Computational Sustainability:

Computational Methods for a Sustainable Environment, Economy, and Society

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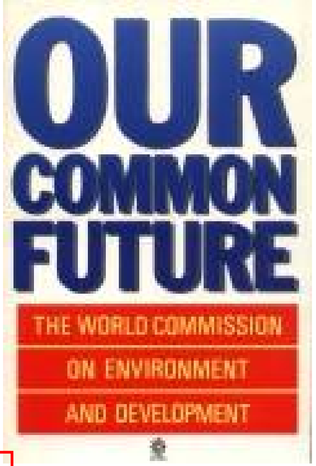
Sponsored by:

Cornell University
Center for a Sustainable Future

This talk is an adaptation of the NSF reverse site visit talk or the Expeditions In Computing Program (June 2008).
Thanks to the ICS members who helped shape the vision I ormulated n this talk .

Sustainability and Sustainable Development

The 1987 UN report, “Our Common Future” (Brundtland Report):



OUR COMMON FUTURE

THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT

- Raised serious concerns about the State of the Planet.
- Introduced the notion of sustainability and sustainable development:

Sustainable Development: “development that meets the needs of the present without compromising the ability of future generations to meet their needs.”

The UN General Assembly stressed that
environmental problems were global in nature
and stated the urgency of
policies for sustainable development.

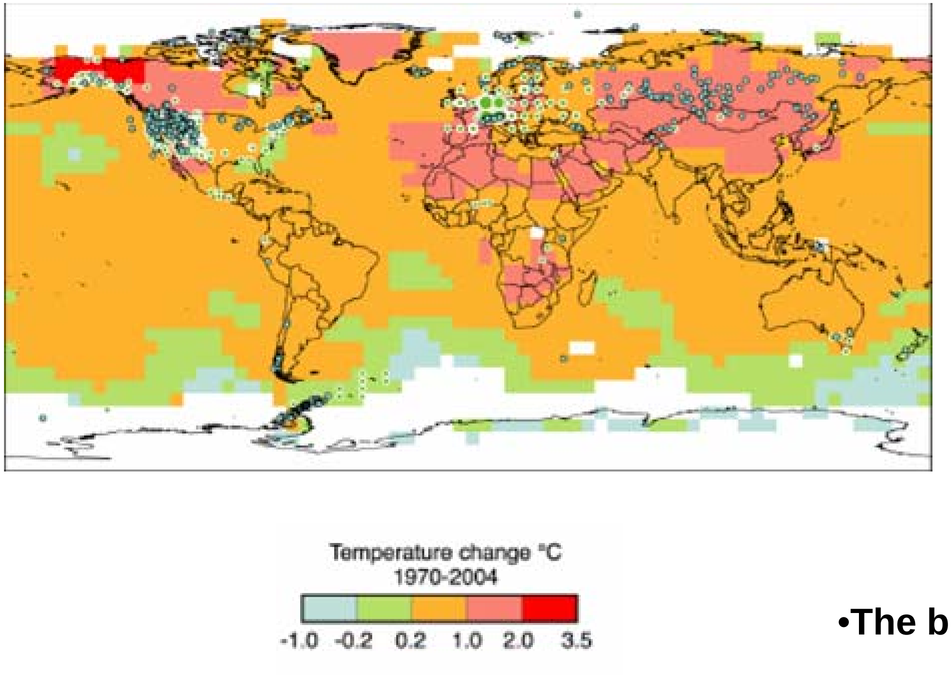
Gro Brundtland
Norwegian Prime Ministe
Chair of WCED

UNITED NATIONS

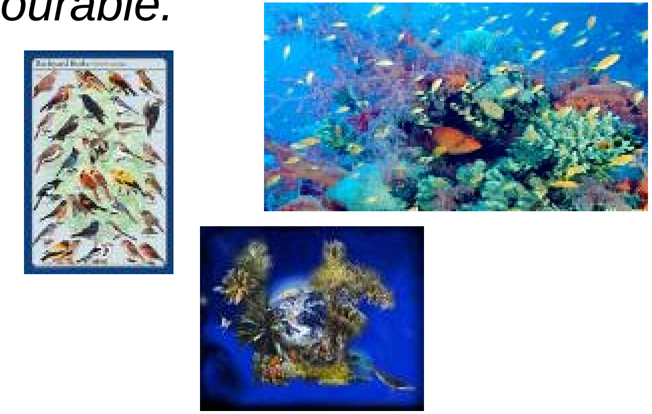
UN World Commission on Environment and Development,1987.

Follow-Up Reports:
Intergovernmental Panel on Climate Change (IPCC 07)
Global Environment Outlook Report (GEO 07)

"There are no major issues raised in Our Common Future for which the foreseeable trends are favourable."



Global Warming



Erosion of Biodiversity

Examples:

•The biomass of fish is estimated to be 1/10 of what it was 50 years ago and is declining.

•At the current rates of human destruction of natural ecosystems, 50% of all species of life on earth will be extinct in 100 years.

+130 countries

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC) UNEP

[Nobel Prize with Gore 2007]

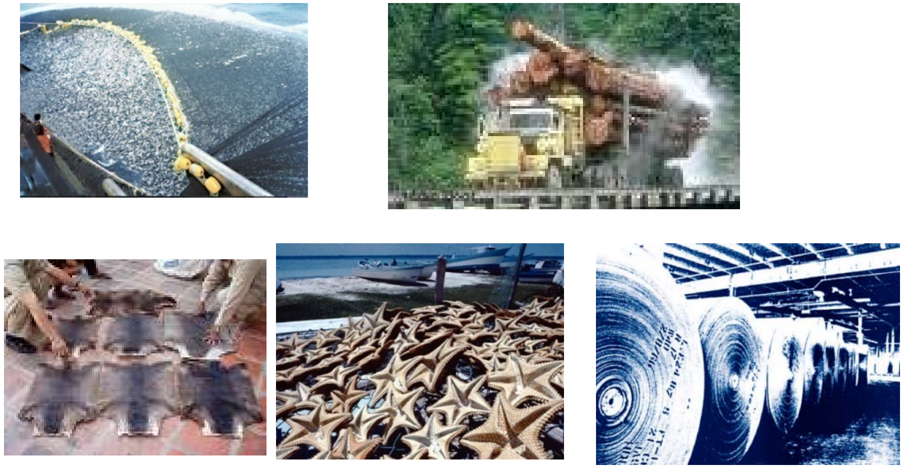
Main Causes of Damage to Earth:

Poor Management of our Natural Resources

Habitat Loss and Fragmentation

Pollution

Over-Harvesting



Outline

I Computational Sustainability

II Computational Themes in Our Research

III Institute for Computational Sustainability

IV Compsust09

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Uneven Information Technology Impact

- The advancements in communication and computation have dramatically transformed traditional business models.

  e.g., electronic markets, just-in-time manufacturing, combinatorial auctions, and customer data mining.

- The impact of information technology has been highly uneven, with little benefit in terms of the environment.

