Appendix E

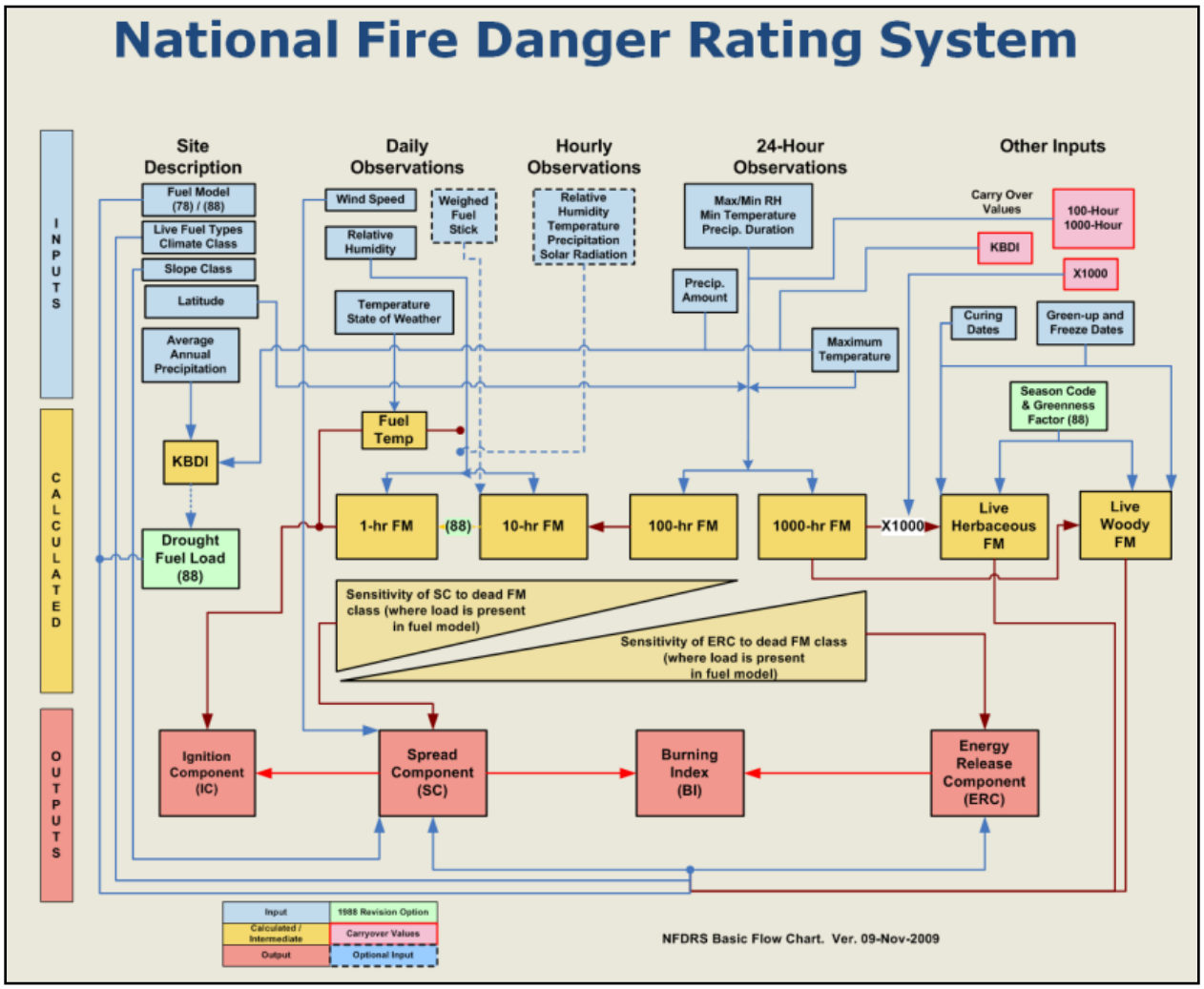
Appendix E. NFDRS Technical Reference

Use this appendix as a reference for National Fire-Danger Rating System (NFDRS) technical information. Topics in this appendix include:

- NFDRS structure Chart
- NFDRS weighted averages
- Staffing Level and Adjective (Public) Fire Danger Rating
- Industrial Precaution levels automated in WIMS
- Lightning Activity Levels
- Recalculating NFDRS indices
- Live fuels NFDRS climate classes

NFDRS structure Chart

The diagram below shows the NFDRS structure for both the 1978 and 1988 fuel models.



The shaded wedges show the contribution of dead fuel moisture to Spread Component (SC) and Energy Release Component (ERC). Based on either the 1978 or 1988 fuel model, the dashed lines show optional paths through the NFDRS system.

Assign NFDRS Weighted Avg. EAVG

The NFDRS weighted averages function combines data from selected fire weather stations and produces an integrated fire danger rating for the area represented by the weather stations. To utilize the weighted average function a SIG must be created with the selected stations. The SIG is then adjusted using the EAVG - NFDRS Weighted Average. Outputs are based on the selected fuel model and station weighting. In creating the SIG, the fire manager must:

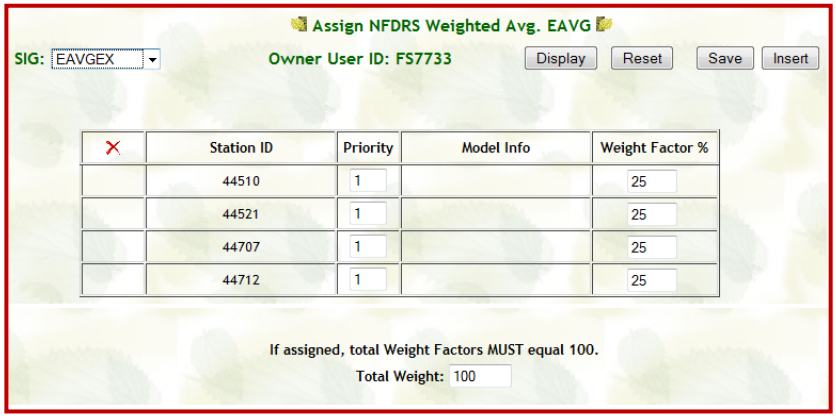
- Select station(s) to represent the area
- Determine fuel model on which to generate the output
- Determine the station-weighting factor (the influence of each station on the weighted area fire danger).
    - The weighting factors of the stations within the SIG must total 100 percent.

