Fire Effects Monitoring Protocols
National Forests and Grasslands in Texas

Revised March 8, 2020

Introduction

The fire effects monitoring protocols and plot design for the National Forests and Grasslands in Texas (NFGT) were first developed in 2011 in order to meet the "minimum monitoring standards" established by the Region 8 monitoring team and to establish efficient and cost effective methods for evaluating hazard fuels reduction and vegetative effects from prescribed burning on Forest Lands. Modifications were made to the recommended regional plot design and sampling methods in order to address specific needs and concerns identified in earlier research projects, monitoring programs and preliminary "pilot" monitoring plots on the NFGT. The NFGT plot design was based on the Upland Island Wilderness monitoring plots established in 2007 through a cooperative project with Stephen F. Austin University. The new plot design was easier, more flexible and less time consuming to install and collect data, particularly when working in dense understory vegetation or remote areas. Plot size and data collection methods in the Texas protocols are very similar to the regional standard design and follow recommended protocols. Furthermore, the monitoring plan is consistent with the goal of establishing a basic set of uniform data across the Region for comparative analysis and program level validation.

Following is the latest revision of the NFGT fire effects monitoring protocols that were first employed in the 2019 fire season and will be the standard for fire effects monitoring in 2020. These revised protocols were developed in order to improve and stream-line data collection procedures and to facilitate data entry and management within the FFI framework. All fuel technicians and field crews involved in collecting data and establishing plots are required to fully understand and follow these protocols.

The protocols described below are applicable to both the general forest plots and wilderness plots, however, the wilderness plots are smaller in size and contain fewer subplots for some variables. These protocols do not cover grassland plots.

Monitoring Types:

A monitoring type is a fuel/vegetation complex with similar management history and burn prescription. The most important monitoring types on the Forest will be identified based on ecological classification units, vegetation types, past management history (including burn history), fuel loadings, management objectives, soils, topography, and other edaphic factors. Each monitoring type will have a specific set of management and monitoring objectives and data from each monitoring type will be analyzed separately. A minimum of 4 macro plots will be established within each type however additional plots may be needed in order to achieve the desired statistical confidence level from the data analysis. Monitoring types may also be assigned to larger project units for analysis. Project units usually represent a geographic area and may consist of one or more monitoring types. A minimum of 20 plots will be established on

Davy Crockett NF and on the Sam Houston NF. A minimum of 30 plots will be established on the Angelina/Sabine. A list and descriptions of the currently established monitoring types are found in Appendix XX.

Establish Management Goals and Objectives:

Management goals and objectives will be developed for each monitoring type. A management goal is a broad statement of the desired state or target/threshold condition. For most areas on the NFGT the goals are to reduce fuel loadings that pose an unacceptable risk to the fire fighter and public safety, to establish critical wildlife habitat and to restore ecosystems and improve the Fire Regime Condition Class.

An objective is a clear quantifiable description of a threshold value, amount of change, or trend that you are striving to achieve for a particular population or habitat characteristic within a stated time period; it may also set a limit on the extent of undesirable change (e.g. limiting mortality or reducing fuels by a certain amount). Specific management objectives will vary according to the ecosystem type, prescribed fire regime and the vegetation and fuel conditions. The following examples of management objectives are applicable to the dry upland longleaf pine ecosystems on the southern Angelina and Sabine National Forests.

- Maintain mean fuel loadings for litter and dead and downed woody fuels to less than 3 tons per acre.
- Limit overstory mortality to <5% following three burn intervals.
- Reduce woody coverage of shrubs and understory trees to less than 10%.
- Increase herbaceous understory coverage to over 50%.

Monitoring Objectives:

Within the longleaf pine monitoring type, we want to be 80% confident that, following three burn intervals, the sample mean of fuel loadings, litter and duff depths, shrub and herbaceous coverage and density, and overstory mortality is within 25% of the true mean.

