AN ASSESSMENT OF THE 1984-85 DROUGHT IN NORTHERN NEW JERSEY

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ABSTRACT

The 1984-85 drought in southeastern New York, eastern Pennsylvania, and New Jersey was evaluated in terms of precipitation anomalies, the Palmer Hydrological Drought Index and associated return periods, and reservoir levels. In comparison to other droughts occurring during the period from 1900 to 1983, it was determined that, although severe, the 1984-85 drought was less severe than others of equal duration (e.g., 1980-81). The 1984-85 drought was apparently exacerbated by nonmeteorological factors, which shows that the water management system has become more susceptible to droughts of lesser intensity.

1. INTRODUCTION

The tri-state area of southeastern New York, eastern Pennsylvania, and New Jersey experienced very dry conditions from August 1984 throught April 1985, which resulted in the imposition of severe water-use restrictions in many locations. The severity of the restrictions raised meteorological questions. Why did this particular dry period cause such a large water supply deficit? And how did it compare to other droughts? To answer the latter of these questions, the duration, intensity, and frequency of this dry spell was compared to other droughts.

2. METHODOLOGY

Droughts may be evaluated in a variety of ways including the examination of precipitation anomalies, through the use of the Palmer Hydrological Drought Index (PHDI), and its statistically derived return periods (4), and through the evaluation of reservoir levels. The Palmer Drought Severity Index (PDSI), a measure of drought duration and intensity, is based on observed and derived meteorological parameters and includes monthly precipitation, soil moisture, and potential evapotranspiration (Palmer, 5). In constructing the index, Palmer incorporated lag terms such that the beginning and end of a wet or dry period could be determined. The lag terms express moisture received from precipitation as a percentage of the moisture needed to end a wet or dry period. This percentage is a function of the normal monthly precipitation and the precipitation that fell in the preceding several months. The importance of changes in soil moisture, which occur more slowly, will be diminished by the inclusion of lag terms. Thus, when precipitation returns to near normal, the index will indicate the end of a wet or dry period with less regard to soil moisture conditions.

A more recent index, the Palmer Hydrological Drought Index (PHDI) omits the lag terms found in the PDSI (Karl and Knight, 6). PHDI better evaluates hydrologic conditions which react more slowly to changing weather patterns. For example, the PDSI will indicate the end of a wet or dry period when precipitation patterns return to near normal regardless of the soil moisture conditons. The PHDI will not, since it lacks the "climatological backstepping" found in the PDSI. The only way to end a wet or dry period in the PHDI is through significant changes in soil moisture conditions.

In this study, droughts were defined as a consecutive period of at least three months in which a critical value of the PHDI $\leq$ -1.5 persisted in any of nine climatic divisions selected for study (Table 1). The critical PHDI value chosen was - 1.5 and

State	Climatic Division Number and Name
New Jersey	01 - Northern
	02 - Southern
	03 - Coastal
New York	02 - Eastern Plateau
	04 - Coastal
	05 - Hudson Valley
Pennsylvania	01 - Pocono Mountains
	02 - Central Mountains
	03 - Southeastern Piedmont

Table 1. Climatic divisions in New Jersey, New York, and Pennsylvania used in this study.

corresponds to a "mild to moderate" drought (Table 2), and represents a negative departure of one or more categories from the normal. To compare 1984-85 with earlier droughts, those which lasted nine months or longer were extracted from the data set. The nine-consecutive-month period was selected because it corresponded to the duration of below-normal precipitation experienced from August 1984 to April 1985. Twenty distinct long term droughts were identified and are ranked in Table 3. PHDI data were available for the period from 1900 to 1983. The 1984-85 drought was then compared to all droughts of at least nine consecutive months with a critical PHDI value of -1.5 or less, at any one of the climatic divisions used.

Having identified the major droughts by duration and intensity, the remainder of the study concentrated on one climatic division, New Jersey - 01 (northern) using New Brunswick, New Jersey as the key station. Precipitation deficits from New Brunswick, New Jersey, were obtained by subtracting nine-month running means of precipitation from the normal nine-month running means (Harnack, 7). Table 4 indicates that 1984-85 ranks eleventh, making it less severe than other recent droughts (1960s, 1980-81, and 1976-77) in terms of precipitation deficits.

