ONE HUNDRED YEARS OF QUAIL MANAGEMENT IN ARIZONA

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ABSTRACT

Populations of Gambel's (*Callipepla gambelii*), scaled (*C. squamata*), and Montezuma (*Cyrtornyx montezumae*) quail in Arizona have fluctuated greatly in the 100 years since statehood as have regulations governing their take. The greatest fluctuations in numbers have been annual, but there is some evidence for a long-term decline in the numbers of all species. Quail hunt success has declined significantly since 1962 according to both check station information ($r^2 = 0.27$; $P<0.0001$) and hunt questionnaire data ($r^2 = 0.35$; $P<0.001$). Past attempts to improve or stabilize quail populations through bag limit and season adjustments have failed to impact quail numbers. Research investigating the influence of harvest on quail numbers showed that subsequent year population sizes fluctuated independent of harvest and that hunting had little effect on population size. Thus, season lengths increased over the years with late winter hunting opportunities becoming increasingly popular after 1979. Studies comparing hunted and non-hunted areas have not been conducted since late season hunting was initiated, and are needed to convince the public that quail populations in areas closed to late season hunting remain similar to those in areas open to late season hunting. Habitat conditions have also changed, deteriorating generally but improving on certain federal lands. Quail management efforts to improve hunt success by providing rainwater catchments and other habitat manipulations have not been effective at increasing population size, and water developments for livestock have resulted in long-term range deterioration. Decreasing population sizes and quail hunt success during the last 50 years, if due to environmental changes, cannot be addressed by regulation changes.

Citation: Brown, D. E. 2012. One hundred years of quail management in Arizona. Proceedings of the National Quail Symposium 7:9–20.

Key words: Arizona, *Callipepla gambelii*, *C. squamata*, common raven, *Corvus corax*, *Cyrtonyx montezumae*, Gambel's quail, hunt history, hunt success, Montezuma quail, population trend, scaled quail

INTRODUCTION

Quail hunting was an important sport in Arizona Territory along with taking quail for subsistence and commercial purposes. The sport involved in taking Arizona's quail was recognized as early as January 1864, when mining engineer J. Ross Browne wrote:

> "*Quail were very abundant as we drew near our first camping place on the Gila. I killed about two dozen on the wing; that is to say that I was on the wing myself when I shot, but the quail were on the ground...*"
> J. Ross Browne, 1869:76

The arrival of the railroads in Arizona in the 1880s opened markets on the Pacific Coast, and the commercial hunting of quail and doves became conspicuous, if not pervasive. Fearing their sport might be in jeopardy, sportsman's organizations such as the Tucson Gun Club prevailed on the territorial legislature to amend the game code in 1893 to extend the sport hunting of quail and other small game through March, and to outlaw the sale and shipping of wildlife during the closed season (Brown 1989).

Gambel's quail appear to have generally persisted in good numbers despite the droughts and landscape changes attendant with, and succeeding, the turn of the 20th century. This was due to the species' natural adaptability to shrub-dominated habitats rather than grassland and the expansion of grain cultivation after 1900 (Brown 1989). Some chroniclers such as Herbert Brown (1900) and Will Barnes (*in* Gorsuch 1934) described Gambel's quail populations as being larger prior to the droughts of the 1890s than later. The evidence is clear, however, that the more grassland-oriented species—scaled quail and Massena (Montezuma, locally known as fool or Mearns') quail declined in both distribution and abundance. Another grass-forb obligate quail, the masked bobwhite (*Colinus virginianus ridgwayi*) was extirpated from the state by 1900 (Brown 1904).

There was still good quail hunting to be had in Arizona after 1900 in spite of game laws often being ignored. An abundance of river bottom vegetation and wheat farming gave Arizona a reputation for quail hunting par excellence (O'Connor 1939). It was also recognized at an early date that Gambel's quail hatching success and population size was influenced by the amount of rainfall during the previous winter (Brown 2009). As today, quail hunting had its ups and downs, and some banner years were reported:

> *Yesterday was the opening day of the quail season, and many local nimrods tried their luck with the gun. The little brown birds at one time bid fair to be an unknown quantity in Arizona, but of late years a wise law for his protection has been in operation and his call can now be heard on all the hills and in all the valleys. At one time trappers captured the quail by the thousands and shipped them by the car load to the markets of*

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California. The sportsmen became alarmed at the rapid extermination and the legislature did the rest. Quail are now plentiful all over the country. *Arizona Daily Star*, 16 October 1903

MANAGEMENT

The advent of cities and commerce meant that sport hunting had come to stay and, in 1905, the sale of game was outlawed entirely. The legislature in 1909 limited quail hunting to an open season of 16 October through 31 January, and this season remained in effect in the first state game code passed in 1912 along with a bag limit of 25 quail.

