Introduction

Oklahoma is developing an effective and comprehensive water plan to meet future water supply challenges. With the growth in population and income there is a growing demand for water for both consumptive and non-consumptive uses.

The water management plan will required to serve as a guide to all Oklahomans to meet the consumptive and non-consumptive needs of water for the next 50 years.

Objectives

Determine the optimal allocation of reservoir water among consumptive and non-consumptive uses to maximize net social benefit.

Examine the effect of water management of lake resources when recreational values are and are not included as control variables in the optimization process.

Data

Lake Tenkiller of northeastern Oklahoma has been chosen for this study. Historical lake level data from 1995 to 2007 were obtained from USACE website. Data from DOE and OWRB as well as survey data (Boyer et. al 2008) were also used.

Methods

Deterministic non-linear programming technique was used in this model. The model considers two consumptive uses and a non-consumptive use. A mass balance equation is used as a constraint that equates the inflows and outflows and also determine the level and volume of water in the lake. Maximum lake level were limited to maintain the flood control capability of the reservoir.

The mathematical model:

Maximize :

\[
\text{Net Social Benefit} = \sum_{m=1}^{12} (\text{Hydroelectric Power Generation Benefits}_m + \text{M & I Water Supply Benefits}_m + \text{Lake Recreational Benefits}_m)
\]

Subject to:

\[
\text{Volume}_{m+1} = \text{Volume}_m + \text{Inflow}_m + \text{Rainfall}_m - \text{Outflow}_m - \text{Evaporation}_m
\]

\[
\text{Power Generation Water Release} \leq \text{Power Generation Water Release}_{max}
\]

\[
\text{Lake Level} \leq \text{Lake Level}_{max}
\]

\[
\text{Total Water Release} \geq \text{Water Release}_{min}
\]

\[
\text{Volume}, \text{Inflow}, \text{Rainfall}, \text{Outflow}, \text{Evaporation} \geq 0
\]

*subscript m represents each month.

Results

When recreational benefits were included in the objective function of a preliminary model, both net social benefits and projected number of summer visitors, were increased by maintaining near optimal lake levels. This affected the timing of releases for power generation. Increased net benefits from recreational use were found to more than offset revenue losses from changing the timing the hydropower generation.

Discussion

The benefit from each use depends upon the lake level and/or water release. The total benefits of the lake to Oklahoma are maximized by allocating water among recreation, hydropower, and municipal uses so the net benefits from last unit of water use are equal. Benefits from municipal use varied little with price. Maximum benefits to Oklahoma from Tenkiller were obtained by first supplying municipal needs and then near optimal lake level from June-August.

Acknowledgments

The authors acknowledge Oklahoma Water Resources Research Institutes for funding this research. Special thanks to ORWA people for helping in this work.

References


Contact Information: deepayan.debnath@okstate.edu