Phenology User Guide

USFWS Native Prairie Adaptive Management

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INTRODUCTION

The Native Prairie Adaptive Management Project (NPAM) decision framework for tallgrass units is built around the concept that cool-season windows (fall and spring) exist during which grassland management can impact cool-season invasive grasses without negatively impacting native warm season grasses (e.g., Willson and Stubbendieck 2000). Defoliation within the window occurs through either a prescribed fire or grazing event. Timing and duration of the defoliation event relative to the cool-season window is critically important. Neither the fall nor spring cool-season window is static. Start and end periods for both fall and spring windows likely differ among years and locations, making phenology data an important component of monitoring (and management).

Because of the need to collect consistent and accurate data on phenology, this guide was created as a stand-alone reference for NPAM cooperators who manage tallgrass units. Identifying phenological stages provides critical data to inform the tallgrass model. The subsequent protocols should provide necessary details to collect these data, without imposing an inordinate workload on the cooperators. These phenology data protocols do not impose an excessive work load; they are, however, exceedingly important and require a commitment from the cooperators to consistently follow the guidelines outlined here. This is especially important due to the natural variation in the data being collected.

For some aspects of this project, there is little to no information in the literature to guide phenology-based management. It is unclear at which phenological stage Kentucky bluegrass may be most vulnerable to fire (Sather 1996). At the time of this writing, Dr. Shawn DeKeyser and colleagues at North Dakota State University have initiated research on Kentucky bluegrass management. Similarly, there is less specific information available regarding management applications in fall than is available for spring. It is our hope that the phenology data collected through NPAM and other ongoing research will allow us to revise and refine some of the phenological stages described in this document.

Phenology data are collected for NPAM at two spatial scales: 1) the management-unit scale, and 2) the station-level scale. These are two related but different data collection efforts.

1. MANAGEMENT UNIT PHENOLOGY

Management unit-level phenology data are required to determine whether a burn or graze management action occurs in or out of the cool-season window.

1.1 MANAGEMENT UNIT PHENOLOGY | WHO COLLECTS DATA

Management unit phenology will be monitored by NPAM cooperators with tallgrass prairie units. The project coordinator and advisory team will provide training and guidance as needed to ensure consistent, reliable data collection (typically this training will occur as part of the Field Activity Workshops). Ideally, the same staff member (usually the biologist or manager) will collect phenological data within and among years.

1.2 MANAGEMENT UNIT PHENOLOGY | WHERE TO COLLECT DATA

Management unit phenology must be monitored at each tallgrass management unit that is receiving a burn or graze management action. A single "measurement" may entail data collection at more than one sampling location within and possibly adjacent to a unit, depending on whether a burn or graze is implemented. The single measurement for a burned unit and the measurement at the beginning of a grazing event are made within the management unit. However, because a grazing event alters phenology within a grazed unit, the phenology measurement at the end of the graze is made on a nearby *reference unit* that was not grazed or burned during the management year. The reference unit should be chosen such that at the beginning of the grazing event, the reference unit has the same phenological stage as the management unit that is about to be grazed (e.g., beginning leaf-stage of smooth brome should be the same on the unit receiving management and the reference unit).

1.3 MANAGEMENT UNIT PHENOLOGY | DATA COLLECTION

Management unit phenology data are collected on the date a burning event occurs and on the start and end dates of a grazing event. Thus, one phenology measurement is made for a burned unit and two measurements are made for a grazed unit. The observer spends 10-15 minutes walking around the management unit to get a feel for the average conditions across the unit, being sure to account for any natural variation that could influence phenology (e.g., soil moisture, slope). Note that the phenological cues that are observed and recorded will depend on the season of the treatment. For reference, photos and diagrams of grasses at various phenological stages are shown in Appendix A.

A data form for recording management unit phenology is provided in Appendix B. The cooperator will enter phenology data in the NPAM database along with their other management action data for the management unit.

