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Waterfowl Ecology and Utilization of Uinta Mountain Water Areas

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WATERFOWL ECOLOGY AND UTILIZATION

OF UINTA MOUNTAIN WATER AREAS

by

Steven Roger Peterson

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

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Steven Roger Peterson

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ABSTRACT

Waterfowl Ecology and Utilization of Uinta Mountain Water Areas

by

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Waterfowl utilization was recorded by observing study units at different elevations from the time water areas were ~~available~~ thawed in the spring until they were ~~inaccessible~~ frozen in the fall. (available when?)

Sixteen species of waterfowl were observed in the Uinta Mountains; mallards, green-winged teal, pintails, and ring-necked ducks were breeders.

Ninety-eight percent of all waterfowl observed were below 10,000 feet.

Waterfowl numbers were highest during migratory periods and lowest in the breeding season.

Adult waterfowl were observed most often on natural water areas and beaver ponds greater than one acre.

Water areas at lower elevations had high indices of aquatic invertebrates and contained aquatic plants with high seed producing capabilities whereas water areas at high elevations had little waterfowl food.

Utilization of high mountain areas by spring migrants and breeders was dependent on ~~snow removal~~ spring breakup, but freeze-up in the fall did not seriously affect fall utilization. No one factor controlled the distribution of waterfowl in the Uinta Mountains.

(66 pages)

INTRODUCTION

Justification

Numerous studies have been conducted to determine waterfowl use and productivity of water areas below 6000 feet in Utah. Virtually nothing was known of the extent waterfowl utilized high mountain water areas in Utah and the contribution waterfowl breeding in the mountains made to the waterfowl resource in Utah. Waterfowl managers have constantly strived to develop new techniques for evaluating all aspects of this recreation potential because of increased recreational demands. This study was an additional step in providing waterfowl managers with a better understanding of this resource.

Objectives

Objectives of the Uinta Mountain waterfowl study were as follows:

(1) To determine the relative species composition of waterfowl in the Uinta Mountains.

(2) To define the types, distribution and use of water areas in the Uinta Mountains.

(3) To investigate migrational movements of waterfowl from the Uinta Mountains.

(4) To invetigate some factors that may influence waterfowl use of water areas existing in the Uinta Mountains.

(5) To estimate waterfowl production in study units and project this estimate to all the Uinta Mountains.

LITERATURE REVIEW

High Elevation Waterfowl Studies

Few waterfowl ecology studies have been undertaken at high elevations. In 1954, Frary conducted a production study on the White River Plateau in Colorado and in 1964 the Colorado Game, Fish and Parks Department initiated a breeding pair survey in mountains surrounding the San Luis Valley in southern Colorado (Rutherford and Hayes, 1964). Pattie and Verbeek (1966) reported mallards[1], green-winged teal, and shovelers on Beartooth Plateau, Montana.

Nelson (1875) in his travels through Utah, Nevada, and California, reported sighting a blue-winged teal brood in the mountains 30 miles south of Fort Bridger, Wyoming. Hayward (1931) reported Dr. V. M. Tanner observed a red-breasted merganser on Grandaddy Lake in late August. In 1945, Hayward observed mallard, common goldeneye, bufflehead, pintail and red-breasted merganser in the Uinta Mountains. Twomey (1942) observed pintail and ruddy duck at 8000 feet or above, but other species of waterfowl were not listed as having been observed above that elevation in the Uintas. Cottam (1947) reported blue-winged teal, green-winged teal and cinnamon teal as breeding in the Uinta Mountains. Behle and Ghiselin (1958) considered the mallard an uncommon transient on high lakes of the Uinta Mountains.

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[1]Table 10 in the appendix gives the scientific and common names of waterfowl used in text.

General Principles of Altitude-Latitude Relationships

Where applicable, aspects of waterfowl ecology and utilization of water areas at different elevations in the Uinta Mountains are compared with similar facets of waterfowl ecology and utilization of water areas at northern latitudes. A resume' of general principles of altitude-latitude relationships is presented here.

Merriam (1894) put forth two basic principles: (1) northward distribution of terrestrial animals and plants is governed by the sum of positive daily temperatures above the normal daily mean of 43° F for the growing and repoductive season; and (2) southward distribution of plants and animals is governed by the mean temperature of a brief period during the hottest part of the year. Life zones are altitudinal or latitudinal only in a general way (Hall and Grinnell, 1919).

A biotic event in temperate North America lags four days for each degree of latitude, 5 degrees of longitude, and 400 feet altitude in a northward, eastward and upward direction in spring and early summer , and reverses in the summer and fall and in the southern hemisphere (Hopkins, 1938).

In western North America at the same altitude, a variation in temperature with latitude occurs amounting to about 1.5 to 2.0° F increase in mean annual temperature for each degree decrease in latitude (Alter, 1941).

In mountains located on the equator, an altitudinal rise of 12,000 feet is approximately equivalent to 30 degrees latitude; timberline which occurred at 22,800 feet, is equivalent to 57 degrees of latitude, and the snowline constant at 25,200 feet is equivalent to about 63 degrees latitude. Also, 500 miles of latitude was equivalent in climatic conditions to 2500 feet in altitude in mountains of the semi-arid interior of western United States (Woodbury, 1954). Anderson and Holmgren (1966) applied this equivalent to plant phenology and concluded the same species of flower which blooms about April 15 at 5000 feet may bloom about July 1 at 8000 feet on comparable aspect.

A general relationship does exist between biotic events of a given elevational zone and a corresponding latitudinal zone. For purposes of comparison in this paper, the aspen zone in the Uintas will be considered equivalent to the Aspen Parkland in Canada, the conifer zone equivalent to the boreal forest and the alpine zone equivalent to the tundra in Northern Canada (Table 1).

Table 1. Elevational zones in the Uinta Mountains, Utah and equivalent latitudinal zones in Central Canada[a]

Elevational Zones Uinta Mountains, Utah		Equivalent Latitudinal Zones, Canada	
Vegetation	Range in Elevation	Vegetation	Range in Latitude
Aspen	7500-8700[b]	Aspen Parkland	50°-55°
Conifer	8700-11,000	Boreal Forest	55°-65°
Alpine	11,000-13,498	Tundra	65°-70°

[a]Elevational ranges are those given by Graham, ~~1944~~ 1937 (Pages 40-58); latitudinal ranges are those illustrated by Weaver and Clements, 1929.

[b] Elevational range of aspen may extend from 7,000-10,000 feet according to Arnold (John F. Arnold, [illegible], [illegible], [illegible] Ranger District, Wasatch National Forest, U.S. Forest Service, Intermountain Region, [illegible] 15, [illegible])

STUDY AREA

Geographical Location and Geology

The Uinta Mountains are approximately 150 miles long, 35 miles wide and lie between longitude 111° 15' and 109° 40' East in Northeastern Utah, Southwestern Wyoming and Northwestern Colorado (Figures 1 and 2). The mountain range consists of a great anticline plateau with an average elevation of 10,000 to 11,000 feet (Hayward, 1945). Maximum elevation above the surrounding country is about 7,000 feet. Figure 2 shows 8,000; 9,000; and 10,000 foot contour intervals as well as the number of square miles and percent of the total area in each of these three elevational zones.

Glaciation assisted in leveling this high plateau and formation of small water areas behinds moraines or in rock basins gouged out by the ice (Hayward, 1945).

The sequence and characteristics of sedimentary rocks in the Uinta Mountain region are similar to the Rocky Mountain region and Wasatch Mountain area (Forrester, 1937), but Pre-Cambrian quartzite substratum in the Uintas contrasts with the limestone bulk of Mount Timpanogos in the Wasatch range. This rock coupled with poorer drainage, has resulted in a general acid condition of the soil and water in the Uintas (Hayward, 1945).

Water Areas

The Uinta Mountains contain thousands of water areas, especially the relatively flat area above 10,000 feet. The south slope between

Figure 1. Geographical location of Uinta Mountains in relation to the State of Utah on the North American Continent.

