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UTAH SCIENCE

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Researchers at Utah State University have long been concerned about the wildlife in Utah, concerned enough to find out how to restore formerly prevalent animals to their habitat. In addition, exotic game birds have been introduced to some of Utah's upland ranges. In this quarter's **Utah Science** you can read about the present status of the bighorn sheep in Utah. How moose have immigrated to the north slope of the Uinta Mountains, and how researchers have found that chukars don't necessarily need guzzlers—in addition to the other agriculturally oriented subjects.

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UTAH SCIENCE

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PAST AND PRESENT – – –

BIGHORN SHEEP IN UTAH

J. JUAN SPILLETT AND LARRY B. DALTON

One of the world's most coveted big-game trophies is the massive head of a mature male wild sheep. A wild sheep is not dangerous nor is it one of the larger big-game animals. However, because of its elusiveness and the nature of its rugged, rocky habitat, only those with skill and stamina generally are fortunate enough to observe this most challenging and exciting animal in its natural surroundings.

Wild sheep inhabit mountainous ranges from the Mediterranean across the Middle East into Central Asia and eastern Siberia, and the Rocky Mountain chain in North America from Alaska to Baja California in Mexico. Taxonomists do not agree as to the number of wild species of sheep which inhabit this "Great Arc," but most concede that our two species of North American bighorns—the White or Dall sheep (*Ovis dalli*) and the Canadian bighorn (*O. canadensis*)—originated from Eurasian bighorn that migrated across the Bering Land Bridge to North America during the Pleistocene epoch that dates back to 500,000 to 1 million years.

Big game hunters classify the North American bighorns into four groups:

(1) the White or Dall sheep (*O. dalli dalli*) found in Alaska and the adjoining Yukon and Mackenzie territories in Canada;

(2) the Stone or Black sheep (*O. d. stonei*), a grayish-blue-black sheep found in the southern Yukon and adjoining British Columbia;

(3) the Rocky Mountain bighorn (*O. canadensis canadensis*), which is the largest of the North American bighorns and ranges from British Columbia and Alberta south through western Montana and Wyoming, Idaho, Colorado and northern Utah; and

(4) the Desert bighorn, which includes perhaps eight subspecies of *O. canadensis* which inhabit southern Utah, Nevada, California, Arizona, New Mexico, western Texas, and northern Mexico. A hunter fortunate enough to bag a mature male from each of these four groups achieves what is known among trophy hunters as a "Grand Slam," more-or-less the ultimate status symbol among trophy hunters.

PREHISTORIC EVIDENCE OF BIGHORNS IN UTAH

Bighorn sheep were prevalent before the appearance of the white man throughout what is now Utah. Two subspecies of bighorn sheep, the Rocky Mountain bighorn (*O. c. canadensis*) and the Desert bighorn (*O. c. nelsoni*), are found in the state today.

Skeletal remains of bighorns have been found in many parts of the state (figure 1, table 1). Some bighorn remains dating back to a late Pleistocene period (early to middle Wisconsin in age) have been found at the Hardman gravel pit near Salt Lake City, and at the old Scofield Dam construction site in Carbon County. These consist of the posterior cranial elements with horn cores, which are thought to represent an evolutionary population which eventually developed in *O. canadensis*.

Bighorn dung, which archeologists report to be about 11,000 years old, and sheep remains showing use by prehistoric man have been found in various layers during the excavation of Danger Cave near Wendover. It has been postulated that bighorns could have existed in this area before then, but there is no evidence of this because the cave previously was filled with the waters of Lake Bonneville.

The bighorn must have been important to prehistoric men who inhabited what is now Utah, because bighorn remains often are found in caves which they inhabited. For example, numerous skulls and other skeletal bones from both male and female sheep, as well as bighorn hides and bone awls, were found in a cave inhabited by prehistoric men in American Fork Canyon south of Salt Lake City. This and other cases offer convincing evidence that prehistoric people used the bighorn extensively as a source of both food and clothing. In fact, some archeologists have postulated that the bighorn was the most important source of animal protein for Indians in Utah before the whiteman's civilization caused a decrease in bighorn populations.

HISTORICAL REPORTS OF BIGHORNS IN UTAH

The earliest records of bighorns in Utah are the petroglyphs and pictographs left behind by early man (figure 2). These early records depicting bighorn sheep have been found in many parts of Utah, but are most evident in the southwestern part of the state. The first recorded sighting of an American wild sheep by a white man was by Coronado in California in 1540. It was not until 1697, however, that a Mission Father named Francis

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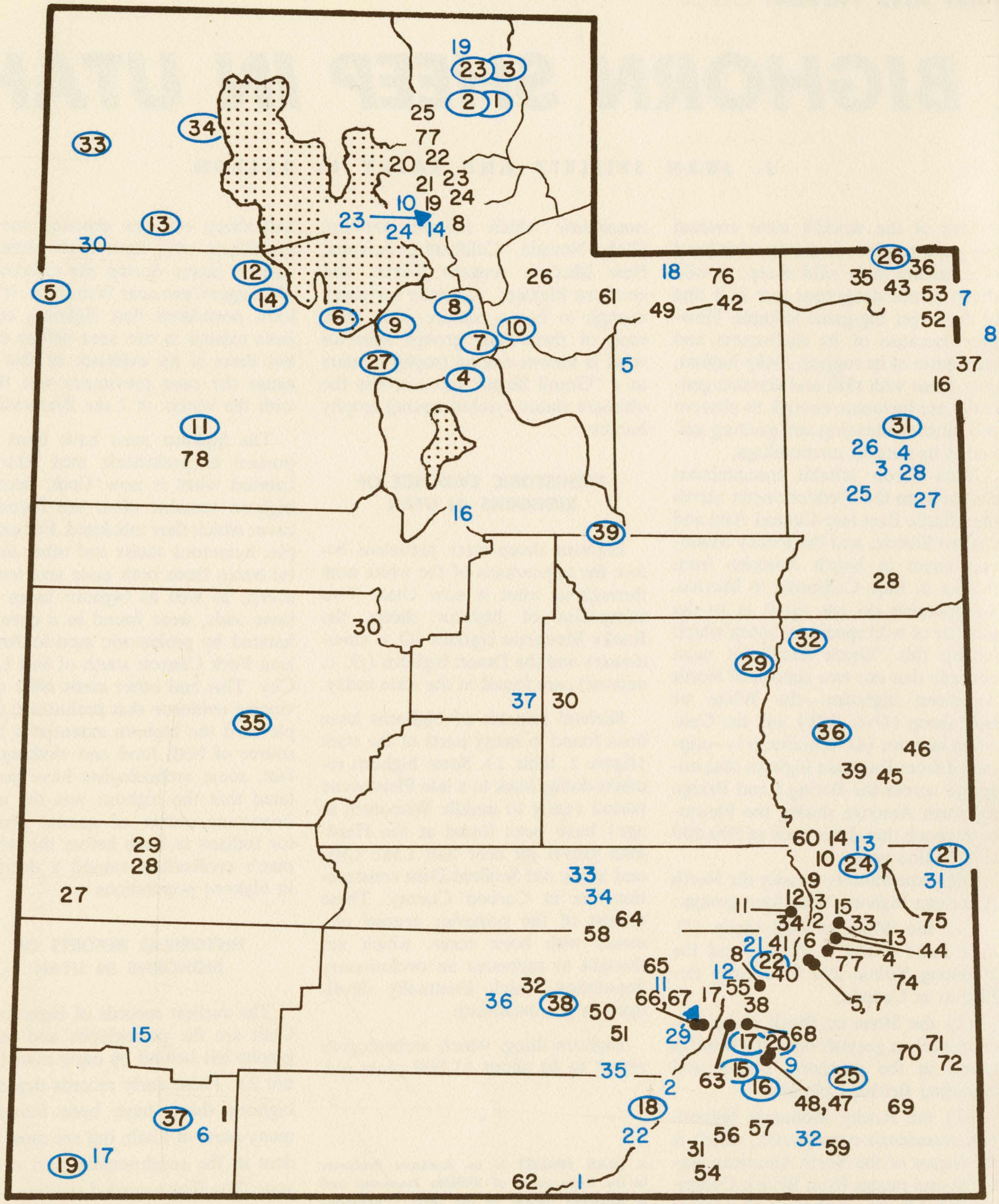

Figure 1. Map of Utah showing sites where bighorn skeletal remains have been found (colored circles, table 1); sightings of bighorns before 1950 (colored numbers, table 2); and bighorn sightings since 1950 (black numbers, table 3).

Table 1. Key to figure 1—skeletal remains of bighorns found in Utah (circled numbers)

	Year	Location of sheep skeletons	Observer and/or source
1.	1968	Skull—Providence, Utah rock quary.	(Anderson, 1970)
2.	1968	Skull—Providence, Utah rock quary.	(Campbell, 1970)
3.	1967	Skull—Right Hand Fork of Logan Canyon.	(Holden, 1970)
4.	1941	Skeletal remains—cave in American Fork Canyon about 3 miles above the Timpanogos Cave offices.	(Hansen and Stokes, 1941)
5.	?	Skeletal remains and droppings—Danger Cave, near Wendover, Utah.	(Dibble *et al,* 1959)
6.	1970	Skull—Stansbury Island.	(Wilson, 1970)
7.	1907	Skull—head of Hughes Canyon near the twin peaks in Salt Lake City, Utah.	(Barnes, 1927)
8.	1900s	Several bighorn skulls—Hardman gravel pits northeast of Salt Lake City. Now in the Geology Department at the University of Utah.	(Stokes and Condie, 1961)
9.	1968	Skull—Black Rock Canyon in the Oquirrah Mountains. Found by highway construction crews.	(Madsen, 1970)
10.	1967	Skull—Silver Creek. Found by highway construction crews.	(Madsen, 1970)
11.	1969	Skull—Tooele County at the west base of Granite Mountain.	(University of Utah, Museum of Zoology)
12.	1958	Skull—Tooele County on the west side of Lakeside Mountain.	(University of Utah, Museum of Zoology)
13.	1967	Skull—Box Elder County on the northeast side of the Newfoundland Mountains.	(University of Utah, Museum of Zoology)
14.	1958	Skull and a single horn—Tooele County on the west side of Lakeside Mountain.	(University of Utah, Museum of Zoology)
15.	1965	Skull—2 miles west of Soldier Crossing and Utah Highway 95 on Piute Mesa.	Ruby Drobnick (University of Utah, Museum of Zoology)
16.	1965	Skull—Slope Hollow on the southeast ridge of Fry Point Mesa, San Juan County.	Rodney John (University of Utah, Museum of Zoology)
17.	1950s	Skull—Jacob's Chair, White Canyon. Poached by uranium miners.	(University of Utah, Museum of Zoology)
18.	1954	Skull—bighorn killed at the junction of Hall's Crossing and the Colorado River. Donated by June King.	(University of Utah, Museum of Zoology)
19.	1958	Skull—Beaverdam Mountain, 15 miles west of St. George.	Arthur Bruhn (University of Utah, Museum of Zoology)
20.	1963	Skull—Horse Flat, White Canyon, San Juan County.	Rodney John (University of Utah, Museum of Zoology)
21.	1954	Skull—LaSal Mountains. Confiscated by Utah Fish and Game ½ miles north of LaSal.	(University of Utah, Museum of Zoology)
22.	1966	Ram skeleton—near Dark Canyon along the east side of the Colorado River Terrace.	(Follows, 1969)
23.	1970	Ram skull—in a draw northwest of Zanavoo Lodge in Logan Canyon.	(Abee, 1970)
24.	1957-1960	Two skulls—found by Col. Mikesell in a cave on the south end of Squaw Flat in Canyonlands. Now at Pat Creek Ranch near Moab, Utah.	(Drobnick, 1970)

Table 1. Key to figure 1 (Cont.)

	Year	Location of sheep skeletons	Observer and/or source
25.	1950	Skull—from an illegally killed bighorn confiscated by Fish and Game at the Bears Ears.	(Drobnick, 1970)
26.	1960	Skull—on east side of Hide Out Flat Ridge at Flaming Gorge by clearing crew foreman.	(Drobnick, 1970)
27.	1953	Skull—Coons Peak, in the Oquirrah Mountains.	Eldon, Jenkins (Drobnick, 1970)
28.	1970	Two ram skulls—Book Cliffs west of P.R. Springs in the Main Canyon drainage.	(Drobnick, 1970)
29.	1969	Skull—along Range Creek in Desolation Canyon, now at the Highway Junk House in Wellington, Utah.	(Drobnick, 1970)
30.	1957	Skull—uncovered by storms in a 9-foot deep wash at forest boundary and Oak Creek Canyon in the Canyon Mountains east of Oak City, Utah.	(Drobnick, 1970)
31.	1933	Skull—20 miles east of Ouray.	J. K. Doutt (Drobnick, 1970)
32.	1936	Skull—Florence Creek in Desolation Canyon.	J. K. Doutt (Drobnick, 1970)
33.	1970	Skull—cave along Utah Highway 30 at southern end of Grouse Creek Mountains.	(Wagner, 1970)
34.	?	Bighorn remains—Hogup Cave.	(Jennings, 1970)
35.	1955	Skull—about 8 miles east of Desert Range Experiment Station on the mountain slope.	(Butcher, 1971)
36.	1955	Bighorn remains—Turner Ranch site representing the Fremont Culture just north of Thompson, Utah.	(Wormington, 1955)
37.	1955	Bighorn or deer bones—identified in the archaeological investigations of Zion National Park.	(Schroeder, 1955)
38.	1959-1961	Bighorn bone fragments—prevalent in archaeological investigations of the Coobs Site at Boulder, Utah.	(Lister, 1959, 1960, and 1961)
39.	?	Bighorn ram skull (Pleistocene)—collected about 80 feet below surface during construction of the old Scofield Reservoir.	George Polve (Price Museum, County Building)

Maria Piccolo recorded the first detailed description of an American bighorn.

