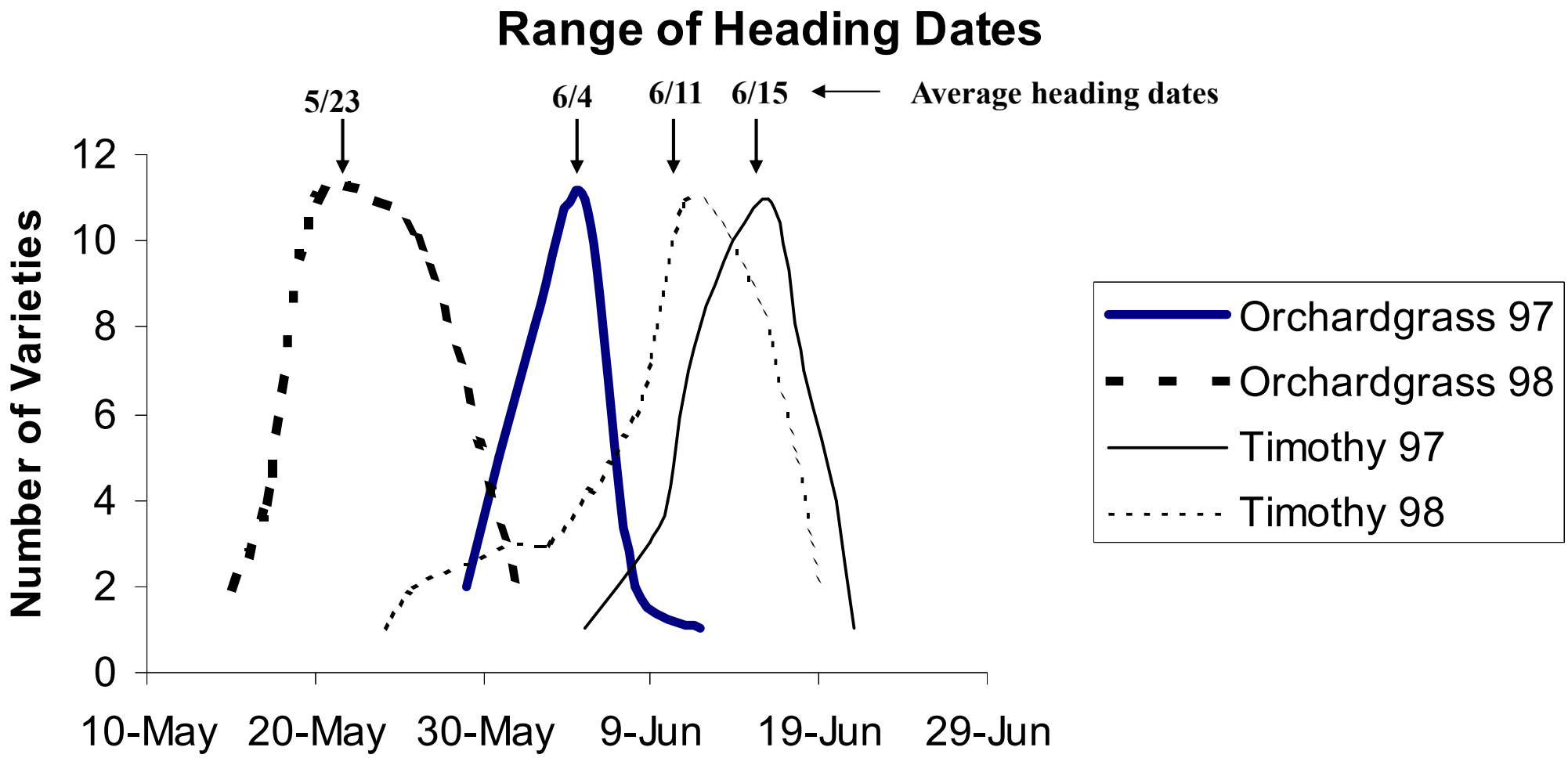
UVM Farm

50 Timothy cultivars
30 Orchardgrass cultivars
Seeded in fall 1995
Evaluated in 1997 and 1998

"Heading Date" was determined when the first five tillers in each plot reached early head emergence

(http://pss.uvm.edu/vtcrops/?Page=research/GrassVarieties.html)

