



Analysis of trumpeter swan habitat on the Targhee National Forest of Idaho and Wyoming
by Mary Elizabeth Maj

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management

Montana State University

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Abstract:

Trumpeter swan habitat was studied on the Targhee National Forest, Idaho and Wyoming in 1980 and 1981. Comparative analyses of habitat variables were performed on three presently, three historically and three non-used lakes in an effort to define nesting and brood rearing habitat. Swan production on the Forest was documented from 1979 through 1981. Thirteen swan nests and nest sites were measured and qualitatively described. Six to nine nesting pairs were located on the Forest. An average clutch size of 4.4 eggs and hatching success of 84% resulted in a total of 26 cygnets fledged from the Forest. Analyses of egg composition, dimensional measurements, the time of cygnet mortality and the consistently poor production over many years on particular lakes indicate that mortality may be site specific. Statistically significant differences in alkalinity, carbon dioxide, dissolved oxygen, total hardness, pH and conductivity, and carbon dioxide, temperature and pH were detected between lake groups and monthly averages, respectively. The area of the study lakes ranged from 5.3 to 59.3 hectares, average water depth ranged from 0.36 to 4.5 meters. Presently and historically used lakes had significantly greater shoreline irregularity. Although the abundance of emergent or submergent vegetation was not significantly different between the three lake groups, significantly more total vegetation was found in presently used lakes. The greatest species diversity in vegetation and invertebrates was found in presently and historically used lakes. Results of the study indicate that swans are utilizing eutrophying lakes on the Targhee for nesting, while the non-used lakes are more oligotrophic. The historic and current number of breeding pairs on the Forest appears to be closely associated with the tristate population. Unoccupied historically used lakes show a high degree of similarity with the presently used lakes. Based on these similarities, it would appear that nesting habitat is not limited on the Targhee. The number of trumpeters utilizing the Targhee for nesting are more likely regulated by the number of individuals recruited into the area from Red Rock Lakes National Wildlife Refuge.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Trumpeter swan habitat was studied on the Targhee National Forest, Idaho and Wyoming in 1980 and 1981. Comparative analyses of habitat variables were performed on three presently, three historically and three non-used lakes in an effort to define nesting and brood rearing habitat. Swan production on the Forest was documented from 1979 through 1981. Thirteen swan nests and nest sites were measured and qualitatively described. Six to nine nesting pairs were located on the Forest. An average clutch size of 4.4 eggs and hatching success of 84% resulted in a total of 26 cygnets fledged from the Forest. Analyses of egg composition, dimensional measurements, the time of cygnet mortality and the consistently poor production over many years on particular lakes indicate that mortality may be site specific. Statistically significant differences in alkalinity, carbon dioxide, dissolved oxygen, total hardness, pH and conductivity, and carbon dioxide, temperature and pH were detected between lake groups and monthly averages, respectively. The area of the study lakes ranged from 5.3 to 59.3 hectares, average water depth ranged from 0.36 to 4.5 meters. Presently and historically used lakes had significantly greater shoreline irregularity. Although the abundance of emergent or submergent vegetation was not significantly different between the three lake groups, significantly more total vegetation was found in presently used lakes. The greatest species diversity in vegetation and invertebrates was found in presently and historically used lakes. Results of the study indicate that swans are utilizing eutrophying lakes on the Targhee for nesting, while the non-used lakes are more oligotrophic. The historic and current number of breeding pairs on the Forest appears to be closely associated with the tri-state population. Unoccupied historically used lakes show a high degree of similarity with the presently used lakes. Based on these similarities, it would appear that nesting habitat is not limited on the Targhee. The number of trumpeters utilizing the Targhee for nesting are more likely regulated by the number of individuals recruited into the area from Red Rock Lakes National Wildlife Refuge.

INTRODUCTION

Before the turn of the century, Trumpeter Swans (*Cygnus buccinator*) bred throughout North America from North Carolina, Texas and California to Alaska and Ontario, Canada (Coale, 1915) (Figure 1). The locations at the extremes of their ranges were believed to have supported only small groups of swans. Prior to the 1900's, the most significant breeding habitat for trumpeters south of Canada was believed to be located in three ecologically distinct regions. These regions include southern Minnesota and northern Iowa, the Flathead Valley of western Montana and those portions of Montana, Wyoming and Idaho which encompass the Red Rock Lakes National Wildlife Refuge (RRLNWR), Yellowstone (YNP) and Grand Teton (GTNP) National Parks (Banko, 1960).

During the late 1800's, many observers spoke of the eminent extinction of this species. Surveys conducted in the 1930's accounted for less than 100 individual trumpeter swans in the contiguous United States. Reduction in numbers and distribution was surmised to have been caused by extensive habitat loss and exploitation of the birds for food and trade items as man moved south and westward (Rogers and Hammer, 1978).

Today, only the RRLNWR-YNP-GTNP complex supports a native breeding population south of Canada. The precursors of this tri-state population were believed to have been short distant migrators, as is the present population. Due to their essentially nonmigratory

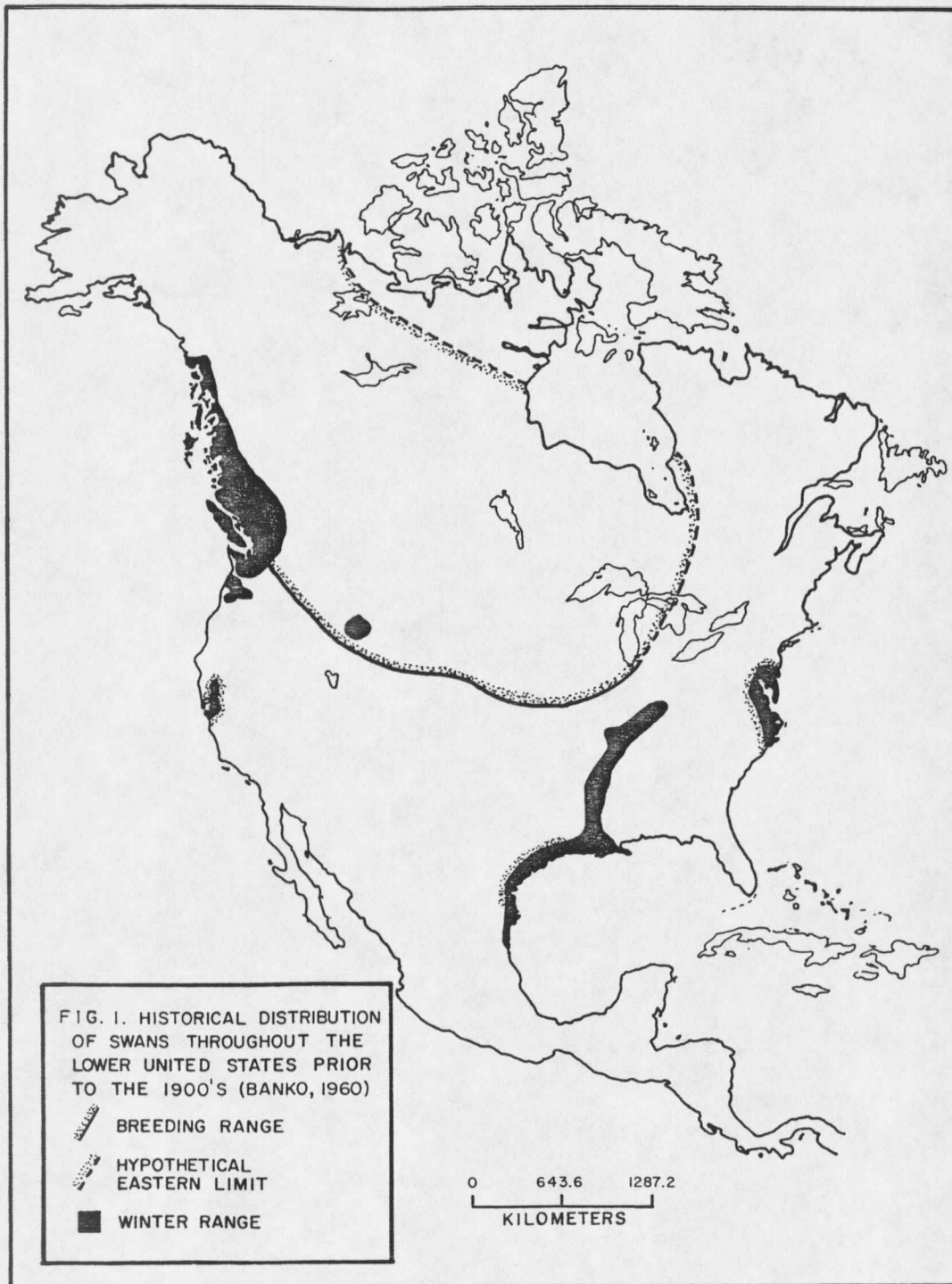


Figure 1. Historical distribution of swans throughout the lower United States prior to the 1900's.

behavior, and the protection and inaccessability of essential habitat surrounding and making up YNP and RRLNWR, this small population was able to persist. Three years after the establishment of Red Rock Lakes Refuge in 1935, restoration and introduction of swans into new and historic breeding areas began. The remnant stock of trumpeters located on the RRLNWR were utilized for these programs.

Difficulty in accurately distinguishing the trumpeter from the smaller Whistling Swan (*Cygnus columbianus*) led to the delayed verification of an Alaskan population until 1954 (Hansen et al., 1971). The Alaskan population, numbering about 9,000 birds, has recently been expanding its distribution throughout the state. Originally discovered along the Copper River Delta in southwestern Alaska, eight subgroups are now identified between the Kenai Peninsula and Fort Yukon (King and Conant, 1981).

Geographically separated from the Alaskan population, the mid-continent population, totalling approximately 1,000 birds, is made up of swans nesting throughout Alberta, Canada and the previously mentioned tri-state population. The migratory Canadian swans winter with the tri-state birds in southeastern Idaho along the Snake River. Continued increases in the midwinter counts throughout this wintering territory lead many to believe the Canadian segment is slowly pioneering new breeding areas. Discovery of the Alaskan population and recovery and continued production of the trumpeter throughout North America led to the removal in 1968 of this bird from its rare classification (Trumpeter Swan Society, 1969).

The Targhee National Forest (TNF) provides suitable nesting habitat for the tri-state population. Swan use on the forest was first documented in 1932. Since that time, 44% of the lakes located within the Ashton District have been used as nesting sites (Table 17). Surveys made between 1932 and 1981 account for an average annual adult and cygnet population of 23 and 6, respectively (Table 18).

Cygnet mortality, in excess of 70%, has reduced the recruitment of young birds into the tri-state population (Page, 1976; Shea, 1979). Due to extreme climatic conditions, only eleven cygnets were known to have fledged in this area during 1980, six of which were fledged on the Ashton District.

Increasing use of the Forest's resources has the potential to impact trumpeter swans and/or their habitat. The Forest is currently undergoing an accelerated timber harvest in order to salvage timber being infected by the Mountain Pine Beetle (*Dendroctonus ponderosa*). Key lakes fall within the oil and gas Overthrust Belt and the Island Park Geothermal Area. Conversely, manipulation of aquatic habitats provides an opportunity to enhance trumpeter swan habitat on the Forest.

The purpose of this study was to develop a management plan based upon the ecological characteristics of trumpeter swan nesting and brood rearing habitat. The specific objectives of the study were:

- 1) Document trumpeter swan distribution and production;
- 2) Characterize breeding and brood rearing habitat through comparisons of physiochemical and biotic parameters of 12 selected lakes;

3) Quantify structural dimensions of trumpeter swan nests.

Familiarity with the study area and preliminary data on trumpeter swan distribution and production were obtained in 1979 while assisting with a study on the cause of pre-fledging mortality in Yellowstone National Park and the Targhee National Forest.

The first year of field research was conducted from June through September, 1980. Four additional days were spent in May determining swan distribution, nest site use and clutch sizes. The second field season extended from late April through mid-October, 1981.

STUDY AREA

Location

The study area is located within the boundaries of the Ashton Ranger District, approximately 90% of which is in Fremont County, Idaho, with the remaining 10% in Wyoming's Teton County (Figure 2). The elevational range of the District is between 1677 and 3047 meters (m) with the specific study lakes lying between 1829 and 1982 m.

By law the U.S. Forest Service is responsible for the management of the wildlife habitat within its jurisdiction (The Multiple Use-Sustained Yield Act of 1960). The wildlife resource itself is the responsibility of both the Wyoming and Idaho Fish and Game Departments.

Climate

The climate of the area is characterized by moist weather accompanied by low temperatures in the winter and reduced precipitation and warm, dry days in the summer. Sixty-six percent of the mean annual precipitation (46.41 centimeters (cm)) occurs during the winter in the form of snow (Final Environment Impact Statement for the Island Park Geothermal Area, Idaho, Montana, Wyoming, 1980). The mean annual temperature is 5.6°C for the Ashton, Idaho vicinity with extremes of -8.9°C and 17.8°C, occurring during January and July, respectively (Table 1).

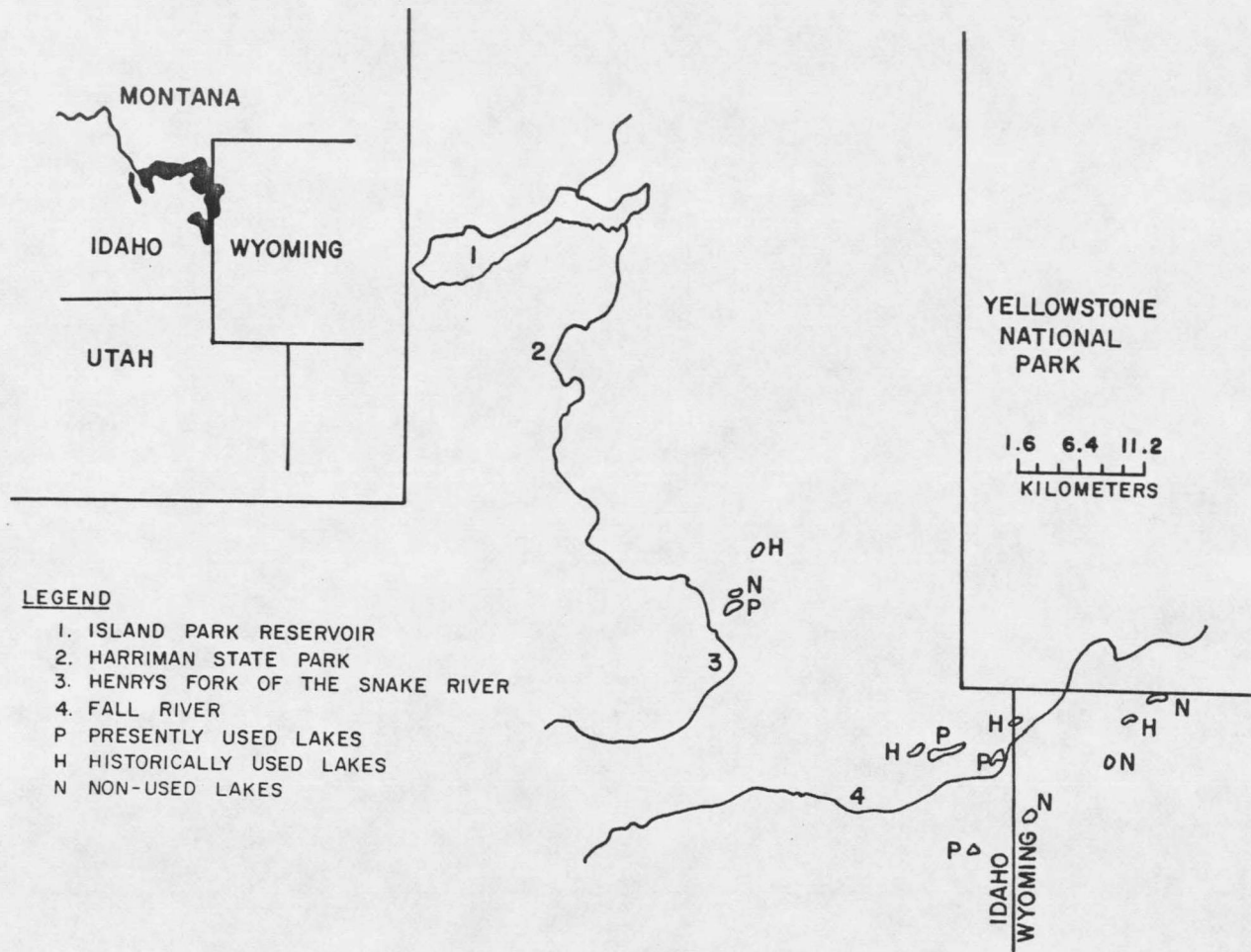


Figure 2. Map of the general location of the Targhee National Forest (insert) and location of specific study lakes on the Forest.

Table 1. Temperature and precipitation during the study measured at Ashton, Idaho. (Climatological data for Idaho).

Month	Temperatures				Precipitation			
	Ave. Min.	Ave. Max.	Ave. Temp.	Departure from Normal	Total	Departure from Normal	.25 cm to 1.26 cm	1.27 cm to 2.53 cm
1980								
April	58.8	30.0	44.4	3.7	.78	-0.44	4	0
May	63.2	39.0	51.1	0.1	4.73	2.86	11	3
June	71.9	42.7	57.3	0.2	.89	-1.32	4	0
July	80.5	48.9	64.7	1.0	1.43	0.79	3	1
August	76.2	45.2	60.7	-1.1	2.32	1.28	3	2
September	72.1	40.6	56.4	2.4	1.31	0.16	3	1
1981								
April	65.1	31.7	43.9	3.2	1.76	0.54	5	0
May	61.1	8.9	50.0	-1.0	5.68	3.81	11	6
June	71.0	43.1	57.1	0.0	1.34	-0.87	4	1
July	82.8	47.3	65.1	1.4	0.95	0.31	2	1
August	85.4	49.0	67.2	5.4	0.34	-0.70	1	0
September	75.7	39.8*	57.8*	3.9	0.46	-0.69	3	0

There was no record of daily temperatures below 0°C nor precipitation greater than 2.54 cm.

* Incomplete monthly data.

Geology

Volcanic activity has influenced the structure and composition of the local geologic features. This is most notable along the eastern and northern boundaries of the District where the Yellowstone Plateau and Island Park Caldera, respectively, are the prominent topographic features. Metamorphic rocks are found throughout the area, influencing the local soils and aquifers. Glacial activity provided outwash to the stream channels and valleys (Whitehead, 1978).

Vegetation

The proposed Land Management Plan for the Targhee National Forest (1981) identifies six unique management units for the Ashton District. These units are distinguished by their vegetational composition, physiogeographic features and continuity of resource management. The study lakes occurred in two of the units.

Nine of the study lakes occurred in a unit to the south of Yellowstone National Park where glacial activity has left a zone highly diversified with shallow lakes, seeps and marshes. These habitats are typically vegetated with sedge, rushes and grasses with a shrubby overstory of willow (*Salix* spp.). Douglas fir (*Psuedotsuga menziesii*) grows along the major streams with alpine fir (*Abies lasiocarpa*) and spruce (*Picea* spp.) scattered throughout. Resource management of this area is designed to protect and enhance wildlife habitat found within its boundary.

Three of the lakes were located in a unit in the northcentral part of the District. Downcutting by the Henrys Fork of the Snake River and the Warm River has left this country with rugged topography and steep narrow canyons. Lodgepole pine is the predominate vegetation. In addition to managing this area for its high scenic and recreational value, timber salvage programs will continue.

