Final Report for Period: 09/2007 - 08/2008 **Submitted on:** 12/01/2008

Principal Investigator: Gross, Louis J. **Award ID:** 0427471

Organization: U of Tennessee Knoxville

Submitted By:

Gross, Louis - Principal Investigator

Title:

ITR: Grid Computing for Ecological Modeling and Spatial Control

Project Participants

Senior Personnel

Name: Gross, Louis

Worked for more than 160 Hours: Yes

Contribution to Project:

Oversight and management of the various project components in collaboration with the co-PI's. Co-director of the post-docs supported on the project and director of the Ecology post-docs supported through the project. Assist in advising all graduate students supported on the project. Co-director of the workshops supported by the project.

Name: Lenhart, Suzanne

Worked for more than 160 Hours: Yes

Contribution to Project:

Advisor for the Mathematics graduate students supported on the project. Co-advisor with the Lead PI of all Mathematics post-docs supported through the project.

Name: Berry, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Advisor for all Computer Science students supported on the project. Co-director with the Lead PI of all Computer Science post-docs supported on the project.

Name: Shaw, Shih-Lung

Worked for more than 160 Hours: Yes

Contribution to Project:

Advisor for all Geography graduate students supported on the project. Collaborator with the Computer Science graduate students and the Computer Science post-doc supported on the project in the research to combine high performance computing with geographic information systems. In particular, leader of the GIS components of the research on spatial control of wildfires.

Post-doc

Name: Fuller, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Fuller was the main ecological scientist involved in collaborations with the computer science and mathematics graduate students. He directed the two workshops on computational science for natural resource managers and collaborated on methods for relative assessment for complex natural systems as well as guided a project on spatial invasive species spread.

Name: Wang, Dali

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. wang was the lead computational scientist involved in this project. He led all parallelization efforts associated withe the ecological models as well as collaborated with students in computer science and geography to develop methods for optimal spatial management for invasive species control and wildfire control.

Name: Whittle, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Whittle was the main mathematical post-doc involved in this project. He collaborated with the PIs and several graduate students to develop methods for optimal spatial management of invasive species and methods to model and analyze the spatial spread of an invasive bird, taking account of the impacts of spatial variation in life history fgactors for the species.

Name: Federico, Paula

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Federico is continuing efforts of the earlier research to develop spatial control methods for natural resource management systems. in particular, she is focusing on control of agent-based models and comparing simulation and analytic methods for this control.

Graduate Student

Name: Asano, Erika

Worked for more than 160 Hours: Yes

Contribution to Project:

Erika Asano completed her dissertation in mathematics while supported on this award, with several components of her dissertation involving efforts on this project. These include models for the control in space of raccoon rabies, utilizing an optimal control framework, as well as devloping a spatial model for teh spread of an invasive bird.

Name: Ding, Wandi

Worked for more than 160 Hours: Yes

Contribution to Project:

She was a student supported in part on this award, but also spent part of one year supported as a post-doc. her focus was on mathematical methods to analyze optimal fishery harvests accounting for spatial aspects of the system as well as accounting for spatial aspects of control in managing the spatial spread of raccoon rabies.

Name: Bodine, Erin

Worked for more than 160 Hours: Yes

Contribution to Project:

Erin Bodine has focused her efforts as a mathematics graduate student supported by this project on optimal methods to augment a threatened or endangered population through translocation of individuals from a reserve or captive bred population.

Name: Yin, Ling

Worked for more than 160 Hours: Yes

Contribution to Project:

Yin Ling developed the GIS tools used to analyze alternative spatial control methods for wildfire management and worked with computer-science graduate students and post-doc to incorporate parallel simulation methods into a GIS framework.

Name: Duke-Sylvester, Scott

Worked for more than 160 Hours: Yes

Contribution to Project:

He was supported as an Ecology and Evolutionary Biology graduate student and completed his dissertation while supported on this project. His dissertation work included two main components supported by this project, one of which involved the spatial development of vegetation succession as affected by the interactions of hydrology, nutrients and fire disturbance. This was applied to the Everglades landscape. Another component of his dissertation was a model for analyzing the optimal management of spread of an invasive plant in South Florida.

