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Heartland I&M Fire Effects Monitoring

Handbook for Monitoring Prescribed and Wildland Fire



TAPR Big Pasture post-fire 2009

Adapted from the Northern Great Plains and National Fire Monitoring handbooks.

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INTRODUCTION

The Heartland I&M Network (HTLN) Fire Ecology program is designed to bring fire ecology support to parks within the network that are not already receiving support from the NPS fire ecology program. These parks include Effigy Mounds NM, George Washington Carver NM, Herbert Hoover NHS, Homestead NM of America, Pipestone NM, Tallgrass National Prairie Preserve, and Wilsons Creek NB. Fire ecologists at Ozark Highlands and Voyagers work with some HTLN parks. The HTLN fire ecology program combines visions and protocols of both the HTLN long-term monitoring and NPS fire ecology programs. By using this hybrid approach we hope to enhance both programs resulting in the best possible information being delivered to the parks.

The NPS Fire Monitoring Handbook (2003) identifies four levels of fire monitoring:

- Level 1 – Environmental
- Level 2 – Fire Observation and Reconnaissance
- Level 3 – Short-term Change
- Level 4 – Long-term Change

This handbook outlines field procedures for collecting fire ecology data prior to a burn, during a burn, and immediately post-burn (Levels 1 and 2). This plan will address Levels 1 and 2 as they relate to monitoring efforts for prescribed and wildland fire activities. Long-term vegetation monitoring protocols (Levels 3 and 4) are published and available on the web <http://science.nature.nps.gov/im/units/htln/> (James et al. 2009).

LEVEL 1: ENVIRONMENTAL

This level provides a basic overview of the baseline data that can be collected prior to a burn event. The cadre of data consists of weather, daily fire danger rating, and staffing levels (during the fire season), fuel moisture, soil moisture, fuel load, and geographic information.

WEATHER

Broad links to weather and fire weather data within the HTLN include:

- *RAWS* – <http://www.raws.dri.edu/>
- *ROMAN* – <http://raws.wrh.noaa.gov/roman/>
ROMAN houses all data from the GOES weather stations. Data from the most recent observation at the station is available on the home page of each station. Past data can be found by following the ‘Past Data’ link.
- *Western Regional Climate Center* – <http://www.wrcc.dri.edu/>
WRCC houses all historic data from [RAWS](#) stations.
- *High Plains Regional Climate Center* – <http://www.hprcc.unl.edu/>
HPRCC contains historic NWS weather station data from parks in North Dakota, South Dakota, and Nebraska.
- *MesoWest* – <http://www.met.utah.edu/mesowest/>

This site houses data from weather stations across the U.S., including RAWS and NWS stations. One of the most unique features of this website is an interactive surface weather map.

Sites specific to each park including the National Weather Service are listed below. If a weather station is not listed for the park, the closest alternative was mapped.

EFMO and HEHO

www.dnr.state.mn.us/forestry/fire/index.html
<http://www.crh.noaa.gov/arx/?n=firewx> (LaCrosse)
<http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdWBOS>

TAPR

<http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdKTAL>
http://www.met.utah.edu/cgi-bin/roman/meso_base.cgi?stn=TGSK1
http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=148061
<http://www.crh.noaa.gov/top/> (Topeka)

HOME

<http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdNRAI>
<http://www.crh.noaa.gov/oax/> (Omaha)
http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=250622

PIPE

<http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdMRDS>
http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=216565
<http://www.crh.noaa.gov/fsd/> (Sioux Falls)

WICR and GWCA

<http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdMMTV> (Mt. Vernon station)
<http://www.crh.noaa.gov/sgf/> (Springfield)

FIRE DANGER RATING AND STAFFING LEVELS

The various factors of fuels, weather, topography and risk are combined to assess the daily fire potential for an area. Fire danger is usually expressed in numeric or adjective terms. Fire danger ratings are typically reflective of the general conditions over an extended area, often tens of thousands of acres, affecting an initiating fire. Ratings can be developed for either current (observed) or future (predicted) situations. They can be used to guide decisions two or three days in advance (subject to the limits of the forecasting system) as well as to compare the severity of one day or season to another. Fire danger ratings describe conditions that reflect the potential for a fire to ignite, spread and require suppression action over a large area.

Two indices, burning index (BI) and energy release component (ERC), are used to determine staffing levels. Staffing Levels are expressed as numeric values where 1 represents the low end of the fire danger continuum and 5 the high end.

Burning Index

The Burning Index is a number related to the contribution of fire behavior to the effort of containing a fire. The BI (difficulty of control) is derived from a combination of Spread Component (how fast it will spread) and Energy Release Component (how much energy will be produced). In this way, it is related to flame length, which, in the Fire Behavior Prediction System, is based on rate of spread and heat per unit area. However, because of differences in the calculations for BI and flame length, they are not the same. The BI is an index that rates fire danger related to potential flame length over a fire danger rating area. The BI is expressed as a numeric value related to potential flame length in feet multiplied by 10. The scale is open-ended which allows the range of numbers to adequately define fire problems, even during low to moderate fire danger.

Energy Release Component

The Energy Release Component is a number related to the available energy (BTU/per ft²) within the flaming front at the head of a fire. Daily variations in ERC are due to changes in moisture content of the various fuels present, both live and dead. Since ERC represents the potential "heat release" per unit area in the flaming zone, it can provide guidance to several important fire activities. It may also be considered a composite fuel moisture value as it reflects the contribution that all live and dead fuels have to potential fire intensity. The ERC is a cumulative or "build-up" type of index. As live fuels cure and dead fuels dry, the ERC values get higher thus providing a good reflection of drought conditions. The scale is open-ended or unlimited and, as with other NFDRS components, is relative. Conditions producing an ERC value of 24 represent a potential heat release twice that of conditions resulting in an ERC value of 12. Since wind and slope do not enter into the ERC calculation, the daily variation will be relatively small.

FUEL MOISTURE SAMPLING

Fuel moisture contributes to fire intensity and fire severity. Although grasslands consist primarily of 1-hr fuels, we will collect 10-hr fuel moisture using the standard 10-hr fuel moisture sticks (allowing for on-site assessment) as well as collect 1-hr fuels by clipping. A 0.01-m² hoop will be used for the latter and 3-4 samples collected per sample site. A detailed description of protocols, a datasheet, and a map of sampling locations can be found in Appendix 2.

FUEL LOAD

Downed Woody Fuels

Downed woody fuel load of forested areas is estimated by using the planar intercept method (Brown et al. 1982). Fuels transects are most often associated with long-term vegetation monitoring sites within burn units. Woodland fuel loads are collected at WICR, EFMO, HOSP, and PERI. Transects are 50 ft long; 1- and 10-hour fuels are tallied from 0 to 6 ft, 100-hour fuels are tallied from 0 to 12 ft, and 1000-hour fuels are tallied from 0 to 100 ft. A go-no-go gauge (Figure 1) is used to separate particles into size classes. Intercepts are counted along the transect plane up to 6 ft from the ground. Cones, bark, needles and leaves are *not* counted along the transect. Stems and branches attached to standing shrubs or trees are also not counted. Litter and duff depth measurements visually estimated along each fuels transect at 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 ft using a clear plastic ruler or graduated trowel. For additional details on

measuring downed woody material, refer to the Fire Monitoring Handbook (NPS 2003) or Brown et al. (1982). A data sheet can be found in Appendix 3.

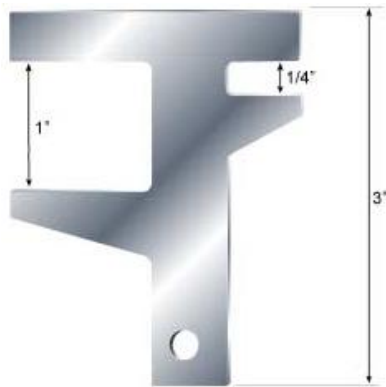


Figure 1. Go-no-go gauge.

Woodland fuels are collected as a regular part of HTLN monitoring. The fire effects crew will coordinate with the HTLN plant ecologist to ensure pre- and post-fire fuels measurements are collected.

Herbaceous Biomass insitu

Fuel load in grassland areas is estimated by clipping vegetation from a known area to determine tons/acre of grassy fuels. Ideally, three to four samples will be collected during the growing season before a prescribed fire is scheduled. Samples will be collected near each vegetation monitoring site in scheduled burn units. If no vegetation monitoring plots are present in the unit, sample locations can be randomly selected from the unit. Collect at least three samples from each location. Samples are collected using a circular frame with an area of 0.1 m² and placed in a paper bag. For pre-burn sampling, stand at the four corners of the site facing into the site. Toss the sampling frame over your right shoulder to locate the sample. The sample sites must be at least 4 m (4 large steps) from each corner of the site to avoid confounding vegetation monitoring. Clip vegetation, including standing dead plants, to within 1 inch of the ground or grass crown and place in bag. Avoid cutting threatened or endangered species. Also collect litter, but avoid duff. Add it to the bag of clippings.

Samples are oven-dried for 24 hours at 65° C and weighed. The dry weight is then used to calculate total fuel load. The weight of the bag must be subtracted from the sample weight for an accurate measurement. If the same type of bag is used for several samples, dry and weigh 10 similar bags, then use the average dry bag weight as the container weight in all calculations.

Sample bags should be labeled with the following information: Park code_site number, data (ddmonthyyyy), sample number.

Herbaceous Biomass photoboard method (TAPR only)

An indirect measurement of biomass has been tested for accuracy at TAPR. This method involves taking a picture of a white board from a known distance and height. The image was calibrated against clipped biomass and a calibration curve produced. Future sampling will not require clipping, only photography. The protocol can be found in Appendix 6.