Fall Treatments

For a fall treatment (applied between September 1 and December 31), the observer will monitor the phenology of the dominant warm-season native grasses and cool-season invasive grasses (both smooth brome and Kentucky bluegrass) at the management unit (reference photos are provided in Appendix A). The observer will make an ocular estimate of the following:

1. Whether the majority (>50%) of warm-season native grass plants at the unit are still actively growing or have gone to seed.
   Flowering and seed production will vary by species; focus on the dominant species at the site. The seed should be ripe and easy to remove by hand.
2. The percent of cool-season invasive grasses at the unit that are fall green-up plants.
   Fall green-up plants are fresh tillers that have started growing after a period of summer dormancy. During this stage, the fall green-up plants are usually a bright green to evergreen color. This category does not include plants that are in the process of senescence, which are a yellow or light green color, often with brown mottling.
3. The percent of cool-season invasive grasses at the unit that are completely senesced.
   Plants that have completely senesced will be completely brown in color. Late in the season, this category will include both spring and fall plants.

This information will allow the observer to classify the unit at the time of the management action into one of three fall phenological stages in the database:

1. >50% of warm-season native grasses are still active,
2. >50% of warm-season native grasses have gone to seed and >25% of cool-season invasive grasses are fall green-up plants, or
3. >50% of warm-season native grasses have gone to seed and >75% of cool-season invasive grasses have completely senesced.

Spring Treatments

For a spring treatment (applied between January 1 and August 31), the observer will monitor the phenology of smooth brome at the management unit (a leaf stage diagram is provided in Appendix A). The observer will make an ocular estimate of the following:

1. The percent of smooth brome at the unit that has at least 5 leaves.
   Count the number of leaves on several plants. The 5-leaf stage corresponds with tiller elongation, the most vulnerable stage for smooth brome in the spring.
2. The percent of smooth brome at the unit that has developed an inflorescence.
   A visible inflorescence corresponds with the end of tiller elongation.

This information will allow the observer to classify the unit at the time of the management action into one of three spring phenological stages in the database:

1. >50% of smooth brome has fewer than 5 leaves,
2. >50% of smooth brome has at least 5 leaves, but inflorescences are not yet visible, or
3. >50% of smooth brome inflorescences are visible or have already passed.

2. STATION-LEVEL PHENOLOGY

Whereas management-unit level phenology data are focused on capturing phenology at specific points in time (i.e., the start and end of treatment), the aim of station-level monitoring is to track the progression of phenology during the year. Station-level phenology data are sometimes referred to as "window watcher" data. Surveys will occur within a broader sampling timeframe that is likely to encompass the actual phenological window. Progression of phenology is quantified by recording the timeline of changes in phenological cues.

2.1 STATION-LEVEL PHENOLOGY | WHO COLLECTS DATA

Station-level phenology data (sometimes referred to as "window watcher" data) will be collected by tallgrass cooperators. If there are spatial gaps not being surveyed by NPAM participants, the project coordinator may solicit assistance from non-NPAM resource professionals. The project coordinator and advisory team will provide training and guidance as needed to ensure consistent, reliable data collection (typically this training will occur as part of the Field Activity Workshops). The same staff member (usually the biologist or manager) should collect phenological data within years and, ideally, among years.

2.2 STATION-LEVEL PHENOLOGY | WHERE TO COLLECT DATA

Station-level phenology sites are intended to help monitor phenological progression across the station and ultimately define the start and end of the fall and spring cool-season windows each year for the specific location. Some considerations for identifying a site to collect station-level phenological data include:

- The site should be native sod with some smooth brome and/or Kentucky bluegrass present.
- As much as possible, choose a site that is fairly representative of prairies across the station.
- The site should not have received a defoliation treatment within the last year, since this may affect phenological development.

- The site should be convenient to survey frequently. Most observers will use an area that is located at or very near to their office.
- The window watcher site does not need to be an NPAM management unit.
- Try to avoid other site-specific, unusual situations that may affect the plant community (e.g., unusual invasive species, extreme slopes or moisture conditions).

