Appendix A

Literature Review

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Beaver Lake Boating Carrying Capacity Study

Literature Review

January 2017

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Table of Contents

List of Figures

List of Tables

Acronyms

ANS	Aquatic Nuisance Species
WALROS	Water and Land Recreation Opportunity Spectrum

Literature Review

A.1 Introduction

Located in the Ozark Mountains of northwest Arkansas, Beaver Lake is a popular attraction for nature lovers and water enthusiasts during all seasons. Its recreational amenities, scenery, and clear water coupled with its location near one of the fastest growing metropolitan areas in the United States[1] makes it a prime destination for a multitude of recreational boating activities. Increases in lake visitation along with regional population growth have raised crowding-related concerns among lake managers and visitors. As a result, lake managers have been tasked with identifying a range of recreational boating use levels at Beaver Lake that address environmental protection goals while also preserving users' recreational experiences. A level of use that balances environmental protection and user enjoyment may be considered the optimum recreational carrying capacity (Reclamation 1977). Boating carrying capacity is defined to include consideration of both the number and types of watercraft on the lake.

The purpose of a carrying capacity study is to characterize "the level of use beyond which impacts exceed levels specified by evaluative standards" (Shelby and Heberlein 1986). The literature reviewed in preparation of this document suggests that carrying capacity is not a matter of computing a single maximum value of desired boating density, but instead includes perceptions of recreational users and managers as well as site-specific management goals. This document explores the methodologies and results of a variety of studies throughout the United States that evaluated ecological, facility, spatial, and social components to arrive at levels of visitor use that could be accommodated while sustaining desired resource and social objectives.

The purpose of this document is to provide an overview of the existing literature on techniques for estimating recreational boating carrying capacity. This literature review includes boating carrying capacity studies conducted for other recreational lakes around the country as well as research literature on recreational carrying capacity methodologies. This document serves as a guideline for the preparation and implementation of a recreational boating carrying capacity study at Beaver Lake.

A.1.1 Developing a Recreational Carrying Capacity Study

The overall goals and objectives of each individual study reviewed varied. Some carrying capacity studies are focused solely on one aspect of carrying capacity, such as recreational safety, while others provide a comprehensive view of the elements that may affect boating carrying capacity. The methodology used to estimate carrying capacity is specific to the overall goals and objectives of the study for each lake. Within this section, several key concepts and methodologies are reviewed, each aimed at developing management strategies to balance the recreational uses of the lake with protection of environmental resources. Overall carrying capacity may be derived using one or a combination of several of these methodologies.

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[1] The U.S. Metro Economies Report published in 2014 by HIS Global Insight shows the Fayetteville-Springdale-Rogers metropolitan statistical area as having the seventh fastest-growing economy among large metropolitan areas in the nation.

A.1.2 Concepts in Determining Recreational Boating Carrying Capacity

Key concepts common to many recreational boating carrying capacity studies include:

- Lake Use
- Useable Boating Surface Area
- Boating Density

Each of these concepts is defined below.

A.1.2.1 Lake Use

Lake use characteristics are the data that indicate how the lake is currently being used. Data may be collected using various techniques to determine use during peak and non-peak times to determine the total number of boats on the lake, types of boats in use, origin of watercraft, and the distribution of use among visitors. Peak lake use estimates allow a snapshot of current lake use during peak periods or maximum crowding conditions. These estimates are often based on boating counts taken during peak periods such as summer weekends or holidays. It is important to note that recreational users, especially visitors, may be willing to tolerate crowded conditions for a short period on high use weekends without it negatively affecting their overall experience (Bosley 2005). However, these peak periods could have negative environmental and safety impacts leading to exceedance of an optimum carrying capacity. Peak use estimates can be used to derive peak boating densities expressed as acres per boat. Boating densities can be calculated as an aggregate, applicable to the entire lake and all boat types, or may be broken down by lake zone and/or specific types of watercraft. For large lakes, such as Beaver Lake, the calculation of boating densities for various zones of the lake is encouraged, as boating use is typically unevenly distributed. For example, when evaluating safety concerns, it may be useful to isolate areas such as narrow passages or portions of the lake where operation of multiple motor boats would cause greater safety concerns. Methodologies for determining use characteristics is discussed later in this document.