Computational Nature of Decision and Policy Making Problems in Sustainability

Key sustainability issues concerning the definition of policies for sustainable development translate into decision, optimization, statistical and learning problems that fall into the realm of computer science and related fields (information science, operations research, applied mathematics, and statistics).

Computational Sustainability Problems

- Unique in scale, impact, complexity, and richness;
- Often involving combinatorial decisions, in highly dynamic and uncertain environments.

→ Offer challenges but also opportunities for the advancement of the state of the art in computing and information science.

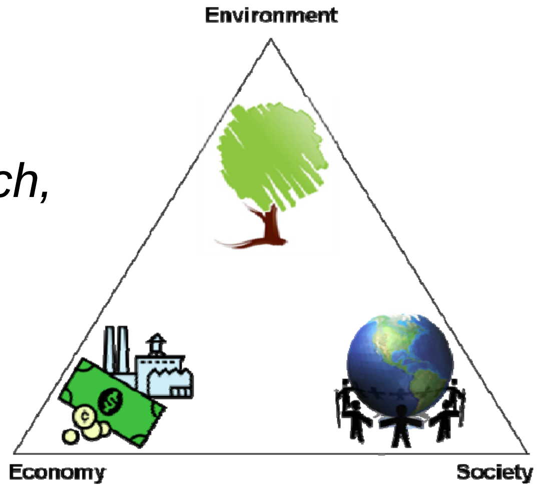
- Unfortunately, in general computer scientists are not aware of these challenging problems.

Vision

Computer scientists can — and should — play a key role in increasing the efficiency and effectiveness of the way we manage and allocate our natural resources, while enriching and transforming Computer Science.

Computational Sustainability

Computational Sustainability --- interdisciplinary field that aims to apply techniques from computer science, and related fields(information science, operations research, applied mathematics, and statistics) for balancing environmental, economic, and societal needs for sustainable development.



Focus:
Developing computational & mathematical models and methods for decision making concerning the management and allocation of resources in order to help solve some of the most challenging problems related to sustainability

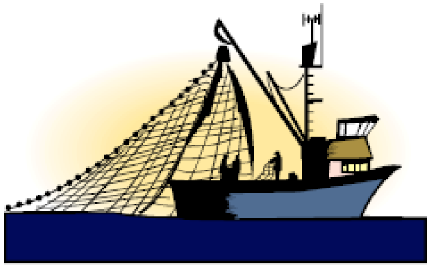
Examples of Computational Sustainability Problems

Examples of Sustainability Themes

I Conservation and Biodiversity

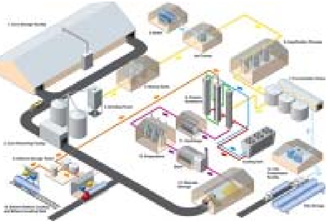
Wildlife Corridors

II Balancing Socio-economic Demands and the Environment

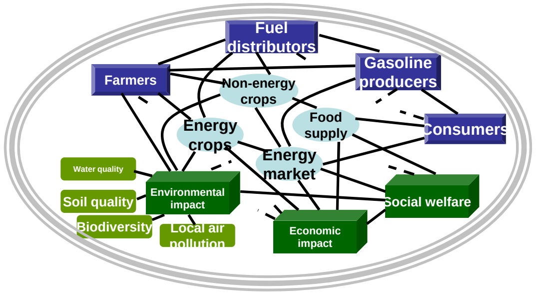


Policies for harvesting renewable resources

III Renewable Energy



Ethanol Refinery



Biofuels and other alternative energies

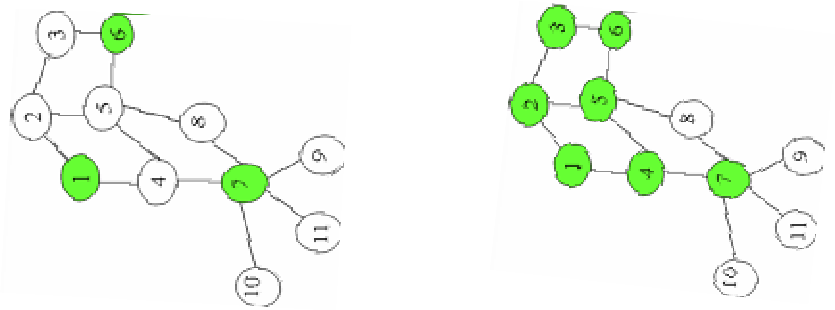
Challenges in Constraint Reasoning and Optimization:

Conservation and Biodiversity: Wildlife Corridors

Wildlife Corridors link core biological areas, allowing animal movement between areas.

Typically: low budgets to implement corridors.

Computational problem → **Connection Sub-graph Problem**



Connection Sub-Graph - NP-Hard

Worst Case Result --- Real-world problems possess hidden structure that can be exploited allowing scaling up of solutions→ Science of Computation.

Connection Sub-graph Problem

Given a graph G with a set of reserves:

Find a sub-graph of G that:

contains the reserves;
is connected;
with cost below a given budget;

and
with maximum utility

“Typical” Case Analysis: Synthetic Instances

How is hardness affected as the budget fraction is varied?

Problem evaluated on semi-structured graphs

m x *m* lattice / grid graph with *k* terminals

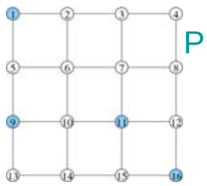
Inspired by the conservation corridors problem

Place a terminal each on top-left and bottom-right

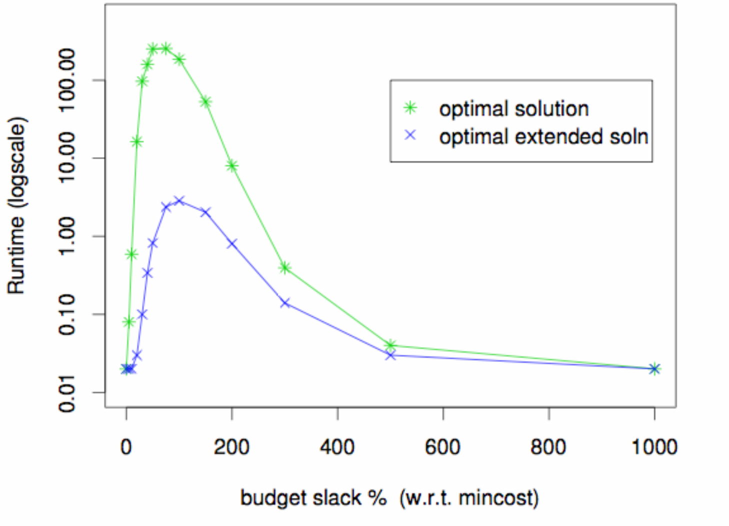
Maximizes grid use

Place remaining terminals randomly

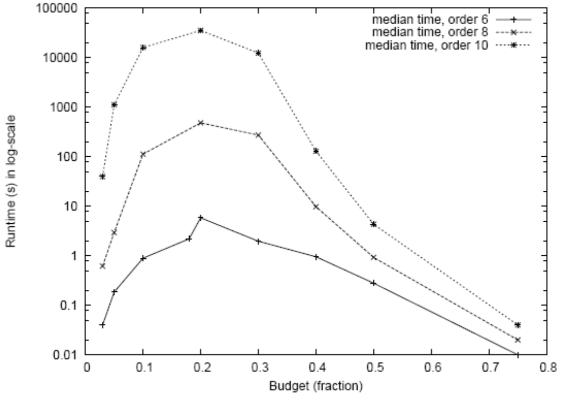
Assign uniform random costs and utilities from {0, 1, …, 10}