Sampling Protocols

Plot Selection

The location of sample plots within a sampling unit will be accomplished primarily through ArcGIS applications. The general area to be sampled will be selected through a process of map analysis and field surveys. A polygon shapefile of the selected sampling unit will then be created from existing shapefiles such as soil or stand layers, or by digitizing the new shapefile. A plot location point (PLP) for each potential plot in the sample unit will be selected using the Create Random Points tool in ArcGIS. The PLP will be located in the field using GPS equipment. From the PLP, the plot center will be located by moving in randomly selected compass direction and distance (1 to 10 meters or paces). When the plot center falls within the rejection criteria, a new random azimuth and distance will be used. If additional plots are needed

in the field, a random azimuth and distance will be selected from the center of the area to be sampled.

Plot Design

Each general forest plot will consist of a 9000 ft^2 circular design. Three transects of 53.5ft (53ft, 6 in) radiating from plot center will equally divide the plot into three sectional sub-plots. Wilderness plots are 4356 ft^2 (1/10 acre) with 37.25ft (37ft, 3 in) transects. The direction for transect A will be randomly selected from 301° to 60°. Transect B and C will be located at 120° angles from transect A. Transects may be offset slightly to avoid trees. A two foot section of ½ inch rolled steel rod will be driven in the ground at plot center and at the end of each transect. These will be used to attach transect tapes for locating sub-plots. A 6 or 8 inch nail should be driven to below ground level immediately adjacent to and on the north side of each rod. These will be used to locate using a metal detector should the above ground rods be removed or disturbed. In addition, a reference tree near plot center will be mapped and tagged. Azimuth and distance from reference tree to plot center will be measured and recorded on data sheets.

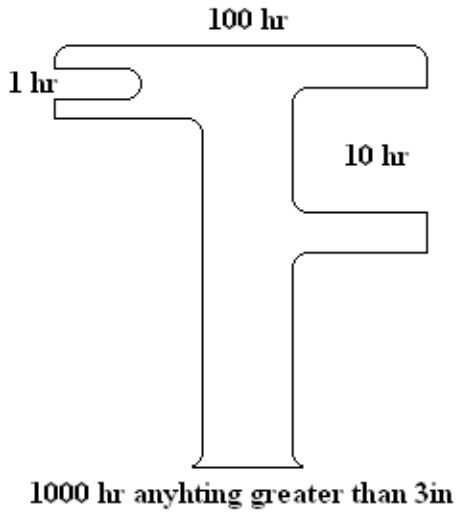
On each Plot Data cover sheet, a map should be included that shows directions to the plot from the nearest road. This map should include any reference trees or other features. Numbered tags should be attached to reference trees for identification. GPS coordinates should be included on maps.

Dead and down fuel loadings and fine fuel biomass will be determined along each transect following methods developed by Brown. Litter, duff and herb samples will be taken in at least two subplots on each transect (This procedure should be done on initial sample and afterwards only as needed). Litter and duff depth and estimated herbaceous fuel coverage will be recorded in five subplots at 10 foot intervals along the left side of each transect. Understory vegetation cover and live woody density, height and % cover will be measured within three 2x5 ft rectangular subplots established along the right side of each transect. Percent cover of herbaceous species will be measured within each of the 2x5 ft sub-plots. Overstory vegetation data will be collected within the entire subplot and midstory vegetation data will be collected either within the entire plot, or within one of the sectional subplots.

The above methods will be addressed in detail below.