Water

Three watersheds found on the District include the Falls, Henrys Fork of the Snake and the Warm rivers. Marshes, ephemeral ponds, lakes and two reservoirs make up 600 hectares (ha) of the District. Prior to entering the District in the north, the thermally fed Henrys Fork meanders through Idaho's Harriman State Park. This Park is the primary wintering site for the mid-continent trumpeter swan population (Shea, 1979). It is believed that the Ashton District swans winter here, within 64 kilometers (km) of their summer habitat.

METHODS

Lake Selection

Information from the U.S. Fish and Wildlife summer swan surveys was used in the selection of 12 study lakes. Lakes were selected on the basis of recent and historical swan use and non-use. Geographic proximity, relative sizes of the lake, drainage characteristics and land management were also used as criteria.

Distribution and Productivity

Information on swan distribution and productivity was attained through aerial and ground observations. The first of two aerial censuses was flown on June 10, 1980. On July 14, 1980, one more flight was conducted in order to determine cygnet survival and brood movements.

The chronology of ice break up, nest construction and incubation was observed in the spring of 1981. Persistent rain and snowfall precluded daily visits to some of the lakes in April and May of 1981. Each nest site was visited once in order to weigh and measure eggs and determine clutch size prior to hatching (June 1).

Daily visits to the nest sites were initiated one week prior to the expected day of hatching and were continued for one month in order to determine hatching success and cygnet survival. Expected hatching dates were based on previous records (Shea, 1979). Since the cygnets

were often brooded on the nest for the first 24 hours following hatching, unhatched eggs were not collected until the cygnets were spending most of the daylight hours in the water (2-3 days post hatching). Loss of any cygnets (death or overland brood movement) was followed up with an intense search throughout the lake with emphasis on shorelines, nest mounds and loafing sites. After the first month following hatching, visits were reduced to at least one per week to determine brood survival and movement.

Postmortem Examination

Dead cygnets and unhatched eggs were sent for examination to the U.S. Fish and Wildlife Health Lab, Madison, Wisconsin in 1980 and to the Animal Health Lab, Diagnostic Lab, Bozeman, Montana in 1981. Unhatched eggs collected in 1981 were weighed, measured and their contents examined for embryo development.

Egg Composition

The contents of two unhatched eggs collected in 1981 were sent to the Ral Tech Scientific Services Laboratory, Madison, Wisconsin for analysis. The amount of moisture, fat, carbohydrates, calories, protein and ash were determined for each egg. ICP spectroscopy was used to quantify calcium, phosphorous, magnesium, manganese, zinc, sodium and iron. One was selected from a nest site at RRLNWR from which cygnets have been successfully fledged in recent years. This egg was considered the standard. An egg from the Ashton District was selected from a nest site that has been active but from which cygnets

had not been fledged until 1981. Records from this nest site date back to 1978 (Shea, 1979).

Morphometric Measurements

Morphometric parameters examined on each of the 12 study lakes included: area, depth, length, breadth, shoreline development and length and water fluctuations. Area, length, breadth, and shoreline development and length were determined using aerial photographs and an electronic digitizer. Depth profiles were determined on all lakes in 1980. Using a weighted rope, measurements were taken at 9 m intervals along the length of each lake with four additional lines bisecting the longitudinal transect. On large lakes or those of irregular shape, an additional bisecting transect was added. Additional depth measurements were obtained along the vegetation transects.

Shoreline development was calculated by dividing the lake perimeter by the circumference of a circle having an area equal to that of the study lake (Wetzel, 1975).

Water fluctuation was determined using a 1 m long, wooden lath. Each lath was marked at 1 cm increments and placed at 1 to 5 m from the shore. Water depth was read at least once every two weeks from June through September.

Lake breadth was the greatest distance between opposing shorelines that bisected the line defined as lake length at right angles. Lake length is defined as the greatest distance between the most distant points on opposing shorelines, excluding land interference (Wetzel, 1975).

Water Chemistry

Seven water chemistry parameters were measured monthly from June through September in 1980 and 1981. Water samples were collected along one of the vegetation transects in water less than 2 m deep.

Conductivity was measured with a Beckman conductivity meter. All other measurements, excluding water temperature, were made with a Hach Model DR-EL (Direct reading engineers laboratory) portable water analysis laboratory. The methods used for measuring water chemistry variables were those presented with the Hach water analysis kit.

Aquatic Invertebrates

Aquatic invertebrates were collected once a month from June through September in 1980 and 1981 on all study lakes. In 1980, a single, 20 m sweep sample was taken along the vegetation transect on each lake. In 1981, the sampling sites were increased to four per lake and three sampling methods, sweep, core samples and an emergent trap were used. Sample sites were placed in areas of repeated swan use or along one of the coordinate directions on lakes where swans were not present.

Sweep samples were collected with a funnel net, 30.48 cm in diameter at the open end, with netting which measured 5.51 squares to the cm. In 1981, the sweep sample was increased to 50 m. A core sample was collected in a 1.2 m long PVC tube, 4 cm in diameter with 10 cm increments marked along the outside. The sample was taken in

water no greater than 40 cm in depth in which the tube was imbedded 10 cm into the substrate. Two emergent traps as described by Speros (1968) were used on each lake from June through August. The traps were randomly placed among emergent or floating vegetation and the contents collected every 5 days. This sampling method was discontinued after the peak of invertebrate emergence in August.

All samples were preserved for later identification. Samples were washed through a screen sieve (U.S. series equivalent 40), 35 mesh to the inch, 0.417 mm openings, prior to sorting. Invertebrates were identified using Pennak (1978), Usinger (1965), Merritt and Cummins (1978) and Wiggins (1977).

The U.S. Forest Service Aquatic Ecology Laboratory in Provo, Utah identified and quantified half of the 1980 invertebrate samples. Data analyses were performed on the June and July invertebrate samples.

Aquatic Macrophytes

Aquatic vegetation was sampled each month from June through September on all 12 study lakes during both field seasons. Sample sites were located in areas of habitual swan use or, if swans were never present, in areas that appeared representative of the lake vegetation. A 1 m square frame was floated on the water surface at each of ten stations and percent cover by species was occularly estimated for both surface (emergent and floating) and bottom (submergent) vegetation. Hitchcock and Cronquist (1973) was used for plant identification.

During 1980, vegetation was estimated at 3 m intervals along a 30 m long transect starting at the shoreline and extending perpendicular to the shore. In 1981, four 100 m transects were established in each lake parallel to the shoreline in water no deeper than 1 m. Estimates were made at 10 m intervals.

Vegetation Maps

Lake vegetation was mapped from infrared aerial photos taken of 7 lakes on July 14, 1980 and of 5 lakes on July 11, 1981. Percent open water, emergent, submergent and floating vegetation were quantified for each lake using an electronic digitizer. Ground truthing aided in the delineation of macrophyte composition and distribution. Since stands consisted of more than one plant species, vegetation descriptions were based on dominate plants and their associated species.

Nest and Nest Site Parameters

Quantitative measurements at each nest were taken as described by Kaminski and Prince (1977). Measurements and the description of the surrounding vegetation were made after abandonment or hatching occurred.

Data Analyses

Analysis of variance and the Student's t test were used to test for significant differences among the measured habitat parameters (Lund, 1979). A test was considered significant if the null

hypothesis was rejected at $\alpha=.05$. A pair-wise comparison was performed when a significant difference was detected between lake groups or months. This analysis permitted identification of the specific month(s) or lake group(s) that had significantly different data values.

RESULTS

Distribution and Production

Sixty-five bodies of water, ranging from small ephemeral ponds less than 1.8 ha to large man-made reservoirs greater than 380 ha, exist on the Ashton District. Since 1932, trumpeter swan use has been recorded on 48 of these bodies of water. The recorded presence of a nest of cygnets has been used as the criteria for classifying 29 of these lakes or marshes as nesting territories (Table 17). The assumption that the presence of cygnets constitutes a nesting territory is not entirely valid as brood movement between lakes prior to fledging has been reported (Shea, 1979; Banko, 1960). However, this criterion appears to be the most consistent method for determining production from historical data.

The average adult and cygnet population on the District since 1932 has been 23 and 6, respectively. These 50-year averages constitute 6% of the tri-state adult population and 7% of the tri-state cygnet population (Figure 3). The average cygnet to adult ratio has been 0.26 which differs insignificantly from the tri-state cygnet to adult ratio of 0.27.

Arrival on Breeding Grounds

In 1981, all lakes were still completely frozen on April 1. By May 9 all lakes were ice free. Variations in ice free dates within

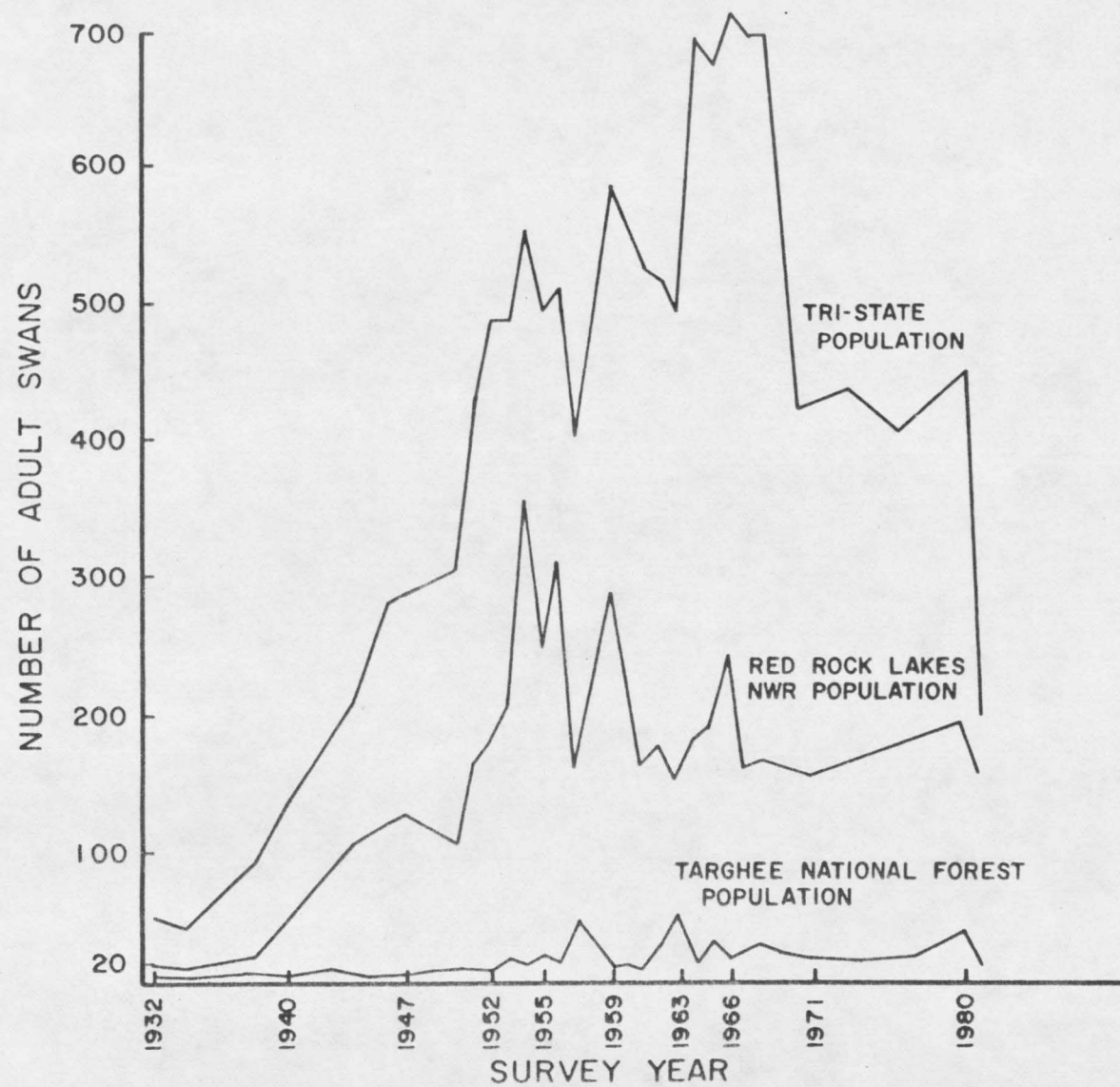


Figure 3. Adult trumpeter swan populations in Montana, Idaho and Wyoming from 1932 to 1981.

one year are attributed to differences in elevation (Table 2), the amount of vegetation and spring runoff of the individual lakes.

Table 2. Elevation and thawing dates of some lakes on the Ashton Ranger District, Idaho and Wyoming, 1981.

Location	Elevation (m)	Thawing Dates
Richey Pond	1616.9	April 1
Krapu Pond	1799.5	April 22
Long Meadows Lake	1866.6	April 27
Chain Lake	1915.4	April 29
Swan Lake	1866.0	May 1
Mesa Marsh	1805.6	May 1
Bergman Reservoir	1952.0	May 1
Indian Lake	1952.0	May 1
Thompson Hole Lake	1891.0	May 1
Steele Lake	1927.6	May 1
Lower Goose Lake	1891.0	May 1
Mesa Marsh Pond	1805.6	May 1
Eccles Marsh	1870.6	May 4
Loon Lake	1966.6	May 9
Fish Lake	1966.6	May 9
Moose Lake	1964.2	May 9

Trumpeter swans were present on the District in both 1980 and 1981 prior to the start of the research. Between April 22 and May 11, 1981, 23 adults and one immature swan were observed at 22 different locations on the District (Table 3). However, it was believed that some of the sightings were observations of the same individuals at different sites. Others have observed the early spring arrival of pairs to their breeding areas prior to ice-out (Shea, 1979; Banko, 1960). Prior to ice breakup in the early spring, feeding probably occurs on the wintering grounds 64 km to the northwest along the Henrys Fork of the Snake River. By the middle of April, feeding sites in the form of ephemeral ponds and marshes created by runoff are available. New growth of *Ranunculus*

Table 3. Locations of trumpeter swans on the Ashton Ranger District, Idaho and Wyoming, during 1981.

Location	Aquatic Habitat Classification	No. Swans	First Sighting	Last Sighting
Mesa Marsh	Marsh	2	April 22	Oct 11*
Thompson Hole	Lake	2	May 4	Oct 11
Eccles	Marsh	2	May 13	Oct 11
Long Meadows	Lake	2	April 27	Oct 11
Indian	Lake	2	April 24	Oct 11
Chain Lake	Lake	2	April 29	Oct 11
Swan Lake	Marsh	2 AT-1 CYG	April 20	Oct 11
Krapu	Ephemeral pond	2	April 22	May 15
Bear Lake	Lake	2	April 27	Oct 11
Rock Lake	Lake	2	May 9	Oct 11
Ernest Lake	Lake	2	May 11	May 11
North Vance Pond	Ephemeral pond	1	May 1	May 9
North East Eccles	Marsh	2	May 13	May 15
North West Eccles	Marsh	2	May 17	May 19
South West Steele	Ephemeral pond	2	April 27	May 1
Pineview	Lake	2	June 16	Oct 11
East Widgit	Ephemeral pond	2	June 16	July 6
Widgit	Lake	4	June 16	July 6
Beaver Pond	Ephemeral pond	2	April 22	May 13
North Antelope Flats	Ephemeral pond	2	May 8	May 14
Wyoming Creek	Ephemeral pond	2	April 27	April 27

* October 11, 1981 was the last day on the district.

sp., *Sparganium* sp., *Utricularia* sp. and *Typha* sp. have all been observed in the open water by mid-April.

Territory and Territorial Defense

In most instances (90%), only single pairs were observed on a given lake throughout the summer. The size of a territory was thus determined by the size of the lake which ranged from 5.3 to 100.8 ha and averaged 15.2 ha.

Two cases were observed when more than one pair of swans were present on a lake simultaneously. From August through September, 1979, eleven swans utilized Indian Lake. One pair nested and resided there all summer but was unsuccessful in brood rearing. Confrontations between the nine intruding swans and the resident pair were rarely observed. Due to the large size of the lake (100.8 ha), avoidance may have been the mechanism that reduced confrontations as the nine intruders were never observed within a 90 m radius of the nest site. Set territories were not defined or defended by the intruding swans although a moving area around distinguishable pairs was defended. Intraspecific aggression displayed as vocalization, chasing and wing stretching was observed when one pair approached another. Similar displays were described by Hansen et al. (1971), Banko (1960) and Shea (1979).

Territorial defense was observed in 1981 when a single adult trumpeter flew overhead and later tried to land on Eccles Marsh (13 ha). The resident pair vocalized as the single adult flew above the marsh. Upon landing, the intruder was quickly driven off by the

resident individuals. The chase continued into the air until the intruder was no longer in view. After the nesting pair returned, a mutual display of head bobbing, wing flapping and vocalization was observed.

Interspecific aggression described by Shea (1979) was never observed although a pair of Canada geese (*Branta canadensis*) nested on Eccles in full view of the swans nest mound. Moose and waterfowl frequented the lakes occupied by nesting trumpeters during the summer. At no time was there any behavioral display that appeared aggressive in nature between these species and the swans.

Nest Construction

Nest construction had been initiated prior to the start of both field seasons but was observed to continue into the start of incubation in May, 1981. My observations of the involvement of both adults, gathering of nest material and the creation of a moat surrounding the nest concurred with those previously described by Banko (1960) and Hansen et al. (1971). After incubation was initiated, maintenance of the nest consisted of a single incubating adult picking material from the outer edges and drawing this material to the center of the nest.

Nest and Nest Site Description

During the study, 13 nests, 2 in YNP and 11 on the Ashton District, were examined and described (Table 4). Five of the nests were built upon an anchored mound of sod, vegetation and mud. These mounds were often constructed by the swans within a stand of emergent

Table 4. Description of trumpeter swan nest and nest sites on the Ashton Ranger District, Idaho and Wyoming, and in Yellowstone National Park.

Location	Vegetation around Nest	Nest Mound Structure	Average Water Depth around the Nest (cm)	Distance to Shore (m)
Swan Lake (Hwy) 1980 and 1981	<i>Typha</i> , <i>Carex</i> <i>Scirpus</i>	Muskrat mound (?)	29	100
Mesa Marsh 1980	<i>Typha</i> , <i>Scirpus</i>	Anchored	92.5	163.25**
Mesa Marsh 1981	<i>Typha</i>	Anchored	79.5	217.14**
Widgit 1980 and 1981	<i>Carex</i>	Island	24.1	30.18
Thompson Hole 1980	-	Man-made	20	124.8
Thompson Hole 1981	<i>Salix</i> , <i>Carex</i>	Tree roots	33.7	14.15
Long Meadows 1980	<i>Carex</i>	Island	42.8	45
Long Meadows 1981	<i>Carex</i> , <i>Nuphar</i>	Anchored	45.1	44.5
7# Mile Bridge YNP 1981	<i>Typha</i> , <i>Scirpus</i>	Anchored	29.2	?
7+1# Mile Bridge YNP 1981	<i>Sparganium</i> , <i>Scirpus</i> , <i>Eleocharis</i>	Anchored	20.3	3.3
Chain 1980 and 1981	<i>Carex</i>	Beaver Lodge	19.8	12
Indian 1981	<i>Nuphar</i>	Island	10.6	12.2
Eccles 1981	<i>Carex</i>	Not anchored	73.5	32.7

** Approximated from aerial photos.

Table 4. Continued.

