

CAPITOL REEF NATIONAL PARK
TINAJA WETLAND SURVEY

PROPOSAL
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Introduction

A survey of tinajas located within the Waterpocket Fold of Capitol Reef National Park (CARE) will be initiated in June, 1993 (tinajas include the aquatic and wetland riparian vegetation resources). The purpose of this survey is to determine the extent of tinaja wetland drainages within the Waterpocket Fold and to categorize wetlands for further study.

Tinajas are depressions eroded out of sandstone bedrock by the action of water, wind, or other physical or chemical weathering processes (Spence and Henderson 1993). Those in CARE differ from the typical pothole or plunge pool found throughout the southwest in that they occur as a series of discrete pools (except during runoff) within a relatively small, sloping drainage ($<1 \text{ km}^2$). It is the Waterpocket Fold, a 160-km long sandstone monocline, which has facilitated the creation of these tinaja wetlands and drainage systems. The tinajas in CARE are most abundant in Navajo sandstone and range in size from small, ephemeral pools to large perennial pools. Some have well-developed stands of riparian vegetation while others are surrounded by bare rock.

Various classification schemes have been developed for wetland systems in the United States (Martin et al. 1953, Shaw and Fredine 1956, Cowardin et al. 1979). Cowardin's classification has become the most accepted system and is being

used in the National Wetland Inventory. Under this hierarchical classification the tinajas would be palustrine systems with rock bottoms, unconsolidated bottoms, or aquatic beds. The substrate could be further classified as bedrock or sand. This system is not sufficiently specific and will not adequately represent the full scope of tinajas at CARE. It would provide only three types of wetlands since classifying to dominance type would require a more intensive study.

Although there has been a plethora of articles written about the prairie potholes and a classification system designed for them (Stewart and Kantrud 1971), the tinajas differ greatly from the prairie potholes. The basis of the prairie pothole classification system is water depth and the extent of vegetation in zones around the wetland. Because tinajas are often cup-shaped (i.e., deep throughout their basin) and occur in sandstone basins with little or no soil development, discrete vegetation zones (e.g., deep marsh, wet meadow) based upon a continuum of decreasing moisture from the center to the edge of a wetland do not occur.

Just as others have developed wetland classification systems for a specific region (Kurz and Wagner 1957, Stewart and Kantrud 1971, Golet and Larson 1974, Aikens and Jefferson 1973, Millar 1976, Brown et al. 1981)), we believe that a separate classification system is necessary for tinajas. By devising a specific classification system we can more easily understand the parameters important in determining the chemical and biological

dynamics of the tinajas. The classification system developed for the tinajas will be hierarchical following Cowardin (1979) and Stewart and Kantrud (1971), however, parameters applicable to tinajas will be assessed (e.g., exposed or protected).

Several papers discuss the formation, types and significance of potholes or rock tanks (Elston 1917, 1918, Bryan 1920,). Bryan (1920) describes five types of rock tanks he identified in the southwestern United States: 1) plunge pools, 2) normal potholes, 3) joint-block irregularities, 4) scour depressions, and 5) riffle hollows. Of these, normal potholes seem to be most similar to Capitol Reef's tinajas. Elston (1917) elaborates on the formation of normal potholes found in New York, however, he doesn't attempt to classify them.

Although studies have investigated the biology and physiochemical characteristics of rock pools in the southwestern U. S. (Romney 1971, Dodson 1987, VanHaverbeke 1990, Haefner and Lindahl 1991), no classification system has been proposed for the unique biological, chemical, and physical characteristics of tinajas. In their classification system for surface water sources of the southwest, Brown et al. (1981) identified potholes as a category within one level of their system, however, potholes themselves were not classified further. Brown and Johnson (1983) inventoried and characterized individual tinajas at Organ Pipe National Monument based upon selected physical parameters, however, there was no classification scheme developed. Big Bend National Park has inventoried their tinajas, however, they have

not measured any parameters except flow when it occurs (Mike Fleming, Resource Management Specialist, Big Bend National Park, pers. commun.). Haefner and Lindahl (1991) classified the 28 tinajas they studied at Capitol Reef into six types based upon their physical and temporal features (e.g., volume and tank duration, respectively). However, during the course of their study they found that there were many abiotic and biotic variables among tanks of similar size and duration that made them quite different from each other. In this inventory we will include a variety of features so that the tinajas can be more narrowly grouped.