The station weighting factor is based on the fire manager's local experience, including:

- Percent of the total area represented by each station
- Resource values
- Historic fire occurrence
- Public use patterns

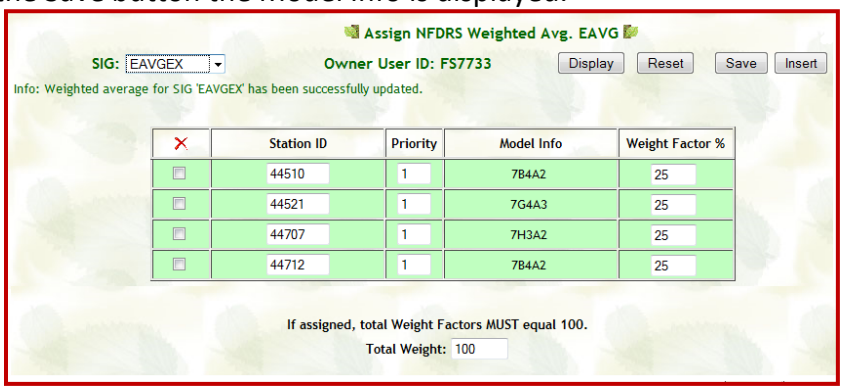
A new SIG, when created is based on each stations Priority 1 fuel model and the weighting is equally distributed between each station. Some edits are required if the total weighting does not equal 100. To edit fuel model selection and weights the Assign NFDRS Weighted Avg. EAVG must be utilized.

In this example a newly created SIG – EAVGEX is displayed in EAVG. The weight factors for the four stations have been automatically set equal based on the number of stations in the SIG. The fuel model priority is set as one for each station, but fuel model information will not be displayed until the SIG has been saved in EAVG.

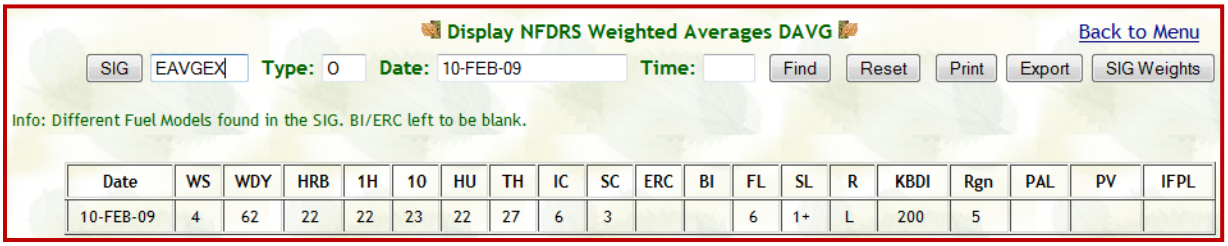


- A fuel model must appear in the station catalog before it can be used to calculate weighted average values for a SIG.

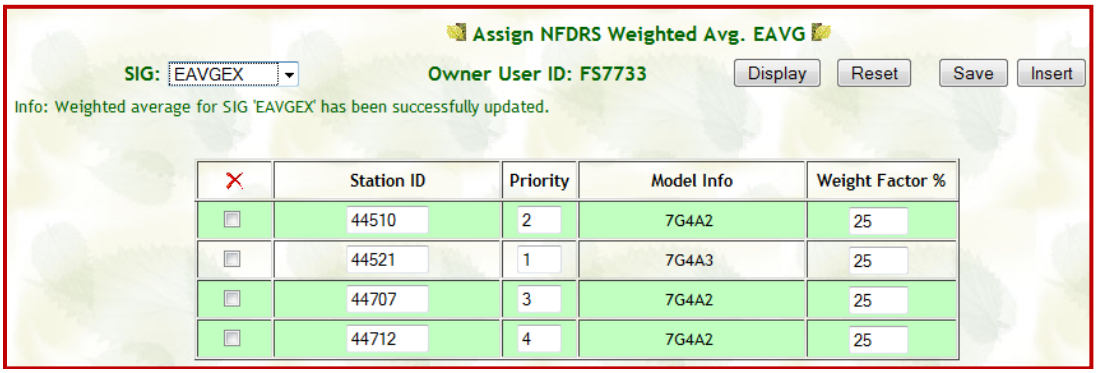
After selecting the Save button the Model Info is displayed.



In the example above the Priority 1 fuel models are not identical so any output in DAVG for this SIG will not generate BI or ERC. Notice the Info message to that fact in the DAVG run on the SIG below.



The Station Catalog (ESTA) or the Display/Edit Default NFDRS Parameters (ENFDR) form can be used to view station fuel models and select the priority fuel model line for the SIG to generate all outputs. The example below shows the EAVG with the correct Priority fuel model lines selected to generate all outputs for this SIG for a fuel model 7G.



Below is the DAVG for the SIG after the Priority fuel model lines have been modified and saved.

Display NFDRS Weighted Averages DAVG Back to Menu

SIG EAVGEX Type: O Date: 10-FEB-09 Time: Find Reset Print Export SIG Weights

Date	WS	WDY	HRB	1H	10	HU	TH	IC	SC	ERC	BI	FL	SL	R	KBDI	Rgn	PAL	PV	IFPL
10-FEB-09	4	62	22	22	23	22	27	8	6	5	13	10	1-	L	200	5	A		

How WIMS redistributes NFDRS weight assignments for SIGS with non-reporting stations

To compensate for stations missing weather observations, WIMS redistributes the related weight assignments to the stations that have observations and can produce NFDRS indices.

For example, the station numbers listed below have the following NFDRS weight assignments:

Station Number	Weight Factor %
A	10
B	15
C	25
D	30
E	20
	100%

If station '' B'' is missing data, WIMS redistributes the weight assignments to the remaining stations as follows:

A = 100 * (10 / (10 + 25 + 30 + 20)) = 12% [*A = 100 * (A / (A + C + D + E)) = 12%*]

C = 100 * (25 / (10 + 25 + 30 + 20)) = 29% [*C = 100 * (C / (A + C + D + E)) = 29%*]

D = 100 * (30 / (10 + 25 + 30 + 20)) = 35% [*D = 100 * (D / (A + C + D + E)) = 35%*]

E = 100 * (20 / (10 + 25 + 30 + 20)) = 24% [*E = 100 * (E / (A + C + D + E)) = 24%*]

100%

Each stations assigned weight is divided by the total weighting of the reporting stations.

If stations ''C'' and ''D'' are missing data, WIMS redistributes the weight assignments to the remaining stations as follows:

A = 100 * (10 / (10 + 15 + 20)) = 22%

B = 100 * (15 / (10 + 15 + 20)) = 33%

E = 100 * (20 / (10 + 15 + 20)) = 45%

100 %

How WIMS handles weighted variables, components, indices, and values

The NFDRS weighted averages function DAVG calculates a weighted arithmetic average for:

- Wind Speed (WS)
- Woody Fuel Moisture (WDY)
- Herbaceous Fuel Moisture (Herb FM)
- One-hour Timelag Fuel Moisture (1H)
- 10-hour Timelag Fuel Moisture (10)
- 100-hour Timelag Fuel Moisture (HU)
- 1000-hour Timelag Fuel Moisture (TH)
- Ignition Component (IC)
- Spread Component (SC)
- Energy Release Component (EC)
- Burning Index (BI)
- Fire Load Index (FL)
- Keetch-Byram Drought Index (KBDI)

To obtain a weighted Ignition Component (IC) for stations A, B, and C

The example below shows sample weighting factors for stations A, B, and C.