Location	Nest Material	Nest Mound			Slope	Nest Cup		
		Length*	Width*	Height*		Length*	Width*	Height*
Swan Lake (Hwy) 1980 and 1981	<i>Typha</i> , <i>Carex</i> , <i>Scirpus</i> , Sod	201	175	40	41%	41.91	35.56	12.07
Mesa Marsh 1980	<i>Typha</i> , <i>Scirpus</i>	74	61	74	21%	40.7	32.4	10.16
Mesa Marsh 1981	<i>Typha</i> , Sod	198	182	28	30%	41.91	34.93	15.24
Widgit 1980 and 1981	<i>Carex</i> , Sod	175	147	37	47%	88.9	81.28	0
Thompson Hole 1980	Straw, sod, mud	335	248	95	50%	129.54	96.52	0
Thompson Hole 1981	<i>Salix</i> , <i>Carex</i> , sod	185	150	46	47%	38.1	27.94	10.16
Long Meadows 1980	<i>Carex</i> , <i>Potentilla</i> , sod	183	175	34	42%	43.18	38.1	11.43
Long Meadows 1981	<i>Carex</i> , <i>Nuphar</i> , sod	262	170	41	30%	38.1	38.1	0
7# Mile Bridge YNP 1981	<i>Typha</i> , <i>Scirpus</i>	221	165	32	38%	27.31	30.48	0
7+1# Mile Bridge YNP 1981	<i>Sparganium</i> , <i>Scirpus</i> , <i>Eleocharis</i>	170	150	27	32%	0	0	0
Chain 1980 and 1981	<i>Carex</i> , sod, sticks	840	700	70	23%	90	81	0
Indian 1981	Grass, sod	152	140	30	27%	35.56	33.02	8.89
Eccles 1981	<i>Carex</i> , <i>Scirpus</i> , sod	193	130	19	31%	33.02	33.02	13.34

*Measured in centimeters.

vegetation such as *Typha* spp., *Carex* spp. or *Scirpus* spp. One nest mound was made of similar material but was not within a stand of emergent vegetation. This mound was apparently not anchored and could be rotated and lowered when force was applied. Banko (1960) documented the use of abandoned muskrat houses as nesting sites on RRLNWR. Muskrats were known to inhabit Swan Lake and, therefore, it is unknown as to whether the swans had actually built this mound. Only one beaver (*Castor canadensis*) lodge was utilized although beaver lodges were located on six other territories. This lodge was quite old and had been abandoned by beaver and utilized by swans since at least 1979. Sedge was added to the top of the nest and no lodge material other than sod was incorporated into the nest. Three nests were located on islands found within the lakes. All nests located on an island were found near the edge. Semi-aquatic vegetation from the island (*Potentilla* spp. and *Eriophorum* spp.) and aquatic vegetation (*Carex* spp. and *Typha* spp.) were used as nest material.

A man-made nest mound was used on Thompson Hole in 1980. In the fall of 1979, the U.S. Forest Service raised the outlet with an earthen dam in order to increase the water depth. The impetus for this project was the overland brood movement by the swans during dry years to a lake approximately 1 km away. The old nest mound was moved to the center of the lake, straw was added in order to stabilize the slopes and native grasses were planted to provide cover. Swans used this site after incorporating sedge stems and roots into the already existing straw and old nest material.

New nests were built on Swan Lake, Thompson Hole, Long Meadow and Mesa Marsh in 1981. Unlike the previous site on Long Meadows, the 1981 nest site was no longer in view from a nearby logging road. The road at this time was gated and not used for hauling timber but did receive periodic use from Forest Service personnel and contractors working in the area. The elusive behavior of the pair may have influenced their selection of a more inconspicuous nest site.

The lack of accessible nest material and the instability of the old nest mound, both related to high water in the spring of 1981, may have been the impetus for selecting a new nest mound on Thompson Hole. The new mound was located on the upturned roots of a lodgepole pine. Flooded willows were the predominate emergents surrounding the nest. Although *Carex* sp. was the predominate genus surrounding most of the nests, it did not appear to be the preferred cover. In all cases where *Typha* spp. or *Scirpus* spp. were available in large stands offshore, these locations were used in spite of abundant *Carex* sp. This seeming preference may be due to one or a combination of several factors. Both *Typha* spp. and *Scirpus* spp. produce a greater biomass per stem resulting in a larger amount of decadent material from the preceeding years growth, both produce a source of both food and cover and a surface area on which to build a nest.

The average distance between each of nine nests and the shore was 42.9 m. The distance appeared dependent on available nest sites such as islands, raised mounds, beaver lodges and emergent vegetation. The nests averaged 2.5 x 2 m and rose an average height of 44.1 cm above the water surface. The slope of 13 nests averaged 35% (Table 4).

Nest cups were more circular than the mounds, their length and width averaged 49.9 cm and 43.3 cm, respectively. The depth of the cup varied from 0 to 15.5 cm.

The water depth around the mounds ranged from 10.6 to 95.5 cm. These variations are in part due to the moat that was created around the nest as material was removed by the swans.

Current Production

Between 1979 and 1981, 21 nesting attempts were observed on the District. Nineteen of these nesting attempts had successfully hatched at least one egg for a 90% nesting success (Table 5).

Table 5. Trumpeter swan production on the Ashton Ranger District, Idaho and Wyoming.

	1979	1980	1981
Number of Nest Pairs	6	6	9
Number of Eggs Laid	22	26	45(+)
Average Clutch Size	3.7	4.3	5 (+)
Number of Eggs Hatched (Percent)	18(82%)	23(88%)	37(82%)
Number Survived to Fledging (Percent)	3(17%)	6(26%)	17(46%)
Number Broods at Hatching	6	6	8
Number Cygnets/Broods at Hatching	3	3.8	4.5
Number Broods at Fledging	2	3	5
Number Cygnets/Broods at Fledging	1.5	2	3.4
Percent Mortality by Fledging	84%	74%	54%
Cygnets Fledged per Nesting Adult Pair	0.5	1	1.9

The clutch sizes for the three years ranged from 3 to 6, averaging 4.4. The average clutch size increased significantly from 3.7 in 1979 to 5.0 in 1981 ($p=0.0018$). The average clutch size for each year on the District was not significantly different ($p=0.072$) from that documented on the RRLNWR during the same time period. RRLNWR also had

an increase in clutch size, with 5 eggs per nest in 1979 to 5.33 in 1981.

Hatching success ranged from 82% to 88%. These values did not differ significantly ($p=0.372$). Over the same time period, RRLNWR had an average hatching success of 48%.

Hatching success on the District was quite high compared to the 62% reported by Shea (1979) for YNP, 55% for the Alaskan birds (Hansen et al., 1971) and 51 to 66% recorded by Scott et al. (1972). All three researchers attributed hatching failures to flooding, predation and abandonment of both fertile eggs and undeveloped embryos. During my study, one nest was abandoned in 1981 after two eggs were found missing from the nest. During this study, flooding was never documented as a cause of hatching failure. Temporary inlets and outlets on each lake allowed adequate drainage during the early summer months when snow melt supplied the major increment of water. Similarly, predation on eggs was never observed.

Twenty-six cygnets were fledged from the District between 1979 and 1981, 17% in 1979, 26% in 1980 and 47% in 1981. These annual differences were not statistically significant ($p=0.317$).

Utilizing a model first developed by Page (1976) and further refined by Turner and MacKay (1978), I calculated the number of breeding years necessary in order to replace the current adult breeding population on the District. Because survival rates of one year and older birds were not known for the Targhee swans, survival rates determined by Turner and MacKay (1978) for the migratory Canadian population were utilized; however, the only similarity between the

Targhee and the Canadian swans is the occupancy of similar winter habitat. Based on the average clutch size, hatching success and rate of fledging calculated for the Targhee birds plus the survival rates from the Canadian birds, the District pairs would require 9.4 nesting attempts in order to replace themselves. Shea (1979) had calculated 22.0 nesting attempts for the YNP swans and 10.3 nesting attempts for the tri-state population.

Necropsies

In 1980, one cygnet and four unhatched eggs were collected for examination. The cause of the cygnet's death was undetermined. No significant bacteriological agents were found in the eggs although all were heavily contaminated with miscellaneous coliform bacteria associated with postmortem decomposition. Two eggs were infertile while two contained partially developed cygnets.

Necropsies were performed on four swans collected in 1982. One banded, six-year old female collected at RRLNWR in June, 1981 had calcified nodules in the air sac, an ulcerated gizzard and a cyst in the spleen. The cause of death was diagnosed as avian tuberculosis.

The cause of death of two 11-day old cygnets collected from Chain Lake could not be determined. Thorough examination of one bird was hindered due to extensive postmortem decomposition. The postmortem condition of the second bird was good. Although six leeches were found in the nares, no definitive cause of death was determined.

In January, 1982, the Idaho Fish and Game collected a decapitated swan from along the Snake River between Chester and Ashton, Idaho.

The substantial development of down and subcutaneous fat along the ventral surface indicated the bird was in good physical condition. Crushed cervical vertebrae, lack of subcutaneous hemorrhaging and torn muscles in the neck indicated that the head had been removed after the bird died. The cause of death was believed to have been from hitting a powerline along the river (personal communication, J. Curry).

Unhatched Eggs

Fifty-seven unhatched eggs were collected in 1981 from RRLNWR, YNP and the TNF. Known hatching failures were due to flooding (4%), infertility (47%), abandonment (4%), predation (2%) and displacement from the nest (2%). The contents varied between partially developed embryos (40%), undifferentiated albumin and yolk (58%) and the contents of one egg was unknown (2%) due to predation. Thirty-five percent of these eggs were known to have gone the full term of incubation (Table 19).

A one-way analysis of variance was performed on the mean weight, length and width between all three groups of eggs. The eggs collected from the TNF weighed significantly ($p=0.015$) more than the RRLNWR eggs. No significant difference in weight was detected between the YNP and the TNF eggs or between the eggs from YNP and RRLNWR. No significant difference was found between the egg length or width of the three groups (Table 19). The differences in egg weights may be related to the time at which the eggs were collected and weighed. The Targhee eggs were weighed early during incubation while those collected from

YNP and RRLNWR were weighed after hatching had occurred. Moisture lost throughout incubation may account for these observed differences.

Egg Composition

Shea (1979) theorized that low cygnet production and survival in YNP may, in part, be due to poor and/or limited winter habitat utilized by the tri-state swan population. Page (1976) found an increase in the number of nesting attempts, egg hatchability and cygnet survival following winters of increased supplemental feeding on RRLNWR. Others have documented the correlation between the pre-laying nutritional level of the female and reproductive capabilities (Cooper, 1978), egg hatchability (King, 1973), clutch size (Bengston, 1971; Ankney and Bisset, 1976, 1978; Krapu, 1981), egg size (Scott, 1973), onset of laying (King, 1973) and survival after hatching based on yolk content (Kear, 1965).

In view of these findings, two swan eggs, one from RRLNWR (standard) and one from the TNF, were analyzed for 7 nutritional components and 13 minerals. Values from comparable egg analysis performed on seven different avifauna were retrieved from the literature and used to calculate means and standard deviations (Table 20). A Student's t test was used for comparison of the two swan eggs with these calculated means. Inadequate data from the literature reduced the number of minerals and nutritional components that could be used for comparison.

The egg from RRLNWR had significantly less protein but significantly more carbohydrates than the egg collected from the TNF. These

differences could be related to the fact that swans on the RRLNWR are fed a poultry supplement throughout the winter. This is merely a hypothesis since it is not known which swans actually winter on the RRLNWR.

Water Chemistry

Several water chemistry parameters were examined during 1980 and 1981. A Hach field kit was used both years, but many of the chemicals were replaced in 1981. Differences noted between years are believed to reflect the change in chemicals rather than in water chemistry (Table 21).

Analysis of variance by month and status (swan use) was performed for each parameter. A statistically significant difference in top and bottom water temperatures was observed between all lakes based on 1981 monthly averages. Carbon dioxide, dissolved oxygen and pH were all significantly different between lakes based on their status for 1981 (Table 6). Analysis of water chemistry data showed far more differences by both month and status in 1980 than in 1981. Dissolved oxygen and total hardness were both significantly different by month and status while alkalinity and conductivity were significantly different by status alone. Statistically significant differences were found between the monthly averages for carbon dioxide, pH and top and bottom temperatures (Table 6).

Oxygen

Dissolved oxygen in water is derived from two sources: atmospheric and photosynthetic (Reid and Wood, 1976). Throughout both

Table 6. Analysis of variance (P values) of water chemistry variables measured on study lakes on the Ashton Ranger District, Idaho and Wyoming, in 1980 and 1981.

	Month	Status	Degrees of Freedom	
Water Chemistry Variables 1980				
Alkalinity	0.1732	0.0060*	3	2
CO ₂	0.0001*	0.0538	3	2
DO	0.0007*	0.0359*	3	2
pH	0.0075*	0.3928	3	2
Surface Temperature	0.0197*	0.2966	3	2
Bottom Temperature	0.0245*	0.4133	3	2
Total Hardness	0.0074*	0.0181*	3	2
Conductivity	0.7170	0.0077*	3	2
Water Chemistry Variables 1981				
Alkalinity	0.9076	0.0618	3	2
CO ₂	0.7284	0.0000*	3	2
DO	0.2416	0.0002*	3	2
pH	0.1083	0.0001*	3	2
Surface Temperature	0.0000*	0.2488	3	2
Bottom Temperature	0.0000*	0.8824	3	2
Total Hardness	0.7334	0.0753	3	2

*Indicates significance at the .05 level.

summers, the lakes with no recorded swan use had significantly greater amounts of dissolved oxygen (D.O.) ($p=0.014$) in 1980 and ($p=0.000$) in 1981 than did the used and historically used lakes (Figure 4). This higher D.O. content in non-used lakes was attributed to: (1) their having less vegetation and, therefore, less biological demand, (2) being larger and, therefore, more susceptible to seasonal wave action and (3) being deeper and having colder water temperatures.

Carbon Dioxide

The major sources of carbon dioxide (CO_2) are atmospheric, biological (respiration and bacterial decomposition), external water sources (seeps and ground water) and chemical reactions such as the acid-carbonate reaction (Reid and Wood, 1976). The concentrations of free CO_2 in both 1980 and 1981 were significantly greater in the used lakes than in the non- and historically used lakes (Figure 5). This difference is due to greater respiration and bacterial decomposition in lakes having greater amounts of macrophytes.

Temperature

Thermal stratification was not determined on all lakes. Four of the study lakes that had a maximum water depth of less than 2 m did not show any stratification although summer thermal stratification has been observed in water less than 1 m in depth (Paulin, 1973). Conceivably, the remaining eight lakes may have undergone stratification although a substantial depletion of D.O. often associated with this phenomenon was not documented (Figures 6 and 7).

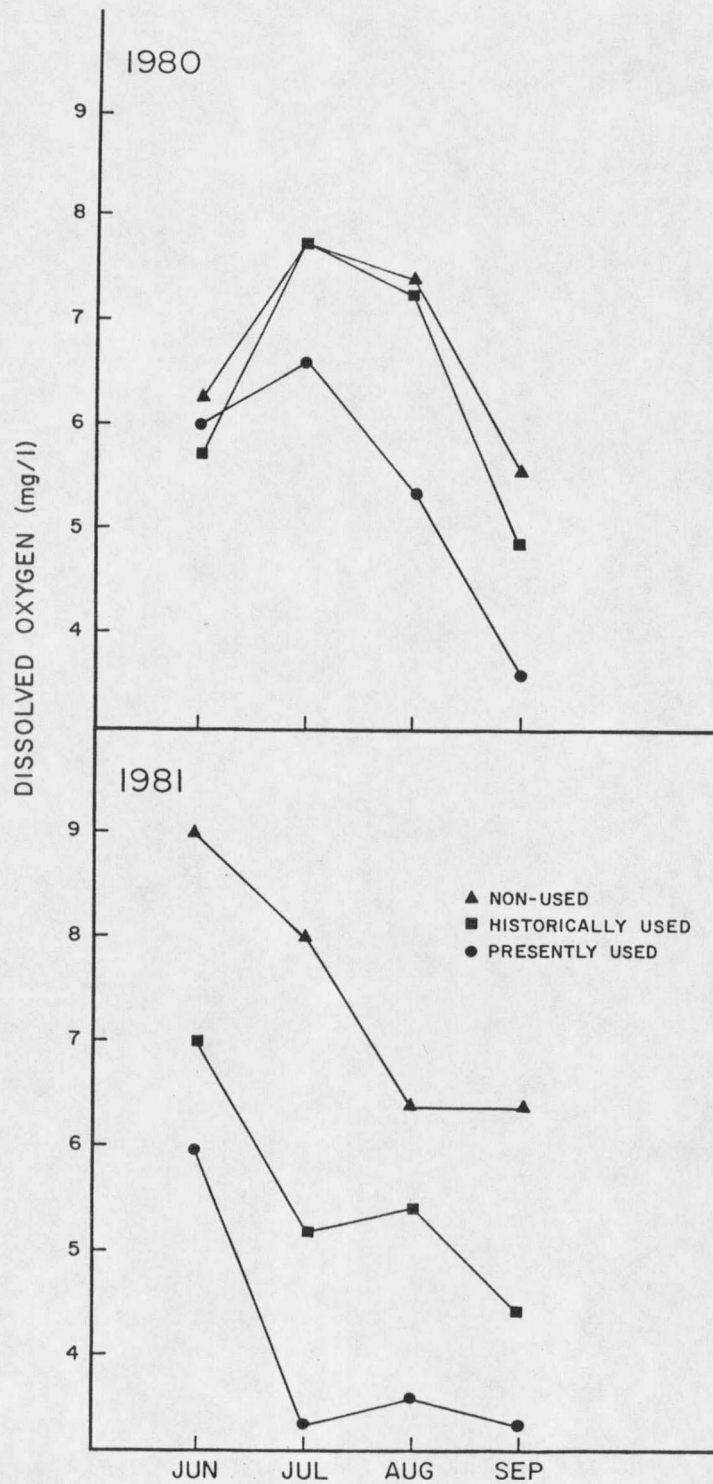


Figure 4. Mean dissolved oxygen (mg/l) for each of the three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

