

# Modeling Forum

## Results of the 2002 Interdisciplinary Contest in Modeling

Chris Arney, Co-Director

Dean of the School of Mathematics and Sciences  
The College of Saint Rose  
432 Western Avenue  
Albany, NY 12203  
arneyc@mail.strose.edu

John H. "Jack" Grubbs, Co-Director

Dept. of Civil and Environmental Engineering  
Tulane University  
New Orleans, LA 70112  
jgrubbs@tulane.edu

### Introduction

A total of 106 teams of undergraduates, from 71 institutions in 5 countries, spent the second weekend in February working on an applied mathematics problem in the 4th Interdisciplinary Contest in Modeling (ICM).

This year's contest began at 8:00 P.M. on Friday, Feb. 7, and ended at 8:00 P.M. on Monday, Feb. 11. During that time, the teams of up to three undergraduates or high-school students researched and submitted their optimal solutions for an open-ended interdisciplinary modeling problem involving environmental science. After a weekend of hard work, solution papers were sent to COMAP.

The two of the papers that were judged to be Outstanding appear in this issue of *The UMAP Journal*. Results and winning papers from the first three contests were published in special issues of *The UMAP Journal* in 1999 through 2001.

In addition to the ICM, COMAP also sponsors the Mathematical Contest in Modeling (MCM), which runs concurrently with the ICM. Information about the two contests can be found at

---

*The UMAP Journal* 23 (1) (2002) 11–23. ©Copyright 2002 by COMAP, Inc. All rights reserved. Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice. Abstracting with credit is permitted, but copyrights for components of this work owned by others than COMAP must be honored. To copy otherwise, to republish, to post on servers, or to redistribute to lists requires prior permission from COMAP.

[www.comap.com/undergraduate/contests/icm](http://www.comap.com/undergraduate/contests/icm)

[www.comap.com/undergraduate/contests/mcm](http://www.comap.com/undergraduate/contests/mcm)

The ICM and the MCM are the only international modeling contests in which students work in teams to find a solution.

Centering its educational philosophy on mathematical modeling, COMAP uses mathematical tools to explore real-world problems. It serves the educational community as well as the world of work by preparing students to become better informed and better-prepared citizens, consumers, and workers.

This year's problem, which involved understanding and managing the habitat of the Florida scrub lizard, proved to be particularly challenging. It contained various data sets to analyze, had several challenging requirements needing scientific and mathematical connections, and also had the ever-present requirements to use creativity, precision, and effective communication. The author of the problem, environmental scientist Grant Hokit, was one of the final judges, and his commentary appears in this issue.

All the competing teams are to be congratulated for their excellent work and dedication to scientific modeling and problem solving. This year's judges remarked that the quality of the papers was extremely high, making it difficult to choose the two Outstanding papers.

In 2002 the ICM continued to grow as an online contest, where teams registered, obtained contest instructions, and downloaded the problem through COMAP's ICM Website.

## **Problem: The Scrub Lizard Problem**



**Figure 1.** Florida scrub lizard. Photo by Grant Hokit.

## If We SCRUB Our Land Too much, We May Lose the LIZARDS

The Florida scrub lizard is a small, gray, or gray-brown lizard that lives throughout upland sandy areas in the Central and Atlantic coast regions of Florida. The Florida Committee on Rare and Endangered Plants classified the scrub lizard as endangered.

You will find a fact sheet on the Florida Scrub Lizard at <http://www.comap/undergraduate/contestsicm/2002problem/scrublizard.pdf>. [EDITOR'S NOTE: We do not reproduce that document here.]

The long-term survival of the Florida scrub lizard is dependent upon preservation of the proper spatial configuration and size of scrub habitat patches.

### Task 1

Discuss factors that may contribute to the loss of appropriate habitat for scrub lizards in Florida. What recommendations would you make to the state of Florida to preserve these habitats and discuss obstacles to the implementation of your recommendations?

### Task 2

Utilize the data provided in **Table 1** to estimate the value for  $F_a$  (the average fecundity of adult lizards),  $S_j$  (the survivorship of juvenile lizards between birth and the first reproductive season), and  $S_a$  (the average adult survivorship).