The example below shows SIG weighting factors for stations A, B, and C. The weight assigned to Station A is 22 the days IC for A is 38. The weight (w) and IC(i) are multiplied and then divided by 100 resulting in the 8.36.

Each stations IC is processed in the same way, then the sum of the IC factor for each station is added together resulting in the 48.76. Since there are no decimal points in NFDRS the value is rounded up to 49.

Station	Weighting Factor (w)	IC (i)	(w)(i)/ 100	AVG IC
A	22	38	8.36	
B	44	47	20.68	
C	34	58	19.72	
	100		48.76	round 49

Remember when averaging stations with different fuel models no weighted average Energy Release Component (EC), Burning Index (BI), and Fire Load Index (FL) will be displayed.

Staffing Level

Staffing Level is the bottom line of fire-danger rating, it can be thought of as a readiness level. It helps us understand where along the fire danger-rating continuum we are today – at the cool end, the hot end or somewhere in-between. The concept behind the staffing level is that different decisions or different actions are taken based on the current and forecasted "staffing level".

The Fire Danger Continuum is a range of possible outputs of a fire danger index or component,

0 84

given a set of NFDRS parameters and weather inputs. For example, the range of ERC for a station ranges from 0 to 84. The continuum would then have a range of outputs from the historical low of 0 to the historical high of 84.

This range is based on years of weather data from a station. The more data that is available for a station, the more accurately the data represents the climatology of the station and the range of its continuum. Remember the range is based on a selected fuel model and a date and year range.

The range of the output values defines the decision space for that particular NFDRS output.

With a decision to break the continuum down into 5 decision classes, staffing level 1 is on the cool end of the continuum with staffing level 5 on the hot end of the continuum.

The Fire Danger Continuum can be split into 9 classes or staffing levels, most agencies use 5 or 6. The splits are based on climatological breakpoints set by the agency. The Forest Service utilizes the 90th/97th percentile values as breakpoints. The Department of Interior agencies uses 80th and 95th.

The staffing level breakpoints are based upon a statistical analysis of historical fire weather, done in FireFamily Plus, of the cumulative frequency of occurrence of an NFDRS output.

Management determines which Staffing Index (index or component) to drive the Staffing Level (SL).

The statistics are such that SL 5 represents the top 3 percent of the burning index days observed over a 20-year or more period. Staffing Level 4 represents the range of burning indexes that fall between the 91st and the 97th percentiles. Staffing level 3 is very broad and represents about 70 percent of the days during the fire season (Note: This can vary significantly with the fuel model). Staffing Levels 1 and 2 represent the cool end of the fire danger-rating continuum; the SL 1 represents the bottom 5 or so percent of the days and SL 2 the remaining 15 percent of the days.

| SL 1 | SL 2 | SL 3 | SL 4 | SL 5 |

90th percentile value 90th percentile value 90th percentile

97th percentile

divided by 4 divided by 2

Using a specified Staffing Index (SI), WIMS determines the staffing class or readiness level of the suppression organization based on the supplied values of the breakpoints.

The SI field on the Create NFDRS Parameters form allows you to specify which Staffing Index will be used to determine Staffing Level. Users also set the number of Decision Classes (DC) and the Staffing Index Breakpoint values on this form.

In the example below there are 6 decision classes and the staffing index is BI.

Display/Edit Default NFDRS Parameters

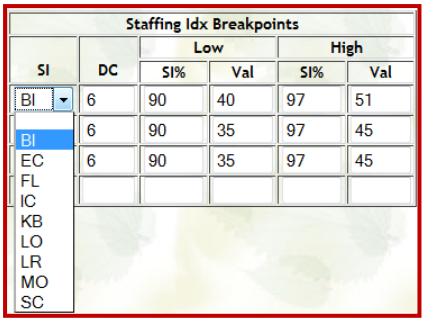
Back to Menu

Station ID: 012701 Effective Date: 01-may-08 Find Reset Save View Change Archive

78 & 88 NFDRS	100-hr	16	Fuel Stick Date	N/A
	1000-hr	21	Stick Age (Days)	N/A
88 NFDRS	1hr=10hr	☑	Season Code = 2	
	KBDI	101	Greeness Factors - Herb = 20, Shrub = 20	

Del	Pri	ID	** 78 NFDRS Only ** HS	Herb Date	Greenup Date	88 sb	Slp	Grs	Cli	Herb FM	Woody FM	X-1000	Staffing Idx Breakpoints SI	DC	Low SI%	Low Val	High SI%	High Val
☐	1	8E				D	2	P	3	92	156	15	BI	6	90	40	97	51
☐	2	7G	F	22-Nov-08	01-Apr-08		2	P	3	105	70	15	BI	6	90	35	97	45
☐	3	8R				D	2	P	3	92	156	15	BI	6	90	35	97	45

The SI field has a dropdown list from which to choose an NFDRS output.



The actual number of staffing classes used by an administrative unit may be any value from 3 to 9. For this reason, WIMS always computes the staffing class based on the nine-class system, but displays the staffing class based on the completed DC field (number of display classes) in the station catalog.

Breakpoints for the staffing class in the nine-class system are listed below:

Computed class level	Upper value for class
0	SI = 0
1	SI-low/8
2	SI-low/4
3	(SI-low)(3/ 8)
4	SI-low/2
5	(SI-low)(3/4)
6	SI-low
7	(SI-low + SI-high)/2
8	SI-high
9	More than SI-high

The table below shows the Displayed Staffing Class based on the desired number of DC's. As previously stated WIMS always computes the staffing class based on the nine-class system. Units with 5 DC will see staffing level 1,2,3,4 and 5. Units with 7 DC will see 1,2,3-,3+,4-,4+ and 5.