2.3 STATION-LEVEL PHENOLOGY | DATA COLLECTION

Station-level phenology observations are made at a 2-4 day interval during both a fall and a spring observation period (see below for definitions). The observer spends 10-15 minutes walking around the site, stopping at 5-10 different areas. When choosing the stops, the observer will account for any natural variation at the site that could influence phenology (e.g., soil moisture, slope). If the situation occurs where cool-season invasive grasses and warm-season native grasses are not evenly interspersed at the site, it may be necessary to have up to 10 stops for the fall survey; five to address the cool-season invasive grass senescence progression, and a separate five to address the warm-season native grass progression.

Each of the stops should be marked with a pin flag at the initial visit of each year. The observer will collect data at these marked areas throughout the season to allow for consistency of sampling. Within an approximately 1-m^2 plot at each of the five stops, the observer will make an ocular estimate of the phenological cues described below. Estimates at each stop will be made in 10% intervals (0-10, 10-20, 20-30, etc.). Note that the cues used to track progression of the cool-season window will differ by season. For reference, photos and diagrams of grasses at various phenological stages are shown in Appendix A.

Fall and spring data forms (Appendices C and D) are provided to record observations at each visit. The data forms include a request for the soil drainage of the selected site. To obtain this information, go to the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. On the main web soil survey page, define the area of interest, click on the soil map tab, and then click on the map unit name for the relevant soil. A pop-up box will open with a description for the map unit, including the drainage class, under Properties and Qualities. There are significant uncertainties about the phenology of grasses in the project area, including current unknowns as well as the potential effects of climate change. Any additional comments or observations about phenology, weather patterns, etc. at the site will be very helpful as the project continues in the future.

Submit observation data forms to the project coordinator via email or fax by July 15 each year. The project coordinator and database coordinator will enter the data into an Access database

and update the phenology models annually. The phenological data will be shared with cooperators and other supporters on an annual basis.

Fall Observation Period

During the fall observation period (approximately September 1 through freeze-up), the observer will monitor the phenology of the dominant warm-season native grasses and cool-season invasive grasses (both smooth brome and Kentucky bluegrass) at the site (reference photos are provided in Appendix A). At each stop, the observer will make an ocular estimate of the following:

1. The percent of warm-season native grass plants at the stop that has gone to seed.
   Flowering and seed production will vary by species; focus on the dominant species at the site. The seed should be ripe and easy to remove by hand.
2. The percent of cool-season invasive grasses at the stop that are fall green-up plants.
   Fall green-up plants are fresh tillers that have started growing after a period of summer dormancy. During this stage, the fall green-up plants are usually a bright green to evergreen color.
3. The percent of cool-season invasive grasses at the stop that are in the process of senescence.
   Plants in the process of senescence will be a yellow or light green color, often with brown mottling. Another way to think of this: Of the cool-season invasive grasses in the plot, what percent is between the lush green of fall green-up plants and the complete brown of the fully senesced plants. Early in the season, only the spring plants will be in this category; later in the season, this will include both spring and fall plants.
4. The percent of cool-season invasive grasses at the stop that are completely senesced.
   Plants that have completely senesced will be completely brown in color. Late in the season, this will include both spring and fall plants.

Note: The reference photos in Appendix A should help distinguish among the cool-season phenological stages listed in #2-#4 above. At a given stop, the percents assigned to the three cool-season phenology stages should sum to 100%.

At the end of the survey period, the project coordinator will summarize the observation data by identifying the dates when the following phenological stages occurred:

1. >50% of the dominant native warm-season grass plants at the site have gone to seed.
2. >25% of the cool-season invasive grasses at the site are composed of fall green-up plants.
3. >75% of the cool-season invasive grasses at the site have completely senesced.

Spring Observation Period

During the spring observation period (approximately April 15 through June 30), the observer will monitor the phenology of smooth brome at the site (a leaf stage diagram is provided in Appendix A). At each stop, the observer will make an ocular estimate of the following:

1. The percent of smooth brome at the stop that has at least 5 leaves.
   Count the number of leaves on several plants. The 5-leaf stage corresponds with tiller elongation, the most vulnerable stage for smooth brome in the spring.
2. The percent of smooth brome at the stop that has developed an inflorescence.
   A visible inflorescence corresponds with the end of tiller elongation.