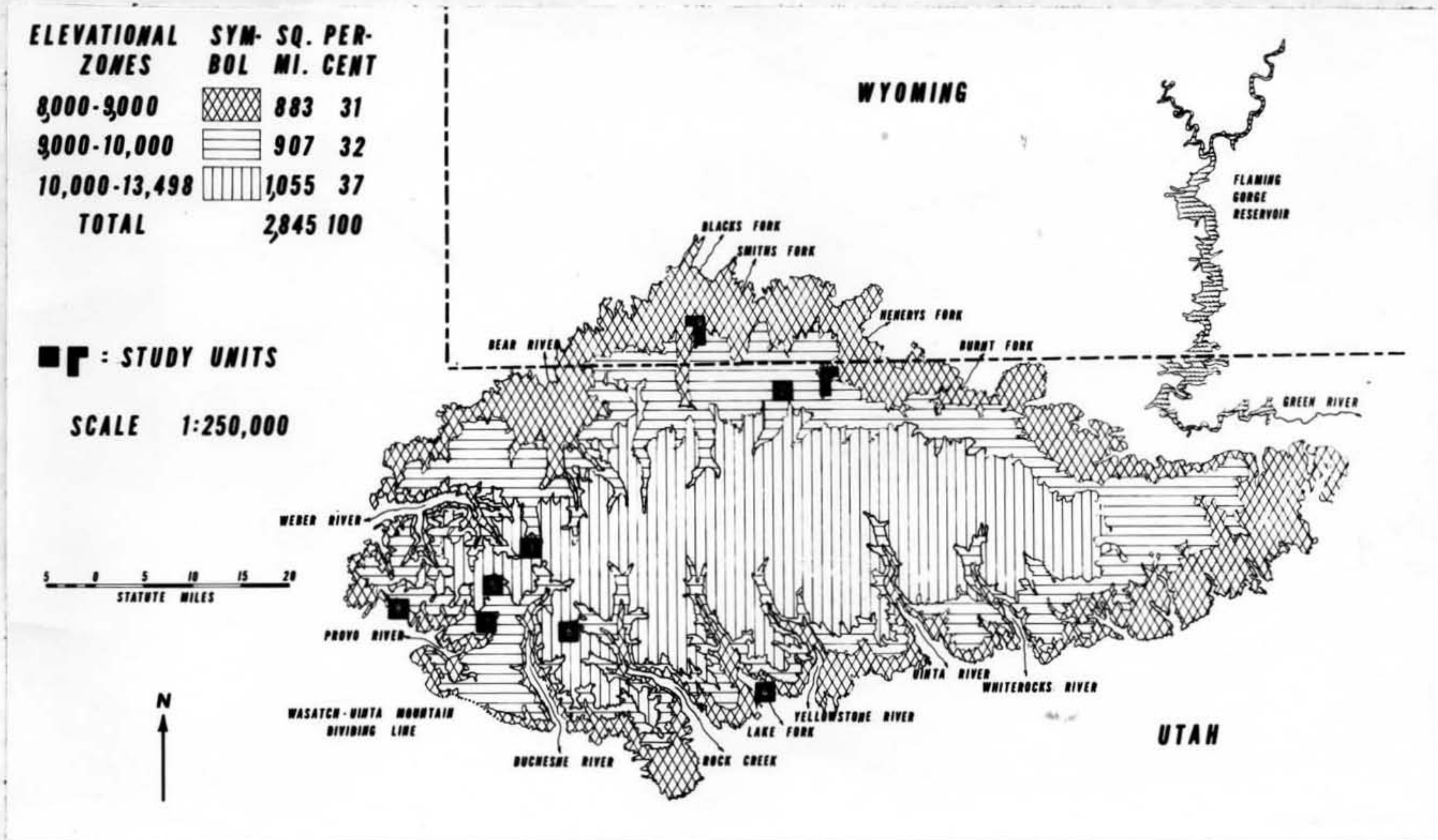

Figure 2. Location of study units, major drainages and 8,000; 9,000; and 10,000 foot contour intervals in the Uinta Mountains, Utah.

8000 and 10,000 feet is relatively steep and consequently few basins are present but terminal and recessional moraines in some canyons have blocked the courses of main streams and formed chains of lakes. On the north slope, broad mesas between 8000 and 10,000 feet contain many water-holding basins. The eastern two-thirds of the mountain range is drained by the Green River and its tributaries while the Bear, Weber, and Provo rivers originate in the western one-third (Figure 2). Few beaver ponds are present on the south slope because of the steep stream gradients. ~~topography.~~ On the more gradual north slope extensive stands of willow (Salix) and aspen (Populus) have developed, and relatively flat stream gradients ~~river beds~~ have permitted beavers to build large beaver pond complexes. Numerous irrigation reservoirs have been constructed ~~built~~ in the Uinta Mountains, primarily on the south slopes. ~~flowing rivers.~~ Figures 3-12 illustrate types of water areas in the Uinta Mountains.

Climate

Local climate is strongly modified by changes in elevation, slope and aspect. Recent research makes possible estimates of annual temperature and precipitation with a fair degree of reliability (Richardson, 1967). Most precipitation occurs in late summer, winter and early spring (Hayward, 1945). Snow can occur any time but the ground usually does not become permanently covered until mid-November. Snow usually remains on the ground until the middle of May at low elevations and the middle of June at high elevation. There is a general increase in precipation as elevation increases (Table 2).

Figure 3. Water area 117 is a natural catchment basin less than one acre at 8975 feet elevation on the north slope, June 3, 1966.

Figure 4. Water area 331 is a natural catchment basin less than one acre at 10,335 feet elevation on the north slope, June 10, 1966.

Figure 5. Water area 216 ~~is~~ a natural catchment basin greater than one acre at 9320 feet elevation on the north slope, June 21, 1965.

Figure 6. Water area 601 ~~is~~ a natural catchment basin greater than one acre at 10,310 feet elevation on the south slope, October 13, 1965.

Figure 7. Water area 911 is a beaver pond less than one acre at 8,420 feet elevation on the north slope, August 6, 1966.

Figure 8. Water area 201 is a beaver pond greater than one acre at 9,195 feet elevation on the north slope, June 29, 1965.

Figure 9. Water area 403 is a stream at 7,500 feet elevation on the south slope, October 12, 1965.

Figure 10. Water area 120 is a beaver pond-willow bottom complex greater than one acre at 8,750 feet elevation on the north slope, June 21, 1965.

Figure 11. Water area 512 [illegible] a meadow greater than one acre at 9,760 feet elevation on the south slope, July 20, 1965.

Figure 12. Water area 401 [illegible] a reservoir greater than one acre at 7,600 feet elevation on the south slope, October 12, 1965.

Table 2. Kamas snow survey data (Adapted from Richardson, 1967)

Elevation feet	Snow Depth (inches)		Water (inches)	
	Average	Range	Average	Range
7,500	24	0-57	8	0-18
7,600	38	10-65	13	3-24
7,800	38	19-64	12	7-24
8,500	55	25-89	19	9-34
9,000	57	24-90	21	11-35
9,800	79	46-112	26	17-39
9,900	72	45-104	25	18-38
10,000	85	53-114	30	24-40

Terrestrial Vegetative Communities

Graham (1937) [p. 40-59] reported [redacted] vegetational zones of the Uinta Mountains (Figure 13). Cottam (1930, p. 48) found some rather unusual floristic features in this mountain range and stated: "Some of the best examples of zone jumbling to be found in Utah are furnished by this region." The relatively smooth physiognomy of the high plateau made development of a vast climax coniferous forest possible and general acid conditions resulted in the presence of acid tolerant plants (Hayward, 1945).