Father Escalante was the first whiteman to record bighorn sheep in Utah. In 1776 he claimed bighorns were very abundant along the Colorado River, and the frequency of their tracks was comparable to large flocks of domestic sheep. Most trappers and explorers who entered Utah also recorded something about bighorns in their journals.

Osborne Russell, an early western trapper, visited Utah in late 1841 and 1842. One evening in December of 1841, while he was camped near the present town of Willard, Utah, he hiked into the rugged cliffs nearby to hunt for camp meat. When daylight came the next morning Russell claimed he was surrounded by about 100 bighorns. He shot a number of sheep and had to return to camp to get help to carry them out. He returned to these mountains again in February of 1842, and again was successful in killing bighorns.

According to most reports bighorns were easy to kill when trappers were the only white men in the Rocky Mountains. Dodge, a western trapper, claimed that if a hunter could approach a band of sheep, he could easily kill five or six. According to Dodge, with the first shot a band of sheep would bunch up to watch the smoke from the gun. Then four or five could easily be killed before they became frightened. In contrast, some western trappers wrote in their journals about the elusive capabilities of the bighorn. It also was occasionally recorded that the bighorn could elude predators and man by diving over the edge of a high precipice. It was believed that bighorns could survive the fall by landing on their enormous horns.

The flesh of bighorns was considered to be delicious, and Indians and trappers alike pursued the bighorn for its meat. Washington Irving, while writing about the adventures of Captain Bonneville, eluded to the fact that the Indians considered the flesh of the bighorn to be more sweet and delicate than any other kind of wild meat. The same was true for many trappers and early settlers in the Rocky Mountain Region. When given a choice generally they preferred bighorn meat to all other forms of game.

Captain Fremont reported bighorns in the Uinta area of Utah during June, 1844. His party killed several bighorns at Browns Park, along the Green River. Browns Park, known to the trappers as Browns Hole, was a favorite wintering place for trappers. There was an abundance of game, including bighorn sheep, in the surrounding mountains. Fremont also reported bighorns in the rocks along the river bottom where Vermillion Creek enters the Green River.

Dellenbaugh, a member of the Powell expedition, was amazed at the abundance of deer, bear and mountain sheep which he observed between Browns Park and Split Mountain in 1871. Powell previously reported seeing mountain sheep in 1869 around a small park at the confluence of the Yampa and Green Rivers. He explained that the Indians often used a steep trail to enter the park to kill bighorns. Powell's party also killed two bighorns in Cataract Canyon along the Colorado River during July of 1875. The two sheep were a feast for his expedition, as their supplies were low and had been damaged by the river.

George Hobbs, a Mormon pioneer in the late 1800s, was led to the bottom of seemingly impassable slick rocks while following a bighorn sheep down to the edge of the Colorado River at a place now called Hole-in-the-Rock. Hobbs also reported bighorns to be curious, and recorded how one came within 15 feet of his campfire.

These and other locations of recorded bighorn sheep sightings in Utah between 1776 and 1950 are included in figure 1 and table 2.

PROTECTIVE UTAH LAWS

Prior to 1876 the Territory of Utah had no regulations regarding the taking of bighorn sheep. In 1876 a July through December hunting season was set for all big game animals. Between 1876 and 1899 game laws still were very liberal, but after statehood, the Utah State Legislature passed a law in 1899 prohibiting the taking of bighorn sheep. This law remained in effect until 1967 when 10 permits were issued for desert bighorns in the Fry Canyon area in San Juan County. Each year since, 10 permittees have been authorized to hunt mature trophy rams, and between 1967 and 1970 a total of 22 rams have been harvested.

There are not, however, enough Rocky Mountain bighorns in Utah to provide a harvestable surplus, and game managers generally agree that it will be far into the future before the Rocky Mountain bighorn will be hunted as a game animal in this state.

DECLINE IN BIGHORN POPULATION

Although bighorns inhabited almost every mountain range in Utah before the coming of the white man, the advance of Western civilization caused a steady decline in bighorn sheep numbers. This decline was noted as early as 1870. Civilization brought domestic animals and created centers from which our natural resources could be exploited. This meant trouble for bighorns, because they are unable to tolerate the activities of mining, and cattle and sheep raising.

Studies conducted by the Utah Cooperative Wildlife Research Unit at

Figure 2. This petroglyph, located in Comb Wash, San Juan County depicts the huntings of the bighorn sheep by prehistoric man in Utah.

Table 2. Key to figure 1—Recorded bighorn sightings in Utah before 1950 (colored numbers)

	Year	Location of sheep sightings	Observer and/or source
1.	1776	Colorado River—"Crossing of the Fathers."	Escalante (Wilson, 1968)
2.	1776	Breaks of the Colorado River.	Escalante (John, 1968)
3.	1871	Green River through Split Mountain.	(Dellenbaugh, 1962)
4.	1871	Green River in Whirlpool Canyon.	(Dellenbaugh, 1962)
5.	1939	Mt. Baldy in the Uintah Mountains.	N.B. Cook (Cowan, 1940)
6.	1939	Junction of the Virgin River and the North Fork of the Virgin River in Zion National Park.	Cliff Presnall (Cowan, 1940)
7.	1844	Green River and Browns Hole.	(Fremont, 1845)
8.	1844	Junction of Green River and Vermillion Creek, inside Colorado.	(Fremont, 1945)
9.	1942	White Canyon, San Juan County. Residents saw Indians leaving White Canyon with three pack horses loaded with 60 to 70 bighorn hides.	(Wilson, 1968)
10.	1841	Wasatch Mountains near Willard, Utah. Russell killed mountain sheep here on two different days.	Osborne Russell (Haines, 1955)
11.	1947	Henry Mountains.	(Durrant, 1952)
12.	1946	Junction of Colorado River.	(Durrant, 1952)
13.	1923	Twenty miles below Moab, Utah on Colorado River bottoms. Rancher reported seeing bighorns every time he visited his cattle.	Mel Stewart (Barnes, 1927)
14.	1896	Band of bighorns—Willard Peak.	(Barnes, 1927)
15.	1899	Bighorns were known on Little Pinto in southwestern Utah.	(Barnes, 1927)
16.	1926	Bighorns—Mt. Timpanogos.	(Barnes, 1927)
17.	1919	Bighorn found floating dead in the Virgin River.	(Barnes, 1927)
18.	1910	Bighorns reported around the mouth of Black's Fork on the north slope of the Uinta Mountains.	(Barnes, 1927)
19.	1905-1914	Bighorn—killed in Logan Canyon near Tony Grove. Many bighorns also seen in Cottam Canyon.	Ted Seeholzer (Durrant, 1952)
20.	1875	Junction of Yampa and Green Rivers.	(Powell, 1869)
21.	1875	Cataract Canyon on the Colorado River.	(Powell, 1869)
22.	1897	Hole-in-the-Rock, along the Colorado River. Bighorn led a Mormon pioneer to the bottom of a seemingly impassable slick rock.	George Hobbs (Jones, 1957)
23.	1917	Bighorns—seen on Willard Peak.	Rulon White (Huff, 1970)
24.	1923	Bighorns—Willard Peak. These were the last native Rocky Mountain bighorns reportedly seen in the Willard Peak area.	Rulon White (Huff, 1970)
25.	1938	Ram observed near Dinosaur Quarry.	(Barmore, 1962)
26.	1943	National Park Service verified the presence of bighorns on Split Mountain.	(Barmore, 1962)
27.	1921	Robert C. Thorne believed bighorns to exist on Blue Mountain. Last animal shot there in 1921.	(Barmore, 1962)
28.	1944	Last bighorns from original Dinosaur National Monument herd seen by Robert C. Thorne near the mouth of Split Mountain Canyon.	(Barmore, 1962)
29.	1938	Golden Durfey estimated 100 to 300 bighorns in the Little Rockies.	Golden Durfey (Follows, 1969)

Table 2. Key to figure 1 (Cont.)

	Year	Location of sheep sightings	Observer and/or source
30.	1910	Bighorn—killed 25 miles north of Wendover, Utah.	(Buechner, 1960)
31.	1949	Several bighorns reported near the top of Mt. Peale, San Juan River.	Charles Hunt (Buechner, 1960)
32.	1878	Bighorns—sighted at the Goosenecks of the San Juan River.	Chris Christiansen (Buechner, 1960)
33.	1933	Sheepherder shot a ewe at Capital Wash in Capital Reef National Monument.	Golden Durfey (Follows, 1969)
34.	1948	Last bighorn in Capital Reef National Monument killed.	Charles Kelley (Follows, 1969)
35.	1920s	Hunter killed a ram on Deer Point in Capital Reef National Monument.	Charles Chestnut (Follows, 1969)
36.	1938	Bighorn observed in fields below Boulder, Utah. Last reported bighorn in that area.	(Davis, 1970)
37.	1940	Mature ram—observed in Joe's Valley during the winter of 1940. The ram was curious and followed Edmond's horses.	(Edmonds, 1970)

Utah State University have shown that the diet of bighorns consists primarily of climax plants. When overgrazing occurs, climax plants become less available to bighorns and, because of improper nutirtion, they are then unable to combat diseases and parasites. In most areas these factors probably have contributed more to the demise of bighorn populations than has shooting.

UTAH BIGHORN POPULATIONS

Despite the fact that the advent of the white man in Utah resulted in shrinking bighorn sheep populations, remnant populations persist in various parts of the state and the list of valid bighorn sightings since 1950 continues to grow (table 3).[1]

Bighorns apparently inhabited the entire Wasatch Mountain Range in north central Utah, but disappeared from this area prior to 1930. Bighorn sheep were reported on Mt. Nebo in the 1800s, and a bighorn was killed near Tony Grove in Logan Canyon in 1905. Rulon White of Ogden saw 23 head of bighorn sheep behind Willard Peak in 1917, and about 15 animals in the same area in 1923. This was the last time native Rocky Mountain bighorns were reported in this area, although bighorns were reported on Mt. Timpanogos as late as 1927.

Recorded sightings of native Rocky Mountain bighorn sheep along the Wasatch Front are sparse. However, skeletal remains found at various points along the Wasatch Mountains indicate bighorns once inhabited the entire range (figure 3).

Bighorn sightings on the mountain ranges in the Great Salt Lake Desert and bordering the Great Salt Lake in

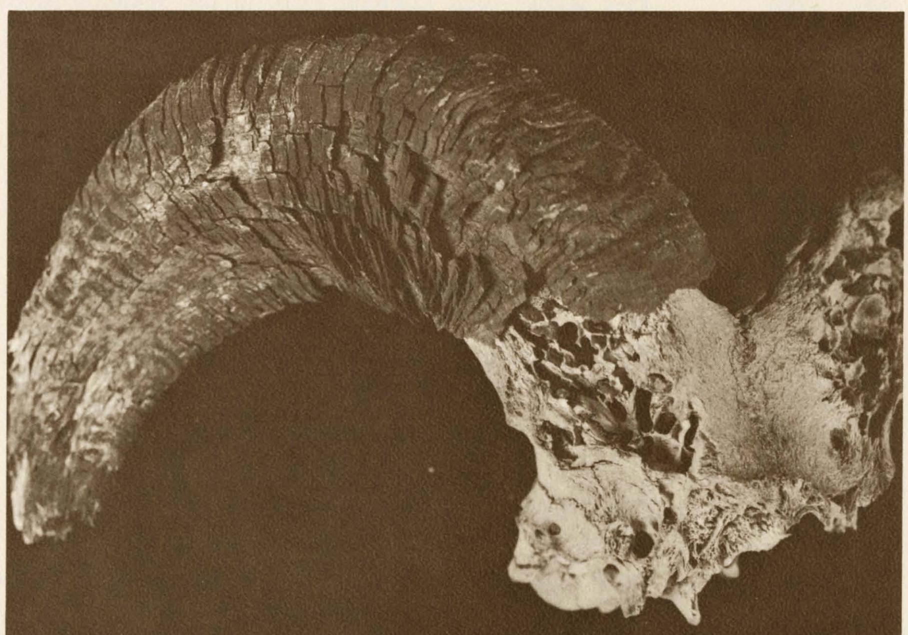

Figure 3. This bighorn ram skull portion was found in Logan Canyon on May 16, 1970 by Albert Abee.

[1] Additional information concerning bighorn sheep in Utah is solicited by the authors.