Runtime

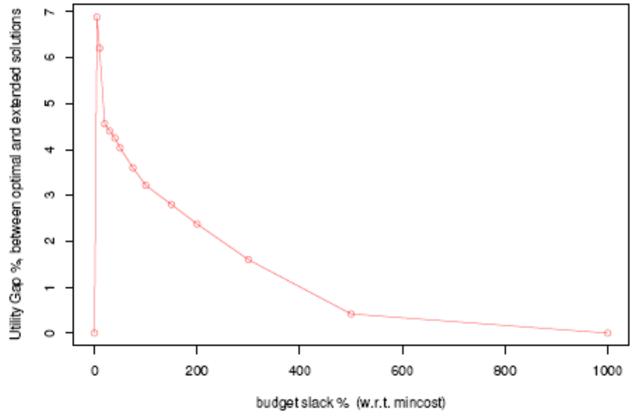


Runtime for Optimal Solution



From 6x6 to 10x10 grid (100 parcels): 1000 instances per data-point;

Utility Gap (Optimally Extended Min cost/ Optimal)

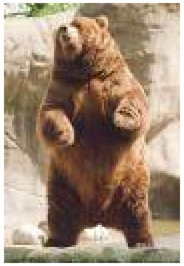


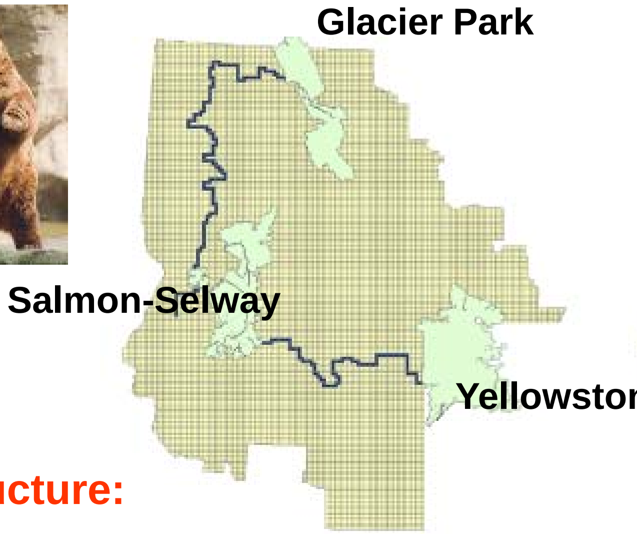
Real world instance:

Corridor for grizzly bears in the Northern Rockies, connecting:

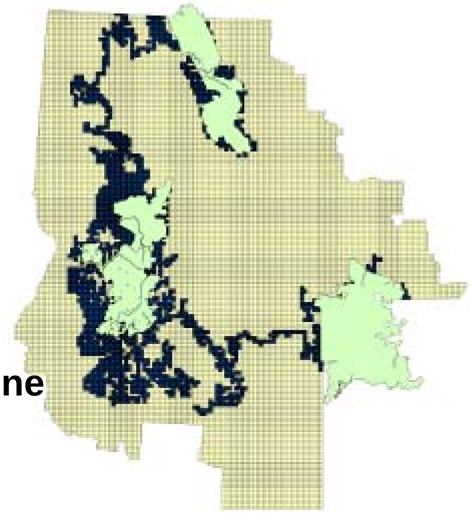
Yellowstone
Salmon-Selway Ecosystem
Glacier Park

(12788 nodes)





5 km grid
(12788 land parcels):
minimum cost solution



5 km grid
(12788 land parcels):
+1% of min. cost

Scaling up Solutions by Exploiting Structure:

Typical Case Analysis
Identification of Tractable Sub-problems
Exploiting structure
Streamlining for Optimization
Static/Dynamic Pruning

Our approach allows us to handle large problems and reduced corridor cost dramatically compared to existing approaches [Conrad et al. 2007]

Interdisciplinary Research Project (IRP):

Wildlife Corridors (Conrad, Gomes, van Hoeve, Sabharwal, Sutter)

CompSust09: Poster and Ashish Sabharwal will talk more about this problem

Additional Levels of Complexity: Stochasticity, Uncertainty, Large-Scale Data Modeling

- Highly stochastic environments
- Multiple species (hundreds or thousands), with interactions (e.g. predator/prey).
- Spatially-explicit aspects within-species
- Different models of land conservation (e.g., purchase, conservation easements, auctions) typically over different time periods
- Dynamical models

  Dynamics of Species
  Movements and migrations;

CompSust09:

Natural Resource Analysis and Decision Making
Williams, Runge, Conroy
McDonald-Madden

Species Distributions, Biodiversity & Ecological Models:
Elith, Farnsworth,Fink,
Hochachka ,Kelling,
Langley, Los,Munson,
Phillips, Riedewald, Sabaddin,
Sheldon

Ecological Monitoring & Computer Vision
Dietterich, Guestrin, Los,
Kumar, Krause, Nichols,
Pauwels

Optimization models for Red-Cockaded Woodpecker management

Dilkina, B., Elmachtoub, A., Finseth, R., Sheldon, D., Conrad, J., Gomes, C., Shmoys, D., Amundsen, O., and Allen, W.
Cornell University and The Conservation Fund

Introduction

- Degradation and loss of longleaf pine ecosystem has led to decline of Red-Cockaded Woodpecker (RCW)
- 'Keystone' species – primary excavators of nest cavities used by at least 27 vertebrate species
- Historically 1.0 to 1.6 million breeding groups, today only 5,600 existing RCW breeding groups
- Highly specific habitat – need mature pine trees infected with Red Heart fungus
- Cooperative breeders – territory groups consisting of one breeding pair and up to four 'helpers'
- Conservation and habitat management crucial to continued viability of Red-Cockaded Woodpecker

Research Objectives

The goal of this research is to develop methods to prioritize land acquisition adjacent to current RCW populations to aid in their recovery.

We seek to pose this as a formal optimization problem: where and when should one acquire land parcels and/or translocate birds to maximize the number of RCW breeding groups.

To solve this problem we develop a diffusion model to describe spatial patterns in RCW populations, and pose this as a stochastic network design problem.

Study Area

Palmetto Peartree Preserve (3P) consists of 10,000 acres of wetland forest in Tyrrell County, North Carolina.   As of September 2008, there were a total of 32 active RCW territories within the preserve.