**Table 1.**

Summary data for a cohort of scrub lizards captured and followed for 4 consecutive years. Hatchling lizards (age 0) do not produce eggs during the summer they are born. Average clutch size for all other females is proportional to body size according to the function  $y = 0.21(\text{SVL}) - 7.5$ , where  $y$  is the clutch size and SVL is the snout-to-vent length in mm.

Year	Age	Total number living	Number of living females	Avg. female size (mm)
1	0	972	495	30.3
2	1	180	92	45.8
3	2	20	11	55.8
4	3	2	2	56.0

### Task 3

It has been conjectured that the parameters  $F_a$ ,  $S_j$ , and  $S_a$  are related to the size and amount of open sandy area of a scrub patch. Utilize the data provided in **Table 2** to develop functions that estimate  $F_a$ ,  $S_j$ , and  $S_a$  for different patches. In addition, develop a function that estimates  $C$ , the carrying capacity of scrub lizards for a given patch.

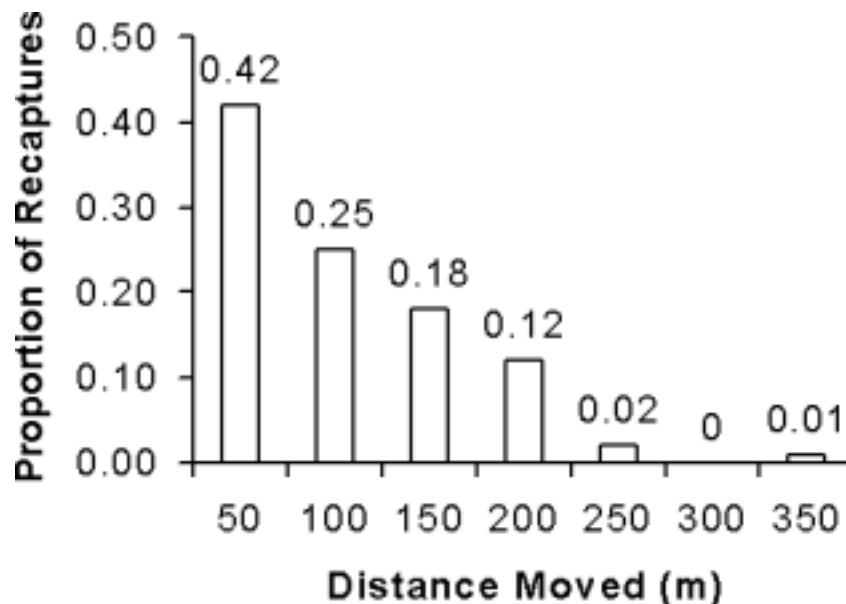
**Table 2.**

Summary data for 8 scrub patches including vital rate data for scrub lizards. Annual female fecundity ( $F_a$ ), juvenile survivorship ( $S_j$ ), and adult survivorship ( $S_a$ ) are presented for each patch along with patch size and the amount of open sandy habitat.

Patch	Patch size (ha)	Sandy habitat (ha)	$F_a$	$S_j$	$S_a$	Density (lizards/ha)
a	11.31	4.80	5.6	.12	.06	58
b	35.54	11.31	6.6	.16	.10	60
c	141.76	51.55	9.5	.17	.13	75
d	14.65	7.55	4.8	.15	.09	55
e	63.24	2.12	9.7	.17	.11	80
f	132.35	54.14	9.9	.18	.14	82
g	8.46	1.67	5.5	.11	.05	40
h	278.26	84.32	11.0	.19	.15	115

#### Task 4

Many animal studies indicate that food, space, shelter, or even reproductive partners may be limited within a habitat patch, causing individuals to migrate between patches. There is no conclusive evidence on why scrub lizards migrate. However, about 10% of juvenile lizards do migrate between patches, and this immigration can influence the size of the population within a patch. Adult lizards apparently do not migrate. Utilizing the data provided in the histogram in **Figure 2**, estimate the probability of lizards surviving the migration between any two patches  $i$  and patch  $j$ .



**Figure 2.** Migration data for juvenile lizards marked, released, and recaptured up to 6 months later. Surveys for recapture were conducted up to 750 m from release sites.