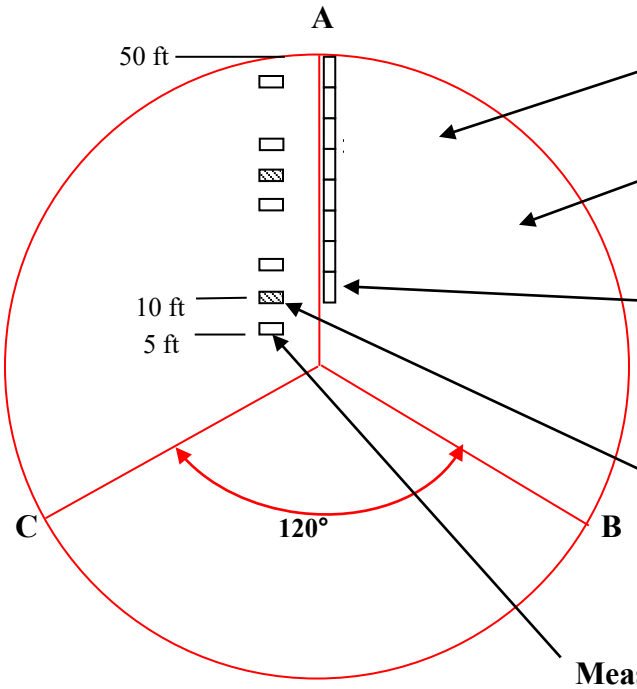
Dead and Downed Woody Fuels

Dead and downed woody fuels will be measured along three equally spaced transects radiating from plot center. Sampling methods developed by Brown (1978) will be used with one hour fuels measured within 6 to 12 ft of plot center, 10 hour fuels within 6 to 12 ft of plot center, 100 hour fuels within 6 to 18 ft of plot center and 1000 hour fuels within 0 to 50 ft of plot center.



Fuel Gauge for measuring dead and down fuels.

Circular Plot 9,000 ft^2 (53.5 ft radius) with 3 Transects (A, B and C).
In Wilderness use 4,356 ft^2 (37.25 ft radius)



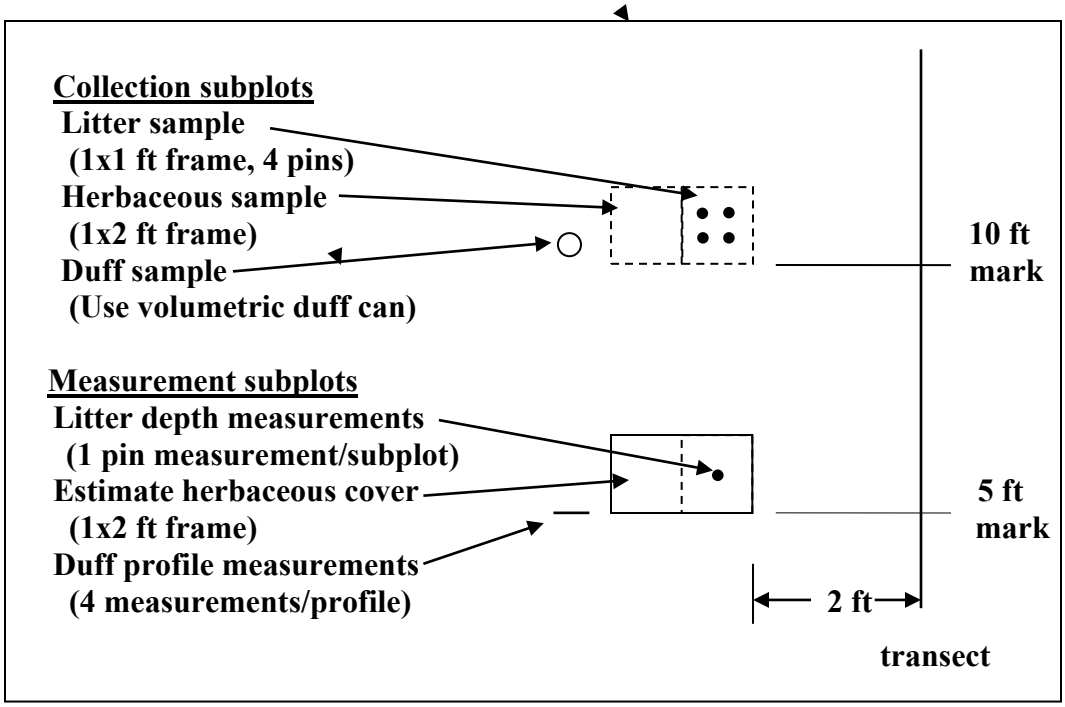
Overstory (≥ 6 in DBH)
Circular Plot 9,000 ft^2 (53.5 ft radius)

Midstory (≥ 2 in and < 6 in DBH)
Circular Plot 9,000 ft^2 (53.5 ft radius)
or 1/3 segment (3000 ft^2)