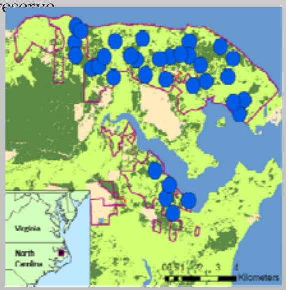


Figure 1. 3P RCW territories shown in blue

Patch-based Diffusion Model

- Based on cascade models for spread of influence in social networks ; also related to metapopulation models in ecology

Model Description

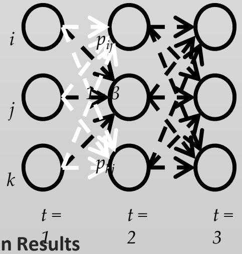
- Territories i, j =1, …, n.
- Occupied or unoccupied at each time step
- May colonize other territories (probability p_{ij}), or go extinct (probability β) in each time step
- Unoccupied territories become occupied if colonized by one or more other territories
- All colonization and extinction events independent

Parameters

- Colonization probability decays with distance, and only succeeds if target territory has suitable habitat

$$p_{ij} = \begin{cases} q_{ij} & \text{if territory } j \text{ is suitable} \\ 0 & \text{otherwise} \end{cases}$$

Illustration



Simulation Results

- Spatial configuration is very important. Dense and highly connected configurations are most stable.
- The four scenarios below show the effect of territory density on occupancy in the 3P study

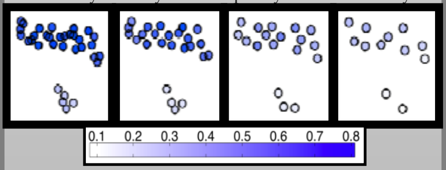
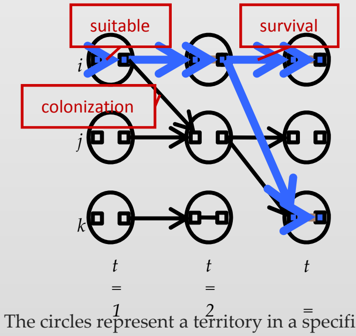


Figure 3. Shading indicated probability the territory is occupied after 100 years of simulation.

Occupancy as Network Connectivity

- We can describe the occupancy patterns of RCWs using a graphical network model



- The circles represent a territory in a specific year
- Horizontal lines between squares inside the circles indicate suitability of that territory in that year
- Horizontal lines between circles indicate non-extinction from one year the next. These are present with probability 1 - β
- Diagonal lines indicate potential colonization events; colonization occurs only if the source territory is occupied. These edges are present with probability p_{ij}
- Blue lines indicate actual colonization and non-extinction (e.g. territory i colonizes territory j at t=2)
- The occupied territories at t=3 are only those that can be reached from t=1 by a sequences of edges

Optimization

- We sample many scenarios representing different outcomes of colonization and extinction events
- Goal: maximize the number of colonized territories at time T, averaged over all scenarios
- Decision variables: which territories to purchase (i.e., make suitable) and in which time period
- Budget constraint limits the total cost of the territories we can purchase
- Purchase constraints let us buy each territory once
- Flow constraints between territories
- Capacity constraints restrict flow to suitable and colonization edges
- Integrality conditions on decision and flow variables

$$\text{maximize} \quad (1/K)\sum_{k=1}^{K}\sum_{i\in C} x^{rk}(i,T)$$

$$\text{subject to} \quad \sum_{i\in C}\sum_{t=1}^{T} b(i,t)\,y(i,t) \le B;$$

Budget constraint

Purchase constraints

$$\sum_{t=1}^{T} y(i,t) \le 1;$$

Suitability constraints

$$x^{rk}(i,t) \le \sum_{s=1}^{t} y(i,s), \quad \forall r,k,i,t$$

Colonization constraints

$$z^{rk}(i,j,t) \le a^{k}(i,j,t), \quad \forall r,k,i,j,t$$

$$\sum_{i\in} z^{rk}(i,j,t) = x^{rk}(j,t), \quad \forall r,k,j,t$$

Flow constraints

$$x^{rk}(i,t) = \sum_{j\in} z^{rk}(i,j,t+1), \quad \forall r,k,i,t$$

$$x^{rk}(i,t),\ y(i,t),\ z^{rk}(i,j,t) \in \{0,1\} \qquad \forall r,k,i,j,t$$

Solving Large-Scale Models

- Large mixed-integer programs (MIP) like ours are very difficult to solve
- We have employed the following "LP-rounding" approach rather than solving the MIP directly:
  - Solve the relaxed LP version
  - Set any integer variables <.1 to 0
  - Set the largest integer variable to 1
  - If new bounds result in infeasibility, set the previous variable to 0
  - Repeat until an integer solution is reached
- This approach is generally much faster than solving the original and obtains close to optimal results
- The table below shows the results for testing our 33 territories for 10 years, 5 simulations, random territory costs and a variable budget B

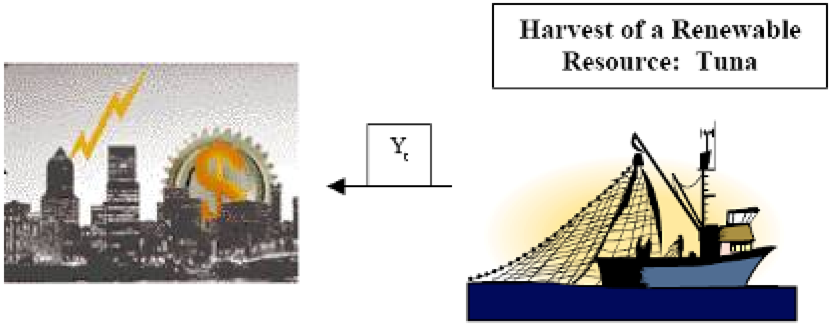
	Average Occupied Territories in 10th year		
Budget	IP solution	Lp rounding	%optimal
300	6.6	5.8	87.9%
400	8.4	6.6	78.6%
500	10.2	10	98.0%
600	12	11.4	95.0%
700	13.6	13.2	97.1%

Acknowledgments

The authors gratefully acknowledge the support of the National Science Foundation, award number 0832782. The authors also thank Dr. Jeffrey Walters of the Virginia Polytechnic Institute for granting the use of the RCW DSS.

Challenges in Dynamic Models and Optimization :

Economy



$$X_{t+1} - X_t = F(X_t) - Y_t$$

Non-linear dynamics

X_t = the fish stock (tuna)
Y_t = the rate of harvest
$F(X_t)$ = the net growth function

Fishery Management
Conrad, Quiinn, Sethi, Yakubu

Dynamic Opt. for Natural Resourcces
Williams, Runge, Conroy, Howitt

Fire Management in Forests
Claire Montgomery

Coral Disease
Steve Elner

We are interested in defining optimal (good) **policy decisions**
(e.g. when to open/close a fishery ground over time).

New Class of Hybrid Dynamic Optimization Models

Combinatorial optimization problems with an underlying dynamical model.