Desired number of staffing level classes	Displayed Staffing Class

3	0	1	1	1	1	1	1	4	4	5
4	0	1	1	1	1	3	3	4	4	5
5	0	1	1	2	2	3	3	4	4	5
6	0	1	1	2	2	3-	3+	4	4	5
7	0	1	1	2	2	3-	3+	4-	4+	5
8	0	1	1	2-	2+	3-	3+	4-	4+	5
9	0	1-	1+	2-	2+	3-	3+	4-	4+	5
Computed 9-Class Level	0	1	2	3	4	5	6	7	8	9

How WIMS determines the weighted staffing level

Before WIMS calculates the weighted Staffing Level, the staffing class of each station must be determined using the nine-class system. WIMS utilizes management assigned breakpoint percentiles that drive the staffing class calculations for each fuel model in the station catalog. Using the outputs from different fuel models, WIMS then generates a weighted staffing level from the different fuel models and WIMS assigns a class factor according to the schedule below:

Staffing class	(x)	Class factor (m)*
0	0	0
1-	1.25	1.19
1+	1.75	1.68
2-	2.25	2.37
2+	2.75	3.36
3-	3.25	4.76
3+	3.75	6.73
4-	4.25	9.51
4+	4.75	13.43
5	5.25	19.03

The weighted staffing level (SL) is then determined:

Station	Weight Factor (w)	Staffing Class	Class Factor (m)	(m) (w)/ 100
A	22	2-	2.37	.52
B	44	3+	6.73	2.96
C	34	4-	9.51	3.23
	100			6.71

As shown below, the shaded area shows how the 6.71 value translates to a weighted staffing class:

Staffing class	(m) (w)/ 100
0	0-0.99
1-	1.00-1.40
1+	1.41-1.99
2-	2.00-2.82
2+	2.83-3.99
3-	4.00-5.65
3+	5.66-7.99
4-	8.00-11.30
4+	11.31-15.99
5	Greater or equal to 16.00

The weighted staffing class is 3+ (3 high). The actual staffing level (SL field) on the Display NFDRS Weighted Averages form is then based on the number of display classes (DC) identified in the station catalog. If the station catalog shows '' 5'' display classes (staffing levels), a '' 3'' would display in the SL field. If the station catalog shows '' 6'' display classes, a '' 3+ '' would display in the SL field.

WIMS displays only the nine point Staffing classes, from 1-to 5. WIMS does not display the weighted staffing class '' 0''.

Adjective Fire-Danger Rating

In March 1974, Forest Service, BLM, and State Forestry representatives established a standard fire-danger rating system designed to communicate the relative severity of the current fire danger situation to the public.

The "adjective fire danger" is analogous to "Smokey's arm" or other media used to convey fire danger to the public. The "adjective fire danger" is based on a combination of the *staffing level*, which can be driven by any NFDRS output; and the *ignition component* (the probability that a firebrand would cause a wildland fire requiring some form of suppression response). Typically,

the "adjective fire danger" is in the "moderate" and "high" ranges about 70 percent of the time during the fire season. "Low" occurs about 25 percent of the time, with the remainder of the days in the "very high" or "extreme" range.

This adjective class should only be utilized for public information. Staffing level (SL) is used for in-house fire readiness.

Using the IC, the SL, and the adjective fire-danger matrix, WIMS determines the fire-danger rating (R). Adjective fire-danger is expressed as one of five levels

- Low (L) or Green
- Moderate (M) or Blue
- High (H) or Yellow
- Very High (VH) or Orange
- Extreme (E) or Red

The table below shows the adjective fire-danger matrix. The NFDRS output used for the Staffing Index is a management decision. The Staffing Level is based on that Staffing Index. The other half of the matrix is always the Ignition Component(IC).

Staffing Levels (SL)	Adjective Fire Danger Rating (R)				
1-, 1, 1+	**L**	**L**	**L**	**M**	**M**
2-, 2, 2+	**L**	**M**	**M**	**M**	**H**
3-, 3, 3+	**M**	**M**	**H**	**H**	**VH**
4-, 4, 4+	**M**	**H**	**VH**	**VH**	**E**
5	**H**	**VH**	**VH**	**E**	**E**
Ignition Component	**0-20**	**21-45**	**46-65**	**66-80**	**81-100**

Industrial Precaution levels automated in WIMS

How WIMS determines IFPL calculations for USFS Region 6

USFS Region 6 uses the Industrial Fire Precaution Level (IFPL) system to regulate activities to minimize risks associated with industrial operations. Industrial operation restrictions increase as IFPL values increase. WIMS calculates daily Precaution Values (PV) using one of the equations below:

West of the Cascades (assumes Fuel Model G)

$$PV = \left({ERC}/{22} \right) + \left({(IC-5)}/{20} \right)$$

If PV > 3, then

$$PV = 3.0 + 2\left(PV - 3.0\right)$$

East of the Cascades (assumes Fuel Model C)

$$PV = \left({ERC}/{4} \right) + \left({(IC-45)}/{10} \right)$$

Southwest Oregon, Siskiyou Mountains (assumes Fuel Model F)

$$PV = \left({ERC}/{6} \right) + \left({(IC-45)}/{10} \right)$$

These IFPL equations are based on NFDRS parameters associated with historic industrial fire occurrence in the Pacific Northwest and have no applicability outside this area.

IFPL Class	Corresponding Precaution Value
1	At or below 1.999
2	2.000 -2.9999
3	3.000 -3.9999
4	4.000 and above

IFPL Class levels are generated along with NFDRS outputs in DAVG if the Stations of the SIG are designated as Region 6 stations. In each of the three Region 6 areas specific fuel models are entered into the station catalog specifically for the generation of IFPL. The IFPL is generated for the SIG based on that designated fuel model priority. In the example below the SIG, IFPLEX, is based on one station in the East of the Cascades area with a fuel model C as priority 1 fuel model.

|

The Precaution Value (PV) generated is displayed in the PV column of the DAVG as is the IFPL level in the IFPL column.

Display NFDRS Weighted Averages DAVG

Back to Menu

SIG IFPLEX Type: O Date: 11-JUL-08 Time: Find Reset Print Export SIG Weights

Date	WS	WDY	HRB	1H	10	HU	TH	IC	SC	ERC	BI	FL	SL	R	KBDI	Rgn	PAL	PV	IFPL
11-JUL-08	8	76	83	2	3	4	10	43	9	15	29	21	3-	M	146	6		3.55	3

Notice the 6 in the Rgn column is a hyperlink, (different color and underlined). Selecting the hyperlink will generate the Display Region 6 Information.

Display Region 6 Information

SIG: IFPLEX Type: O Date: 11-JUL-08 Time:

The IFPL calculations displayed below apply to Oregon and Washington users only. IFPL users should refer to the PNWCD Interagency IFPL implementation guidelines for selection of the fuel model and other calculation considerations.

