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GROUND-WATER LEVEL IN THE FLOOD PLAIN AND ADJACENT UPLANDS OF THE SANGAMON RIVER

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ABSTRACT

The influence of river level, precipitation, and evapo-transpiration on the water table fluctuations of the streamside forest ecosystem was determined from observation well data at four locations in the upper Sangamon River bottoms and adjacent uplands. Water levels in the soil profile of the flood-plain areas of the streamside forest were strongly controlled by the level of the water in the stream channel. Changes in the upland water table, however, were not closely correlated to river level changes. Precipitation was the environmental variable most strongly influencing changes in the upland ground-water system. Evapo-transpiration losses in mid-transect areas may exceed infiltration of ground water from the river and drainage from higher levels during certain summer periods. An hypothesis concerning the possible changes which may occur upon construction of the William L. Springer Project is discussed. The study is a contribution of the Springer-Sangamon Environmental Research Program.

INTRODUCTION

Flooding in the streamside forests and man-affected adjacent areas of the Sangamon River valley is a natural, although often dramatic event. While much is known about fluctuations in the Sangamon and other Midwestern rivers, little is known of the dynamics of the groundwater table in the areas adjacent to the stream channel. Flood control dams and levees have been a common attempt to mitigate the dramatic flooding events. The effect of impounding a river in raising the surface water elevation is a simple prediction to make. The prediction of the effect of impounding a flowing stream on the ground-water levels in adjacent lands is much more difficult. The current study was initiated to determine the influence of river stage on the level of ground water in the streamside forest and adjacent upland forests in the Sangamon River valley of east-central Illinois. The study is a contribution to the Springer-Sangamon Environmental Research Program, a multi-disciplinary research program designed to study the dynamics of aquatic and streamside forest ecosystems and to monitor ecological changes in the Sangamon River valley before, during, and after construction of the William L. Springer Lake Project (Bell, 1972). Knowledge gained in this area would not only be of importance in the streamside forest ecosystem, but would help predict effects of river impoundment on the water table of adjacent agricultural and urban lands as well.

METHODS

Ground-water observation well transects were established in the upper Sangamon River basin at four study areas. The Allerton Park Bridge transect (Sec. 21, T18N, R5E, 3rd P.M.; 40°00'N, 88°38'W) traverses a very broad natural flood plain with little topographic change and provides an excellent location to observe the influence of river stage and distance from the river bank on the ground-water table dynamics. The transect consists of 14 wells, spaced at 25 m intervals in a line perpendicular to the river channel.

A gradient of elevations running from the streamedge up into upland, unflooded areas is traversed in the Upper Allerton Park, Hart Woods, and Oldweiler Woods sites. The Upper Allerton Park series (Sec. 21, T18N, R5E, 3rd P.M.; 40°00'N, 88°38'W) contains six observation wells covering the elevational gradient from the stream bank at 628 ft. to an upland elevation of 642 ft. and is located approximately 400 m upstream from the Allerton Park Bridge site. Allerton Park is located approximately 4 miles southwest of Monticello, Illinois. The observation-well transect in the Nettie Hart Memorial Woods, a University owned natural area north of Mahomet, Illinois, (Sec. 26, T21N, R7E, 3rd P.M.; 40°13'N, 88°21'W) consists of three flood-plain wells and two upland wells spaced at 20 m intervals. The transect of wells in Oldweiler Woods (Sec. 24, T17N, R3E, 3rd P.M.; 39°55'N, 88°49'W) contains eight wells, spaced at 25 m intervals, and covers approximately 100 m of flood plain and 75 m of uplands. The Oldweiler Woods is a privately owned woodland on the Sangamon River south of Argenta, Illinois.

The study areas were chosen not only to provide a diversity of sites for the study of the effects of environmental variables and river level on the ground-water table, but to provide pre-impoundment data for areas of the Sangamon River upstream from the construction site of the Springer Dam. The Oldweiler Woods flood plain will be in the zone of the river to be completely inundated. The upland wells at Oldweiler Woods will, however, provide excellent continuing data on the influence of the Springer Lake on the water table of the upland forests adjacent to the impoundment. The two sites in the Robert Allerton Park lie in the portion of the river scheduled to experience a change in the natural flooding pattern and will be important sites to document alterations from the pre-impoundment condition. The Hart Woods series provides ground-water data in the control areas of the river basin; those areas unaffected by the Springer Lake Project.

An observation well consists of a 10-foot length of 3/4" P.V.C. pipe drilled with drain holes and enmeshed in plastic screening. The pipe is placed in a 2" auger hole and encased in pea gravel. Ground water flows into the well through the small holes until equilibrium with the water table is reached. The elevation of the water table is determined by blowing into a calibrated length of copper tubing lowered into the well and noting the depth at which bubbling is heard. Elevation of each observation well head was determined with a surveying level from established bench marks. The water table elevation at each well was determined at weekly intervals.