A.1.2.2 Useable Boating Surface Area

Useable surface area is calculated to determine the portion of the lake that can be used for boating activities and would vary depending on which pool elevation is chosen. For example, the maximum pool elevation was used for a study at Stagecoach State Park in Colorado (Colorado State Parks 2011). The most common way to calculate usable lake surface area is to subtract a shoreline buffer zone of predetermined width (typically 100 to 200 feet) from the total acreage of the lake; however, this may not be a reliable means of estimating useable surface area for lakes with steep and/or deep shorelines (such as that of Beaver Lake). Studies also suggest buffer zones around emergent aquatic vegetation, docks, marinas, and public swimming areas (Bosley 2005).

A.1.2.3 Boating Density

Carrying capacity analyses often include the calculation of two types of boating density, current boating density and optimum boating density. Current boating density is expressed as acres per watercraft and is a snapshot of the existing conditions. It is calculated by dividing the total watercraft on a particular waterbody by the useable boating surface area. Optimum boating density is dependent on site-specific attributes and users' preferences. Reservoir-specific factors to take into account in calculating optimum boating density include water depth, shoreline configuration, lake setting and context, visitors' perceptions, number of accidents involving other boats, boat type and speed, and dominant boating activities. Past studies indicate acreage specifications from 1.3 acres per watercraft for fishing or non-motorized boating up to 3,200 acres per boat for a primitive recreational boating setting (Bosley 2005).

A.2 Components of Carrying Capacity

In reviewing past studies, it was determined that there are four main components to a comprehensive recreational carrying capacity study (EDAW 2004, Olvany and Pitchford 2010, Colorado State Parks 2011). Recreational boating carrying capacity can be determined considering any combination of these four indicators, depending on the overall goals and management objectives of the project. The four components include ecological, facility, spatial, and social carrying capacity. The procedures and data requirements for establishing standards of quality or thresholds for each of these indicators is discussed in further detail in the sections below.

A.2.1 Ecological Carrying Capacity

Ecological carrying capacity refers to the ability for the ecosystem to cope with human impacts associated with recreational activities. These would include impacts on wetlands and riparian communities, trash accumulation and pollution, soil erosion and shoreline damages, and loss of groundcover. Ecological capacity may also include impacts on cultural resources at developed and dispersed recreation areas.

Ecological carrying capacity can be one of the most difficult indicators to quantify. In many cases, the presence of a single boat can be as disturbing as many boats, depending on the activity (Colorado State Parks 2011). Impacts to the natural environment can be measured from major disturbances and may be either short or long term, depending on the impact. These may include shoreline erosion or damage, a significant drop in waterfowl rafting, damage to vegetation, deterioration of water quality, increased trash or pollution, and/or dispersal of invasive plant species (Olvany and Pitchford 2010). Water quality related impacts, including pollution and increases in turbidity, can be measured through establishment of a long-term surface water sampling plan. Other impacts, such as shoreline erosion and vegetative damage, may take several years of field observations to document trends. One study indicates that portions of a lake less than 5 feet deep are the most susceptible to environmental impacts, including turbidity, shoreline erosion, destruction of fish spawning areas, and loss of fish and wildlife habitat (Rajan and Pradeepkumar 2011). Ecological impacts can also be qualitatively measured through user survey questions aimed at perceptions of water clarity and quality and/or shoreline property owners' perceptions of shoreline damage and erosion.

A.2.2 Facility Carrying Capacity

Facility carrying capacity refers to the ability of the recreational facilities to accommodate the number of users. Facilities may include parking lots (boat trailer and vehicle parking), marina slips, boat launches, and other day use sites. Analysis of this component may include metrics such as wait times to use facilities or parking space vacancy rates.

Facility carrying capacity is dependent on the size of available facilities and metrics such as boat launch procedures for each reservoir. In a study completed at Stagecoach State Park in Colorado, estimates of facility capacity included an evaluation of wait times to complete Aquatic Nuisance Species (ANS) inspections prior to boat launch (Colorado State Parks 2011). Reservoirs that do not require inspections could derive launch wait time estimates from monitoring and recording boat launch waits during several peak season times. Estimates of facility capacity may also include field counts of available boat trailer and vehicle parking spaces and/or available marina slip rentals during peak boating periods (CDM Smith 2012).