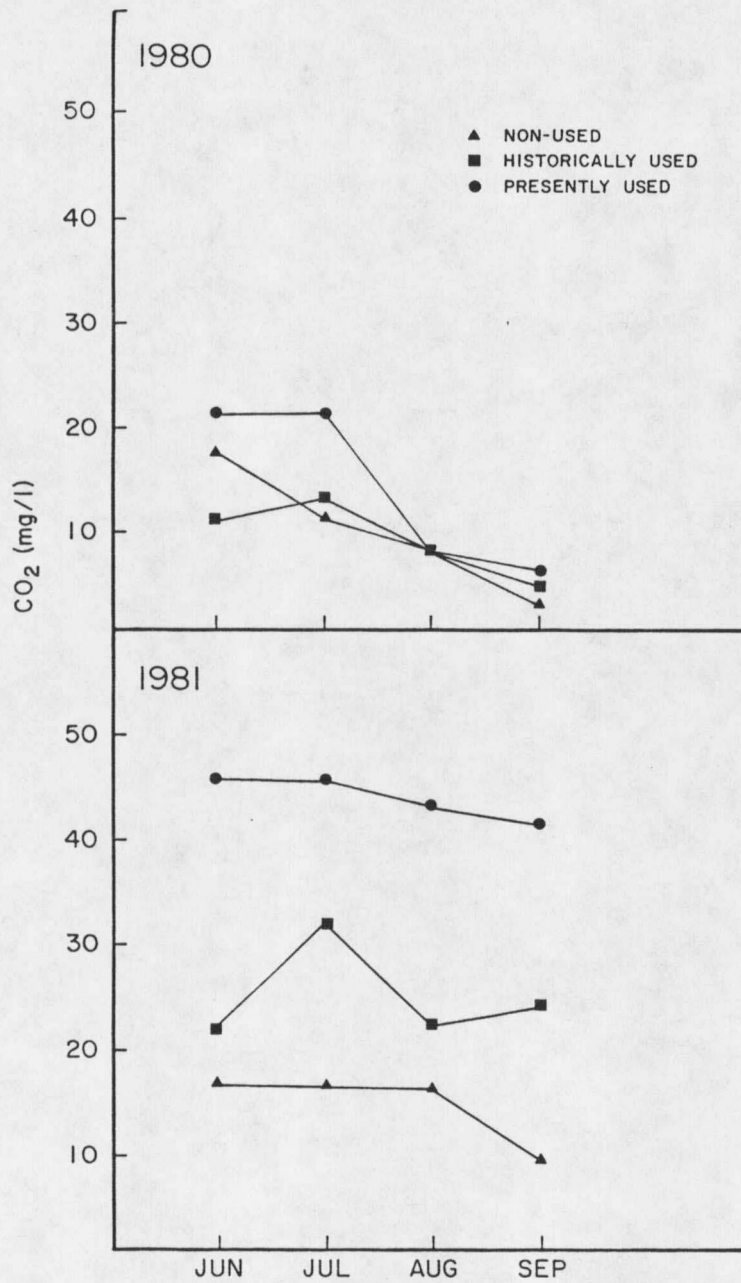


Figure 5. Mean carbon dioxide (mg/l) for each of three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

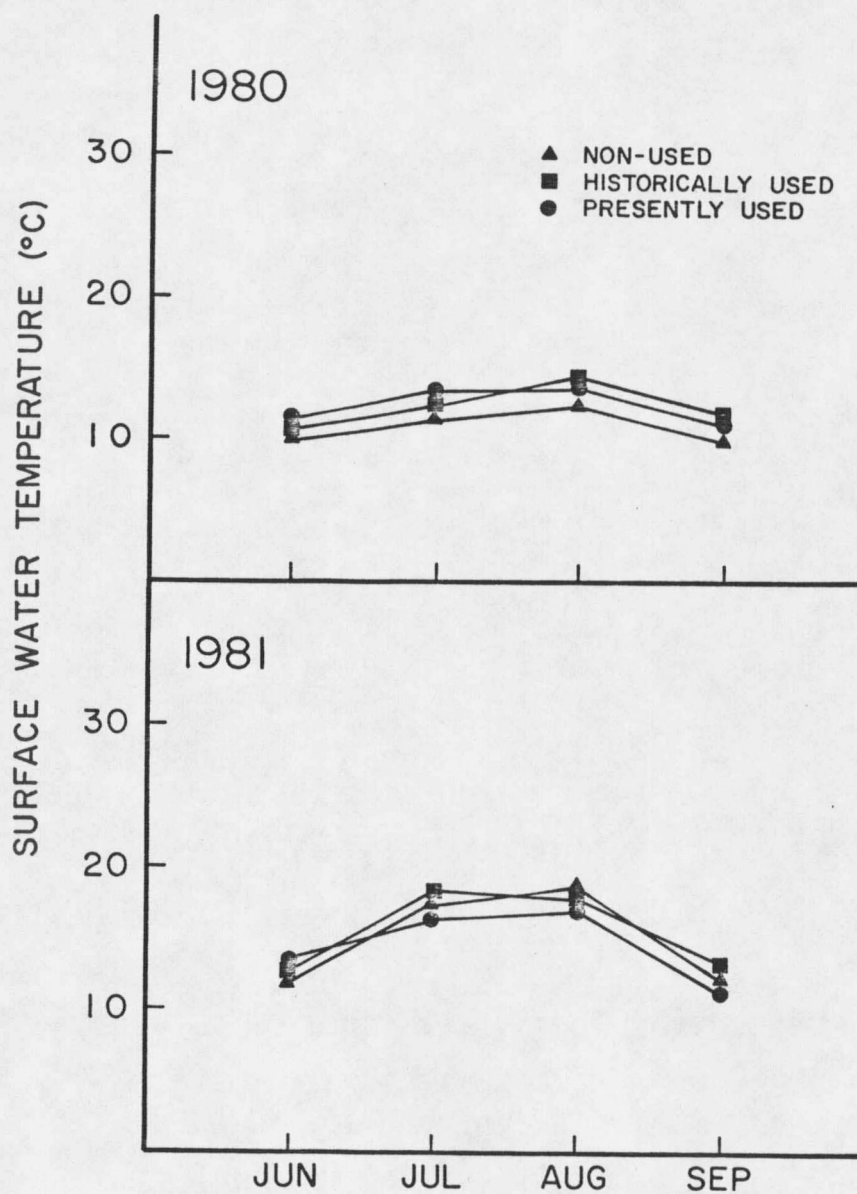


Figure 6. Mean surface water temperature (°C) for each of the three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

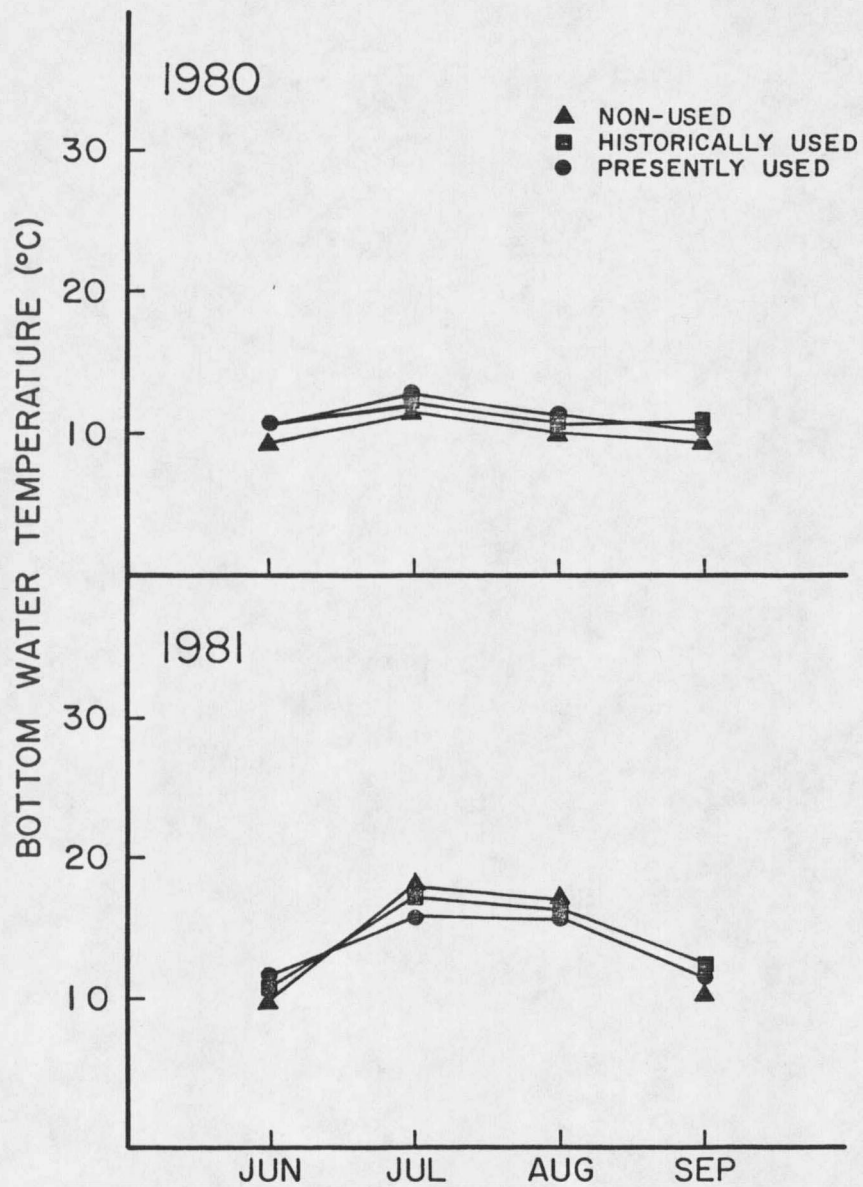


Figure 7. Mean bottom water temperature (°C) for each of the three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

Monthly water temperatures were significantly different both years (Figures 6 and 7). This would be expected since all of the lakes exhibited increasing temperatures throughout the summer with a subsequent decrease in the fall.

pH

The pH values of the presently and historically used lakes ranged from 4 to 8, and these lakes were classified as acidic to neutral. The pH values of the non-used lakes ranged from 7 to 8, and these lakes were classified as slightly alkaline.

Both 1980 and 1981 pH values increased throughout the summer months and tended to decrease with the onset of fall; however, only 1980 monthly pH values were significantly different ($p=0.0075$) (Table 6). These seasonal trends are related to the concentration of free CO_2 . Increasing photosynthetic activity throughout the summer reduces free CO_2 concentrations which when dissolved in water produces readily dissociated carbonic acid (H_2CO_3). As photosynthesis slows down towards the end of summer, free CO_2 reserves increase in excess of their demand, and the pH tends toward an acidic condition.

Non-used lakes consistently had higher monthly pH values than did the presently and historically used lakes (Figure 8). These higher values are most likely due to a naturally occurring lower concentration of free CO_2 than to a greater biological uptake of free CO_2 which is related to plant biomass.

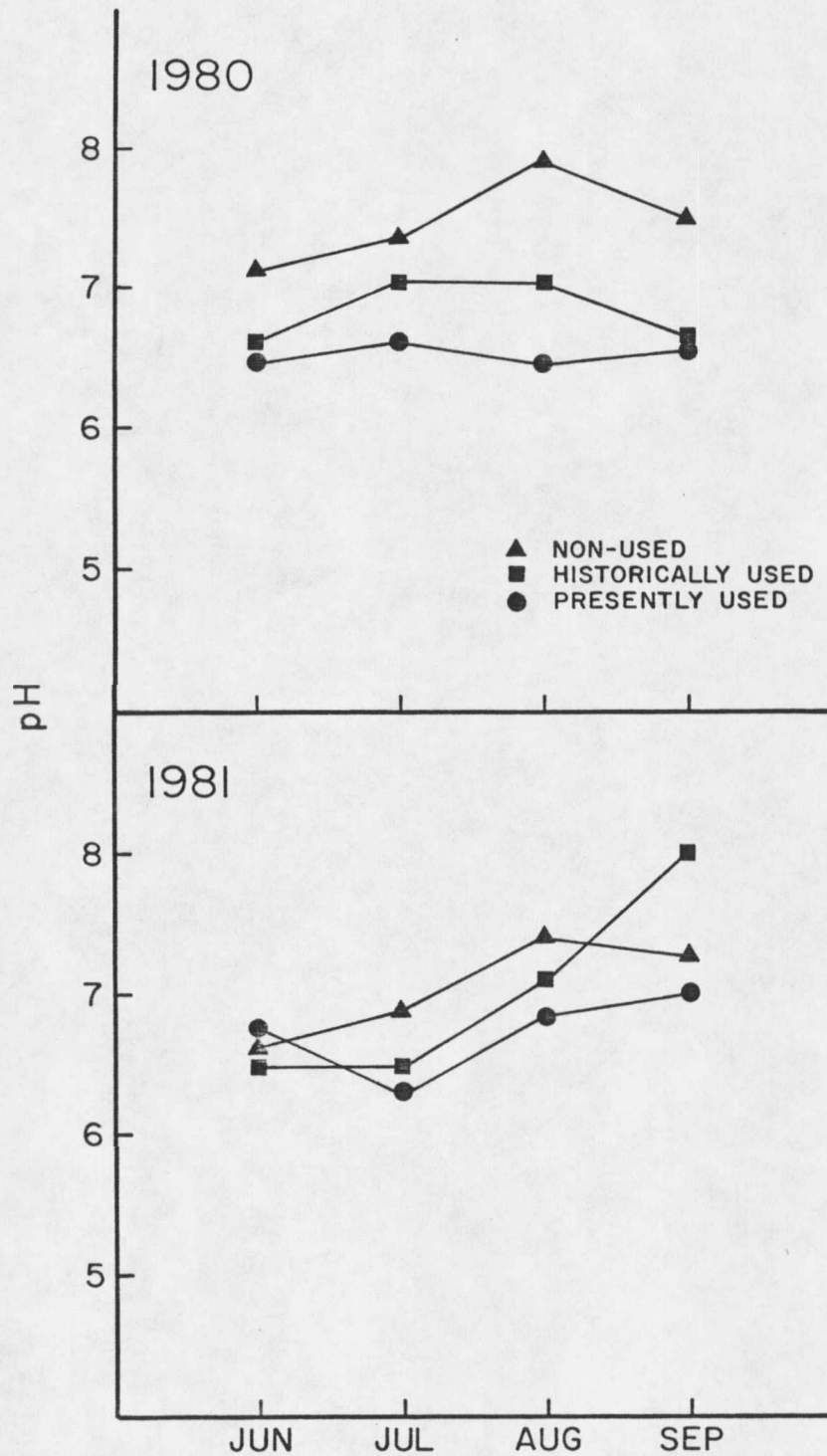


Figure 8. Mean pH for each of the three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

Alkalinity

All of the study lakes could be classified as medium water lakes in which bound CO_2 ranges from 30 to 35 ppm with a pH value of approximately 7 (Reid and Wood, 1976). Presently used lakes had significantly greater ($p=0.0060$) alkalinity values than the non-used or historically used lakes in 1980 (Figure 9).

Within the pH range of the lakes, alkalinity is due to the amount of bicarbonate ions (HCO_3^-) in solution. The higher alkalinity values measured in the presently used lakes are related to the fact that these lakes had greater plant biomass and, therefore, a proportionately higher rate of photosynthesis than did the historically and non-used lakes. Photosynthetic activity reduces free CO_2 which when dissolved in water produces readily dissociated carbonic acid (H_2CO_3). As free CO_2 continues to be taken up by aquatic macrophytes through photosynthesis, the pH increases to a point (pH 6-10) where bicarbonate ions are the predominate form of carbon dioxide. At a pH above 8.3, although not detected in this study, alkalinity would have been attributed primarily to carbonate ions (CO_3^{2-}).

Conductivity

The ability of a substance to conduct an electric current is referred to as its specific conductivity (Hem, 1978). Since multiple ions occur in fresh water, their specific concentrations were not determined. However, the proportionate abundance of each generally follows as such; $\text{Ca} > \text{Mg} > \text{Na} > \text{K}$ (Reid and Wood, 1976).

No significant difference was detected between monthly conductivity values, but values for historically and non-used lakes were

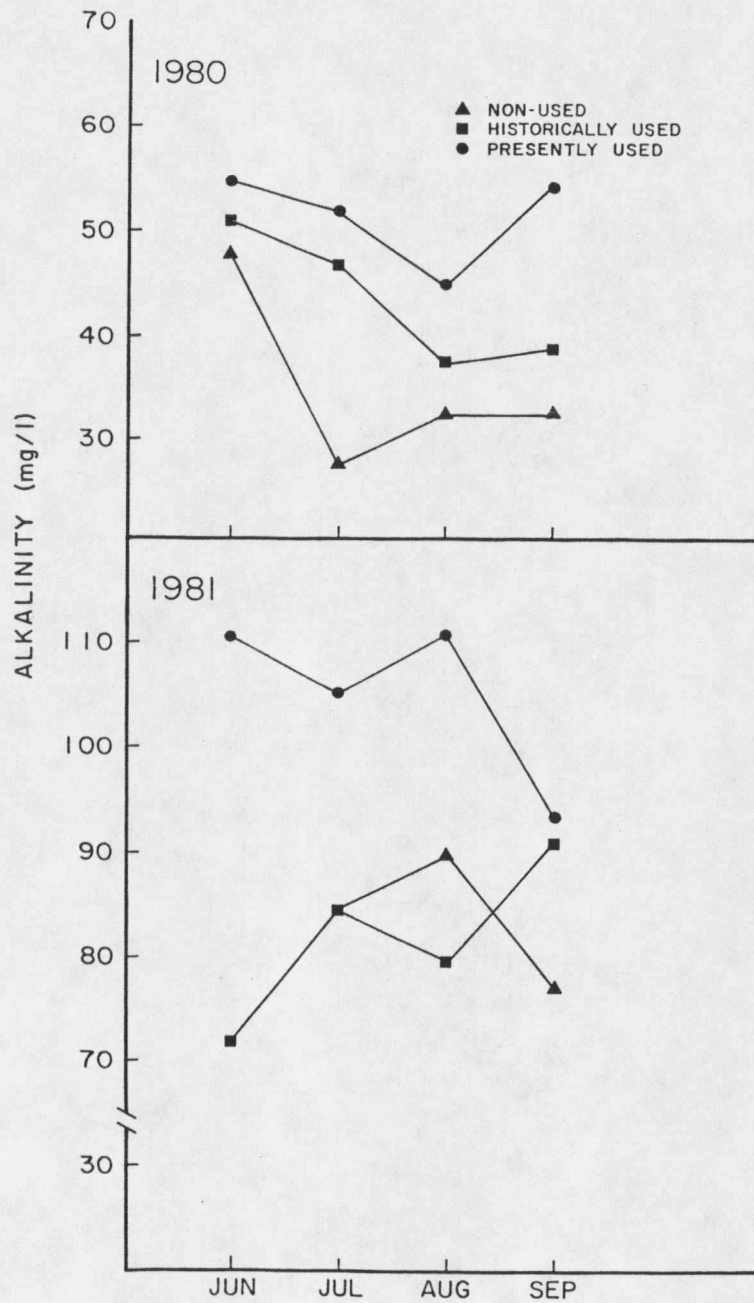


Figure 9. Mean alkalinity (mg/l) for each of the three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

significantly lower than those of the presently used lakes indicating their reduced productivity potential (Figure 10). Temporal and spacial differences in conductivity are, in part, due to the rate of evaporation, water depth and the biological demand of particular ions throughout the year.

Total Hardness

Total hardness is, in part, a measure of both calcium and magnesium ions in solution. Total hardness curves closely reflect the alkalinity curves as would be expected since both are related to bicarbonate and carbonate ion concentrations (Figure 11). Plants undergoing active photosynthesis split CO_2 from bicarbonate ions. Carbon dioxide then combines with the available calcium resulting in the precipitation of calcium carbonate (marl) which is often observed as a white crusty coating on plant species such as *Chara* sp. Total hardness values were significantly different between months ($p=0.0074$) and were significantly higher in the presently used lakes than the historically and non-used lakes ($p=0.018$). (Table 6). These differences in total hardness values are related to the different concentrations of free CO_2 found between the lake groups or months.

Lake Morphology

Dynamic processes influence the evolutionary development of a body of water, ultimately expressed in its floral and faunal composition and production (Ryder et al., 1974; Hutchinson, 1957; Hansen et al., 1971). Physical and morphometric variables were examined in order to assess these processes and biotic differences between lakes.