Understory (<2" DBH)
3 to 8 2x5 ft sub-plots/transect
Begin @ 10 ft
Offset to the right of transect

Collection subplots (see insert)
4 1x2 ft sub-plots/transect
Begin @ 10 ft with 10 ft intervals
Offset 2 ft to the left

Measurement subplots (see insert)
5 1x2 ft sub-plots/transect, (4 in wilderness)
Begin @ 5 foot mark with 10 ft intervals
Offset 2 ft to the left



Collection Procedure for Litter, Duff and Herbaceous Biomass

Initial weight measurements for litter, duff and herbaceous fuels will be made from samples collected in two 1x2 foot sub-plots typically located 2 ft to the left of the each transect at the 10 ft and 30 ft mark on the transect. The 1x2 foot frames will be placed with the long side perpendicular to the transect line and the lower right corner (the corner of the frame closest to the origin) at the appropriate location. The location will be recorded as the x,y distance from the plot origin with x being the distance on the transect and y the offset distance. Samples should not be collected within two feet of the base of large trees. Collection and analysis methods will follow methods developed by Brown (1978).

Litter samples will be collected from the right half of the frame and herbaceous samples from the entire 1x2 ft frame. Prior to removing the litter, four 6 in nails will be driven in the ground with their heads level with the top of the litter layer. Hand clippers or sharp blades will then be used to cut through the litter along the inside edge of the frame while not disturbing the pins. The litter will then be removed and placed in collection bags to be dried and weighed in the lab. Litter depth will be recorded by measuring the distance from the top of the nail to the top of the duff layer to the nearest 10^{th} of an inch. If pins are not available, litter depth will be measured with the conventional method of inserting a ruler through the undisturbed litter prior to collection. These measures will be recorded as "pre-collection" litter depths. After collection, all pins will be removed and litter scattered over the bare area to facilitate fire spread.

If duff collections are needed, a sample will be collected from the center of the litter plot using duff cans of known depth and volume. If duff does not completely fill the can, record the average distance from the top of the can to the top of the duff (depth to contents). Litter and duff data will be used to develop bulk density measures for the plot and to correlate litter and duff depth to fuel loading. Follow-up sample collections will be made only as needed and, for duff samples, should be offset a few inches from the original measurement. All sample bags or cans should be labeled with the plot and transect number, subplot number or tree tag, type of fuel (litter, herb), and date of collection.

Measurements of Litter and Duff Depth for Fuel Loading Estimates

In order to measure the depth of litter and duff before and after each fire, data will be collected in five 1x2 ft subplots at 10 ft intervals along the transect and centered between 2 and 4 feet from the transect. Initial pre-burn subplots will be established beginning at the 5 foot mark of each transect. The location of the subplots will be recorded on the data sheets using the x,y coordinate system described above. In the immediate post burn severity analysis, data will be collected from the same subplot.

Measurements of litter and duff depth can be used with bulk density estimates from sampling collections to estimate fuel loadings. If bulk density estimates were not calculated from fuel collections then bulk density estimates from literature may be used.

Pre-burn data: Prior to each prescribed burn, the litter depth will be measured in the right half of the 1x2 ft frames by carefully driving a 6 inch nail into the ground to where the nail head is flush with the top of the litter. The nail should be placed in the center of each 1x1 ft subplot as illustrated in the diagram. Once the nail is in place, the litter can be moved just enough to allow a ruler to be inserted along the side of the nail to the top of the duff. Litter depth will be recorded by measuring the distance from the top of the nail to the top of the duff layer to the nearest 10^{th} of an inch. Following the measurement, the nail is removed and the litter returned to its original position. Optionally, 4 measurements may be recorded with a nail in each quadrat of the subplot using the same procedure.

The duff depth will be estimated by using a sharp spade or trowel to expose a 6 inch long profile of the duff layer in the left portion of the 1x2 ft subplot. Remove some of the litter layer on the undisturbed side so as to show a clear delineation of the duff layer. Four measurements will be made at equal distance along the exposed profile. Following the measurements, the duff and litter will be restored to the original position. A wire flag will be inserted in the ground at the center of the location of the profile to mark the spot for follow-up measurements. Prior to the next burn, the profile should be taken a few inches above the last location.