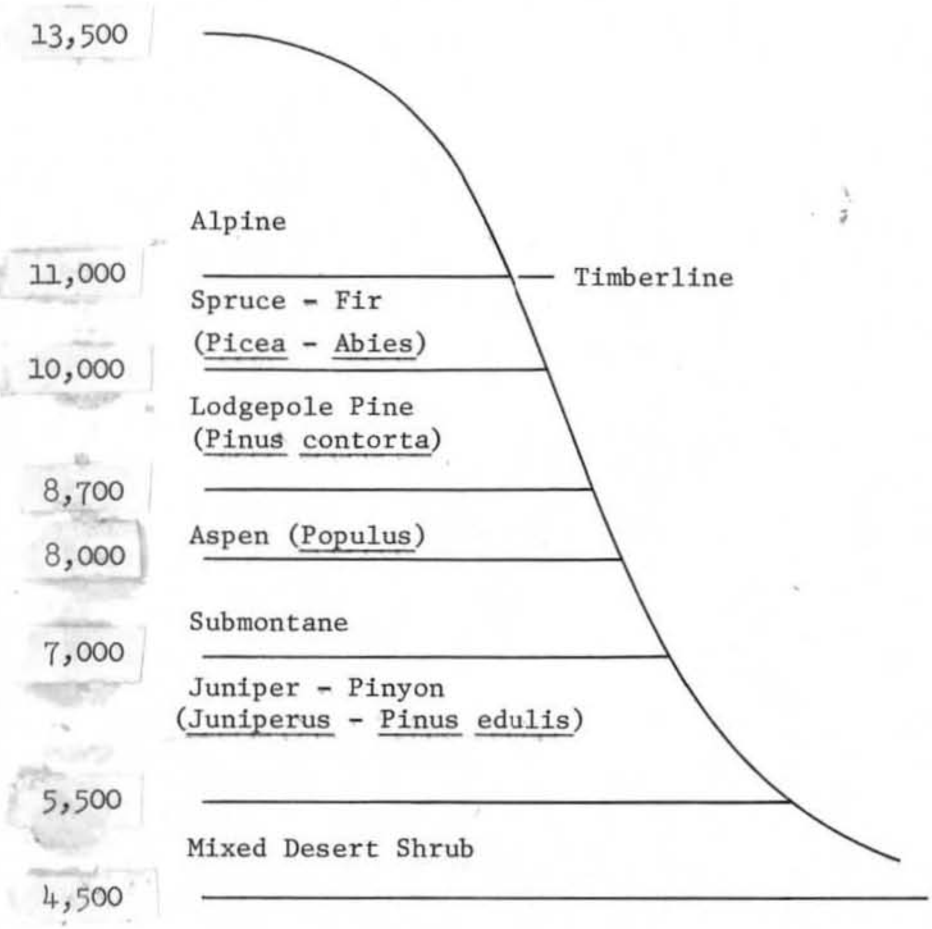

Figure 13. Altitudinal vegetation zones of the Uinta Mountains, Utah (Adapted from Graham, 1937).

PROCEDURES

Selection of Study Units

Investigations on the study area were planned as a two year project. In 1965, six study units (numbers 1-6) of approximately four square miles each, were established. For logistics, all six study units were distributed in the western half of the mountain range; this half is representative of the entire Uinta Mountains. Three study units were located on the south slope and three were on the north slope. Two study units, one on each slope, were established in each of three pre-selected altitudinal ranges: 7,500 to 9,000 feet; 9,000 to 10,000 feet and over 10,000 feet. Exact locations of study units are given in Table 12 of the appendix while the maps are on file at the Utah Cooperative Wildlife Research Unit in Logan, Utah.

Water areas were not distributed evenly through the elevational range in some study units. Consequently, in 1966, three additional study units (numbers 7-9) were established.

I confined my repeated observations to water areas within these study units. Analysis was made by slope and elevation; hereafter, in the text reference to a particular study unit is referred to by its mean elevation and slope, not its number.

Aerial Reconnaissance

Study units were observed by air during the springs of 1965 and 1966 to determine: (1) access routes into each study unit, (2) extent of spring break-up, and (3) whether waterfowl were present in or around selected study units.

Measurement of Some Factors that May Influence Waterfowl Use

Non-biotic and biotic phenomena were measured to determine some of the factors that may influence waterfowl use of high mountain water areas. Factors that could be measured quickly were recorded from all water areas within study units, otherwise a random sample was selected.

Non-biotic factors

Availability. The approximate date water areas became free of ice in the spring and either permanently dry during the summer or frozen [redacted] in the fall was recorded.

Elevation. Elevation of all water areas was checked at least once with an altimeter which was accurate to 10 feet.

Slope, type, and size. The mountain slope on which each water area was located (north or south), type of water area (reservoir, beaver pond, stream, natural catchment basin, and other) and size of each reservoir, beaver pond, and natural catchment basin (o to <1.0 acres or 1.0 acres and larger) was recorded from aerial photographs and on site inspection.

Alkalinity. In 1966, the total alkalinity of sample water areas was recorded two or three times.

Biotic factors

Aquatic invertebrates. One sample of aquatic invertebrates was taken during the brood season in 1966 in each randomly selected water area. A cone-shaped net was swept "s[redacted]" through approximately one cubic meter of water depths varying [redacted] from 4 to 15 inches.

Vegetative factors. Specimens of vascular aquatic plants were collected and identified. Changes in plant phenology were recorded for selected aquatic vascular plants in randomly selected water areas. Presence of aquatic vascular plant genera in each water area was recorded after vegetation had matured.

Measurement of Waterfowl Use

All water areas within each study unit were inspected approximately once every two weeks during accessible periods, [redacted] and waterfowl present [redacted] were recorded. More effort was concentrated in 1966 on observing low elevation water areas because few waterfowl were observed at high elevations in 1965. High elevation water areas were checked in the spring and fall for migratory waterfowl, but throughout June, July and August, the highest two study units were visited only to measure non-biotic and biotic factors. During the course of these trips, [redacted] all water areas were checked for waterfowl.

RESULTS AND CONCLUSIONS

Population Characteristics of Waterfowl Utilizing Study Units

Species composition

Species composition of waterfowl on study areas varied. Sixteen species of waterfowl were observed ~~in the study area~~ in 1965, but only ten species were observed in 1966. In 1965, 63 percent of all adult waterfowl observed were mallards. Each of the other 15 species made up from ~~less than~~ 1, to 9 percent of the total. In 1966, of all waterfowl observed, 70 percent were mallards, 22 percent were green-winged teal, and ~~the other~~ 8 species accounted for the remaining eight percent. ~~The~~ At higher the altitudes ~~the~~ fewer species were observed. Mallards, green-winged teal and ring-necked ducks (breeders) were observed at more elevations than other waterfowl. Non-breeders were observed only at lower elevations (Tables 3 and 4).

Percent of adult mallards and other waterfowl observed each trip for 1965 and 1966 was computed. Waterfowl other than mallards were not separated because each species made up a relatively small proportion of the total. The percent of the population composed of mallards is highest in the breeding season and lowest during migration. A relatively small breeding population exists after spring migrants leave. In the fall, this population increases with the addition of young produced in the area and an influx of migrants. A peak is reached in September or October. ~~which~~ This peak ~~they~~ drops off sharply as waterfowl leave the area before freeze-up (Figure 14). The trend exhibited in figure 14 is similar to all areas observed with a mean elevation less than 9,400 feet. No trend was depicted above that elevation because few waterfowl were observed.

Table 3. Relative species composition of all waterfowl observed in study units in 1965, Uinta Mountains, Utah

Species	Mean Elevation and Slope									% of total by species
	7600, South	8122, South	8562, North	8931, North	9393, North	9611, South	9939, South	10,282, South	10,355, North	
	Percent									
Bufflehead	1	Not observed	Not observed			Not observed				1
Coot	1				<1					1
Goldeneye, Common	1									1
Goose, Canada				<1						<1
Mallard	12			24	23		2			63
Merganser, Common	3									3
Pintail	4			1						5
Redhead					1					1
Ring-necked Duck				1	4		<1			5
Ruddy Duck	2									2
Scaup, Lesser	1			<1						1
Shoveler	1									1
Teal, Blue-winged				2	1					3
Teal, Green-winged	1			5	3			<1		9
Unidentified	1			1	2					4
Widgeon, American				<1						<1
Wood Duck	<1									<1
% of total by study unit	29			34	35		2	<1	0	100

Table 4. Relative species composition of all waterfowl observed in study units in 1966, Uinta Mountains, Utah

Species	Mean Elevation and Slope									% of total by species
	7600, South	8122, South	8562, North	8931, North	9393, North	9611, South	9939, South	10,282, South	10,355, North	
	Percent									
Bufflehead	<1									<1
Coot	1			<1	<1					1
Goldeneye, Common	<1									<1
Goose, Canada										0
Mallard	8	4	26	13	18	<1	1	<1		70
Merganser, Common	1									1
Pintail				2	<1					2
Redhead										0
Ring-necked Duck	<1			<1	1	<1		<1		2
Ruddy Duck	1									1
Scaup, Lesser										0
Shoveler										0
Teal, Blue-winged	<1		<1							1
Teal, Green-winged	5	<1	3	2	11	<1		<1		22
Unidentified	<1	<1	<1	1	<1			<1		1
Widgeon, American										0
Wood Duck										0
% of total by study unit	16	4	29	18	31	<1	1	1	0	100