Table 3. Key to figure 1—Recorded sightings of bighorn sheep in Utah since 1950 (black numbers)

	Year	Location of sheep sightings	Observer and/or source
1.	1953	Ram—Watchman promontory in Zion National Park.	(Metherell, 1970)
2.	1969	Ram—top of Lathrop Trail on Canyonlands National Park.	(Budge, 1970)
3.	1969	One ram, two ewes, and one lamb—White Rim, 1 mile inside of Canyonlands National Park.	(Budge, 1970)
4.	1969	One ram, three ewes, and two lambs—White Rim area in Canyonlands National Park.	(Budge, 1970)
5.	1969	Ram—southern base of Junction Butte in Canyonlands National Park.	(Budge, 1970)
6.	1969	Bighorn—3 miles north of Monument Basin.	(Budge, 1970)
7.	1969	Two bighorns—at airstrip on the White Rim road.	(Budge, 1970)
8.	1969	Sixteen bighorns—5 miles above Gypsum Canyon.	(Budge, 1970)
9.	1969	Two rams, two ewes, and one lamb—Musselman Arch.	(Budge, 1970)
10.	1969	One bighorn—gate below Dead Horse Point.	(Budge, 1970)
11.	1969	Four ewes—White Rim road below Sharps Trail.	(Budge, 1970)
12.	1969	Four ewes and two lambs—near the ranger trap on White Rim.	(Budge, 1970)
13.	1969	One ram, three ewes, and two lambs—Murphay Range.	(Budge, 1970)
14.	1969	One ram and one ewe—below Dead Horse Point.	(Budge, 1970)
15.	1969	Four ewes and four lambs—Loop of the Colorado River.	(Budge, 1970)
16.	1970	Bighorns observed in 1969 and 1970 at Jones Hole in Dinosaur National Monument.	(Hannah, 1970)
17.	1967	Fresh bighorn tracks—across the Colorado River from the mouth of Dark Canyon.	(Follows, 1970)
18.	1967	One ram, one ewe, and one lamb—Francis Peak.	Fish and Game files, Ogden, Utah
19.	1968	Five sheep—Ben Lomond Peak in the Wasatch Mountains.	Lynn Mikkelson (Fish and Game files, Ogden, Utah)
20.	1968	Six bighorns—above canal at Willard, Utah.	Fish and Game files, Ogden, Utah
21.	1967	Six bighorns—½ mile north of Rulon White's residence in Ogden, Utah.	Seth Thorpe (Fish and Game files, Ogden, Utah)
22.	1967	Nine bighorns—Willard Peak by Fish and Game personnel.	Fish and Game files, Ogden, Utah
23.	1967	Bighorn—shot during deer season near Willard picnic area.	Fish and Game files, Ogden, Utah
24.	1968	Seven bighorns—spotted at a salt lick on Willard Peak by Fish and Game personnel.	Fish and Game files, Ogden, Utah
25.	1968	Ram—along Highway 91 near Mantua.	Fish and Game files, Ogden, Utah
26.	1959	Bighorn ram—bred a domestic sheep in Coalville. Hybrid offspring still living.	Herman Edgel (Fish and Game files, Ogden, Utah)
27.	1968	Four bighorns—seen in the Needle Range by Utah Division of Fish and Game range survey team.	(John, 1970)
28.	1966	Bighorn ram—bred domestic sheep in the Wah Wah Mountains.	(John, 1970)
29.	1968	One ram and six ewes—reported in the Wah Wah Mountains.	(John, 1970)

Table 3. Key to figure 1 (Cont.)

	Year	Location of sheep sightings	Observer and/or source
30.	1964	Ram—observed at the Feron dump by a Fish and Game employee.	(John, 1970)
31.	1969	Bighorns—along the San Juan River at Nakai Dome.	(John, 1970)
32.	?	Bighorns—Deer Point along the Breaks of the Escalante River.	(John, 1970)
33.	1969	Bighorn—southeast end of the neck inside Canyonlands National Park.	(Budge, 1970)
34.	1966	Five bighorns, two ewes, two yearling rams and one lamb—2 miles south of the White Rim Slot.	(Budge, 1970)
35.	1958	Four bighorns—Green River in Red Canyon, upstream from Green Lakes.	Bruce Leam (Barmore, 1962)
36.	1969	Three bighorns—near Flaming Gorge dam site.	(Barmore, 1962)
37.	1959	Two ewes—mouth of Whirlpool Canyon.	(Barmore, 1962)
38.	1966	Nine bighorns—mouth of Gypsum Canyon during June.	(Follows, 1969)
39.	1958	Ram—watering in the Upper Courthouse at Arches National Monument.	Dan Winburn (Follows, 1969)
40.	1954	Forty-eight bighorns—above the Confluence in Canyonlands National Park. The sheep appeared sick and had sores on their ears.	(Follows, 1969)
41.	1969	Thirteen bighorns—southwest of Junction Butte in the Sals Hole area.	Carl Wadsworth (Follows, 1969)
42.	1954	Five sheep—east side of Red Castle Peak in the Uinta Mountains.	Robert F. Hoag, Jr. (Buechner, 1960)
43.	1955	Two rams, four ewes, and two lambs—Commissary Park, Ashley National Forest.	(Buechner, 1960)
44.	1954	Old ram—often seen on Deadman Point and around Spring Canyon in Canyonlands National Park.	LaVern Young (Follows, 1969)
45.	1950s	Two bighorns—along the west boundary of Arches National Monument near Suicide Curve.	Bates E. Wilson (Follows, 1969)
46.	1958	Ram—lower Fiery Furnace area of Arches National Monument.	Bates E. Wilson (Follows, 1969)
47.	1958	Thirty-four ewes and lambs—just off the Moss Backs in White Canyon in Natural Bridges National Monument.	Chap Blake (Follows, 1969)
48.	1968	Two ewes and a lamb—seen going off the Moss Backs into White Canyon.	Carl Mahon (Follows, 1969)
49.	1960	Mature ram—observed in Uinta Mountains by Fish and Game pilot.	Ralph Noble (Drobnick, 1970)
50.	1968	Fifteen bighorns—Deer Point Mesa at the southern end of the Waterpocket Fold.	Keith McFall (Drobnick, 1970)
51.	1970	Several bighorns—observed by construction crews at Clay Hill Pass on the Halls Crossing road.	(Drobnick, 1970)
52.	1956	Ram—killed by a sheepherder in lower Crouse Canyon in the Uinta Mountains. This ram previously observed alive and photographed by Fish and Game personnel.	Steve Radosevich (Drobnick, 1970)
53.	1963	Mature ewe—seen with a band of domestic sheep in Crouse Canyon in the Uinta Mountains by Fish and Game personnel.	John Fannery (Drobnick, 1970)
54.	1969	Ram—spotted in Fish and Game helicopter survey near mouth of the Castle Creek on the north side of the San Juan River.	Rodney John (Drobnick, 1970)

Table 3. Key to figure 1 (Cont.)

	Year	Location of sheep sightings	Observer and/or source
55.	1969	One ram and nine ewes—spotted in Fish and Game helicopter survey at the mouth of the first small canyon north of Gypsum Canyon on the east side of the Colorado River.	Rodney John (Drobnick, 1970)
56.	1965	Tracks of six ewes and one ram—found by Carl Mahon and Rudy Drobnick at Nakai Dome.	(Drobnick, 1970)
57.	1968	Seven bighorns—Mikes Canyon along the San Juan River.	(Drobnick, 1970)
58.	1967	Twenty-four bighorns—above timberline on the north side of Mt. Ellen in the Henry Mountains.	(Drobnick, 1970)
59.	1956	One ram and four unclassified bighorns—seen by river floaters at the mouth of John's Canyon along the San Juan River.	Norm Nevilles and Frank Wright (Drobnick, 1970)
60.	1959	Thirteen bighorns—seen by Fish and Game personnel at Dead Horse Point.	Lee Robertson (Drobnick, 1970)
61.	1965	Mature ram—Uinta Mountains at Lofty Lake north of the head of Weber River.	Ralph Noble (Drobnick, 1970)
62.	1968	One ram and two ewes—Nipple Bench between Warm and Wah Weap Creeks, Kane County.	Ralph Noble (Drobnick, 1970)
63.	1950 to present	Sightings in this are very numerous (see Wilson, 1968, and Irvine, 1969). This area probably contains Utah's major desert bighorn population.	(Drobnick, 1970)
64.	1969	Bighorns—observed in the Poison Spring Canyon drainage.	(Warburton, 1970)
65.	1969	Bighorns—Mt. Hillers.	(Warburton, 1970)
66.	1966	Bighorns—Hites Crossing on the west side of the Colorado River.	(Warburton, 1970)
67.	1968	Bighorns—White Canyon near the Colorado River.	(Warburton, 1970)
68.	1968	Bighorns—Dark Canyon.	(Warburton, 1970)
69.	1966	Bighorns—Fish Creek on Comb Ridge.	(Warburton, 1970)
70.	1968	Bighorns—Cottonwood Creek.	(Warburton, 1970)
71.	1966	Bighorns—Harts Draw upstream from Indian Creek.	(Warburton, 1970)
72.	1966	Bighorns—west of Monticello City limits.	(Warburton, 1970)
73.	1969	Bighorns—mouth of Indian Creek.	(Warburton, 1970)
74.	1968	Bighorns—Harts Draw near the Manti-La Sal National Forest boundary.	(Warburton, 1970)
75.	1969	Bighorns—Lockhart Basin.	(Warburton, 1970)
76.	1970	Two bighorn rams—observed and photographed during July in the area near the confluence of the East Fork of Blacks Fork and the Little East Fork.	(Reddin, 1971)
77.	1970	A mature ram and a ewe—3 miles east of Brigham City, Utah, on Highway 91 in early October.	(Mathews, 1970)
78.	1964-1966	About 12 bighorns—at spring near Perkins Cabin, south end of Granite Peak.	Dan Rydalch (Ralph Holmgren, 1971)

northwestern Utah also are sparse. Skeletal remains, however, have been found on Stansbury Island, Granite Mountain, and on the Oquirrh, Newfoundland, and Lakeside Mountains. A bighorn was killed 25 miles north of Wendover in 1910, and various reports indicate that a remnant bighorn population may persist on Granite Mountain in restricted areas on the Dugway Proving Grounds which are administered by the U.S. Army.

There have been sporadic reports of Rocky Mountain bighorn sightings in the Uinta Mountain area since 1849 until the present. Trappers and explorers persistently remarked about the abundance of bighorns along the Green River near Browns Park and Split Mountain Canyon, which is now a part of Dinosaur National Monument. National Park Service personnel verified the presence of bighorns on Split Mountain in 1943, but claimed that this herd disappeared completely sometime between 1944 and 1951. The Colorado Fish and Game reintroduced Rocky Mountain bighorn sheep into the Monument in 1952. Since then bighorns have been observed quite frequently along the rivers that flow through the Monument.

A remnant bighorn population also inhabits the high peaks of the Uinta Mountains and the canyons at Flaming Gorge. However, outside of occasional sightings, little is known about this population. A Rocky Mountain ram wandered into the Coalville, Utah area and bred a domestic ewe belonging to Herman Edgel during the fall of 1959. A hybrid ewe lamb was born the following spring, and it has since been reported to have given birth to a lamb. A bighorn skull wedged in a large juniper tree was found near Fruitland in the 1950s and presently can be seen at the Current Creek Cafe on Utah Highway 40 east of Strawberry Reservoir. The two latest recorded sightings of bighorns in the Uintas were: a mature ram seen north of the Weber River at Lofty Lake in 1965, and two bighorn rams seen and photographed near the confluence of the East Fork of Blacks Fork and the Little East Fork during the summer of 1970.

Insofar as is known, the west central portion of Utah, commonly known as the West Desert and which includes Juab, Millard, San Pete and Sevier counties, has no bighorn populations. However, horns of a bighorn sheep were found near Salina and a bighorn skull was found in the Canyon Mountains east of Oak City.

Utah is unique in that it is believed that the ranges of the Rocky Mountain bighorn and the Desert bighorn meet somewhere along the Colorado River drainage in the east central part of the state. Nevertheless, historical and recent bighorn sightings in this area are sparse. Bighorns occasionally were observed in Arches National Monument during the 1950s. The two most recent sightings, however, were both in 1958: one in the Upper Courthouse area and the other in the Lower Fiery Furnace area. A solitary bighorn ram also was reported near the Feron garbage dump in Emery County in 1964.

Similarly, although archeological and historical evidence indicates that bighorns were plentiful in southwestern Utah during the late 1800s and early 1900s, recent reports of bighorns west of the Colorado River in southern Utah are not common. A bighorn ram bred some domestic ewes in the Wah Wah Mountains in 1966, and a bighorn ram and six bighorn ewes were seen in the Wah Wahs in 1968. Bighorns also were observed in the Needles Mountain Range in 1968. Although bighorns commonly were observed in Zion National Park during the 1930s and 1940s, their numbers dwindled and the last bighorn reported in the Park was a ewe observed on a promontory called the Watchman in 1953. In 1970, a band of 15 bighorns was observed on the Waterpocket Fold, an area to be included in the new extension of the Capital Reef National Monument. Recent sightings of bighorns in the Little Rockies in the southern end of the Henry Mountains also have been reported.

The location of the largest, present-day bighorn population in Utah is in San Juan County, from Dead Horse Point along the Colorado River to the confluence of the Colorado and Green Rivers, through Cataract Canyon down to Red Canyon, and the drainage of the San Juan River. Numbers are relatively sparse between the confluence and Dead Horse Point and along the San Juan River, but the area in Cataract Canyon south of Gypsum Canyon (including lower Dark Canyon, Woodenshoe Canyon, White Canyon and the Red Canyon Drainage) is thought to harbor bighorns in huntable numbers.

Two master-of-science studies sponsored by the Utah Division of Wildlife Resources and supervised by the Utah Cooperative Wildlife Research Unit have been conducted on the desert bighorn populations in the White and Red Canyon areas. As a result of these studies, interest in Utah's desert bighorns has steadily increased, and limited hunts for trophy bighorn rams have been held annually since 1967.

Much of the desert bighorn's habitat in Utah was virtually unexplored until the discovery of uranium in the late 1940s. Miners and prospectors saturated much of southeastern Utah during the uranium "boom," and reports of desert bighorns began to increase. Miners living in the desert often illegally hunted the bighorn for both sport and food. In a few cases, the bighorn apparently was a primary source of meat.

Navajo Indians also hunted desert bighorns. In 1942, residents of White Canyon reported seeing Indians leaving the canyon with 60 or 70 bighorn hides loaded on three pack horses.

With a decrease in mining activities, the initiation of more conservative grazing programs, and increased interest by both State and Federal agencies in the welfare of the bighorn, desert bighorn populations undoubtedly will increase. Both studies conducted in the White and Red Canyon areas have indicated increasing bighorn populations.