SOIL MOISTURE SAMPLING

Soil moisture sampling is most often done in conjunction with biomass sampling by collecting a soil sample from within the circular frame after the herbaceous material has been removed. Brush away any remaining herbaceous material or litter and duff after biomass collection and collect soil from the upper 2-3 cm. It is best to take soil samples in the interstitial spaces between grass clumps. Remove rocks and pebbles before putting soil in the tin. Avoid roots if possible. Place the soil in a small tin collecting enough soil to completely fill the tin. Samples should be weighed as soon as possible after collection, then oven-dried for 48 hours at 65° C and re-weighed. Dry weight can then be used to calculate moisture content. A data sheet can be found in Appendix 5. (% soil moisture = (sample wet weight -sample dry weight)/ sample dry weight *100) *At HEHO contact Cary Wiesner prior to sampling. Do not collect soil samples at EFMO.*

GEOGRAPHIC INFORMATION (GIS)

A GIS database of fire occurrences is maintained on the HTLN server in the geodatabases folder. This geodatabase contains a historical record of spatial data of burned areas for each park. Data from the National Fire Reporting System were validated with data provided in Fire Management Plans, and discussion directly with parks. This record will be maintained as a repository of regional data. Other spatial data relevant to fire include topographic maps, vegetation maps, and monitoring site locations. Other basic data (boundaries, roads, etc.) for HTLN parks can also be found on the HTLN server. The HTLN GIS specialist will provide GPS units with the needed data to fire effects field crews.

LEVEL 2: FIRE OBSERVATION

Fire Ecologists often serve as Fire Effects Monitors (FEMOs) on prescribed and wildland fires. The primary responsibility of a FEMO is to document fire observations during a fire. Monitoring fire conditions includes data on ambient conditions and fire and smoke characteristics. These data are coupled with information gathered during environmental monitoring to predict fire behavior, identify potential problems, and understand fire effects.

FIRE BEHAVIOR

The objective of monitoring fire characteristics in forest, shrubland, or grassland types is to observe safely while simultaneously obtaining representative fire behavior measurements wherever possible. Take fire weather and behavior observations (rate of spread, flame length, and flame depth) in the same vegetation types represented by your plots and in an area where the fire behavior is representative of fire behavior on the plots. Where safe, you can make fire behavior observations near a monitoring plot.

Rate of Spread

Rate of Spread (ROS) describes the fire progression across a horizontal distance; it is measured as the time it takes the leading edge of the flaming front to travel a given distance. ROS is expressed in chains/hour, but it can also be recorded as meters/second. Make your observations only after the flaming front has reached a steady state and is no longer influenced by adjacent ignitions. Use a stopwatch to measure the time elapsed during spread. The selection of an appropriate marker, used to determine horizontal distance, is dependent on the expected ROS. Pin flags, rebar, trees, large shrubs, rocks, etc., can all be used as markers. Markers should be spaced such that the fire will travel the observed distance in approximately 10 minutes. If the burn is very large and can be seen from a good vantage point, changes in the burn perimeter can be used to calculate area ROS. If smoke is obscuring your view, try using firecrackers. Record data in chains/hour (roughly the same as feet/minute).

Flame Length

Flame length is the distance between the flame tip and the midpoint of the flame depth at the base of the flame—generally the ground surface, or the surface of the remaining fuel (see Figure 2). Flame length is described as an average of this measurement as taken at several points. Estimate flame length to the nearest inch if length is less than 1 ft, the nearest half foot if between 1 and 4 ft, the nearest foot if between 4 and 15 ft, and the nearest 5 ft if more than 15 ft long. Flame length can also be measured in meters.

Flame Depth

Flame depth is the width, measured in inches, feet or meters, of the flaming front (see Figure 2). Monitor flame depth if there is a management interest in residence time. Measure the depth of the flaming front by visual estimation.

Note: Where close observations are not possible, use the height (for FL) or depth (for FD) of a known object between the observer and the fire behavior observation interval to estimate average flame length or flame depth.

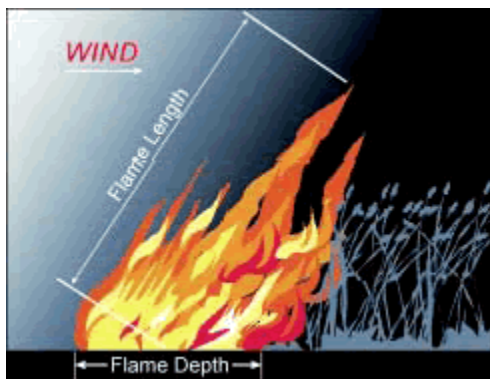


Figure 2. Graphical representation of flame length and depth.

FIRE WEATHER

FEMOs are responsible for measuring, recording, and broadcasting weather observations throughout a burn period. This often includes requesting a spot weather forecast for the project area at the beginning of the operational period. Spot weather requests are generally made on the

internet but can be done over the phone when necessary. Spot weather forecasts are prepared for GWCA and WICR by the [Springfield office](#), EFMO and HEHO are prepared by the [LaCrosse office](#), PIPE is prepared by the [Sioux Falls office](#), TAPR is prepared by the [Emporia office](#), and Home is prepared by the [Omaha office](#). The lead FEMO usually reads the spot weather forecast at the briefing at the beginning of the operational period. The burn boss or incident commander should inform the FEMO how often to make weather observations and on which radio frequency to broadcast the observations. This is commonly done once an hour and broadcast over the command frequency. Appendix 7 contains a fire weather datasheet as well as a spot weather forecast evaluation form.

SMOKE MONITORING

Smoke observations should be made throughout the burn period and include information about the smoke column and visibility in the area of the burn. It is especially important to record the time and location of the observation along with any pertinent information about the smoke column and visibility. A data sheet is included in Appendix 8. Not all information will necessarily be collected at every observation point. The situation will dictate which information is important to collect. For example, if the FEMO is working near a road and smoke is impacting visibility on the road, only information about visibility may be collected at that time. Photos may also be taken as additional documentation of conditions.

FIRE PROGRESSION/IGNITION PATTERN

Since FEMOs often work closely with ignition teams, there is a good opportunity to document fire progression and ignition patterns throughout a prescribed fire. It works well to use the incident action plan (IAP) map provided at briefing to keep notes. Record time and location of the test fire, as well as time that ignition officially commenced. Also record general routes followed by the ignition team and times that they reached identifiable landmarks. Try to denote the ignition techniques used throughout the burn area and approximate fire spread. An example can be found in Appendix 9.

PHOTOGRAPHS

There is no strict protocol established for taking photographs during fires. Photos may be taken whenever there is something interesting to photograph. It is useful to have photographs of fire behavior, smoke, firefighters working on the line, etc. If the opportunity arises to document a significant event on the fire, be sure to record the time and location of the photo as well as other information describing the event. Photos are stored on the HTLN server.

For pre- and post-burn sampling, photographs of transects should be taken in a systematic way. Flags should be placed at each end of the transect so that the entire transect is identifiable in the picture. A white dry erase board should be labeled with park code_site#, transect position (eg. AS-AF), date, and burn status. A picture of each transect should be taken with one person holding the white board from the outside of the site. The board should be held close enough to the photographer to read the writing on the white board. Fill the image with the transect and as much of the site as is feasible (as opposed to including the transect and area to the outside of the site). The image number and description should be recorded in a field notebook so that they can be properly labeled after download. Image labels include park code_site, date (DDmonthYY), burn status, and transect position (eg., HEHO_16Aprl09_PREBURN_10AS_AF).

IMMEDIATE POST-BURN ASSESSMENT

Burn severity is assessed and photos are taken on all plots following prescribed or wildland fire. Burn severity is rated and coded separately for organic substrate and vegetation. Rate burn severity according to the code definitions in Appendix 10. Downed woody fuels are also re-measured during the immediate post-burn visit.

Forest

Forest plots are generally visited within two to three weeks following prescribed fire. This allows time for impacts to overstory trees to become visible. Burn severity ratings are determined at the same points on the forest dead and downed fuel inventory transect lines where duff depth is measured: 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 feet. At each sample point, evaluate burn severity to the organic substrate and to above-ground plants in a 0.10 m² area (circular hoop). Also evaluate severity on the vegetation monitoring transects at 3m intervals, using the same staggering technique as for vegetation monitoring (A line starts at 3 m, B-line starts at 0 m). Use the burn severity coding matrix included on the datasheet to determine the severity ratings.

Grasslands and Shrublands

Grassland and shrubland plots are often visited the day after a fire or even the same day as the fire. Severity is assessed on the HTLN long-term monitoring vegetation community sites. Record post-burn severity conditions on the 'Grassland and Shrubland Plot Burn Severity Data Sheet' (Appendix 10). Assess burn severity at 3 m intervals as marked on the datasheet for both transects A and B. At each sample point, evaluate burn severity to the vegetation and substrate in a 0.1 m² area (circular hoop) and record the values on the data sheet. Use the burn severity coding matrix included on the datasheet to determine the severity ratings.

FIRELINE SAFETY

- For the monitoring plots to be representative, they must burn under the same conditions and ignition techniques used in the rest of the prescribed fire block. **Fire monitor safety, however, must always be foremost.**
- For safety, inform all burn personnel at the pre-burn briefing that the unit contains monitoring plots. It is recommended that you provide a brief discussion on the value of these plots, and your role on the burn.
- Inform all ignition personnel that they are to burn as if the plots do not exist. This will help avoid biased data, e.g., running a backing fire through a plot while using head fires on the rest of the unit.
- Throughout the burn, maintain communications with the ignition specialist and/or ignition team.
- If it would be unsafe to stand close to the flame front to observe ROS, you can place timing devices or firecrackers at known intervals, and time the fire as it triggers these devices.
- Where observations are not possible near the monitoring plot, and mechanical techniques such as firecrackers or in-place timers are unavailable, establish alternate fire behavior monitoring areas near the burn perimeter. Keep in mind that these substitute observation intervals must be burned free of side effects caused by the ignition source or pattern.