Name: Buchanon, Nic

Worked for more than 160 Hours: Yes

Contribution to Project:

He was first involved as an undergraduate student and then as
a graduate student. He completed his MS in Computer Science while supported in part by this project. His focus was on methods to link simulation models to GIS with an emphasis on new products from ESRI that allow direct linkages to externally-developed and coded simulations. This led to his development of a case study linking simulation to GIS and led to his employment by ESRI upon

graduation to carry out further development along these lines.

Name: Baines, Kristen

Worked for more than 160 Hours: Yes

Contribution to Project:

She completed her MS in Computer Science while supported on this project. Her project involved methods to mimic wildfire spread and link this with parallelization methods for spatial control. She implemented a tool to allow managers to control the location of fire breaks on a landscape and investigate its impact on fire spread.

Name: White, Kyle

Worked for more than 160 Hours: Yes

Contribution to Project:

He is a graduate student in Computer Science carrying on the parallelization methods for control of fire which were began by a post-doc, in collaboration with the geography personnel on this project.

Name: Miller, Rachael

Worked for more than 160 Hours: Yes

Contribution to Project:

She has been developing models for optimal control of invasive species as part of her Ph.D. dissertation which has been supported in part by this project.

Name: Leander, Rachel

Worked for more than 160 Hours: No

Contribution to Project:

Rachel Leander continued efforts to investigate the optimal timing of intervention strategies for control of invasive species using mathematical models of control theory.

Name: Clayton, Timothy

Worked for more than 160 Hours: No

Contribution to Project:

He worked on the effect of a birth pulse in an optimal control problem for the distribution of vaccine packets in an ODE system for rabies in raccoons. This work was included in his Ph.D. dissertation in Mathematics, completed in fall 2008.

Name: Zhong, Peng

Worked for more than 160 Hours: No

Contribution to Project:

She worked on methods of control theory for optimal harvesting problems applied to integrodifference equation models.

Undergraduate Student

Name: Davidson, James

Worked for more than 160 Hours: Yes

Contribution to Project:

In collaboration with a graduate student, another undergraduate and technical programmer he developed software, and carried out simulation and testing for a data warehousing approach used to facilitate the spatial optimization of fire break selection using a cluster of linux machines. This was linked to a GIS-based simulation for visualization and local adaptation of nearly optimal solutions.

Name: Fletcher, Robert

Worked for more than 160 Hours: Yes

Contribution to Project:

In collaboration with a graduate student, another undergraduate and technical programmer he developed software, and carried out simulation and testing for a data warehousing approach used to facilitate the spatial optimization of fire break selection using a cluster of linux machines. This was linked to a GIS-based simulation for visualization and local adaptation of nearly optimal solutions.

Technician, Programmer

Name: Carr, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

He is a programmer collaborating on efficient parallelization of the simulations linking fire control on a parallel computational framework to geographic information systems in collaboration with the Computer Science and Geography students and post-doc.

Name: Comiskey, Ethel

Worked for more than 160 Hours: Yes

Contribution to Project:

She is a programmer collaborating on the development of methods to augment threaten and endangered populations in collaboration with a graduate student supported on the project and the Lead PI, as well as providing assistance for the fire control modeling.

Name: Peek, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Michael has supplied expertise in database, coding and computer management for all the computational aspects of this project for the variety of post-docs and students supported as well as developed teh methods to allow parallelization to utilize the variety of machines available within the Institute for Environmental Modeling.

Other Participant

Research Experience for Undergraduates

Organizational Partners

Emory University

A former graduate student supported on this project (Scott Duke-Sylvester) has a post-doctoral appointment in Biology Department at Emory University, under the supervision of Dr. Leslie Real. Both of these individuals have continued a collaboration with several Math students supported on this project to develop models for the spatial control of rabies. This has resulted in one publication to date with two others in revision.

