FEWG – A WORKING GROUP FOR NCDFR MTM

NC Fire Danger Technote 03 – May 15th, 2009

What is the Buildup Index?

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The Buildup Index (BUI) was part of the 1964 National Fire Danger Rating System (NFDRS). It is defined as "a number that reflects the combined cumulative effects of daily drying and precipitation in fuels with a 10 day time lag constant". The BUI can represent 3 to 4 inches of compacted litter or can represent up to 6 inches or more of loose litter. The oven dry weights of the litter can be as much as 14 to 21 tons per acre. BUI also includes the dead decaying branch wood averaging up to 3 inches in diameter that can be found on the forest floor. This is the 1, 10, and 100-hour dead timelag fuels. This is a considerable contrast to the Keetch-Byram Drought Index (KBDI) which evaluates the upper layers of the soil profile and the duff layer on the forest floor. In the 1978 NFDRS, which is the version presently used by the Division, the BUI was replaced by the Energy Release Component (ERC). The BUI can be roughly equated to representing the 1, 10, & 100 hr. time lag fuels and is the precursor to the ERC.

The non-woody live herbaceous fuels: grasses, weeds & ferns inhibit a fire's ignition & ability to spread. In the BUI calculation the impact of fine, live fuels are considered by the stage of vegetative growth. These live green fine fuels help determine how quickly the BUI will increase or decrease based on the vegetative stage (Green, Transition or Cured). The determination of the Vegetative / Herbaceous Stage is assessed by an ocular observation & judged by District Fire Environment Managers. There are 3 herbaceous classes to consider:

Green (< 25% of the vegetation is dead),
Transition (25% to 75% is dead)
& cured (>75% is dead).

The Cured Stage is normally found at the end of the growing season. However, it can develop in the growing season when there is insufficient rainfall. The shift from Green to Transition is needed when the BUI reaches 50 & to Cured when the BUI exceeds 100.

A better rating to consider when assessing the cumulative effects of daily drying is the Energy Release Component (ERC). It reacts similarly to the BUI. However, the ERC considers all dead time lag and living (herbaceous & woody) fuel classes. Being a relatively new component, it will take time to develop an appreciation for its values and ranges by different fuel models (ERC range for a pocosin is 27 to 66 while the range for an ERC for hardwood litter is 10 to 35).

What is the BUI impact to fire suppression?

Buildup index is an indicator of the relative dryness of the several inches of surface fuels lying on the ground at and that are beneath the upper, fresh, thin layer. It simply reflects the dryness or wetness of fuels (other than the fine flashy fuels – grasses) that can have a pronounced effect on fire behavior (1hr. 10hr. & 100hr. time lag fuels). Drying weather facilitates more fuels becoming available. As the drying of the surface fuels on the ground extends progressively deeper on mineral soils, fire lines become harder to hold. Imbedded organic material (roots) in the upper soil will ignite and burn. Fires persist longer and can eventually creep under fire lines or breaks. This facilitates fire escapes as surface fuels on the other side of the fire line are kindled.

Excessively deep surface fuels on mineral soils or the organic soils respond differently to wetting and drying than ordinary fuels on mineral soils. Under these conditions the BUI is not the best indicator to measure dryness. However, the BUI provides information as to a fire's behavior through its increases in:

1) Rate of spread (ROS),
2) Fire intensity (FI or energy release),
3) & the difficulty to hold or contain a fire within the firebreak.

As the BUI increases, the width of the burning head fire will increase as well as the flame length. Under a well- developed buildup situation, fires are more persistent, burn deeper, and are harder to extinguish. The BUI has been used as an index in fire preparedness / readiness plans /blow up alerts. However, it requires firefighters to identify the levels of BUI that can be associated with local fire experience. Under the worst case drying conditions the BUI can go from 0 to 50 in 10 days. This represents a 63% moisture deficiency in the forest fuels. The BUI progression is based on an exponential drying curve over time. This is why in the fall and spring of the year under the cured vegetative stage, the BUI can quickly climb back to dangerous levels.

Byram's analysis work on "blowup fires / large-scale convection fires" indicated that certain fuel and weather conditions are conducive to extreme fire behavior (crowning, spotting, vortices, plume-dominated fires (blowup) or wind driven fires). For these types of fires to occur a critical point must be reached where the energy release of the fire exceeds the energy of the wind. At that point large-scale convection fires can occur. Byram's and other research work have shown that these fires have been associated with:

1) The passage of dry cold fronts, 2) adverse or Brotak's wind profiles (see Common Denominators to Large Fire Growth in North Carolina), 3) a Haine's Index ≥ 4, and 5) the BUI ≥ to 50.