REINTRODUCTION OF BIGHORNS IN UTAH

As previously mentioned, the Colorado Fish and Game successfully reintroduced Rocky Mountain bighorns into the Dinosaur National Monument in 1952. The Utah Division of Wildlife Resources also is considering a number of areas for the reintroduction of the Rocky Mountain bighorn into its former ranges in Utah. Between 1961 and 1965, the Division made arrangements to obtain a parent stock of bighorn sheep, and by April of 1966 had obtained a total of 34 animals from Wyoming and Canada. These were placed in two paddocks on Brigham Mountain above Brigham City. However, because of snow and wind damage to sections of the fences, a few bighorns have escaped from the paddocks each winter. As a result of these escapes, there have been occasional sightings of bighorns in the Willard Peak area and along the Wellsville Mountain Range. It appears these escapees will result eventually in the establishment of a herd of Rocky Mountain bighorns on the Wasatch Range. The bighorns remaining in the paddocks will be held as parent stock from which releases will be made when suitable areas have been determined.

The National Park Service in 1967 began looking into the possibility of reintroducing desert bighorn sheep into Zion National Park. An 80-acre paddock for parent stock was completed in the Park in January, 1970. The paddock includes year-round bighorn habitat, is secluded from the view of tourists to minimize disturbances, and is strategically located for ease of surveillance and care of the parent stock. Plans also are to conduct a detailed study regarding the basic conditions under which desert bighorns may be restored into other areas. Desert bighorns have not yet been located for this project, however. The Park Service presently is considering whether or not it would be advisable to use Rocky Mountain rather than desert bighorns for the introduction.

A few skeletal remains of bighorns have been found in the Book Cliffs of northeastern Utah (figure 1, table 1), and the Hill Creek Indians have reintroduced Rocky Mountain bighorns into the Book Cliffs on the Uinta and Ouray Indian Reservation at Florence Creek Canyon. They received 10 bighorns (nine ewes and an immature ram) from Wyoming in 1969. However, nothing concerning these bighorns has been reported since their releases. The Hill Creek Indians also hoped to receive more bighorns for release from Wyoming during the winter of 1970-71, but plans did not materialize.

Many problems are involved in the reintroduction of bighorns. A major problem is the inevitably frequent handling of such sheep during capture, transportation, veterinarian checks and unloading. Bighorns are easily injured and readily contract pneumonia. Concerning the latter, Dr. Ross Smart of the Veterinary Science Department at Utah State University has developed a cultured vaccine, which appears to be effective in combating pneumonia in bighorns. Maintaining captive bighorns in a healthy and vigorous condition, nevertheless, is extremely difficult. This is one reason why bighorn sheep are displayed

Figure 4. This band of 10 desert bighorns (4 rams, 4 ewes, and 2 lambs) was observed one December in the Red Canyon area at San Juan County.

by only a small number of the world's zoos.

FUTURE OF UTAH'S BIGHORN SHEEP

The future for the bighorn in Utah appears to be bright. Existing stocks are being protected and conservationists are working towards the reintroduction of Rocky Mountain and desert bighorns into suitable areas.

The Bureau of Land Management has made a special request to the mining industry to reduce explorations in bighorn habitats during the lambing season. Cooperation from such industries will greatly enhance the chances of lamb survival, as it is claimed that if a lamb can survive its first year it can be expected to live approximately 10 years.

Water appears to be a limiting factor for desert bighorn populations. Through cooperative efforts by the Bureau of Land Management and the Utah Division of Wildlife Resources, 12 seeps or springs were developed or improved during 1968 and 1969 so that bighorns could use them all year. The Utah Division of Wildlife Resources, the Bureau of Land Management and the Intermountain Forest and Range Experiment Station also are cooperatively investigating the possibilities of improving the forage on desert bighorn ranges.

Despite the fact that governmental interest in Utah's bighorns has grown steadily through the 1960s and considerable progress has been made concerning their conservation, much remains to be done before the values—both economic and aesthetic—of the bighorn can be fully realized. Public interest and conservation action must be stimulated. Reestablishment of bighorn populations also must be given priority in selected areas to ensure that this magnificent animal may again become plentiful at least in a few of its former haunts in Utah.

Utah's economy and the non-resident deer hunter

JOHN D. HUNT

In 1970 approximately 19,600[1] non-residents purchased Utah deer hunting licenses (table 1). To examine the partial economic impact of the non-resident hunter on Utah's economy, a pilot study was undertaken by Utah State University's Institute for the Study of Outdoor Recreation and Tourism. A special sample of non-resident hunters was examined[2] as part of the Institute's *Continuing Comprehensive Study of Utah Travel* conducted for the Utah Department of Development Services.

On October 15 and 16, 1970, 450 hunter parties were stopped on US Highway 91 west of Santa Clara, Utah. They were asked several questions about party size, number of hunting licenses, vehicle type, and other information. Following a brief explanation of the study they were given a diary questionnaire. They were asked to complete the information on the questionnaire during their visit to Utah and return it as soon as they departed. Seventy-two of the questionnaires were returned. Control data collected from the 450 parties at the roadblock compared very favorably with similar data entered on the questionnaires and returned by the 72 respondents. This favorable comparison of data indicates that a non-response bias is probably not evident. Assuming that the expenditure patterns and various socio-economic information of the sample are representative of the total population, the following information gives a limited description of Utah's non-resident deer hunter industry.

It is estimated that, exclusive of hunting and fishing license expenditures, Utah non-resident deer hunter parties spent approximately $618,700 during the 1970 season in Utah (table 2). Since the hunters spent at

[1] **Source:** Utah Division of Wildlife Resources

[2] This special sample was not assumed to be necessarily representative of the total non-resident hunter population because it represented a sample of only those hunters who entered Utah on US-91 at Santa Clara. While it was assumed that the major portion of Utah non-resident hunters do enter Utah at this point, it is known that many enter on other highways. In addition, it was recognized that the US-91 entrance is highly representative of California hunters while other highways may be the entrance for hunters from other regions of the country.

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Table 1. Number of hunters, size of party — non-resident hunter, 1970

Non-resident	1970
Licenses (hunters)[a]	19,600
Number of licenses per party[b]	1.8
Number of hunting parties[c]	10,889
Party size[b]	3.1
Number of people in all parties[d]	33,755

[a] Source: Utah Division of Wildlife Resources
[b] Data collected at highway roadblock of all 450 sampled parties
[c] Number of licenses (19,600) divided by number of licenses per party (1.8)
[d] Number of hunting parties (10,889) multiplied by party size (3.1)

least 50 dollars for a non-resident hunting license, they contributed substantially more money to the Utah Division of Wildlife Resources than to the State's business economy. The approximate $980,000 collected for non-resident deer hunting licenses was bolstered by the purchase of fishing licenses by some parties.

The hunter parties spent an average of 4.8 nights in Utah. Daily expenditures were less than 4 dollars per person. This daily expenditure level is substantially less than that of general non-resident tourists visiting Utah.[3] This difference probably resulted because a much greater proportion of hunters are campers than is the case with the general vacationing tourist. While nearly 70 percent of the hunting parties came to Utah in some type of recreation vehicle, over 80 percent of the general vacationing tourists came by car only (table 3). Of the nights spent in Utah by hunters, 64 percent were spent camping. It is interesting to note that nearly one and 1/2 percent of the non-resident hunter parties stayed in cabins or homes which they owned in Utah. The propensity of hunters to camp or stay in private cabins is reflected in the distribution of expenditures among purchase types (table 4).

Over 92 percent of the 1970 non-resident hunter parties had visited Utah before. This high figure would suggest that only a few new hunters may be coming to Utah each year.

Our limited research indicates that non-resident hunters contribute relatively little to the State's economy. However, the economic impact is highly significant upon certain southern Utah communities. Although the entire non-resident hunting picture was not examined it is interesting to note where the study respondents made their expenditures. By rank, St. George, Panguitch, Cedar City, Beaver, Richfield, Parawon, and Santa Clara received over 60 percent of the hunter expenditures. The remaining expenditures were scattered among 41 other communities and lodges.

Generally speaking, the hunter party exhibits a low daily expenditure level as compared to other non-resident tourists. It is estimated that non-resident hunters contribute less than 1 percent of the total dollars generated by non-resident tourism in Utah each year. Although this economic contribution of the non-resident hunter may be relatively small, it is important. Selected businesses and several southern Utah communities may receive a major portion of their income during the deer hunting season. In addition, the contribution to the operational budget of the Utah Division of Wildlife Resources through purchase of licenses is highly significant.

[3] Hunt, John D. and Perry J. Brown. 1970. Utah Travel — 1969-70. Institute for the Study of Outdoor Recreation and Tourism, Utah State University, Logan, Utah. 42 pp.

Table 2. Expenditures — non-resident hunter, 1970

Total Expenditure	$618,700[a]
Per party per visit	56.81
Per person per visit	18.33
Per person per day	3.82

[a] This does not include the expenditure for any non-resident hunting or fishing licenses.

Table 3. Vehicle type — hunter versus general tourist, 1970

Vehicle Type	Hunter	Tourist[a]
Car	30.4	84.0
Car and trailer	5.1	6.0
Pickup, Pickup Camper, Pickup Camper & Trailer	62.5	8.0
Other	2.0	2.0

[a] Source: Hunt, John D. and Perry J. Brown. 1970. Utah Travel, 1969-70, Institute for the Study of Outdoor Recreation and Tourism, Utah State University, Logan, Utah. 42 pp.

Table 4. Expenditure by purchase type — non-resident hunters

Purchase Type	Percent	Dollars
Food	37.8	$233,900
Lodging	19.6	121,300
Transportation	31.3	193,600
Other retail	11.2	69,300
Entertainment	0.1	600
Services	a	----
TOTAL	100.0	$618,700

[a] Less than 0.1 of one percent

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Chukars don't need guzzlers

WILLIAM W. SHAW and JESSOP B. LOW

As the human population increases, the desire for outdoor recreation is causing more and more people to utilize our rapidly dwindling wilderness areas. The vast deserts of the western United States are being increasingly used for outdoor activities and scientists at Utah State University are investigating techniques for introducing and managing game species in desert regions that might otherwise provide no hunting.

The chukar partridge is a quail-like species from Europe and Asia that has been successfully introduced to many mountainous areas throughout the West. These birds seem to thrive best in dry, rocky mountains in many areas of the state; such habitats support no native game species. In these areas, chukars can provide hours of outdoor diversion for the hunter who is willing to pursue them in their rugged habitat.

Permanent sources of drinking water for the birds are scarce in deserts and game managers have developed a technique for making more sources available. Water from rain and snow is collected on large galvanized iron aprons that drain into underground storage tanks. Throughout the summer months, this stored water flows into a small drinking basin in which the water level is automatically maintained by a float valve. These devices are called "guzzlers" and have been used to improve habitat for many desert species such as quail, mourning dove, and deer.

It is possible that such devises may improve chukar habitat and thus make possible more recreation in desert regions. To investigate the feasibility of this technique, the Utah Coperative Wildlife Research Unit and the Utah Division of Fish and Game have sponsored 4 years of investigation on the Dugway and Thomas Mountain Ranges near Dugway, Utah.

It was known that chukars tend to concentrate around these guzzlers in summer months. However, the fact that the birds use the water does not necessarily mean that providing water improves their productivity, survival, or availability to hunters. To answer these questions, 12 guzzlers were installed on the two mountain ranges and extensive field work conducted. After 3 years, the guzzlers on one range were made nonfunctional and the chukar populations on the two ranges were compared during the next year.

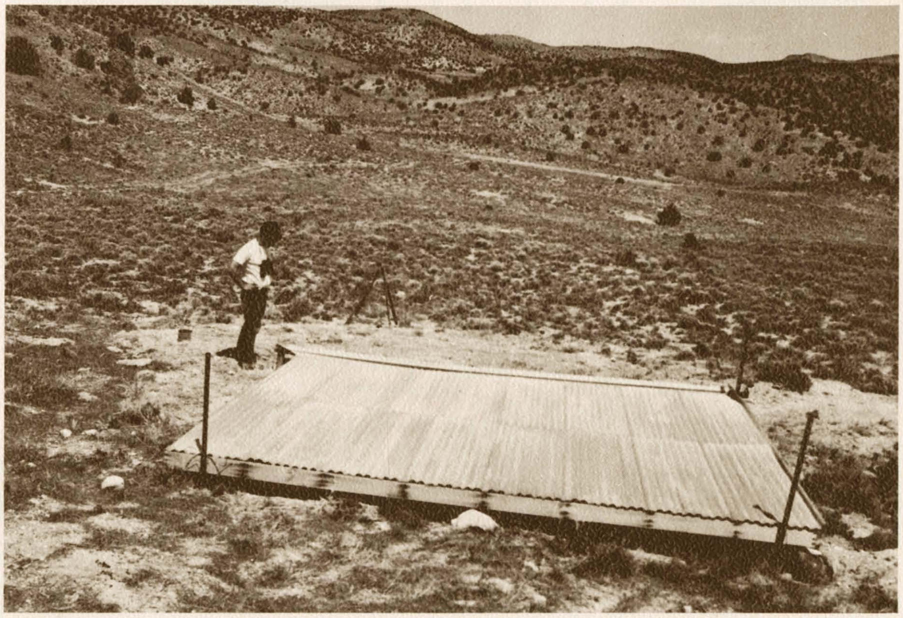

Figure 1. Rain-catchment apron used in guzzlers on the Thomas and Dugway Mountains. Water from precipitation drains to a gutter on one side of the apron and then into underground storage tank. From the tank, the water flows to a drinking basin where the chukars drink.
(Photo by J. B. Low)

Various techniques were employed to gain insight into chukar ecology. The birds were trapped and marked with colored backtags to determine their movement patterns. Censuses were conducted to determine the distribution of the birds in relation to water. Chukars were collected and their stomach contents analyzed for food items, and hunters were interviewed to find if hunting success was influenced by water availability.