University of Bath

K. A. jane White collaborated on research with S. Lenhart and A. Whittle

University of Nevada Las Vegas

Daniel Kern collaborated on research with Rachael Miller and Suzanne Lenhart

Xavier University

Hem Raj Joshi collaborated on research with S. Lenhart

Indiana University-Purdue University School of Medicine

Charles Babbs collaborated with Suzanne Lenhart on research.

University of Vermont & State Agricultural College

Brian Beckage collaborated with Louis Gross and Scott Duke-Sylvester on research related to fire and disturbance effects on savannas.

Other Collaborators or Contacts

Jane White of Bath University, England has collaborated on development of control models for gypsy moths, H. R. Joshi of Xavier University has collaborated on models for control of fisheries, Holly Gaff of Old Dominion University (some of this carried out while she was at the

University of Maryland) has collaborated on models for spatial aspects of tick-borne disease and rabies control in raccoons, Brian Beckage of the University of Vermont has collaborated on models for fire spread and plant population management.

Activities and Findings

Research and Education Activities:

See the webpage about the work on this project:
http://www.tiem.utk.edu/ITR06/

We worked on research applicable to natural resource models and management throughout this very multi-disciplinary project. Numerous publications in various areas of science have already appeared and others are forthcoming. The research areas cross mathematics, ecology, conservation biology, computer science and geography. Research efforts continued throughout the final year, particularly by graduate students completing their dissertation projects, by a postdoctoral fellow (Paula Federico) developing a first-ever model for optimal control of individual-based models, and by undergraduates developing computer implementations for fire spread control models.

Five graduate graduate students were trained in part through funding from this project and graduated in 2006-7 (Asano, Ding and Duke-Sylvester completed Ph.D.s in Mathematics and Ecology and Evolutionary Biology, Buchanan and Baines completed Masters degrees in Computer Science). Additionally, several students either completed (Timothy Clayton in Mathematics) or are due to complete (Rachael Miller in Mathematics) their Ph.D. in 2008-2009. Several papers have been submitted or accepted on the work of these students with several others in preparation. Five graduate students continued efforts on this project with some level of support during 2008-9 (Bodine, Clayton, Leander, Miller, Zhong) and an additional graduate student (Yin) completed a publication for a geography journal based on her work on the project.

Five post-docs have been supported through this project (Ding, Federico, Fuller, Wang and Whittle).

Of the post-docs and students supported on the project, three have moved to tenure-track assistant professor positions at other universities (Asano, Ding, Whittle), three have moved to post-doctoral positions elsewhere (Duke-Sylvester, Federico, Fuller) and two are working in industry (Baines, Buchanan).

Two workshops for Natural Resource Managers were held (in April 2006 and April 2007).
Details about the topic coverage of these is available at the webpage http://www.tiem.utk.edu/workshop07/WkshpSched06 .
Approximately 30 participants attended each of the two workshops, with a diverse collection of institutions represented among the participants, including state and federal resource management agencies, universities, and private firms.

Findings:

A complete list of publications is posted on the project web site at
http://www.tiem.utk.edu/ITR06/reflist.html
with links to the papers. A total of 27 papers are included on this list.

1. Work on optimal control of invasives

H. Gaff, H. R. Joshi and S. Lenhart, 2007. Optimal Harvesting during an invasion of a sublethal plant pathogen, Environment and Development Economics Journal.12:673-686
This work applies optimal control to design a strategy for managing pathogen in crops. The underlying model is a system of integrodifference equations.

A. Whittle, S. Lenhart, L. J. Gross, 2007. Optimal Control for Management of an Invasive Plant Species, Mathematical Biosciences and Engineering. 4(1):101-112
This paper investigates optimal strategies for managing the spread of invasive plants, with a main focus and small outlier foci. This paper expands on the work of Moody and Mack, which is one of the most cited papers on control of plant invasives

A. Whittle, S. Lenhart, and J. White, Optimal Control of Gypsy Moth Populations, Bulletin of Math Biology 70(2):398-411
This work investigated optimal pest control strategies for a discrete time model of gypsy moth, using a type of virus to slow the

spread. Numerical results are given for illustration.

