

Computer Calculation of the Keetch-Byram Drought Index—Programmers Beware!

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The Keetch-Byram Drought Index or KBDI (Keetch and Byram 1968) has been or is still being used as a guide for estimating the cumulative moisture deficiency in deep duff or upper soil layers. Such information is needed for planning fire management operations in many regions of the world (McArthur 1966, 1967; Cheney 1971; Mount 1972; Valentine 1972; Wade and Ward 1973; Burgan, Fujioka, and Hirata 1974; Just 1978; Noble, Bary, and Gill 1980; Crane 1982; Sirakoff 1985; Swart 1986; Burgan 1988; Melton 1989; Donaldson and Paul 1990; Jordan 1990). As well, the KBDI has been widely utilized in various fire research studies (Burgan 1976; Haines, Johnson, and Main 1976; Dayananda 1977; Miller 1978; Olson 1980; Lorimer and Gough 1982, 1988; Hall and Gwalema 1985; Johansen 1985; Van Wagner 1985; Burrows 1987; Gill, Christian, Moore, and Forrester 1987; Brown, Booth, and Simmerman 1989).

It has come to my attention (Crane 1983) again that there are two significant typographical errors in the original 1968-published USDA Forest Service Research Paper SE-38 dealing with the drought index developed by John J. Keetch and George M. Byram. Crane (1982) determined that the equation used to calculate the daily drought factor was in fact incorrect. The last constant in the numerator of Equation 18 on page 31 of Keetch and Byram's (1968) publication should have been 8.30 and

not 0.830 (fig. 1). The end result of this error is a drought factor that is always slightly higher than the correct value (table 1). Crane (1982) also suggested that the last constant in the numerator of Equation 15 on the same page should have been

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0.213 instead of 2.113. However, in a review draft of Keetch and Byram (1968) dated October 22, 1966, which was kindly provided by D.R. Packham (Commonwealth of Aus-

tralia, Bureau of Meteorology, Melbourne, Victoria), it's clear that the errors in Equations 15 and 18 were both typographical in nature, and the constant in the former should have been 0.2113. It's worth noting that the drought factor tables contained in Keetch and Byram's (1968) report, which are based on Equation 18, are correct however.

Just how insignificant are these sources of error in calculating the KBDI? On a day-to-day basis, the error may have only a small effect on the resultant value (table 1). However, a computer-calculated value would eventually depart considerably from the correct value due to the cumulative nature of the KBDI, especially during a rainless period (Fujioka 1991). There will of course always be differences between equation-calculated values and those derived from tables when it comes to fire danger indices (Deeming 1975).

English unit equation [corrected] from Keetch and Byram (1968)

$$dQ = \frac{[800 - Q] [0.968 \exp(0.0486T) - 8.30] dr}{1 + 10.88 \exp(-0.0441R)} \times 10^{-3}$$

S.I. unit equation from Crane (1982)

$$dQ = \frac{[203.2 - Q] [0.968 \exp(0.0875T + 1.5552) - 8.30] dr}{1 + 10.88 \exp(-0.001736R)} \times 10^{-3}$$

| Symbol | Quantity | English units | S.I. units |
|--------|----------------------------------|---------------|------------|
| dQ | Drought factor | 0.01 in | mm |
| Q | Moisture deficiency ¹ | 0.01 in | mm |
| T | Daily maximum temperature | °F | °C |
| R | Mean annual precipitation | in | mm |
| dr | Time increment | = 1 day | = 1 day |

¹ Yesterday's KBDI or value as reduced by the daily net precipitation (i.e., the amount in excess of 0.20 in or 5.1 mm).

Figure 1—The two versions of the equation used to calculate the daily drought factor in computing the Keetch-Byram Drought Index (KBDI).

Table 1—Increase in the value of the daily drought factor of the Keetch-Byram Drought Index (KBDI) as a result of the typographical error in Equation 18 of Keetch and Byram (1968). Please note that due to the nature of the error in Equation 18, the increase above the actual value is independent of daily maximum temperature.

| Mean annual precipitation | | Yesterday's KBDI ¹ or value as reduced by the daily net precipitation | | | | | | | | |
|---------------------------|-------|--|-----|-----|-----|-----|-----|-----|-----|-----|
| (in) | (mm) | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 800 |
| 10 | 254 | 0.7 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 0.1 | 0 | 0 |
| 20 | 508 | 1.0 | 0.8 | 0.7 | 0.5 | 0.4 | 0.3 | 0.1 | 0 | 0 |
| 30 | 762 | 1.3 | 1.1 | 1.0 | 0.8 | 0.6 | 0.4 | 0.2 | 0 | 0 |
| 40 | 1,016 | 1.8 | 1.6 | 1.3 | 1.0 | 0.8 | 0.5 | 0.3 | 0 | 0 |
| 50 | 1,270 | 2.4 | 2.0 | 1.7 | 1.4 | 1.0 | 0.7 | 0.3 | 0 | 0 |
| 60 | 1,524 | 3.0 | 2.5 | 2.1 | 1.7 | 1.3 | 0.8 | 0.4 | 0 | 0 |
| 70 | 1,778 | 3.5 | 3.0 | 2.5 | 2.0 | 1.5 | 1.0 | 0.5 | 0 | 0 |
| 80 | 2,032 | 4.0 | 3.4 | 2.8 | 2.3 | 1.7 | 1.1 | 0.6 | 0 | 0 |

¹In the original formulation of the KBDI, 800 represented the maximum possible value. However, the metric or S.I. unit scale of the KBDI technically limits the value to 203.

To my knowledge, an errata to Keetch and Byram (1968), which highlights the aforementioned problems, has never been issued. However, the misprints in Equations 15 and 18 have been corrected in a 1988-revised reprinting of the original publication, although no mention of these corrections is made. This note has been prepared to alert those, who may be calculating the KBDI by computer, to these two errors, since it's not always readily apparent whether they have been detected by other users. The corrected version of Equation 18 and the one rederived by Crane (1982) in terms of the International System (S.I.) of units are presented here (fig. 1) in the interest of completeness. Furthermore, the references compiled here constitute a selected bibliography on the KBDI. ■

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