River stages for the Allerton Park sites were recorded at the Allerton Park Bridge by a continuous recording stream edge. River levels for the

Oldweiler Woods and Hart Woods sites were determined as the level of the ground water in the well closest to the stream edge. Precipitation was measured by tipping bucket rain gages in weather stations located in the Upper Allerton site, the Hart Woods site, and the Oldweiler Woods site.

RESULTS

The results of the analysis of the relationship between river stage and the level of the water table for the Allerton Park Bridge site are summarized in Table 1. For all river stages the level of the ground-water table is strongly correlated to the water level in the river channel. When all samples are considered, river level accounts for 96% of the variance in the water table at a distance of 25 m from the river and still accounts for 90% of the variance in well 13 at a distance of 300 m from the river. When river stage is separated into flood, high flow within or near bank level, and low flow, additional information appears. Under low flow conditions of less than 300 ft^3sec^{-1} (627 ft), a very slight increase in ground-water level occurs with increasing distance from the river. Under conditions of more rapid streamflow, the ground-water table in the land near the stream is depressed as the flow rate downstream creates a pressure deficit in the flood-plain ground water system and water is being pulled into the stream flow faster than it is replaced from adjacent upland areas. Under conditions of river levels in excess of 630 ft, ponding of the water in the areas of the observation wells results in a similar condition to the low flowages where increasing distance from the water's edge results in slight increases in the elevation of the water table. Under most conditions, the water table in the flood plain can be determined fairly closely from the level of the water in the stream channel. As river discharges increase, ground-water levels near the river edge may actually be slightly below the river stage.

Table 1. Ground-water observation well data for flood plain near the Allerton Park Bridge. Elevation of well in feet above M.S.L. Distance from river in meters. Data for ground water level listed as average difference and standard deviation (in feet) from river level for flood, high flow, and low flow river stages.

Well No.	Dist. from river(m)	Elev.(ft)	Difference from river level: Flood stage 630 ft	High flow 627-630 ft	Low flow 627 ft
1	0	628.45	--	-0.09±0.30	0.02±0.02
2	25	629.74	--	-0.09±0.14	0.19±0.04
3	50	629.66	--	-0.10±0.14	0.31±0.04
4	75	629.86	--	-0.12±0.13	0.30±0.04
5	100	629.30	--	-0.03±0.13	0.39±0.05
6	125	629.45	--	0.08±0.15	0.50±0.04
7	150	630.54	0.03±0.02	0.19±0.12	0.62±0.05
8	175	631.60	0.09±0.14	0.54±0.20	1.10±0.04
9	200	631.69	0.22±0.17	1.01±0.17	1.47±0.05
10	225	631.75	0.01±0.15	0.77±0.24	1.25±0.06
11	250	632.11	0.13±0.21	1.19±0.21	1.69±0.05
12	275	632.45	1.15±0.09	1.72±0.24	2.19±0.22
13	300	631.78	0.36±0.13	1.18±0.20	1.62±0.07
14	325	632.20	0.50±0.14	1.18±0.20	1.70±0.05

Flood-plain water tables in the three elevational gradient sites were also strongly influenced by the level of the water within the river channel. Figure 1 presents the relationship between elevation of the river and elevation of the flood-plain water table at a distance of 50 m from the streambank at the Upper Allerton, Hart Woods, and Oldweiler Woods study sites. River level accounted for 84% of the variance in the ground-water table when the three sample areas were analyzed together.