## Task 5

Develop a model to estimate the overall population size of scrub lizards for the landscape given in **Table 3**. Also, determine which patches are suitable for occupation by scrub lizards and which patches would not support a viable population.

**Table 3.**

Patch size and amount of open sandy habitat for a landscape of 29 patches located on the Avon Park Air Force Range. See **Figure 3** for a map of the landscape.

Patch identification	Patch size (ha)	Sandy habitat (ha)
1	13.66	5.38
2	32.74	11.91
3	1.39	0.23
4	2.28	0.76
5	7.03	3.62
6	14.47	4.38
7	2.52	1.99
8	5.87	2.49
9	22.27	8.44
10	19.25	7.58
11	11.31	4.80
12	74.35	19.15
13	21.57	7.52
14	15.50	2.82
15	35.54	11.31
16	2.93	1.15
17	47.21	10.73
18	1.67	0.13
19	9.80	2.23
20	39.31	7.15
21	2.23	0.78
22	3.73	1.02
23	8.46	1.67
24	3.89	1.89
25	1.33	1.11
26	0.85	0.79
27	8.75	5.30
28	9.77	6.22
29	13.45	4.69

## Task 6

It has been determined from aerial photographs that vegetation density increases by about 6% a year within the Florida scrub areas. Please make a recommendation on a policy for controlled burning.



Figure 3. Map of landscape of 29 patches located on the Avon Park Air Force Range.

## The Results

Solution papers were coded at COMAP headquarters so that names and affiliations of authors would be unknown to the judges. Each paper was read preliminarily by two “triage” judges at the U.S. Military Academy at West Point, NY. At the triage stage, the summary and overall organization are the basis for judging a paper. If the judges’ scores diverged for a paper, the judges conferred; if they still did not agree on a score, a third judge evaluated the paper.

Final judging took place at the United States Military Academy, West Point, NY. The judges classified the papers as follows:

	Outstanding	Meritorious	Honorable Mention	Successful Participation	Total
Scrub Lizard	2	16	28	60	106

The two papers that the judges designated as Outstanding appear in this special issue of *The UMAP Journal*, together with commentaries. We list those teams and the Meritorious teams (and advisors) below; the list of all participating schools, advisors, and results is in the **Appendix**.

## Outstanding Teams

Institution and Advisor	Team Members
<p>“Where’s the Scrub? Aye, There’s the Rub”  Maggie L. Walker Governor’s School  Richmond, VA  John Barnes</p>	<p>Victoria L. Chiou  Andrew Carroll  Jessamyn J. Liu</p>
<p>“Cleaning Up the Scrub: Saving the  Florida Scrub Lizard”  Olin College of Engineering  Needham, MA  Burt Tilley</p>	<p>Nicole Hori  Steven Krumholtz  Daniel Lindquist</p>

## Meritorious Teams (16 teams)

Beijing University of Posts & Telecommunications, Beijing, China (He Zuguo)  
Carroll College, Helena, MT (Sam R. Alvey)  
Central South University, Changsha, China (Zhang Hongyan and Zheng Zhoushun)  
Dickinson College, Carlisle, PA (Brian S. Pedersen)  
Elon University, Elon, NC (Crista Coles) (two teams)  
Fudan University, Shanghai, China (Cao Yuan)  
Harvey Mudd College, Claremont, CA (Michael E. Moody)  
Monmouth College, Monmouth, IL (Christopher Fasano)  
Northwestern Polytechnical University, Xian, China (Xiao Hua Yong)  
Tsinghua University, Beijing, China (Hu Zhiming)  
United States Air Force Academy, USAF Academy, CO (Jim West)  
University of Missouri, Rolla, MO (Mohamed Ben Rhouma)  
University of Science and Technology of China, Hefei, China (Tao Dacheng )  
University of Science and Technology of China, Hefei, China (Zhang Hong)  
Youngtown State University, Youngstown, OH (Scott Martin)

## Awards and Contributions

Each participating ICM advisor and team member received a certificate signed by the Contest Directors and by the Head Judge. Additional awards were presented to the Governors School team from Institute for Operations Research and the Management Sciences (INFORMS).