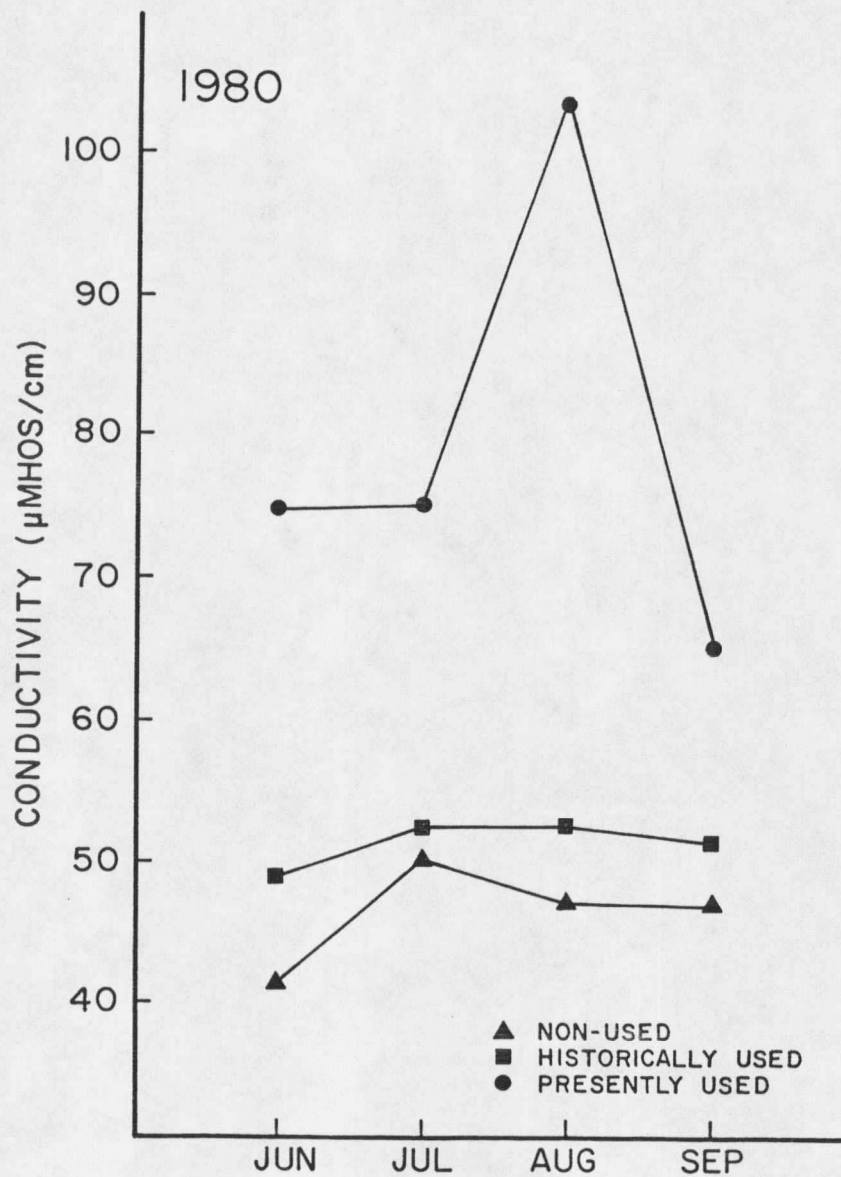


Figure 10. Mean conductivity (microhms/cm) for each of the three lake groups studied in 1980 on the Targhee National Forest, Idaho and Wyoming.

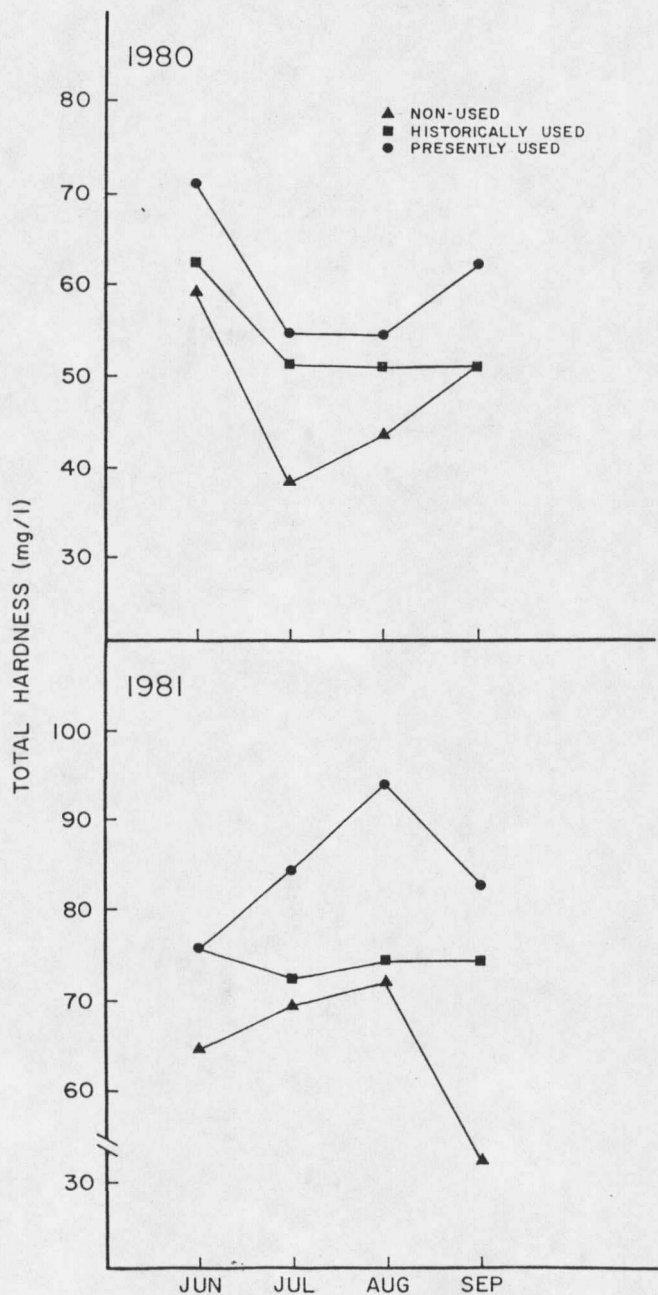


Figure 11. Mean total hardness (mg/l) for each of the three lake groups studied in 1980 and 1981 on the Targhee National Forest, Idaho and Wyoming.

Shoreline development (D_L) measures the amount of irregularity in the lake periphery. The degree of irregularity is related to soil stability, littoral processes such as sedimentation, wave action and erosion and external factors such as grazing and logging. D_L ratio increases as the irregularity of the lake increases, with a value of 1 representing a perfectly circular lake.

Shoreline development ratios when grouped on the basis of swan use (lake status) were significantly greater ($p=0.023$) for presently and historically used lakes than non-used lakes (Table 7). The ratios ranged from 1.1 on a non-used lake to 2.6 for a historically used lake (Table 22).

The area of the study lakes ranged from 5.3 to 59.3 ha with the mean depth ranging from 0.36 to 4.5 m (Table 22). No significant differences were detected between lakes based on the two variables or for minimum and maximum depths (Table 7).

Seasonal water levels in the lakes were maintained from precipitation and snow runoff, seeps and springs contributing only minor amounts of water. The total water fluctuation from June through September ranged from +8 cm to -95 cm in 1980 and +7 cm to -95 cm in 1981. The greatest fluctuations in water level occurred during the month of July (Table 8). These differences were primarily related to the influents and effluents of each lake of which most were only temporarily active (67%). Monthly water fluctuations for 1980 and 1981 combined and averaged by lake status showed no significant difference.

Table 7. Means (standard deviations) and P values of morphometric measurements made of the study lakes on the Ashton Ranger District, Idaho and Wyoming.

Parameter	Used		Historical		Non-used		P Value
Area (ha)	19.64	(26.49)	14.78	(10.52)	11.06	(2.36)	0.768
$\bar{X}$ depth (m)	0.73	(0.33)	1.84	(1.87)	2.79	(1.81)	0.212
Max. depth (m)	1.34	(0.68)	5.18	(7.53)	6.00	(4.74)	0.429
Min. depth (m)	0.09	(0.03)	0.53	(0.96)	0.12	(0.12)	0.504
Shoreline length (m)	2477.85	(1260.14)	2615.80	(1025.82)	1578.52	(304.60)	0.297
Shoreline development	1.96	(0.27)	2.05	(0.43)	1.34	(0.19)	0.023*
Lake length (m)	649.62	(307.20)	766.48	(294.52)	485.00	(116.86)	0.430
Lake width (m)	345.72	(271.56)	329.72	(177.31)	301.33	(23.55)	0.945

* Indicates significant at the 0.05 level.

Table 8. Water fluctuations in study lakes on the Ashton Ranger District, Idaho and Wyoming, during 1980 and 1981.

Location	May	June	July	Aug	Sept	Seasonal
<u>1980</u>						
<u>Presently Used Lakes</u>						
Thompson Hole		0	-3.5	-17.0	-1.0	-21.5
Long Meadows		0	+1	+2	+5	+8
Chain Lake		0	-6	-5	-5	-16
Mesa Marsh		0	-2	-1	-6	-9
<u>Historically Used Lakes</u>						
Loon Lake		0	-2	-5	+1	-6
Steele Lake		0	-2	-29	+1	-30
Lower Goose Lake		0	-4	-10	-2	-16
Beaver Pond		0	-2	-3	-1	-6
<u>Non-used Lakes</u>						
Fish Lake		0	-4	-7	+2	-9
Moose Lake		0	0	-5	0	-5
Bergman Reservoir		0	0	+2	emptied for irrigation	+2, emptied
Mesa Marsh Pond		0	-5	-17	-6	-28
<u>1981</u>						
<u>Presently Used Lakes</u>						
Thompson Hole	0	-4	-15	-13	-8	-40
Long Meadows	0	-3	0	-3	-1	-7
Chain Lake	0	-4	-11	-14	-7	-40
Mesa Marsh	0	-2	-8	-18	-9	-37
<u>Historically Used Lakes</u>						
Loon Lake	0	-1	-6	-8	-11	-26
Steele Lake	0	-3	-12	-23	emptied	-38
Lower Goose Lake	0	-4	-13	-16	-10	-43
Beaver Pond	0	-7	-11	-12	-8	-38
<u>Non-used Lakes</u>						
Fish Lake	0	-2	-5	-8	-11	-26
Moose Lake	0	-2	-3	-10	-9	-24
Bergman Reservoir	0	-3	-16	-76		-95, emptied
Mesa Marsh Pond	0	-8	-7	-23	emptied	-38, emptied

Vegetation

The percent of open water (no visible aquatic vegetation stands), emergent and submerged vegetation (including floating leaves) was delineated from infrared aerial photographs (Table 9). The used lakes had significantly greater amounts of vegetation coverage than did the historically used and non-used lakes ($p=0.038$). No statistically significant difference in amount of emergent and submergent vegetation was found between the lakes ($p=0.347$).

Clearly defined homogeneous stands of one plant species were rarely observed in the study lakes. This was particularly true of the presently and historically used lakes which had greater species diversity than the non-used lakes. An exception to this occurred within stands of emergent vegetation where homogeneous clumps of one species were observed.

Ten of the most abundant plant species identified in 1981 are presented in Table 10. Half of the species listed have been documented as food items for swans (Scott et al., 1972; Palmer, 1976; Banko, 1960).

In addition to being a food item, *Carex* spp., *Nuphar polysepalum* and *Eleocharis* spp. were often found to be utilized as nest material. *Nuphar polysepalum* more so than any other species provided visual cover for the birds from the ground. Security cover is usually associated with emergent vegetation. However, swans often remained inconspicuous among *Nuphar* plants because of the white background produced by light reflected from the surface of the leaves.

Table 9. Percent vegetation and open water of study lakes on the Ashton Ranger District, Idaho and Wyoming, during 1980 and 1981.

Location	% Open Water (ha)		P Value	% Vegetation (ha)		P Value	% Emergent (ha)		P Value	% Submergent (ha)		P Value
<u>Presently Used Lakes</u>												
Thompson	16%	(1.2)	0.038	84%	(6.3)	0.038	12%	(0.77)	0.347	88%	(5.53)	0.347
Long Meadows	17%	(1.1)		83%	(5.3)		69%	(3.62)		31%	(1.67)	
Chain	2%	(0.11)		98%	(5.2)		53%	(2.76)		47%	(2.44)	
Mesa Marsh	9%	(5.61)		91%	(53.73)		12%	(6.58)		88%	(47.15)	
<u>Historically Used Lakes</u>												
Steele	9%	(0.55)		91%	(5.4)		41%	(2.20)		59%	(3.2)	
Loon	46%	(16.6)		54%	(19.4)		66%	(0.13)		99%	(19.27)	
Beaver Pond	18%	(5.26)		82%	(23.38)		2%	(0.51)		98%	(22.87)	
Lower Goose	16%	(1.2)		84%	(6.1)		8%	(0.48)		92%	(5.63)	
<u>Non-used Lakes</u>												
Moose	64%	(6.65)		36%	(3.67)		6%	(0.22)		98%	(3.44)	
Fish	75%	(7.95)		25%	(2.58)		7%	(0.18)		93%	(2.40)	
Mesa Marsh Pond	8%	(0.67)		92%	(8.27)		100%	(8.27)		0%	(0)	
Bergman Reservoir	96%	(13.9)		4%	(0.55)		100%	(0.55)		0%	(0)	

Table 10. Most abundant plants in order of abundance found on the study lakes on the Ashton Ranger District, Idaho and Wyoming.

Mean for all Lakes	Species	Presently Used	Historically Used	Non-used
<u>1980</u>				
20%	<i>Nuphar polysepalum</i>	1	1	2
6%	<i>Carex</i> spp.	-	-	1
6%	<i>Sparganium</i> spp.	2	2	5
3%	<i>Myriophyllum spicatum</i>	3	5	8
3%	<i>Calamogrostis canadensis</i>	8	3	10
2%	<i>Calamogrostis inexpansis</i>	-	7	-
2%	<i>Eleocharis acicularis</i>	-	4	7
2%	<i>Eleocharis palustris</i>	5	-	9
1%	<i>Potamogeton berchtoldii</i>	4	6	-
1%	<i>Ranunculus aquatilis</i>	-	-	3
	<i>Ceratophyllum demersum</i>	7	-	-
	<i>Sium suave</i>	9	-	-
	<i>Potamogeton natans</i>	-	-	6
	<i>Potamogeton gramineus</i>	-	9	-
	<i>Potamogeton epihydrus</i>	-	8	-
	<i>Hippuris vulgaris</i>	-	-	4
	<i>Callitriche verna</i>	6	-	-
	<i>Nitella flexilis</i>	10	-	-
	<i>Sparganium minimum</i>	-	10	-
<u>1981</u>				
13%	<i>Nuphar polysepalum</i>	1	1	1
3%	<i>Carex</i> spp.	2	-	3
3%	<i>Myriophyllum spicatum</i>	4	2	4
2%	<i>Ranunculus aquatilis</i>	-	-	2
2%	<i>Sparganium</i> spp.	5	3	8
2%	<i>Eleocharis acicularis</i>	-	4	5

Table 10. Continued.

Mean for all Lakes	Species	Presently Used	Historically Used	Non-used
<u>1981</u> (Continued)				
1%	<i>Nitella flexilis</i>	3	9	-
1%	<i>Potamogeton gramineus</i>	-	6	6
1%	<i>Eleocharis palustris</i>	-	-	7
1%	<i>Najas flexilis</i>	6	-	-
	<i>Potamogeton epihydrus</i>	-	5	10
	<i>Potamogeton natans</i>	10	7	9
	<i>Potamogeton berchtoldii</i>	7	-	-
	<i>Polygonum amphibium</i>	8	-	-
	<i>Hippuris vulgaris</i>	9	-	-
	<i>Ceratophyllum demersum</i>	-	8	-
	<i>Chara</i> spp.	-	10	-

1980

The percent bottom coverage (vegetative and reproductive parts were below the waters surface) and percent surface coverage (vegetative and reproductive parts were above the waters surface) of 37 vascular plants and 2 algal species was estimated (Table 23). The distinction between bottom and surface cover was made since both types provide nest material, serve as a food source for waterfowl and substrate for aquatic invertebrates (Krecker, 1939), while emergent and floating vegetation also serves as visual cover (Hotchkiss, 1941; McAtee, 1939; Martin and Uhler, 1939).

Species diversity was greatest in the presently used lakes, having 16 to 22 species ($\bar{X}=18.8$), while historically used lakes had 13 to 21 species ($\bar{X}=15.5$) and the non-used lakes had 4 to 21 species ($\bar{X}=10.5$).

Sparganium spp. was the only plant which showed any significant difference in percent bottom cover by lake status ($p=0.045$). This genus was found in significantly greater amounts in the presently and historically used lakes than in the non-used lakes. *Carex* spp., *Myriophyllum spicatum*, *Sium suave* and *Potamogeton alpinus* had P values greater than 0.05 but less than 0.08 (Table 11). *Potamogeton graminus* ($p=0.038$) and *Utricularia minor* ($p=0.03$) had significantly different monthly averages. Analysis of surface vegetation by lake status revealed significantly greater amounts of *Carex* spp. ($p=0.034$) in the non-used lakes than in the presently or historically used lakes. *Sium suave* was present in significantly ($p=0.049$) greater amounts in the presently used lakes than in the historically and non-used lakes. *Myriophyllum spicatum*, *Potamogeton alpinus* and *Calamagrostis canadensis*

Table 11. Means (standard deviations) and P values of vegetation (bottom cover) estimates made in 1980 on study lakes on the Ashton Ranger District, Idaho and Wyoming.

Plant species	Used		Historical		Non-used		P Values
<i>Carex</i> spp.							0.077
<i>Myriophyllum</i> <i>spicatum</i>	1.201	(1.238)	1.122	(1.656)	0.221	(0.575)	0.058
<i>Potamogeton</i> <i>alpinus</i>							0.062
<i>Sium suave</i>							0.065
<i>Sparganium</i> spp.	1.277	(1.459)	1.15	(1.793)	0.146	(0.301)	0.045*

Plant species	June		July		August		September		P Values
<i>Potamogeton</i> <i>graminus</i>	0.012	(0.037)	0.292	(0.375)	0.288	(0.375)	0.052	(0.014)	0.038*
<i>Utricularia</i> <i>minor</i>	0	0	0.002	(0.008)	0.023	(0.040)	0.002	(0.008)	0.030*

* Indicates significance at the 0.05 level.

had P values between 0.05 and 0.09. A significant difference in the amount of surface cover between months was found for *Potamogeton graminus* ($p=0.009$) (Table 12).

1981

Four new plant species identified in 1981 included: *Najas flexilis*, *Potamogeton zosteriformis*, *Isoetes* spp. and *Carex rostrata* (Table 23). *Equisetum palustre*, although identified in 1980, was not noted in 1981. The three *Sparganium* species identified in 1980 could not be individually identified in 1981 since seed heads were never observed. Colder monthly temperatures and higher amounts of precipitation may have inhibited the full development and growth of this species in 1981 (Table 1).

Plant species were again distinguished as providing surface or bottom cover. Quantified as percent cover, no significant difference in total vegetation (all months combined) compared by lake status was found. The greatest species diversity was again found in the presently used lakes, ranging from 18 to 21 species ($\bar{X}=19.3$), historically used lakes had 12 to 18 ($\bar{X}=14.8$) and the non-used lakes 6 to 17 ($\bar{X}=12$).