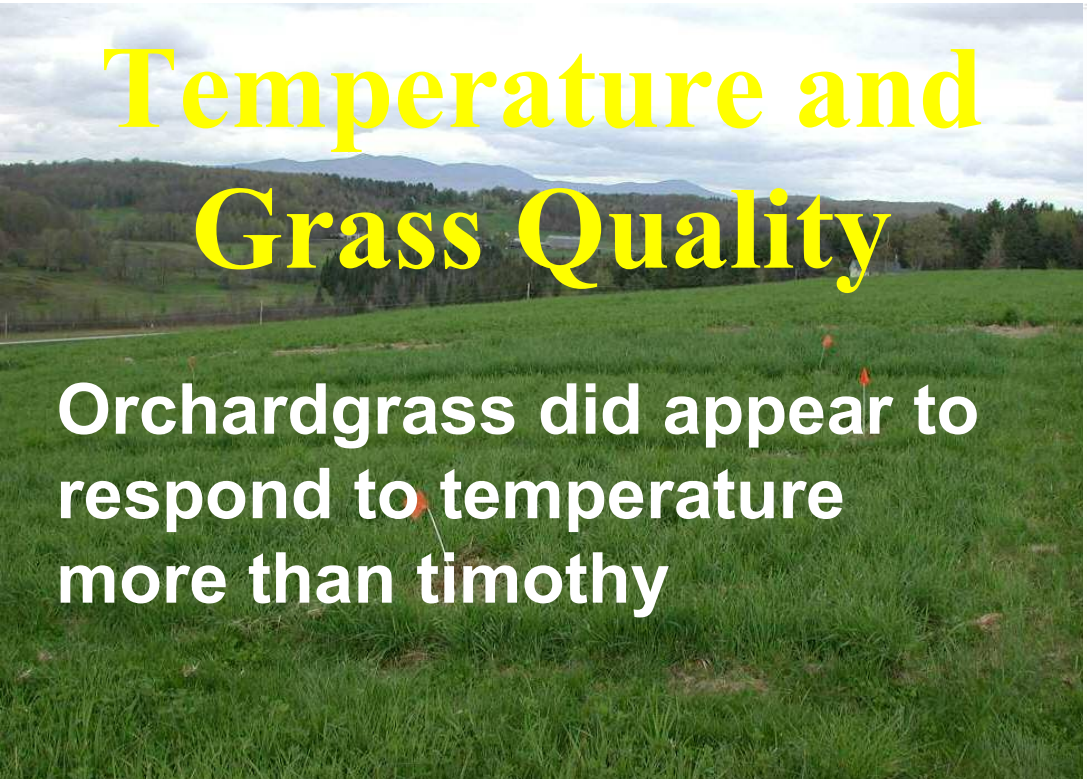
Time of Grass Seedhead Development As Influenced By Temperature and Day Length



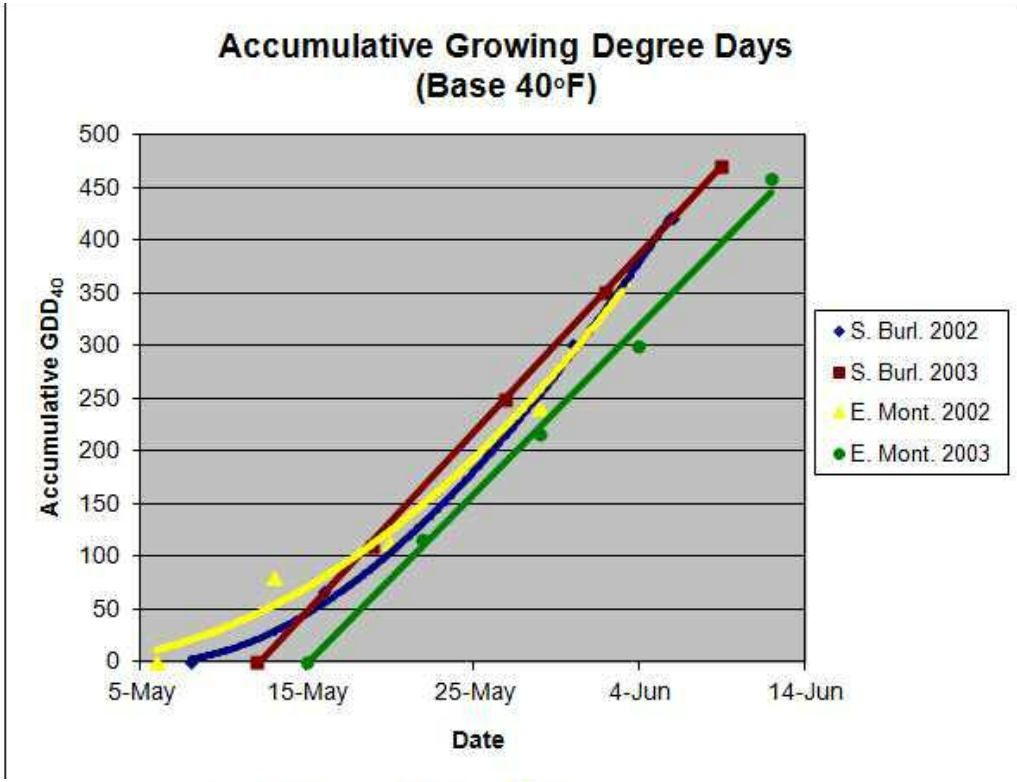
Frequency distributions for date of heading for the same set of orchardgrass varieties (n = 30) and timothy varieties (n=44) in 1997 and 1998, respectively.