After 4 years of study, it was revealed that in this habitat, drinking water may not actually be as important to chukars as intitially believed. Although the birds tended to concentrate around water, the absence of free water had no adverse effects on bird productivity, survival, or availability of birds to hunters. It was found that a large part of their diet was insects and apparently they were able to get enough water from food and natural water catchment basins filled by occasional showers to meet their needs.

Of course this does not mean that all populations of chukars can survive without permanent sources of water. Other areas may have fewer rain showers or less succulent foods. It does mean that in comparable desert habitats, installation of rain-catchment devices may not be a feasible technique for increasing chukar populations and thus providing more hunter recreation.

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Moose immigration prompts research

DAVID E. WILSON

Moose are the largest members of the deer family, often weighing up to 1800 pounds. They have the widest distribution of the North American deer, ranging from Maine to Alaska (figure 1). However, their distribution within the contiguous 48 states is quite limited and made up primarily of southerly extensions of population centers in Canada and British Columbia.

Four subspecies of moose occur in North America. The Eastern Moose (*Alces alces americana*) has a distribution in the northern New England states from Maine and Nova Scotia westward through Quebec to central northern Ontario, where it intergrades with the Northwestern Moose (*A. a. andersoni*). This subspecies has limited populations in northern Michigan and Minnesota.

The Alaskan Moose (*A. a. gigas*) extends throughout the forested areas of Alaska, western Yukon, and northwestern British Columbia. The Yellowstone or Shiras Moose (*A. a. shirasi*) is the subspecies found in Utah, and its range extends from a population center in southeastern British Columbia through southwestern Alberta, south through Idaho and western Montana into western Wyoming. Only an occasional occurrence of this subspecies has been noted in extreme northeastern Utah.

It appears that moose were formerly much more abundant in North America. For example, in 1929 moose numbers were estimated at 1 million animals. This number had dropped to approximately 195,000 by 1949, however.

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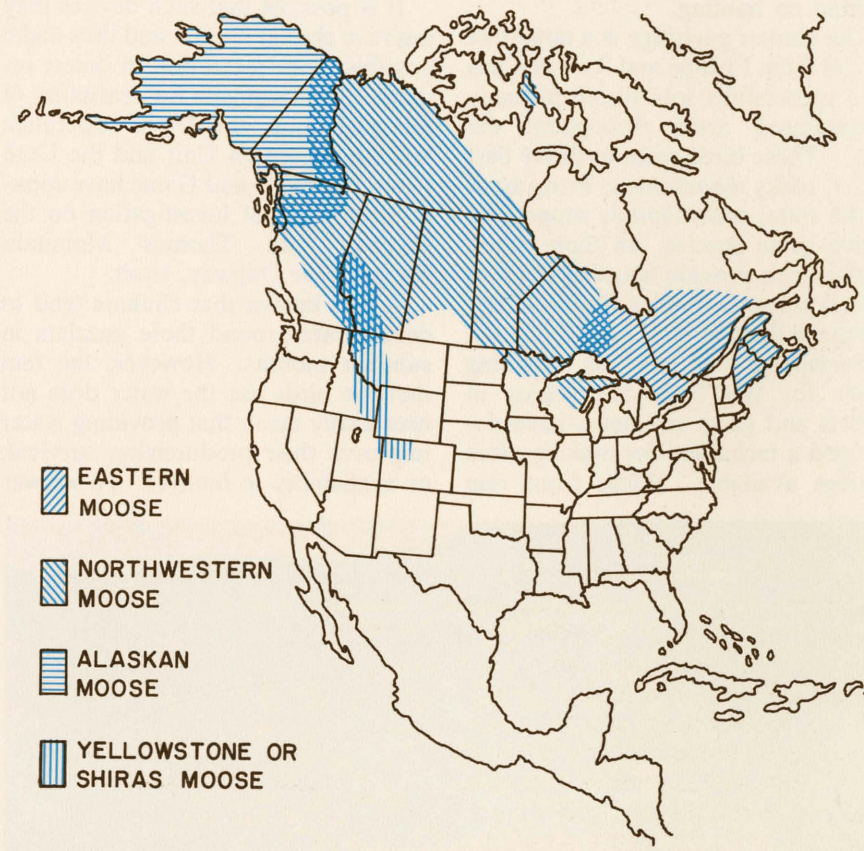

Figure 1. Map of North America showing distribution of the four species of moose.

Although the total numbers of the first three subspecies mentioned above have declined, their distributions throughout Canada and British Columbia have remained relatively stable, with a tendency for the distributions in the United States to decline or move North.

The Shiras Moose, on the other hand, is extending its range in a southerly direction and increasing its numbers at a significant rate. From the first sightings in the Yellowstone Park area of Wyoming in the late 1860s, the Shiras Moose had increased to an estimated 3,197 in Wyoming by 1950.

The first sightings of Shiras Moose in the Uinta Mountains in Utah was in 1918, when a cow and calf were spotted near the Utah-Wyoming state line in the Bear River drainage. As late as 1944, the southern limits of established populations were put in the vicinity of Kemmerer and Lander, Wyoming. Occasional individuals were reported to have drifted into southern Wyoming and northern Colorado. It seems apparent that the Uinta moose population originated as a southern extension of the Jackson Hole herd and, although the population was not endemic to Utah, it now appears to be a resident population.

In 1956, the Utah Division of Fish and Game began annual aerial censuses of the new moose population in the Uinta Moutains of Utah. Moose numbers by then had increased to 59 animals in that area. For 10 years, population numbers fluctuated from 57 to 100 animals, but in 1966, the rate of increase dramatically accelerated. By 1971, the moose population on the north slope of the Uintas had increased to more than 371 animals (343 by aerial census plus 24 hunter and 4 illegal kills). This was an increase of 500 percent during the previous 5 years (figure 2).

In light of their rapidly increasing numbers, the moose population is occupying a prominent position in the fauna of the Uinta Mountain area. This potential influence pointed out the need for established management practices, before excessive moose numbers caused damage to the habitat by overbrowsing.

A research project, sponsored jointly by the Utah Cooperative Wildlife Research Unit at Utah State University and the Utah Division of Fish and Game, was initiated in 1969 to study various aspects of the food habits of moose, to provide basic data for management. Annual winter aerial censuses had shown that deep snows forced the moose out of the higher elevations and concentrated them in the willow covered stream bottoms at the base of the north slope of the Uinta Mountains (figure 3). The restricted winter range was considered a limiting factor to the population, so the eventual goal of the project was to establish a range carrying capacity or the number of moose that could be supported by the vegetation on this winter range on a sustained-yield basis.

Objectives were to: (1) identify the key food species in the winter diet of the moose, (2) determine the total availability of the key food species on the winter habitat, and (3) determine how much of the key food species a moose needs per day. The carrying capacity would be determined by comparing how much food a moose needs to how much food is available.

Other aspects of the project included immobilizing and tagging moose to determine movements, tracking moose on snowshoes to record feeding habits, aerial censusing, and vegetation density analyses.

The research project will provide management data so moose numbers can be regulated to maintain the population within the carrying capacity of the habitat and in equilibrium with other established big game species. When the capacity of the current habitat is reached, a program of relocation of moose to other areas in Utah for the purpose of establishing new populations will enable Utah's moose population to maintain its current growth potential, while still providing maximum esthetic and recreational values for the public.

(Figure 3 on page 108)

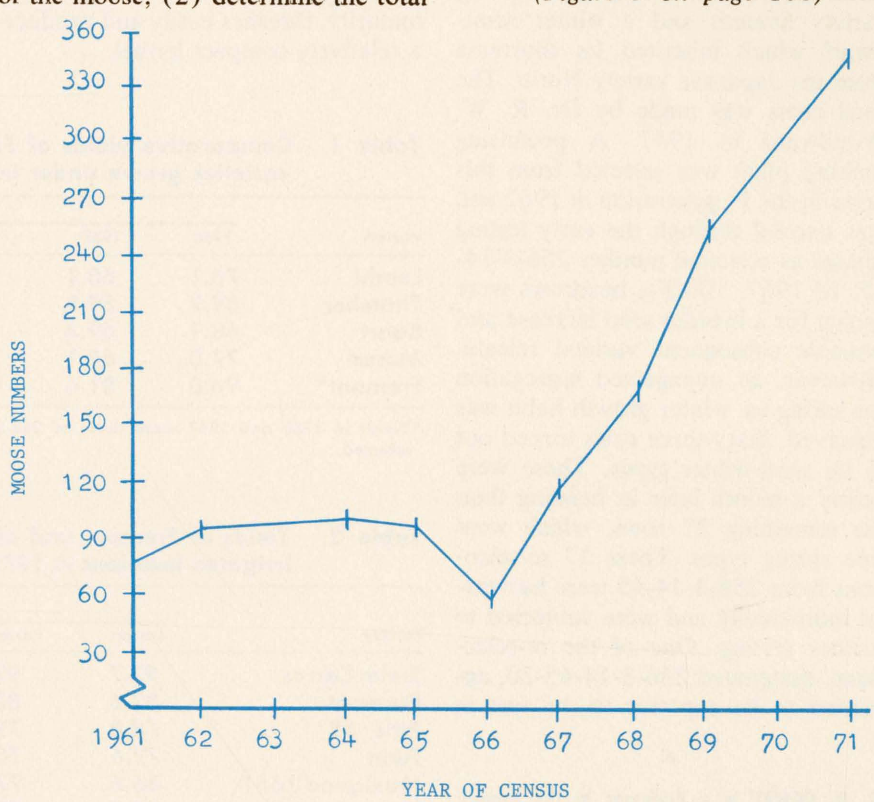

Figure 2. Annual censuses indicate a dramatic increase in moose numbers since 1966.

FREMONT- A NEW HARD RED SEMI-DWARF SPRING WHEAT

W. G. DEWEY and R. S. ALBRECHTSEN

The first semi-dwarf wheat variety developed at Utah State University was released in limited quantities to commercial seedsmen in 1970. The new variety, named Fremont after one of the early explorers of the Intermountain area, resulted from the cooperative efforts of the Utah Agricultural Experiment Station and the U.S.D.A.

DIVERSE PARENTAGE

Fremont derives from a complex series of crosses. Its official pedigree is Hussar X Turkey 2X Ridit 3X Oro X Ridit 4X Norin V Brevor 5X Lee 6X Svenno. The last cross in this series involved the tall Swedish spring variety Svenno and a winter semi-dwarf which inherited its shortness from the Japanese variety Norin. The final cross was made by Dr. R. W. Woodward in 1957. A promising looking plant was selected from this cross in the F_5 generation in 1962 and was carried through the early testing phases as selection number 256-3-14-45. In 1967, 100 F_{10} headrows were grown for a breeder seed increase and possible subsequent varietal release. However, an unexpected segregation for spring vs. winter growth habit was observed. Sixty-three rows turned out to be semi-winter types. These were nearly a month later in heading than the remaining 37 rows, which were true spring types .These 37 re-selections from 256-3-14-45 were harvested individually and were subjected to further testing. One of the re-selections, designated 256-3-14-45-20, appeared to be superior to the rest in certain breadmaking characteristics. This line was increased at Yuma, Arizona during the winter of 1968-69, named Fremont, and released in 1970.

DISTINGUISHING CHARACTERISTICS

Fremont is a bearded, white-chaffed spring wheat with unusually large heads. It has hard red kernels and is classed as a breadwheat. Although it is considered to be a semi-dwarf, it is not as short as Red River 68 and some of the Mexican semi-dwarfs which have recently come into this area. It is comparable in height with the winter semi-dwarf varieties Gaines and Nugaines. Fremont is medium in maturity, threshes easily and produces a relatively compact kernel.

AGRONOMIC PERFORMANCE

Fremont is being recommended for use under irrigation and conditions of high soil fertility. Under these conditions, Fremont and the breeding line from which it was selected (256-3-14-45) have demonstrated a consistent yield advantage over standard tall spring varieties such as Lemhi, Thatcher and Baart (table 1). Over the past 5 years this yield increase has averaged between 20 and 30 percent. Occasional yields in excess of 100 bushels per acre have been recorded in experimental plots and in seed increase fields. This is still well below the top yields obtainable with fall-planted semi-dwarfs such as Gaines and Nugaines. However, it is unlikely that a spring semi-dwarf will be de-

Table 1. Comparative yields of Fremont and standard tall spring wheat varieties grown under irrigation at Logan, Utah

Variety	Bushels per acre					
	1966	1967	1968	1969	1970	5 Yr Avg
Lemhi	76.1	60.1	81.9	43.6	67.4	65.8
Thatcher	69.2	59.8	70.4	52.1	70.9	64.5
Baart	68.1	69.4	76.0	60.0	82.1	71.1
Moran	77.0	62.1	73.8	68.4	76.5	71.6
Fremont*	94.0	81.6	109.6	66.1	83.8	87.0

*Yields in 1966 and 1967 were those of 256-3-14-45, the breeding line from which Fremont was selected.

Table 2. Yields of Fremont and other semi-dwarf varieties grown at four irrigated locations in 1970

Variety	Bushels per acre				
	Logan	Farmington	Morgan	Ephraim	4 Loc Avg
Siete Cerros	97.7	93.8	51.5	70.9	78.5
Fremont	83.6	82.4	70.4	67.7	76.1
Pitic 62	78.8	79.3	66.3	76.7	75.3
Twin	72.6	70.3	70.4	81.8	73.8
Maxigene 1651	86.6	77.7	60.1	67.9	73.1
Springfield	78.0	55.3	70.8	78.4	70.6
Red River 68	86.9	76.2	56.6	60.7	70.1
Rogue 66	80.8	67.9	56.7	54.0	64.8

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veloped which will yield with the fall types because of the longer growing period available to the latter. Comparative yield data for Fremont and some of the other semi-dwarf spring wheats being introduced into Utah from other areas are limited. However, it appears to be comparable in yield with the better yielding new spring semi-dwarfs (table 2).