PRESCRIBED FIRE MONITORING REPORT

The HTLN Fire Ecology Program and Fire Effects Monitors (FEMOs) are responsible for writing prescribed fire monitoring reports following each prescribed fire. The main purpose of this report is to document detailed information regarding fire observations and fire conditions. Fire managers often need a summary of this information immediately following a fire. This information may be used to refine prescriptions, strategy, and tactics over both the short- and long-term. A template for the report can be found in Appendix 11. Completed reports are posted on the HTLN server and given to the FMO, burn boss, park natural resources manager, and regional fire ecologist.

REFERENCES

- Brown JK, Oberhue RD, Johnston CM. 1982. Inventorying surface fuels and biomass in the Interior West. USDA Forest Service, Intermountain Forest and Range Experiment Station. General Technical Report INT-129. Ogden, UT. 48 pp.
- James, K. M., M. D. DeBacker, G. A. Rowell, J. L. Haack and L. W. Morrison. 2009. Vegetation community monitoring protocol for the Heartland Inventory and Monitoring Network. Natural Resource Report NPS/HTLN/NRR — 2009/141. National Park Service, Fort Collins, Colorado.
- Schlobohm, Paul and Brain, Jim. 2002. Gaining an understanding of the National Fire Danger Rating System. National Wildfire Coordinating Group Fire Danger Working Team, National Interagency Fire Center, Boise, ID. 72 pp.
- USDI National Park Service. 2003. Fire monitoring handbook. National Interagency Fire Center, Boise, ID. 274 pp.

Appendix 1 – National Weather Service Stations

WICR and GWCA

NOAA's National Weather Service
Springfield, MO Weather Forecast Office
Springfield-Branson Regional Airport
5805 West Highway EE
Springfield, MO 65802-8430
417-863-8028

EFMO and HEHO

NOAA's National Weather Service
La Crosse, WI Weather Forecast Office
N2788 County Road FA
LaCrosse, WI 54601
608-784-7294

HOME

NOAA's National Weather Service
Omaha/Valley, NE Weather Forecast Office
6707 North 288th Street
Valley, NE 68064-9443
402-359-5166

PIPE

NOAA's National Weather Service
Sioux Falls, SD Weather Forecast Office
26 Weather Lane
Sioux Falls, SD 57104-0198
605-330-4247

TAPR

NOAA's National Weather Service
Topeka, KS Weather Forecast Office
1116 NE Strait Avenue
Topeka, KS 66616-1698
785-234-2592

Appendix 2 –Temporary Monitoring Plot Establishment

Primary monitoring plots chosen for fire effects work will be the HTLN vegetation community monitoring sites. Sometimes there will not be enough sites within the scheduled burn units to provide a valid sample. In that event, additional temporary monitoring macroplots will be established for that burn event. The HTLN bird monitoring grid will serve as the basis for these temporary monitoring macroplots.

1. Using the GIS data, list all of the potential bird plots located within the scheduled burn units. Avoid plots on the boundaries of burn units or within riparian areas.
2. From that list, randomly choose plots to fill out the needed sample size. No less than 3 plots, including vegetation community sites and bird plots, should be chosen. Six plots would be a preferred sample size especially for smaller areas. If more possible plots are available than are needed for an adequate sample, randomly choose among the eligible avian plots.
3. In the field, the coordinates for the bird plot will serve as the NE corner of the plot whenever possible, (Corner AS). Transects should be laid out along the contours as in the HTLN protocol with the B-line being lower on the slope.
4. Mark the corners with chaining pins, or other marker, for easier relocation post-burn. GPS locations and mark nearby trees with flagging (as high up as possible) to aid relocation. Sample as indicated in this monitoring plan.
5. Woody fuels transects should be established from the transect endpoints as per HTLN protocol. Random azimuths should be generated prior to going to the field. Mark the ends of the fuels transects with chaining pins for easier relocation post- burn. Sample as per HTLN protocols. Make sure to measure the transects slope.
6. Remove transect markers upon completion of post-burn sampling.

Appendix 3 – Fuel Moisture Sampling

SAMPLING PROTOCOLS

Fire fuels:

Abstract

The purpose of collecting fuel moisture samples is to aid the Fire Management Program in determining fire danger and fire behavior based on fuel conditions. Sampling available wildland fuel moistures of several types will be undertaken throughout the fire season. Sampling will also take place in other parks in association with planned prescribed fires.

Procedures for Sample Collection

Samples will be collected prior to a prescribed fire. Several samples of each fuel will be collected and their fuel moistures averaged. Collected materials will be placed in airtight containers and weighed as soon as possible to accurately determine material weights. The samples will be dried in a convection oven at 65° C for 24 to 48 hours (depending on size), re-weighed, and fuel moistures calculated. The formula used is (wet weight – dry weight)/(dry weight).

Samples will be taken in three classes: **1)** fine fuels which are critical to the spread of fire; **2)** woody fuels which represent a large portion of the fuel loading and will have the longest residual burning time; **3)** live fuels that could affect the spread and intensity of the fire. These fuels are summarized in Table 1.

Table 1

	No. of Samples	Characteristics	Drying time
Fine Dead Fuels			
Oak litter	3	~0-1" fuel depth	24 hr
Oak duff	3	~1-4" fuel depth	24 hr
Grass litter	3	0-1" Fuel depth	24 hr
Woody Fuels			
10 hr	3	Fuel sticks by weight	
Live Fuels			
oak	3	leaves	24 hr
grass	3	Leaves and stem	24-hr

Samples will not be collected if there is freestanding water on the fuels. If it has recently rained, sampling will occur after the surface moisture has dried. In order to correlate with NFDRS, fuels should be collected as close to **1400 hrs as possible and fuel sampling location is situated on a predominantly south aspect.**

Fine Fuels

- Three to four samples of each of the fine dead fuel categories will be collected.

- Litter – Top layer of the forest floor composed of loose debris (largely recently fallen needles and leaves), little altered in structure by decomposition. Both brown and slightly gray needles are acceptable but highly weathered litter should be avoided.
- Duff – the layer of forest floor material lying below the litter and above mineral soil; incompletely decomposed organic matter in which the original structure is no longer discernible. Bark, woody material, and soil are not acceptable representations of duff (Corbett et al. 1997).
- Care should be taken to avoid collecting any live material in the sample.

Woody Fuels

1000-hour

- Samples of large fuels will be taken from solid dead and down branches or trunks of ponderosa pine.
- Samples are generally a diameter of 10-20 cm (4"-8")
- Samples should be cut with a handsaw (or less preferably a chainsaw with the oiler set on low) to 3-5 cm (1"-2") thickness.
- The log may be elevated or in contact with the litter surface with less than half its diameter below the surface.
- "Cookies" should be cut at least one meter from the end of the log
- Collect a total of three samples
- As an alternative, take at least three measurements of this fuel type with the protimeter.

10-hour

- 10-hour samples will be collected in large tins
- Sample will consist of a variety of diameters from 0.6-2.5 cm (¼"-1")
- Collect sticks with and without bark
- Collect some elevated and some surface fuels.
- Collect a total of three samples.
- As an alternative, take at least three measurements of this fuel type with the protimeter.

Live Fuels

- Three to four samples of live herbaceous plants (grass and forbs) will be collected.
- Collections should be made to represent shaded and unshaded areas, young and old individuals.
- Care should be taken not to collect dead or diseased parts of plants, flowering or seeding parts or woody material.
-

Procedure:

Grassland--Locate sample positions as in soil moisture sampling. Prior to collecting soil samples at that site, clip vegetation to within 1 inch of the soil or grass crown. Put material into numbered, pre-weighed tin and record tin number and type of material. Collect litter (horizontal dead material) and place in a separate tin. If duff is present, place it in a separate tin and record information. If the layers are not present within the sampling frame, take sample from adjacent to the frame.

Woodland-- Locate sample positions as in soil moisture sampling. Prior to collecting soil samples at that site, clip live vegetation to within 1 inch of the soil or grass crown. Collect leaf litter and place in a separate tin. If duff is present, place it in a separate tin and record information. 1-and 10-hour woody fuels can also be collected in separate tins. If eastern redcedar trees are present within the site, collect leaves in another tin. If all the ground layers are not present within the sampling frame, collect samples from adjacent to the frame. If layers are still not available, record that on the sampling sheet.

10-hr fuels sticks deployment protocol

Purpose:

The fuels sticks are used to estimate fuel moisture. Although typically used in woodland settings, we would like to try them out in grasslands. Using the sticks will give us an on-the-spot estimate of fuel moisture that is standardized. Even though grasslands are dominated by 1-hr fuels, it will give us a baseline for comparison over time.

Equipment

One set of 10-hr fuel moisture sticks, two metal holders, 10-inch ruler clippers. To purchase a scale to measure the sticks, or additional sticks they can be found at http://www.forestry-suppliers.com/product_pages/View_Catalog_Page.asp?mi=1554

Placement of the sticks:

The sticks should be deployed a minimum of two weeks prior to a prescribed fire. They can be deployed at any time prior to the minimum time period. It would be best to put them out when the sample site is clear of snow. The area should be relatively easily accessed for sampling, but be secure from visitor or cattle/bison tampering. It might be best to place the sticks in an area that is not planned to be burned or grazed that season to avoid burning up the sticks or destruction by curious cattle. The deployment site should be on a SW facing slope if the burn unit includes one, otherwise find a relatively level spot. Pick a site with fuels representative of the burn unit. In tallgrass prairie, if you can't find an interstitial space in the vegetation that is adequate, you may need to clip the grass to around 8-10 inches to create a better spot.

