

Computational Sustainability: Computational Methods for a Sustainable Environment, Economy, and Society

Project Summary

Humanity's use of Earth's resources is threatening our planet and the livelihood of future generations. Computing and information science can — and should — play a key role in increasing the efficiency and effectiveness in the way we manage and allocate our natural resources. We propose an expedition in **Computational Sustainability**, encompassing computational and mathematical methods for a sustainable environment, economy, and society.

Intellectual Merit. The advancements in communication and computation in the last two decades have already transformed traditional computational models and provided exciting opportunities, with the emergence of new paradigms and concepts such as electronic markets, just-in-time manufacturing, combinatorial auctions, and customer data mining. Unfortunately, the impact of information technology has been highly uneven, mainly benefiting large corporate firms in profitable sectors, with little or no benefit in terms of the environment. Nevertheless, a survey of the sustainability literature reveals that several key sustainability issues translate into decision and optimization problems that fall into the realm of computing and information science, even though in general they are not studied by computer scientists. These problems range from wildlife preservation and biodiversity to balancing socio-economic needs and the environment to large-scale deployment and management of renewable energy sources. Given the well-recognized need for better management and utilization of Earth's rapidly depleting resources, it is imperative and urgent that computer scientists turn their attention to computational problems that arise in this context.

We propose transformative research in computing and information science across different dimensions: **1.** We introduce a new research area, **Computational Sustainability**, with the overarching goal of studying and providing solutions to computational problems for balancing environmental, economic, and societal needs for a sustainable future. Such problems are unique in scale, impact, complexity, and richness, often involving combinatorial decisions, in a highly dynamic and uncertain environment, offering challenges but also opportunities for the advancement of the state of the art in computing and information science. **2.** Our work will integrate in unique ways various areas within computer science and applied mathematics: constraint reasoning, optimization, learning, and dynamical systems. Furthermore, we will develop models that enable computationally feasible approaches for analyzing systems with highly interconnected components or agents. **3.** Our work will also foster a cross-fertilization of approaches and ideas between several research communities. Our research team is highly interdisciplinary, bringing together computer scientists, biologists, environmental scientists, biological and environmental engineers, mathematicians, and economists from seven different colleges, in twelve different departments at Cornell, Bowdoin College, the Conservation Fund, Howard University, Oregon State University, and the Pacific Northwest National Laboratory.

Broader Impact. To coordinate our research and outreach, we will establish the *Institute for Computational Sustainability* (ICS) at Cornell. ICS will conduct research, educational activities (including courses and research seminars), and outreach activities to disseminate the importance and urgency of research in computational sustainability within the computing and information science community. Moreover, computational sustainability will attract segments of under-represented students and researchers traditionally not involved in computing and information science. In addition, ICS will impact the community and policy makers via sustainability projects bringing together faculty, students, and practitioners. These efforts will be enabled by concrete interactions and participation of ICS members in several institutions with a sustainability mission, such as the Center for a Sustainable Future at Cornell, Cornell Cooperative Extension, the Laboratory of Ornithology, the African Food Security and Natural Resources Management Program, the Community and Rural Development Institute at Cornell, and the Conservation Fund.