Analysis of bottom cover species revealed that total amounts of *Carex rostrata* were significantly greater ($p=0.28$) in the non-used lakes than in the presently and historically used lakes (Table 13). Total amounts of *Nuphar polysepalum*, *Potamogeton natans* and *Sparganium* spp. were significantly greater ($p=0.000$, $p=0.034$, and $p=0.002$, respectively), in presently and historically used lakes than in the non-used lakes. *Potentilla palustris* ($p=0.023$), *Sium suave*.

Table 12. Means (standard deviations) and P values of vegetation (surface cover) estimates made in 1980 on study lakes on the Ashton Ranger District, Idaho and Wyoming.

Plant Species	Used		Historical		Non-used		P Values
<i>Carex</i> spp.	0.055	(0.166)	0.082	(0.205)	4.255	(8.686)	0.034*
<i>Myriophyllum</i> <i>spicatum</i>	1.203	(1.237)	1.122	(1.656)	0.222	(0.580)	0.058
<i>Potamogeton</i> <i>alpinus</i>							0.062
<i>Sium suave</i>	0.469	(1.016)	0.0015	(0.007)	0.015	(0.029)	0.049*
<i>Calamagrostis</i> spp.							0.085

Plant Species	June	July	August	September	P Values
<i>Potamogeton</i> <i>graminius</i>	0.012 (0.037)	0.327 (0.401)	0.381 (0.448)	0.065 (0.054)	0.009*
<i>Utricularia</i> <i>minor</i>					0.068

* Indicates significance at the 0.05 level.

Table 13. Means (standard deviations) and P values of vegetation (bottom cover) estimates made in 1981 on study lakes on the Ashton Ranger District, Idaho and Wyoming.

Parameter	Used		Historical		Non-used		P Values
<i>Carex rostrata</i>	.008	(.016)	0	0	0	0	0.028*
<i>Ceratophyllum demersum</i>							0.067
<i>Hippuris vulgaris</i>							0.097
<i>Myriophyllum spicatum</i>	6.78	(5.22)	1.35	(1.90)	0.045	(0.15)	0.00*
<i>Nuphar polysepalum</i>	2.46	(2.30)	0.316	(1.01)	0.038	(0.083)	0.00*
<i>Potamogeton amplifolius</i>							0.09
<i>Potamogeton berchtoldii</i>	1.16	(1.61)	0.25	(0.85)	0.03	(0.08)	0.01*
<i>Potamogeton epihydrus</i>	0.18	(0.29)	1.35	(2.12)	0.12	(0.15)	0.012*
<i>Potamogeton friesii</i>	0	0	0.16	(0.34)	0	0	0.039*
<i>Potamogeton natans</i>	0.17	(0.23)	0.03	(0.15)	0.06	(0.12)	0.034*
<i>Potamogeton palustris</i>	0.03	(0.06)	0	0	0	0	0.023*
<i>Potamogeton pusillus</i>							0.085
<i>Potamogeton robbinsii</i>							0.085
<i>Ranunculus aquatilis</i>							0.08
<i>Sium suave</i>	0.04	(0.08)	0.01	(0.01)	0.003	(0.01)	0.04*
<i>Sparganium</i> spp.	1.05	(1.81)	2.98	(3.33)	0.09	(0.12)	0.02*
<i>Eleocharis acicularis</i>							0.074
<i>Calamagrostis</i> spp.							0.086
<i>Utricularia minor</i>							0.063

($p=0.040$) and *Potamogeton berchtoldii* ($p=0.01$) were found in significantly greater amounts in the presently used lakes than in the historically and non-used lakes. Significantly greater amounts of *Potamogeton epihydricus* ($p=0.012$) and *Potamogeton friesii* ($p=0.039$) were found in historically used lakes (Table 13). Nine other species had P values between 0.067 and 0.097, none of which are defined as statistically significant.

There were no statistically significant differences in total amounts of bottom cover species when compared between months, although *Potamogeton friesii* and *Myriophyllum spicatum* had P values of 0.054 and 0.068, respectively (Table 13).

Analysis of surface cover species showed statistically significant differences in total amounts of five species compared by lake status and one species compared by monthly totals. *Carex rostrata* ($p=0.034$), *Eleocharis palustris* ($p=0.000$) and *Scirpus* spp. ($p=0.041$) were found in significantly greater amounts in non-used lakes than presently and historically used lakes. *Lemna trisulca* and *Polygonum amphibium* were both found in significantly greater amounts in the presently used lakes than in the non- or historically used lakes ($p=0.019$ and $p=0.012$) (Table 14).

Although the P values were not statistically significant, *Sagittaria cuneata* and *Hippuris vulgaris* had relatively low values of 0.095 and 0.096, respectively. Monthly totals of *Lemna trisulca* were significantly different ($p=0.013$) (Table 14).

Table 14. Means (standard deviations) and P values of vegetation (surface cover) estimates made in 1981 on study lakes on the Ashton Ranger District, Idaho and Wyoming.

Plant Species	Used		Historical		Non-used		P Values
<i>Carex rostrata</i>	2.73	(2.92)	0.008	(0.03)	0	0	0.034*
<i>Hippuris vulgaris</i>							0.086
<i>Eleocharis palustris</i>	0.038	(0.06)	0	0	.22	(0.21)	0.017*
<i>Lemna trisulca</i>	0.063	(0.094)	0.011	(0.044)	0	0	0.012*
<i>Polygonum amphibium</i>	1.31	(2.48)	0.0095	(0.027)	0	0	0.019*
<i>Sagittaria cuneata</i>							0.095
<i>Scirpus</i> spp.	0.003	(0.013)	0	0	0.039	(0.079)	0.041*

Plant Species	June		July		August		September		P Values
<i>Lemna trisulca</i>	0.002	(0.008)	0.0075	(0.11)	0.021	(0.056)	0	0	0.013*
<i>Myriophyllum spicatum</i>	1.19	(1.54)	4.33	(5.42)	3.62	(2.85)	1.77	(1.13)	0.068
<i>Potamogeton friesii</i>	0	0	0	0	0.19	(0.39)	0.02	(0.03)	0.054

* Indicates significance at the 0.05 level.

Invertebrates

No attempt was made to quantitatively determine invertebrate use by swans but only to describe another ecological parameter that may be important in nest site selection. Invertebrates are considered to be of primary importance to swans and other waterfowl during pre-laying, pre-hatching and up to approximately one month after hatching (April-July) (Banko, 1960; Palmer, 1976; Swanson and Meyer, 1973; Bartonek et al., 1969). Therefore, data analyses were performed on the June and July samples alone.

Swans are known to feed by using their bills for pulling vegetation from the substrate, by skimming the waters surface and using their feet to stir up the substrate or in digging vegetation (Hampton, 1981; Banko, 1960). Three methodologies were selected in 1981 to sample the ecotones most available to swans based on their feeding behavior. These samples are at best useful in approximating the relative invertebrate abundance. Analysis of variance was used in comparing the abundance of invertebrates between months and lake groups. Specimens collected from all three samplers were combined and taxa were placed into their appropriate order for the purpose of data analysis. The heterogeneous nature of the lake vegetation did not allow for comparison of invertebrate taxa with specific macrophyte taxa or lifeforms.

1980

Forty-two taxa were identified in 1980 comprising 19 orders (Table 24). The greatest taxa diversity was found within the

presently used lakes ($\bar{X}=17.75$) although the greatest number of individuals, all taxa combined, was in the historically used lakes. The total number of individuals collected in June and July differed by less than 100 individuals (June, 9636; July, 9707 individuals) and two more taxa were collected in June than in July.

Daphnia was the most abundant taxa collected in 1980 with Chironomidae, Pelecypoda, Oligochaeta and Gastropoda following in decreasing order. Historically used lakes had significantly greater numbers of *Acarina* individuals ($p=0.032$) than did the presently used and non-used lakes. Individuals in the order Diplostraca were collected in the presently used lakes only. There was no significant difference in the total number of individuals per order by months, although the orders Pelecypoda ($p=0.09$) and Diplostraca ($p=0.096$) had P values less than 0.10 (Table 15).

1981

Fifty-two taxa were identified in 1981 comprising 19 orders (Table 24). The greatest diversity in taxa was found in the historically used lakes ($\bar{X}=27.75$) although the difference in the number of taxa in presently ($\bar{X}=27.25$) and non-used lakes ($\bar{X}=26.75$) was not significant. The greatest number of individuals were found in the presently used lakes with historically and non-used lakes following in decreasing order. July samples had 1.6 times as many individuals as did the June samples. Chironomidae was the most abundant taxa collected in 1981 followed by *Daphnia*, Pelecypoda, *Hyalella* and Oligochaeta in decreasing order.

Table 15. Means (standard deviations) and P values for invertebrate samples collected in 1980 and 1981 from the study lakes on the Ashton Ranger District, Idaho and Wyoming.

Invertebrates	Used		Historical		Non-used		P Values
Conchostraca	31.13	(46.11)	0	0	0	0	0.047*
Hydracarina	0.344	(0.668)	1.375	(1.136)	0.25	(0.707)	0.032*
Pelecypoda							0.09
Cladocera	99.94	(72.44)	26.60	(35.94)	24.81	(19.23)	0.009*

Invertebrates	June		July		August		September		P Values
Diptera									0.061
Ephemeroptera	1.15	(1.03)	3.64	(3.75)	0	0	0	0	0.036*

* Indicates significance at the 0.05 level.

Individuals in the suborder Cladocera were found in significantly greater numbers ($p \approx 0.00$) in the presently used lakes than in the historically and non-used lakes. Individuals in the order Ephemeroptera were collected in significantly greater numbers ($p = 0.036$) in July than in June. Although not statistically significant, comparison of the monthly total of individuals in the order Diptera generated a P value of 0.061 (Table 15).

DISCUSSION AND CONCLUSIONS

Distribution and Production on the Targhee National Forest

The historic and current number of breeding pairs on the Forest appears to be closely associated with the tri-state population. The ratio between the Ashton and tri-state adult populations has remained relatively stable with the exception of two major divisions. The relatively stable adult population on the District differs from the tri-state adult population which fluctuated 34% in four years during the 1950's. The peak adult populations on the District were observed 3 to 7 years following the peak adult populations on the RRLNWR, on which the largest sector of the tri-state population is found. Prior to the early 1950's, the RRLNWR swan population was undergoing a rapid increase in response to its newly acquired protection in 1935. The rate of increase started to decline around 1951 at which time the ratio between the non-breeding and breeding adults was increasing. This increase in the non-breeding population resulted from a saturation of nesting territories on the Refuge following the population increases of the 1930's and 40's (Banko, 1960).

An average time lag of 5 years would be expected between years of high production and the recruitment of those individuals into the breeding population. Thus, the increases in the adult population on the District in 1957 (51 adults and 12 cygnets) and again in 1963 (54 adults and 17 cygnets) were most likely due to an influx of breeding age

adults from RRLNWR. The minor fluctuations about the 50 year average and the drop in adult population on the District in the immediate years following 1957 and 1963 suggest that a limited number of optimal nesting territories occur on the District.

Analysis of egg composition, dimensional measurements and the time of cygnet mortality indicate that mortality is site or pair specific and not entirely related to the nutritional status of the laying female.

A pair-wise comparison of the eggs collected from RRLNWR, YNP and from the TNF in 1981 showed that the TNF eggs weighed significantly more than the RRLNWR eggs ($p=0.015$). If the yolk and other nutrient material increases proportionately to increases in egg weight, then one would expect better hatching success from the heavier egg. In addition, since newly hatched chicks rely upon the absorbed yolk material for the first 48 hours post hatching, one would expect a higher survival rate from chicks that hatched from heavier eggs (Kear, 1965), assuming adequate amounts of the necessary nutrients were present in the yolk. Ankney and Bisset (1976) found that intra-clutch weight differences observed in the lesser snow goose (*Chen caurulescens*) were in part due to the sequence of egg laying, with the last egg weighing the least and that these differences were not related to clutch size. They also stated that under poor environmental conditions an embryo from a heavier egg had a greater chance of survival than one from a lighter egg. Parsons (1975) found egg weight to be an important factor in explaining some of the hatching failure and post hatching

mortality he observed in the herring gull (*Larus argentatus*) although he states the sequence of laying appears more important.

Johnsgaard (1973) proposed that large birds such as swans, having the smallest average clutch size of the Anatidae, are not likely to have a clutch size regulated by the average food availability. Instead he suggests that clutch size may be limited by decreasing parental care, limitations posed by the environment on the optimum breeding time and an increased probability of nest predation.

Since 130-190 days are required to lay an average clutch of five eggs, incubate the eggs to full term and raise the cygnets to fledging, limitations in the breeding time may be an important factor within the tri-state area where the frost-free days number approximately 90 per year (Johnsgaard, 1978). Of the 33 eggs collected from RRLNWR in 1981, 55% (18) of the eggs contained at least partially developed embryos. Developed embryos were not observed in any of the three eggs collected from the Targhee. The proportion of unhatched, developed embryos observed on the RRLNWR leads one to speculate that swans within this area are bringing off less than an average size brood due to limitations in the length of the breeding season. Partially developed embryos which do not hatch may be an indication that the laying female is initiating incubation prior to completing the clutch (personal communication, J. Ball). This adjustment in the sequence of laying and incubation by the female may be in response to yearly environmental conditions.

Location of the nest, size of the adults, the defense of the cygnets by the adults and the physically close structure of the family

group after hatching suggest that predation is not a limiting factor in clutch size. Changes in parental behavior have not been observed adequately to address their possible role in regulating clutch size.

RRLNWR experienced its highest cygnet mortality (29%) from July 25 to August 20, 1981, but by October 1, 1981, 59% of the cygnets on the RRLNWR and 50% off of the RRLNWR had died (personal communication, R. Sjostrom). Similarly, examination of the cygnet mortality in 1980 and 1981 on the Targhee indicates that the highest cygnet mortality does not occur within 48 hours of hatching but between 2 and 6 weeks post hatching. Six of the cygnets that succumbed in 1980 (18%) died within 48 hours and an additional 82% mortality occurred by October 16. Five of the cygnets that succumbed in 1981 (25%) died within the first 48 hours with an additional 75% mortality occurring thereafter until October 11 (Table 16).

Another pertinent observation of the cygnet mortality on the Targhee is the site specificity. Historical records from 1932 to 1982 indicate that there are particular lakes on the Forest that have had consistently poor cygnet survival. Records of Widgit Lake indicate that in spite of 8 years of non-consecutive use by swans, no known record of fledged cygnets exists. Although this was not a study lake, production data were gathered from 1979 to 1981 and a minimum of nine eggs were laid during that time. Chain Lake (a study lake) had 9 years of recorded use by swans. From 1979 to 1981, only one cygnet was observed as late as October from 14 eggs. On the other hand, Thompson Hole has had 16 years of recorded swan use, with 21 cygnets observed as late as August and October (historical summer surveys are flown

Table 16. Occurrence of cygnet mortality on the Ashton Ranger District, Idaho and Wyoming, from 1979 to 1981.

<u>1979</u>					
0	3	3	1	2	3
0-3 days post hatching	3-7 days	7-14 days	14-30 days	30 days to fledging	Number fledged
<u>1980</u>					
6*	4	0	2	1	6
0-3 days post hatching	3-7 days	7-14 days	14-30 days	30 days to fledging	Number fledged
<u>1981</u>					
5	5	5	2	0	17
0-3 days post hatching	3-7 days	7-14 days	14-30 days	30 days to fledging	Number fledged

1979 The time of hatching and death of 6 cygnets are unknown.

1980 The time of hatching and death of 4 cygnets are unknown.

1981 The time of hatching and death of 3 cygnets are unknown.

* Three of these cygnets were thought to have died due to avian predation on the same day they hatched.

in late August). Although nesting records of swan use on Mesa Marsh were started in 1980, this lake has had exceedingly high cygnet survival rates, averaging 82% (Table 18).

Based on only 13 banded birds, the average age of adult birds on the RRLNWR is 6 years, although captive swans have been known to live up to 22 years (Banko, 1960). If the birds on the Targhee have a similar average adult survival, it would appear that the same adults have not utilized the above mentioned lakes for 9 to 16 years. If this is true, it again supports the hypothesis that cygnet mortality may be site specific.

Trumpeter Swan Habitat

Swans are utilizing the older, eutrophying lakes on the TNF for nesting and brood rearing. These lakes have an average water depth of 1.2 m, shoreline development ratios greater than or equal to 1.6, no less than 83% of their total area covered by vegetation, 26% of the total area within a water depth of less than 1 m and a diverse macrophyte and invertebrate community.

Hansen et al. (1971) and Page (1976) both found shoreline development to be an indicator of optimum nesting habitat for trumpeter swans, with wetlands having highly irregular shoreline (D_L) supporting a greater number of nesting pairs per area. This relationship has been observed for other waterfowl species (Drewien and Springer, 1969; Patterson, 1976).

Values of D_L on the study lakes were relatively low (Table 22) compared to those found on RRLNWR (Page, 1976). Unlike RRLNWR where

multiple nesting territories exist on one large body of water, the Targhee lakes supported only one nesting pair per lake. Although the D_L and area appear inadequate at this time for supporting more than one pair of swans per lake, there does appear to be selection for lakes with a greater D_L . This selection is most likely related to the fact that lakes with greater D_L are generally older and have more developed and complex aquatic floral and faunal communities (Hutchinson, 1957).

Transects which were established perpendicular to the shoreline in 1980 allowed for examination of species distribution along a depth gradient (Table 25). Plant zonation was not determined in the true sense since maximum and minimum depth limitation were not determined for individual species.

Totally submerged plant communities are typically found in water greater than 1 m deep. Floating leaved species inhabiting depths of 0.5 to 1 m with emergent vegetation communities located adjacent to the shore in water less than 1 m deep. Free floating hydrophytes are commonly found in wind sheltered areas or amongst emergent and floating vegetation (Sculthorpe, 1967).

Macrophyte distribution within the study lakes generally followed this same trend although overlap existed. One obvious exception was that a floating leaved species, *Nuphar polysepalum*, was the only apparent plant growing at water depths not inhabited by other hydrophytes which in seven lakes ranged in depth from 79 to 380 cm. Macrophyte growth in the remaining five lakes was unrestricted by depth. Low growing aquatic vegetation may not have been observed in deeper

waters because dense stands of *Nuphar polysepalum* limited light which in turn inhibited macrophyte growth and observability.

Certain hydrophytes are associated with specific textural types of substratum. Emergent and submerged vegetation are not typically found in the gravel-sand zone. This is in part due to the coarse texture of the substrate and the accentuated wave action that occurs closer to shore (Wilson, 1935; Sculthorpe, 1967). Better adapted to this zone are low growing and rosette life form exemplified by the genera *Najas*, *Chara* and *Isoetes* which were frequently found in non-used lakes. In addition to the above mentioned hydrophytes *Ranunculus aquatilis*, *Myriophyllum spicatum*, *Eleocharis acicularis* and *Potamogeton amplifolios* were found within this zone in the study lakes. Acidic soils associated with areas of undecomposed organic debris generally have fewer species with floating leaved hydrophytes predominating. Similar zones found within the study lakes were inhabited by *Nuphar polysepalum*, *Potamogeton natans* and *Potamogeton robbinsii*. The greatest species diversity was found on a silt-decomposed organic material substratum. *Potamogeton epihydrus*, *P. gramineus*, *Alisma plantago*, *Eleocharis palustris*, *Carex* spp., *Hippuris vulgaris*, *Glyceria* spp., *Callitriche verna* and *Sparganium* spp. were the representative hydrophytes. This soil type and associated hydrophytes were more common to the presently and historically used lakes.