Wear gloves and avoid touching the sticks with your bare hands as the oils can bias the measurements. Orient the holders North-South along the slope. Press the metal holders into the ground far enough apart to provide adequate support to the sticks. The brackets of the holders should be about 10 inches above ground when installed. If deploying the sticks on a slope, keep the sticks parallel to the slope, if possible. Please record the date of deployment and collect a GPS point at the site. If at all possible, send those two pieces of data to the HTLN Fire ecologist.

Sampling

There is a special scale to weigh the sticks prior to a fire. The fire ecologist or fire monitor on the fire will be responsible for collecting the measurement. It is my hope that we can learn more about the fire and its effects by collecting these types of measurements.

Post-fire sampling

The sticks may remain in place after the fire especially if you would like to continue to monitor fuel moisture or you have additional burns planned. If keeping the sticks out throughout the growing season, you may need to periodically clip the grass beneath the sticks to keep plants from growing up through them. It is advised to deploy a new set of sticks each year and I hope to continue to provide those to you.

Weather Observations

- At the time of each collection weather observations will be taken.
- Record dry and wet bulb temperatures, dew point, relative humidity, wind speed and direction, and cloud cover.
- Precipitation can be measured from the park weather station or rain gauge placed at the sampling site.

Equipment Needed

- Pre-weighed containers in 2 sizes. Aluminum tins with tight fitting lids will be used for fine dead and live samples.
- Paper bags. 1000-hour samples can be placed in pre-weighed paper bags or use no container if samples are solid.
- Clippers. A sharp pair of hand shears work well for clipping needles and leaves. Scissors are an acceptable substitute.
- Handsaw. Bowsaw or other sharp light handsaw for cutting cookies up to 20 cm (8") in diameter. A chainsaw can be used if care is taken to leave no oil residue on the sampled material.
- Belt Weather Kit. A standard fire-issue belt weather kit containing sling psychrometer, wind meter, distilled water, and weather observation form is used to record weather at the time of sampling.
- Data sheets. A standard form for each site can be developed to record sample weights and fuel moisture percentages. The form also assures that appropriate numbers of each sample are collected.

Park: _____

Prairie/woodland (circle)

Date: _____

Observer: _____

	Tin #	Wet Weight	Tare Weight	Dry Weight	Protimeter reading
LIVE FUELS					
Oak 1					
Oak 2					
Oak 3					
DEAD FUELS					
DUFF 1					
DUFF 2					
DUFF 3					
LITTER 1					
LITTER 2					
LITTER 3					
10 HR 1					
10 HR 2					
10 HR 3					
1000 HR 1					
1000 HR 2					
1000 HR 3					

10 HR Fuel Moisture Stick

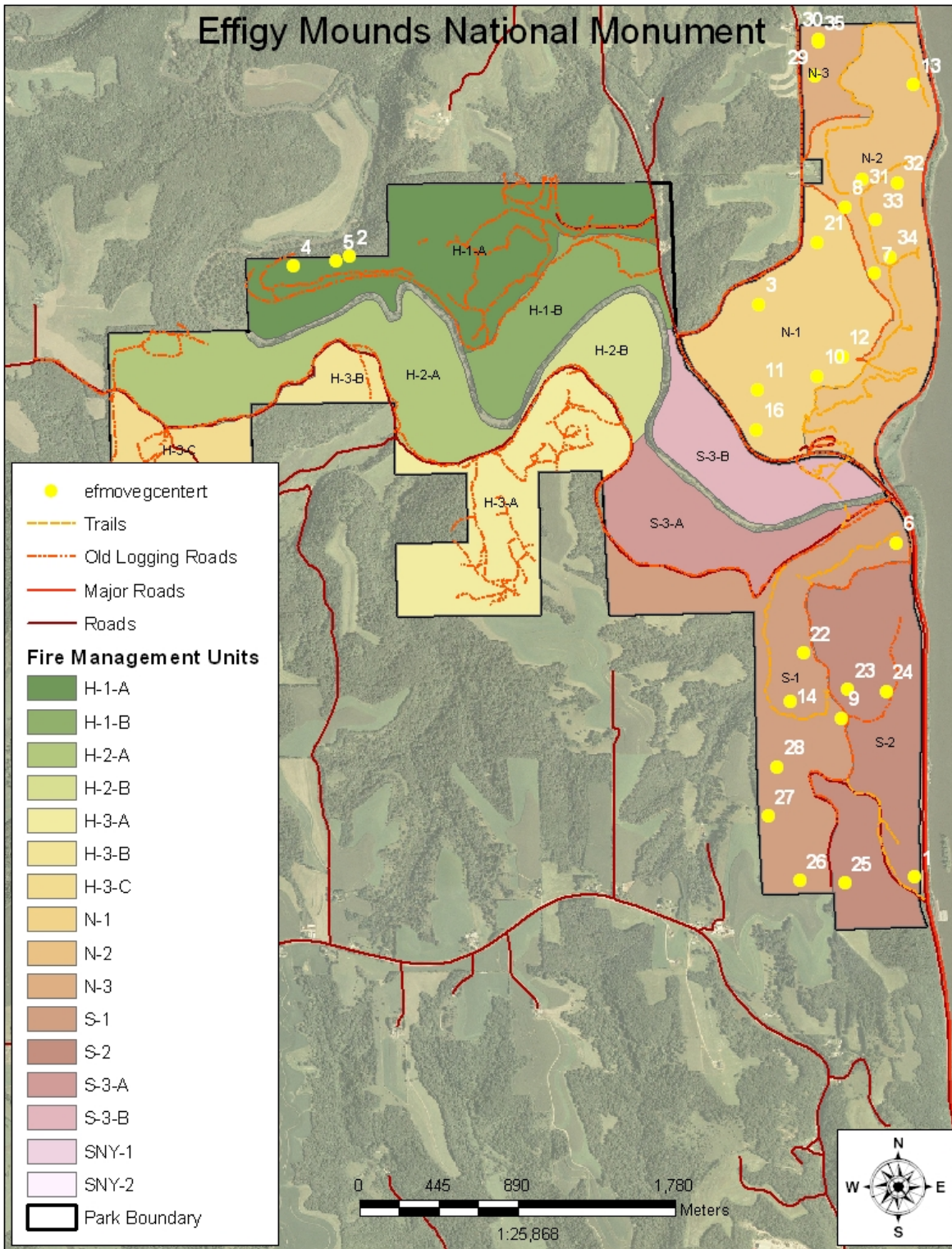
=

WX OBSERVATIONS

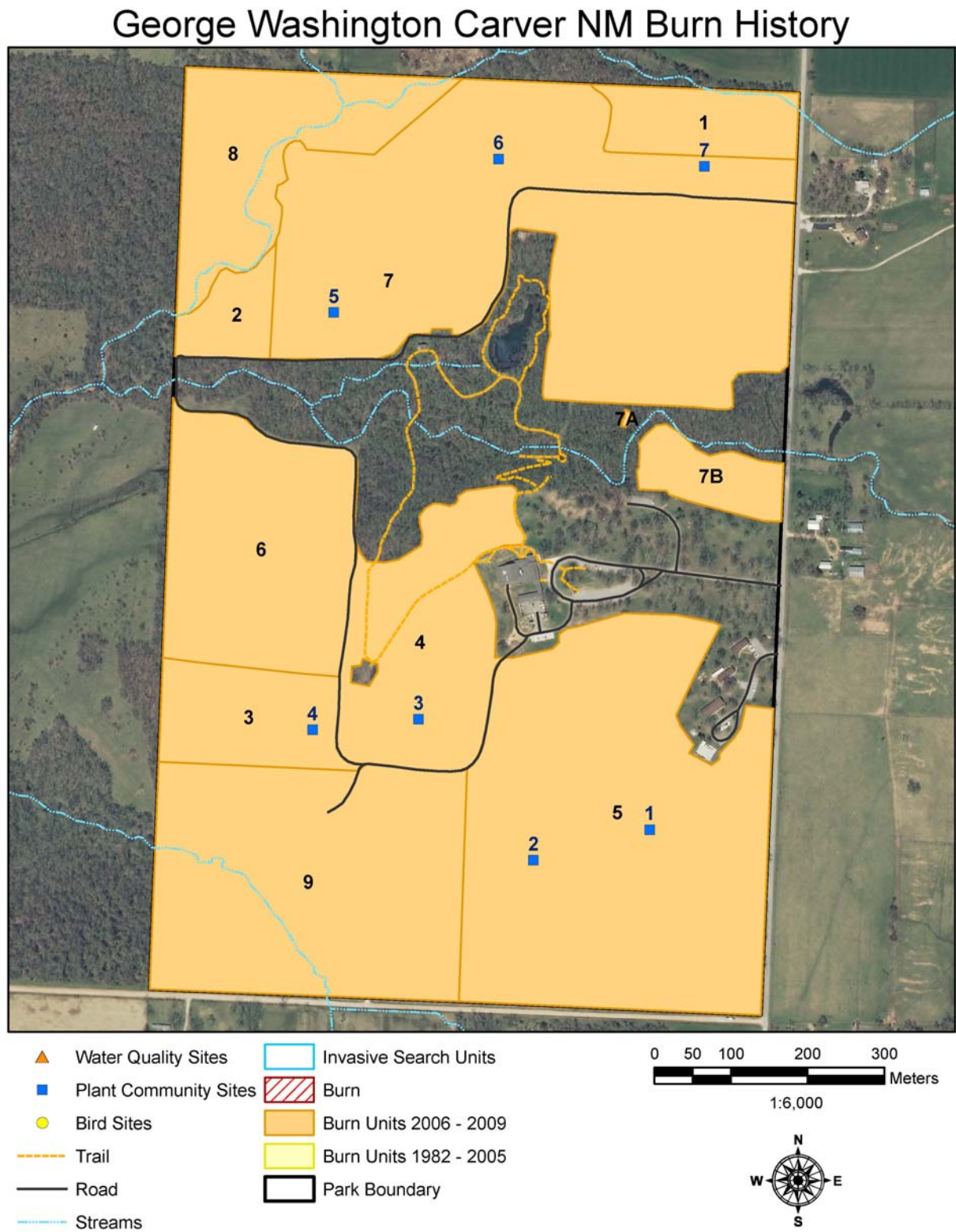
Date	Time	Dry Bulb	Wet Bulb	Dew Point	RH	Cloud cover/type
FDFM		Wind Dir/speed				