Part of Fremont's yield advantage over the taller varieties can be attributed to its shorter stature and, consequently, to its greater resistance to lodging. It normally averages 10-12 inches shorter than varieties such as Lemhi and Baart and 3-4 inches taller than the shortest semi-dwarfs (table 3).

Fremont is moderately resistant to stripe rust.

Table 3. Height and lodging comparisons among tall and semi-dwarf spring wheat varieties (avg of four irrigated nurseries grown in 1970)

Variety	Height (Inches)	Percent lodging
Lemhi	42	9
Thatcher	42	14
Baart	45	38
Moran	41	18
Siete Cerros	31	0
Fremont	33	5
Pitic 62	34	10
Twin	33	3
Maxigene 1651	28	1
Springfield	32	1
Red River 68	32	1
Rogue 66	29	1

BAKING QUALITY

The bulk of our high quality breadwheat has traditionally been grown on drylands where low yields and high protein go hand in hand. Maintaining good breadmaking quality with 100 bushel per acre yields, under irrigation, presents something of a new problem. As yields go up, protein, which is a major quality component, goes down unless nitrogen is supplied in quantities sufficient to meet both the demands of increased grain production and protein accumulation in the grain. If nitrogen is limiting, the latter usually suffers most. Grain protein can be maintained at satisfactory levels under high-yielding irrigated conditions, but it will take a new look at present fertilization practices by many of our growers. To be acceptable as a milling wheat, protein levels must be kept above approximately 12 percent. This can be done under irrigation, but it may require several times the rate of nitrogen fertilization normally applied to dryland wheat.

The quality characteristics for Fremont and several other hard red spring breadwheats are compared in table 4. The dryland winter wheat variety Cache is included as a check, inasmuch as it presently is the predominant wheat variety in Utah and constitutes a significant part of the milling wheat being processed in the state. Two of the most important breadmaking qualities are mixing stability and loaf volume. Fremont and most of the other varieties tested were superior to Cache in these characteristics.

SEED AVAILABILITY

Three seed increase fields of Fremont were grown in northern Utah and southern Idaho in 1970. Approximately 3,000 bushels will be available in the spring of 1971. The seed will be distributed through commercial seedsmen and not by Utah State University.

AG FACTS

Per acre values of farmland and buildings went up 3 percent nationally in the year ended March 1, 1971.

* * *

Sperry Rand notes that the assets of American agriculture equal about half the market value of all U.S. corporations listed on the New York Stock Exchange.

* * *

By the time he is 70, the average American will have used 26 million tons of water, 10,000 pounds of meat, 14 tons of milk and cream, and 9,000 pounds of wheat.

* * *

A dairy cow producing 11,000 pounds of milk a year (about 5,000 quarts) consumes an average of 45 tons of fuel — 8 tons of feed and 37 tons of water. That's 247 pounds a day.

* * *

If every family in the United States owned its own farm, each of us would be living on 27.5 acres and caring for six acres of crops. Most of our acreage would be in pasture, woodland or fallow ground.

Table 4. Breadmaking quality characteristics of Fremont and other hard red spring wheats grown under irrigation at Logan (1969) and at Farmington (1970), Utah

	Test weight (lbs/bu)		Percent protein		Mixing stability (minutes)		Loaf volume	
Variety	1969	1970	1969	1970	1969	1970	1969*	1970**
Thatcher	61.5	59.1	16.0	15.2	2.0	8.1	675	48.50
Fremont	62.7	58.2	15.0	13.7	13.0	11.9	850	49.25
Moran	60.0	59.4	15.7	14.2	9.0	11.4	875	50.00
Red River 68	62.8	62.8	16.0	14.3	10.0	11.7	850	49.50
Maxigene 1651	63.7	60.8	15.4	14.3	9.5	11.8	825	48.75
Peak •	----	60.0	----	13.7	----	14.1	----	49.25
Cache (Dryland)	63.5	60.6	14.4	14.8	3.0	8.4	525	47.00

*The 1969 quality data are from the Ogden Flour Mills. Loaf volumes are in cc's.
**The 1970 quality data are from Pillsbury Mills. Loaf volumes are in inches.

Downy mildew on alfalfa

SHELDON B. WAITE

Downy mildew of alfalfa is epidemic on susceptible varieties of alfalfa in northern Utah during cool, wet springs and early summers. Thirty percent of the leaflets of susceptible varieties of alfalfa have often been observed with downy mildew.

Downy mildew of alfalfa is a widespread disease found in most areas where alfalfa is grown. It has been reported as occurring in Asia, South America, Australia, North America, and Africa. The economic importance of this normally endemic disease increases with cool temperatures and high humidity which favor the spread of the disease.

Peronospora trifoliorum, the fungus which causes the disease, grows into and takes nutrients from leaves of susceptible plants. As a result the upper leaf surface bleaches and becomes pale yellow. The fungus sends branches out of the lower leaf surface on which the sporangiospores, which serve the same function as seeds, are produced. Normally we refer to the sporangiospores as spores. The spores are then carried by wind to other plants.

Sporangiospores were collected from fields of highly infected alfalfa at the Greenville farm near Utah State University at 2-hour intervals of 144 hours. Leaflets covered with fungal growth were detached from the field grown plants and transferred to the laboratory where they were placed in 500-ml beakers containing 300 ml of distilled water and agitated to dislodge the mature sporangiospores. The sporangiospore-containing water was poured into 100-ml beakers and incubated at 15 C. After 30 hours, spore samples were removed with an eye dropper, placed on a slide, and the percentage of germinating spores

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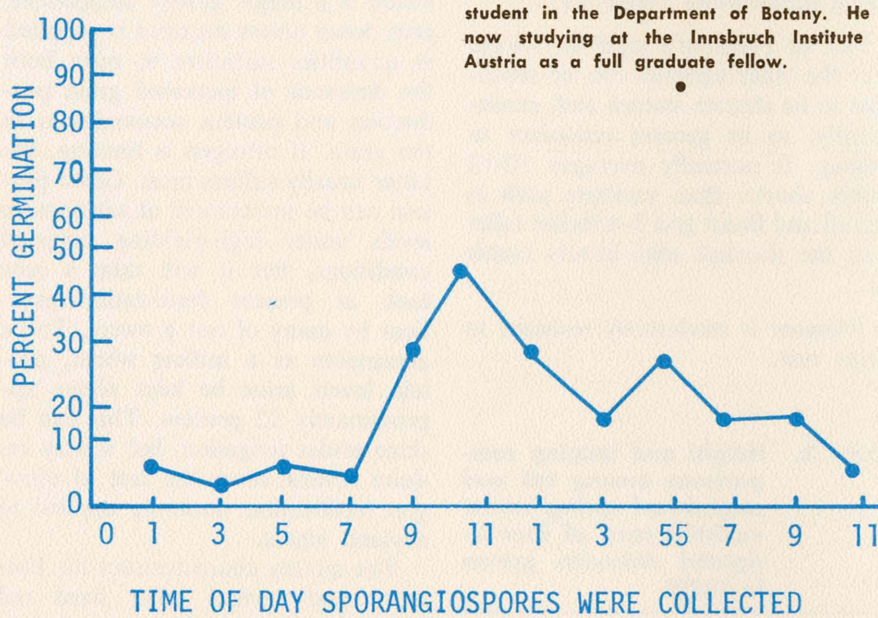

Figure 1. The effect of the time of day to sporangiospore percent germination.

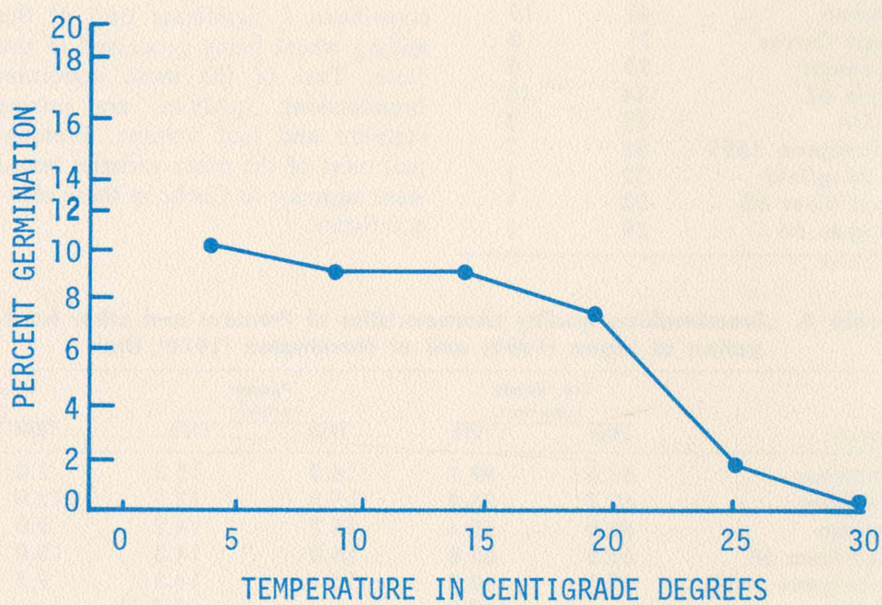

Figure 2. The percent germination of sporangiospores of downy mildew incubated 30 hours at various temperatures.

was counted. The highest percentages of germinating spores were observed from the 11:00 a.m. collections where 51 percent were observed to have germinated. The 9:00 a.m. and 1:00 p.m.-collected spores germinated 33.3 percent and 34.5 percent respectfully for the next highest germination percentages during the 24 hour period. A cycle in spore germination is apparent from the results of this experiment (figure 1).

TEMPERATURE STUDIES

Collected spores were subjected to temperatures ranging from 5 to 30 C at 5 degree increments. At 5 C, 11.7 percent of the sporangiospores germinated, while none germinated at 30 C. This accounts for the decreasing amount of mildew found on the alfalfa leaflets as the field temperatures increase during July and August (figure 2).

The spores used for this study were collected during warmer weather than were those used to study the time-of-day affect on spore germination. This probably accounts for the reduced germination of the spores in the temperature study.

LIGHT EFFECTS

Sporangiospore suspensions were placed in beakers in controlled growth chambers adjusted to 8 hours of darkness and 16 hours of light each day. Duplicate or control suspensions were covered with aluminum foil and also placed in the growth chamber to measure the effect of light on the germinating sporangiospores. The percentages of germinating sporangiospores were about the same for both light and non-light samples. Germ tube growth averaged 159 microns in length for sporangiospores subjected to light while the germ tube length averaged 195 microns for those kept in complete darkness.

Sporangiospore suspensions were placed near a north facing window that allowed 150 foot-candles of natural light to enter the room. Half of the beakers were completely covered with aluminum foil while the other half were exposed. The sporangiospores subjected to natural light averaged 190 microns in length. Light apparently does not decrease germination of sporangiospores but it does inhibit the growth of the germ tube.

Custom farm service: a method for increasing profits on small farms

TERRY PETERSON and ROICE H. ANDERSON

The agricultural industries are seeing a change which may help small farmers compete with those who have larger operations. The new phenomena is the availability of custom services in a package deal. Some firms are supplying services as a bundle and the farmer pays a fixed amount for the bundle of services. The Amalgamated Sugar Company in Cache County, Utah is experimenting with such a bundle of services providing a number of services to farmers who are producing small acreages of sugar beets.

Farm services have been classified into four general areas: product services, credit services, soil services, and management services. The product services include such things as delivery and application of fertilizer, planting, cultivation, blending, and many others. The credit service includes an open line of credit to the farmer, lease arrangements, and prearranged financing.

Soil services usually include soil testing, fertilizer use, usage recommendations, and technical advice. Management service, which is the service area of the future includes the general area of livestock and crop management recommendations, financial and computer management services. Use of these service bundles could enable small-acreage operators to reduce costs by enabling them to forego the purchase of expensive equipment and minimize labor costs.

In 1970 a study was made of the Farm Service Division of Amalgamated Sugar Company in Cache Valley, Utah. The major objective was to learn of the operation of the Farm Service Program and appraise the performance of the services which the company provides. The method of appraisal used was to compare the profitability of small-acreage growers who used the services with larger acreage growers who did not. Five size categories were selected and costs were obtained by personal interview with operators. All farmers in the four smaller categories used the services while those in the largest category did not.

As explained by sugar company officials, the Farm Service Program served two main purposes. (1) To encourage the small-acreage grower to keep sugar beets in his crop rotation. (2) To introduce and demonstrate new cultural practices, equipment, and chemical procedures to all sugar beet producers in the area. It is the ultimate goal of the sugar company to eliminate most of the manual field labor from sugar beet production through mechanizaiton. A new innovation to beet growers is the electronic thinner but before this can be used effectively, the beet field must be qualified through proper seed spacing,

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plant emergence, weed control, and soil conditioning. The Farm Service Program is now demonstrating these field requirements.

The Farm Service has a fleet of tractors, drills, cultivators, and other field tools which are available to beet growers on a per-acre cost basis. Hired men operate the equipment under the diretcion of field supervisors of the company. A grower can use part of all of the services which the program provides. Payment for these services is charged against the farmer's beet crop and deducted from crop proceeds at time of final settlement.

Operations from the initial planting through the cultivating stage of the crop must be performed at the right times to be most effective. Growers serviced by the program are introduced to precision drilling and cultivating where the crop is planted in standard row widths and plant spacing. At time of planting, a guide system is used allowing the cultivation equipment to follow in the guide tracks left by the initial drilling. This allows for effective cultivation and ease of equipment handling.