Facility capacity can be used as the limiting factor to avoid impacts associated with other forms of recreational carrying capacity (Colorado State Parks 2011). For example, if spatial carrying capacity is close to being exceeded, then by managing the facility capacity it may be possible to influence actual boat density and thus maintain spatial carrying capacity goals.

A.2.3 Spatial Carrying Capacity

Spatial carrying capacity refers to physical constraints of the lake related to its size and useable area for various types of boating activities. Spatial carrying capacity is the number of boats that can comfortably operate their chosen recreational activity in a specific area of the reservoir. This aspect of carrying capacity must take into account the useable acreage of the reservoir and it includes an evaluation of use characteristics that indicate how the lake is being used.

In recreational boating carrying capacity studies, techniques used to estimate the total number of boats in use during peak and non-peak times may include on-the-water surveying, aerial fly-overs, and/or parking lot vehicle counts (Bosley 2005). Field data collection of boat density on smaller lakes may include scanning the water with binoculars from various vantage points along the shoreline (Lake Ripley Management District 2003) or boat surveys of open water and shorelines (Cherokee CRC 2010, JFNEW 2007). Larger lakes may require fixed wing or helicopter flyovers (JFNew 2007, Pinecrest Lake 2012, CDM Smith 2012) or the use of aerial photography (ERM, Inc. 2004). In some cases, aerial photography can be used to validate the findings of on-water or aerial observations. Boat count and boat type data can also be collected during field surveys of launch or ANS inspection points. Additionally, maximum boating density can be estimated via collection of watercraft registration within townships and counties with little out-of-area visitation (JFNew 2007). Counts of vehicles and/or boat trailers at marinas and boat launches may provide estimates of watercraft origin (CDM Smith 2012).

On-the water surveying provides a point in time capture of boat use and allows collection of data on number, location, and boat type, speed, and activity. Boat speed may be relevant dependent on overall project goals and management objectives and can be recorded generally as fast-moving (i.e., wake producing) or stationary and slow-moving (Lake Ripley Management District 2003). Additionally, shoreline surveys conducted via slow-moving boats can be utilized to record moored, docked, and beached watercraft. Boat speed and shoreline counts can be used to estimate lake use rate and use patterns (Warren and Rea 1989). Launch and ANS inspection point data provide insight into the number and types of watercraft on a lake during a particular time and general information on the point of origin. In each of these methodologies, watercraft are generally classified as speed boats, pontoon boats, fishing boats, personal watercraft, sailboats, or paddle craft (canoes, kayaks, and inflatables).

Each of these methods results in a watercraft census, which provides either a snapshot of the number of boats on the lake or reservoir during a specific point in time or an estimate of potential maximum watercraft density. In order to provide the most accurate picture of actual usage, the census should capture activity at several points in time (Doshi 2006). While an estimate of the number of boats on the water during peak use periods is essential to any carrying capacity study, additional information, including boat type, boat speed, shoreline counts, and/or off-peak counts offer insights on different aspects of overall use and management. For example, it may not make sense to base management protocols solely on the number of boats on the water, but instead to factor in increases in the number of motor or speed boats, which typically need greater surface acreage for safe operation (Warren and Rea 1989). Analysis of spatial carrying capacity may also include indicators of boating safety such as analyses of historic and current boating accident data. This data can be viewed for the entire lake or by lake zones to indicate any areas of concern.

A.2.4 Social Carrying Capacity

Social carrying capacity refers to visitors' perceptions of crowding as defined by a lake's users. This capacity is reached when conflict arises or when the user chooses to no longer utilize the resource (Colorado State Parks 2011).

Users' perceptions of optimal boating density are measured via survey instruments. These may include onsite field surveys at ramps and marinas, telephone surveys, and/or mail surveys. Generally, responses to onsite surveys are aimed at perceptions of crowding on a specific day, whereas users' responding to mail-back or telephone surveys report their overall perceptions of crowding. Onsite surveys are considered advantageous because reported perceptions are more closely linked to an actual experience; however, both survey methods can be used to determine the threshold at which users' can no longer enjoy the lake due to their personal perception of crowding.