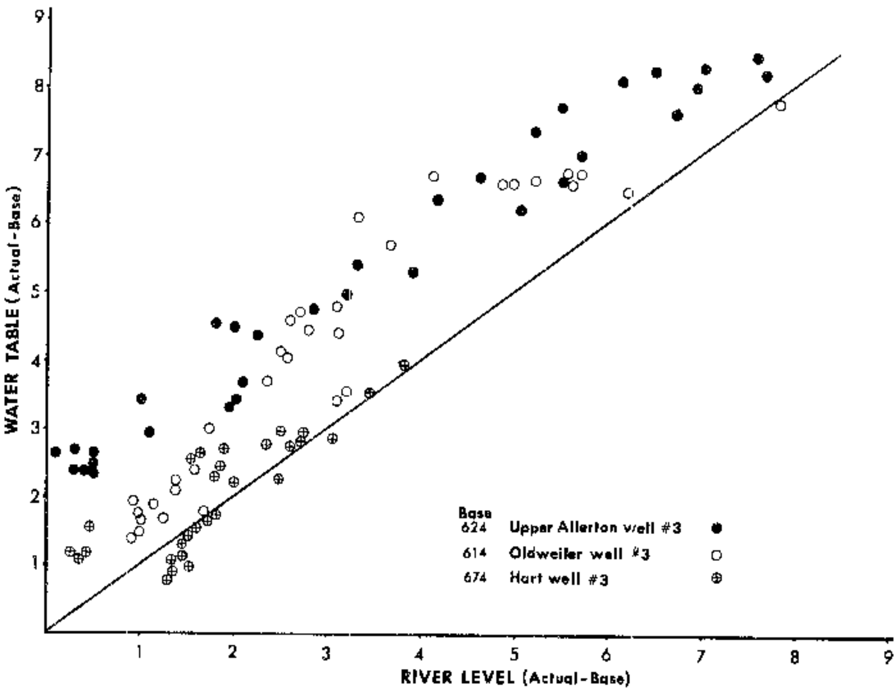

Fig. 1. Relationship of river stage to ground-water table at approximately 50 m from the river at the Upper Allerton, Oldweiler Woods, and Hart Woods sites. Data are graphed as the actual elevation (ft) above a base elevation for each site. Diagonal line represents equal river and water-table levels.

The influence of river level on ground water over the entire elevational gradient can be determined by calculating the fraction of variance in ground-water levels accounted for by variance in river level, for each well in the transect. The percent of the variance (coefficient of determination) accounted for in the water table by river level along the elevational gradients at the Upper Allerton and Oldweiler Woods sites is shown in Figure 2. River level accounts for more than 80% of the variance in the ground-water table near the river's edge. However, with increasing distance, the coefficients of determination drop to the 40–60 range at distances of 50–75 m from the river and remain fairly constant to the edge of the upland at about 125 m from the river and about 2 m (vertical distance) above the bank elevation. In the upland zone, the coefficient of determination drops to 22 at 150 m from the river (5.3 m vertical distance above the bank) and 7 at 175 m (9.2 m vertical). Weekly total rainfall, measured at the weather station in the Oldweiler uplands accounts for approximately 70% of the variance in weekly measurements of the water table at the observation wells located 5.3 and 9.2 m above the river bank. Weekly rainfall accounted for only approximately 15% of the variance in the flood-plain water table. While river level appears to be the strong determinant of ground-water levels in the flood-plain, rainfall is the environmental variable most strongly controlling upland ground-water levels.

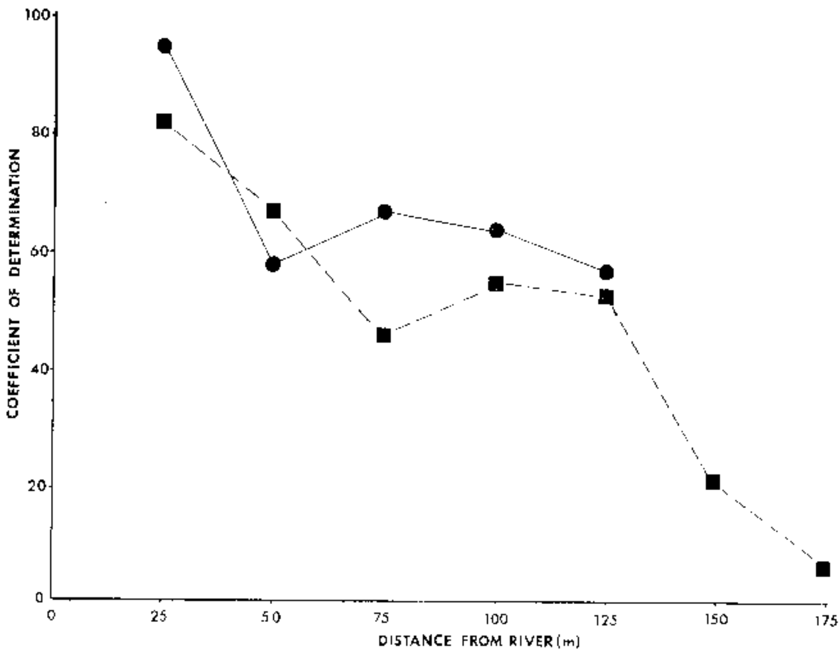

Fig. 2. Coefficient of determination between river level and water table vs. distance from river bank at Oldweiler Woods (dashed line) and Upper Allerton (solid line).

During the growing season evapo-transpiration losses from the vegetation can markedly affect the ground water levels in mid-gradient areas during periods of low river flow and low precipitation. The scatter diagram for the relationship between river level and ground-water level at Oldweiler Woods well #5 (100 m from the river bank) shows a remarkable number of readings below the river level (Fig. 3). Most of these values occurred in the period of low river flows and low precipitation during August and September. Evapo-transpiration of moisture from the streamside forest trees appears to be occurring more rapidly than the influx of ground water from the upland sources by precipitation and run-off or from infiltration of water from the river.

