CONSERVING WETLAND WATER BY SUPPRESSING EVAPORATION

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INTRODUCTION

There is a particular concern today regarding adequate fresh water supplies for human consumption.

Watershed wetlands are a potential source of water supplies if properly managed. Before feasible management practices can be developed or used, however, knowledge of the role of wetlands in the hydrologic cycle is necessary.

This study was undertaken to investigate the management technique of evaporation suppression on wetlands to increase water yields and augment water supplies during the dry months of the year; and to evaluate the role of wetlands in water storage. The latter objective has implications for flood control.

Experimental Site

The site selected for this study was Jewell Pond, a 4.45-ha (10.9-acre) wetland located in the town of Stratham, New Hampshire.

Figure 1. Aerial photograph of Jewell Pond showing the differentiation between the open water and vegetated areas.

Although Jewell Pond is 4.45 ha in size, only 1.11 ha (2.7 acres) are open water surface. The remaining 3.34 ha (8.2 acres) consist of muck and peat deposits, supporting a dense growth of buttonbush (*Cephalanthus occidentalis*) and leatherleaf (*Chamaedaphne calculata*). A visual analysis of Jewell Pond is provided by the low altitude, oblique aerial photograph in Figure 1.

The geologic conditions around the site are quite representative of the New Hampshire coastal region. The upland portions of the area consist of very poorly sorted glacial till in the form of drumlins with irregularly shaped kame terraces (ridges) along some of the drumlins (3). The lower elevations consist of marine-deposited silts and clays, sometimes overlain by sandy stream deposits, or underlain by bedrock within a few feet of the surface. The underlying bedrock of the area is the Eliot formation, belonging to the Merrimack group and believed to be of Middle Silurian age (2).

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Instrumentation

The meteorological data collected and the instruments used are listed in Table I. The hydrologic data collected consisted of pond level fluctuations by a water-level recorder; pond discharge by a 90-degree V-notch weir; and periodic water table measurements.

THE 1969 INVESTIGATION PERIOD

The first portion of this study was conducted during June through August, 1969. Jewell Pond was analyzed in its natural state to determine its hydrologic characteristics and to relate the collected data to a water budget equation. The equation as used was:

$$ET = R - Q - E \pm \Delta S_w \pm \Delta S_p \quad \ldots\ldots\ldots (1)$$

where:

ET = evapotranspiration;
R = rainfall;
Q = stream discharge;
E = open water evaporation;
ΔS_w = the change in storage for the open water body; and
ΔS_p = the change in storage for the area of peat.

When using the water budget equation all terms must be adjusted for the area involved in each term. This may be done either by doing the computations in hectare centimeters or by using area percentages.

TABLE I METEOROLOGICAL INSTRUMENTS EMPLOYED IN THIS STUDY

Data collected	Instrument used
Precipitation	Weighing bucket type recording rain gauge.
Air temp and dew point depression	A motor-aspirated temperature and dew cell unit, recorded on a multipoint recorder.
Water temp (at a 10.2-cm depth)	A temperature probe connected to the recorder.
Wind speed	A recording anemometer and an accumulating anemometer.
Incoming solar radiation	An integrating pyranometer.
Net radiation	Two miniature net radiometers; one over the vegetation and the other over the open water.
Water and vegetation surface temperature	An infrared thermometer.
Pan evaporation	A Weather Bureau "class A" evaporation pan.

TABLE II DATA AND RESULTS SUMMARY (ALL VALUES IN CM)

Year 1969	1970†
Rainfall (measured)	
20.3	15.9
Discharge (measured)	
4.6	4.4
Evaporation (open water calculated)	
21.0	14.2‡ (26.7) §
Evapotranspiration (vegetated area calculated)	
36.4	36.3
Change in storage (open water measured)	
35.6	40.6
Change in storage (vegetated area estimated)	
10.7	12.2

† Evaporation retardant used.
‡ Shows a 47% reduction in water loss.
§ Potential evaporation.

The surface runoff into the pond was assumed to be insignificant because the normal rainfall intensity for the area during June, July, and August usually does not exceed the infiltration rate of the glacial till soils that surround the site; and the consumption of water by both the hardwood forest on the hills and the grasses in the fields at the ends of the pond equals or exceeds the quantity of water received as rainfall during the summer. This high consumption of water by the plants tends to keep the soil relatively dry and increases the ability of the soil to hold and store water when rainfall occurs. Surface runoff during the summer has been found to be significant only when a storm of very high intensity or very long duration occurs (6).

Groundwater flow was assumed to be of minor importance with any net flux being absorbed in the evapotranspiration term (ET); net groundwater flow was also assumed to be constant from one year to the next.

During the 1969 investigation, the precipitation was 20.3 cm (8.00 inches); the stream discharge was equivalent to 4.6 cm (1.8 inches); open water evaporation was 21 cm (8.3 inches); and the change in storage caused a water level decline of slightly over 35.6 cm (14 inches) (Table II).