(Region 6 Only Calculation for first models of C, F and G)
Current Region: 6
Precaution Values: 3.55
Industrial Fire Precaution Level (IFPL): 3

How WIMS determines Project Activity Levels -PAL for USFS Region 5

PAL is the Region 5 Forest Service method of regulating Industrial Operations. It is derived from a matrix using the Energy Release Component (ERC) and Ignition Component (IC) outputs run on a fuel model G. The matrix is based on the analysis of equipment fire occurrence on the national forests in California and is divided into 6 levels

ERC/IC	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
0-10	A	A	A	B	C	C	C	C	C	C
11-20	A	A	B	B	C	C	C	C	C	C
21-30	A	B	B	B	C	C	C	C	C	C
31-40	A	B	C	C	C	D	D	D	D	D
41-50	B	B	C	C	D	D	D	D	D	D
51-60	B	B	C	C	D	Ev	Ev	Ev	E	E
61-70	B	B	C	C	D	Ev	Ev	Ev	E	E
71-80	B	B	C	C	D	Ev	Ev	Ev	E	E
81-90	C	C	C	D	D	Ev	Ev	Ev	E	E
91-100	C	C	C	D	D	E	E	E	E	E
>100	C	C	C	D	D	E	E	E	E	E

The PAL is available only in DAVG. The ERC and IC outputs are crossed on the matrix to locate the PAL Level. In the example below the outputs resulted in a PAL of D.

Display NFDRS Weighted Averages DAVG

Back to Menu

SIG MDF4 Type: O Date: 12-JUL-08 Time: Find Reset Print Export SIG Weights

Date	WS	WDY	HRB	1H	10	HU	TH	IC	SC	ERC	BI	FL	SL	R	KBDI	Rgn	PAL	PV	IFPL
12-JUL-08	4	70	1	1	3	3	9	50	8	79	59	42	3+	H	256	5	D		

The PAL value in the DAVG output table is a hyperlink, as the Rgn(region) was for IFPL. Selecting the hyperlink displays the matrix with the cross of the ERC and IC highlighted. Information above the matrix provides SIG, Type and Date information on the observation along with the actual values generated for the IC and ERC. The location on the matrix allows manager to make informed decisions on establishing the PAL for the next day. The PAL Value Chart button when selected will open a window with a master copy of the matrix.

Display Region 5 PAL

SIG: MDF4 Type: O Date: 12-JUL-08 Time:

IC: 50 ERC: 79 PAL: D

PAL Value Chart

ERC/IC	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
0-10	A	A	A	B	C	C	C	C	C	C
11-20	A	A	B	B	C	C	C	C	C	C
21-30	A	B	B	B	C	C	C	C	C	C
31-40	A	B	C	C	C	D	D	D	D	D
41-50	B	B	C	C	D	D	D	D	D	D
51-60	B	B	C	C	D	EV	EV	EV	E	E
61-70	B	B	C	C	D	EV	EV	EV	E	E
71-80	B	B	C	C	D	EV	EV	EV	E	E
81-90	C	C	C	D	D	EV	EV	EV	E	E
91-100	C	C	C	D	D	E	E	E	E	E
>100	C	C	C	D	D	E	E	E	E	E

Lightning Occurrence Index

Lightning Occurrence (LO) is meant to account for fires set by lightning on the day being rated and for fires set the previous day not yet discovered that must be considered in the rated day's fire business (holdover fires).

Three Lightning Occurrence Indices are calculated each day:

- Yesterday's Lightning Occurrence Index uses the LO from two days ago, yesterday's Ignition Component, and the Lightning Activity Level reported today to characterize the lightning situation that occurred yesterday (from midnight to midnight).
- Today's Lightning Occurrence Index uses yesterday's recalculated LO, today's predicted Lightning Activity Level, and observed Ignition Component.
- Tomorrow's Lightning Occurrence Index uses today's preliminary LO and tomorrow's predicted Lightning Activity Level and Ignition Component.

Several Lightning Activity Levels (LALs) are reported from the Create Observation or Edit Observation form, or are included by the fire weather forecaster in point or trend forecasts. Lightning Risk (LR) is calculated from the appropriate LAL and the lightning risk scaling factor identified in the station catalog.

How WIMS obtains yesterday's lightning risk

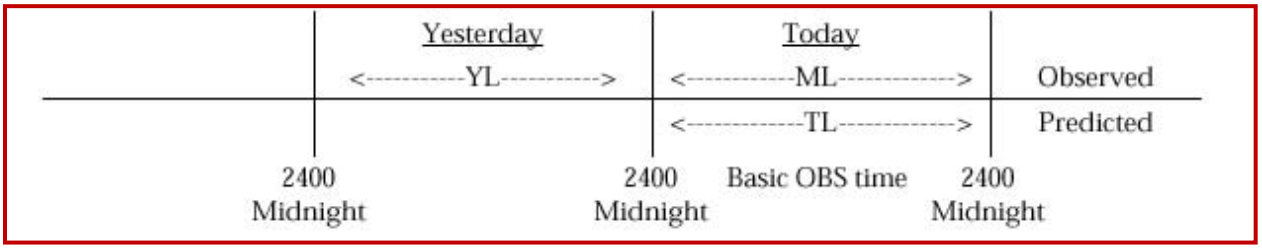
The YL field (yesterday's lightning) on the Create Observation and the Edit Observation forms best describes the lightning occurrence from midnight to midnight the previous day. YL replaces the LAL used to calculate yesterday's preliminary LO in yesterday's fire weather record, and eventually becomes part of the archived weather data in NIFMID and used by FIRDAT.

How WIMS obtains today's Lightning Risk (LAL)

To estimate today's Lightning Activity Level, WIMS uses LAL to determine the current day's lightning risk during the processing of this afternoon's fire weather observation. During the basic observation time (1300 local standard time) two LALs are available:

1. The LAL predicted on yesterday's fire weather forecast for today is called Tomorrow's Lightning (TL).
2. The LAL that describes the Lightning Occurrence experiences between midnight last night and the basic observation time today is reported in the ML field (Morning's Lighting) of the Create Observation and the Edit Observation forms.

WIMS chooses the higher of these two LALs. This value is replaced in the fire weather record by Yesterday's Lightning (YL) that will be reported tomorrow.



Where:

- YL is the observed LAL for yesterday.
- ML is the observed LAL today since midnight.
- TL is the LAL predicted yesterday for all of today.

How WIMS obtains today's lightning risk for predicting tomorrow's Fire Load Index

After the current day's fire weather observation becomes available, WIMS makes a second estimate of the LAL for the current day and selects the higher of:

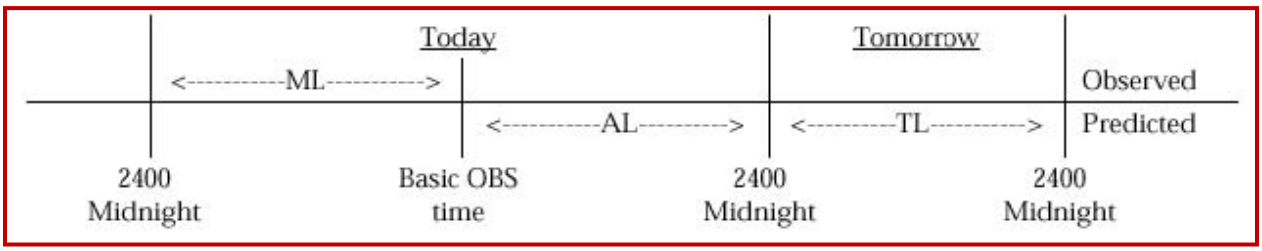
- The ML reported in the fire weather observation
- The LAL predicted for the period from midnight of the current day and the basic observation time.