The Farm Service Program is introducing standardized mechanical and chemical procedures that will simplify beet production. Custom operators, chemical and equipment dealers can be more efficient in providing services to growers when simple farming procedures are used. It is hoped that such standardizaiton will increase yields and result in lower costs of producing sugar beets.

The table below summarizes the average net returns per acre of all farmers in each of the size categories studied.

The 0-10 acre category reaped the highest return per acre while the return on the largest size category was slightly lower. Theoretically, the larger beet growers should have a higher return per acre than smaller growers because of the economies of efficiencies which are realized as acreage increases. The Farm Service Program may be largely responsible for the high return per acre on the small plots. The fact that the smaller farmers received a higher yield also contributes to their higher return.

Small acreage operations usually use family labor to thin and hoe beets and this lowers the cost of their operation and higher yields usually result from the quality of work performed. The custom services of the Farm Service Program allows the small acreage farmer to take advantage of the economies of scale which accrues to larger farmers while retaining the personal attention to their beet crop.

Smaller-acreage farmers avoid the investment in expensive specialized beet machinery and hire the specialized operations on a cheaper, custom rate basis. The cost of using precision equipment is spread over many farms and thus the smaller farmers are able to increase their unit profitability.

Like any other new phenomena the Farm Service Program has experienced some problems and difficulties. The table below points out some problems encountered and the percentage of farmers contacted who experienced the particular problem.

The two greatest problems were timeliness of operation and incompetent and inexperienced operators.

Sixty-eight percent of farmers interviewed agreed that in general the Farm Service Program was a "good thing" and it benefited both farmer and the sugar company. Both farmers and sugar company officials believed that the problems could be remedied as more experience is gained with this type of service.

In the future, many programs such as this may be available to different types of farmers throughout the country. Custom feeding of cattle is being examined as well as specialized services used on fruit farms and truck gardens. These types of services will be used in various agricultural industries where high machinery costs can be spread over larger acreage and mechanization can be substituted for manual labor.

Table 1. Costs and returns of the different size categories of beet enterprises

Size category (number of acres)	Gross returns per acre	Variable cost per acre	Net returns per acre
0-10	284.40	177.04	107.36
11-20	261.00	161.04	99.96
21-30	266.40	176.54	89.44
31-40	268.20	184.01	104.11
Over 40	261.00	154.00	105.00

Table 2. Major problems farmers encountered with the services of the farm service division.

Problem	Percentage of farmers who encountered the problem
Timeliness of operation poor	56%
Incompetent and inexperienced operators	56%
Poor application of services	24%
Machines not functioning properly	4%

ANOTHER LOOK AT _ _ _

Iron chlorosis in Utah

J. C. BROWN

Approximately 30 years ago I was a graduate student at Utah State University and assisted scientists in treating plants for iron chlorosis. The treatments involved adding sulfur and ferrous iron to the soil and spraying the plans wih a ferrous sulfate solution. Our treatments were of a temporary nature and only partially successful. In those days, iron chlorosis was spotty or localized in particular areas of the state.

During the summer of 1971 I traveled from northern to southern Utah, principally via Highway 91, and iron chlorosis was prevalent in practically every city I visited and in many orchards. The number of chlorotic plants in Utah has increased considerably during the past 30 years, which prompted this review of the problem.

A LOOK AT THE PLANTS

Maple, black ash and sycamore are the shade trees most often chlorotic. The degree of iron chlorosis varies with the locality, and occurs in different age trees. It is not uncommon to see a chlorotic tree or shrub surrounded by green plants. Why do these plants differ in their susceptibility to iron chlorosis? Peach trees are more often chlorotic than other fruit trees. Iris, roses, and various shrubs often develop chlorosis as well as some beans, raspberries, grapes and strawberries.

NATURE OF THE PROBLEM

Any soil factor that promotes oxidation of iron from the ferrous to the ferric (Fe^3) form will aggravate iron

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Figure 1. Different degrees of iron chlorosis in shade trees of Utah.

chlorosis. An alkaline soil containing relatively high concentrations of phosphate and bicarbonate ions will tend to maintain iron in the ferric (Fe^{3}) form. Decomposing organic matter in an alkaline soil will increase the carbon dioxide concentration of the soil and increase the bicarbonate concentration in the soil solution. These conditions promote high pH in soils, increase phosphate concentration in the soil solution, and tend to maintain iron in the ferric (Fe^{3}) form. Plants that cannot counteract the alkaline soil factors will develop iron deficiency. The fate of the plant depends on its ability to change iron from the ferric (Fe^{3}) to the ferrous (Fe^{2}) form at the root. Thus, the occurrence of iron chlorosis depends on the kind of soil (acid or alkaline), soil management practices, as well as the plant species or variety grown. Accumulation of excess copper, zinc, nickel, manganese, and phosphate in an alkaline soil may cause iron chlorosis in plants.

IRON CHELATES

About 1950, industry introduced iron chelates for use in agriculture. Leonard and Stewart[1] first used them to correct iron chlorosis in field experiments in Florida. A chelating agent is an organic compound that complexes with or surrounds the iron atom and keeps it water soluble. A number of iron chelates are available locally with instructions on how to use them and the rates to be used for a specific plant species. Most alkaline soils contain sufficient iron for plant growth, but this iron is not always available to the plant. Soluble iron can be increased in the soil by adding an iron chelate to the soil. The ability of plants to absorb iron from an iron chelate depends on the kind and concentration of chelating agent, concentration of iron, and plant species or variety grown. Roots and chelating agents compete for the iron in a soil. Roots that compete most effectively reduce the iron in the iron chelate from the ferric to ferrous form. This reduction decreases the stability of the iron chelate and makes the iron available to the root. Some iron chelates will not release iron to the plant because the plant does not have the ability to reduce ferric iron.

Iron chelates are being used effectively for some crops, but their cost has made their use uneconomical for most field crops. Iron chelates appear as a temporary solution to the iron chlorosis problem. Prospects for a permanent solution have developed in recent years with the suggestion that "plants be selected or developed through plant breeding to fit the soil."

PLANT FACTORS

We now understand many of the factors involved in the uptake of iron by plants. It is an adaptive process that depends on the available iron supply in the soil. If the plant develops iron stress (iron deficiency), the metabolism of the plant changes as follows:

(1) Reduction, ferric to ferrous iron, increases at the root.

(2) Hydrogen ions are released from the root.

(3) A reductant (reduces ferric to ferrous iron) is released from the roots of some plants.

(4) Citrate accumulates in the roots.

The first three factors favor the reduction of ferric iron. Most of the iron is translocated as iron citrate after it enters the root. An increase in activity of these factors increases the ability of the plant to take up and translocate iron. But plants differ in their ability to adapt to iron stress and may be classified either as Fe-efficient or Fe-inefficient plants. An Fe-efficient plant has greater ability to take up iron from an alkaline soil than does an Fe-inefficient plant. This abil-

[1] Leonard, C. D. and I Stewart 1953. An available source of iron for plants.. Proc. Amer. Soc. Hort. Sci. 62:103-109.

Figure 2. Chlorotic trees and shrubs surrounded by green plants showing how plants differ in their susceptibility to iron chlorosis.

Figure 3. Typical iron chlorosis in ornamental shrubs and flowers grown in Utah.

ity to adapt to an iron stress is genetically controlled. Thus, selecting or breeding the plant to fit the soil is a possible solution to the chlorosis problem.

SELECTING OR DEVELOPING PLANTS TO FIT PROBLEM SOILS

Selecting or developing plants to fit particular soils is in accord with the growing public interest in pollution control and soil conservation. Using an iron-efficient plant eliminates the need for additives to make iron in soils available. When we learn why and how plant species or varieties differ in the uptake of an element, we are better equipped to treat other agricultural problems that may develop. We have good reason to avoid indiscriminate addition of metals such as Cu, Zn, Cd, Mn, and Ni, to our soils and know we should not apply phosphate fertilizer to our soils unless it is needed. Nurseries might consider eliminating iron-inefficient plants from their stock as a means of decreasing the incidence of iron chlorosis in the field. Rapid progress will only be made, however, when national, state and local administrators recognize iron chlorosis as a problem and take cooperative steps to establish programs to select or breed new varieties which will retain the desired high yields and quality along with the ability to utilize iron from basic soils.

Figure 4. On the left, iron chlorosis in iron-inefficient (top to bottom) T3238fe tomato, ys_1 corn, and PI-54619-5-1 soybean. On the right, iron-efficient T3238 Fe tomato, Pa 54 corn and Hawkeye soybean did not develop iron chlorosis. A recessive gene controls susceptibility to iron chlorosis in ys_1 corn and PI-54619-5-1 soybean.

Trends and adjustment in American Agriculture, 1950-1970

ROICE H. ANDERSON

The story of agriculture in supplying food and fiber to consumers of the United States is an impressive one. Several measures of output, input, prices and efficiencies are available to tell this story and impress the world with the effectiveness of the capitalistic free enterprise system as it operates in the agricultural segment of our economy. Agriculture, more than any other industry, meets the criteria of the pure competition model of economic structure. Undifferentiated products, many buyers and sellers, and ease of entry characterize this industry.

In fact of increasing inflation, rising wage rates, interest rates, taxes and other costs, consumers in the United States continue to get an increased variety and improved quality of foods for a constantly decreasing percentage of their incomes. Constant at 23 percent of the disposable income from 1929 to 1950, expenditure for food dipped sharply to about 16.5 percent of income in 1970. This overall measure includes both production and marketing aspects of the food story. This paper deals more precisely with changes and adjustments in the production of food and fiber and will be confined largely to changes in the 20-year period, 1950-1970.

Aggregate agricultural production from 1950 to 1970 increased by more than 40 percent, while the composite of all resources used in that production increased by only about 10 percent. The overall efficiency of agricultural production as measured by output per unit of input increased by about 25 percent in this 20-year period. The increase in output per man

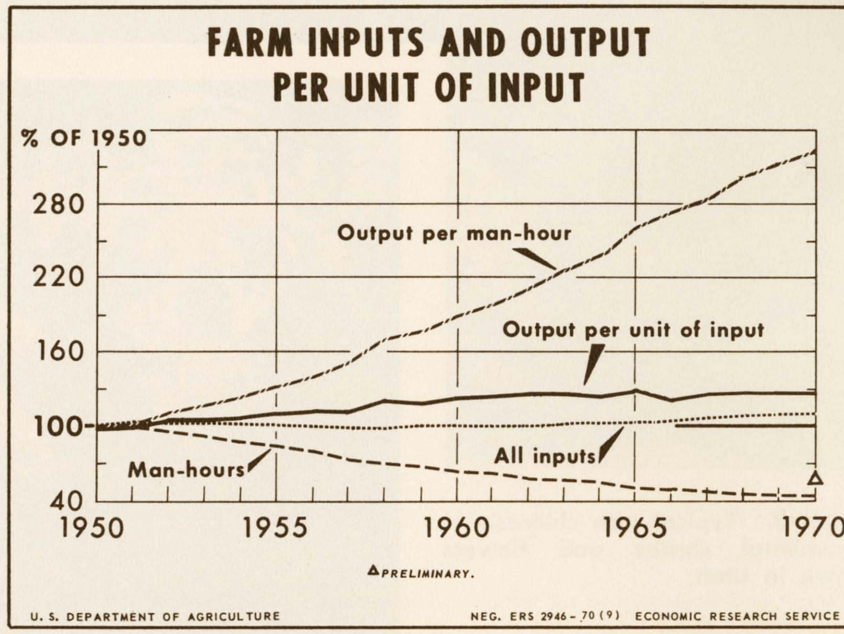

Figure 1. Man hours used, total inputs, and farm output per unit of input and per man hour, 1950-1970.

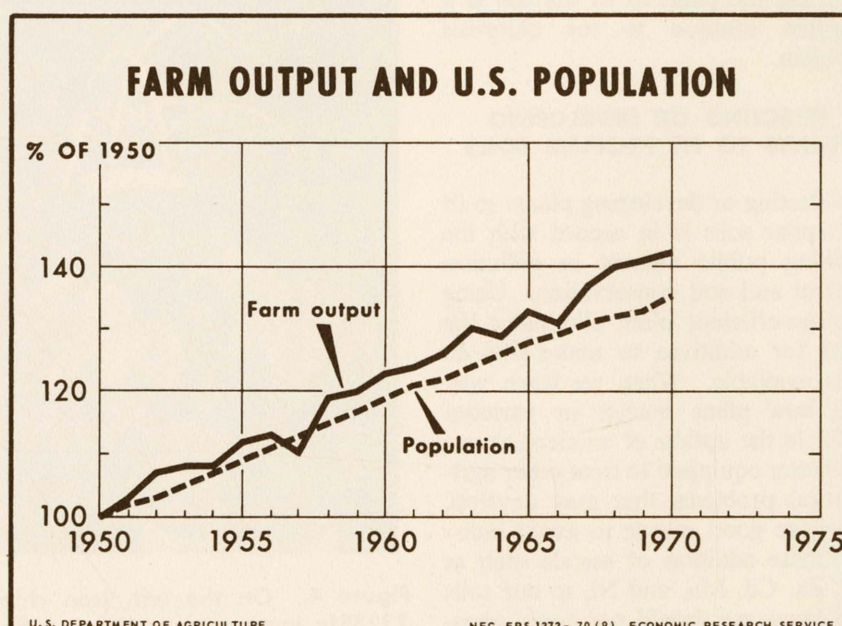

Figure 2. Crop and livestock production and U.S. population, 1950-1970.

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hour was particularly striking (figure 1). The increase in output exceeded population growth in the country during the period resulting in an increasing per capita supply of food and fiber available (figure 2).