2. Work on invasives and other population models

K. R. Fister and S. Lenhart, 2006. Optimal Harvesting in an Age-Structured Predator-Prey Model, Applied Math and Optimization 54: 1-15.
This work investigated optimal harvesting control in a predator-prey model in which the prey is represented by a first-order PDE with age-structure and the predator is represented by an ODE in time.

W. Ding, H. Finotti, S. Lenhart, Y. Lou, Y. Ye. Optimal Control of Growth Coefficient on a Steady State Population Model, submitted to J. of Nonlinear Analysis: Real World Applications.
This work considers optimal strategies to improve the growth of a population, modeled with an elliptic PDE. The objective functional balances the maximization of the population level against the cost of improving the environment (enhancing the growth coefficient).

D. Kern, S. Lenhart, R. Miller, J. Yong, 2007. Optimal control applied to native-invasive population dynamics, J. of Biological Dynamics 1 (4): 413-426.
This work considers the maximization of a native species by controlling the growth functions of the invasive and native species, using an intervention that causes damage to the invasive specie and encourages the native species. A new existence result for the optimal control in the case of the control occurring in a quadratic way in the ODE system is established. This work is motivated by competition of cottonwood and salt cedar species in the Southwest US.

E. Bodine, L. J. Gross, and S. Lenhart, Optimal control applied to a model of species augmentation, to appear in Mathematical Biosciences and Engineering.
This ODE system models the augmentation of one species from a captive population. The control gives the timing and levels of movement of the individuals.

Gross together Beckage and Platt worked on populations models including overyielding effects and climate change.

Beckage, B., L. J. Gross and W. J. Platt. 2006. Responses of pine savannas to disturbance and long-term climate change. Applied Vegetation Science 9:75-82.

Beckage, B. and L. J. Gross. 2006. Overyielding and species diversity: what should we expect? New Phytologist 172:140-148.

Note that Whittle, Fuller and Asano have been working on modeling the invasion of Eurasian collared doves in North America, using an integrodifference model. An innovative feature is the dependence of the growth term on latitude through the number of frost free days. Two papers are under development for this work, some of which was included in the Ph.D. dissertation of Asano.

3. High Performance and Geographical Information Systems

Gross, Berry and Wang have several papers on integrated ecosystem simulations, including parallelization results, spatially-explicit structures and landscape features.

Wang, D., M. W. Berry, N. Buchanan and L. J. Gross. 2006. A GIS-enabled Distributed Simulation Framework for High Performance Ecosystem Modeling.
Proceedings of ESRI International User Conference, August 7-11, 2006.

Wang, D., M. W. Berry and L. J. Gross. 2008. A Parallel Structured Ecological Model for High End Shared Memory Computers. Lecture Notes in Computer Science (First International Workshop on OpenMP, 2005) 4315:107-118

Wang, D., M. W. Berry, L. J. Gross. 2006. On Parallelization of a Spatially-Explicit Structured Ecological Model for Integrated Ecosystem Modeling. International Journal on High Performance Computer Applications 20:571-581.

Wang, D., E. A. Carr, M. W. Berry and L. J. Gross. 2006. A Parallel Fish Landscape Model for Ecosystem Modeling on a Computing Grid. Simulation Journal:
Transactions of The Society of Simulation and Modeling International 82(7):451-466

4. Several other papers related to new developments of optimal control methods have been published or are in submission:

E. Asano, L. J. Gross, S. Lenhart, and L. A. Real, Optimal control of vaccine distribution in a rabies metapopulation model, to appear in Mathematical Biosciences and Engineering.
This paper investigates control of vaccination in a metapopulation ODE model for rabies in raccoons.

W. Ding, L. J. Gross, K. Langston, S. Lenhart and L. S. Real, Rabies in Raccoons: Optimal Control for a Discrete Time Model on a Spatial Grid, J. of Biological Dynamics 1 (4), 2007, 379-393.
This paper considers optimal vaccine bait distribution in a discrete time model with a discrete spatial grid for rabies in raccoons. The feature of discreteness in time and space is unusual in control problems for such biological systems.

