WETLAND HYDROLOGIC MODELS
Annotated Bibliography
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Author(s): Costanza, R. and F.H. Sklar
Year: 1985
Title: "Articulation, accuracy and effectiveness of mathematical models: A review of freshwater wetland applications"
Journal (Issue): *Ecological Modelling*, 27, 45-68
Study Type: Literature Review
Abstract: Eighty-seven mathematical models of freshwater wetlands and shallow water bodies were classified by wetland type, location, and degree of nonlinearity, and rated by three new indices: articulation; accuracy; and effectiveness. Articulation measures the size and complexity of the model in the three modes of components, space, and time. Accuracy combines measures of goodness-of-fit in each mode. Effectiveness measures explanatory power as a combination of articulation and accuracy. For the models reviewed accuracy was seen to fall with increasing articulation, probably as a result of increasing complexity and cost. Effectiveness, however, rose to a maximum at intermediate articulation and then fell, reflecting the fact that highly accurate models tended to be low in articulation (they said much about little), while highly articulate models tended to be low in accuracy (they said little about much). These methods for ranking models may prove useful for further analysis and the results of this analysis may provide a useful guide to model builders concerned with maximizing the effectiveness of their models using limited resources.
Model: Too numerous to list.

Author(s): Crowe, A.S., S.G. Shikaze, and C.J. Ptacek
Year: 2004
Title: "Numerical modelling of groundwater flow and contaminant transport to Point Pelee marsh, Ontario, Canada"
Journal (Issue): *Hydrological Processes*, 18, 293-314
Study Type: Model Development
Abstract: A numerical model was developed for simulating groundwater–wetland interactions and contaminant transport. The model calculates transient hydraulic head and a transient free surface in a two-dimensional, heterogeneous domain, with variable and transient boundary conditions (infiltration, evapotranspiration, surface water), and water and contaminant fluxes across the aquifer–wetland interface. Contaminant transport is also simulated, with contaminant sources located at the free surface, wetland, or within the saturated domain. The model was applied to assess groundwater–wetland interactions and the transport of septic-system-derived contaminants at Point Pelee, Ontario, Canada. The model successfully simulated the field observations of groundwater flow and contaminant plumes. Where the barrier bar is narrow, the seasonal reversal in the direction of groundwater flow is caused by differences in the elevation of the water surface of Lake Erie and that of the marsh. This, in turn, induces the contaminants to oscillate between movement towards the lake during the winter and towards the marsh during the summer. Hence, contaminant plumes are bimodal in shape. Where the barrier bar becomes

wider, the lake and the marsh have less effect, and hence contaminants move in one direction, along the principal direction of groundwater flow towards the marsh.
Model: GW-WETLAND

Author(s): Dall'O', M., W. Kluge, and F. Bartels
Year: 2001
Title: "FEUWAnet: A multi-box water level and lateral exchange model for riparian wetlands"
Journal (Issue): *Journal of Hydrology*, 250, 40-62
Study Type: Model Development
Abstract: Riparian wetlands as typical aquatic-terrestrial interfaces control, in a very specific way, nonpoint water and related chemical fluxes exchanging between catchment areas to their respective water systems (streams, lakes). The existing groundwater and soilwater flow models reveal gaps in dealing with the complex behaviour of processes and the considerable spatial and temporal heterogeneity of riparian wetlands. Based on long-term experience gained through field observations and the interpretation of model produced data, a multi-box aggregation of processes which determines lateral as well as vertical flows and, as a whole, water balance, is used to discretise a generic riparian wetland transect situated between an upland aquifer and a receiving water body.