## Judging

### *Director*

Chris Arney, Dean of the School of Mathematics and Sciences,  
The College of Saint Rose, Albany, NY

### *Associate Directors*

Michael Kelley, Dept. of Mathematical Sciences, U.S. Military Academy,  
West Point, NY

Gary W. Krahn, Dept. of Mathematical Sciences, U.S. Military Academy,  
West Point, NY

### *Judges*

Richard Cassidy, Dept. of Industrial Engineering, University of Arkansas,  
Fayetteville, AR

Grant Hokit, Dept. of Biology, Carroll College, Helena, MT

Marie Vanisko, Dept. of Mathematics, Carroll College, Helena, MT

### *Triage Judges*

Darryl Ahner, Eric Drake, Alex Heidenberg, D. Jacobs, Alan Johnson, Gary  
Krahn, E. Lesinski, Joe Myers, Mike Phillips, K. Romano, Kathi Snook, B. Stewart,  
Ani Velo, and Brian Winkel, all of the U.S. Military Academy, West Point,  
NY.

## Source of the Problem

The Scrub Lizard Problem was contributed by Grant Hokit, Dept. of Biology,  
Carroll College, Helena, MT.

## Acknowledgments

Major funding for the ICM is provided by a grant from the National Science  
Foundation through COMAP. Additional support is provided by the Institute  
for Operations Research and the Management Sciences (INFORMS).

We thank:

- the ICM judges and ICM Board members for their valuable and unflagging efforts, and
- the staff of the Dept. of Mathematical Sciences, U.S. Military Academy, West Point, NY, for hosting the triage judging and the final judging.



## Cautions

*To the reader of research journals:*

Usually a published paper has been presented to an audience, shown to colleagues, rewritten, checked by referees, revised, and edited by a journal editor. Each of the student papers here is the result of undergraduates working on a problem over a weekend; allowing substantial revision by the authors could give a false impression of accomplishment. So these papers are essentially *au naturel*. Light editing has taken place: minor errors have been corrected, wording has been altered for clarity or economy, style has been adjusted to that of *The UMAP Journal*, and the papers have been edited for length. Please peruse these student efforts in that context.

*To the potential ICM Advisor:*

It might be overpowering to encounter such output from a weekend of work by a small team of undergraduates, but these solution papers are highly atypical. A team that prepares and participates will have an enriching learning experience, independent of what any other team does.

## Appendix: Successful Participants

## KEY:

P = Successful Participation

H = Honorable Mention

M = Meritorious

O = Outstanding (published in this special issue)

INSTITUTION	CITY	ADVISOR	I
ARIZONA			
McClintock	Tempe	Ivan Barkdoll	P
CALIFORNIA			
Harvey Mudd College	Claremont	Michael Moody	M, H
Sonoma State University	Rohnert Park	Elaine McDonald	P
COLORADO			
Colorado State University	Fort Collins	Michael Kirby	P
United States Air Force Academy	USAF Academy	Jim West	M
GEORGIA			
Georgia Southern University	Statesboro	Laurene Fausett	P
ILLINOIS			
Monmouth College	Monmouth	Christopher Fasano	M
INDIANA			
Earlham College	Richmond	Mic Jackson	H
KENTUCKY			
Asbury College	Wilmore	David Coulliette	H, P
Northern Kentucky University	Highland Heights	Gail Mackin	P
MASSACHUSETTS			
Babson College	Wellesley	Steven Eriksen	P
Olin College of Engineering	Needham	Burt Tilley	O
MICHIGAN			
East Grand Rapids Public Schools	Grand Rapids	Mary Elderkin	P
Lawrence Technological University	Southfield	Howard Whitston	H
		Ruth Favro	P
MINNESOTA			
St. Cloud State University	St. Cloud	Dominic Naughton	P
MISSOURI			
University of Missouri-Rolla	Rolla	Mohamed Ben Rhouma	M
MONTANA			
Carroll College	Helena	Sam Alvey	M
Montana Tech of the Univ. of Montana	Butte	Richard Rossi	H, P

