Simulating Groundwater Level Anomalies In A 55-Year Record In The Irrigated Wisconsin Sand Plain

William (Bill) Bland
Birl Lowery
Dept. of Soil Science
University of Wisconsin-Madison

ABSTRACT: Shallow groundwater and sandy soils support a thriving irrigated potato and vegetable industry in Central Wisconsin. Depth to groundwater has increased in recent years to levels observed some 50 years ago, and the role of irrigation in this phenomenon is contentious. Numerous small lakes have disappeared, to the dismay of relatively recent riparian owners. We simulated groundwater depth using a simple 1-dimensional water budget, varying fraction of land under irrigation, trends in seasonal evapotranspiration from both perennial vegetation and cropped lands, and head-dependent lateral outflow. Compared to groundwater fluctuations observed in a 55-year record of a well at the Hancock Agricultural Research Station the model performs well except in the most recent decade, during which it fails to predict the current decrease in groundwater elevation.

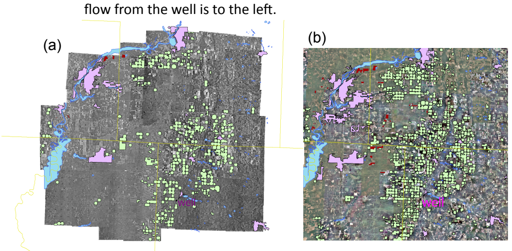
Figure 1. Long Lake in central Wisconsin, summer 2008.

PROBLEM: Groundwater levels have fallen in recent years to historic lows, causing area lakes to disappear, much to the consternation of riparian property owners (Fig. 1). Extensive irrigation (Fig. 2) from the unconfined aquifers beneath the sandy loam and loamy sands of the region are thought by many to be at fault. Center-pivot irrigation expanded dramatically in the region between the early 1950s and the early 2000s.

OBJECTIVE: We sought to explore the roles of land use change from perennial scrub and prairie vegetation to irrigated crops on groundwater level, through simulation modeling.

METHODS: A simple water balance model estimated groundwater recharge and withdrawals from either a perennial vegetative cover (with a 1.0-m thick rootzone), or an irrigated potato crop (0.3-m rootzone). The crop rootzone was re-wet as necessary to maintain crop evapotranspiration (ET) at the potential rate. Irrigation was counted as negative recharge. The perennial vegetation actual ET was a function of soil moisture, resupplied only by precipitation. Monthly values of potential ET were fixed throughout the simulation, unless otherwise noted.

Figure 2. The location of the well we studied is marked in these images; on the left (a) is ca. 1980 and on the right 2005 (b). A glacial moraine is evident by the lack of pivots. Groundwater flow from the well is to the left.



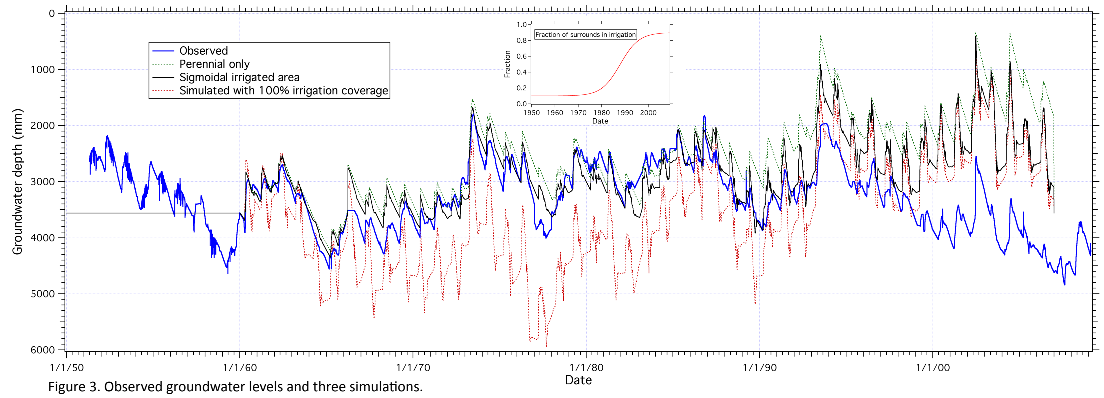
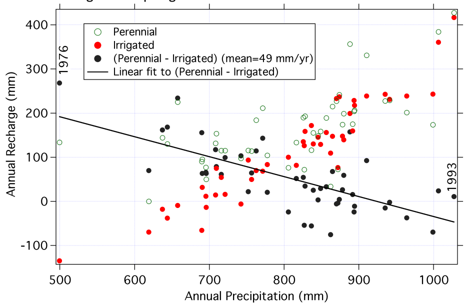


Figure 3. Observed groundwater levels and three simulations.

RESULTS AND DISCUSSION: A comparison of simulated groundwater levels to observations demonstrates that an increasing fraction of irrigation coverage through time improves agreement (Fig. 3). However, even with 100% irrigation coverage, the drop in groundwater during the most recent decade cannot be reproduced. Recharge to groundwater from either fully perennial or irrigated covers, and their difference, is a function of annual rainfall (Fig. 4). Recharge from perennial vegetation is never less than 0 in the model, but for irrigated cover it is negative in drier years. On average, we simulate that irrigation reduces recharge compared to (non-phreatophytic) perennial vegetation by 49 mm/year. However, precipitation in recent years was above the mean for 1960 to present so the recharge difference has been less than this. Expanded irrigation does not appear to explain the recent low groundwater levels.

Figure 4. Annual groundwater recharge simulated for perennial and irrigated crop vegetative covers.



THE UNIVERSITY of WISCONSIN MADISON