The resulting mathematical model, FEUWAnet, endowed also with an original methodology to adapt parameters, has been applied to a riparian alder wetland adjacent to Lake Belau (northern Germany). Results of simulations illustrate a good fit between calculated water levels and observed values and an accordance of calculated water balance to previous independent evaluations. This confirms that the sound simplifications of real situations performed by the FEUWAnet mathematical model are a promising way to deal with hydrological complexity of riparian zones. Moreover, FEUWAnet permits, to a certain extent, one to unravel the spatial heterogeneity and temporal variation of lateral (from catchment area to water systems) and vertical (from canopy to groundwater zone) water fluxes typical of riparian ecosystems: this is the necessary step to undertake when developing integrated models capable of assessing the effectiveness of riparian systems in controlling the fluxes of nonpoint pollution discharging in the open water bodies.
Model: FEUWAnet

Author(s): Guertin, D.P., P.K. Barten, and K.N. Brooks
Year: 1987
Title: "The Peatland Hydrological Impact Model: Development and testing"
Journal (Issue): *Nordic Hydrology*, 18, 79-100
Study Type: Model Development
Abstract: Questions concerning the effects of drainage, peat mining and timber harvesting on streamflow response in the northern Lake States of the U.S.A. led to the development of the Peatland Hydrologic Impact Model (PHIM). PHIM is a generalized, deterministic, continuous simulation model, that is physically-based to the extent possible. Three independent land-type sub-models represent watershed conditions common in the region. The appropriate land-type sub-model(s), either natural peatland (NWATBAL), mined peatland (MWATBAL), or mineral soil upland (UWATBAL) are configured by the model user to represent the watershed. The sub-models were applied to test the model on the streamflow response from three different peatland watersheds. Stormflow events were simulated for a 3,758 ha natural peatland and a 155 ha mined

peatland. Annual water yield simulations for a 9.72 ha upland-peatland watershed produced a mean ratio of predicted/observed streamflow of 1.01±0.08 for six test years. The model is generalized so that it should be adaptable to similar physiographic regions with minor modifications.
Model: PHIM

Author(s): Kazezyilmaz-Alhan, C.M., M.A. Medina, Jr., and C.J. Richardson
Year: 2007
Title: "A wetland hydrology and water quality model incorporating surface water/groundwater interactions"
Journal (Issue): *Water Resources Research*, 43, W04434
Study Type: Model Development
Abstract: In the last two decades the beneficial aspects of constructed treatment wetlands have been studied extensively. However, the importance of restored wetlands as a best management practice to improve the water quality of storm water runoff has only recently been appreciated. Furthermore, investigating surface water/groundwater interactions within wetlands is now acknowledged to be essential in order to better understand the effect of wetland hydrology on water quality. In this study, the development of a general comprehensive wetland model Wetland Solute Transport Dynamics (WETSAND) that has both surface flow and solute transport components is presented. The model incorporates surface water/groundwater interactions and accounts for upstream contributions from urbanized areas. The effect of restored wetlands on storm water runoff is also investigated by routing the overland flow through the wetland area, collecting the runoff within the stream, and transporting it to the receiving water using diffusion wave routing techniques. The computed velocity profiles are subsequently used to obtain water quality concentration distributions in wetland areas. The water quality component solves the advection-dispersion equation for several nitrogen and phosphorus constituents, and it also incorporates the surface water/groundwater interactions by including the incoming/outgoing mass due to the groundwater recharge/discharge. In addition, output from the Storm Water Management Model (SWMM5) is incorporated into this conceptual wetland model to simulate the runoff quantity and quality flowing into a wetland area from upstream urban sources. Additionally, the model can simulate a water control structure using storage routing principles and known stage-discharge spillway relationships.
Model: WETSAND