***Post-burn data*:** Immediately following the burn, the litter depth will again be recorded in each quadrat using the same procedure as in the pre-burn method. If there appears to be a reduction in the duff layer, a measurement of the duff will be made using the same procedure as above. The profile will be taken a few inches above the last location.

Measurements of Tree Duff

In some monitoring types, additional duff sampling will be made at two or three trees visually judged to be the oldest and/or largest trees in the plot. These trees will be tagged and the location of the subplots will be described on the data sheets. One tree subplot will be established approximately 1 to 2 feet from the base of each selected tree with the subplot facing the plot center. Prior to the sampling for the second burn, each subplot will be shifted to a new randomly selected position around the base of the tree and its location described on the data sheets.

Pre-burn data: Four 8 inch nails will be carefully driven into the ground in each subplot to where the top of the nailhead is flush with the top of the litter. The distance from the top of the litter to the top of the duff is then measured (without disturbing the litter) and recorded as the initial litter depth. The nails are left in their location and a wire flag is inserted in the middle of the subplot to locate the plot and to prevent inadvertent disturbance of the nails. A spade will be used to expose the duff about 6 inches away from the nails and a vertically held ruler will be used to measure the duff depth at four points on the exposed duff profile. A sample of the duff should be collected nearby to determine bulk density. Care should be taken not to disturb the location of the nails.

Post-burn data: Immediately following the burn, two measurements will be taken: one from the top of the nail to the remaining forest floor and one from the top of the nail to the surface of the mineral soil. From this information the pre-burn and post-burn depth of litter and duff is calculated. This method is the preferred method for use in areas where there is a heavy duff

layer and potential for duff consumption. As a precautionary note, a pre-burn measure of the duff should be made just in case the pins are disturbed.

Overstory

The overstory will be sampled in the circular 9000 ft^2 plot with a radius of 53.5 ft from plot center. Individual trees equal to or greater than 6" DBH will be recorded by species and DBH. All damaged trees will be assigned a damage code. The location of each tree should be marked and numbered on the plot diagram. Duff trees and reference trees should also be assigned the appropriate code as labeled on the field sheet. Optionally, tags with the tree number may be applied to the trees.

Midstory

All midstory trees and shrubs within plot radius with DBH greater than or equal to 2" and less than 6" will be recorded by species and damage code. The location of each tree will be marked on the plot diagram and numbered. Depending on the number of midstory trees, trees may be recorded for the entire circular plot or for only one section between transects.

Understory

Understory vegetation will be measured in 3 contiguous 2' x 5' rectangular plots situated linearly on the right side of each transect beginning at the 10 ft mark (use three subplots unless advised by fire ecologist to use more). Data is required for all life forms and species listed on field data sheets as follows: Life Forms – UFORBGRASS, U-FORB, U-GRASS, U-FERN, U-VINE and U-WOODY; Species/Species Group – Bluestem (Pinehill bluestem), Wood-Oats (*Chasmanthium* spp.), LYJA (Japanese climbing fern), PTAQ (bracken fern), GESE (yellow jasmine), and TORA2 (Poison Oak). Other life forms and species of interest/concern should be listed under "other". Surface substrates (i.e. litter, tree trunks, bare ground, rocks, etc.) may also be listed. UFORBGRASS is the overall coverage formed by all grasses and forbs taken together. U-Woody consists of all woody shrubs and small trees < 2" DBH. Vegetation should be identified to the species level if possible. If not, record the genus or family and, for grasses, whether it is a bunch grass or not.

Aerial coverage of the subplot will be recorded for each species, substrate and life form using understory cover classes. Vegetation may be rooted either within or outside the plot.

In prior samples, data included the number of stems for each diameter ground level (DGL) class for each woody species rooted within the subplot, if they are live or dead and the average height class. Methods developed by Reeves were then used to estimate weights of East Texas woody species based on the DGL data. Continuation of this methodology is optional.