Appendix 4. Park maps

MAP OF SAMPLING SITES AT EFMO

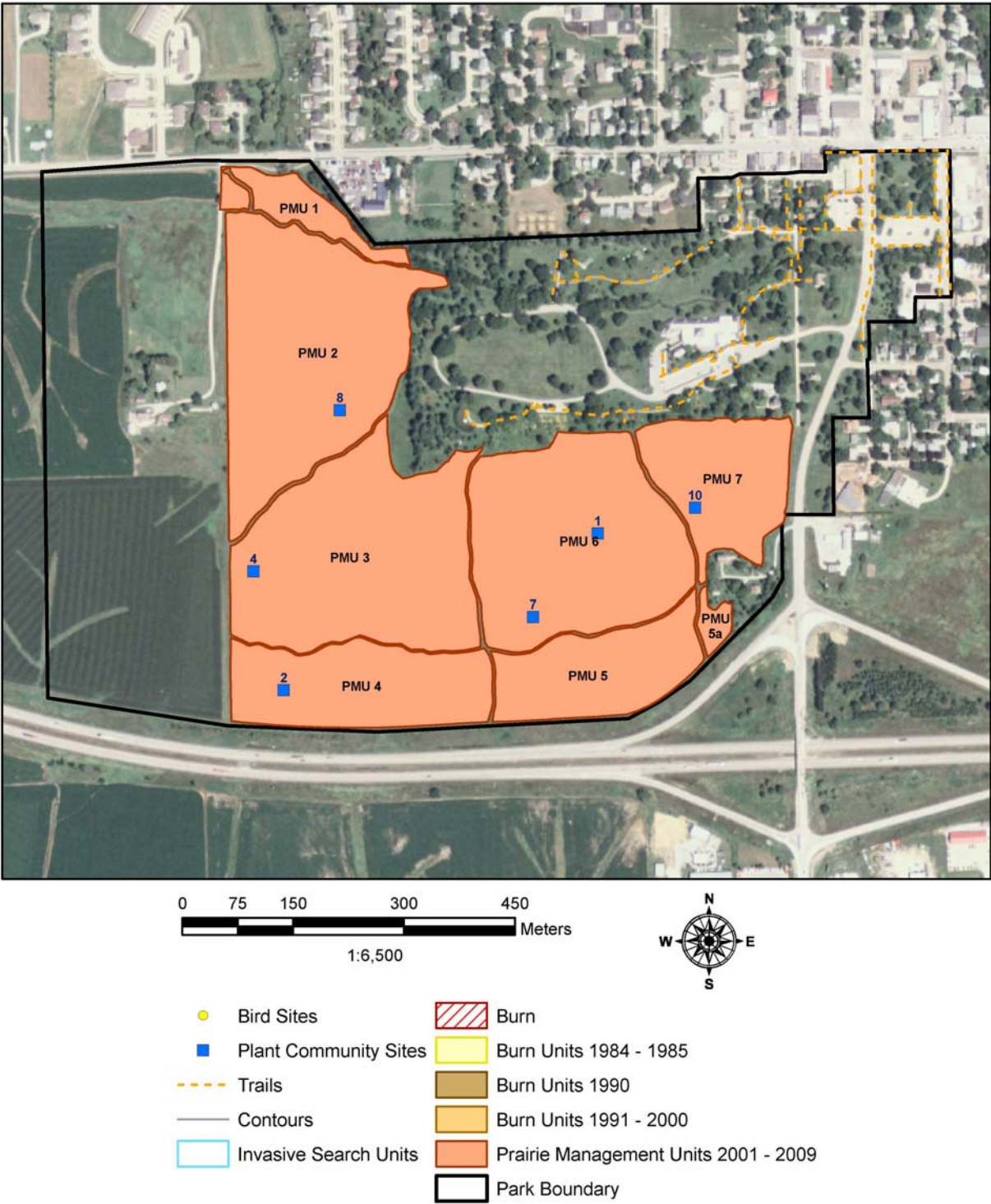


MAP OF SAMPLING SITES AT GWCA



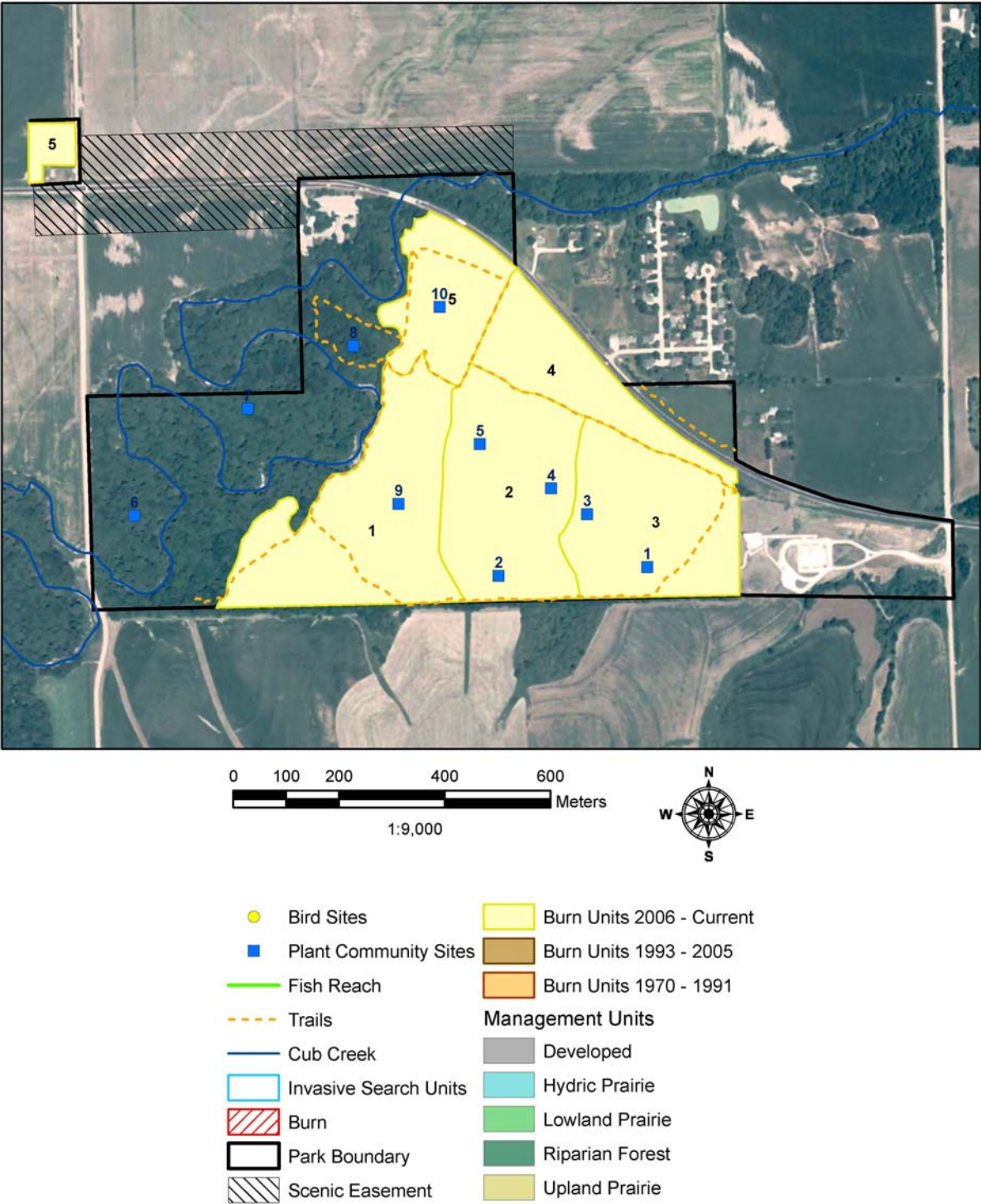
MAP OF SAMPLING SITES AT HEHO

Herbert Hoover NHS Burn History

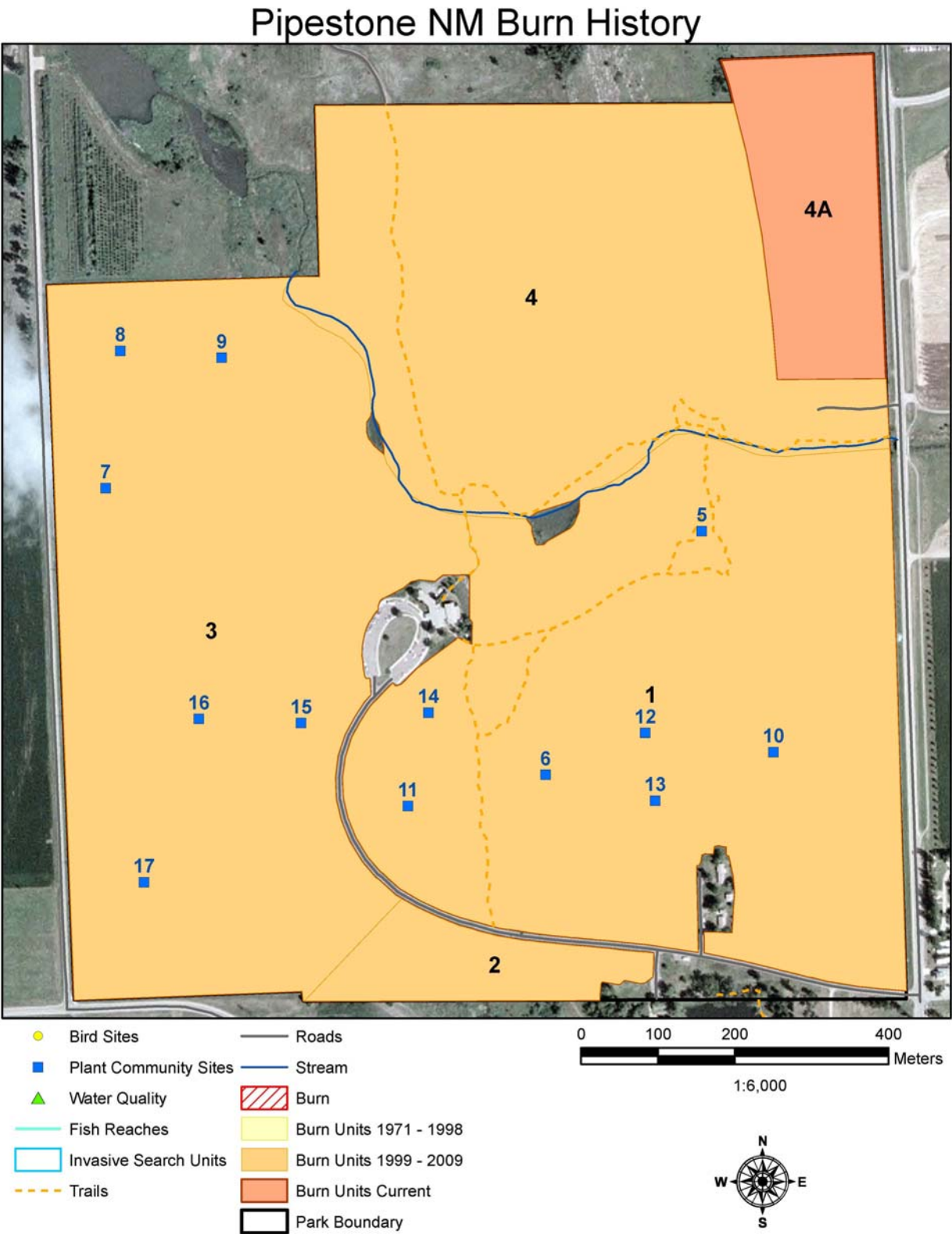


MAP OF SAMPLING SITES AT HOME

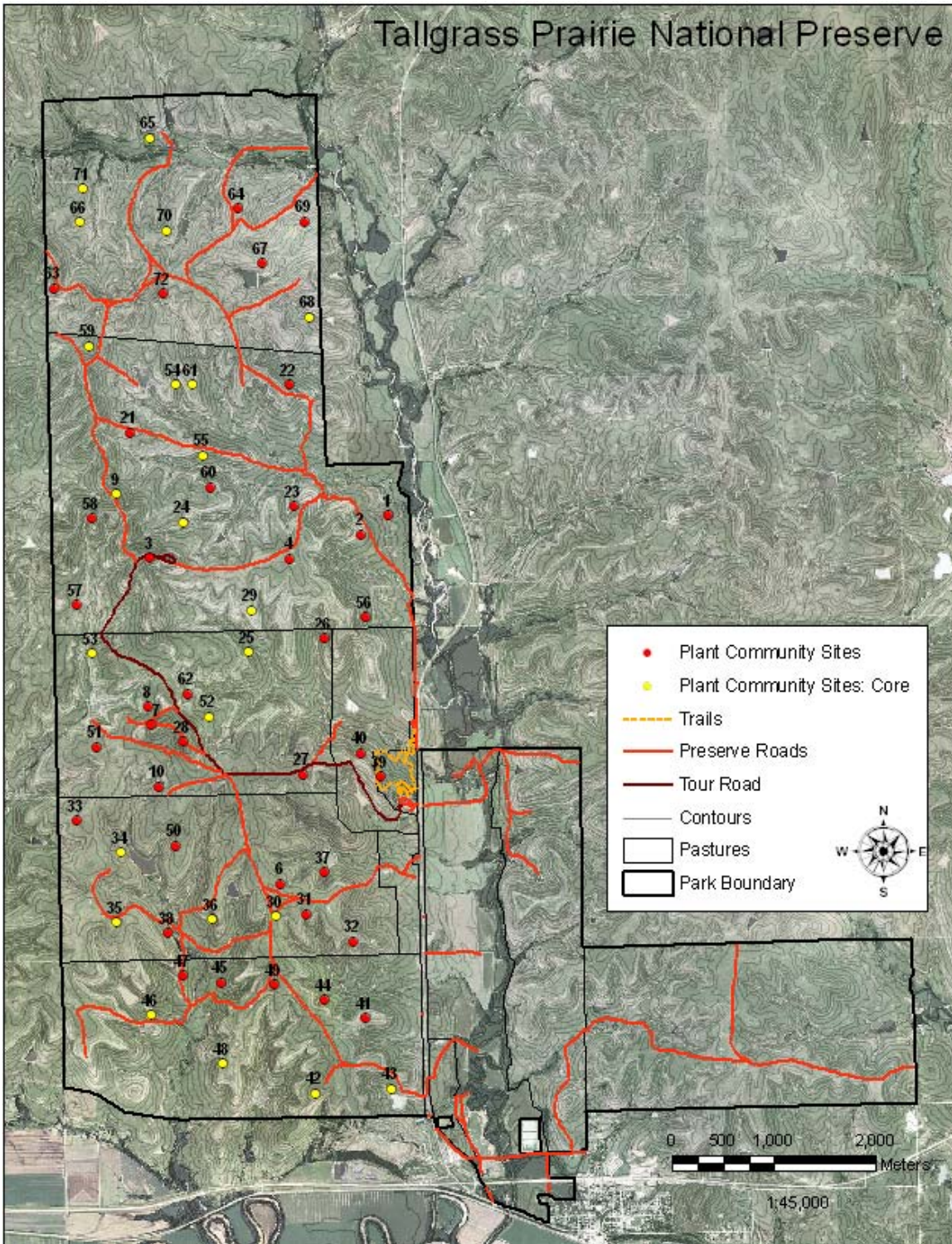
Homestead NM of America Burn History



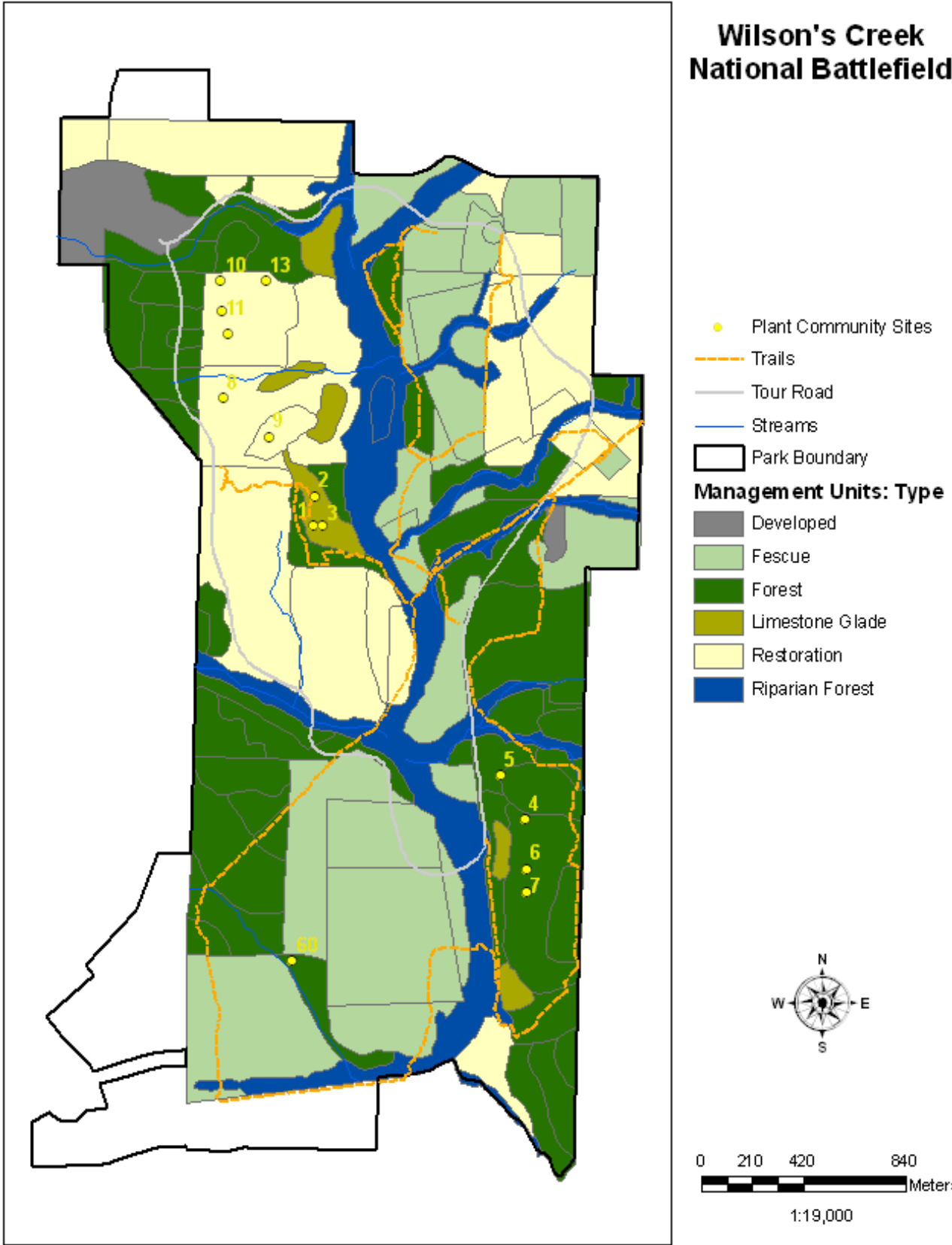
MAP OF SAMPLING SITES AT PIPE

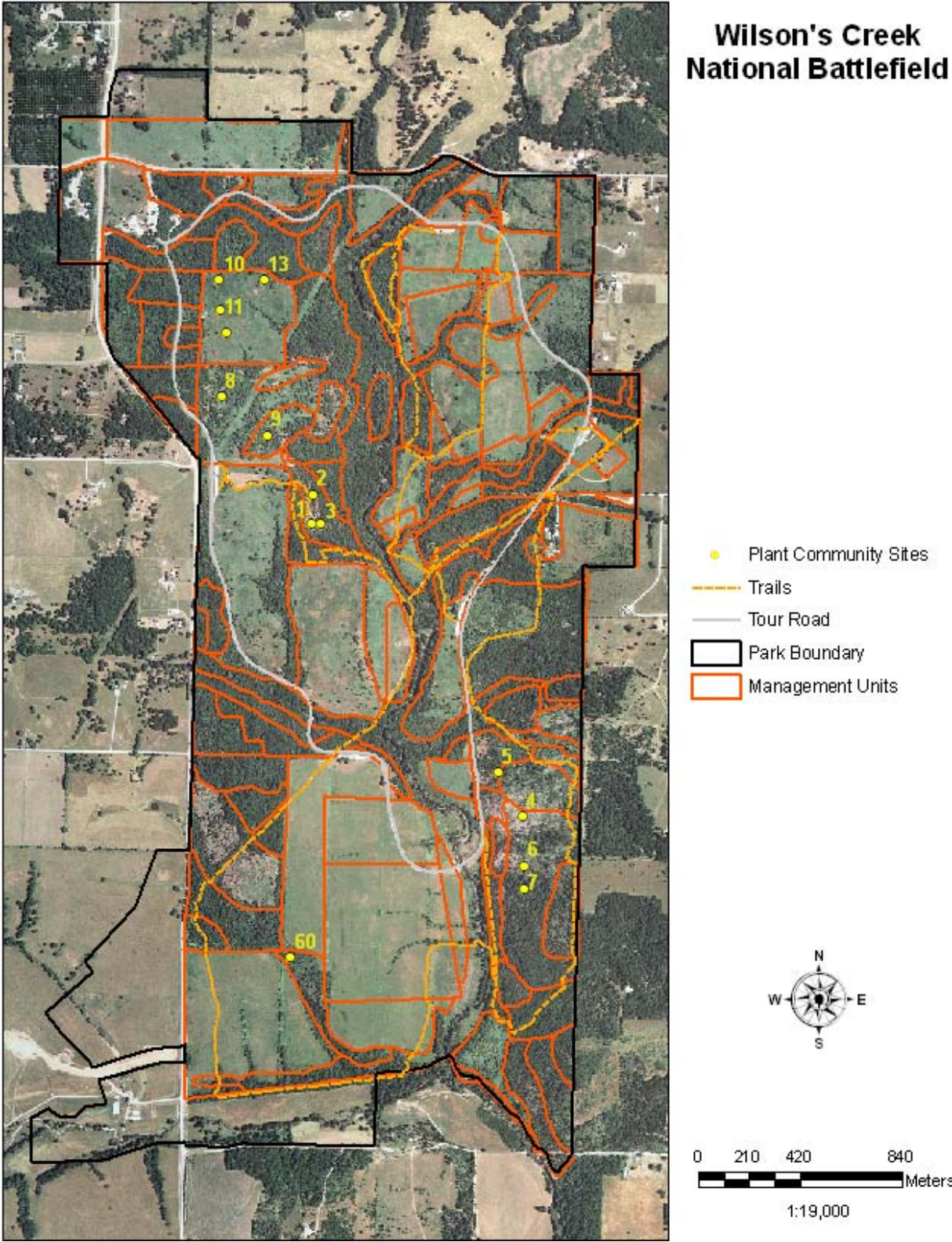


MAP OF SAMPLING SITES AT TAPR



MAP OF SAMPLING SITES AT WICR





APPENDIX 5 – DOWNED WOODY FUELS

EQUIPMENT LIST

Go/No Go gauge
50 m tapes
50 ft tapes
Chaining pins
Plastic clear ruler
Graduated trowel
Flagging
Pin flags
Compass
Clinometer
GPS
Metal detector
Datasheets
Maps
Pencils
Clip board
Camera
Spare rebar
Spare yellow caps
mallet

Downed Woody Fuel Load Data Sheet

FMH-19

Park/Unit 4 Character Alpha Code: _____

Forest Plot Fuels Inventory Data Sheet

(Downed Woody Fuel Load Data Sheet)

Page ____ of ____

Site ID: _____

Date: ____/____/____

Burn Unit: _____

Recorders: _____

Burn Status: Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00 PRE _____ Post -01yr -02yr -05yr -10yr -20yr Other: -yr -mo

Transect lengths (ft): 0-0.25 6 0.25-1: 6 1-3: 12 3+s: 50 3+r: 50

	# Intercepts			Diameter (in)		Litter and Duff Depths (in)					
	0-.25"	.25-1"	1-3"	3+s	3+r	L	D	L	D		
	(1-hr)	(10-hr)	(100-hr)	(1,000-hr)							
Transect 1						1			25		
AS						5			30		
Dir. ____°						10			35		
Slope ____%						15			40		
						20			45		
Transect 2						1			25		
AF						5			30		
Dir. ____°						10			35		
Slope ____%						15			40		
						20			45		
Transect 3						1			25		
BS						5			30		
Dir. ____°						10			35		
Slope ____%						15			40		
						20			45		
Transect 4						1			25		
BF						5			30		
Dir. ____°						10			35		
Slope ____%						15			40		
						20			45		

Date Entered: ____/____/____

Initials _____

Definitions

Litter — Includes freshly fallen leaves, needles, bark, flakes, fruits (e.g., acorns, cones), cone scales, dead matted grass, and a variety of miscellaneous vegetative parts. Does not include twigs and larger stems.