Reservoir levels, although influenced in part by nonmeteorological factors, provide an integrated measure of water use and availability and may reflect conditions prior to and during a drought. Reservoir levels are seasonal, with maximum recharge in the winter and spring; and minimum levels in the summer and fall. Data for the Wanaque Reservoir in the Passaic River Basin were available for the two periods 9/80-4/82 and 8/84-6/85, corresponding to the 1980-81 and 1984-85 droughts, respectively (Hassan 8). These data indicate that the recent dry period of 8/84-4/85 was preceded by record spring rainfall, resulting in capacity conditions and reservoir overflow. Reservoir levels in 1980-81 were lower, with lowest levels coinciding with the seasonal minimum.

PHDI Value	Category
> 4.00	Extreme Wetness
3.00 - 3.99	Severe Wetness
1.50 - 2.99	Mild to Moderate Wetness
-1.49 - 1.49	Normal
-1.50 - -2.99	Mild to Moderate Drought
-3.00 - -3.99	Severe Drought
< -4.00	Extreme Drought

Table 2. Palmer Hydrological Drought Index Values and categorical classification of drought severity.

Finally, a comparison of PHDI value return-periods indicates relative drought intensity. For the three most recent droughts of 1976-77, 1980-81, and 1984-85 PHDI values were lowest for 1980-81 (-3.5 in 1/81, severe drought) and highest for 1976-77 (-1.6 in 1/77, moderate drought). PHDI values were unavailable for 1984-85 and so PDSI values were substituted. This may be done because the two indices are essentially equivalent during extreme wet and dry periods (Karl, 9). The 1984-85 minimum PDSI was -3.3 (in 04/85, severe drought). The droughts of 1980-81 and 1984-85 have return-periods of approximately ten years as determined by the National Climatic Data Center (unpublished computer output, 1985 and Havens (10). This comparison implies that the two droughts were of similar intensity and should have affected the region in roughly the same manner.

Month/Year	Rank	Duration (months)
05/1962-07/1967	1	63
06/1929-02/1933	2	45
09/1908-03/1912	3	43
04/1921-08/1924	4	41
08/1953-09/1955	5	26
10/1924-08/1926	6	23
01/1941-08/1942	7	20
04/1900-07/1901	8	16
03/1918-06/1919	9	16
07/1980-09/1981	10	15
06/1949-07/1950	11	14
08/1916-07/1917	12	12
11/1976-10/1977	13	12
06/1913-03/1914	14	10
06/1939-03/1940	15	10
07/1944-04/1945	16	10
09/1968-06/1969	17	10
06/1912-02/1913	18	9
05/1914-01/1915	19	9
05/1957-01/1958	20	9

Table 3. Droughts ranked by duration.

3. CONCLUSIONS

Although a serious precipitation deficit existed in the southeastern New York, eastern Pennsylvania, and New Jersey area during 1984-85, it was less severe than others of equal duration. Therefore, in meteorological terms, the recent drought should not have created greater water shortages than past droughts and implies that non-meteorological factors were responsible for the shortages. Because the water distribution system is antiquated, and water demand continues to increase, the area is less drought tolerant than in the past. The recurrence of a drought as intense as that of the 1960s would be disastrous (11). Further study of the causes of drought combined with an integrated water resource program is needed to prevent major economic

Begin (Mo/Yr)	End (Mo/Yr)	Normal Precip	Total Precip	Actual Deficit	Percent Deficit
04/65	12/65	34.81	18.92	15.89	45.7
12/62	08/63	34.29	18.68	15.61	45.5
08/80	04/81	34.41	21.93	12.48	40.8
05/39	01/40	33.79	21.71	12.08	35.8
06/76	02/77	33.55	22.08	11.47	34.2
02/14	10/14	36.00	24.03	11.97	33.3
10/24	06/25	30.38	20.94	9.44	31.1
02/23	10/23	34.55	24.40	10.15	29.4
08/30	04/31	31.37	22.22	9.15	29.2
01/57	09/57	32.84	23.61	9.23	28.1
08/84	04/85	33.91	24.56	9.35	27.6
07/53	03/54	32.80	23.34	8.48	25.8
09/41	05/42	30.98	23.08	7.90	25.5
08/16	04/17	32.91	24.61	8.30	25.3
06/49	02/50	32.61	24.67	7.94	24.4

Table 4. Nine-month drought periods ranked lowest for New Brunswick, New Jersey indicating the appropriate normal and actual total nine-month precipitation, precipitation deficit, and percent deficit. Thirty-year normal periods were computed for each decade (i.e., 1901-1930, 1911-1940,..., and 1951-80).

disruptions and hardships and may permit orderly growth.

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