Summary

Due to the popularity of wilderness recreation such as taking river trips, managers of the wilderness recreation areas are confronted with all kinds of problems. In this article, we aim to obtain optimal strategies according to solutions of our models. Some of our findings are meaningful and applicable for river trips management.

We first formulate a partial model based on relatively strict assumptions to address the problem under a simple circumstance. Through elementary analysis and deduction, we obtain the theoretical results of the simplified problem under four different conditions. Specific results are shown in the article.

In order to obtain more realistic and applicable results, we remove some of the assumptions to address the problem under a more complicated circumstance. We introduce the network maximum flow theory to build a modified maximum flow model. Due to its complexity and significant difference from the traditional models, we design and analyze an algorithm and get the results under some simple circumstances. The results are presented in the appendix.

Since the maximum flow model is only able to generate results of the maximum capacity of the river, we then use genetic algorithm to overcome this shortcoming. The matrices that we get after iteration indicates the best schedules.

Based on previous analysis and results, we construct two computer simulation models to simulate more complicated circumstances. Through the first one, we obtain the relationship between the river capacity and the number of campsites Y, which is approximately linear. Detailed results are illustrated in Figure 3. We also conduct sensitivity analysis for the parameters of which the results indicate that our model has good stability. The other simulation model simulates what occurs in reality, taking detailed trip schedule into account. On-shore activities and how the contact affects the process of looking for campsites are considered. With this model, we obtain the numerical results and put them in Figure 8 to illustrate the relationship between the number of encounters and the incoming trips .We also calculate the satisfaction degree of tourists with this model, which is meaningful to managers.

Based on the analysis and the results of the models, we include our recommendations in the one-page memo and describe the future work that we can do.

Contents

Improving the River Trips Management Through Optimization and Simulation

Introduction

Recreation in wilderness area has always been fascinating for people all over the world. Spending some time with friends or family in wilderness on holiday gives people a chance to sense the pastoral peace so that they can refresh themselves. However, the popularity of wilderness recreation has created some rather difficult problems for managers of wilderness areas. What they need to determine is how to maximize the number of the visitors and provide visiting experiences of high quality simultaneously.

A Review of Literature

In order to address the problem of wilderness recreation management, many scholars have presented their solutions to the problem. Generally, there are two major kinds of methodology including mathematical decision modeling and computer simulation modeling. Romesburg (1974) contributed a lot in exploring how to use mathematical decision modeling could to improve wilderness recreation management. As for computer simulation modeling, there are large amounts of literature related to it. In the early 1970s, computer simulation models were built to address the wilderness recreation management problem. Based on Stankey's (1972) hypothesis of the relationship between visitor's satisfaction and the number of encounters occurred, some scholars (Heck and Webster,1973; Smith and Krutilla,1976) built their simulation models. Among which, the Wilderness Simulation Model (WSM) developed by Smith and Krutilla was improved by many scholars(Shechter and Lucus ,1978; van Wagtendonk, 1979) in the subsequent years.

Restatement of the problem

What we need to address is a river trips management problem. Despite the fact that it is a kind of wilderness recreation management problem, the methodology can be quite different from that in the literature because of the specific requirements of this problem.

Our objectives are:

- To maximize the number of the trips while minimizing the encounters occurred.
- To obtain optimal strategies of the mix of trips of duration and propulsion under different conditions.
- To calculate the carrying capacity of the river and describe the best schedules

under different conditions.

- To give suggestions on the Big Long River trips management.

Our approaches are:

- We read a lot of related literature and use details depicted on the internet about the river trips to refine our assumptions.
- We simplify the problem with strict assumptions to build elementary models at first and then modify them to address more realistic problems with more complicated methods including formulating a modified network maximum flow model and Genetic Algorithm.
- We build a complicated computer simulation model to simulate the realistic situation and make recommendations based on its results.

It is rather difficult to examine all the aspects of the problem at a time. Thus, we tried to simplify the problem with assumptions and then address it from the simplest one. Assumptions are modified to be more reasonable so that the conditions under which the problem is addressed are more realistic. In this way, it could be much easier for us to solve the complex problems in reality. As for this problem, there are more than one objective and lots of constraints. Therefore, we shall convert the problem into a single-objective one and address it through elementary analysis.

Partial Models Based on Elementary Analysis

Simplifying the problem

It is rather difficult to examine all the aspects of the problem at one time. Thus, we try to simplify the problem with assumptions and then address it from the simplest one. Assumptions are modified to be more reasonable, so that the conditions under which the problem is addressed are more realistic. In this way, it would be much easier for us to solve the complex problems. As for this problem, there are more than one objective and lots of constraints. Therefore, we shall convert the problem into a single-objective one and address it through elementary analysis.

Assumptions and Assumption Justification

- Contact is not allowed occur among trips. We make this assumption in order to simply the problem. Besides, this situation should usually be first considered because it allows a maximum wilderness.
- All the tourist teams should keep moving in the river except when camping at

night.

- All trips share the same schedule, which means that they leave or arrive at the campsite at the same time each day. This and the above assumption simplify the problem so that an elementary method can be used to make a general analysis.
- There are enough campsites for the trips. It enables all the trips to arrive at a campsite respectively at the same time in the evening.