At the end of the survey period, the project coordinator will summarize the observation data by identifying the dates when the following phenological stages occurred:

1. >50% of smooth brome plants at the site were at the 5 leaf stage.
2. >50% of smooth brome plants at the site had reached inflorescence.

3. LITUREATURE CITED

Sather, N. 1996. Element stewardship abstract for *Poa pratensis*, *Poa compressa*. The Nature Conservancy, Arlington, VA. 21 pp.

Willson, GD and J. Stubbendieck. 2000. A provisional model for smooth brome management in degraded tallgrass prairie. Ecological Restoration 18:34-38.

APPENDIX A – PHENOLOGY GUIDE

Fall – Fall Green-up Compared to Senescence

Fall green-up plants (freshly green)

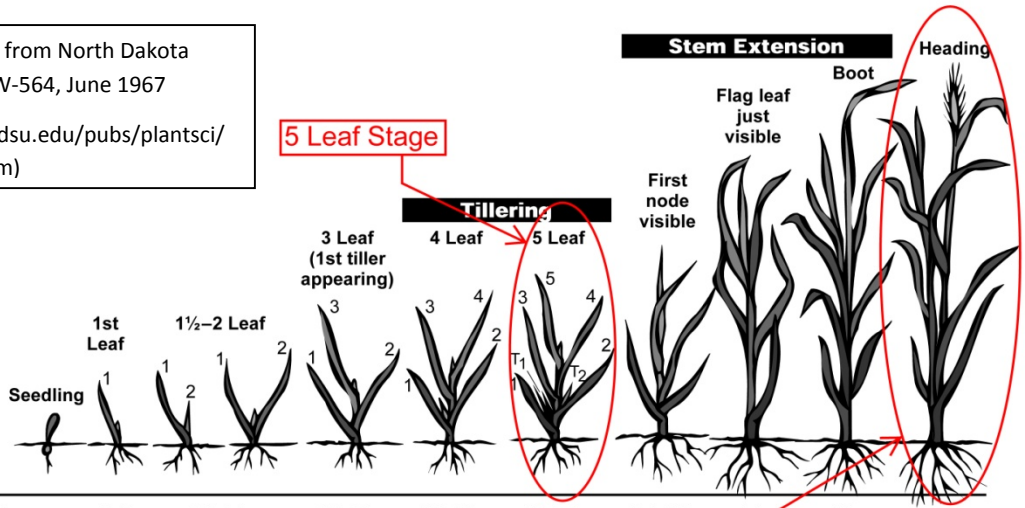
Grasses that are in the process of senescing (yellow, light green)

Grasses that have completely senesced (brown)

Spring – Leaf and Inflorescence Stages

Diagram modified from North Dakota State University, W-564, June 1967

(http://www.ag.ndsu.edu/pubs/plantsci/weeds/w564w.htm)



Early Planting (days)	7-8	14-16	20-22	26-28	31-33	34-36	44	53	58
Late Planting (days)	6-7	11-13	16-18	21-23	25-27	2			49
Growing Degree Day* (units)	72	144-215	358	501	644	715	1075	1359	1500

The lettering on the drawing represents the following: 1=1st leaf on the main stem of the plant; 2=2nd leaf on the main stem; 3=3rd leaf on the main stem; 4=4th leaf on the main stem; 5=5th leaf on the main stem and T=Tiller – not counted as a leaf when determining leaf stages.