E. Jung, S. Lenhart, V. Protopopescu, and C. Babbs, Optimal control applied to a thoraco-abdominal CPR model, to appear in IMA Journal Mathematical Medicine and Biology.
The unique discrete optimal control technique in this paper may have applications to other biological models. The state at the next time step uses the controls over the previous 2 time steps.

H. R. Joshi, S. Lenhart, K. Albright and K. Gipson, Modeling the effect of information campaigns on the HIV epidemic in Uganda, to appear in Mathematical Biosciences and Engineering.
The HIV epidemic in Uganda is modeled using an equation for the effect of the information campaigns and breaking the susceptible class into subclasses based on behavior change due to the information. Data from Uganda are used to estimate parameters in this model.

Training and Development:

This project has involved regular collaborative working groups that combine the disciplines involved. We generally had weekly meetings of two groups - one focused more on the ecological and mathematical components, and one focused on the geographic and computer science components. In addition, gatherings of the entire research team were held each term.

A main focus of the training has been building cross-disciplinary linkages. This has resulted in three of the post-docs with different fields of education collaborating on a project they developed on an invasive species modeled in space and time, a collaboration between the ecologists, computer scientists and geographers on methods to control wildfire, and an ongoing collaboration between ecologists and mathematicians on invasive species and disease modeling.

Students and post-docs have presented their results at a wide variety of conferences and workshops, as well as in our seminars.

A major outreach effort associated with this project has been the Workshops oriented towards natural resource managers with a goal of providing an introduction to modern computational science approaches that are applicable. The lead organizer of these workshops was one of the post-docs supported on the project, but the presentations and hands-on workshops at these involved essentially everyone supported by the project. Major themes of these workshops were high performance computing, temporal modeling of natural systems, optimal control methods for natural resources, and linkages of simulation methods to GIS. The workshop participants uniformly stated that the workshops were worth attending. Comments from participants in the first workshop were used to modify the content in the second workshop (there was no overlap in attendees aside from the presenters from UTK - there were a total of 51 different participants from institutions other than UTK in the two workshops) to better focus it on topics of direct interest to the participants. All lectures and workshop materials were provided to the attendees through a web-page. Additionally, a publication on the workshop topic was developed by two of the post-docs and two of the PIs and was distributed in pre-print form to all attendees (this has since appeared in the IEEE journal computing in Science and Engineering).

Outreach Activities:

We hosted two workshops on Computational Science for Natural Resource
Managers on April 19-22, 2006 and on April 11-14, 2007. See the webpage
http://www.tiem.utk.edu/workshop07/ for details on this as well as other portions of this report.
In addition to tutorial and research lectures on work from
this project and discussions on the projects of the participants, these workshops included computer labs demonstrating spatial control and Geographic Information Sciences.

Approximately sixty talks have been given on research supported by this project at numerous meetings and workshops, including talks at the Joint Math Meetings, SIAM annual meetings, Natural Resource Modeling conference, Supercomputing, Ecological Society of America annual meeting, ESRI Annual meeting in GIS, and the Society for Math. Biology annual meetings.

Journal Publications

H Gaff, H R Joshi and S Lenhart, "Optimal Harvesting during an invasion of a sublethal plant pathogen", Enviromental and Development Economics Journal, p. 673, vol. 12, (2007). Published,

A Whittle, S Lenhart and L T Gross, "Optimal control for management of an invasive plant species", Mathematical Biosciences and Engineering, p. 101, vol. 4, (2007). Published,

K. R. Fister and S. Lenhart, "Optimal harvesting in an age-structured predator-prey model", Applied Math and Optimization, p. 1, vol. 54, (2006). Published,

A. Whittle, S. Lenhart, and J. White, "Optimal control of gypsy moth populations", Bulletin of MAth Biology, p. 101, vol. 4, (2008). Published,

W. Ding, "Optimal control of hybrid ODE systems with applications to a tick disease model
a Tick Diease Model", Mathematical Biosciences and Engineering, p. 633, vol. 4, (2007). Published,

