2002 年美国大学生数学建模竞赛 MCM、ICM 试题

2002 MCM A: Wind and Waterspray

An ornamental fountain in a large open plaza surrounded by buildings squirts water high into the air. On gusty days, the wind blows spray from the fountain onto passersby. The water-flow from the fountain is controlled by a mechanism linked to an anemometer (which measures wind speed and direction) located on top of an adjacent building. The objective of this control is to provide passersby with an acceptable balance between an attractive spectacle and a soaking: The harder the wind blows, the lower the water volume and height to which the water is squirted, hence the less spray falls outside the pool area.

Your task is to devise an algorithm which uses data provided by the anemometer to adjust the water-flow from the fountain as the wind conditions change.

2002 MCM B: Airline Overbooking

You're all packed and ready to go on a trip to visit your best friend in New York City. After you check in at the ticket counter, the airline clerk announces that your flight has been overbooked. Passengers need to check in immediately to determine if they still have a seat.

Historically, airlines know that only a certain percentage of passengers who have made reservations on a particular flight will actually take that flight. Consequently, most airlines overbook-that is, they take more reservations than the capacity of the aircraft. Occasionally, more passengers will want to take a flight than the capacity of the plane leading to one or more passengers being bumped and thus unable to take the flight for which they had reservations.

Airlines deal with bumped passengers in various ways. Some are given nothing, some are booked on later flights on other airlines, and some are given some kind of cash or airline ticket incentive.

Consider the overbooking issue in light of the current situation: Less flights by airlines from point A to point B Heightened security at and around airports Passengers' fear Loss of billions of dollars in revenue by airlines to date

Build a mathematical model that examines the effects that different overbooking schemes have on the revenue received by an airline company in order to find an optimal overbooking strategy, i.e., the number of people by which an airline should overbook a particular flight so that the company's revenue is maximized. Insure that your model reflects the issues above, and consider alternatives for handling “bumped” passengers.

Additionally, write a short memorandum to the airline's CEO summarizing your findings and analysis.

2002 ICM: Scrub 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 athttp://www.comap.com/undergraduate/contests/mcm/contests/2002/problems/icm2002data/scrublizard.pdf

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 Fa (the average fecundity of adult lizards); Sj (the survivorship of juvenile lizards- between birth and the first reproductive season); and Sa (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*(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 Fa , Sj , and Sa , 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 Fa, Sj , and Sa 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 (Fa), juvenile survivorship (Sj), and adult survivorship (Sa) are presented for each patch along with patch size and the amount of open sandy habitat.

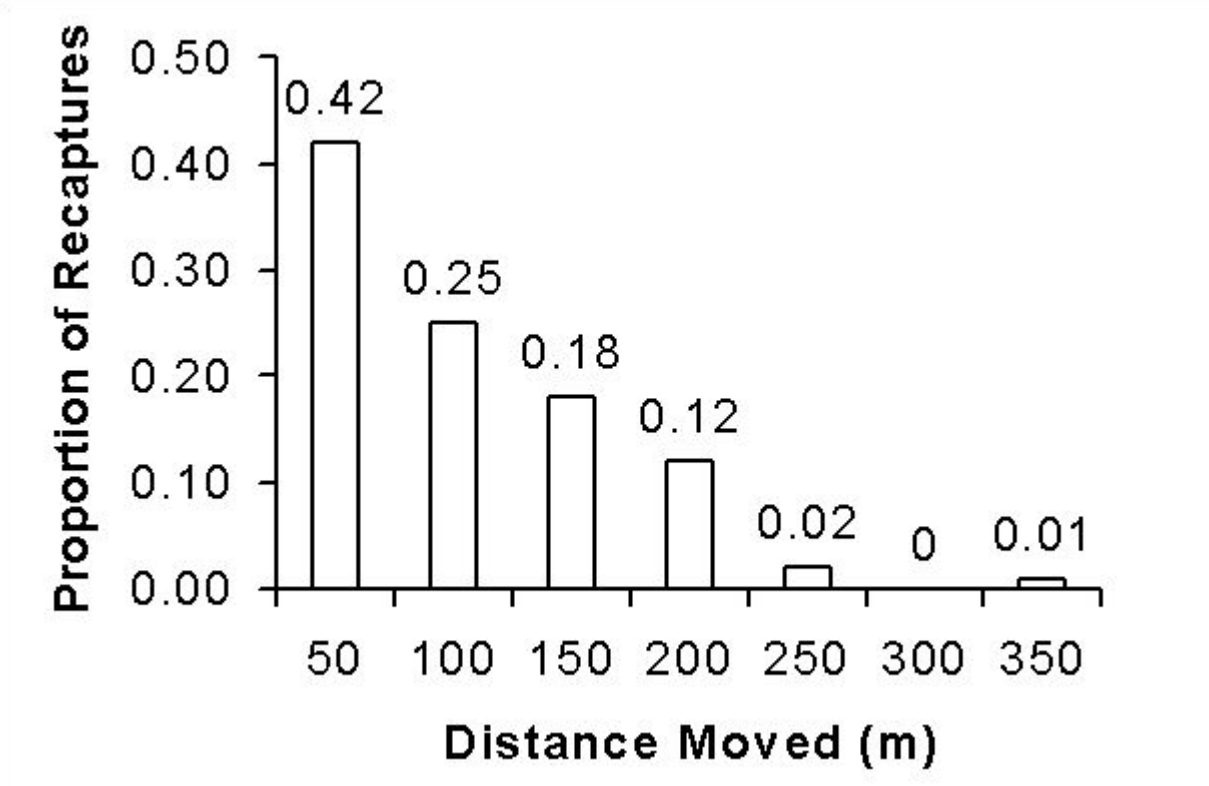
Patch	Patch Size (ha)	Sandy Habitat (ha)	Fa	Sj	Sa	Density (lizards/ha)
a	11.31	4.80	5.6	0.12	0.06	58
b	35.54	11.31	6.6	0.16	0.10	60
c	141.76	51.55	9.5	0.17	0.13	75
d	14.65	7.55	4.8	0.15	0.09	55
e	63.24	20.12	9.7	0.17	0.11	80
f	132.35	54.14	9.9	0.18	0.14	82
g	8.46	1.67	5.5	0.11	0.05	40
h	278.26	84.32	11.0	0.19	0.15	115

Task 4: There are many animal studies that 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 percent 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 below estimate the probability of lizards surviving the migration between any two patches i and patch j.

Table 3

Histogram

Migration data for juvenile lizards marked, released, and recaptured up to 6 months later. Surveys for recapture were conducted up to 750m 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.

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

http://www.comap.com/undergraduate/contests/icm/2002problem/map.jpg

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

Patch Identification	Patch Size (ha)	Sandy Habitat (ha)
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.