Management Unit Phenology Data
USFWS Native Prairie Adaptive Management

Observer _____ Management Unit _____

Management Action (check one): ☐ BURN ☐ GRAZE

Date management started: _____ Date management ended: _____

Fall Treatment (applied between September 1 and December 31)

Phenology on day of burn or start of graze:

Warm-season native grasses (check one):
☐ > 50% of warm-season native grasses are still active
☐ > 50% of warm-season native grasses have gone to seed
Cool-season invasive grasses (check one):
☐ < 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 75% of smooth brome and/or Kentucky bluegrass has completely senesced (i.e., brown in color)

Phenology at end of graze:

Warm-season native grasses (check one):
☐ > 50% of warm-season native grasses are still active
☐ > 50% of warm-season native grasses have gone to seed
Cool-season invasive grasses (check one):
☐ < 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 75% of smooth brome and/or Kentucky bluegrass has completely senesced (i.e., brown in color)

Comments:

Management Unit Phenology Data
USFWS Native Prairie Adaptive Management

Observer _____ Management Unit _____

Management Action (check one): ☐ BURN ☐ GRAZE

Date management started: _____ Date management ended: _____

Spring Treatment (applied between January 1 and August 31)

Phenology on day of burn or start of graze:

Smooth brome leaf stage (check one):
☐ > 50% of smooth brome has fewer than 5 leaves
☐ > 50% of smooth brome has at least 5 leaves
Smooth brome inflorescence (check one):
☐ > 50% of smooth brome is not yet showing inflorescences
☐ > 50% of smooth brome is showing inflorescences

Phenology at end of graze:

Smooth brome leaf stage (check one):
☐ > 50% of smooth brome has fewer than 5 leaves
☐ > 50% of smooth brome has at least 5 leaves
Smooth brome inflorescence (check one):
☐ > 50% of smooth brome is not yet showing inflorescences
☐ > 50% of smooth brome is showing inflorescences

Comments:

APPENDIX C – STATION-LEVEL FALL PHENOLOGY DATA FORM

Station-Level Phenology – Fall Data
USFWS Native Prairie Adaptive Management

Observer _____ Phone _____ Email _____

Site Name _____

Legal Description: State _____ County _____ Township _____ Range _____ Section _____ Quarter _____

Soil drainage class (check one): ☐ Poorly Drained ☐ Moderately Drained ☐ Well Drained http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Date	% of dominant warm-season native grasses that have gone to seed					% of cool-season invasive grasses that are fall green-up plants (freshly green)					% of cool-season invasive grasses that are in the process of senescing (yellow, light green)					% of cool-season invasive grasses that have completely senesced (brown)				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)																			
Stop #→	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Example 9/1/2012	80-90	70-80	80-90	70-80	70-80	0-10	10-20	10-20	0-10	10-20	70-80	60-70	60-70	70-80	60-70	0-10	10-20	0-10	0-10	0-10

APPENDIX C – STATION-LEVEL FALL PHENOLOGY DATA FORM

Date	% of dominant warm-season native grasses that have gone to seed					% of cool-season invasive grasses that are fall green-up plants (freshly green)					% of cool-season invasive grasses that are in the process of senescing (yellow, light green)					% of cool-season invasive grasses that have completely senesced (brown)				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)																			
Stop #→	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Comments:

APPENDIX D – STATION-LEVEL SPRING PHENOLOGY DATA FORM

Station-Level Phenology – Spring Data
USFWS Native Prairie Adaptive Management

Observer _____ Phone _____ Email _____

Site Name _____

Legal Description: State _____ County _____ Township _____ Range _____ Section _____ Quarter _____

Soil drainage class (check one): ☐ Poorly Drained ☐ Moderately Drained ☐ Well Drained http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Date	% of smooth brome with at least 5 leaves					% of smooth brome with an inflorescence				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)									
Stop #→	1	2	3	4	5	1	2	3	4	5
Example 4/15/2012	20-30	30-40	Example 30-40	20-30	30-40	0-10	0-10	Example 0-10	0-10	0-10

APPENDIX D – STATION-LEVEL SPRING PHENOLOGY DATA FORM

Date	% of smooth brome with at least 5 leaves					% of smooth brome with an inflorescence				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)									
Stop #→	1	2	3	4	5	1	2	3	4	5

Comments:

Station-Level Phenology – Spring Data Site Name_____ 2 of 2