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A parallel implementation of ALFISH: simulating hydrological compartmentalization effects on fish dynamics in the Florida Everglades ☆

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Abstract

A landscape modeling system called the Across Trophic-Level System Simulation (or ATLSS) has been developed in an effort to project the consequences of proposed water regulation plans for restoration of the South Florida Everglades. The ATLSS Landscape Fish Model (ALFISH) is a component of the ATLSS package (written in C++), which is used to provide dynamic measures of the spatially-explicit food resources available to wading birds,

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namely fish. The original (serial) ALFISH model requires as much as 30 h for 31-year simulations of specified scenarios. The model's execution time has been successfully improved (by a factor of 4.5) by partitioning its data input and executing the model simultaneously (in parallel) on those partitions. This paper demonstrates how the model's communications between partitioned data can be blocked to simulate compartmentalization effects on the input data. Minimal effects (below 1%) on the output of the original (serial) version are demonstrated. Regarding portability, both models (serial and parallel) have been successfully executed on two different computing environments: an SMP (Symmetric Multi-Processor) with 14 processors and a 14-processor network cluster.

Keywords: Computational ecology; Parallel implementation; Spatially-explicit simulation; Symmetric multi-processor; Cluster; Network of workstations; Data parallelism; Load balancing

1. Introduction

The natural systems of South Florida have been greatly impacted by human changes in land use and hydrologic patterns over the past century, due to development. A major restoration effort is currently underway across South Florida. Restoration requires knowledge of how changes in management will alter environmental factors such as hydrology and how these factors in turn affect the biotic components of the ecosystem. The planned restoration concerns the historical Everglades which covers an area of approximately 10,500 km^2, extending south from Lake Okeechobee for over 200 km and from east to west about 80 km at the widest point. This region includes Everglades National Park and Big Cypress National Preserve, containing a mosaic of many types of wetland habitats (e.g., cypress swamp, marl prairie, deep slough, mangrove estuary), as well as some upland habitats (e.g., pine flat-woods) [2].

Water flows are controlled to meet agriculture and urban water demands. Regulations in conjunction with constraints due to rainfall inputs determine hydrology, the dominant driving force affecting the fresh-water wetlands of southern Florida. Changes in hydrology during the last several decades are thought to have caused the observed population decline in many of the species adapted to the natural water cycle. To analyze the possible effects of these historical changes and to project the consequences of proposed plans for the restoration of the Everglades, a landscape modeling system, Across Trophic-Level System Simulation (ATLSS), has been developed [2].

1.1. Model overview

ATLSS models are designed to assess the effects on key biota of alternative water management plans of water flow regulation across the Everglades landscape. They are spatially-explicit, meaning that they account for heterogeneity across the landscape. This paper is focused on the enhancement of one ATLSS model, ALFISH, which projects the fresh-water fish populations and provides the food base for wading bird models. ALFISH compares, in a spatially-explicit manner, the relative