The most obvious difference observed between varying water depths was species diversity. No plant species had an average depth range of less than 0.1 m (25.4 cm), 15 species had a range of between 0.1 and .25 m (25.4 cm to 63.5 cm), 7 species had a range of 0.25 to 0.5 m

(63.5 cm to 127 cm) and 2 species had an average range between 0.5 and 0.75 m (127 cm to 190.5 cm). This relationship between species diversity and water depth has been previously observed by Paullin (1973) at RRLNWR.

Although the abundance of emergent vegetation was not significantly different between the three lake groups, the abundance of total vegetation was. On the presently used lakes, greater than 31% of the vegetation was floating, primarily *Nuphar polysepalum*. This plant species was effective in providing cover. Therefore, it would appear that security cover afforded the swans by floating or emergent vegetation is an important variable in nest site selection.

Both in 1980 and 1981 the greatest macrophyte diversity was found in the presently used lakes followed in order by the historically used and non-used lakes. In addition, the total percent vegetation was significantly greater in the presently and historically used lakes than in the non-used lakes. Submergent vegetation was the most represented life form. It is believed that these factors are primarily responsible for the greater species diversity and abundance of aquatic invertebrates found in the presently and historically used lakes.

Krull (1970), Kreckler (1939) and Rosine (1955) documented that a greater aquatic invertebrate biomass exists within vegetative lifeforms that express the greatest underwater structural complexity. Three species which they reported are *Ceratophyllum* spp., *Myriophyllum* spp. and *Hippuris* spp.

Myriophyllum spicatum was equally represented between lake groups (33%) in 1981 but was not equally distributed between lakes within the

the non-used category. One and one-half percent of the total amount of *Myriophyllum spicatum* found in non-used lakes was found in Mesa Marsh Pond, with the remaining 98% found in Bergman Reservoir. Ninety-five percent of the *Ceratophyllum demersum* identified in 1981 was located within the historically used lakes and the remaining 5% was in the presently used lakes. Ninety-three percent of *Hippuris vulgaris* identified in 1981 was found in the presently used lakes, 6% was found in the historically used lakes and 0.7% was found in non-used lakes. Voigts (1976) found greater total invertebrate abundance in stands of submerged vegetation that was adjacent to emergent species. This relationship between aquatic invertebrates and macrophytes is based on the role that plants play in providing cover, a surface area for invertebrate foods such as periphyton, algae and bacteria and a surface area for attachment and oviposition of invertebrates (Rosine, 1955; Sculthorpe, 1967).

RECOMMENDATIONS FOR MANAGING TRUMPETER SWANS
ON THE TARGHEE NATIONAL FOREST

Management Goals

1. Maintain and if possible enhance the trumpeter swan population on the Targhee National Forest.

Recommendations

1. Maintain and enhance current condition of aquatic habitat used by breeding adults.
2. Enhancement of potential nesting territories should be designed to provide for: water level stabilization, protection of emergent vegetation zone, nest construction, maintenance of aquatic vegetation stands such that no less than 60% of the surface area of a pond/lake is covered with emergent and/or floating hydrophytes, no less than 20% of a pond/lake area with a water depth of 1 m or less, and abatement of shoreline erosion.
3. Locate major developments such as administrative sites, campgrounds and summer homes at least 1 km from aquatic habitat used by swans. Construct new roads and trails at least 0.5 km from nesting habitat. Maintain a visual barrier (at least 3 sight distances) between newly constructed roads/trails and lake/pond shoreline. A visual barrier should also be provided

between major resource activity sites such as timber cutting units, energy exploration sites and testing grounds, and areas of heavy livestock concentration (salt grounds, bedding grounds, corrals).

4. Schedule resource management, recreational and habitat manipulation activities on breeding areas prior to April 1 or after July 15 and on winter habitat prior to November 1 and after April 1. Reduce travel along established roads that are adjacent and within view of nesting swans by managing them as closed from April 1 to July 15.
2. Continue to monitor both non-breeding and breeding swans on the Forest; initiate and cooperate in an extensive summer and winter swan survey throughout the tri-state area; provide population data to other management agencies upon request.

Recommendations

1. Continue to update records of swan use on the Forest with particular attention given to breeding attempts and success and winter habitat use.
2. Conduct Forest-wide surveys of both summer and winter habitat at least every 3 years in order to assess pioneering by swans into new areas. Encourage State and Federal agencies through assistance, to conduct more extensive summer and winter surveys throughout the tri-state area.
3. Provide other agencies and research groups involved with swan management with a year-end report. This report should include

early spring use on the Forest, breeding pair use, production data and winter habitat use.

3. Provide the public with an opportunity to enjoy swans by promoting educational and recreational programs that do not conflict with other goals.

Recommendations

1. Provide the public with information on the presence of swans on the Forest, their biological and ecological requirements and the protection afforded them under the Migratory Bird and Treaty Act.
2. Direct the public to sites at which non-consumptive activities such as observing and photographing swans and educational programs can be conducted without disturbance to the nesting adults and their young. Currently such sites exist at Swan Lake (Hwy 91) and Indian Lake.

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APPENDIX

Table 17. Classification of lakes on the Ashton Ranger District, Idaho and Wyoming.

Body of Water	Use*	Aquatic Habitat Classification
Fish	U	Lake
Rock Lake	NU	Lake
Rock Marsh	U	Marsh
Junco	NU	Lake
Winegar Hole	NU	Lake
Lake of the Woods	U	Lake
Grassy Lake Reservoir	N	Reservoir
Winegar Marsh	N	Marsh
Upper Goose	U	Lake, ephemeral
Lower Goose	NU	Lake
Swan Lake (Falls River)	NU	Lake
Swan Lake (Highway 91)	NU	Marsh
Thompson Hole	NU	Lake
Steele Lake	NU	Lake
Beaver	U	Lake
Horseshoe	U	Lake
Gerrit (Beaver Pond)	NU	Lake
Wyoming Creek Pond	NU	Lake
Sawmill Creek Pond	NU	Lake
Tillery	N	Lake
Moose	U	Lake
Hidden	N	Lake
Porter Ranch Pond	N	Lake
Ernest	NU	Lake
Bergman Reservoir	U	Reservoir
Pond east of Bergman	U	Lake, ephemeral
Pond north of Ernest	N	Lake, ephemeral
Squirrel Meadow Pond	N	Lake
Indian	NU	Lake
Boone Creek Pond	U	Lake
Dog Creek Pond	U	Lake
Widgit	NU	Lake
Winegar Creek Pond	N	Lake
Southeast Dog Creek Pond	N	Lake
Rock Creek Pond	U	Lake
Conant Creek	NU	?
Loon	NU	Lake
Hatchery Butte Pond	N	Lake
Puddle/Forest	NU	Lake
Chain	NU	Lake
Rising Creek Pond	U	Lake
Porcupine Creek Pond	U	Lake
North of Pineview	NU	Lake
Warm River Lookout	U	Lake

Table 17. Continued.

Body of Water	Use*	Aquatic Habitat Classification
Pond on Bear Creek	NU	Lake
Putney Meadows	NU	Lake
Mesa Marsh	NU	Marsh
Mesa Marsh Pond	U	Lake, ephemeral
Tule	NU	Marsh, ephemeral
Eccles Marsh	NU	Marsh, ephemeral
Railroad Pond	NU	Lake
Long Meadows	NU	Lake
East of Paddy	NU	Lake
Porcupine	U	Lake
Bear	NU	Lake
Cub	N	Lake, ephemeral
East of Pineview	NU	Lake
West Slope	U	?
West of Thompson Hole	N	Lake
Northeast Moss Springs	N	Lake
Beaver-Shoe	N	Lake
JX Ranch Pond	N	Lake
Lilypond-Pineview	N	Lake, ephemeral
Partridge-Flat Creek Pond	N	Marsh, ephemeral
Northeast of Gerrit	U	Marsh

* Used = U 19

Used and Nest = UN 29

Non-used = N 17

Marshes 8

Lakes/pond 53

Reservoirs 2

Unknown 2

Table 18. History of site use on the Targhee National Forest, Idaho and Wyoming, from 1932 to 1981.

Location	No. Years Swan Present	Last Successful Brood	Total Broods	Total Cygnets	1979			1980			1981		
					Swans	Nest	Cygnets	Swans	Nest	Cygnets	Swans	Nest	Cygnets
Rock Lake	2	-	0	0	0	0	0	0	0	0	0	0	0
West Slope	1	-	0	0	0	0	0	0	0	0	0	0	0
Conant Cr.	3	1961	1	1	0	0	0	0	0	0	0	0	0
Boone Cr.	7	-	0	0	0	0	0	0	0	0	0	0	0
Dog Cr. Pond	2	-	0	0	0	0	0	0	0	0	0	0	0
Widgit Lake	8	-	0	0	2	yes	0	2	yes	0	2	yes	-
Pond east of Bergman	2	-	0	0	0	0	0	0	0	0	0	0	0
Moose	1	-	0	0	0	0	0	0	0	0	0	0	0
Indian	21	1981	11	29	2	yes	0	2	no	0	2	yes	5
Loon	11	1966	3	5	0	0	0	0	0	0	0	0	0
Puddle/Forest	1	1944	1	3	0	0	0	0	0	0	0	0	0
Chain	9	1980	3	5	2	yes	0	2	yes	1	2	yes	0
Ernest	6	1979	1	2	2	yes	2	2	no	0	0	0	0
Rock Lake Marsh	13	1959	3	8	2	?	0	2	no	0	2	no	0
Fish	4	-	0	0	0	0	0	0	0	0	0	0	0
Junco	4	1953	4	8	0	0	0	0	0	0	0	0	0
Winegar Hole	7	1955	1	3	0	0	0	0	0	0	0	0	0
Lake of the Woods	5	-	0	0	0	0	0	0	0	0	0	0	0
Upper Goose	4	-	0	0	0	0	0	0	0	0	0	0	0
Lower Goose	11	1966	3	4	?	?	?	2	no	0	2	no	0
Swan (FRB)	7	1953	3	5	0	0	0	0	0	0	0	0	0
Thompson Hole	16	1981	10	22	2	yes	2	2	yes	0	2	yes	2
Steele	8	1966	3	7	0	0	0	0	0	0	0	0	0
Horseshoe	1	-	0	0	0	0	0	0	0	0	0	0	0
Beaver Lake	4	-	0	0	0	0	0	0	0	0	0	0	0
Wyo. Cr. Pond	2	1953	1	3	0	0	0	0	0	0	0	0	0
Sawmill Cr. Pond	1	1959	1	3	0	0	0	0	0	0	0	0	0
Rising Cr. Pond	1	-	0	0	0	0	0	0	0	0	0	0	0
Porcupine Cr.	1	-	0	0	0	0	0	0	0	0	0	0	0
Gerrit	7	1965	2	4	0	0	0	2	no	0	2	no	0
*Swan (Hwy 91)	2	1980	1	1	?	?	?	2	yes	1	2	yes	0
North of Pineview	2	1965	2	7	0	0	0	0	0	0	0	0	0

Table 18. Continued.

Location	No. Years Swan Present	Last Successful Brood	Total Broods	Total Cygnets	1979			1980			1981		
					Swans	Nest	Cygnets	Swans	Nest	Cygnets	Swans	Nest	Cygnets
Warm River	1	-	0	0	0	0	0	0	0	0	0	0	0
Bear Cr. Pond	1	1961	1	2	0	0	0	0	0	0	0	0	0
Putney Meadows	5	1956	1	4	4	no	2	6	no	0	0	0	0
1 mile east of Pineview	3	1981	1	4	0	0	0	0	0	0	2	?	4
Mesa Marsh Pond	2	-	0	0	?	?	?	2	no	0	5	no	0
Mesa Marsh	2	1981	2	9	?	?	?	2	yes	4	2	yes	5
Tule Lake	3	1977	1	3	0	0	0	0	0	0	0	0	0
Eccles Marsh	3	-	0	0	0	0	0	2	no	0	2	yes	0
Railroad Pond	1	-	0	0	0	0	0	2	no	0	0	0	0
Long Meadows	4	1981	1	1	2	yes	0	2	yes	0	2	yes	1
East Paddy Lake	1	1966	1	2	0	0	0	0	0	0	0	0	0
Porcupine Lake	1	-	0	0	0	0	0	0	0	0	0	0	0
Bear Lake	4	1966	1	3	2	no	0	2	no	0	2	no	0
Bergman Res.	2	-	0	0	0	0	0	0	0	0	0	0	0
*Squirrel Meadows	12	1977	10	51	0	0	0	0	0	0	0	0	0

* Incomplete survey data.

** Combined locations.

Table 19. Description of unhatched eggs collected in 1981 from Targhee National Forest, Yellowstone National Park and Red Rock Lakes National Wildlife Refuge of Idaho and Wyoming.

Location	No. Egg	Wt (gr)	Length (mm)	Width (mm)	Cause of Mortality	Incubation Term	Contents
Foster Lake YNP	1	-	-	-	Predation		
	2	290	111	71	Infertile	Full	Undifferentiated yolk and albumin
	3	300	113	73	Infertile	Full	Undifferentiated yolk and albumin
Trumpeter #1 YNP	1	250	108	74	Infertile	Full	Undifferentiated yolk and albumin
	2	250	111	73	Infertile	Full	Undifferentiated yolk and albumin
	3	250	107	72	Infertile	Full	Undifferentiated yolk and albumin
Trumpeter #2 YNP	1	260	114	75	Infertile	Full	Undifferentiated yolk and albumin
	2	270	112	77	Infertile	Full	Large air sac 21 mm deep. Undifferentiated yolk and albumin
	3	260	114	75	Infertile	Full	Undifferentiated yolk and albumin
	4	270	115	75	Infertile	Full	Undifferentiated yolk and albumin
	5	250	117	75	Infertile	Full	Undifferentiated yolk and albumin
7# Mile Bridge YNP	1	340	126	78	Flooded	Not full	Undifferentiated yolk and albumin
	2	340	125	77	Flooded	Not full	Undifferentiated yolk and albumin

Table 19. Continued.

Location	No. Egg	Wt (gr)	Length (mm)	Width (mm)	Cause of Mortality	Incubation Term	Contents
Richy Pond	1	300	108	73	Abandoned	Not full	Undifferentiated yolk and albumin
Private land	2	315	111	77	Abandoned	Not full	Undifferentiated yolk and albumin
Ashton, Id.	1	290	112	75	Abandoned	Not full	Embryo present
Indian Lake	1	350	123	75	Infertile	Full	Undifferentiated yolk and albumin
TNF	2	360	122	79	Infertile	Full	Undifferentiated yolk and albumin
Long Meadows	1	240	113	73	Infertile	Full	Undifferentiated yolk and albumin
TNF	2	230	115	75	Infertile	Full	Undifferentiated yolk and albumin
Shambow Pond	3	250	116	74	Infertile	Full	Undifferentiated yolk and albumin
RRLNWR	4	250	112	74	Infertile	Full	Undifferentiated yolk and albumin
	5	235	114	74	Infertile	Full	Undifferentiated yolk and albumin
River Marsh	1	180	122	79	?		Embryo present
RRLNWR #1	1	290	115	75	Infertile	Full	Undifferentiated yolk and albumin
River Marsh	2	280	115	75	Infertile	Full	Undifferentiated yolk and albumin
RRLNWR #2	3	250	118	73	Infertile	Full	Undifferentiated yolk and albumin

Table 19. Continued.

Location	No. Egg	Wt (gr)	Length (mm)	Width (mm)	Cause of Mortality	Incubation Term	Contents
River Marsh RRLNWR #3	1	250	117	72	?	Full	Embryo present
	2	310	118	77	Infertile	Full	Undifferentiated yolk and albumin
	3	310	117	77	Infertile	Full	Undifferentiated yolk and albumin
River Marsh RRLNWR #4	1	90	111	73	Infertile	Full	Dehydrated yolk and albumin
South Shore Upper Lake RRLNWR #1	1	290	119	76	?	Full	Embryo present
	2	300	115	76	?	Full	Embryo present
	3	270	113	75	?	Full	Embryo present
	4	300	117	75	?	Full	Embryo present
	5	300	119	76	?	Full	Embryo present
Swan Lake RRLNWR	1	300	115	77	Infertile	Full	Undifferentiated yolk and albumin
River Marsh RRLNWR #4	2	290	118	76	Infertile	Full	Undifferentiated yolk and albumin
River Marsh RRLNWR #5	1	290	117	75	?	Full	Embryo present
	2	310	121	77	?	Full	Embryo present
	3	300	119	76	?	Full	Embryo present
	4	310	120	77	?	Full	Embryo present
River Marsh RRLNWR #6	1	260	115	75	Infertile	Full	Undifferentiated yolk and albumin
Lower Red Rock Lake RRLNWR #1	1	310	111	77	?	Full	Embryo present
	2	300	110	75	?	Full	Embryo present
	3	300	112	75	?	Full	Embryo present
	4	280	114	75	Infertile	Full	Undifferentiated yolk and albumin
	5	290	112	76	?	Full	Embryo present

Table 19. Continued.

Location	No. Egg	Wt (gr)	Length (mm)	Width (mm)	Cause of Mortality	Incubation Term	Contents
Lower Red Rock Lake	1	230	120	76	?	Full	Embryo present
RRLNWR #2	2	260	120	79	?	Full	Embryo present
	3	260	123	77	?	Full	Embryo present
Henrys Lake	1	?	?	?	?	Full	Embryo present
Idaho							
Silver Lake	1	290	115	76	?	Full	Embryo present
HSP	2	272	112	73	?	Full	Embryo present
	3	310	122	77	?	Full	Embryo present
	4	290	116	76	?	Full	Embryo present

Table 20. Composition of seven avifauna eggs and two trumpeter swan eggs.

	Swan ¹	Swan ²	Chicken ³	Chicken ⁴	Duck ⁴	Goose ⁴	Turkey ⁴	Chicken ⁵	Mallard ⁶	Gull ⁶
Calories (kcal)	184	166	152							
Proteins (percent)	13.6	11.0*	12.0	12.8	13.7	13.9	12.0	12.8- 13.4		
Lipids (percent)	13.3	11.8	10.9	11.8	14.4	12.9	11.8	10.5- 11.8		
Ash (percent)	1.0	1.0						.8- 1.0		
Sodium (mg)	103	98.65	129							
Zinc (mg)	1.53	1.62	1.3	.7007- 1.007						
Manganese (mg)	.03	.10	.038	.0054- .019						
Iron (mg)	2.18	2.67	1.97							
Moisture (percent)	69.7	72.2		73.7	69.6	70.0	73.7		64.5*	75.4
Carbohydrates (percent)	2.4	4.0*		1.0	1.2	1.2	1.0	0.3- 1.0		
Calcium (mg)	61.38	90.01	53.0							
Phosphorous (mg)	207.5	226.9	202.0							
Magnesium (mg)	8.61	12.44	11.5							

Table 20. Continued.