Project Objectives

With this background information, the following are the specific objectives of the survey:

- 1) To determine the locations of all major tinaja drainages and tinajas within the Waterpocket Fold; to produce a map of these drainages and tinajas using GIS.
- 2) To categorize and group tinajas based on physical and biological characteristics.
- 3) To determine those features of the Waterpocket Fold which predict the presence of significant drainages and the permanence of individual tinajas.
- 4) To determine the number of tinajas or tinaja drainages susceptible to impacts caused by future developments, i.e., increased visitor and stock use. Such impacts include trampled vegetation, increased erosion and sedimentation, decreased water

quality, and displaced wildlife.

Methods

An aerial reconnaissance of the Waterpocket Fold at the southern end of Capitol Reef (south of Highway 24) will be conducted. General locations of tinaja drainages will be plotted on 7.5 minute USGS topo maps. From previous work, it is known that tinaja drainages are concentrated from the Burr Trail to the southern end of the park. Therefore, the aerial reconnaissance will concentrate on locating drainages north of the Burr Trail.

After the aerial reconnaissance, systematic surveys will be conducted on foot from the Burr Trail to the park's southern boundary and in areas north of the Burr Trail where tinaja drainages were identified during the aerial survey. Teams of two people will hike along the eastern side of the Waterpocket Fold entering each drainage encountered. Each drainage will then be specifically plotted on a USGS topo map and given a unique identification number. The team will hike the length of each drainage and then draw a detailed sketch map showing the relative location and size of each tinaja found within the drainage. If available, GPS technology will be used to identify accurate UTM coordinates. Location data will be entered into the park GIS (ARC/INFO) and a map produced showing drainage locations and individual tinaja complexes. A photograph will be taken of each tinaja and each tinaja drainage.

Basic information will be collected at each tinaja and recorded on a standard data sheet. This information will be used

in developing the classification system used to group the tinajas for further biological and chemical characterization. The parameters we have selected to measure are based upon the work of Brown and Johnson (1983), Haefner and Lindahl (1991), Spence and Henderson (1993) and personal observations and sampling of five tinaja drainages each containing several tinajas by CARE's Resource Management and Science (RMS) staff. Advice was also provided by Dr. Jill Baron of the National Park Service's Water Resources Division and Dr. Tim Graham of the Cooperative Park Studies Unit at the University of California at Davis (previously worked on tinajas at Capitol Reef and other parks throughout the Colorado Plateau). Dr. David Cooper from the Department of Fishery and Wildlife Biology at Colorado State University has agreed to join the park's RMS staff in a field trip to some tinajas to discuss our selected parameters and methods of measuring. Since he will be visiting us prior to initiation of our field work, we will be able to incorporate his recommendations into the project. Dr. John Spence, who has done considerable work on the vegetation of tinajas within Capitol Reef, has also agreed to join us in the field in May, 1993, to discuss our proposed methods of assessing the riparian vegetation.

Following is a discussion of each parameter to be measured. Although we may later discover that some parameters are not important in grouping the tinajas, we are attempting to measure all variables that may be important and can be quickly measured

by trained personnel.