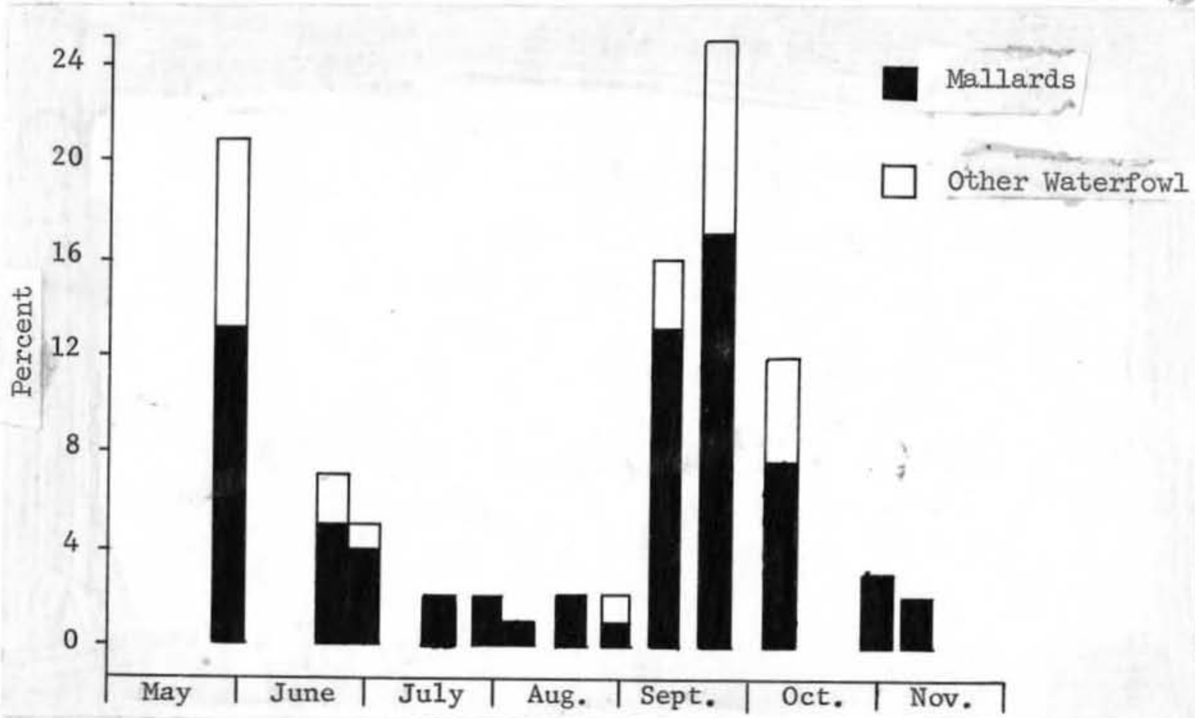

Figure 14. Percent adult mallards and other waterfowl in study unit 1, mean elevation 8,931 feet, north slope, Uinta Mountains, Utah, 1965.

Few migrants were noted in the spring of 1965 because most water areas were either unavailable to waterfowl or inaccessible to me during the migration period. During the last week in May, widgeon, mallards, pintail, green-winged teal and one Canada goose were observed in the lowest study unit on the north slope; mallards, common mergansers, ruddy ducks, shovelers and green-winged teal were observed in the lowest study unit on the south slope. A coot was observed once on June 19, 1965 at 9,300 feet on the north slope. In 1966, these same species except shovelers, widgeon, and Canada geese were observed during the spring. Blue-winged teal and a bufflehead were seen in 1966 but not in 1965.

In the fall, 1965, 13 of 16 species were observed in the study area; widgeon, Canada geese, and shovelers were not seen.

Common goldeneyes, American mergansers, lesser scaup, and ruddy ducks were numerous on a reservoir at 7,600 feet on the south slope late in the fall; whereas, mallards were the most abundantly observed duck in beaver ponds and natural catchment basins at low elevations on the north slope. All eight species of fall migrants observed in 1966 had been recorded in the fall of 1965. Buffleheads, redheads, ruddy ducks, lesser scaup, and wood ducks were observed in the fall of 1965 in addition to those species observed in the fall of 1966.

Four species of waterfowl were found to breed in the Uinta Mountains; these included: mallards, green-winged teal, ring-necked ducks, and pintails. In both years, breeding waterfowl were not observed above 10,000 feet. Mallards and green-winged teal were concentrated in water areas of the aspen zone and heavy stands of lodgepole pine in the lower coniferous zone. Pintails were found breeding at 8,900 feet on the north slope in 1966, but were not observed breeding in the study area in 1965. Mallard pairs were observed more often than other breeders while ring-necked ducks were least numerous.

Breeding species composition and abundance in vegetative zones of the Uinta Mountains agrees fairly closely with breeding species recorded in western mountain areas and equivalent areas of Central Canada. In mountains ringing the San Luis Valley, Colorado, Rutherford and Hayes (1964) recorded 13 species of breeding waterfowl with mallards and green-winged teal accounting for 50 and 15 percent, respectively, of all pairs observed. Frary (1954) recorded mallards and green-winged teal breeding in the spruce-fir region of the White River Plateau in western Colorado. Hayward (1952) did not observe breeding waterfowl in the alpine region of the Uinta Mountains. Many investigators, including Monroe (1944), Soper (1951, 1954), Willein and Lumsden (1964), Hanson, Rogers, and Rogers (1949), and Macpherson and McLaren (1959) found mallards, green-winged teal, and ring-necked ducks to be the main breeders in that order of the aspen parklands and boreal forest. As latitude increased, these species decreased in numbers.

Breeding pair chronology

The earliest date pairs were observed was May 18 in 1965 and May 7, in 1966 while latest date pairs were observed was July 8 in 1965 and June 26 in 1966. The earliest date mallard pairs were recorded does not necessarily mean this was the first day pairs arrived. The back-dating of broods showed breeding pairs were present before water areas (except streams) were free of ice.

Pair bonds remained longer in birds breeding at lower elevations or when water areas became available earlier. In late years, or at elevations where the habitat did not become available until late June, pair bonds quickly dissolved and hens began nesting. Pairs were observed for about five weeks at the lowest elevations studied on the north and south slopes whereas pairs were not observed longer than two weeks at the highest elevation mallards breed.

Brood observations

No broods were observed above 10,000 feet and over three-fourths of all broods were mallards. Mallards started incubating about June 1 in 1965 and May 5 in 1966 between 8500 and 9500 feet on the north slope. Incubation was two to five weeks earlier in 1966 than in 1965 for the same elevations (Table 5). In both years, mallards nested when much snow was present and many water areas frozen. As the summer progressed, visibility over most water areas, except at high elevation decreased.

Table 5. Calculated extreme dates of incubation for mallard broods observed in study units in the Uinta Mountains, Utah, 1965 and 1966[a]

Mean elevation and slope	1965		1966	
	Earliest	Latest	Earliest	Latest
7,600 South	May 15	June 23	May 3	May 12
8,122 South	Study Unit Not Observed		May 10	May 16
8,562 North	Study Unit Not Observed		May 9	June 7
8,939 North	May 27	June 22	May 5	July 3
9,393 North	June 2	July 17	May 6	July 12
9,611 South	Study Unit Not Observed		No Broods Observed	
9,939 South	June 28	June 28	May 21	May 22
10,282 South	No Broods Observed		No Broods Observed	
10,355 North	No Broods Observed		No Broods Observed	

[a]Incubation dates were estimated by back-dating brood observations with rates given by: Gallop, J. B. and W. Marshall, 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Technical Committee, 14p. (Processed).

In 1965 brood counts were considered good up until the latter part of July, brood counts were poor by the latter part of June in 1966. Average number of ducklings per brood for complete mallard broods was 5.5 in 1965 and 4.8 in 1966 (Table 6).

Hatching dates for mallards breeding at different latitudes were compared with hatching dates observed in the Uinta Mountains (Figure 15). At lower latitudes hatching is drawn out through the summer whereas at more northern latitudes, hatching periods are shortened. Excluding Uinta Mountain data, earliest dates of hatching are earlier at lower latitudes. In chronologically early years in the Uinta Mountains as in 1966, mallard hatching periods approach those recorded by Wingfield (1951) around Salt Lake City, Utah, or by Hochbaum (1959) near Delta, Manitoba. In chronologically late years, as in 1965, the main period coincides with mallard hatching periods for far northern latitudes but total length of the hatching period remains the same as southern latitudes. The longer hatching period in southern latitudes and in the Uinta Mountains, is probably due to a longer period available for waterfowl to renest and bring off a brood.