Open water evaporation was calculated by the Penman evaporation equation (4). The ratio between the calculated Penman value and the evaporation pan data was 0.78, close to the anticipated ratio of 0.80 for a partially submerged evaporation pan to actual evaporation from an open water surface. The change in storage in the peat deposits was assumed to be 30% of the pond level decline, determined from a limited number of measurements to obtain the water yield under gravitational drainage per foot of saturated peat. The 30% estimate is an arithmetic mean used during the investigation period and may vary ±15% depending on composition, amount of compaction, and decomposition of the material. The evapotranspiration for the vegetated area was 36.4 cm (14.3 inches), which is 1.7 times the evaporation from the open water (Table II).

Even though the data used in this investigation were collected during the summer when water losses were high, the results indicate that the yearly evapotranspiration loss from wetland vegetation may equal or exceed that of open water evaporation. The predicted annual evaporation for the Jewell Pond area is 63.5 cm (25 inches), and the estimated evapotranspiration for wetland vegetation is about 68.6 cm (27 inches) based on the calculated values and the Thornthwaite evapotranspiration equation (4).

The results obtained in 1969 for wetland evapotranspiration were comparable with Wyoming (7) and Minnesota (1) data. Conversely, the 1969 Jewell Pond data varied significantly from observations on North Dakota prairie potholes (5); the divergence was attributed to differences between wetland characteristics. The evapotranspiration values obtained in this study were considered typical for wetlands with the characteristics of Jewell Pond.

The evapotranspiration values obtained from the 1969 water budget were compared with those calculated by five methods commonly used for estimating evapotranspiration. The ratio of the value computed by the Thornthwaite equation to the value computed from the 1969 water budget was closest to unity (0.99). The Thornthwaite equation was therefore deemed the most suitable and was used for the computation of evapotranspiration in 1970. It should be noted that Thornthwaite's equation was developed primarily from experience in the central and eastern United States (4). The ratios obtained compared well with the relations obtained in other investigations (8).

THE 1970 INVESTIGATION PERIOD

The second portion of this study was conducted during June through August, 1970. An evaporation retardant was used on the open water portion of Jewell Pond to determine the impact of evaporation suppression on the wetland water budget, and the suitability of its use in wetland management. The retardant used was a mixture containing 59% hexadecanol, 34% octadecanol, and 7% impurities in the form of a dry powder. The retardant was sprinkled by hand from a boat at an average rate of 220 g/ha (1.2 lb/acre) per week, after an initial application of 460 g/ha (2.5 lb/acre). There were no major problems encountered in maintaining the retardant layer. Wind velocities of about 15 mph (24 km/h) or more did blow the film to shore on a few occasions; the bulk of the retardant, however, was redistributed naturally after the wind subsided.

The water budget approach was used for calculating the results; however, evaporation was the term to be determined. Evapotranspiration for the vegetated area (36.3 cm) (14.3 inches) was calculated by the Thornthwaite equation, as it was considered the best method as indicated from the 1969 results. The seasonal rainfall was 15.9 cm (6.3 inches); the stream discharge 4.4 cm (1.7 inches); and the change in storage caused a water level drop of 40.6 cm (16 inches) (Table II).

The open water evaporation loss (14.2 cm) (5.6 inches) was then calculated by using the evapotranspiration value computed above in the water budget equation. The potential evaporation loss (26.7 cm) (10.5 inches) was obtained by applying the 0.78 correction factor, obtained in 1969, to the measured pan evaporation (34.3 cm) (13.5 inches). The difference between the potential evaporation and the water budget evaporation, or evaporation reduction (12.5 cm) (4.9 inches) was divided by the potential evaporation and reported as percent reduction by the use of the retardant (47%) (Table II).

CONCLUSIONS

The wetland investigation at Jewell Pond, Stratham, New Hampshire, led to the following conclusions:

1. The quantity of water lost to evapotranspiration in a muck and peat bog covered with bushy vegetation was 1.7 times the quantity of water lost by evaporation from an open water surface during the summer of 1969.

2. Wetlands appear to be areas that could yield significant quantities of water during periods of water shortage through management practices. The total quantity of water lost to evaporation and transpiration during the 1969 investigation period was 32.6 cm (12.8 inches).

3. The use of evaporation retardants as a wetland management practice will significantly reduce open water evaporation.

4. Wetlands are also valuable for flood control, in that the total water released from Jewell Pond during the 1969 investigation period was equivalent to 37.2 cm (14.6 inches) of precipitation over the entire pond area. The precipitation received during the same period was nearly 20.3 cm (8 inches). These data show that Jewell Pond stored 16.9 cm (6.6 inches) of water and released it slowly during the low-flow period of the year. Water released from the Pond was mainly by evaporation and transpiration, and not stream flow.

SUMMARY

Evapotranspiration from the muck and peat bog of Jewell Pond in Stratham, New Hampshire was 1.7 times as great as the evaporation from the open water surface during the summer of 1969. The wetland released 16.9 centimeters (6.6 inches) of water from storage during the same period. During the summer of 1970, an evaporation retardant was used to reduce open water evaporation. The objective of this management practice was to increase water yields and augment water supplies during dry months. The retardant successfully reduced evaporation by 47 percent. Additional water supplies obtained by the use of evaporation retardants could be used for domestic and commercial consumption.

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