This second estimate is called the Afternoon's Lightning (AL). To recalculate the Lightning Occurrence Index for today, WIMS uses AL, the Ignition Component (IC) from the observation, and the Lightning Occurrence Index (LOI) from yesterday. This updated LOI is used to predict tomorrow's LOI.

How WIMS obtains tomorrow's lightning risk for predicting tomorrow's Fire Load Index

The WIMS danger rating processor uses the value in the TL field on the Point or Trend Forecast form to determine tomorrow's lightning risk.

1. The LAL predicted on yesterday's fire weather forecast for today is called tomorrow's lightning (TL).
2. The LAL that describes the lightning occurrence experiences between midnight last night and the basic observation time today is reported in the ML field (morning's lightning) of the Create Observation and Edit Observation forms.



Where:

- ML is the observed LAL today since midnight.
- AL is the predicted LAL for the remainder of today (basic Observation time to midnight) for today's forecast.
- TL is the LAL predicted yesterday for all of today.

For more information, refer to Deeming, John E, Robert E. Burgan, and Jack D. Cohen. 1978. '' The National Fire-Danger Rating System. ''

More about recalculating NFDRS indices

The recalculate function in WIMS allows you to recalculate NFDRS indices that may have been affected by bad or missing data or adjustments made to the model in ENFDR.

The model is affected when adding missing weather observations or changing NFDRS parameters like herbaceous stage, fuel moisture or breakpoint values. It is a good idea to understand the affect of this new information on today's NFDRS index values:

- New information that is less than seven days old will have the greatest effect on today's NFDRS index values.
- New information older than seven days will not generally affect these values.

If a significant number of missing observations are added within the last 45 days, be sure to recalculate the NFDRS indices.

Exception: The 1000-hour timelag fuel moisture content value may be affected by some changes for up to 55 days. Calculation of the 1000-hour timelag fuel moisture value is greatly affected by long durations of precipitation.

To handle missing data

1. Go back and enter the missing weather observations.
2. Using the procedure outlined in "Recalculating NFDRS indices'' in Chapter 5, '' Beyond the basics, '' recalculate the NFDRS indices from the date of the oldest entered observation to the current day.

To handle an NFDRS parameter change

Use this procedure to adjust herbaceous conditions codes, and 100-hour and 1000-hour and the X-1000 timelag fuel moisture contents.

1. Using the Edit NFDRS Parameters form (FASTPATH: ENFDR), edit the appropriate NFDRS parameters as outlined in "Editing NFDRS parameters" in Chapter 9, "Working with NFDRS."
2. Using the procedure outlined in "Recalculating NFDRS indices" in Chapter 5, "Beyond the basics," recalculate the NFDRS indices.

Live fuels

The moisture content of living fuels is controlled by the physiological processes of the plant. The two live fuels that make up the 1978 NFDRS fuel classes include:

- Herbaceous plants
- Woody shrubs.

Herbaceous plants

Herbaceous plants do not develop persistent woody tissues and include grasses, forbs, and ferns. Herbaceous plants are divided into annual and perennial types. When the live fuel

moisture falls below 30 percent, herbaceous plants are considered cured and the moisture content defaults to that of the 1-hour timelag fuels.

For 1978 NFDRS fuel classes, the maximum herbaceous fuel moisture content is 250 percent.

Woody shrubs

During the growing season, perennial woody shrubs are allowed a maximum moisture content of 200 percent. The woody shrub fuel moisture model does not allow the estimated shrub moisture content to fall so low that the shrubs must be considered dead. These plants are considered dormant when the moisture content falls to the default woody fuel moisture set by the climate class.

For the 1978 NFDRS fuel model, the maximum woody fuel moisture content is 200 percent.

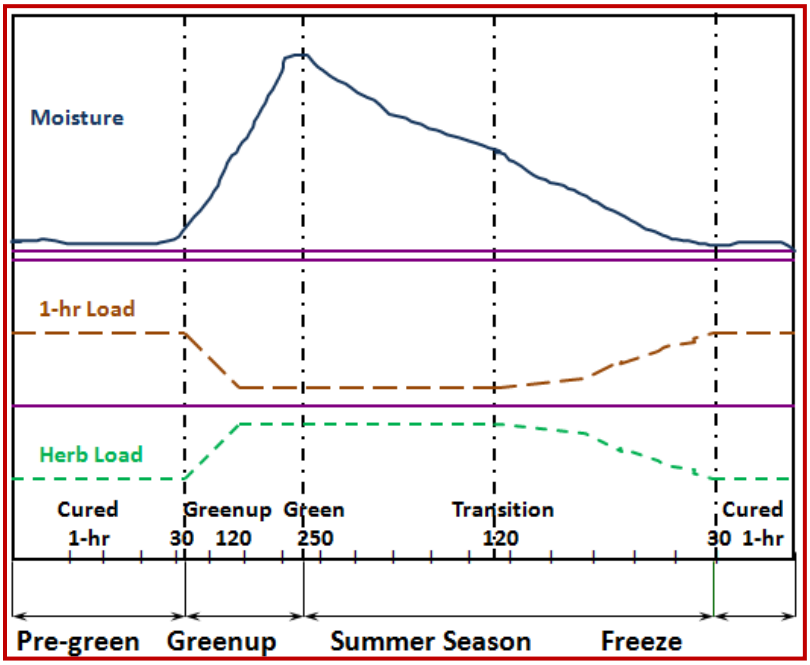
Live fuel moisture models

Live fuels act as either a heat sink or heat source. Live fuels become a heat source when their moisture content drops enough to allow desiccation and ignition during dead fuel combustion. If their moisture content remains above a critical level, live fuels act as a heat sink.

The live fuel model broadly approximates the moisture content of living herbaceous plants and the leaves and twigs of small woody shrubs. Maximum live fuel moistures at 25 percent 1000-hour timelag fuel moisture are 250 percent for herbaceous fuels and 200 percent for live woody shrubs.