INSTITUTION	CITY	ADVISOR	I
NEW JERSEY			
Rowan University	Glassboro	Hieu Nguyen	P
		Samuel Lofland	P
NEW YORK			
U.S. Military Academy	West Point	Mike Huber	H
		Mike Johnson	H
NORTH CAROLINA			
Elon University	Elon	Crista Coles	M, M
Piedmont Community College	Roxboro	Lisa Cooley	P
OHIO			
Ohio Wesleyan University	Delaware	Richard Linder	P, P
Youngstown State University	Youngstown	Angela Spalsbury	H
		Scott Martin	M
OREGON			
Eastern Oregon University	La Grande	Jeffrey Woodford	P
Franklin High School	Portland	David Hamilton	P, P
PENNSYLVANIA			
Bloomsburg University	Bloomsburg	Kevin Ferland	P
Clarion University of Pennsylvania	Clarion	Andrew Turner	H
Dickinson College	Carlisle	Brian Pedersen	M
Lafayette College	Easton	Thomas Hill	H
TEXAS			
Texas A&M University	College Station	Jay Walton	H
VIRGINIA			
Maggie L. Walker Governor's School	Richmond	John Barnes	O, P
		Crista Hamilton	P
WASHINGTON			
Pacific Lutheran University	Tacoma	Mei Zhu	H
WISCONSIN			
Beloit College	Beloit	Paul J. Campbell	P
CANADA			
York University	Toronto, ON	Morton Abramson	P
CHINA			
Anhui University	Hefei	Cheng Junsheng	H
		Wang Dapeng	P
Beijing Union University	Beijing	Ren Kailong	P
Beijing Univ. of Chemical Technology	Beijing	Yan Cheng	H
Beijing Univ. of Posts & Telecomm.	Beijing	He Zugu	M, P

INSTITUTION	CITY	ADVISOR	I
Central South University	Changsha	Chen Xiaosong	H
		Zhang Hongyan and Zheng Zhoushun	M
Chongqing University Inst. of Math. & Phys.	Chongqing	Qu Gong	P
		He Renbin	P
Dalian University of Technology	Dalian	Liaoning and Yu Hongquan	P, P
East China Univ. of Science and Technnology	Shanghai	Ni Zhongxin	H, P
Experimental High School of Beijing Normal University	Beijing	Wang Jiangci	P
Fudan University	Shanghai	Cai Zhijie	H
		Cao Yuan	M
Hangzhou Univ. of Commerce	Hangzhou	Zhu Ling	H
Harbin Engineering University	Harbin	Luo Yuesheng	P
		Zhang Xiaowei	P
Harbin Institute of Technology	Harbin	Shang Shouting	P
		Zheng Tong	P
Harbin Univ. of Science andTechnology	Harbin	Chen Dongyan	H
		Li Dongmei	P
Hefei University of Technology	Hefei	Su Huaming	P
		Du Xueqiao	P
Jiamusi University College of Mathematics	Jiamusi City	HeiLong and Ji Bai Shan	P
Jilin Institute of Technology	Changchun	Lu Jin	H
		Bai Ping	P
		Li Yan	P
		Huang Qingdao	P
Jilin University	Changchun	ZhangKuiyuan	P
Jinan University	Guangzhou	Hu Daiqiang	P
		Zhang Lin	P
Nanjing University of Science and Technology	Nanjing	Qian ping	P
		Wu Min	P
Nankai Institute of Mathematics	Tianjin	Fu Lei	H
Northwestern Polytechnical University	Xi'an	Feng Nie	H
		Xiao Yong Hua	M
Peking University	Beijing	Liu Yulong	H, P
Shanxi University	Taiyuan	Wang Guang	P
		Ding Juntang	P
South China Univ. of Technology	Guangzhou	Liang Fa	H
		Hong Yi	P
Tsinghua University	Beijing	Hu Zhiming	M
		Ye Jun	P
University of Science and Technology of China	Hefei	Zhang Hong	M
		Tao Dacheng	M
Xi'an Jiaotong University	Xi'an	He Xiaoliang	H, P

INSTITUTION	CITY	ADVISOR	I
Zhejiang University	Hangzhou	Yang Qifan	P
		Yong He	P
Zhongshan University	Guangzhou	Chen Zepeng	P
		Tang Mengxi	P
FINLAND			
Päivölä College	Tarttila	Merikki Lappi	H
IRELAND			
University College Dublin	Dublin	Michael Mackey	H, P

## Editor's Note

For team advisors from China, we have endeavored to list family name first, with the help of Zheng Rong.