Duff — The fermentation and humus layers; does not include the freshly cast material in the litter layer, nor in the post-burn environment, ash. The top of the duff is where needles, leaves, fruits and other castoff vegetative material have noticeably begun to decompose. Individual particles usually are bound by fungal mycelia. The bottom of the duff is mineral soil.

Downed Woody Material — Dead twigs, branches, stems and boles of trees and shrubs that have fallen and lie on or above the ground.

Obstructions Encountered Along Fuel Transects — If the fuel transect azimuth goes directly through a rock or stump, in most cases you can run the tape up and over it. If the obstruction is a tree, go around it and pick up the correct azimuth on the other side. Be sure to note on the data sheet on which side of the bole the tape deviated so that it will be strung the same way in the future.

Litter and Duff Measurement Rules

- If the transect is longer than 50 ft, do not take additional litter and duff measurements.
- Do not take measurements at the stake (0 point); it is an unnatural structure that traps materials.
- At each sampling point, gently insert a trowel or knife into the ground, until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Vertically measure the litter and duff to the nearest tenth of an inch.
- Refill holes created by this monitoring technique.
- Do not include twigs and larger stems in litter depth measurements.
- Occasionally moss, a tree trunk, stump, log, or large rock will occur at a litter or duff depth data collection point. If moss is present, measure the duff from the base of the green portion of the moss. If a tree, stump or large rock is on the point, record the litter or duff depth as zero, even if there is litter or duff on top of the stump or rock.
- If a log is in the middle of the litter or duff measuring point, move the data collection point one foot over to the right, perpendicular to the sampling plane.

Tally Rules for Downed Woody Material

- Measure woody material first to avoid disturbing it and biasing your estimates.