Notations

Notations	Descriptions
D	the number of nights that a trip lasts
j	the number of days since a trip launched
D_1	the number of nights the earlier trip planed
D_2	the number of nights the later trip planed
j_1	the number of days since the earlier trip launched
j_2	the number of days since the later trip launched
Δt	the interval time of the two trips' launch time

Partial Models Under Different Conditions

In order to analyze the problem thoroughly, we need to know the detailed data. To simplify the process of the analysis, first we just take only two trips into consideration. As a result, we formulate the partial models under four different conditions.

1) Two fast boats

A fast boat launched from the First Launch. Some days later, another fast boat launched. According to the assumption that no contact allowed, we have

$$D_2 - D_1 + j_1 - j_2 \geq 0,$$

where $(j_1 - j_2)$ is the time the earlier boat ahead of. When $D_2 - D_1 + j_1 - j_2 = 0$, the interval time of the two boats' launch time Δt_1 should meet the inequality $\Delta t_1 \geq \dfrac{225}{8(Y+1)}$, which means that the first boat should launched at least Δt_1 earlier than the second boat.

2) Two slow boats

A slow boat launched from the First Launch. Some days later, another slow boat launched. In the similar discussion as above, the first boat should launch at least $\Delta t_2 = \dfrac{225}{4(Y+1)}$ earlier than the second boat in the daytime.

3) The fast ahead

A fast boat launched from the First Launch. Some days later, a slow boat launched. Two boats cannot contact, indicating

$$D_2 - D_1 + j_1 - j_2 \geq 0 .$$

When $D_2 - D_1 + j_1 - j_2 = 0$, the interval time of the two boats' launch time Δt_3 should meet the inequality $\Delta t_3 \leq \dfrac{1}{4}(\dfrac{225}{D_2+1} - \dfrac{225}{D_1+1})$, which means that the second boat should launch at most Δt_3 earlier than the first boat in the daytime.

4) The slow ahead

A slow boat launched from the First Launch. Some days later, a fast boat launched. Similarly, the interval time of the two boats' launch time Δt_4 should meet the inequality $\Delta t_4 \geq \dfrac{225}{4(D_1+1)} - \dfrac{225}{8(D_2+1)}$, which means that the first boat should launch at least Δt_4 earlier than the second boat in the daytime.

A modified network maximum flow model

Comparing to a maximum flow problem

In optimization theory, the objective of solving a maximum flow problem is to find a feasible flow which is maximum through the given single-source, single-sink flow network. Similarly, in order to find out the maximum number of trips that the river could accommodate, we need to find a way to calculate the maximum flow of trips traveling on the river. Thus, it inspires us to consider the Big Long River with campsites on its shore as a network with two terminals. The First Launch can be considered as the single source of the network while the Final Exit is the single sink. Besides, all the campsites, which distributes uniformly on shore can be viewed as the nodes of the network. Most importantly, the edges of the network represent the possible traveling direction of the boats among the nodes. From Figure1 shown below, we can clearly see what the river with campsites on shore looks like after being simplified. However, there is one characteristic that makes this digraph quite different from ordinary digraphs. What this digraph demonstrates are all the possible ways in which a boat could travel while looking for a campsite. As a result, each edge only represents a single direction from one campsite to another one further from the First Launch. Moreover, each campsite can be viewed as a node with the capacity of only one trip. Therefore, using maximum flow theory, we establish a modified network maximum flow model.

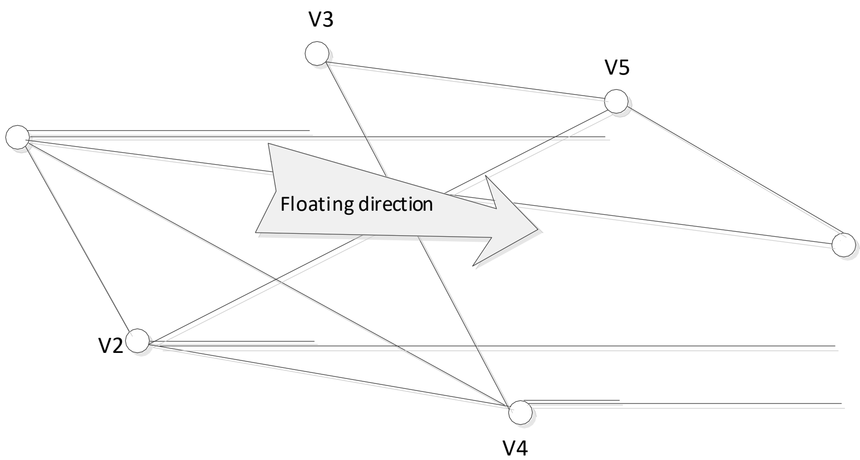

Figure 1 Digraph

Modifying the assumptions

As is depicted above, we expect this model to do better in describing the reality. Thus, we need to modify some strict assumptions made above in Model One. We list the modification of previous assumptions as follows.

- Contact with other trips on the river is considered.
- During the trip, there is time for on-shore activities including hiking and visiting the attraction sites.
- Tourist teams are allowed to choose from the given propulsion freely.
- The trip schedule varies from team to team according to their choices of propulsion and the length of the trip.
- The time spent on shore in every traveling day ranges from 1 to 7 hours. (source: http://canyonx.com/experience.php) The average time spent outside the campsite everyday is 9 hours (example: traveling from 8 a.m. to 5 p.m. each day).

With the modification being made, this model virtually relaxes all the constraints of assumptions in Model One. In order to make our assumptions more realistic, all the values of parameters are set according to online data gleaned in daily life.