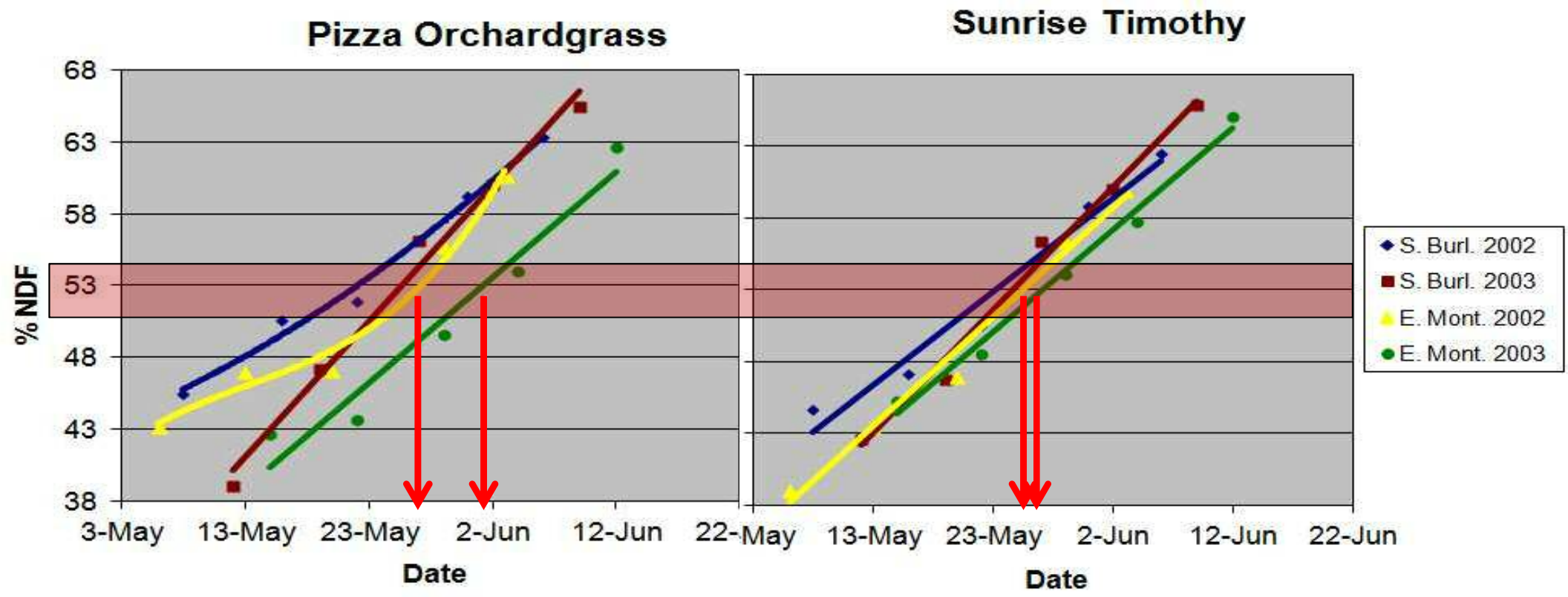
(http://pss.uvm.edu/vtcrops/?Page=research/GrassVarieties.html)

Temperature and Grass Quality



Orchardgrass did appear to respond to temperature more than timothy





Environmental Interaction

Defoliation and Drought

- During deficit water stress, plants rely more on stored carbohydrates for growth
- During deficit water stress, growth slows down due to a lack of turgor pressure; however, photosynthesis continues at least until stomates close due to more severe drought.
- Therefore, leaf area is extremely important for new growth and residual height and longer rest periods are critical to assure adequate storage of CHO.