To avoid these disaster fires prompt successful initial attack is necessary before the "critical points" are reached. In heavy brush fuels these conditions need to be evaluated with fuel loading of 14 to 21+ tons per acre and a fire size of 17 to 40 acres, or in light to moderate fuels with fuel loading of 4 to 12 tons per acre and a fire size of 40 to 60 acres.

Critical threshold / decision points shared by Division personnel, researchers, & personal observations:

BUI = 0 < 25	NORMAL
BUI = 25 ≥ but < 40	CRITICAL (old Division Policy requires BUI > 40 to be reported to the CO)
BUI = ≥ 40	EXTREME (in Byram's study on Blowup Fires, the wildfires examined had a BUI of ≥ 50)

In fuels where loading is not heavy as in the pocosins or southern roughs in the coastal plain, critical threshold / decision points can be readjusted based upon observations in the piedmont hardwood fuels. It takes more acres in the Piedmont than in the Coastal Plain as referenced above by the fuel loading.

BUI = 0 < 30	NORMAL
BUI = 31 ≥ but < 80	CRITICAL
BUI = ≥ 80	EXTREME

What is the KBDI?

Without direct sampling, to cumulatively quantify moisture depletion in deep duff or organic soils, a drought index is required. The KBDI was developed in 1968 and was incorporated in NFDRS as part of the 1988 revision. It is a stand alone drought index and can be used to estimate the consumption of dead vegetation material in the litter and duff layers. The KBDI is defined as "a number representing the net effect of evapo-transpiration and precipitation in producing cumulative moisture depletion in the upper soil layers and the duff (decaying organic material) over the mineral soil duff. The soil and duff layer gains moisture from rainfall and looses moisture by evapo-transpiration. With cumulative drying or onset of drought conditions, a rough estimate / association can made as it pertains to the KBDI values and the difficulty to the fire suppression effort.

What is the KBDI impact to fire suppression?

The moisture content of the upper soil, as well as the covering layer of duff has an important effect on the fire suppression efforts. Fires in the deep duff fuels are of particular concern to suppression resources and planners. When long term drying sets in, all fuels begin to dry, fires burn deeply, damage is excessive, and fire extinguishment / mop-up are expensive. Relatively small fires can be costly and large fires can be disastrous. During extreme drought normally moist areas such as branches, bays, and swamps can no longer serve as fire barriers. Fires may slow, but they eventually burn through these natural barriers. The Recent Pocosin Study Project has quantified that ground fire can be supported in the organic soils when the soil moisture content is < 190 %. Higher moisture contents cannot sustain continuous burning.

The KBDI effects:

the drying out of the deep organic soils,
the drying of organic materials (roots) imbedded in the upper shallow layers of mineral soil, and the living brush & tree crowns by lowering their moisture contents (wilting stress) so they become susceptible to crown fires.

In the summertime, a KBDI value of 621 is a level where green vegetation is under complete wilt stress. Crowning or torching is very likely. The impact of drought is a gradual process and plants begin to react at KBDI values around 200. KBDI values of ≥ 450 can cause feeder root damage in pine trees. KBDI is a very useful planning tool for fire control operations during mop-up situations and smoke management implications (residual burning). The KBDI permits the rough estimation of the flammability of organic material in the ground or organic soils. Fires go down in the ground starting at a KBDI value of 275 (lightning strikes).

Depending on management activities a KBDI value of 400 is serious and a value of 500 is extremely serious. Wildfires occurring at these KBDI values, the soil's humus and duff layers can be expected to be totally consumed. The fire's spread rates are faster. Crowning potential and the fire's energy release can also be expected to increase. The KBDI cannot and should not be considered as a replacement for the BUI. The KBDI and the BUI represent entirely different moisture regimes. The KBDI response to weather is much slower than with the BUI. The KBDI extends much further down into the ground, at least 30 inches in clay soils and deeper in light sandy soils. It is very important to realize that the BUI can have already surpassed its critical value of 40 in the coastal plain or 80 in the piedmont clay soils, while the KBDI can be somewhere between a value of 100 to 380 for the coastal plain or 160 to 560 for the piedmont.