Beckage, B., L. J. Gross and W. J. Platt., " Responses of pine savannas to
disturbance and long-term climate change", Applied Vegetation Science, p. 75, vol. 9, (2006). Published,

Beckage B and Gross L J, " Overyielding and species diversity: what
should we expect?", New Phytologist, p. 140, vol. 172, (2006). Published,

Wang, D., M. W. Berry and L. J. Gross., " On parallelization of a Spatially-Explicit Structured Ecological Model for Integrated Ecosystem
spatially-explicit structured ecological model for integrated ecosystem
simulation", International J of High Performance Computing Applications, p. 571, vol. 20, (2006). Published,

Wang, D., M. W. Berry, N. Buchanan and L. J. Gross., " GIS-enabled
Distributed Simulation Framework for High Performance Ecosystem Modeling.", Proceedings of ESRI International User Conference, August 7-11, 2006., p. , vol. , (2006). Published, http://gis.esri.com/library/userconf/proc06/papers/papers/pap_1272.pdf

Wang, D., M. W. Berry and L. J. Gross., "A Parallel Structured Ecological Model for High End Shared Memory Computers
Model for High End Shared Memory Computers", Lecture Notes in Computer Science
(First International Workshop on OpenMP, 2005), p. , vol. , ( ). Accepted,

Wang, D., E. A. Carr, M. W. Berry and L. J. Gross, "A Parallel Fish Landscape Model for Ecosystem Modeling on a Computing Grid
Landscape Model for Ecosystem Modeling on a Computing Grid.", Simulation Journal: Transactions of The Society of Simulation and Modeling International
Transactions of The Society of Simulation and Modeling International, p. 451, vol. 83, (2006). Published,

Gaff, HD; Gross, LJ, "Modeling tick-borne disease: A metapopulation model", BULLETIN OF MATHEMATICAL BIOLOGY, p. 265, vol. 69, (2007). Published, 10.1007/s11538-006-9125-

H. R. Joshi, S. Lenhart, H. Lou, and H. Gaff
H. Gaff, "Harvesting Control in an Integrodifference Population Model with Concave Growth Term", Nonlinear Analysis: Hybrid Systems, p. 417, vol. 1, (2007). Published,

D. L. Kern, S. Lenhart, R. Miller and J. Yong, "Optimal Control applied to native-invasive population dynamics", J. of Biological Dynamics, p. , vol. , ( ). Accepted,

W. Ding, L. J. Gross, K. Langston, S. Lenhart and L. S. Real, "Rabies in Raccoons: Optimal Control for a Discrete Tim Model on a Spatial Grid", J. of Biological Dynamics, p. 379, vol. 1, (2007). Published,

W. Ding and S. Lenhart, "Optimal Harvesting of a Semilinear Elliptic Fishery Model", Natural Resource Modeling, p. , vol. , ( ). Submitted,

Salinas, R. A., S. Lenhart and L. J. Gross, "Control of a metapopulation harvesting model for black bears", Natural Resource Modeling, p. 307, vol. 18, (2005). Published,

Wang, D., E. Carr, L. J. Gross, and M. W. Berry, "Toward ecosystem modeling on computing grids", Computing in Science and Engineering, p. 44, vol. 7, (2005). Published,

Whittle, A. J., S. Lenhart and L. J. Gross, "Optimal control for management of an invasive plant species", Mathematical Biosciences and Engineering, p. 101, vol. 4, (2007). Published,

Fuller, M. M., D. Wang, L. J. Gross and M. W. Berry, "Computational science for natural resoource management", Computing in Science and Engineering, p. 40, vol. 9, (2007). Published,

M. M. Fuller, L. J. Gross, S. M. Duke-Sylvester and M. Palmer, "Testing the Robustness of Management Decisions to Uncertainty: Everglades Restoration Scenarios", Ecological Applications, p. 711, vol. 18, (2008). Published,

Bodine, E.N, L.J. Gross, and S. Lenhart., "Optimal control applied to a model for species augmentation", Mathematical Biosciences and Engineering, p. , vol. , (2008). Accepted,

