Math 430 - Mathematical Modeling - Project 2

The following project is due at 11:59 am on Monday, November 4. The project is to be done by groups of 4 to 5 students. You may form your own groups. However, no group can contain more than 3 people from one of the project one groups. If you don't already have a group that you want to work with, please contact me and I'll assign you to a group. Once you've formed your group, please send a message to me with the list of your team members. All groups should be formed by 5 pm Friday, October 11. If there are any students who have not yet been formed at that point I will assign students to form the complete groups.

This project is based on a mathematical modeling competition problem. You may not refer to published solutions or commentary on the contest problem. However, you can refer to general resources on wildlife population management.

A large National Park in South Africa contains approximately 11,000 elephants. Management policy requires a healthy environment that can maintain a stable herd of 11,000 elephants. Each year park rangers count the elephant population. During the past 20 years whole herds have been removed to keep the population as close to 11,000 as possible. This process involved shooting (for the most part) and occasionally relocating approximately 600 to 800 elephants per year.

Recently, there has been a public outcry against the shooting of these elephants. In addition, it is no longer feasible to relocate even a small population of elephants each year. A contraceptive dart, how-ever, has been developed that can prevent a mature elephant cow from conceiving for a period of two years.

Here is some information about the elephants in the Park:

- There is very little emigration or immigration of elephants.
- The gender ratio is very close to 1:1 and control measures have endeavored to maintain parity.
- The gender ratio of newborn calves is also about 1:1. Twins are born about 1.35% of the time.
- Cows first conceive between the ages of 10 and 12 and produce, on average, a calf every 3.5 years until they reach an age of about 60. Gestation is approximately 22 months.
- The contraceptive dart causes an elephant cow to come into oestrus every month (but not conceiving). Elephants usually have courtship only once in 3.5 years, so the monthly cycle can cause additional stress.
- A cow can be darted every year without additional detrimental effects. A mature elephant cow will not be able to conceive for 2 years after the last darting.

- Between 70% and 80% of newborn calves survive to age 1 year. Thereafter, the survival rate is uniform across all ages and is very high (over 95%), until about age 60; it is a good assumption that elephants die before reaching age 70.
- There is no hunting and negligible poaching in the Park.

The park management has a rough data file of the approximate ages and gender of the elephants they have transported out of the *region* (not just this one park) during the past 2 years. Unfortunately no data is available for the elephants that have been shot or remain in the Park. Your overall task is to develop and use models to investigate how the contraceptive dart might be used for population control. Specifically:

1. Develop and use a model to speculate about the likely survival rate for elephants aged 2 to 60. Also speculate about the current age structure of the elephant population.
2. Estimate how many cows would need to be darted each year to keep the population fixed at approximately 11,000 elephants. Show how the uncertainty in the data at your disposal affects your estimate. Comment on any changes in the age structure of the population and how this might affect tourists. (You may want to look ahead about 30-60 years.)number of elephants to be darted? Comment on the trade-off between darting and relocation.
3. Some opponents of darting argue that if there were a sudden loss of a large number of elephants (due to disease or uncontrolled poaching), even if darting stopped immediately, the ability of the population to grow again would be seriously impeded. Investigate and respond to this concern.
4. The management in the Park is skeptical about modeling. In particular, they argue that a lack of complete data makes a mockery of any attempt to use models to guide their decisions. Your final report should include both detailed technical information and an executive summary written for the park management that responds to their concerns and provides advice.
5. If your model works, other elephant parks in Africa would be interested in using it. Prepare a darting plan for parks of various sizes (300-25,000 elephants), with slightly different survival rates and transportation possibilities.