- Do not count dead woody stems and branches still attached to standing shrubs and trees.
- Do not count twigs and branches when the intersection between the central axis of the particle and the sampling plane lies in the duff.
- If the sampling plane intersects the end of a piece, tally only if the central axis is crossed.
- Do not tally any particle having a central axis that coincides perfectly with the sampling plane.
- If the sampling plane intersects a curved piece more than once, tally each intersection.
- Tally uprooted stumps and roots not encased in dirt. Do not tally undisturbed stumps.
- For rotten logs that have fallen apart, visually construct a cylinder containing the rotten material and estimate its diameter.
- When stumps, logs, and trees occur at the point of measurement, offset 1 ft (0.3 m) perpendicular to the right side of the sampling plane.
- Measure through rotten logs whose central axis is in the duff layer.

Appendix 6 – Biomass

EQUIPMENT LIST INSITU

50 m tapes
Chaining pins
Flagging
Pin flags
Compass
Metal detector
Datasheets
Maps
Pencils
Clip board
Camera
Shears
Grass hooks
Paper bags
0.10 m hoop

EQUIPMENT LIST PHOTOBOARD

Retractable washline
Chaining pins
White board
Monopod
Datasheets
Maps
Pencils
Clip board
Camera

Herbaceous Biomass photoboard method (TAPR only)

1. Navigate to point (Points were randomly generated within frame in GIS.). Erect photoboard so that the board faces perpendicular to the sun. Facing the sun causes shadows and facing away causes the board to look dark. Avoid sampling when the sun is low in the sky.

****Point rejection criteria:** vegetation between the board and camera must be relatively similar. If not, move the point.

2. Align the board perpendicular to the sun to minimize shadows throughout the day. To avoid distortion, the board holder must adjust the board to be both level and plumb using a level. Make sure the camera is vertical using a level. Adjustments to the horizontal axis of the board can be made in Photoshop.
3. Take photograph at 4 m away from the board and 1m high. Record photograph number and/or order on datasheet as well as any pertinent notes.