Carrying capacity surveys most commonly utilize a 5- or 9-point Likert-type scale or digital enhanced photograph simulations to gage users' perceptions of crowding (Bosley 2005). Enhanced photographs are used to illustrate different levels of crowding. Questions associated with these photos may include: What is your preferred boating level; in which photo is the boating level so high that you would no longer use the lake; and which photo indicates a level at which management actions should be taken? Examples of both a Likert-type scale question and photo simulations are shown in Figures 1 and 2, respectively (taken from ERM, Inc. 2004).

How crowded was the lake *today* in terms of boat traffic? (circle number)

Not Crowded				Very Crowded
1	2	3	4	5

Figure A-1. Likert-Type Scale Question

Onsite contact surveys can be administered on shore at boat ramps and/or marinas or on the lake by boat. Mail-back surveys are often distributed randomly to groups likely to have utilized the lake, including adjacent property owners, dock permit holders, marina slip renters, and campers. It is important to develop a sampling plan which results in a sample representative of various user groups

(ERM, Inc. 2004). For example, many studies have found that, especially in rural areas, crowding thresholds of residents are significantly lower than those of visitors from metropolitan areas.

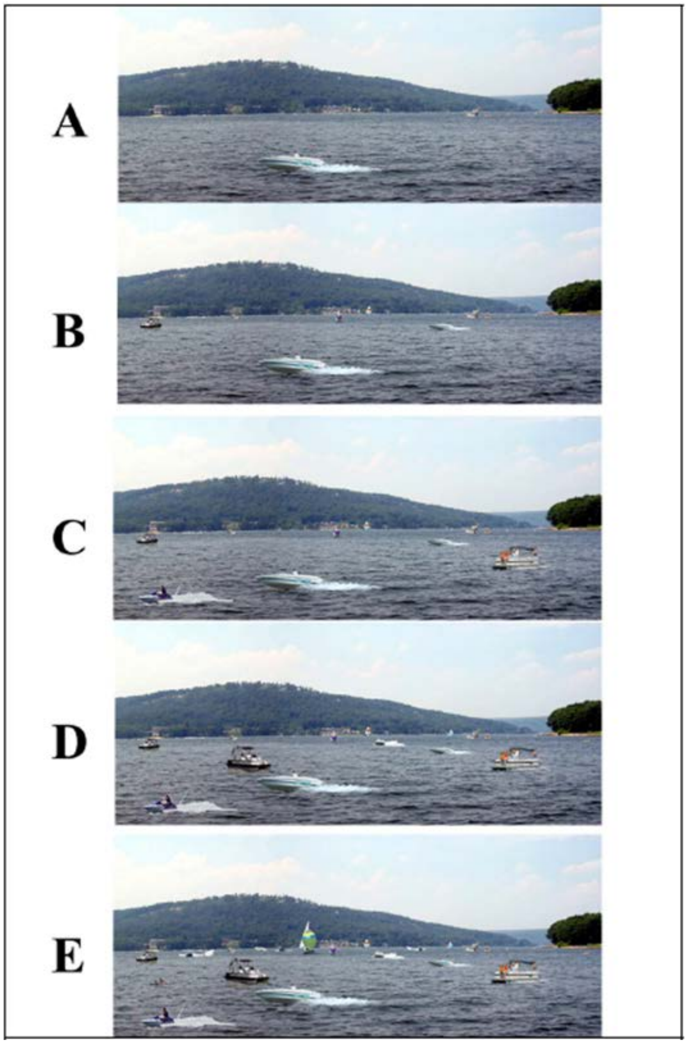

Figure A-2. Example of a Photo Simulation (Source: Deep Creek Lake Study, ERM Inc. 2004)

A.3 Calculating Carrying Capacity

Most studies include components of each of the types of carrying capacity described in the previous section. Overall and zone-specific optimum recreational boating carrying capacity is calculated for a specific lake based on the types of data collected during the study.

Approaches to calculating spatial carrying capacity are the most common type described in the literature. The following sections describe methods used in previous studies. When appropriate data is collected, optimal carrying capacities would also be calculated for each additional component analyzed. For example, optimal social carrying capacity could be determined via statistical analysis of coded survey responses.

A.3.1 Calculating Spatial Carrying Capacity

Calculating the spatial carrying capacity is an essential step in describing the recreational boating carrying capacity of a lake. This calculation will likely include use factors based on published optimum boating densities. The spatial capacity may include consideration of boat type ratios as determined from the field data of existing conditions. While many studies have suggested an optimal number of acres per boat or boat type, the estimates vary widely and often are dependent on one activity in isolation rather than in combination of other uses. Examples of published optimum boating densities are shown in Table 1.