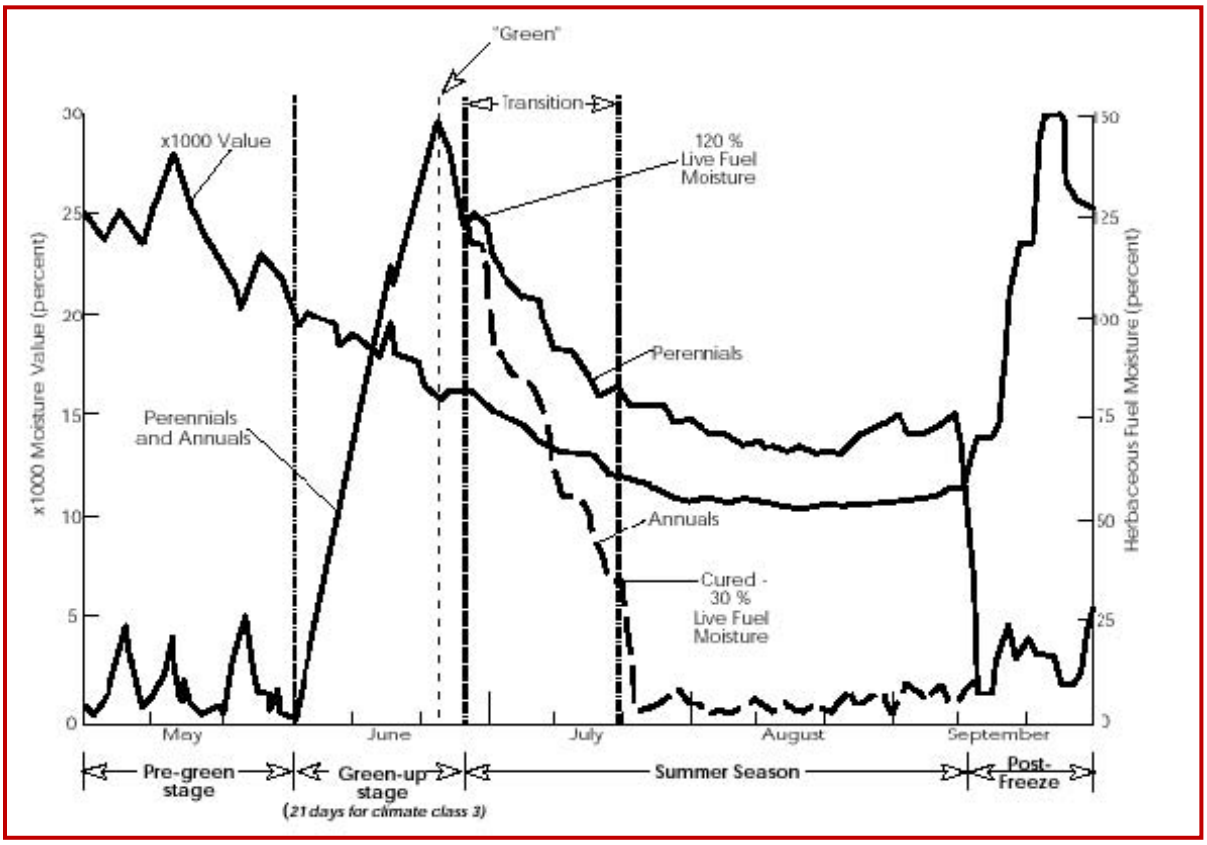
Herbaceous plants are considered cured at 30 percent moisture content, while woody plants are considered dormant if their moisture content drops to 50 percent.

A dynamic live fuel moisture algorithm simulates greening and curing of herbaceous fuels by transferring fuel load between the live herbaceous class and the 1-hour timelag class as the herbaceous fuel moisture levels occur between 30 and 120 percent during the growing season.



x1000, Annual, and Perennial herbaceous fuel moisture models

The diagram below shows the relationship between the x1000 value and the annual and perennial herbaceous moisture models.



As shown above, when the greenup date is set for a station there is a dramatic change in the Perennial and Annual herbaceous fuel moisture models. During the first part of this Transition period, the Annual and Perennial herbaceous fuel moisture models lose moisture at the same rate until they reach 120 percent. From 120 to 30 percent, the Annual herbaceous fuel moisture decreases faster than Perennial herbaceous fuel moisture.

Season Codes and Greenness Factors

Managing the 1988 NFDRS Model requires additional inputs to the daily observation and the validation of NFDRS outputs. Communication with the field on fuel conditions will enable you monitor fuel moisture trends. This step is not unique to users of the 88, maybe just more critical for managing the fuel moistures. The 78 model, once greened up is declared, runs based on start up fuel moistures and daily weather.

Season Codes (SC) and Greenness Factors (GF), which are part of the daily observation, are the Users way of telling the model the condition of the fuels. Understanding fuels, seasonal changes, and recognizing significant weather events is important to effectively managing the season codes, greenness factors, and the fuel model(s). Be cognizant that when using the 88 NFDRS Model, the 78 NFDRS Model is always operating in the back ground. Adjustments of the season codes & greenness factor will modify the Fire Danger outputs but they will never exceed the 78 Model value. If you provide no greenness factors in you observation you are allowing the 78 model to drive your outputs.

Greenness factors are set dependant on the visual relative greenness of herbaceous and woody vegetation using a scale of 0 (dormant) to 20 (max greenness). It is not necessary to increase the greenness factors by one each day. If greening is proceeding slowly or normally, the same values may be entered for several days. If greening is rapid (i.e. Spring) the greenness factors may be increased more often. The curing process (i.e. Fall) is handled similarly, where the greenness factors (herbs & shrubs) are decreased gradually as curing progresses.

There are tools to aid in the determination of fuel conditions and setting appropriate greenness factors.

Normalized Difference Vegetation Index (NDVI) satellite imagery is used to generate Relative Greenness (RG) and Departure from Average images.

Relative Greenness ranks greenness as a percent of maximum potential greenness. The images portray how green the vegetation is compared to how green it has been historically. Because each pixel is normalized to its own historical range, all areas (dry to wet) can appear fully green at some time during the growing season.

Departure from Average is percent of average greenness for the time period of the image. Areas of gray color have normal fuel moistures for the time period of the imagery, based on many years of collected data. DA imagery can be used with SC 3 Summer, to gauge whether GF should be 20 (meaning 78 model) or less than 20 if conditions are more droughty than normal.

The following summary is designed as a quick reference for interpreting the inputs necessary for managing 1988 NFDRS Model.

1 – Winter

- *Use when herbaceous fuels are cured and shrubs are dormant.*
- Set greenness factor to zero (Ø), all lives are cured or dormant. The processor ignores any other input.

2 – Spring

- *Use when herbaceous plants and/or shrubs begin a season's growth.*
- Ensure that through the season code that the daily observations regularly inputted into the model. Breaks can cause problems with the outputs.
- The greenness factor should be raised gradually from Ø to a maximum of 20 according to the rate of green up for critical species (usually 25 – 35 days). Leaving the GF at 20 is letting the 78 model drive the outputs.
- Use to prolong greenup period beyond climate class default if necessary. Look to Relative Greenness (RG) maps for guidance. Relative Greenness ranges 1-100 – so - GF = RG/5 to give 1-20 scale.
- Caution: Raise the greenness factor slowly (1 pt. every couple days or so unless faster green up or drying is observed).
- Continue to use Spring until the herbaceous plants complete the spring growth flush.