Author(s): Mansell, R.S., S.A. Bloom, and G. Sun
Year: 2000
Title: "A model for wetland hydrology: Description and validation
Journal (Issue): *Soil Science*, 165(5), 384-397
Study Type: Model Development
Abstract: WETLANDS, a multidimensional model describing water flow in variably saturated soil and evapotranspiration, was used to simulate successfully 3-years of local hydrology for a cypress pond located within a relatively flat Coastal Plain pine forest landscape. Assumptions included negligible net regional groundwater flow and radially symmetric local flow impinging on a truncated conical pond, deciduous cypress trees and shallow-rooted perennial undergrowth in the pond area, and pine trees in the upland area as well as within the outer 20% of the wetland area. A minimal observed parameter set of daily rainfall, daily air temperature, soil

characteristics, and pond geometry provided model input. The model described temporal patterns of daily pond water and groundwater table elevations with relatively small average signed deviations of -2 and +11 cm, respectively. Potential exists for the model to be utilized as a predictive tool for wetland hydrology, even for conditions where available empirical data for a given site is minimal and appropriate simplifying assumptions are utilized.
Model: WETLANDS

Author(s): Skaggs, R.W.
Year: 1980
Title: *DRAINMOD Reference Report: Methods for Design and Evaluation of Drainage-Water Management Systems for Soils with High Water Tables*
Study Type: Model Development
Abstract: This report was prepared for the Soil Conservation Service, United States Department of Agriculture. The purpose is to provide a guide for developing a computer simulation model for drainage-water management systems on high water table soils. The model and related methodologies presented herein were developed to facilitate the design and analysis for these systems. The methods can be used to evaluate the long-term performance of systems for surface and subsurface drainage, subirrigation, controlled irrigation, and waste water application to artificially drained soils.
Model: DRAINMOD

Author(s): Sun, G., H. Riekerk, and N.B. Comerford
Year: 1998
Title: "Modeling the forest hydrology of wetland-upland ecosystems in Florida"
Journal (Issue): *Journal of the American Water Resources Association*, 34(4), 827-841
Study Type: Model Development
Abstract: Few hydrological models are applicable to pine flatwoods which are a mosaic of pine plantations and cypress swamps. Unique features of this system include ephemeral sheet flow, shallow dynamic ground water table, high rainfall and evapotranspiration, and high infiltration rates. A FLATWOODS model has been developed specifically for the cypress wetland-pine upland landscape by integrating a 2-D ground water model, a Variable-Source-Area (VAS)-based surface flow model, an evapotranspiration (ET) model, and an unsaturated water flow model. The FLATWOODS model utilizes a distributed approach by dividing the entire simulation domain into regular cells. It has the capability to continuously simulate the daily values of ground water table depth, ET, and soil moisture content distributions in a watershed. The model has been calibrated and validated with a 15-year runoff and a four-year ground water table data set from two different pine flatwoods research watersheds in northern Florida. This model may be used for predicting hydrologic impacts of different forest management practices in the coastal regions.
Model: FLATWOODS

Author(s): Sun, G., H. Riekerk, and N.B. Comerford
Year: 1998
Title: "Modeling the hydrologic impacts of forest harvesting on Florida flatwoods"
Journal (Issue): *Journal of the American Water Resources Association*, 34(4), 843-854
Study Type: Field and Model Application

Abstract: The great temporal and spatial variability of pine flatwoods hydrology suggests traditional short-term field methods may not be effective in evaluating the hydrologic effects of forest management. The FLATWOODS model was developed, calibrated and validated specifically for the cypress wetland-pine upland landscape. The model was applied to two typical flatwoods sites in north central Florida. Three harvesting treatments (Wetland Harvesting, Wetland + Upland Harvesting, and Control) under three typical climatic conditions (dry, wet, and normal precipitation years) were simulated to study the potential first-year effects of common forest harvesting activities on flatwoods. Long-term (15 years) simulation was conducted to evaluate the hydrologic impacts at different stages of stand rotation. This simulation study concludes that forest harvesting has substantial effects on hydrology during dry periods and clear cutting of both wetlands and uplands has greater influence on the water regimes than partial harvesting. Compared to hilly regions, forest harvesting in the Florida coastal plains has less impact on water yield.
Model: FLATWOODS