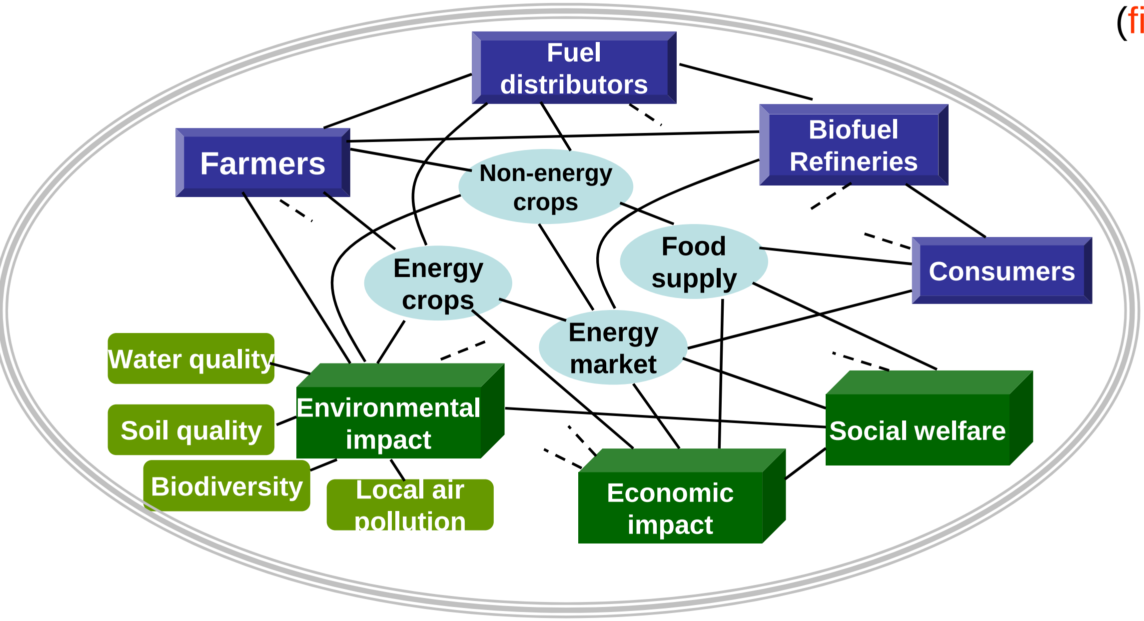
Challenges in Highly Interconnected Multi-Agent Systems:

Renewable Energy

Energy Independence and Security Act

(Signed into law in Dec. 2007)

Ambitious mandatory goal of
36 billion gallons of renewable fuels by 2022
(five-fold increase from current level)



Large Scale Logistics
Planning for Biofuels

Large Scale Logistics Planning

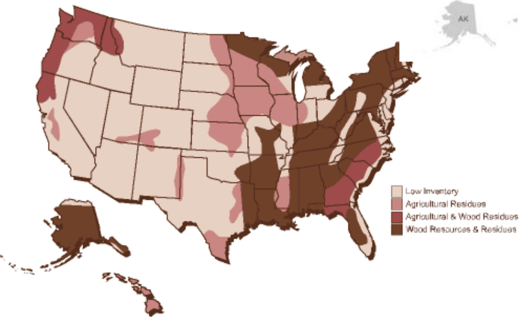
Large-scale investment in new technology provides exciting logistical planning and optimization challenges and opportunities

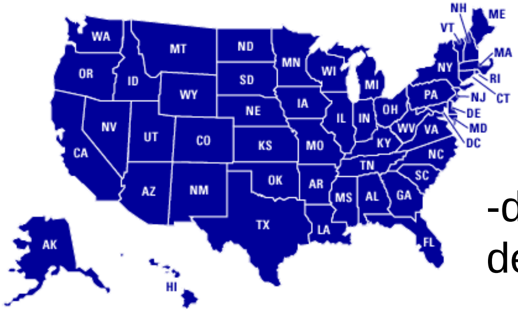
Transportation Network (Roads, Rail, Marine)

Feedstock Map

Distribution Terminals and Inter-Modal Facilities to Transfer Liquid Fuel

Biomass Map





Potential biorefinery

locations

Resulting optimization models are beyond scope of current “facility-location” expertise in several ways:

-large-scale input;
-stochastic nature (e.g.,feedstock and demand)
→new models to capture uncertainty
→new stochastic optimization algorithms;

-dynamics of evolution of demand and capacity

Realistic Computational Economic Models

Current approaches limited in scope and complexity

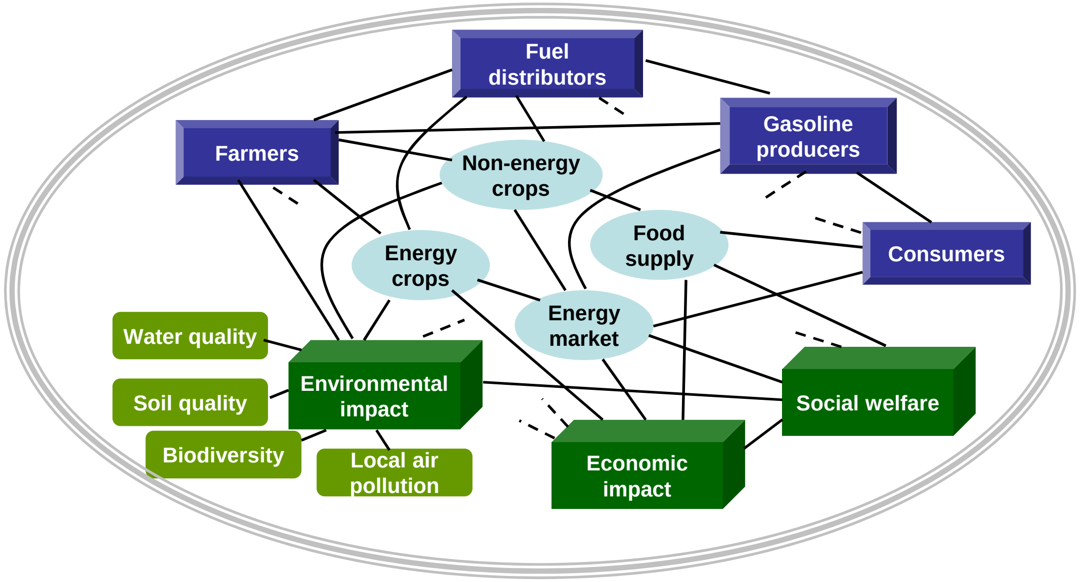
- E.g. based on *general equilibrium models* (e.g., Nash style)
- Strong convexity assumptions to keep the model simple enough for analytical, closed-form solutions (unrealistic scenarios)

  → *Limited computational thinking*

Antonio Bento
General Equilibrium Models for Biofuels

Transformative research directions

- More realistic computational models in which meaningful solutions can be computed
- Large-scale data, beyond state-of-the-art CS techniques
- Study of dynamics of reaching equilibrium — *key for adaptive policy making!*


Fuel distributors
Farmers
Gasoline producers
Non-energy crops
Food supply
Consumers
Energy crops
Energy market
Water quality
Environmental impact
Social welfare
Soil quality
Biodiversity
Local air pollution
Economic impact