Volume: Because it incorporates both surface area (the evaporative interface of a water body) and depth, volume will be used as one indicator of the permanency of the tinajas. At each tinaja maximum length and width will be measured using the high water mark (usually readily apparent in the sandstone) by extending a tape measure across the tinaja. Maximum depth will also be measured at the high water mark by lowering a weighted rope marked at 0.5 m intervals from a rope extended across the tinaja. These measurements will be used to estimate an index to tank volume based upon 1/2 of an ellipsoid ($V=2/3 abc$) where $a=length/2$, $b=tank\ width/2$, and $c=tank\ depth$ (Haefner and Lindahl (1991, Dodson 1987)).

Exposure: The relative degree of exposure to the sun of each tinaja during the summer season will be categorized as exposed, protected, or very protected. Following Brown and Johnson (1983) and Spence and Henderson (1993) an exposed tinaja is defined as one that receives almost no shade during the day. A protected tinaja is one that receives some shade in the morning or afternoon, while a very protected tinaja is one that rarely receives sunlight. The shading can be from overhanging vegetation, boulders, cliffs or rock walls. The amount of exposure will have an impact on the permanency of the tinaja by affecting evaporation and wind. It will also affect water temperature which will impact the chemical and biological characteristics of a tinaja.

Sediments: The type of sediment within the tinaja will be recorded as bedrock or sand. If sand is present, the relative amounts will be estimated as small, medium, and large. Following Brown and Johnson (1982) a small amount of sediment would occupy less than 10% of the maximum volume of the tinaja. A medium and large amount would be 10 to 50% and greater than 50% of the maximum volume, respectively. This will indicate whether the tinaja is acting as a sink for sediments or if sediments are being carried further down the drainage. It will also have an impact on its permanence. This may be difficult to estimate when there is cloudy water in the tinaja.

Emergent Vegetation: During sampling by CARE's RMS personnel, it was observed that emergent vegetation (primarily Typha sp.) harbors different taxa of macroinvertebrates than does non-vegetated areas. Therefore, the extent of emergent vegetation within each tinajas is an important parameter to include in this classification system. The amount of the tinaja basin with emergent vegetation will be categorized as 0, 1-25%, 26-50%, 51-75%, and >75%. The dominant species will also be recorded.

Riparian Vegetation: Spence and Henderson (1993) found that vegetational patterns among tinajas in CARE were related to pool size and degree of protection from the sun. Riparian vegetation can affect the water chemistry and biology in many ways. It can act as a buffer around a tinaja, moderating impacts from flash floods; it can filter out and trap sediments and debris from water moving downstream; it can contribute allochthonous material

to the tinaja; and it can influence the permanency of the tinaja by evapotranspiration and shading. In an attempt to characterize these functions within each tinaja the following variables will be assessed:

1) The percent cover of riparian vegetation within two zones around the tinaja. Percent cover will be estimated visually and categorized as zero, 1-25%, 26-50%, 51-75%, and 76-100% in the near zone (0-3 m from the basin) and far zone (3.1-6 m from the basin). This will provide a visualization of the extent of riparian vegetation around a wetland.

2) The vertical structure of the riparian vegetation. This will be assessed by looking at the riparian vegetation within the two zones identified above and estimating the percent of the riparian vegetation composed of herbaceous vegetation, shrubs or small trees less than 2 m tall, and trees.

3) The dominant (by % cover) species of tree, shrub, and herb within the riparian zone will be recorded. Because we will be employing a seasonal biological technician and a Student Conservation Association volunteer to conduct these inventories, we will not be able to teach them all the vegetation they may encounter around a tinaja. The trees and shrubs will likely be readily learned, however, the herbs will be more difficult. However, we are including it here and during our hiring process will be looking for someone with a botanical background.

Position in the Drainage: The position of a tinaja within a drainage is important since it can impact whether organisms and

debris are imported from tinajas above or exported to tinajas below. Those tinajas intermediate or low in the drainage will receive the cumulative energy of the precipitation falling in the watershed and flowing downhill. Although only a small amount of rain may fall on the tinaja itself, it may receive a great deal more as the runoff accumulates in its basin. Some may be scoured from the force of the water, while those lowest in the drainage may act as sinks for the debris and sediments carried with the water. In contrast, those high in the drainage will have few impacts from flash floods and will primarily receive precipitation that falls in the basin itself.