Author(s): Sun, G., T.J. Callahan, J.E. Pyzoha, and C.C. Trettin
Year: 2006
Title: "Modeling the climatic and subsurface stratigraphy controls on the hydrology of a Carolina Bay wetland in South Carolina, USA"
Journal (Issue): *Wetlands*, 26(2), 567-580
Study Type: Field and Model Application
Abstract: Restoring depressional wetlands or geographically isolated wetlands such as cypress swamps and Carolina bays on the Atlantic Coastal Plains requires a clear understanding of the hydrologic processes and water balances. The objectives of this paper are to (1) test a distributed forest hydrology model, FLATWOODS, for a Carolina bay wetland system using seven years of water-table data and (2) to use the model to understand how the landscape position and the site stratigraphy affect ground-water flow direction. The research site is located in Bamberg County, South Carolina on the Middle Coastal Plain of the southeastern U.S. (32.888 N, 81.128 W). Model calibration (1998) and validation (1997, 1999–2003) data span a wet period and a long drought period, which allowed us to test the model for a wide range of weather conditions. The major water input to the wetland is rainfall, and output from the wetland is dominated by evapotranspiration. However, the Carolina bay is a flow-through wetland, receiving ground water from the adjacent upland, but recharging the ground-water to lower topographic areas, especially during wet periods in winter months. Hypothetical simulations suggest that ground-water flow direction is controlled by the gradient of the underlying hydrologic restricting layer beneath the wetland-upland continuum, not solely by the topographic gradient of the land surface. Ground-water flow may change directions during transition periods of wetland hydroperiod that is controlled by the balance of precipitation and evapotranspiration, and such changes depend on the underlying soil stratigraphy of the wetland-upland continuum.
Model: FLATWOODS

Author(s): Trepel, M., M. Dall'O', L.D. Cin, M. De Wit, S. Opitz, L. Palmeri, J. Persson, N.M. Pieterse, T. Timmermann, G. Bendoricchio, W. Kluge, and S-E. Jorgensen
Year: 2000
Title: "Models for wetland planning, design and management"
In: *Guidelines for Wetland Monitoring, Designing and Modelling,* M. Trepel and S. Opitz, eds.

Study Type: Literature Review
Abstract: In the future, wetlands will be important multifunctional landscape elements in a sustainable land use planning. In this process, models are valuable tools to improve wetland planning and management activity at different spatiotemporal scales. The aim of these guidelines is to promote the use of models for effective wetland conservation and management. Therefore, these guidelines present a scale based concept for wetland planning, design and management. In this concept, different models are described with their specific objectives, limitations, input and output data, and parameters and are illustrated with application examples. The model selection in this paper is based on the experiences of the young researchers, which were employed during the WET project, and is therefore limited.
Model: Too numerous to list.

Author(s): Walton, R., R.S. Chapman, and J.E. Davis
Year: 1996
Title: "Development and application of the Wetlands Dynamic Water Budget Model"
Journal (Issue): *Wetlands*, 16(3), 347-357
Study Type: Model Development
Abstract: A Wetlands Dynamic Water Budget Model was developed and applied to support a large field investigation of processes in the Black Swamp wetlands of the Cache River between Patterson and Cotton Plant, Arkansas. The model is called the Wetlands Dynamic Water Budget Model because it provides magnitudes for the water budget components, as well as water depths, discharges, and flow velocities throughout the modeled system. The development of the computer program is based on concepts and approaches of a number of programs in common use. It includes three dynamically-linked modules that include all the major components of a typical water budget, including precipitation, canopy interception, overland flow, channel flow, infiltration, evapotranspiration, and horizontal ground-water flow. The surface-water module of the model was applied to the Cache River in Arkansas, and augmented a comprehensive hydrologic field study by filling data gaps that occurred due to gage problems and by providing long-term simulation data for broad areas of the wetland, particularly those far away from any measurement station. The results demonstrated that these wetlands are inundated primarily from the backwater produced at downstream constrictions, rather than from the forward-moving flood wave.
Model: Wetlands Dynamic Water Budget Model