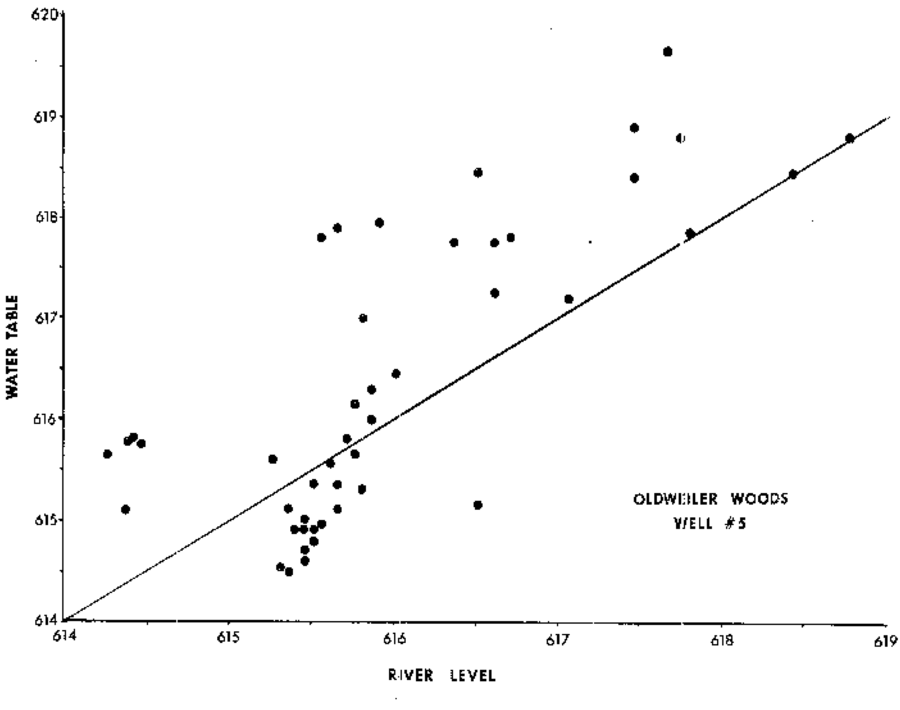

Fig. 3. Relationship of river stage vs. ground-water level at Oldweiler Woods Well #5, 100 m from the river bank. Diagonal line represents equal river stage and water-table level.

DISCUSSION

The streamside ecosystem is under the strong control of the hydrologic fluctuations of the river. Much of the controlling influence in the vegetation is generated by magnitude, frequency, and duration of flooding periods (Bell 1974a, 1974b). The naturally occurring plants and animals have developed under the influence of the flooding regime and are tolerant of the flooding conditions. Cultivated crops planted into the flood susceptible areas, however, are severely affected by the anaerobic conditions of flooding and soil saturation (Bergman, 1959; Conway, 1940; and Kramer and Jackson, 1954). Clearing forested areas and tile-draining former prairie regions has apparently had little effect on the flooding regime of the Sangamon River (Kendeigh, 1973). It follows from the strong correlation of the river level to ground-water level that the fluctuation in the level of the water table in the flood-plain areas of the Sangamon River is much the same today as they were in primitive times.

Impounding the Sangamon River by the Springer Dam, however, will vastly alter the hydrologic events of the stream. From information derived from the present study and the predicted hydraulic changes to occur in stream levels upon construction of Springer Lake, it is possible to formulate an hypothesis concerning the changes which may occur in the water table of adjacent areas. It seems probable that ground-water levels in flood-plain areas will be maintained at or slightly above the level of the normal-use pool during periods of normal stream flow. Water table levels in the adjacent areas greater than about 10 feet above the normal pool will be controlled by factors other than lake level. In the zone of the river above permanent impoundment but within the influence of flood control, ground-water levels will be affected in relation to the alteration in stream dynamics. In the case of the Springer Lake Project, areas of the Upper Sangamon River basin between elevations 623 and 641.7 ft occur within the flood control pool. Areas of upland not previously affected by floodwaters will now experience anaerobic conditions in the soil profile during periods of high water. Ground water in areas above the flood-control pool will continue to respond to precipitation, evaporation, and drainage as prior to the flood control project. Drainage in these areas could be impeded if drain tile outlets lie at elevations below the flood control elevation. Impounded waters could prevent normal flow of tiles during flood-control periods.

Effects on the biological organisms inhabiting the Sangamon River valley will undoubtedly be determined by the ability of the living organisms to tolerate the altered conditions imposed by construction of the William L. Springer Dam and Reservoir. A thorough understanding of existing physical environmental conditions in the streamside ecosystem is essential to the understanding of the streamside forest ecosystem. Knowledge of the dynamics of the ground-water table in this habitat is of major importance in the establishment of this understanding. More complete information on species tolerances is required for assessment of the effects of the changing soil saturation conditions on the streamside forest ecosystem.

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