Table A-1. Summary of Published Optimum Boating Densities

Source	Use/Type of Watercraft	Suggested Density
Ashton (1971) [1]	All combined Uses	5-11 acres/boat
Kusler (1972) [1]	Waterskiing only All other uses	40 acres/boat 15-20 acres/boat
Jackson *et al*. (1989) [2]	Waterskiing and motor-boat Fishing Sailing, kayaking, canoeing All uses combined	20 acres/boat 10 acres/boat 8 acres/boat 10 acres/boat
Warren and Rea (1989)	Motorboats Fishing Boats Sailboats Canoes/Kayaks Waterskiing	9 acres/boat 1.3 acres/boat 4.3 acres/boat 1.3 acres/boat 12 acres/boat
Wagner (1991) [1]	All boating activities	25 acres/boat
Warbach *et al.* (1994) [1]	All motorized uses	30 acres/boat
National Recreation and Park Association (NRPA)[2]	All boating activities	4 acres/boat
Bureau of Outdoor Recreation (BOR) [2]	All boating activities	9 acres/boat
Arizona Outdoor Recreation Coordination Commission[2]	All boating activities	10-20 acres/boat
Wisconsin Comprehensive Plan[2]	All boating activities	20-40 acres/boat
Louisiana Parks and Recreation Commission[2]	All boating activities	20-40 acres/boat
Olvany and Pitchford (2010)	All boating activities	15-20 acres/boat

[1]Found in Doshi 2006
[2]Found in Bosley 2005

In a study of carrying capacity and lake user attitudes for three lakes in Oakland County, Michigan, Ashton (1971) identified optimum boating density ranges of 5 to 9 acres per boat, 4 to 9 acres per boat, and 6 to 11 acres per boat depending on the specific lake. Jaakson *et al*. (1989) studied three lakes in north-central Saskatchewan and identified different boat densities depending on the type of boat (see Table 1). Jaakson *et al*. (1989) assumed an average of 10 acres per boat for acceptable safe boating. These conclusions were value judgements based solely on field observations, and the authors note that such findings are not readily transferable to other lakes. Furthermore, Jaackson *et al*. (1989) state that carrying capacity values for other lakes should be calculated based upon the “morphology of a lake, cultural tolerances of density, and safety considerations of the manner in which water-oriented recreation activities are carried out." Wagner (1991) reported that, based on the viewpoints of many boaters, one boat per 25 acres of water surface is considered sufficient for all recreational boating activities (racing, fishing, skiing). Racers and water skiers feel restricted at less than 10 acres per boat and nearly all motorized watercraft users feel crowded at less than 5 acres per boat. Warbach *et al*. (1994), concluded that approximately 30 acres per motorboat (greater than five horsepower) is an appropriate boat density.

Olvany and Pitchford (2010) completed a study on Canandaigua Lake which included a field survey to determine existing peak boat densities followed by development of a lake-specific carrying capacity using four methodologies. The final recommendation was a carrying capacity range of 15-20 acres/boat. Each of the four methodologies used to arrive at this recommendation is described below.

- Carrying Capacity Analysis & Ordinances Providing Lake Access Regulations: This model for developing a carrying capacity was developed in Michigan and uses a scoring matrix that accounts for various characteristics of inland lakes. Scores for each characteristic fall under either a less restrictive or more restrictive carrying capacity. The differences in sums of the less restrictive and more restrictive categories is used to calculate overall carrying capacity. Characteristics considered include a lake shape factor, bottom soil type, and percentage of shoreline development. For Canandaigua Lake, the analysis resulted in a total carrying capacity of 38 acres per boat.

- Weighted Average Approach: This approach utilized suggested carrying capacities from the literature by boat type as applied to the observed percentages of boats by type that were on the lake during peak day field observations. For Canandaigua Lake, this method resulted in an overall density of 12.6 to 16.8 acres/boat.

- Proportion of High-Speed Watercraft Approach: This approach used the percentage of high-speed watercraft from field observations in the equation: Carrying Capacity (in acres per boat) = 10 + 5*(proportion of high-speed watercraft). This approach resulted in a suggested carrying capacity of 13.5 acres/boat for this lake.