The position in the drainage may also affect the number of hikers visiting a tinaja with those lower in the drainage getting more use than those high in the drainage. The position in the drainage will be classified as high (within the top one-third), intermediate (in the middle one-third) or low (within the bottom one-third).

Slope: The slope of the substrate will be measured to determine the viability of using this variable for predicting the presence of these drainages. From observations by CARE personnel, the tinaja drainages appear to be most abundant in areas of the Waterpocket Fold where the percent slope is less than 70% but greater than about 30%.

Water Color: Because the color of the water can provide an indication of the water chemistry (iron) and biology (phytoplankton), it will be recorded (Jill Baron, pers. commun).

These tinajas are within the Navajo sandstone and therefore may have high iron or manganese levels. Color will be classified as clear, rusty, or green (others may be added). Presence of a rust colored staining on the sandstone at the outlets and inlets of each tinaja will also be noted. The presence of an oily sheen, an indication of organic oils in the tinaja, will be noted since it could inhibit evaporation.

Water Quality: Conductivity, which is an indication of total dissolved solids, will be measured in each tinaja. From our previous monitoring we know that conductivity is typically low (<100 umhos) in these tinajas, however, it is influenced by water volume. Because conductivity could affect the composition of aquatic species inhabiting a tinaja, it is an important parameter to monitor. If possible, pH will also be measured at each tinaja since our previous monitoring has shown variation in pH among tinajas.

Distance to Nearest Trailhead: This parameter will have an impact on the number of hikers that are likely to visit a tinaja. This will be categorized based upon the proximity of the tinaja to one of the following four access routes: The Lower Muley Twist Cutoff Trail parking area; Hall's Creek Overlook; the Airstrip Route; and Lake Powell. The distance will be estimated from a topo map and categorized as 0-2 miles, 2.1 - 5 miles, 5.1 - 10 miles, and >10 miles.

Accessibility: This will also influence the number of hikers that potentially visit a tinaja. It will be based upon the

difficulty of reaching a tinaja once in the drainage due to the presence of obstructions such as choke stones or waterfalls. Accessibility will be categorized as readily accessible (no obstruction); accessible (obstruction which can be hiked around); inaccessible (major obstruction which requires climbing skills to get around).

Evidence of use: Notes will be made on evidence of the use of each tinaja by hikers and wildlife. For hikers, the area will be inspected for footprints and evidence of camping. Relative abundance of wildlife tracks and scats will be recorded, if possible, as well as any species observed.

Aquatic Organisms: A list of macroinvertebrates and amphibians seen within each tinaja will be recorded. An aquatic D-net will be used to sample invertebrates and tadpoles that may be inhabiting those areas of the tinaja where organisms are less visible (e.g., deep water and vegetated areas). Sweeps will be made in each habitat type until no new taxa are found. Technicians conducting these surveys will be trained to identify invertebrates to the family level.

Data Analysis

All data collected during the tinaja inventory will be entered into a computer database (DBASE IV). Tinajas will then be grouped by the various measured parameters using cluster analysis and a classification scheme will be devised. A subset of wetlands within each group will be selected for an in-depth study of their chemical and biological characteristics.

Personnel: 1-2 volunteers, 1-2 biological technicians under the supervision of Capitol Reef National Park's Resource Management Specialist and Biologist.

Time Frame: The tinaja inventory will begin in the summer of 1993 as soon as personnel are available. We expect that the inventory will continue for two field seasons thereafter. The majority of survey work will take place during the spring-summer-fall period of both 1993 and 1994. The actual time required to complete the survey will depend upon the number of drainages and tinajas encountered and the number of people assigned to the project. The first year's survey will provide a sufficiently large sample to classify the tinajas and select those for further chemical and biological characterization.

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