Photographs:

Photographs will be taken at the end of each transect facing toward plot center and from the center facing along each transect line. Photos from the end of each transect should be taken from

a standing position and photos from plot center should be made from kneeling position to highlight surface fuels. Photos should always be taken in a standard order to eliminate the need for photo cards. Record the plot number, photo view (i.e. A-O, B-O, C-O, O-A, O-B or O-C) and date on digital and printed images. Digital photos should be uploaded to Pinyon.

Reference Tables

Understory Cover Classes for Live Woody and Herbaceous Vegetation (%). On field sheet, record upper limit for each cover class. For data input use cover class average on second line.															
<0.1 (T)	**.1-1**	**1-3**	**3-5**	**6-10**	**11-15**	**16-20**	**21-25**	**26-35**	**36-45**	**46-55**	**56-65**	**66-75**	**76-85**	**86-95**	**96-100**
0	**1**	**2**	**4**	**8**	**13**	**18**	**23**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**98**

Diameter Ground Level. On field sheet record number representing each DGL class. For data input use class in mm.							
DGL(cm)	**0 - 0.5**	**0.5 - 1**	**1 – 1.5**	**1.5 - 2**	**2 - 3**	**3 - 5**	**>5**
DGL Class	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Class in mm	**2.5**	**7.5**	**12.5**	**17.5**	**25**	**40**	**#**

Height Class Codes (ft). On field sheet record upper limit for each height class. For data input use height class average on second line.											
Ht (ft)	**0 - 0.5**	**0.5 - 1**	**1 – 2**	**2– 3**	**3 –5**	**5 – 7**	**7 – 9**	**9 – 11**	**11– 13**	**13 – 15**	**> 15**
Code (ft)	**0.3**	**0.8**	**1.5**	**2.5**	**4**	**6**	**8**	**10**	**12**	**14**	**#**

Cover Classes for % Scorch. On field sheet record upper limit for each cover class. For data input use cover class average on second line.												
% Cover	**0**	**0-5**	**5-15**	**15-25**	**25-35**	**35-45**	**45- 55**	**55-65**	**65-75**	**75-85**	**85-95**	**95-100**
Cover Class	**0**	**3**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**98**

Overstory and Midstory
Snag Codes

RS	Recent snag	BBD	Now broken below DBH
LBS	Loose bark snag	DD	Dead and down
CS	Clean snag (little or no bark)	CUS	Cut stump

Note: Some Codes are only used once, to indicate that trees will no longer be tracked in data.

Damage Codes Use codes if condition contributes to the decline or unthriftiness of the tree, or helps identify the tree.

ABGR	Abnormal Growth	CONK	Large shelf fungus	FIRE	Scar/cambial damage	INSE	Insects or damage	MIST	Mistletoe	SPAR	Sparse foliage
BIRD	Bird-caused	CROK	Crooked bole	FORK	Forked top above DBH	LEAN	Leaning bole	MOSS	Moss	SPRT	Sprouts at base
BLIG	Blight	DTOP	Dead top	FRST	Frost crack	LICH	Lichen	OZON	Ozone	TWIN	Twin boles below DBH
BROK	Broken top	EPIC	Sprouts from bole/limbs	GALL	Galls	LIGT	Lightning scar	ROOT	Large exposed roots	UMAN	Human-caused
BROM	Witches Broom	EPIP	Epiphytes	HOLW	Hollowed out	MAMM	Mammal-caused	ROTT	Rot other than conk fungus	WOND	Other wound or crack

Equipment Needs Updated 06-04-12

Maps and Photos (hardcopy and shapefiles):

- Compartments
- Stands
- Landtype Phases (Ecological Classification System – 2020 Revisions)
- Imagery - Base map
- Monitoring Plot Centers