Environmental Interaction

Defoliation and Fall Management of Grasses

- In late summer, cool season grasses produce new tillers that will be the basis for growth the following spring
- Severe defoliation at this time can greatly reduce potential production the next season


Geoff Brink, USDA-ARS

- It is best to let grasses grow uninterrupted 3 or 4 leaves before a killing frost to store sufficient CHO's
- If grazed after this, leave a 3 to 4 inch residue

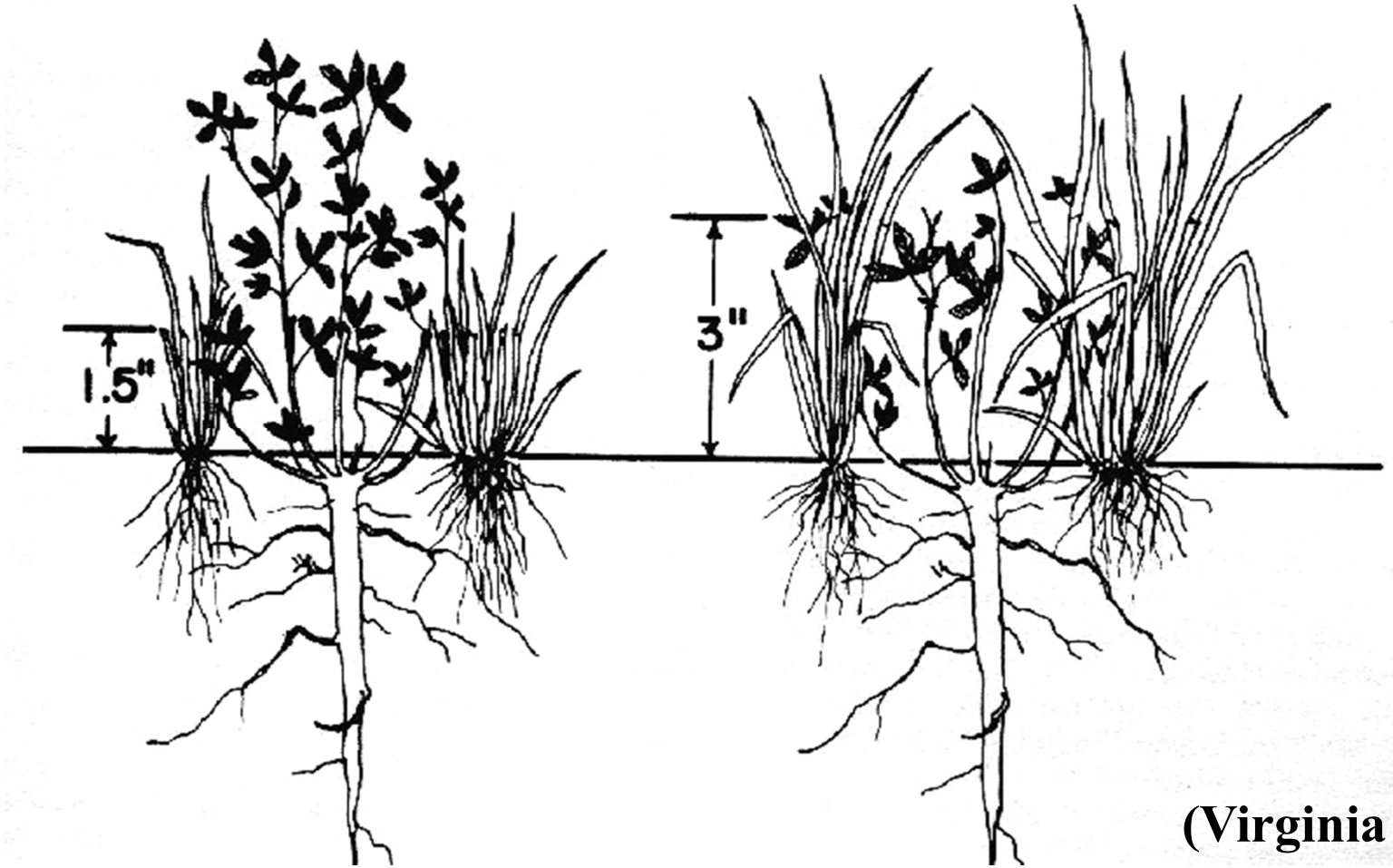
Environmental Interaction

Defoliation and Fall Management of Alfalfa

- **Mismanagement in the fall can lead toward winter injury of alfalfa.**
- **One option is to leave the stand uncut going into the winter**
- **If making a fall harvest, consider the previous cutting management. When cutting intervals are 35 days or less, it is best to avoid harvesting between early September and mid-October; otherwise, make sure there is 45 days between the late summer and fall harvest.**
- **Make sure soil K levels are adequate to high**
- **Leave a 4 to 6 inch stubble**

Botanical Composition

In a mixed stand of orchardgrass and alfalfa



(Virginia Tech)

Botanical Composition

In a mixed stand of grass and legume

- A higher cutting or grazing height usually favors the grass
- Grass shoots continue to grow after defoliation so their regrowth is rapid
- Legumes must initiate new growth from crown or lower axillary buds so regrowth is slower.