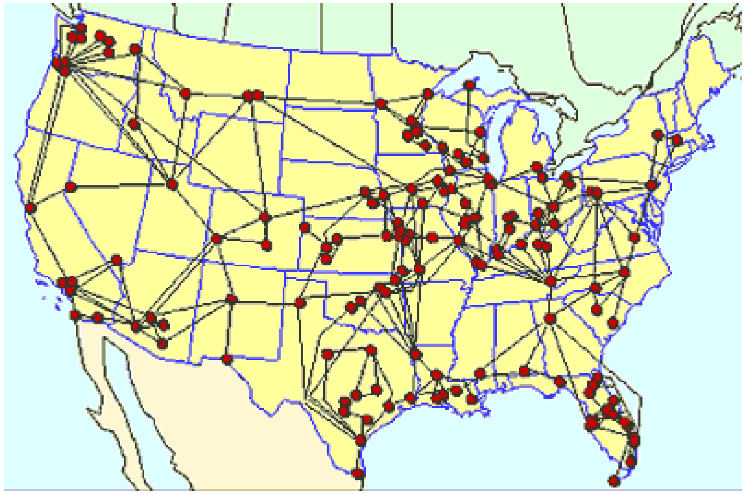
How to measure risks/ predict rare events?

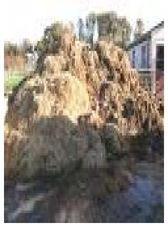
Impact of Biofuels: Dynamic Equilibrium Models

Impact of Land-use on Climate

Policies for a carbon cap and trade economy

Power Grid, Transportation & Sustainable Communities





US Power Grid

Simulation for Land Use and Transportation

Borning

&

Approx. DP for Multiscale Energy Policy Model

Powell

Sustainable Communities

Scott

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Science of Computation

Our approach:

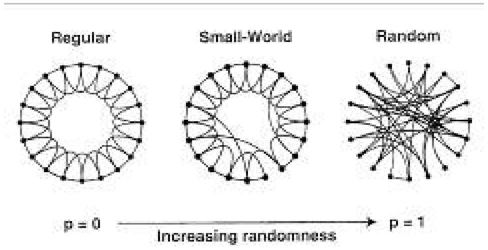
The study computational problems as natural phenomena in which principled experimentation, to uncover hidden structure, is as important as formal analysis

→ **Science of Computation,**

Our team has a track record of making compelling scientific discoveries using such an approach.

Small world phenomenon

Pioneered science of networks



[Watts & Strogatz]

Phase Transitions in Computation

Led to interactions between CS, statistical physics, and math

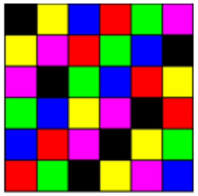
[Selman & Kirkpatrick]

Theme: Science of Computation
Discovering patterns, laws, and hidden structure in computational phenomena

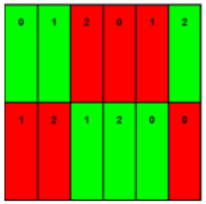
Streamlining Constraint Reasoning

Discovery of structural properties across solutions (machine learning);

Divide (“streamline”) the search space by imposing such additional properties.



Design of Agronomic Experiments for Studying Fertlizers



→ Scaling up of solutions

→Domain Independent Approach:
XOR-Streamlining based on
random parity constraints;
Provable bounds on solution counting

Van Es et al 2005

Deep Research Challenges posed by Sustainability

Key sustainability issues concerning the definition of policies for sustainable development translate into large-scale decision/optimization combining a mixture of discrete and continuous effects, in a highly dynamic and uncertain environment

→ different levels of complexity

Study computational problems as natural phenomena

→ **Science of Computation**

Many highly interconnected components;

→ **From Centralized to Distributed Models**

Multiple scales (e.g., temporal, spatial, geographic)

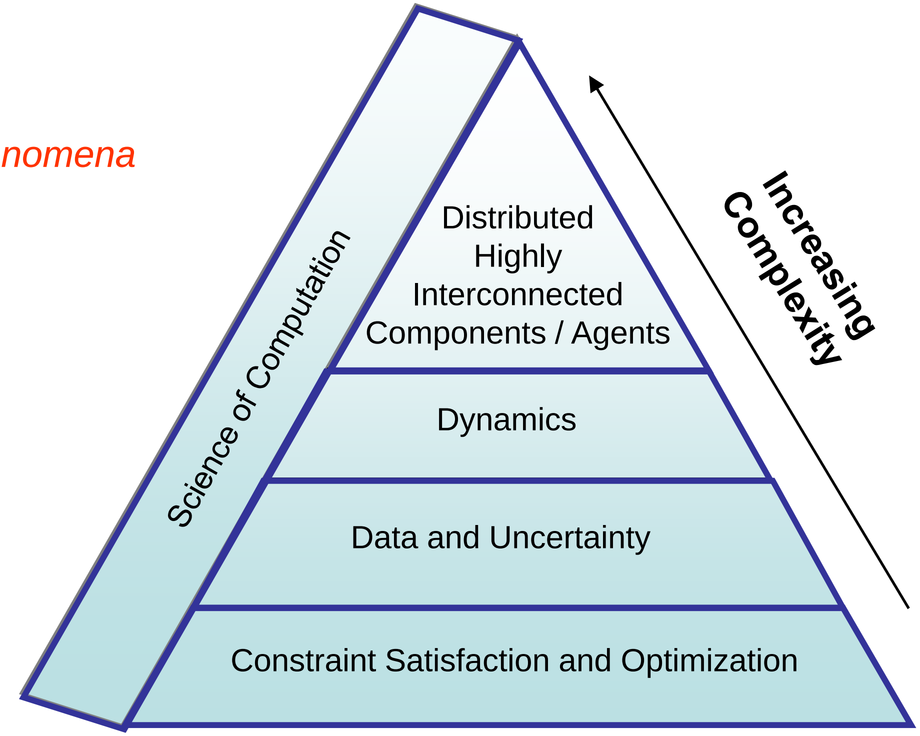
→ **From Statics to Dynamics: Dynamic Models**

Large-scale data and uncertainty

→ **Machine Learning, Statistical Modeling, Stochastic Modeling**

Complex decision models

→ **Constraint Reasoning and Optimization**



Complexity levels in Computational Sustainability Problems

Transformative Computer Science Research: *Driven by Deep Research Challenges posed by Sustainability*

Design of policies to effectively manage Earth's natural resources translate into large-scale decision/optimization and learning problems, combining a mixture of discrete and continuous effects, in a highly dynamic and uncertain environment → increasing levels of complexity