Time was when most of the items used in agricultural production were produced on the farm. Labor was supplied by the operator and his family, horsepower was raised on the farm and supported from feed grown on the farm and soil fertility was maintained by wastes from livestock enterprises. Diversification of enterprises was recommended to provide a perpetual system of inputs and outputs. Such farming practices also supplied a rather wide line of products for consumption by farm families, providing a high degree of self-sufficiency. The proportion of production entering the market channels was small indeed and the proportion of population living on farms was very high.

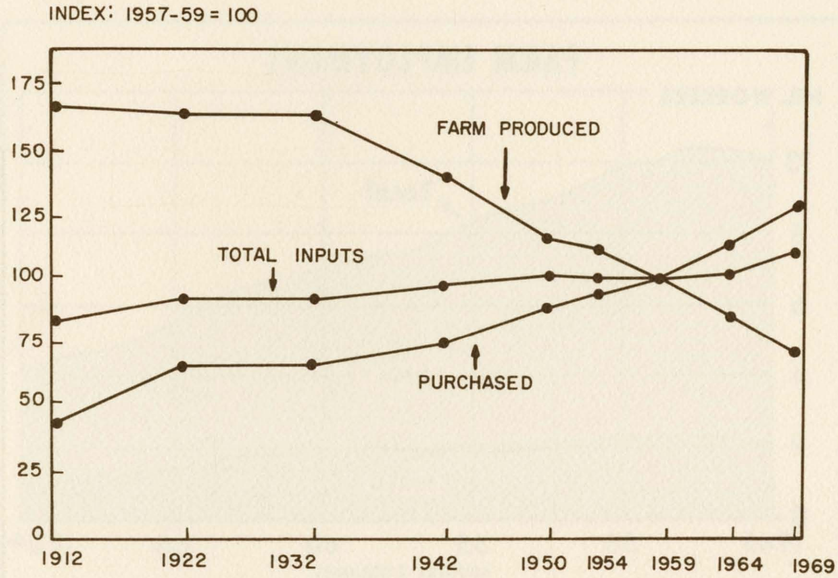

Figure 3. Trends in use of total, purchased, and farm-produced inputs in U.S. agricultural production 1912-1969.

Table 1. Trends in use of selected farm inputs in U.S. agricultural production 1950 — 1969 (1950 = 100)

Year	Labor	Farm real estate	Mechanical power and machinery	Fertilizer and liming materials	All other inputs
1950	100	100	100	100	100
1951	101	101	107	107	106
1952	96	102	112	118	106
1953	92	102	113	122	107
1954	88	103	114	129	109
1955	85	103	115	132	113
1956	80	102	115	134	119
1957	73	103	116	138	118
1958	70	103	115	143	125
1959	68	103	117	160	131
1960	65	104	121	163	134
1961	62	104	117	172	138
1962	59	106	116	184	143
1963	57	107	121	207	148
1964	54	109	119	228	152
1965	51	109	122	238	153
1966	49	110	128	268	160
1967	48	111	130	299	165
1968	46	110	130	315	169
1969	46	110	133	319	174

INPUT ITEMS CHANGE

Today, off-farm sources of power, commercial fertilizers, specialized machines, improved varieties of crops and breeds of livestock have drastically changed the combinations of the input items used in farm production. Outputs, from individual farms, have also changed to specialized rather than diversified products. Using 1957-1959 as a base, the index of total resource inputs used in agriculture increased from 85 in 1912 to 112 in 1969 or only 27 points. During this same period, the off-farm or purchased ingredients increased from 47 to 133, 86 points, while the farm-produced inputs declined from 167 to 75 or 92 points (figure 3). In this process of substitution of purchased for farm-produced items, there have been marked changes in the mix of ingredients used in production. Changes in prices of the ingredients and techniques of production have been largely responsible.

In the last 20 years, mechanical power and other inputs have been substituted for human labor in the mix of resources used in production. From an index of 100 in 1950, labor declined to 46 in 1969, while use of mechanical power and machinery increased to 133 and all other inputs increased to an index of 174 (table 1). Use of commercial fertilizer and liming materials increased from an index of 100 in 1950 to 319 in 1969.

The relative decline in farm employment has been similar for both hired and family workers for the entire 20-year period although reduction in use of hired labor has been particularly rapid in the 10-year period since 1960 (figure 4). Total farm employment declined from about 10 million workers in 1950 to about 4.2 million in 1970. Hired workers account for about one-fifth and family about four-fifths of the labor force.

Prices of the input factors since 1950 gives the clue to the changing mix of ingredients used in the production recipe (table 2). Farm wage rates increased from an index of 100 in 1950 to 235 in 1969. Prices of commercial fertilizer were at exactly the same level in 1969 as they were in 1950. By 1969, prices of farm machinery and farm real estate reached an index of 183 and 275 respectively. Agricultural real estate in the aggregate is rather fixed in quantity and is usually fully utilized. It seems logical that real estate values result from the capitalizing of net income from farming and as such are a result rather than a cause of profits. It should be recognized, however, that power to produce income is not the only factor determining real estate values.

ECONOMIC SQUEEZE

The jaws of the economic pliers are tightening the squeeze on farm profits. Profits per unit of agricultural production are dwindling because the farm operator is caught between low product prices resulting from large per capita supply and consumer demand for food which is relatively unresponsive to increases in income. Individual farmers are faced with product prices and input costs largely beyond their control. Only by adopting new technology, increasing the scale of operations, and adjusting combination of resources used in production as relative prices change can farmers continue to survive.

A research project is in process at Utah State University in cooperation with other western and mid-western states to study markets of cost factors as a method of increasing returns to farmers. The growing importance of off-farm items used in agricultural production suggests the need for such investigation. Two possibilities are being studied: (1) The market structure, conduct, and performance of major input factors and, (2) methods available to producers to make greater potential use of production resources that will reduce unit costs of production.

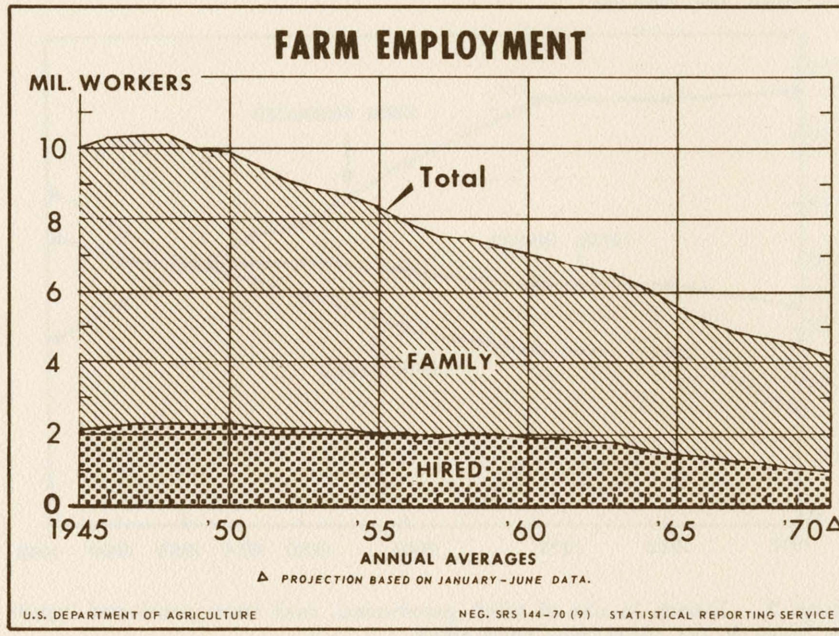

Figure 4. Farm employment, 1945-1970.

Table 2. Prices of selected farm inputs used in U.S. agricultural production 1950 — 1969 (1950 = 100)

Year	Farm wage rates	Farm machinery	Fertilizer	Farm real estate
1950	100	100	100	100
1951	111	108	106	115
1952	118	111	108	126
1953	121	112	109	128
1954	120	113	110	126
1955	121	113	108	131
1956	126	118	106	137
1957	131	123	106	146
1958	135	129	106	152
1959	144	134	106	163
1960	148	138	106	171
1961	151	141	107	172
1962	155	144	106	182
1963	159	146	106	189
1964	163	149	105	202
1965	171	154	106	214
1966	185	160	106	231
1967	199	167	106	246
1968	216	175	103	262
1969	235	183	100	275

TO FIND A VIRUS---

LOIS M. COX

Everybody knows that a virus is easy to catch when you don't want it. Consider, for example, the common cold or some of the more persistent forms of flu. For virologists, however, this method is too haphazard. These scientists want to be able to determine the presence or absence of viruses *before* they produce symptoms in innocent bystanders.

The small size of the average virus (a single polio virus, magnified 1 million times, would be only 3/4 inch in diameter) makes this quite a challenge. But the apparently ubiquitous nature of these disease-inducers makes the effort worthwhile.

The USU Man and Environment program recently funded research that should produce a way to detect small numbers of viruses in air. The project, proposed by W. R. Thornley and John Perez, builds upon previous work by Perez and Rex S. Spendlove. The earlier efforts developed a technique that can detect as few as 10^4 viruses in 6 hours. All other available techniques are too insensitive or require days and then indicate only infective virus particles.

The Perez/Spendlove method indicates infective *and* noninfective virus, thus giving a more accurate measure of existing conditions. Their process depends upon an animal's well-documented habit of forming antibodies when invaded by protein containing organisms such as bacteria or viruses. Each foreign protein generates a very specific antibody. So, to detect whether a particular virus is present in a sample of some material, the USU scientists isolate the proteins that contain antibodies from the blood of a goat that has been injected with the virus. They then attach radioactive iodine to one in ten of the antibody-containing proteins. The labeled proteins are mixed with the sample to be tested. If the particular virus is present, it will unite with its antibodies, some of which will be radioactively labeled.

By running such material through a centrifugation process that separates virus from non-virus material, it becomes obvious whether the virus in question is present. If the viral zone is occupied, the actual amount of virus can be estimated by counting radioactive particles.

The research funded by the Man and Environment program will apply this basic process to air samples. Initially, Perez and Thornley will be testing for the virus known to cause respiratory problems in cattle. Their techniques should not only indicate whether this virus *is* actually transmitted through the air, but also how *far* it is likely to travel if it does become airborne. This sort of information could provide insights into ways to more effectively ventilate buildings.

The researchers also expect to develop a practical way of determining the size of the infectious particles. Since an animal's respiratory apparatus is especially vulnerable to *small* particles, size is a factor in the relative efficiency of some disease-causing viruses.

Eventually, the USU-developed detection techniques may be extended to testing excised tumors for possible causative agents. They could also have application to water and soil samples.

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Plants and drougth stress

Whether a plant grows, "holds steady" or dies, depends upon how it reacts with its external environment. And these reactions can be as complicated as those motivating a 3-year old to suddenly hate wearing shoes.

Two Utah State University botanists, Herman H. Wiebe and Ronald E. Sosebee, recently clarified a little more of the plant/environment picture. They used crested wheatgrass, an important range grass, and cultivated barley to measure the relative effects of drought and grazing on food movement within individual plants.

When plants photosynthesize, they produce mostly carbohydrates. These products are then either converted into structural components, used in shoot (leaf) and root growth, or are stored as reserves. By applying a few drops of radioactive phosphorous to a photosynthesizing leaf, the USU scientists could "track" the translocation of the carbohydrates that were produced.

Clipping (or grazing) encouraged the conversion of carbohydrates into "new" leaves. This pattern predominated even if the plants were under drought conditions.

By contrast, plants that weren't clipped, translocated most of their carbohydrates toward storage areas such as roots when they were under dry conditions. But under wet conditions the non-clipped plants put most of their food energy into new growth.

The USU work indicates that these grasses tend to react quite sensibly with their environment. When confronted with summer drought, a plant did not waste energy producing new shoots, but instead accumulated reserves that could be used when the

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DROUGHT STRESS

(Continued from page 107)

drought broke in the fall. Adequate water plus a loss of foliage promoted less storage and more growth. Deficient water *plus* a loss of foliage, in effect forced the plant to divide its limited resources between storage and growth, and left it vulnerable to any increased or new stress.

The results help us understand why overgrazing is more harmful under drought conditions. They also explain why home lawns that are too closely mowed also require more frequent irrigations.

WILDLIFE NOTES

The Arctic tern is the champion of migrators, nesting in the Arctic and spending its summers near Antarctica.

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The colorful male shoveller sports a green head, chestnut flanks and a black rump, with all three parts distinctly separated by a glistening white border.

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The snowshoe hare changes the color of its fur by shedding the old coat and growing a new one each spring and fall.

AG FACTS

Even with the use of modern pesticides, the average annual loss of crop and livestock production in the U.S. caused by major pests is 33 percent of the potential or over $14 billion each year. Without pesticides, total crop and livestock production would be cut another 30 percent.

* * *

The average person on a U.S. farm had 78.2 percent as much personal income after taxes as the average nonfarm person in 1970. This compares with 77.3 percent in 1969 and 74.5 percent in 1968.

* * *

Modern technology in haymaking has passed by pitchforks and haystacks. In fact, today it might be easier to find a needle in a haystack than finding a haystack itself.

* * *

Farmers only received about 67 percent of United States Department of Agriculture appropriations in 1970. Out of $12.5 billion spent by the government under the heading of "agriculture" that year, only $8.3 billion directly benefited farmers by supporting farm income.

* * *

Hay hasn't always been only a livestock feed. During the Revolutionary War, colonials built a sturdy fort from 700 pound hay bales in one night. Come morning, British troops were amazed to see the imposing structure and abandoned their planned attack on the heights of Dorchester near Boston.

Figure 3. Deep snows in the Uintas force the moose out of higher elevations and concentrate them in the willow covered stream bottoms.