Asano, E., L.J. Gross, S. Lenhart, and L.A. Real, "Optimal control of vaccine distribution in a rabies metapopulation model", Mathematical Biosciences and Engineering, p. , vol. , (2008). Accepted,

Ding, W., H. Finotti, S. Lenhart, Y. Lou, Y. Ye., "Optimal control of growth coefficient on a steady state population model", Journal of Nonlinear Analysis: Real World Applications., p. , vol. , (2008). Submitted,

Joshi, H.R., S. Lenhart, K. Albright and K. Gipson, "Modeling the effect of information campaigns on the HIV epidemic in Uganda", Mathematical Biosciences and Engineering., p. , vol. , (2008). Accepted,

Jung, E., S. Lenhart, V. Protopopescu, and C. Babbs, "Optimal control applied to a thoraco-abdominal CPR model", IMA Journal of Mathematical Medicine and Biology, p. , vol. , (2008). Accepted,

Books or Other One-time Publications

Suzanne Lenhart and John T. Workman, "Optimal Control Applied to Biological Models", (2007). Book, Published
Collection: Mathematical and Computational Biology Series, Chapman and Hall, CRC Press
Bibliography: ISBN 1-58488-640-4

Web/Internet Site

URL(s):
http://www.tiem.utk.edu/ITR06/

http://www.tiem.utk.edu/workshop07/

http://www.tiem.utk.edu/workshop06/

Description:
Main web site for this project which explains the project objectives and notes the personnel involved and provides a publication list with links to papers produced from the project.

The other links are to the Workshops organized as part of this project and include the schedules and links to material distributed at the workshops.

Other Specific Products

Contributions

Contributions within Discipline:
This project has contributed to the several disciplines involved in the project. On the mathematical components the project has led to new mathematical methods to analyze spatial control as well as new methods for discrete-time control of biological systems. these are expansions of maximum principle methods.

On the Computer Science impacts, this project led to the development of new parallelization methods for ecological multimodels, and these methods and models were linked to optimal control schemes for spatial management of wildfires and to GIS products used widely in natural resource management.

On the ecological impacts, the project has resulted in a major publication dealing with how to spatially take account of uncertainty in scenario analyses of complex natural systems. Additionally, models developed as part of the project have elucidated several problems in plant ecology dealing with situations in which over-yielding occurs and when savanna systems may be maintained by disturbance interactions.

Contributions to Other Disciplines:
This project has fostered a collaboration with geographers and natural resource managers. One outcome of this has been development of methods to link simulation models for wildfire management directly to a GIS. The problem is computationally challenging and has required the implementation of parallel processing methods in conjunction with workstation-level GIS. As best we are aware, this is the first instance in which parallel simulation methods have been linked to genetic algorithms within a GIS for optimal management of a spatially-distributed system.

As another contribution, this project developed a set of material for natural resource managers to introduce key computational science methodologies and resulted in a publication that aimed to bridge the gap between the very applied needs of resource managers on the ground and computational science using high performance machines.

Contributions to Human Resource Development:
This project has supported the post-doctoral research activities of 4 individuals, supported graduate efforts by a total of 12 students from mathematics, computer science, ecology and geography, and supplied support for several undergraduates. In addition to funding support for these individuals, the project supported the attendance of more than 45 external attendees from various natural resource management agencies and students in these fields in two workshops which developed their computational expertise.

Contributions to Resources for Research and Education:

The project supported two workshops (each lasting 4 days) which provided a new educational opportunity for natural resource managers to learn about current computational science opportunities related to natural resource management. Each workshop featured a series of formal lectures and interactive computer-based workshops to introduce the attendees to major concepts in computational science applicable across natural resource management.

Contributions Beyond Science and Engineering:

The lead PI used the experiences from this project to inform his participation on a National Research Council Committee which produced in 2007 a major report: Models in Environmental Regulatory Decision Making. Additionally, the methods developed for this project have been discussed with various resource managers involved in aspects of Everglades restoration planning, reserve design and spatial vaccination planning for raccoon rabies control.

Categories for which nothing is reported:

Any Product