	Chicken ⁷	Duck ⁷	Goose ⁷	Quail ⁷	Turkey ⁷	Means	S.D.	Egg #1 T value	Egg #2 T value	T value
Calories (kcal)	158	185	185	158	171	169.88	13.50	1.046	.29	2.365
Proteins (percent)	12.14	12.81	13.87	13.05	13.68	12.9	.893	.78	-2.13*	2.160
Lipids (percent)	11.15	13.77	13.27	11.09	11.88	12.25	1.149	.91	.39	2.160
Ash (percent)	.94	1.14	1.00	1.10	.79	.99	.117	.085	.085	2.365
Sodium (mg)	138	146				122.90	21.11	-.94	-1.15	2.776
Zinc (mg)	1.44	1.41				1.36	.27	.63	.96	2.571
Manganese (mg)						.045	.039	-.38	1.41	3.182
Iron (mg)	2.09	3.85		3.65	4.10	2.93	.91	-.82	-.29	2.447
Moisture (percent)	74.57	70.83	70.43	74.35	78.50	71.65	2.93	-.67	.19	2.179
Carbohydrates (percent)	1.2	1.45	1.35	.41	1.15	1.42	.94	1.04	2.74*	2.201
Calcium (mg)	56.0	64.0		64.0	99.0	69.63	17.66	-.47	1.15	2.447
Phosphorous (mg)	180.0	220.0		226.0	170.0	204.60	22.40	.13	1.00	2.447
Magnesium (mg)	12.0	16.0				12.11	2.64	-1.33	.13	2.776

Table 20. Continued.

¹Long Meadows, TNF.

²River Marsh, RRLNWR.

³Cotterille Glauert, 1979.

⁴Romanoff and Romanoff, 1949.

⁵Stadelman, W. J. and O. J. Cotterill, 1973.

⁶Ricklefs, Robert E., 1977.

⁷Rosati, L. P. and Martha L. Orr, 1976.

*Indicates statistical significance at the 0.05 level.

Table 21. Means (standard deviations) of 1980 and 1981 water chemistry of study lakes, Ashton Ranger District, Idaho and Wyoming.

Month/Status	Alkalinity ppm	CO ₂ mg/l	DO mg/l	pH	Surface Temperature	Bottom Temperature	Total Hardness	Conductivity microhms/cm
<u>1980</u>								
June/Total	51.28 (12.94)	18.33 (6.25)	6.0 (1.28)	6.67 (0.54)	12.50 (2.33)	10.83 (2.41)	65.54 (8.97)	55 (0.02)
June/Used	55.53 (16.32)	22.50 (6.45)	6.0 (1.63)	6.83 (0.85)	13.25 (3.20)	11.25 (3.20)	72.65 (8.50)	75 (0.03)
June/Historical	51.30 (13.96)	13.75 (7.50)	5.75 (1.26)	6.50 (0.24)	12.75 (2.50)	11.25 (2.63)	64.13 (8.55)	48 (0.02)
June/Non-used	47.03 (8.55)	18.75 (4.79)	6.25 (0.96)	6.68 (0.54)	11.50 (1.29)	10.00 (1.41)	59.85 (9.87)	43 (0.01)
July/Total	42.73 (12.26)	16.25 (5.12)	7.42 (1.21)	6.61 (0.38)	14.58 (1.85)	13.50 (1.60)	48.45 (12.96)	59 (0.02)
July/Used	51.25 (19.69)	22.50 (5.00)	6.75 (1.71)	6.38 (0.30)	15.00 (1.41)	14.00 (0.00)	55.58 (16.37)	75 (0.03)
July/Historical	47.03 (8.55)	15.00 (4.08)	7.75 (0.96)	6.55 (0.10)	14.50 (2.08)	13.75 (2.75)	51.30 (13.96)	53 (0.01)
July/Non-used	29.93 (8.55)	11.25 (6.29)	7.75 (0.96)	6.90 (0.73)	14.25 (2.06)	12.75 (2.06)	38.48 (8.55)	50 (0.01)
August/Total	39.88 (8.28)	10.00 (5.38)	6.69 (1.31)	7.19 (0.74)	15.07 (2.02)	12.36 (1.92)	50.83 (13.40)	67 (0.04)
August/Used	46.98 (16.29)	10.00 (7.07)	5.50 (1.29)	6.88 (0.48)	15.38 (1.11)	12.75 (1.71)	55.58 (16.37)	103 (0.08)
August/Historical	38.48 (8.55)	10.00 (4.08)	7.25 (1.50)	7.25 (0.65)	15.50 (3.42)	12.33 (2.31)	51.30 (13.96)	53 (0.02)
August/Non-used	34.20 (0.00)	10.00 (5.00)	7.33 (1.15)	7.43 (1.10)	14.33 (1.53)	12.00 (1.73)	45.60 (9.87)	47 (0.01)
September/Total	43.21 (8.73)	7.36 (3.46)	4.72 (1.70)	7.53 (0.47)	12.67 (2.08)	11.56 (0.66)	55.58 (8.55)	54 (0.02)
September/Used	55.53 (16.32)	8.75 (7.50)	3.50 (1.29)	7.15 (0.95)	13.00 (3.00)	12.00 (0.00)	64.13 (8.55)	65 (0.03)
September/Historical	39.90 (9.87)	8.33 (2.89)	5.00 (1.73)	8.00 (1.00)	13.33 (1.15)	11.67 (0.58)	51.30 (17.10)	50 (0.01)
September/Non-used	34.20 (0.00)	5.00 (0.00)	5.67 (2.08)	7.43 (0.40)	11.67 (2.08)	11.00 (1.41)	51.30 (0.00)	47 (0.02)
<u>1981</u>								
June/Total	85.50 (29.09)	29.17 (7.16)	7.33 (1.57)	6.78 (0.98)	14.00 (1.98)	11.33 (2.53)	72.68 (16.11)	
June/Used	111.15 (45.24)	46.25 (6.29)	6.00 (2.16)	6.53 (0.38)	14.25 (0.96)	12.00 (1.41)	76.95 (22.08)	
June/Historical	72.68 (25.65)	22.50 (10.41)	7.00 (1.41)	6.73 (0.22)	14.00 (2.00)	11.25 (3.20)	76.95 (9.87)	
June/Non-used	72.68 (16.37)	18.75 (4.79)	9.00 (1.15)	7.10 (0.20)	13.75 (2.99)	10.75 (2.99)	64.13 (16.37)	
July/Total	92.63 (30.98)	32.92 (9.60)	6.17 (1.80)	7.05 (0.39)	18.42 (1.65)	17.53 (2.11)	75.53 (22.42)	
July/Used	106.88 (51.06)	46.25 (7.50)	4.25 (0.50)	6.73 (0.46)	17.25 (0.96)	16.50 (1.29)	85.50 (36.94)	
July/Historical	85.50 (27.92)	33.75 (16.52)	6.25 (3.50)	7.03 (0.26)	18.50 (1.91)	18.00 (2.58)	72.68 (16.37)	
July/Non-used	85.50 (13.96)	18.75 (4.79)	8.00 (1.41)	7.40 (0.46)	19.50 (2.08)	19.00 (2.45)	68.40 (13.96)	
August/Total	93.58 (25.75)	28.61 (9.89)	6.22 (1.73)	7.25 (0.50)	19.31 (2.14)	17.14 (2.45)	80.28 (21.71)	
August/Used	111.15 (29.62)	43.75 (8.54)	4.50 (2.38)	6.65 (0.44)	17.75 (2.50)	16.75 (1.26)	94.05 (29.62)	
August/Historical	79.80 (26.12)	23.33 (12.58)	6.67 (1.53)	7.10 (0.36)	20.67 (1.53)	17.00 (4.00)	74.10 (9.87)	
August/Non-used	89.78 (21.52)	18.75 (8.54)	7.50 (1.29)	8.00 (0.71)	19.50 (2.38)	17.67 (2.08)	72.68 (25.65)	
September/Total	87.40 (30.25)	27.20 (13.52)	5.81 (1.00)	7.04 (0.52)	13.89 (1.51)	10.89 (1.22)	68.88 (18.44)	
September/Used	94.05 (34.74)	42.50 (26.61)	4.25 (1.71)	6.78 (0.56)	13.50 (1.29)	11.00 (1.15)	81.23 (29.20)	
September/Historical	91.20 (19.75)	26.67 (10.41)	5.67 (0.58)	6.83 (0.29)	13.67 (2.52)	11.67 (2.53)	74.10 (26.12)	
September/Non-used	76.95 (36.27)	12.50 (3.54)	7.50 (0.71)	7.50 (0.71)	14.50 (0.71)	10.00 (0.00)	51.30 (0.00)	

Table 22. Morphometric measurements of study lakes on the Ashton Ranger District, Idaho and Wyoming.

Lake	Area (ha)	Ave. Depth (m)	Max. Depth (m)	Min. Depth (m)	Shoreline Development	Shoreline Length (km)	Lake Length (m)	Lake Width (m)
Presently Used Lakes								
Thompson	7.5	1.16	2.27	0.049	1.88	1.83	543.05	193.58
Long Meadows	6.4	0.75	1.32	0.128	2.14	1.92	479.88	237.01
Chain	5.3	0.37	0.67	0.099	2.20	1.79	343.39	200.25
Mesa Marsh	59.34	0.62	1.09	0.099	1.60	4.37	1232.16	752.04
Historically Used Lakes								
Steele	5.95	0.36	0.60	0.059	1.98	1.67	518.26	199.82
Loon	17.24	4.57	16.44	1.975	2.63	3.87	1139.16	544.93
Beaver Pond	28.64	1.42	1.92	0.049	1.59	3.02	865.45	404.29
Lower Goose	7.3	0.99	1.77	0.02	1.98	1.89	543.04	169.84
Non-used Lakes								
Moose	10.32	4.31	9.70	0.295	1.25	1.42	460.96	298.22
Fish	10.53	4.25	10.34	0.098	1.11	1.28	365.56	273.12
Mesa Marsh Pond	8.94	0.60	0.89	0.059	1.53	1.63	467.76	303.44
Bergman Reservoir	14.44	2.0	3.05	0.020	1.47	1.98	645.72	330.55

Table 23. Aquatic macrophyte composition (mean percent per station) of the study lakes (by status) on the Ashton Ranger District, Idaho and Wyoming.

Genus	Used	1980		Used	1981	
		Historical	Non-Used		Historical	Non-Used
<i>Alisma plantago</i>	0.2	0.01	0.16	0.005	0	0.005
<i>Carex</i> spp.	0.22	0.33	17.02	4.88	0	3.69
<i>Callitriche verna</i>	2.42	0.02	0	0.05	0.07	0
<i>Ceratophyllum demersum</i>	2.41	0.82	0	0.05	0.85	0
<i>Chara</i> spp.	0	0.03	0.29	0	0.42	0.12
<i>Eleocharis palustris</i>	3.06	0.91	0.81	0.09	0	0.65
<i>Equisetum palustre</i>	0	0.16	0	0	0	0
<i>Glyceria</i> spp.	0.55	0.59	0	0.26	0.05	0.06
<i>Hippuris vulgaris</i>	0.42	0	2.53	0.85	0.06	0.01
<i>Spirodela</i> spp.	0.06	0.08	0	0.15	0.15	0.002
<i>Lemna trisulca</i>	0	0.01	0	0.06	0.01	0
<i>Myriophyllum spicatum</i>	4.81	4.49	0.95	2.86	2.80	2.89
<i>Polygonum amphibium</i>	0.06	0.01	0.03	1.32	0.01	0
<i>Nitella flexilis</i>	1.45	0.05	0.17	3.13	0.82	0.07
<i>Nuphar polysepalum</i>	24.99	27.48	5.21	13.87	16.51	9.0
<i>Potamogeton alpinus</i>	0.71	0	0	0.005	0.003	0
<i>Potamogeton amplifolius</i>	0.01	0	0.06	0	0.22	0
<i>Potamogeton berchtoldii</i>	4.43	0.03	0.22	1.16	0.34	0.03
<i>Potamogeton epihydrus</i>	0.23	1.33	0	0.2	1.47	0.18
<i>Potamogeton friesii</i>	0.01	0.08	0	0	0.16	0
<i>Potamogeton gramineus</i>	1.07	1.02	0.14	0.21	1.31	1.66
<i>Potamogeton natans</i>	1.31	0.76	1.08	0.67	0.93	0.22
<i>Potentilla palustris</i>	0.04	0.02	0.04	0.15	0.003	0.01
<i>Potentilla pusillus</i>	0.01	0.02	0	0.26	0.02	0
<i>Potentilla robbinsii</i>	0	0.01	0	0	0.12	0.04
<i>Ranunculus aquatilis</i>	0.24	0	3.92	0	0	6.91
<i>Sagittaria cuneata</i>	0.81	0.25	0	0.06	0.03	0.02
<i>Scirpus</i> spp.	0	0	0.16	0.01	0	0.04

Table 23. Continued.

Genus	Used	1980		Used	1981	
		Historical	Non-used		Historical	Non-Used
<i>Sium suave</i>	1.88	0.01	0.06	0.05	0.01	0.01
<i>Eleocharis acicularis</i>	0.07	5.06	1.01	0.33	1.58	2.83
<i>Sparganium angustifolium</i>	0.01	0	0	0	0	0
<i>Sparganium emersum</i>	0.16	0	0.36	0	0	0
<i>Sparganium minimum</i>	0.13	0.95	0.16	0	0	0
<i>Utricularia minor</i>	0	0.04	0	0.03	0.14	0.005
<i>Utricularia vulgaris</i>	0.09	0.37	0.33	0.47	0.28	0.06
<i>Calamagrostis canadensis</i>	2.39	6.17	0.63	0.01	0	0.04
<i>Calamagrostis inexpansis</i>	0.07	1.69	0	0.04	0	0
<i>Sparganium</i> spp.	8.79	6.79	1.12	2.06	2.42	0.25
<i>Isoetes</i> spp.	0	0	0	0	0.005	0.04
<i>Carex rostrata</i>	0	0	0	1.42	0.01	0
<i>Najas flexilis</i>	0	0	0	1.81	0.05	0.01
<i>Potamogeton zosteriformes</i>	0	0	0	0.04	0	0

Table 24. Invertebrate composition (monthly totals summed) of the study lakes (by status) on the Ashton Ranger District, Idaho and Wyoming.

Phylum	Class	Subclass	Order	Suborder	Family	Subfamily	Genus	Species	Used	1980	Historical	Non-used	Used	1981	Historical	Non-used
Arthropoda																
Arachnida																
	Acarina															
		Hydracarina							8	44		8	50	3		3
Crustacea																
	Ostracoda								36	8		4	490	14		95
	Copepoda															
		Cyclopoida														
			Cyclops						143	140		700	235	99		0
	Malacostraca															
	Amphipoda															
		Gammaridae														
			Gammarus lacustris						0	368		540	0	59		0
			Hyalella azteca						132	212		27	131	831		522
	Branchiopoda															
		Diplostraca														
		Conchostraca							0	996		0	0	0		0
	Cladocera															
		Daphnia							1475	1984		2023	2126	367		394
Coelenterata																
	Hydrozoa								0	8		0	0	0		0
Nematoda									0	0		8	9	2		7
Annelida																
	Oligochaeta								471	488		321	957	131		36
	Hirudinae								0	0		0	97	72		28
		Glossiphoniidae							120	512		5	33	29		7
		Pharyngobdellida														
		Erpobdellidae														
		Dina							0	0		0	5	2		1
Mollusca																
	Pelecypoda															
		Sphaeriidae							408	1112		257	1095	686		492
	Gastropoda								34	320		815	0	0		0
		Basommatophora														
		Physidae														
			Physa						40	0		0	36	63		870
		Lymnaeidae														
			Lymnaea						11	12		4	0	0		0
		Planorbidae							68	0		32	394	42		182
Insecta																
	Homoptera															
		Delphacidae							0	0		0	1	0		0
		Cicadellidae							0	0		0	5	3		2
	Odonata															
		Anisoptera							48	88		8	8	8		40
		Aeshnidae														
			Aeshna						0	0		0	1	3		0
		Libellulidae														
			Libellula						12	244		2	39	19		94
	Zygoptera															
		Lestidae														
			Lestes						0	0		0	61	78		86
		Coenagrionidae														
			Ischnura						0	0		0	109	17		89
		Argia							129	24		45	0	2		0
	Diptera															
		Tipullidae														
			Hexatoma						0	4		0	0	0		0
		Muscidae														
			Phaenicia													
			Limnophora						9	0		0	0	0		0

Table 24. Continued.

Phylum Class Subclass Order Suborder Family Subfamily Genus Species	1980			1981		
	Used	Historical	Non-used	Used	Historical	Non-used
Insecta						
Diptera						
Chironomidae	831	1740	1217	1461	1782	1045
Chaoboridae						
Chaoborus	16	52	128	494	173	66
Tabanidae	8	8	0	2	5	1
Rhagionidae	0	0	0	0	4	6
Ceratopogonidae						
Palpomyia	16	16	11	28	3	4
Trichoptera						
Hydroptilidae	0	0	4	0	0	0
Limnephilidae	15	4	28	24	1	8
Leptoceridae	0	0	0	0	14	0
Lepidoptera						
Arctiidae						
Spilosoma virginica	0	0	0	0	0	5
Coleoptera						
Haliplidae	21	0	108	61	11	17
Dytiscidae	123	148	17	72	87	33
Chrysomelidae						
Donacia	4	0	0	0	1	1
Curculionidae	0	0	0	5	0	0
Elmidae	4	0	8	0	0	0
Collembola	3	0	40	1	0	0
Ephemeroptera						
Baetidae						
Baetinae	0	56	0	0	0	0
Callibaetis	0	8	4	0	5	4
Heptageniidae	0	0	0	0	0	2
Cingymula	0	8	0	0	0	0
Caenidae						
Caenis	0	3	10	0	8	48
Tricorythidae						
Tricorythodes	0	16	12	0	0	0
Siphonuridae						
Ameletus	0	8	0	0	0	0
Ephemerellidae						
Ephemerella	0	0	0	1	6	34
Hemiptera						
Corixidae	49	144	75	264	160	127
Notonectidae						
Notonecta	0	0	0	54	5	96
Belostomidae						
Belostoma	1	0	0	0	2	0
Naucoridae	0	0	0	0	0	1
Gerridae						
Gerris	0	0	0	6	0	5

Table 25. Zonation of plants on the study lakes on the Ashton Ranger District, Idaho and Wyoming.

Genus	Depth Range (cm)	Average Depth	N
<i>Nuphar polysepalum</i>	5-380	129.21	33
<i>Scirpus</i> spp.	0-96	58.17	6
<i>Calamagrostis canadensis</i>	10-170	81.46	13
<i>Potamogeton natans</i>	3-130	73.33	27
<i>Eleocharis acicularis</i>	0-88	41.81	26
<i>Ranunculus aquatilis</i>	20-190	124.87	15
<i>Myriophyllum spicatum</i>	3-120	62.79	33
<i>Alisma plantago</i>	20-117	55.88	17
<i>Najas flexilis</i>	52-110	88.00	5
<i>Nitella flexilis</i>	7-71	42.27	15
<i>Sparganium</i> spp.	15-134	57.60	30
<i>Potamogeton epihydrus</i>	5-138	57.11	19
<i>Hippuris vulgaris</i>	41-87	66.35	17
<i>Carex</i> spp.	0-128	51.46	14
<i>Potentilla palustris</i>	30-100	51.40	10
<i>Sagittaria cuneata</i>	10-112	49.20	10
<i>Ceratophyllum demersum</i>	77-89	83.00	2
<i>Potamogeton graminus</i>	0-90	55.06	17
<i>Chara</i> spp.	15-100	52.11	27
<i>Eleocharis palustris</i>	24-90	53.00	14
<i>Callitriche verna</i>	10-111	52.92	13
<i>Sium suave</i>	10-108	83.22	9
<i>Utricularia vulgaris</i>	12-134	64.38	24
<i>Lemna trisulca</i>	35-101	61.16	12

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