- Water and Land Recreation Opportunity Spectrum (WALROS): The WALROS approach was applied to Canandaigua Lake and resulted in a classification in the mid-range of the spectrum. Therefore, the resulting carrying capacity identified from this approach was 15 to 35 acres per boat. The WALROS approach is explained in detail later in this document.

Another method for estimating lake-specific, optimal, spatial carrying capacity involves multiplying zone-specific boat type ratios collected during field studies by published optimum boating densities. This approach was utilized in a carrying capacity study completed on Deep Creek Lake in Maryland (ERM, Inc. 2004). This study utilized the optimum boating densities proposed by Warren and Rea (1989) (shown in Table 1). The results of this study are summarized in Figure 3.

		% Boat Use by Zone		
Type of Watercraft	Use Factor	North	Central	South
Motorboats -	9.0 acres per boat	59.8%	59.5%	50.3%
Boat fishing -	1.3 acres per boat	32.2%	32.0%	27.0%
Sailboats -	4.3 acres per boat	0.4%	2.1%	15.4%
Canoes/kayaks -	1.3 acres per boat	0.0%	1.0%	0.3%
Waterskiing boats -	12.0 acres per boat	7.6%	5.4%	7.0%

Figure A-3. Deep Creek Lake Boat Use by Zone

The final carrying capacity calculation for each lake zone takes into consideration the zone's useable surface area, boating use mix, and watercraft use factor (density). Warren and Rea (1989) have developed a set of equations that first divide each zone's usable acreage by the use factor to determine the maximum number of boats by boat type to give a number of boats that should use that zone at any one time. The maximum number of boats is then weighted by the zone-specific percentage of boat use (per spatial analysis) to determine the estimated carrying capacity by boat type.

Similar calculations would be completed for each boat type and lake zone. Summations would be made to determine total lake-wide optimal physical boating density. Optimal spatial carrying capacity estimates are often compared with suggested boating densities determined by the WALROS classification for the specific lake as a means of validating assumptions.

A.3.2 Calculating Social Carrying Capacity

There are no precise standards for determining social carrying capacity. Warren and Rea (1989) suggest that once 33-percent of respondents to photo simulations indicate that the pictured use level is sufficiently high to discourage boating, the carrying capacity has been reached. A study completed in 2004 (ERM, Inc.) suggests that social carrying capacity limits are reached when mean crowding ratings approach 5 on a 9-point Likert scale and over 40 percent of boaters report experiencing moderate to high crowding levels.

Setting appropriate thresholds involves an understanding of the specific lake context and characteristics, user mix, and perhaps use history. Local focus groups might be helpful in identifying lake appropriate thresholds for social carrying capacity.

A.3.3 WALROS

As described above for the Canandaigua Lake study, one approach to evaluating capacity is through the application of the WALROS to a specific lake to describe the lake setting and context. WALROS was developed by the U.S. Department of the Interior, Bureau of Reclamation (2011) and is used to classify recreational opportunities systematically in order to determine appropriate management strategies. The six WALROS classes range across a spectrum of urban, suburban, rural developed, rural natural, semi-primitive, and primitive recreation opportunities. The combination of lake specific (or lake zone-specific) recreation activities, settings, experiences, and benefits define each of these classes. Table 2 provides an overview of the physical, social, and managerial attributes used to differentiate the six WALROS classes.

Table A-2. Attributes Used to Differentiate WALROS Classes

Physical Attributes	Social Attributes	Managerial Attributes
Degree of major development Distance from major development Degree of natural resource modification Sense of closeness to a community Degree that natural ambiance dominates the area	Degree of visitor presence Degree of visitor concentration Degree of recreation diversity Degree of solitude and remoteness Degree of non-recreational activity	Degree of management structures Distance to developed recreation facilities and services Distance to developed public access facilities Frequency of seeing management personnel

The system is aimed at balancing recreational opportunities with the goals of the community while providing planners and managers with a framework and procedures for making decisions that conserve a spectrum of high quality recreational opportunities. Tables 3 and 4 are from the WALROS User's Handbook and illustrate the proposed range of reasonable boating capacities based on classification of an area according to the WALROS system (US Bureau of Reclamation 2011).

