Forage Response to Defoliation – Basic Principles and Application

Presented by:
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University of Vermont
Plant Response to Defoliation

Resources

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

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

New England Forage & Weed ID and Management Training Project
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

<table>
<thead>
<tr>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Spt</th>
<th>Oct</th>
<th>Nov</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mass and sward height</td>
<td>Residue and cutting height</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Low
- Exp.- one hay cut/yr.

Medium
- Exp.- 3 hay cuts/yr.

High
- Exp.- Rotational grazing

Very High
- Exp.- continuous grazing
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 stand (if a mixed stand)

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

The environmental conditions in which forage plants are growing
Plants require energy for growth and maintenance. Photosynthesis (PSN) is the primary source of plant energy in the form of carbohydrates.

Energy for respiration and growth

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.
Plant Response to Defoliation

Morphological Characteristics

Plant Shape and Height

Erect (tall)  Prostrate (short)
Plant Response to Defoliation

Morphological Characteristics

Plant Shape and Height

Erect (tall)  Prostrate (short)

Cutting Or Grazing 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.
Plants would prefer to grow new leaves by producing carbohydrates with old leaves than by moving stored carbohydrates. It’s easier and more efficient.
When an adequate residual is left after grazing . . .

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.

. . . fewer from stored carbohydrates.
When there is an inadequate residual left after grazing . . .

. . . the plant must move stored carbohydrates up from the stem base to produce new leaves.

Smaller proportion of new leaves are being produced from carbohydrates in existing leaves . . .

. . . more from stored carbohydrates.
<table>
<thead>
<tr>
<th>Tall Species</th>
<th>Intermediate Species</th>
<th>Short Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Intermediate varieties of birdsfoot trefoil</td>
<td>‘Empire’ type varieties of birdsfoot trefoil</td>
</tr>
<tr>
<td>Red clover</td>
<td>Ladino type of white clover</td>
<td>Common and Dutch varieties of white clover</td>
</tr>
<tr>
<td>Upright varieties of birdsfoot trefoil</td>
<td>Tetraploid Per. Ryegrass</td>
<td>Kentucky bluegrass</td>
</tr>
<tr>
<td>Alsike clover</td>
<td></td>
<td>Some diploid per. ryegrasses</td>
</tr>
<tr>
<td>Timothy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth bromegrass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orchardgrass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tall fescue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Morphological Characteristics**

**Plant Response to Defoliation**
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.

Stored carbohydrates less likely to be eaten with meadow fescue.
In addition, the meadow fescue maintains more leaf area below grazing height than the orchardgrass, which also encourages regrowth.

More leaf area remains after grazing to capture sunlight.
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.
Plant Response to Defoliation

Anatomical Characteristics

Location of Growing Points

Apical meristem

Axillary buds

Crown buds

Legume Plants

Alfalfa crown buds and new shoots

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Plant Response to Defoliation

Anatomical Characteristics

Location of Growing Points

Axillary buds

Apical meristem

White Clover Stolon
Anatomical Characteristics

Location of Growing Points

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

Apical meristem

Culm

Non-jointing grasses

Vegetative grass tillers

Jointing grasses

Axillary bud with short stem

Crown buds

Reproductive grass tiller

Plant Response to Defoliation
Grass Types

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

Plant Response to Defoliation
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)
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).
Plant Response to Defoliation

Morphological Characteristics

**Plant Shape and Height**

- **Erect** (tall)
- **Prostrate** (short)

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

<table>
<thead>
<tr>
<th>Dry Matter Yield</th>
<th>Stored Energy Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
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Vegetative | Bud | Bloom

Time (days from initiation of growth)
Physiological Characteristics - Stored Energy

**Example: Alfalfa**

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<td>High</td>
</tr>
</tbody>
</table>

- **Phase I**: High Dry Matter Yield, Low Stored Energy Reserves
- **Phase II**: Low Dry Matter Yield, High Stored Energy Reserves
- **Phase III**: Low Dry Matter Yield, Low Stored Energy Reserves

Time (days from initiation of growth)
Plant Response to Defoliation

Physiological Characteristics - Stored Energy

**Example: Alfalfa**

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</tbody>
</table>

**Time (days from initiation of growth)**

**Phase I**
- Insufficient PSN, rely on stored energy

**Phase II**
- Sufficient PSN for growth

**Phase III**
- Excess PSN, energy reserves are replenished

**Vegetative**
- Bud
- Bloom
Physiological Characteristics - Stored Energy

Example: Alfalfa

Dry Matter Yield

Stored Energy Reserves

Vegetative  Bud  Bloom

High

Low

High

Low

Time (days from initiation of growth)

Frequent early cutting depletes energy reserves causing reduction in stand persistence.