Botanical Composition

In a mixed stand of grass and legume

- A lower cutting or grazing height tends to favor the legume.
- In grasses, a low defoliation height removes more leaf area and part of the stored energy reserves (found in the basal portions of the grass stems); therefore, their regrowth rate is reduced.

Plant Response to Defoliation

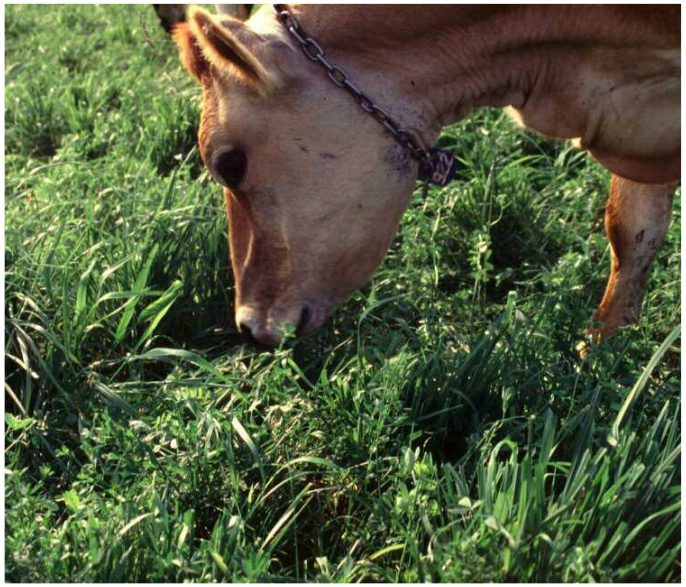
Grass Characteristics

Grass Specie	Growth Type	Time of Heading	Apical Dominance	Tolerance to Early First Cut	Vegetative Growth	Cutting Interval (days)
Timothy	Bunch	Medium-late to Late[2]	Strong	Intolerant	Jointing	40 - 45
Smooth bromegrass	Sod	Medium-late	Strong	Intolerant	Jointing	40 - 45
Reed canarygrass	Sod	Medium	Moderate	Somewhat Tolerant	Jointing	35 - 40
Orchardgrass	Bunch	Early to Medium[2]	Weak	Tolerant	Non-jointing	30 - 35
Tall fescue	Bunch[1]	Medium	Somewhat Weak	Tolerant	Non-jointing	30 - 35
Meadow fescue	Bunch	Medium-late	Somewhat Weak	Somewhat Tolerant	Non-jointing	35
Perennial ryegrass	Bunch	Early to Medium[2]	Weak	Tolerant	Non-jointing	30 - 35

[1] Some cultivars and ecotypes have been found to produce short rhizomes

[2] Wide range in cultivar heading dates for timothy, orchardgrass and perennial ryegrass

Forage Response to Defoliation – Basic Principles and Application



NORTHEAST SARE Sustainable Agriculture Research & Education Professional Development Program

New England Forage & Weed ID and Management Training Project