3 – Summer

- *Use Summer when growth flush is complete and until shrubs begin to show signs of fall curing.*
- Greenness factors should fluctuate gradually; dependant on the relative greenness of the vegetation.
- Fluctuate the greenness factors gradually according to the plants response to the environment (annuals vs. perennials).
- Use GF values of less than 20 ONLY if plants are curing faster than normal OR if fire danger is under rated. Use Departure from Average Greenness (DA) maps to guide changes. The Departure from average, mathematically, is the % of average greenness for the time period of the image.
- If DA is greater than 100%, use GF of 20 because the 88 model is not set up to handle a wetter than normal season.
- If DA is less than 100, GF = DA/5.
- Monitor the NFDRS outputs to the existing fuel conditions.
- Consider the days since rain and duration averaged across the Forest.
- If the NFDRS outputs are under/overestimating the fuel conditions slowly adjust the Greenness Factor.

- If the existing fuel conditions & NFDRS outputs are monitored regularly, the Greenness Factor shouldn't have to be adjusted more than a point at a time to more accurately represent the fuel conditions (Fire Danger).

4 – Fall

- *Use when deciduous shrubs begin to lose their leaves or evergreens enter dormancy.*
- As Fall progresses, greenness factors should gradually be reduced.
- Use to produce a gradual curing effect rather than the sudden drop seen in 78 fuel models after a freeze. Enter 0 when fully cured or dormant. If you leave GF at 20 through this period, vegetation may not cure in NFDRS calculations. You can use Relative Greenness maps to guide decision using GF = RG/5. Return to winter season and GF=0 once all vegetation is cured or frozen.

Live Fuel Moisture. Monitor the live fuel moistures in conjunction with changes in the season codes and greenness factors. One would expect live fuel moisture to stabilize in Season Code 1 (Winter) and increase in Season Code 2 (Spring) responding to changes in greenness as the herbaceous fuels move toward full flush. Live fuel moistures should follow relative changes in greenness in Season Code 3 (Summer) then begin to decrease in Season Code 4 (Fall) as greenness decreases and moves toward dormancy.

Some areas can get information on area fuel status from GACC Predictive Services. One example is the Eastern Great Basin which links to a BLM site. http://www.blm.gov/utah/egbcc/php/fuel_status/public/index.php. Each GACC has some information on fuel moisture by way of FireFamily Plus graphs. But remember those graphs are based on the same weather data as WIMS. At this time, there is not a lot of live fuel moisture monitoring sites with consistent information.

If Live Fuel moisture samples are collected use the values only to validate trends in the woody/herb values as they are site specific information and may not reflect the large scale area covered by the RAWS.

GSI – Growing Season Index can also be an aid in determining fuel moistures. The Southern Area GACC has a link to GSI numbers, imagery and graphs generated for each RAWS station. http://www.phenmon.org/cgi-bin/gsi-sagacc_new.pl

The web site for GSI is:
http://www.phenmon.org/index.php?option=com_content&task=category&sectionid=4&id=13&Itemid=31

Setting the Greenup date for a station

The stage of herbaceous vegetation controls two sets of fuel moistures:

- Herbaceous fuel moisture is affected by transition (H S field = T) and cured (H S field= C) stages. Unless frozen, perennial herbaceous fuels can recover from a cured stage after receiving moisture.

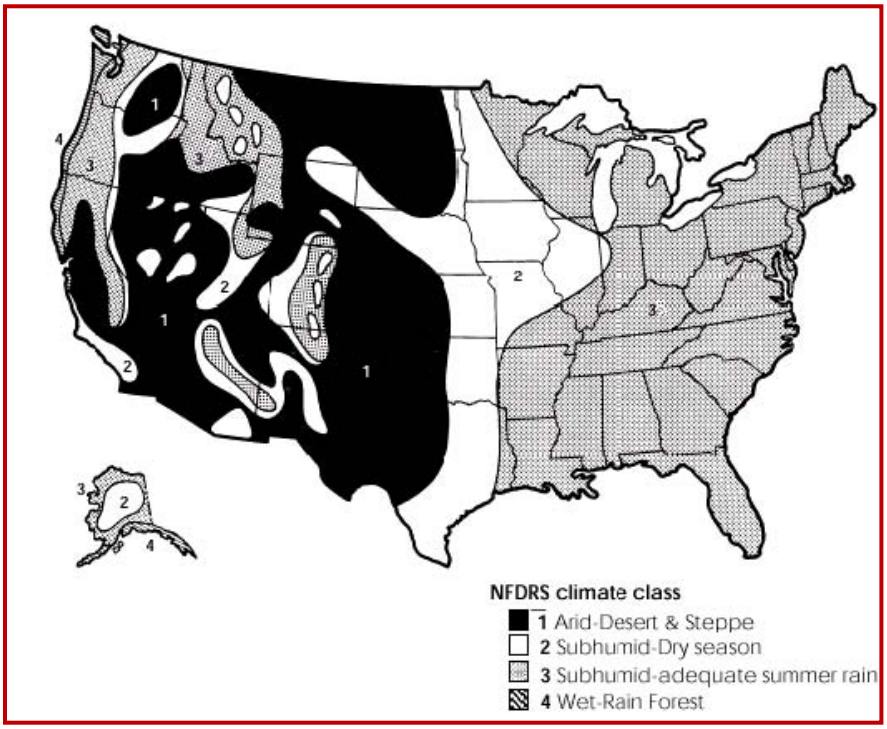
- Woody fuel moisture is affected by a frozen (H S field = F) state. Woody fuels must be frozen prior to Greenup.

The Greenup Date field on the Display/ Edit Default NFDRS Parameters form (FASTPATH: ENFDR) identifies the date at the start of Greenup. The Herb Date field reflects the date the last change was made to the H S field (herbaceous vegetation stage code).

For more information about editing NFDRS parameters, see "Editing NFDRS parameters" in Chapter 6, "Working with Station Information."

NFDRS climate classes

The map of the United States below depicts the general locations of the NFDRS climate classes.



Climate class is valid for NFDRS stations (type 2, type 4, and type 6), and accounts for different plant adaptability to different moisture regimes and their response to rainfall anomalies. During a period without rain, plants adapted to a wet climate lose moisture faster than plants adapted to a dry climate.

Climate class affects several NFDRS parameters that influence live fuel moisture, including:

- Beginning 1000-hour fuel moisture
- Minimum live woody moisture
- Curing rate of herbaceous plants, for moistures between 120 and 30 percent
- Days in Greenup period, for 1978 NFDRS.