Digital Camera
Photo boards and stake (optional)
Compass
Diameter tape
Clinometer (optional)
GPS unit
Rolled flagging
Wire flags
Range pole with contrasting colors @ 6" intervals (optional)
Steel stakes - 2' lengths, 4 per plot
Hammer
Plot i.d. tags
Brass tree tags
Die to mint tags
Aluminum nails
12-16 eight inch galvanized spikes – 4 for buried stake location markers, 8-12 for tree duff pins (optional)
4 six inch nails for litter and duff measurements
Clip boards
Plastic bags for plant collections
Paper sacks for fuel collections (at least 12 per plot)
Clippers
Sharp spade or trowel
1 1x2 ft frame made from ½" PVC
3 100 ft tapes (2 150 ft tapes for rectangular plots, and grassland and brush plots)
1 16 or 25 ft tape
Folding ruler (optional)
6 in ruler graduated to tenth inches
Go-no-go gauge for fuels
Go-no-go gauge for DGL
3 clamps for holding tape to end transect rods
Device for holding tapes on plot center rod
PVC extension tubes made from heavy ½" PVC (length depends on height/density of vegetation)
Duffle bag or backpack to carry equipment to field
Duct tape

Monitoring Status

Monitoring Status	Comment (Description and Appropriate Use)
Pre Burn01	Most appropriately used when unit has not burned in (recent) past. Will be "baseline" data, collected before the first burn.
Baseline	Used in situations where the first data collected is not collected at the beginning of fire reintroduction. Used in lieu of "PreBurn" data, since it is not technically "pre" burn.
Burn01 ImmedPost	Data collected immediately after the 1st burn. Usually is limited to Fuels, Severity and Photos, unless dictated by additional objectives.
Burn01 <1Year	Data collected less than one full year after the burn. Often used when unit was burned in spring, and vegetation data collected in subsequent growing season. R8 5140 Guidebook directs districts to collect data one full year post-burn (which may be 2nd growing season post-burn).
Burn01 Year 1	Data collected one full year after the 1st burn, preferably during growing season (which may be 2nd growing season post-burn). Overstory and Midstory Tree diameters do not need to be re-collected at this time, unless dictated by Objectives.
Burn01 Year 2	Data collected during the second full year after the 1st burn, preferably during growing season (which may be 3rd growing season post-burn).
Burn01 Year 5	Data collected 5 full years after the 1st burn. If unit is re-burned before this time, start monitoring sequence over (for example, Burn02 Year1, Burn02 Year2) without using this Status.
Burn02 ImmedPost	Data collected immediately after the 2nd burn. Usually is limited to Fuels, Severity and Photos, unless dictated by additional objectives.
Burn02 <1Year	Data collected less than one full year after the burn. Often used when unit was burned in spring, and vegetation data collected in subsequent growing season. R8 5140 Guidebook directs districts to collect data one full year post-burn (which may be 2nd growing season post-burn).
Burn02 Year 1	Data collected one full year after the 2nd burn, preferably during growing season (which may be 2nd growing season post-burn). Overstory and Midstory Tree diameters do not need to be re-collected at this time, unless dictated by objectives.
Burn02 Year 2	Data collected during the second full year after the 2nd burn, preferably during growing season (which may be 3rd growing season post-burn).
Burn02 Year 5	Data collected 5 full years after the 2nd burn. If unit is re-burned before this time, start monitoring sequence over (for example, Burn03 Year1, Burn03 Year2) without using this Status.
Pre Burn00	Used uncommonly. If pre-burn data is re-collected because the burn was not accomplished in a timely manner, rename original data 00 and archive it. New data becomes 01.
RX BURN +*YEAR*	Place marker to indicate date of a prescribed burn. You **must** include the year in the name. No protocols will be associated with this date.
RX BURN +*YEAR*	Place marker to indicate date of a prescribed burn. You **must** include the year in the name. No protocols will be associated with this date.
MASTICATION +*YEAR*	Place marker to indicate date of a treatment. You **must** include the year in the name. No protocols will be associated with this date.
HERBICIDE +*YEAR*	Place marker to indicate date of a treatment. You **must** include the year in the name. No protocols will be associated with this date.
ROLLER CHOPPING +*YEAR*	Place marker to indicate date of a treatment. You **must** include the year in the name. No protocols will be associated with this date.
WILDFIRE +*YEAR*	Place marker to indicate date of a wildfire. You **must** include the year in the name. No protocols will be associated with this date.