Frary (1954) recorded an average brood size for mallards and green-winged teal combined of 5.5 and 5.7 in 1952 and 1953. These brood sizes are slightly higer than those compiled for the Uinta Mountains. No broods were observed above 10,500 feet on the White River Plateau as in the Uinta Mountains. McKnight (1962) recorded an average brood size of 7.0 for mallards with a range of 6.1-8.0 from 1957 to 1961 in interior Alaska while Murdy (1964) observed an average mallard brood size of 6.3 on the Pre-Cambrian Shield in the Northwest Territories. Murdy noted smaller brood sizes in chronologically later years. This correlation

Table 6. Numbers and average sizes of complete mallard broods observed in study units in the Uinta Mountains, Utah, 1965 and 1966

Mean elevation and slope	Number of complete broods observed		Avereage number of ducklings per complete brood	
	1965	1966	1965	1966
7,600 South	6	2	5.3	6.0
8,122 South	Not Observed	1	-	8.0
8,562 North	Not Observed	11	-	3.9
8,939 North	7	11	4.1	4.1
9,393 North	13	18	6.5	5.1
9,611 South	Not Observed	0	-	-
9,939 South	1	2	4.0	8.0
10,282 South	0	0	-	-
10,355 North	0	0	-	-
Total and over all average	27	45	5.5	4.8

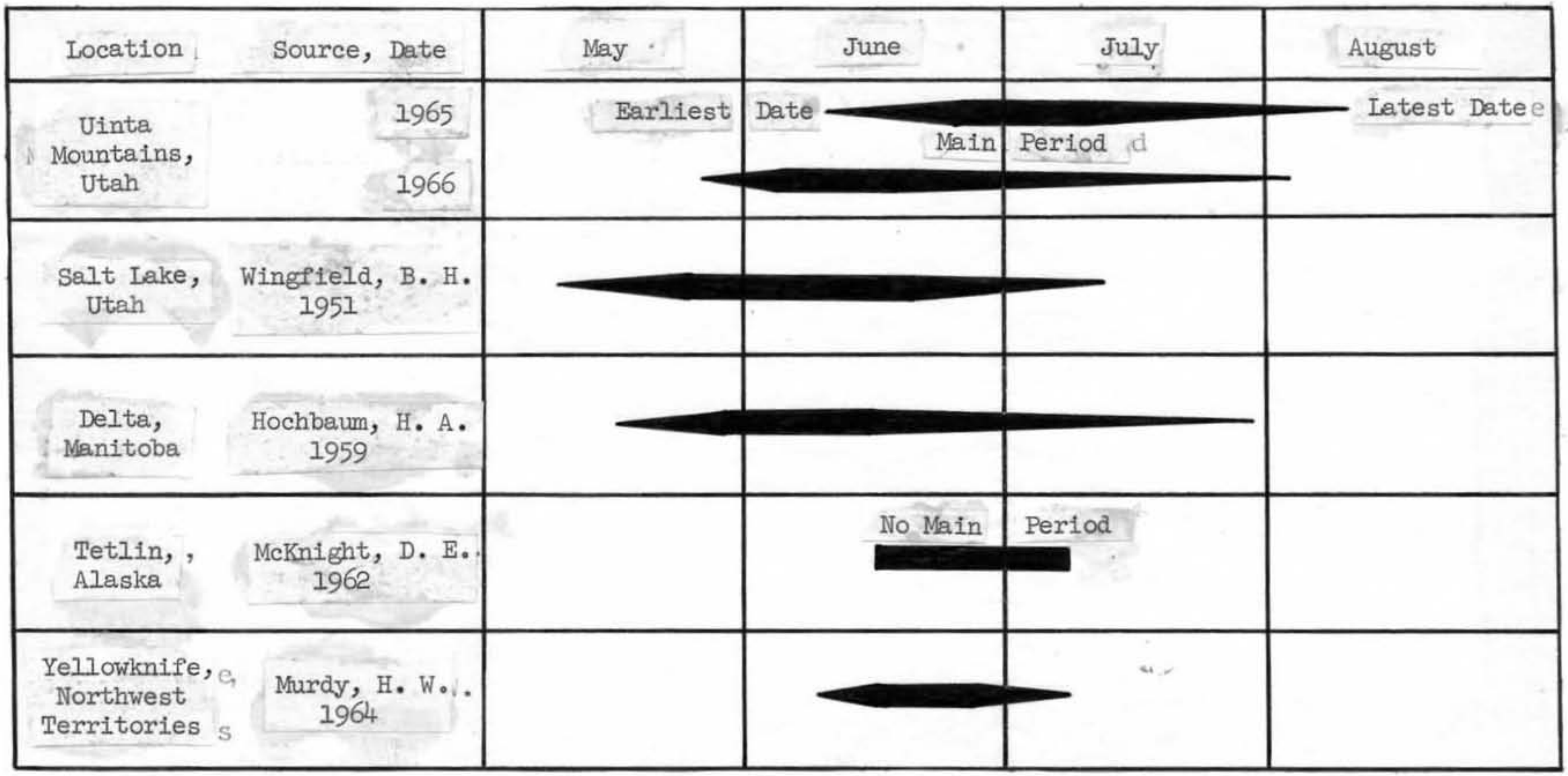

Figure 15. Hatching dates for mallards breeding in the Uinta Mountains, Utah, compared with the hatching dates for mallards breeding at other latitudes.

was not apparent for data collected in the Uinta Mountains. Frary (1954) recorded that no broods were observed above 10,500 feet on the White River Plateau, [illegible] an observation which was also made in the present study in the Uinta mountains.

Estimation of waterfowl production

An estimate of total waterfowl production in the Uinta Mountains can be made if three criteria are known: (1) total number of square miles of potential waterfowl habitat, (2) average number of breeding pairs or broods per square mile, and (3) average number of ducklings per brood.

The approximate number of square miles in each of the three preselected altitudinal ranges was: 8000-9000 feet; 883 square miles; 9000-10,000 feet; 907 square miles; and, 10,000-13,498 feet; 1055 square miles. Because brood production above 10,000 feet was practically non existant, this area need not be considered in computing total waterfowl production. The area remaining, 1790 square miles between 8000 and 10,000 feet, can be considered a potential waterfowl production area.

Average number of pairs per square mile was determined from those study units surveyed below 10,000 feet. All lone pairs and lone males counted on the first trip into each study unit was used for the estimate because a drop in lone males two weeks later indicated some males had left. Only mallard pairs (and broods) are considered because few species other than mallards were observed. Breeding pair counts should be accurate because birds flushed readily at this time of the year and lack of emergent vegetation permitted accurate observation of practically all water areas.

Brood counts can be considered only fair at best. Presence of heavy stands of cover during the brood season and reluctance of broods to flush from cover limited accurate counts. Accurate counts were made on 27 mallard broods in 1965 and 45 in 1966; these counds were used in determining average brood size. Maximum broods observed on any one trip in each study unit has been used to determine the average number of broods per square mile.

Total production in 1965 was estimated at 6,792 from brood data and 17,820 from pair and lone male counts, and in 1966 estimates of total production were 4,642 and 9,192 from brood and pair counts respectively (Table 7). These figures are about five percent of the estimated 250,000 ducks produced in Utah annually (Nelson, 1966). Also, the number of mallards produced per square mile is low if compared with the prairie pothole region of Southern Canada but production per square mile is similar to figures reported for the boreal forest in Canada. Frary (1954) found 6.5 young per square mile on the White River Plateau, Colorado and this figure is close to those calculated from table 7.

Migratory movements

Spring and fall arrival and departure. Waterfowl used water areas at low elevations as soon as the ice started to thaw. Mallards were observed in streams in April, 1965, when 3 to 4 feet of snow covered beaver ponds and natural catchment basins in the same area. Ducks left the streams and utilized natural catchment basins and beaver ponds as soon as open water was present. Spring migrants remained until the middle of June. Fall migrants arrived the first week in September and waterfowl continued to use water areas until all were frozen [redacted] in November.