Early cut

Regrowth
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
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
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

Barandana Orchardgrass
East Montpelier 2003

% NDF

Date of Spring Growth


NDF
Digestible NDF
NDF and Digestible NDF

Barandana Orchardgrass
East Montpelier 2003

Date of Spring Growth

% NDF

Indigestible Portion

Digestible Portion

50% NDFd

58% NDFd
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)

Sampled weekly from early May to mid June
Dates when first 5% of tillers in each stand reached boot/early head stage
(East Montpelier, VT)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pizza OG</td>
<td>6/3</td>
<td>6/4</td>
</tr>
<tr>
<td>Barindana OG</td>
<td>6/3</td>
<td>6/4</td>
</tr>
<tr>
<td>Pennlate OG</td>
<td>5/29</td>
<td>5/29</td>
</tr>
<tr>
<td>Sunrise Tim</td>
<td>6/10</td>
<td>6/12</td>
</tr>
<tr>
<td>Sunset Tim</td>
<td>6/14</td>
<td>6/18</td>
</tr>
<tr>
<td>Palaton RCG</td>
<td>6/10</td>
<td>6/12</td>
</tr>
</tbody>
</table>
Grasses increased about 0.75% NDF per day

Alfalfa increased about 0.52% NDF per day
Optimum NDF for grasses

Grasses increased about 0.75% NDF per day

Optimum NDF for alfalfa

Alfalfa increased about 0.52% NDF per day
Colored arrows indicate date of boot/early head.

Alfalfa in early bud stage.
Too late at these 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
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

Timothy (Smooth bromegrass has similar response)
Plant Response to Defoliation

Environmental Interaction

Spring Growth

Summer Growth

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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).
Alfalfa Quality and Yield

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

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Plant Response to Defoliation

Environmental Interaction

Spring Growth

Summer Regrowth

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Most cool season grasses have a winter requirement for floral induction that may 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.
<table>
<thead>
<tr>
<th>Species</th>
<th>Relative Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td></td>
</tr>
<tr>
<td>Early varieties</td>
<td></td>
</tr>
<tr>
<td>Late varieties</td>
<td></td>
</tr>
<tr>
<td>Perennial Ryegrass</td>
<td></td>
</tr>
<tr>
<td>Early varieties</td>
<td></td>
</tr>
<tr>
<td>Late varieties</td>
<td></td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td></td>
</tr>
<tr>
<td>Smooth bromegrass</td>
<td></td>
</tr>
<tr>
<td>Tall fescue</td>
<td></td>
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<tr>
<td>Timothy</td>
<td></td>
</tr>
<tr>
<td>Early varieties</td>
<td></td>
</tr>
<tr>
<td>Late varieties</td>
<td></td>
</tr>
</tbody>
</table>
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/vterops/?Page=research/GrassVarieties.html)
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.
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.
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.

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.
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)
Plant Response to Defoliation

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

<table>
<thead>
<tr>
<th>Grass Specie</th>
<th>Growth Type</th>
<th>Time of Heading</th>
<th>Apical Dominance</th>
<th>Tolerance to Early First Cut</th>
<th>Vegetative Growth</th>
<th>Cutting Interval (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy</td>
<td>Bunch</td>
<td>Medium-late to Late²</td>
<td>Strong</td>
<td>Intolerant</td>
<td>Jointing</td>
<td>40 - 45</td>
</tr>
<tr>
<td>Smooth bromegrass</td>
<td>Sod</td>
<td>Medium-late</td>
<td>Strong</td>
<td>Intolerant</td>
<td>Jointing</td>
<td>40 - 45</td>
</tr>
<tr>
<td>Reed canarygrass</td>
<td>Sod</td>
<td>Medium</td>
<td>Moderate</td>
<td>Somewhat Tolerant</td>
<td>Jointing</td>
<td>35 - 40</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>Bunch</td>
<td>Early to Medium²</td>
<td>Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>Bunch¹</td>
<td>Medium</td>
<td>Somewhat Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Meadow fescue</td>
<td>Bunch</td>
<td>Medium-late</td>
<td>Somewhat Weak</td>
<td>Somewhat Tolerant</td>
<td>Non-jointing</td>
<td>35</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>Bunch</td>
<td>Early to Medium²</td>
<td>Weak</td>
<td>Tolerant</td>
<td>Non-jointing</td>
<td>30 - 35</td>
</tr>
</tbody>
</table>

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

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