Photography procedure

Take photos at 4 m from the photoboard. Remove measurement rope from the field of view for each shot. The camera should be mounted on a tripod or monopod at 1 m high. Place the camera centered with the photoboard to avoid distortion. Use manual focus, color photo options. We found that the landscape mode worked best. Focus on the photoboard (not intermediate vegetation) as best as possible. The original protocol said to zoom into the photoboard to fill the frame as much as possible with the photoboard, but we found it better to avoid zooming in so that the depth of field for each picture was exactly the same. Make sure to include the bottom of the photoboard in the photograph.

Lab and office procedures:

4. Photographs were processed with Adobe Photoshop CS4. I put a grid over the picture to aid straightening and measuring.
 - A. Digitally straighten image.
 - B. Measure image to find bottom of the photoboard.
 - C. Crop image to just the photoboard. If image didn't include the bottom of the photoboard, the discard sample.
 - D. Display histogram. Adjust threshold (use default if possible). Be consistent in deciding what threshold is best. Use the graph of image intensity as a guide.
 - E. On histogram, click the "!" and record the percent from the values below the histogram. This is the % of black in the picture (Digital Obstruction) which should be equivalent to biomass.
 - F. Use calibration curve to calculate biomass (< 1 yr since burn $y = 1.28x - 6.03$, 1 yr since burn $y = 2.33x - 22.09$, and 2 yr since burn $y = 1.75x - 6.36$).

[illegible]

Appendix 7 – Soil Moisture

EQUIPMENT LIST

50 m tapes
0.01 m hoops
Chaining pins
flags
Compass
GPS
Metal detector
Tins (3-5 per site)
Trowels
Clippers
Grass hooks
Datasheets
Maps
Pencils
Clip board
Camera
Spare rebar
Spare yellow caps
Mallet

HTLN Fire Monitoring Handbook

Park: _____

Date: _____

Burn unit: _____

Recorders: _____

	Site#	Tin#	Wet Weight	Tare Weight	Dry Weight
SOIL 1					
SOIL 2					
SOIL 3					
SOIL 1					
SOIL 2					
SOIL 3					
SOIL 1					
SOIL 2					
SOIL 3					
SOIL 1					
SOIL 2					
SOIL 3					
SOIL 1					
SOIL 2					
SOIL 3					
SOIL 1					
SOIL 2					
SOIL 3					

Appendix 8 – Fire Behavior

EQUIPMENT LIST

Stop watch
Appendix B
Flagging
Compass
GPS
Datasheets
Maps
Pencils
Clipboard
Camera

Fire Behavior observations Park code _____ Observer _____ Burn unit _____ Date _____

<i>Time</i>	<i>Location</i>	<i>Spread Direction</i>	<i>ROS</i>	<i>FL</i>	<i>FZD</i>	<i>Fuel Model</i>	<i>1-hr TLFM</i>	<i>% Shading</i>	<i>% Slope</i>	<i>Comments</i>
Spread Direction: H = heading; B = backing; F = flanking Rate of Spread (ROS): in/sec, ft/min, or ch/hr Flame Length: (FL): nearest inch (0-23 in); 0.5 foot (2-4 ft); 1.0 foot (4-15 ft); 5.0 feet (> 15ft) Flame Zone Depth (FZD): nearest inch (0-23 in); 0.5 foot (2-4 ft); 1.0 foot (> 4 ft)										comments include: - unusual fire behavior - 10-hr TLFM - photo # - other

Appendix 9 – Fire Weather

EQUIPMENT LIST

Flagging
Compass
GPS
Datasheets
Maps
Pencils
Clipboard
Camera
Belt weather kit
Kestral

WEATHER Land Unit: _____ Fire Name: _____ Observer(s): _____ Date: _____ p. _____

Date: _____ p. _____

*State of Weather Codes: 0 = Clear 2 = 50-90% cloud cover 4 = Foggy 6 = Raining 8 = Showering 1 = 10-50% cloud cover 3 = 90%+ cloud cover 5 = Drizzling 7 = Snow or Sleet 9 = Thunderstorms					comments include: - ppt. amount/duration - erratic winds
--	--	--	--	--	--

Evaluation of Spot Weather Forecast

Date: _____

Time: _____

Prescribed Fire: _____

NPS Unit: _____

Parameter	Forecasted	Observed
Winds		
Temperature		
Relative Humidity		
Sky/weather		

Discussion

Signed:

HTLN Fire Monitoring Team

Appendix 10 – Smoke Observations

Smoke observations Park code _____ Observer _____ Burn unit _____ Date _____

<i>Time</i>	<i>Location</i>	<i>Elevation</i>	<i>Elevation of Smoke Column (AGL)</i>	<i>Smoke Column Direction</i>	<i>Approximate Elevation Smoke Inversion Layer (AGL)</i>	<i>Fireline Visibility</i>	<i>Roadway Visibility</i>	<i>Comments</i>

Appendix 11 – Fire Progression/Ignition Pattern

EQUIPMENT LIST

Watch

Maps

Radio communication

Appendix 12 – Immediate Post-burn Assessment

EQUIPMENT LIST

50 m tapes
50 ft tapes
Chaining pins
0.10 m hoops
Flags
Compass
GPS
Metal detector
Datasheets
Maps
Pencils
Clip board
Camera

Woodland Plot Burn Severity Data Sheet

Site Status: _____ Burn Unit: _____ Recorders: _____

When collecting burn severity on vegetation transects, rate each transect at the vegetation measurement points using the Coding Matrix below.

Tape position	Vegetation A	Substrate A	Tape position	Vegetation B	Substrate B
3			0		
6			3		
9			6		
12			9		
15			12		
18			15		
21			18		
24			21		
27			24		
30			27		
33			30		
36			33		
39			36		
42			39		
45			42		
48			45		

Burn Severity Code Definitions

	Vegetation	Substrate
Unburned (5)	not burned	not burned
Scorched (4)	foliage scorched and attached to supporting twigs	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged
Lightly Burned (3)	foliage and smaller twigs partially to completely consumed; branches mostly intact	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned
Moderately Burned (2)	foliage, twigs, and small stems consumed; some branches still present	litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common
Heavily Burned (1)	all plant parts consumed, leaving some or no major stems/trunks; any left are deeply charred	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas
Not Applicable (0)	none present preburn	inorganic preburn

Woodland Plot Burn Severity Data Sheet

Site ID: _____ Park: _____ Date: _____

Site Status: _____ Burn Unit: _____ Recorders: _____

Severity **Brown's lines**

Transect 1 AS	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Transect 2 AF	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Transect 3 BS	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Transect 4 BF	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Coding Matrix:

5 – Unburned	4 – Scorched	3 – Lightly Burned	2 – Moderately Burned	1 – Heavily Burned	0 – Not Applicable
--------------	-----------------	-----------------------	--------------------------	-----------------------	-----------------------

Note: See reverse for detailed definitions.

Grassland and Shrubland Plot Burn Severity Data Sheet

Site ID: _____ Park: _____ Date: _____

Site Status: _____ Burn Unit: _____ Recorders: _____

Tape position	Vegetation A	Substrate A	Tape position	Vegetation B	Substrate B
3			0		
6			3		
9			6		
12			9		
15			12		
18			15		
21			18		
24			21		
27			24		
30			27		
33			30		
36			33		
39			36		
42			39		
45			42		
48			45		

Burn Severity Code Definitions

	Vegetation	Substrate
Unburned (5)	not burned	not burned
Scorched (4)	foliage scorched	litter partially blackened; duff nearly unchanged; leaf structures unchanged
Lightly Burned (3)	grasses with approximately two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable	litter charred to partially consumed, but some plant parts are still discernible; charring may extend slightly into soil surface, but soil is not visibly altered; surface appears black (this soon becomes inconspicuous); burns may be spotty to uniform depending on the grass continuity
Moderately Burned (2)	unburned grass stubble usually less than 2 in. tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning; burns tend to be uniform	leaf litter consumed, leaving coarse, light gray or white colored ash immediately after the burn; ash soon disappears leaving bare mineral soil; charring may extend slightly into soil surface
Heavily Burned (1)	no unburned grasses above the root crown; for other species, all plant parts consumed, leaving some or no major stems or trunks, any left are deeply charred; this severity class is uncommon in grasslands	leaf litter completely consumed, leaving a fluffy fine white ash, this soon disappears leaving bare mineral soil; charring extends to a depth of 1 cm into the soil; this severity class is usually limited to situations where heavy fuel load on mesic sites has burned under dry conditions and low wind
Not Applicable (0)	none present preburn	inorganic preburn

Appendix 13 – Prescribed Fire Monitoring Report

[Park]

[Burn Unit] Prescribed Fire Monitoring Report

Prepared by [name]

Burn Unit Summary

Short narrative summary of prescribed fire. May include map of burn unit.

Date:

Size:

Vegetation type:

Personnel:

Burn Boss:

Ignition Specialist:

Holding Specialist:

Fire Monitors:

Holding Resources:

Objectives

List of objectives from the burn plan.

Weather Observations

[Date]	Temperature		Dew		Wind		
Time	Dry	Wet	Point	RH	Speed	Direction	Comments

Fire Behavior Observations

Time	Location	Spread Direction	Fire Type	Rate of Spread	FL	Comments

Short narrative regarding fire behavior observations.

Fire Progression

Fire progression map. Narrative on ignition patterns and fire progression. Be as specific as possible with times, locations, etc.

Biomass and Soil Moisture Sampling

Type	Sample size	Fuel Loading	Average Fuel Loading	Soil Moisture	Average Soil Moisture

Note:

Fire Monitoring

Narrative including observations from monitoring plots, post-burn severity assessments, and plans for future monitoring visits.

Smoke Monitoring

Short narrative on smoke monitoring. What monitoring occurred and what was observed?

Comments/Conclusions

Include any final comments or concluding remarks. If anything can be said about success of meeting stated objectives, include it here. Use caution if attempting to address any objectives other than immediate post-burn objectives.