Munroe (1944), Soper (1951), Keith (1961), and Murdy (1964) reported migratory waterfowl arrived in Southern Canada in the latter part of March, and in Northern Canada between the latter part of April and the first part of May. Migrants were observed in the Uinta Mountains at least one month later than Southern Canada even though these mountains

Table 7. Data for estimating total mallard broods and breeding pairs in the Uinta Mountains, Utah, 1965 and 1966

	1965	1966
Total square miles between 8000 and 10,000	1,790	1,790
Total square miles in study units between 8000 and 10,000	16	28
Total maximum number of mallard broods observed in one trip from all study units between 8000 and 10,000 feet	11	15
Total maximum number of lone males and pairs observed in one trip from all study units between 8000 and 10,000 feet	29	30
Broods per square mile in study units between 8000 and 10,000 feet	0.69	0.54
Pairs per square mile in study units between 8000 and 10,000 feet	1.81	1.07
Average brood size for completely counted broods	5.50	4.80
Estimated young per square mile		
From average brood size and broods per square mile	3.80	2.59
From average brood size and pairs per square mile	10.00	5.14
Estimated total pairs in Uinta Mountains between 8000 and 10,000 feet	3,240	1,915
Estimated total broods in Uinta Mountains between 8000 and 10,000 feet	1,235	967
Estimated total production		
From average brood size and total broods	6,792	4,642
From average brood size and total pairs (if each pair produced a brood)	17,820	9,192

are much farther south. Migrants observed in the Uinta Mountains are possibly late arrivals on the Wyoming or Utah prairies or remaining migrants traveling north. Hayward (1945) observed spring migrants usually arrived first in the valleys and foothills of the Uinta Mountains and then gradually drifted up to nesting grounds; there was a general post-nesting up-mountain shift in bird populations (presumably other than waterfowl) but this was not a mass movement from one elevation to another. No up-mountain movement, either daily or seasonal, was observed for waterfowl by me. Nelson (1966) reported ~~migrant~~ waterfowl start ~~coming~~ into Utah in late August, and reach a peak in the latter part of September or first part of October. These data are similar to the migration pattern observed in the Uinta Mountains.

Brood movements. Considerable movement of broods from water area to ~~water area~~ occurred. One ring-necked brood traveled approximately one-fourth mile in a straight-line distance at 9300 feet on the north slope in 1965. The lack of observed broods or adults above 10,000 feet indicates that broods do not migrate up the north or south slopes of the Uinta Mountains either before or after they could fly.

Migration to moult. No evidence was observed of male waterfowl migration into the study area in early summer to moult. Mounting males were observed on an irrigation reservoir at the base of the mountain range in the center of the north slope in 1966. A minimum of 25 moulting male ducks were present at one time in June. Whether these birds came from the surrounding prairie or from the Uintas is unknown.

Factors That May Influence Waterfowl Ecology and Utilization of Water Areas

Non-biotic factors

Availability of water areas. Spring break-up was two to five weeks later in 1965 than in 1966. Water areas between 7,600 and 9,000 feet on both slopes became available for waterfowl use about May 19 in 1965 while in 1966 water areas at this elevation were available May 1. In 1966, water areas between 9,000 and 10,000 feet on the north slope were available 1 to 3 weeks earlier than water areas at comparable elevations on the south slope. The highest water areas [redacted] became available July 4 in 1965 and about June 4 in 1966 (Table 8). Water areas at low elevations should be available for waterfowl use about the middle of May and water areas at high elevations should become available about the middle of June.

Fall freeze-up was similar both years. Skim ice formed at high elevations in the middle of August. Occasional deep snowfalls and exceptionally cold nights temporarily caused water areas under one acre to freeze over for a few days. In October most of these water areas were frozen in early morning but mostly open by mid-afternoon. Larger water areas did not freeze over completely until early November. Heavy snowfall in November makes water areas permanently unavailable to waterfowl until the following spring.

Availability of natural water areas less than one acre depends primarily on summer rains, and to a lesser extent on spring runoff. Water areas were filled to capacity long before snow runoff ceased in the immediate area. Excess water flowed from natural outlets until

Table 8. Water area availability in study units in the Uinta Mountains, Utah, 1965 and 1966

Mean elevation and slope	Date available		Date unavailable		Average days available	
	1965	1966	1965	1966	1965	1966
7,600 South	May 15	May 1	Nov. 20	Nov. 25	177	168
8,122 South	-	May 1	-	Nov. 25	-	208
8,562 North	-	May 1	-	Nov. 15	-	156
8,931 North	May 22	May 1	Nov. 20	Nov. 15	181	190
9,393 North	June 4	May 6	Nov. 20	Nov. 15	166	184
9,611 South	-	May 6	-	Nov. 20	-	170
9,939 South	July 1	May 25	Nov. 20	Nov. 15	134	167
10,282 South	July 6	June 6	Nov. 20	Nov. 10	130	145
10,355 North	July 5	June 1	Nov. 20	Nov. 10	132	151
Overall average					153	171

shortly after snow disappeared from surrounding slopes. Water levels were usually high and surrounding shrubs and trees often flooded. Unless shallow water areas were replenished by rainfall or streams, they became dry and inaccessable before fall; small dry water areas can become filled to capacity after one hard rain. In both years about 12 percent of the natural catchment basins became dry prior to freeze-up. Normal moisture conditions in the fall with a low snowfall in the winter can fill water areas to capacity in the spring, but maintenance of an available water area until the following fall is dependent on periodic summer rains. Water areas were available, on the average, two weeks longer in 1966 than in 1965 (Table 8).

The effect of availability of water on waterfowl utilization is most evident in the spring. In 1965 low elevation water areas were available and utilized approximately the first week in June and high elevation water areas were available the first week in July, but not utilized; in 1966 the lower water areas became available and used the first week in May and the higher water areas were available but not used the first week in June. Even though the higher water areas were available one month earlier in 1966 than in 1965, these water areas were still not utilized in 1966. Consequently, deep snows at elevations between 8000 and 10,000 feet definitely curtail utilization of water areas in this zone, but a late spring above 10,000 feet does not affect spring migratory or breeding use because even in an "early year" breeding waterfowl did not use water areas above 10,000 feet to any extent.

The effect of the loss of water areas through the summer may affect production at low elevations, but because few, if any, broods are produced above 10,000 feet, the loss of water areas at this elevation would not make any difference. Between 8000 and 10,000 feet, where water areas were relatively scarce, loss of even a few water areas could seriously affect brood survival.

Availability in the fall does not seriously affect waterfowl utilization. Even though many water areas remained partially open all day at all elevations during the first part of November, few waterfowl were present.

Spring break-up and fall freeze-up at elevations comparable with northern latitudes is approximately one month later in the spring and fall in the Uinta Mountains. Total days water areas are available for waterfowl use is about the same, but the period when these water areas are available is different.

No broods were recorded above 10,000 feet in the Uinta Mountains but Murdy (1965) found broods were produced at a comparable northern latitude. This suggests the time of opening in the spring at high elevations, not the total number of days available, prevents waterfowl from consistently raising broods here.

Elevation of water areas on north and south slopes. Few water areas were present at low elevations, and as elevation increased, so did the number of water areas. Water areas observed at 8000 to 9000 feet were much more numerous on the north slope than on the south slope: 71 to 9 (Table 9). Study units with mean elevations less than 9500 feet contained 42 percent of the water areas but over 98 percent of the waterfowl. Also, more than twice as many waterfowl were recorded on the north slope even though the number of water areas observed on the two slopes was roughly equal. The larger number of water areas below 9500 feet on the north slope could have accounted for the greater number of

Table 9. Changes in numbers of water areas within study units with differences in elevation and slope in the Uinta Mountains, Utah[a]

South slope		North slope	
Elevation	Number of water areas	Elevation	Number of water areas
7,600	2	8,562	13
8,122	7	8,931	58
9,611	26	9,393	85
9,939	54	10,355	60
10,282	84		

[a]Only elevations of beaver ponds, reservoirs and natural catchment basins were used.

waterfowl on this slope. The larger number of water areas above 9,500 feet on both slopes did not affect the number of waterfowl present on either slope.

Types and sizes of water areas. Over two-thirds of all water areas observed were natural chatchment basins and over 50 percent were natural water areas under one acre. The 55 beaver ponds observed were recorded in study units with a mean elevation less than 9,500 feet. Chi-square and F-tests were run to determine whether waterfowl used a particular type or size of water area more than another. The Chi-square test measured the proportion of a particular type or size of water area used by waterfowl in relation to the proportion used of another type or size of water area, whereas the F-test measured how much a particular type or size of water area was used. Only data collected from study units one and two (mean elevations 8,931 and 9,393 feet respectively) were used in the tests because: (1) both of these study units were observed in 1965 and 1966; (2) these study units contained the best representation of types and sizes of water areas present in study units observed, and had fairly large sample sizes in most categories; and (3) these study units had the most waterfowl. Comparison tests were not made on reservoirs and "other" water areas because of small sample sizes and relatively little use. Waterfowl "use" was defined as: "At least one adult duck observed at least once on a particular water area during a regular waterfowl survey of the study unit."

At 8,900 feet on the north slope, adult waterfowl did not prefer any particular type of water area (beaver pond or natural) but they did prefer water areas larger than one acre. At 9,300 feet on the north slope, beaver ponds greater than one acre were present and utilized more than natural water areas (large beaver ponds were absent in the other study unit).