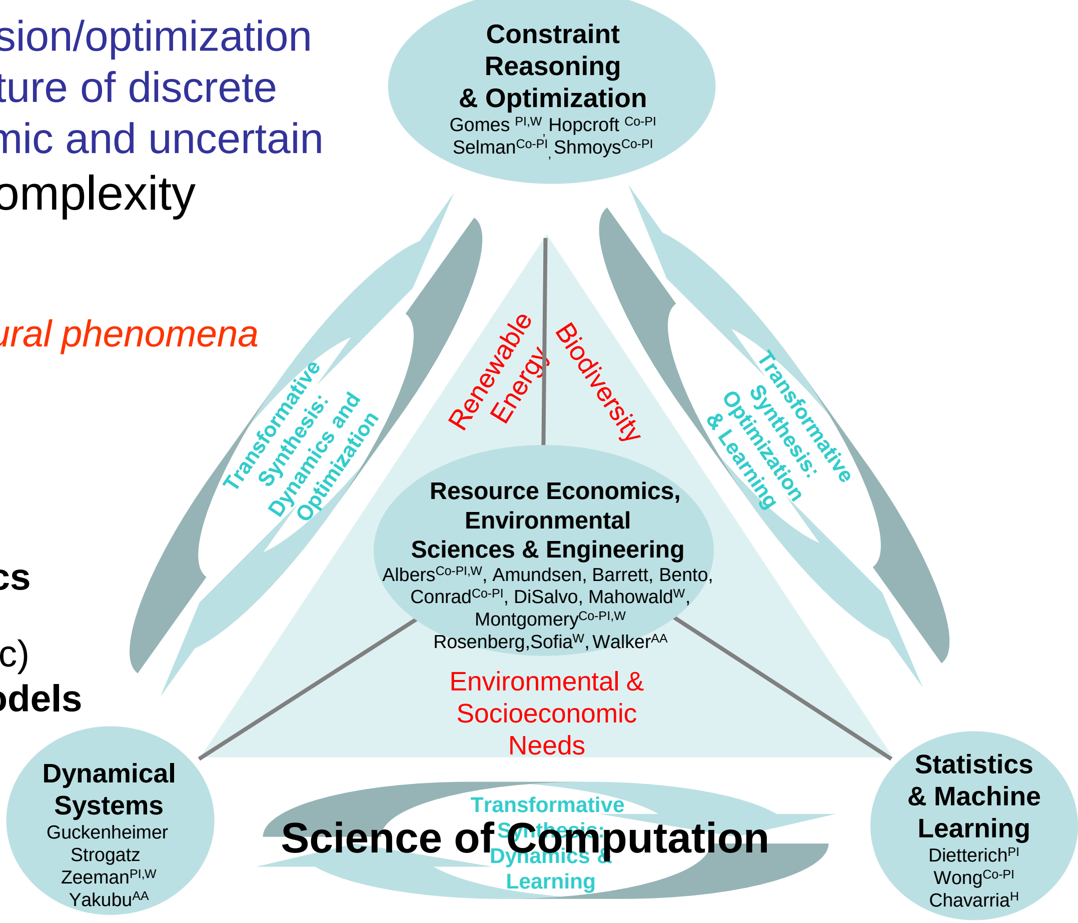
Study computational problems as natural phenomena
→ **Science of Computation**

Many highly interconnected components;
→ **From Centralized to Distributed: Computational Resource Economics**

Multiple scales (e.g., temporal, spatial, geographic)
→ **From Statics to Dynamics: Dynamic Models**

Large-scale data and uncertainty
→ **Machine Learning, Statistical Modeling**

Complex decision models
→ **Constraint Reasoning, Optimization, Stochasticity**



Science of Computation

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III Institute for Computational Sustainability

IV Compsust09

Overall Goals and Mission of Institute For Computational Sustainability

- Perform and foster research in Computational Sustainability
  - new insights into sustainability questions;
  - new challenges and new methodologies in Computer Science and related fields

    (Analogous to Computational Biology)

- Establish a vibrant research community, reaching far beyond the members in the original NSF Expedition.

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Multi-institutional, Multidisciplinary Research Team
6 Institutions, 7 colleges, 13 departments

Bento
Res. & Env.
Economics
Cornell

Shmoys
CS & OR
Cornell

Strogatz
Appl. Math
Cornell

Mahowald
Earth &
Atmos. Sci.
Cornell

Dietterich
CS
OSU

Gomes
CS &
Appl. Econ.
Cornell

Zeeman
Appl. Math
Bowdoin

Yakubu
Appl. Math
Howard

Montgomery
Res. & Env.
Economics
OSU

Hopcroft
CS
Cornell

Albers
Res. & Env.
Econo.
OSU

Chavarria
HPC.
PNNL

Sabharwal
CS
Cornell

Walke
Bio &
Env. En
Cornel

McDonald
City & Reg.
Planning
Cornell

Rosenberg
Consrv.
Biology
Cornell

Guckenheimer
Appl. Math
Cornell

Sofia
Biology

DiSalvo
Chemistry
Cornell

Barrett
Res. & Env.
Economics
Cornell

Amundsen
Conservation
Planning
Cons. Fund

Conrad
Res. and Env.
Economics
Cornell

Selman
CS
Cornell

Wong
CS
OSU

Cooch
Natural Resources
Cornell

Institute for Computational Sustainability
ICS

Cornell University Founded A.D. 1865

Pacific Northwest
NATIONAL LABORATORY

HOWARD
UNIVERSITY

OSU

Bowdoin

America's Partner in Conservation
THE CONSERVATION FUND

Interdisciplinary Research Projects (IRPs): *The Building Blocks of our Expedition*

Seedling IRPs

	IRP Name	Faculty Team
1.	**Wildlife Corridors for Grizzly Bears**	Amundsen, Conrad, Gomes, Selman, Shmoys
2.	**Biofuels**	Bento, Gomes, Mahowald, Shmoys, Strogatz, Walker, Wong
3.	**Bird Conservation**	Rosenberg, Conrad, Dietterich, Gomes, Hopcroft, Strogatz, Zeeman
4.	**Native Plant Habitat Recovery in Victoria, Australia**	Dietterich, Gomes, Selman
5.	**Joint Public/Private Management for Biodiversity**	Amundsen, Montgomery, Dietterich, Gomes, Hopcroft
6.	**Fire Management in Forests**	Albers, Conrad, Guckenheimer, Selman
7.	**Rotational Management of Fishing Grounds**	Conrad, Guckenheimer, Yakubu, Zeeman
8.	**Pastoral Systems in East Africa**	Barrett, Guo, Gomes, Toth

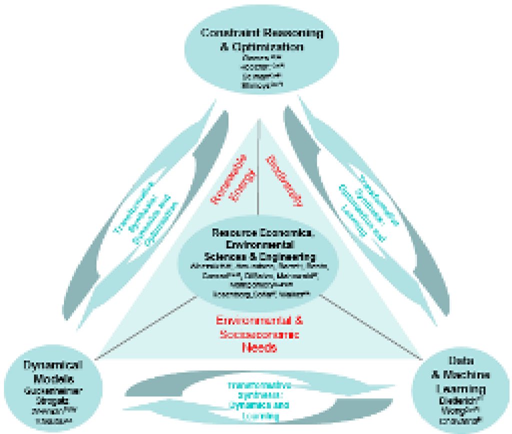
Nurturing New IRPs

Application/Synthesis Facilitators

Application Areas	Computational Themes						Application Facilitators
	Science of Computation	Dynamics & Optimization	Optimization & Learning	Learning & Dynamics	Agent Integration	Dissemination, Outreach, & Diversity	
Conservation and Biodiversity	✓	✓		✓		✓	Conrad, Montgomery, Gomes
Balancing Socio-Economic Demands and Environment	✓	✓	✓	✓	✓	✓	Albers, Conrad, Guckenheimer
Renewable Energy	✓	✓	✓		✓	✓	Bento, Gomes, Shmoys
Synthesis Facilitators	Dietterich, Hopcroft, Selman	Guckenheimer, Shmoys, Zeeman	Dietterich, Gomes, Hopcroft	Guckenheimer, Wong	Bento, Gomes, Shmoys	Hopcroft, Zeeman	