1. **BUI is open-ended index**. It goes from 0 to ∞ (infinity). Although when having reached a BUI of 100, burning conditions (fire danger rating) are considered extreme.
2. **BUI Calculation Procedure:**
    1) Record 1300hr. air temperature, relative humidity, 24 hr. amount of precipitation, and herbaceous stage.
    2) On the correct herbaceous stage chart using air temperature and relative humidity determine fine fuel moisture.
    3) On the same chart with the fine fuel moisture value determine the drying factor.
    4) If the 24 hr. rainfall is **> than .10** inches of rain, then use the corrected buildup chart and with the rainfall amount and yesterday's BUI value determine the correction factor. Subtract it from yesterday's buildup index value. If the precipitation is **< than .11** inches, ignore it. Both give you a corrected or adjusted buildup index value.
    5) With the corrected BUI, add the drying factor to it to obtain today's BUI.
    6) **Special notes:**
        - **.10 inches of 24hr, rainfall or less is considered a rainless day.**
        - **BUI does not stop at a value of 100.**
        - **Drying factor is zero in the presence of ice or snow**
        - **When using the green herbaceous stage chart and BUI reaches a value of 50, switch to the transition herbaceous stage. When in transition if the BUI reaches 100, switch to the cured herbaceous stage chart.**
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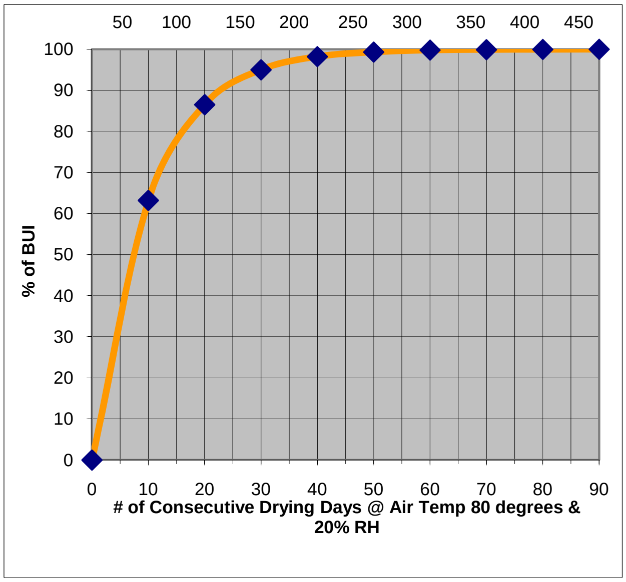
3. **Three BUI** facts are presented below that may help place into perspective the BUI until additional field experience can be acquired. The following terms are:

    1) Standard drying day curve (80 degrees and 20 % relative humidity).
    2) % of BUI is the percent of moisture deficiency or percent of moisture loss considering the fuels are originally saturated (100% = maximum dryness of fuel or 100% moisture deficient).
    3) Percent of fire season days by BUI (for 5-year totals).



In 7 days the fuels on the forest floor would lose 50 % of their moisture at ***standard drying day conditions (80 air temps. & 20% RH***). The BUI would be about 35.

In 10 days the moisture loss would be about 63% and the BUI 50.

In 10 days a BUI of 100 can be reached and the impacted fuels would be 88% moisture deficient.

This drying curve is very rapid with moisture loss occurring quickly & early in the drying process.

Even at a BUI at 450 the moisture loss is at 99.99%. Theoretically, it never will reach 100%. It would just closer to 100% of Buildup Index.

5 Year totals for BUI Values for Eastern Stations (Mar- Apr- May – Oct – Nov)

BUI Values

Airport Location	0-5	6-12	13-19	20-29	30-39	40-49	50-69	70-89	90-99	100-149	150-199	200+
Asheville	59	151	153	172	95	50	61	17	3	4	0	0
Atlanta	65	160	145	161	86	58	56	24	6	3	1	0
Charleston	14	71	113	154	136	101	131	40	5	0	0	0
Alexandria	77	183	150	158	97	49	39	12	0	0	0	0

Distribution of fire season days by BUI (5-year totals from various Eastern Stations located at airports. This information is from John Keetch's work on the Spread Phase for the 1964 NFDRS). Unfortunately this distribution is not by month, but it is more information and it can be helpful.

The table below simple states the same information as the table above. However, it is stated in percent and is rounded off to the nearest Percent (%).

Percent (%) Occurrence for specific ranges of BUI Values for 4 Eastern Stations over 5 Yrs.

(Mar-Apr-May - Oct – Nov)

BUI Values

Airport Location	0-5	6-12	13-19	20-29	30-39	40-49	50-69	70-89	90-99	100-149	150-199	200+
Asheville	8	20	20	22	12	7	8	2	<1	<1	0	0
Atlanta	8	21	19	21	11	8	7	3	1	<1	<1	0
Charleston	2	9	15	20	18	13	17	5	1	0	0	0
Alexandria	10	24	20	21	13	6	5	2	0	0	0	0

Special Note: Because of rounding, the Table's totals for each row may exceed 100%.