From these and other tests, I concluded that adult waterfowl selected more by size of water area than by type but, when large beaver ponds are present, these water areas are used more than natural water areas ~~in the~~ of the same size. ~~range.~~

Total alkalinities of water areas. Total alkalinity tests run in 1966 showed a definite trend of decreasing total alkalinity as elevation increased. Total alkalinity varied from 3 mg per liter $CaCO_3$ in the highest study unit to 59 mg per liter $CaCO_3$ in the low elevation study units. If we consider a total alkalinity of 40 mg per liter $CaCO_3$ as a general dividing line between "soft" and "hard" waters, study units with a mean elevation greater than 9,500 feet are characterized by soft waters. These study units were used relatively little by waterfowl.

Study units with a mean elevation less than 9500 feet are characterized by waters close to this dividing line and these study units were used most by waterfowl.

Murdy (1964) found median values for total alkalinities of water areas in Northern Canada varied from 65 mg per liter $CaCO_3$ to 80 mg per liter $CaCO_3$ and considered these waters to be "hard water". Total alkalinities at high elevations in the Uinta Mountains are considerably lower than comparable water areas in Northern Canada. Lower total alkalinities in the Uintas is probably due to the quartzite substratum.

Biotic factors

Aquatic invertebrates available as waterfowl food. Aquatic intertebrates of the class, Insecta, were collected during the brood season and index values, expressed in cubic centemeters of invertebrates per cubic meter of water, were computed. Water areas less than 8500 feet had indices of aquatic invertebrates between 8 and 10 and also high brood use, whereas water areas above 10,000 feet had indices of aquatic invertebrates less than one and no brood use. Few insects were noted over, on, or in the water at high elevations whereas water areas at low elevations often appeared "covered" with insects.

Hayward (1945) compared terresterial invertebrate populations in the aspen and conifer zones of the Uinta Mountains and found total numbers of invertebrates to be greater in the lower zone. His comparison in terrestrial invertebrates agrees with what I found in the aquatic invertebrates.

Aquatic vascular plants available as waterfowl food and cover. Numbers of aquatic vascular plant genera in natural catchment basins do not change substantially with elevation or size of water area; study units at low elevations, where relatively more waterfowl use was recorded, contained about the same number of genera as water areas at higher elevations where waterfowl use was much less.

Genera did change with elevation. Myriophyllum, Utricolaria, Polygonum, and Potamogeton were relatively frequent in natural water areas less than 9500 feet where waterfowl use was high. Other genera common to all elevations were Glyceria, Sparganium, and Carex. These genera produce many fruits and vegetative parts utilized by waterfowl. Natural water areas at high elevations, where waterfowl use was low, had relatively low frequencies of occurrence of these genera (except Carex and Sparganium), or were characterized by low seed producing genera such as Isotes, Callitriche, and Nuphar. Many large beaver ponds were at least 10 years old and had been colonized by Carex, Potamogeton, and Sparganium; [redacted] many small beaver ponds were new and [redacted] had not been colonized by aquatic vascular vegetation. Aquatic vascular plants collected in study units are listed in Table 11 in the appendix.

Other investigators including Christensen and Harrison (1961), Graham (1937), Robbins (1918), and Similey (1915) recorded the same or similar genera at these elevations in mountainous areas of the west. From a review of the literature, I concluded that water areas at comparable northern latitudes contained genera similar to what I found, but one basic difference was the presence of submersed aquatics such as Potamogeton and Myriophyllum at northern latitudes whereas these genera were absent at comparable high elevations in the Uintas.

When waterfowl arrived in the spring little aquatic vegetation was present on the surface. Within a week after the ice left, leaves were above the surface while Nuphar, Potamogeton, and Polygonum leaves were visible under two to four feet of water. About four weeks after water areas were free of ice and when broods had started to appear, *Nuphar*, *Potamogeton*, and *Polygonum* leaves were on the surface. Some stands of *Carex* became so thick as to impair foraging but made excellent escape cover; I could see only a few feet into a stand of *Carex*, either from water level or from an elevated position. *Nuphar* leaves did not furnish much cover early in the brood season because of their flat profile and relative sparseness. As more leaves reached the surface, they curled and over lapped each other providing much better cover.

DISCUSSION

Many investigators have discussed likely reasons for the distribution of birds (Grinnell 1914, Lack 1934, Ghiselin 1956, and Behle 1960). Other people have investigated hereditary influence in habitat selection (Miller 1942, Svardson 1949, and Lack 1933b) and some investigators have stressed environment in the distribution of birds (Lack 1933a, Grinnel 1914, Beecher 1942, and Kendeigh 1934).

The distribution of breeding waterfowl in the Uinta Mountains below 9500 feet could be due to several reasons. Snow melt or removal obviously affects spring migrant and breeding use. Breeders are not stimulated to ~~breed or~~ start nesting until adequate amounts of food, nesting sites, and nesting materials are uncovered. By the time these stimuli are visible to waterfowl at high elevations they could be physiologically incapable of nesting. of breeding. Even when water areas at high elevations are available sufficiently early for breeding waterfowl, data showed these areas were not used. If similar snow conditions have persisted over the past several thousand years, it could have contributed to a traditional breeding ground at low elevations. This breeding ground is available when pairs are present and adequate food and cover, produced in relatively fertile water, is present for ducklings to develope to maturity. In contrast, water areas at high elevations are not available, as a rule, when breeding waterfowl are physiologically capable of utilizing them. The water is relatively infertile and undoubtly contributes to the parity of aquatic invertebrates and scarce cover. Furthermore, climatic and edaphic factors probably do not permit development of abundant seed producing plants. Hayward (1945) and Hanson et. al. (1949) also postulated food was the governing factor in explaining the distribution of birds in the Uinta Mountains and on the Pre-Cambrian Shield repectively. Accustomed nesting sites are probably lacking. Excessive changes in, or constant low temperature, undoubtly hinders brood survival in this region. The lack of brood observations at high elevations suggests that rigid species requirements are probably seldom met in this area, progeny are quickly eliminated by natural selection, and few adults return to breed. Lack 1945) and Svardson (1949) also discussed this concept with supporting evidence.

The distribution of fall migratory waterfowl is probably governed more by non-heriditary influences than by genetics. Association with a particular type of plant community, water area, or other noticeable feature would certainly influence where migrating waterfowl might settle to rest and obtain food. Miller (1942) termed this "perception of adequate environment." Lack of waterfowl sightings at high elevations during the fall migratory season may be due to the perception of unfavorable stimuii by waterfowl that cause them to stop only briefly or not at all on these water areas, whereas, water areas at low elevation could attract waterfowl because of favorable stimuli. Climate probably does not influence fall migratory waterfowl distribution and utilization. This factor is essentially constant over the entire range throughout the fall and most water areas become unavailable about the same time.

I can only conclude that no one factor by itself has controlled the distribution of breeding and migratory waterfowl in the Uinta Mountains. Instead, a number of heriditary, non-heriditary, and environmental factors, interact to produce the observed distribution.

RECOMMENDATIONS

It does not seem necessary for additional general ecology data to be secured. If it is desireable to include the Uinta Mountain production area into the annual spring waterfowl inventory in Utah, then a trend should be established by flying two east-west transects across the north slope of the mountain range between 8,000 and 9,500 feet. Transects would have to be run as soon as possible after water areas in this elevational zone were available for waterfowl use. To my knowledge, this system has not been tried before in mountainous areas of the west, but I feel it is feasible. However, production estimates indicate only five percent or less of all waterfowl produced in Utah, are produced here, and it does not seem practical to conduct annual production surveys for these few waterfowl.

Because more waterfowl use was recorded on natural water areas and beaver ponds one acre or larger below 9,500 feet, these types and sizes of water areas should be preserved when feasible, but I do not think it is economically feasible to attempt specific developements for waterfowl in mountainous areas of Utah.

SUMMARY

During 1965 and 1966 waterfowl ecology and utilization of water areas in the Uinta Mountains, Utah was studied. Nine study units four square miles each were established to observe waterfowl and record various physical and biological measurements of water areas within these study units.

Sixteen species of waterfowl were observed. Mallards, green-winged teal, ring-necked ducks, and pintails bred in the Uinta Mountains; approximately two thirds of all ducks observed were mallards.

Most waterfowl were between 8,000 and 9,500 feet with little use above 10,000 feet.

Waterfowl numbers were highest in the spring and fall and lowest during the breeding season.

Breeding pairs utilized natural water areas and beaver ponds in the spring as soon as ice melted and hens began nesting immediately.

Moulting waterfowl were encountered in singles or few numbers.

Complete mallard broods averaged 5.5 in 1965 and 4.8 in 1966. Most broods were flying by August 15.