Institute Activities

Research



Coordinating transformative synthesis collaborations

Interdisciplinary Research Projects (IRPs)

Building Research Community

Conference & Workshops

Web Portal

Weekly Seminar

Host visiting Scientists

External Collaborations

ICS

Education

Postdocs

Doctoral students

Honors projects

Research seminar series

Summer REU program targeting minority students

Computational Sustainability courses

Outreach

K-12 Activities

Citizen Science Project

Conservation Fund

Science Exhibits

Cornell Center for a Sustainable Future

Cornell Cooperative Extension

OSU Alliance for Computational Sustainability

Outline

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Conference CompSust09: Goals

Bring together a community of researchers, educators, policy makers, practitioners, and students interested in applying techniques from computer science and related fields to solve key challenges in sustainability.

About 200 researchers from 80+ different research departments, labs and government institutions.

Establish a two-way street between environment researchers and researchers in computer science and related fields:

- Work on a common language for such a multi-disciplinary community.
- Educate computer scientists about computational aspects of challenges in sustainability ;
- Educate of researchers in sustainability about what models and techniques computer science and related fields can offer

Computational Sustainability is a fundamentally new intellectual territory with great potential to advance the different disciplines involved and with unique societal benefits!

Enjoy the Conference!!!

Thank You ☺!

Monday, June 8, 2009

8:00 am **Registration**

9:00 am
Opening Remarks
Cornell University Provost, Kent Fuchs

Computational Sustainability: Computational Methods for a Sustainable Environment, Economy, & Society
Carla P. Gomes

9:30 am ……………………………………… Ken Williams
Natural Resources Analysis and Decision Making

10:10 am ……………………………………… Mike Runge
Challenges in Framing the Problem: Just What are We Trying to Optimize Anyway?

10:50 am **Break**

11:05 am ……………………………………… Mike Conroy
Challenges in Dynamic Optimization for Natural Resource Management

11:45 am ………………………… Eve McDonald-Madden
Spatial and Temporal Issues in Resource Allocation

12:25 pm **Lunch**

1:50 pm ……………………………………… Steve Kelling
Biodiversity Research & Conservation in a Digital World

2:30 pm ……………………………………… Jane Elith
The Art of Modelling Range-Shifting Species

3:10 pm ……………………………………… Steve Phillips
Maximum Entropy Modeling of Species Distributions

3:50 pm **Break**

4:05 pm ……………………………………… Vipin Kumar
Discovery of Patterns in Global Earth Science Data using Data Mining

4:45 pm ……………………………………… Jim Nichols
On the Ugliness of Ecological Monitoring: Computational Constraints Arising from Ecological Data and Inference Methods

5:25 pm **Poster Session I**

Tuesday, June 9, 2009

8:30 am **Registration**

9:00 am ………………………… Wouter Los, Eric Pauwels
Computational facilities for biodiversity research (e-Infrastructures / Examples of computer-assisted photo-identification of individual animals)

9:40 am ……………………………………… Carlos Guestrin
TBA

10:20 am ……………………………………… Andreas Krause
Sensing Challenges in Environmental Monitoring

10:40 am **Break**

10:55 am ……………………………………… Warren Powell
Approximate Dynamic Programming for a Stochatsic, Multiscale Energy Policy Model

11:35 am ……………………………………… Brian Williams
Risk Sensitive Planning, Deep Sea Exploration and Sustainable Connected Homes

11:55 am **Lunch**

1:20 pm ……………………………………… Ian Dobson
TBA

2:00 pm ……………………………………… Alan Borning
The UrbanSim Project: Using Urban Simulation to Inform Public Decision-making about Land Use and Transportation Choices

2:30 pm ……………………………………… James Landay
Environmental Sustainability Through Activity-based Computing

3:00 pm **Break**

3:20 pm ……………………………………… Terry Quinn
Incorporating Biological and Environmental Realism into Fisheries Stock Assessment Models

3:50 pm ……………………………………… Gautam Sethi
Have Your Fish and Eat Them Too: Fishery Management Under Multiple Uncertainty

4:20 pm ……………………………………… Richard Howitt
Modeling Dynamic Network Systems with State-Contingent Penalty Functions

5:00 pm **Poster Session II**

Wednesday, June 10, 2009

9:00 am ……………………………………... Thomas Dietterich
High-Performance Computer Vision for Arthropod Biodiversity Studies

9:40 am ………………………………………. Regis Sabbadin
Model-based Adaptive Spatial Sampling for Occurrence Map Construction

10:10 am ……………………………………….. David Shmoys
Mathematical Programming-based Heuristics: Telecommunication Network Design Meets Species Distribution Planning

10:40 am **Break**

11:00 am **Computational Sustainability Panel**

12:00 pm **Lunch** (on your own)

1:30 pm **Concurrent Working Groups**

Room A ………………………………………..Chair: Cooch
Problems in Quantifying and Managing Uncertainty

Room B ……………………………………….. Chair: Allen
Interactive Decision Support Tools

3:20 pm **Break**

3:40 pm **Concurrent Working Groups**

Room A ……………………………………...Chair: Decker
Assessing Multiple Sources of Human-Behavioral Uncertainty in Social-Ecological Systems

Room B ………………………………………..Chair: Kelling
Species Distribution

Thursday, June 11, 2009

9:00 am …………………………………………. Steve Ellner
How microbial community composition regulates coral disease transmission

9:30 am ………………………………………...... Jon Conrad
Maximin Utility with Fractional Consumption, Extraction, and Harvest Rates

10:00 am ……………………………………….. Antonio Bento
TBA

10:20 am **Break**

10:40 am ....…………………………….. Claire Montgomery
Optimal Forest Fire Fuel Treatment and Timber Harvest in the Face of Endogenous Spatial Risk

11:00 am ……………………………………….... Pat Langley
An Interactive Environment for Constructing Ecological Models

11:20 am ....……………………………………….. Mark Battle
Development of an Optimal Method for Calibration of Gas Analyses

11:40 am …………………………………………. Norm Scott
Transitioning to a Sustainable World: Role of Sustainable Communities

12:00 pm **Lunch** (on your own)

1:30 pm **Concurrent Working Groups**

Room A ………………………………………. Chair: Allen
Sustainable Communities & Sustainable Agriculture

Room B ………… Chair: McDonald-Madden & Shmoys
Problems in Spatial Modeling and Resource Allocation

3:20 pm **Break**

3:40 pm **Working Group**

Room A …………………………………….. Chair: Conrad
Dynamic Optimization of Renewable Resources