Table A-3. WALROS Range of Suggested Boating Capacity by Class

WALROS Class	Range of Boating Coefficients	
	Low End of Range	**High End of Range**
Urban	1 acre/boat	10 acres/boat
Suburban	10 acres/boat	20 acres/boat
Rural Developed	20 acres/boat	50 acres/boat
Rural Natural	50 acres/boat	110 acres/boat
Semi-Primitive	110 acres/boat	480 acres/boat
Primitive	480 acres/boat	3,200 acres/boat

WALROS is an extremely useful tool for conducting complex recreation studies. It provides a template for establishing the physical, social, and managerial attributes of a study area; conducting recreation area and facility inventories; quantifying and mapping the current supply of recreation opportunities; establishing recreation-related carrying capacities; and analyzing potential impacts associated with various alternatives (CDM Smith 2012).

The exercise of evaluating a lake or lake zones by the WALROS categories helps managers understand the context in which users experience the lake. The classification system helps to explain differences in user perceptions between lakes and may illuminate how lake zones on a large lakes vary from each other.

Table A-4. WALROS Boating Capacity Range Decision Tool (from WALROS)

The purposes of this decision tool are to help ensure that managers consider important factors affecting boating capacity and to help document the reasoned analysis used in making a boating capacity decision. For each WROS zone, consider the following factors that may affect boating capacity. *Circle the descriptor that best matches the situation.* The preponderance of the answers will indicate which part of the capacity range may be more reasonable.

Typical size of boats	<15 feet	16 to 25 feet	>25 feet
Typical speed of boats	<10 mph	10 to 25 feet	>25 feet
Diversity of boating:			
1. different types of boats	low	moderate	high
2. different size of boats	low	moderate	high
3. different speed of boats	low	moderate	high
Boater visitation pattern	simple/ predictable	moderate	complex/ unpredictable
Level of boater stewardship/ civility/respect for resource and others visitors	high	moderate	low
Shoreline configuration	simple/ circular	moderate	complex/ meandering
Boater destination or pass-through area	pass-through corridor/in-transit	mixed	destination area/overnight area
Extent of sensitive resources/ potential for impact	low	medium	high
Compatibility with adjacent recreation/non-recreation land uses	high	moderate	low
Islands/shallows/hazards	infrequent	occasional	frequent
Historic public safety record/ accidents/complaints/conflicts	infrequent	occasional	frequent
Level of boater management/rules/ information/education/compliance	high	moderate	low
Other factors:			
Suggested capacity range	**lower end (more boats)**	**mid-range**	**higher end (fewer boats)**

A.4 Utilizing Results

The final step in evaluation of carrying capacity involves comparing the calculated boating carrying capacity to the actual use or current boat density. Based on the difference between the existing condition and the estimated range of desired conditions, management goals and procedures may be adjusted. In addition, projected future conditions can be compared to the calculated optimal carrying capacity as a way to evaluate alternative management plans.

Management actions could be taken to adjust the existing, or projected future, conditions to bring user densities closer to the estimated optimal carrying capacity condition. Such actions could include continued monitoring, expansion or reduction of recreational facilities such as marinas, parking lots, private boat docks, or boat launches, restrictions on speed and horsepower, or increased water patrol and law enforcement. Some studies have also analyzed the effects of future growth, taking into account population projections and expansion plans to estimate future lake use conditions (Bosley 2005).

A study conducted in Michigan by Progressive AE (2001), suggests activities for curtailing use of lakes in cases where capacity is limited or met. Management activities specific to boaters may include watercraft control ordinances such as boating speed limits, establishment of wake controls, and curfew hours on high-speed boating activities. Limitations on renewal and expansion of marina facilities, restrictions on road-end use as public access facilities, and increased dissemination of information regarding boating laws coupled with aggressive enforcement can all be utilized to curtail future increases in use.

No single optimal carrying capacity standard will satisfy all lake users in all situations, as users will have different perspectives on what constitutes crowding. In addition, each lake is unique and identification of an overall optimum recreational boating capacity should take into account site-specific attributes. The future projected conditions must also be evaluated to incorporate potential ecological, facility, and spatial impacts, as well as user perspectives and opinions. The demand for various activities and the condition of the lake must be considered to set realistic goals and standards. Each component can be weighted based on overall project goals and objectives to determine an overall recreational boating carrying capacity.

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