Fall migratory waterfowl arrived the first week in September and continued using water areas until the first of November.

Snow could detain waterfowl use in the spring but did not retard waterfowl use in the fall.

More waterfowl were observed on the north slope than on the south; this difference was attributed to more natural water areas and beaver ponds at elevations below 9,400 feet on the north slope.

Adult waterfowl preferred natural water areas and beaver ponds one acre or larger. Ducks were observed more often on large beaver ponds than on natural water areas.

Water areas at lower elevations had relatively higher indicies of total alkalinity and aquatic invertebrates.

Numbers of aquatic plant genera did not change with elevation or type and size of water area, but water areas at low elevations contained aquatic plants that produced aboundant waterfowl food.

No one factor, [redacted] controlled the distribution of breeding and migratory waterfowl in the Uinta Mountains.

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APPENDIX

Table 10. Scientific and common names of waterfowl species referred to in the text[a]

Scientific name	Common name
Aix sponsa (L.)	Wood Duck
Anas acuta L.	Pintail
Anas carolinesis	Green-winged Teal
Anas cyanoptera Synder and Lumsden	Cinnomon Teal
Anas discors L.	Blue-winged Teal
Anas platrhynchos L.	Mallard
Aythya affinis (Eyton)	Lesser Scaup
Aythya americana (Eyton)	Redhead
Aythya collaris (Donovan)	Ring-necked Duck
Branta canadensis Aldrich	Canada Goose
Bucephala albeola (L.)	Bufflehead
Bucephala clangula (Bonaparte)	Common Goldeneye
Fulica americana Gmelin	American Coot
Mareca americana (Gmelin)	American Widgeon (Baldpate)
Mergus merganser Cassin	Common Merganser
Mergus serrate L.	Red-breasted Merganser
Oxyura jamaicensis (Gmelin)	Ruddy Duck
Spatula clypeata (L.)	Shoveler

[a]Names are those given in: American Ornithologists Union. 1957. Check-list of North American birds, 5th ed. New York. 691 p.

Table 11. Confirmed vascular plants collected in study units in 1965 and 1966, Uinta Mountains, Utah [a,b]

Family	Scientific name
Alismaceae	Alisma triviale Pursh
"	Sagittaria cuneate Sheld
Callitrichaceae	Callitriche hermaphroditica L.
"	Callitriche verna L.
Campanulaceae	Porterella carnosula (Hook. & Arn.) Torr.
Caryophylaceae	Cerastium nutans Raf.
Compositae	Senecio sphaerocephalus Green
Cruciferae	Barbarea orthoceras Ledeb. var.
"	Rorippa nasturtium-aquaticum (L.) Schenz.& Thele.
"	R. obtusa (Nutt.) Britton
Cyperaceae	Carex aquatilis Wahl.
"	C. atrata L.
"	C. canescens L.
"	C. chalciolepis Holm
"	C. douglasii Boot
"	C. geyeri Boott
"	C. hoodii Boott
"	C. illota L. H. Bailey
"	C. interior L. H. Bailey
"	C. kelloggii W. Boott
"	C. lanuginosa Michx.
"	C. limosa L.
"	C. microptera Mkze.
"	C. nebraskensis Dewey
"	C. physocarpa Presl
"	C. rossi Boott
"	C. rostrata Stokes
"	Eleocharis acicularis (L.) Roem. & Schult.
"	E. macrostachya Britton
"	Scirpus pauciflora (Ligh.) Link
"	S. cespitosus L. var. callosus
Gramineae	Agropyron trachycaulum (Link) Malte
"	Agrostis scabra Willd. var. scabra
"	Alopecurus aequalis Sobol
"	Bromus anomalus Rupr.
"	Calamagrostis canadensis (Michx.) Beauv. var. camadensis
"	C. inexpansa A. Gray
"	Catabrosa aquatica (L). Beauv.
"	Danthonia intermedia Vasey
"	Deschampsia caespitosa (L.) Beauv.
"	Glyceria borealis (Nash) Batchelder
"	G. elata (Nash) A. S. Hitchc.
"	Hordeum brachyantherum Nevski
"	Koeleria cristata (L.) Pers.
"	Phleum alpinum L.
"	P. pratense L.

Table 11. Continued

Family	Scientific name
Gramineae	Poa alpina L.
"	P. epilis Scribn.
"	P. pratensis L.
"	Torreyochloa pauciflora (Presl) Church
"	Trisetum spicatum (L.) Richt.
Haloragidaceae	Hippuris vulgaris L.
"	Myriophyllum spicatum L. var. exalbescens (Fern.)
Isotaceae	Isoetes bolanderi Engelm. Jeps.
Juncaceae	Juncus balticus L. var. montanus Engelm.
"	J. bufonius L.
"	J. drummondii E. Meyer
"	J. saximontanus A. Nels. f. saximontanus
"	J. vaseyi Engelm.
"	Luzula parviflora (Rhuh.) Desv.
Labiatae	Prunella vulgaris L.
Lemnaceae	Lemna trisulca L.
Lentibulariaceae	Utricularia minor L.
"	U. vulgaris L.
Liliaceae	Allium acuminatum Hook.
"	Veratrum californicum Dur.
"	Zigadenus elegans Pursh
Menyanthaceae	Menyanthes trifoliata L.
Nymphaceae	Nuphar polysepalum Engelm.
"	Nymphaea odorata Ait.
Onagraceae	Epilobium adenocaulon Hausskn.
"	E. glandulosum Lehm. var. macouni (Trel.) C. L.
"	E. palustre L. Hitchc.
Polygonaceae	Polygonum amphibium L.
"	P. bistortoides Pursh
"	P. kelloggi Greene
"	Rumex crispus L.
"	R. mexicanus Meisn.
Potamogetonaceae	Potamogeton alpinus Balbis var. tenuifoluis (Raf.)
"	P. filiformis Pers. Ogden
"	P. foliosus Raf. var. macellus Fern.
"	P. gramineus L. var. maximus Morong
"	P. nodosus Poir
"	P. pectinatus L.
"	P. pusillus L.
Primulaceae	Dodecatheon pulchellum (Raf.) Merrill
Ranunculaceae	Caltha leptosepala DC.
"	Ranunculus aquatilis L.
"	R. circinatus Sibth. var. subrigidus (W. Drew) L.
"	R. cymbalaria Pursh var. saximontanus Fern. Benson
"	R. flabellaris Raf.
"	R. gmelinii DC.
"	R. natans C. A. Mayer

Table 11. Continued

Family	Scientific name
Rosaceae	Potentilla *gracilis* Dougl. var. *elmeri* (Rydb.) Jeps
Scrophulariaceae	*Mimulus guttatus* DC.
"	*Pedicularis groenlandica* Retz.
"	*Veronica americana* Schwein
"	*V. anagallis-aquatica* L.
Sparganiaceae	*Sparganium angustifolium* Michx.
"	*S. minimum* Fries
Typhaceae	*Typha latifolia* L.
Umbellifereae	*Sium suave* Walt.
Valerianaceae	*Valeriana edulis* Nutt.

[a]Plants were identified from:

Harrington, H. D. 1954. Manuel of the plants of Colorado for the ferns and flowering plants of the state. Sage Books, Denver. 666 p.

Hitchcock, A. S. 1950 i.e. 1951. Manuel of the grasses of the United States. 2d ed., rev. by Agnes Chase. United States Government Miscellaneous Publication 200. 1051 p.

[b]Identification was confirmed by Arthur H. Holmgren, Director, Intermountain Herbarium.

Table 12. Locations of study units within the Uinta Mountains, Utah, on planimetric maps and quadrangles, ~~given in table 58 and 59 respectively~~.

Study unit no.	Planimetric map no.	Township	Range	Sections	Topographic quadrangle
1	321	3 North 3 North	14 East 15 East	24,25,36 19	Gilbert Peak
2	321	3 North	14 East	29,30,31,32	Gilbert Peak
3	302	4 North	9 East	13,14, 23,26,+ unnum. area	Gilbert Peak
4	300	1 North 2 North	5 West 5 West	34,35 2,3	Gilbert Peak
5	302	2 South	9 East	5,6,7,8	Hayden Peak
6	302	2 North 3 North	8 West 8 West	4,5 32,33	Hayden Peak
7	302	2 South 2 South	8 East 9 East	24,25 19,30	Hayden Peak
8	303	2 South 2 South	7 East 8 East	24,25,36 19,30,31	Coalville
9	27W	12 North 13 North	116 West 116 West	6 25,30,31	?

VITA

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Master of Science

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