Little information is available on the vagaries of quail hunting between 1913 and passage of a 'new game code' in 1929. Quail management consisted primarily of trapping and transplanting quail to uninhabited or depleted areas, passing an Initiative in 1916 to close the season on 31 December and lower the daily bag limit to 20 'Gambel or Valley Quail,' and establish refuges closed to hunting (Brown 2012). Quail numbers must have been thought in need of improvement in 1929, as the season was again shortened, this time to 1 November through 31 December and the following year the newly appointed Arizona Game and Fish Commission reduced the bag limit to 15 quail per day. No season on Massena (Mearns') quail was authorized.

The conventional wisdom for game restoration in the 1920s called for strictly enforced closed seasons, additional refuges closed to hunting, and vigorous predator control. Quail and other small game species were subject to the same prescriptions as big game except restocking with pen-reared and exotic game birds was much in vogue. These concepts were later found to be simplistic, if not outright erroneous, but this thinking would dominate quail management in the Southwest for 30 years. More than 60 game refuges had been established by the 1930s—several specifically for species of quail (Fig. 1).

Probably the most significant management action in the 1930s was publication of Gorsuch's (1934) life-history study and conclusion that Gambel's quail could best be increased by preserving and rehabilitating their habitat—primarily through elimination of overgrazing. Gorsuch also recommended controlling the quail's natural enemies, better sportsmanship by hunters, the enforcement of reasonable game laws, and continued study by qualified biologists. It was not until 1939, however, when Arizona agreed to participate in the Pittman-Robertson Act that these recommendations could be implemented.

The first efforts to manage Arizona's premier game bird were for deputy wardens and Federal Aid biologists to make summer brood counts to appraise the commission of the year's quail hunt expectations, and to trap quail from farming areas where depredation complaints had been received. Quail hunt regulations fluctuated with the vagaries of supposed population levels: the bag limit was reduced from 15 to 10 in 1934, increased to 12 in 1937, and reduced to 10 again in 1939.

Arizona's first Federal Aid quail study focused on Cochise County, where the objective was to develop a satisfactory management plan and hunt regulations for Gambel's and scaled quail (Griner 1940b). Probably because of Gorsuch's influences, overgrazing and depredations by kangaroo rats (*Dipodomys* spp.) and ants were considered the most deleterious influences in need of investigation (Griner 1940e). Small 'inviolate' refuges near water sources were established, and it was recommended the county be divided into 4 management units, one to be closed to hunting each year on a rotating basis. The reasoning behind this recommendation, which was not implemented, was to reduce hunt pressure on the same coveys year after year.

Other quail investigations in 1940 concentrated on visiting well-known quail locales, reporting on quail conditions, and making recommendations for refuges and water developments (Griner 1940c, d, e; Kimball 1940a, b, c; Lawson 1940a, b). Drought, overgrazing, and overhunting were considered the primary factors limiting quail numbers, although Griner (1940b) recognized the value of green growth to reproductive success—a phenomenon he attributed to the production of Vitamin B-1. Other quail related activities consisted mostly of responding to requests to trap and disperse quail feeding on crops in the Safford, lower Gila River Valley, and Yuma areas (Griner 1940a, Lawson 1940c).

The winter of 1940–41 was abnormally wet, and much needed. The hunt recommendation was conservative despite an excellent hatch, and only a 15-day season was authorized. Kimball (1941a, b, c) thought that drought and heavy grazing had taken too great a toll of the breeding stock during the previous years. The planned implementation of deferred grazing systems, then being promoted by range conservationists, was also thought to be potentially ruinous to quail as all pastures would be grazed 3 years out of 4. A series of small enclosures were recommended as quail refugia to compensate for an increase in grazing duration

The winter of 1941–42 was not so generous. Summer surveys showed a decline in young to adult ratio, even though the successful hatch of 1941 had boosted the number of quail seen on surveys to a new high (Fig. 2). Kimball (1942b, c) unsuccessfully recommended shortening the month-long November season that had already been approved by the commission because of low recruitment.

The most substantial accomplishment in quail management in the early 1940s was the acquisition by the Arizona Game and Fish Department of tax delinquent lands along the lower Gila River for quail habitat. Similar plans for a management complex near Tucson were thwarted when the land was acquired for Davis-Monthan Air Force Base. One important achievement was the first mailing of a small-game hunt questionnaire to monitor the importance of quail to the state's license purchasers—an effort that with modifications would be implemented in the early 1960s (Brown 2012).

The summer surveys in 1943 indicated a disastrous hatch and an extremely low quail population (Fig. 2), and it was reasoned the high harvest enjoyed in 1942 had been

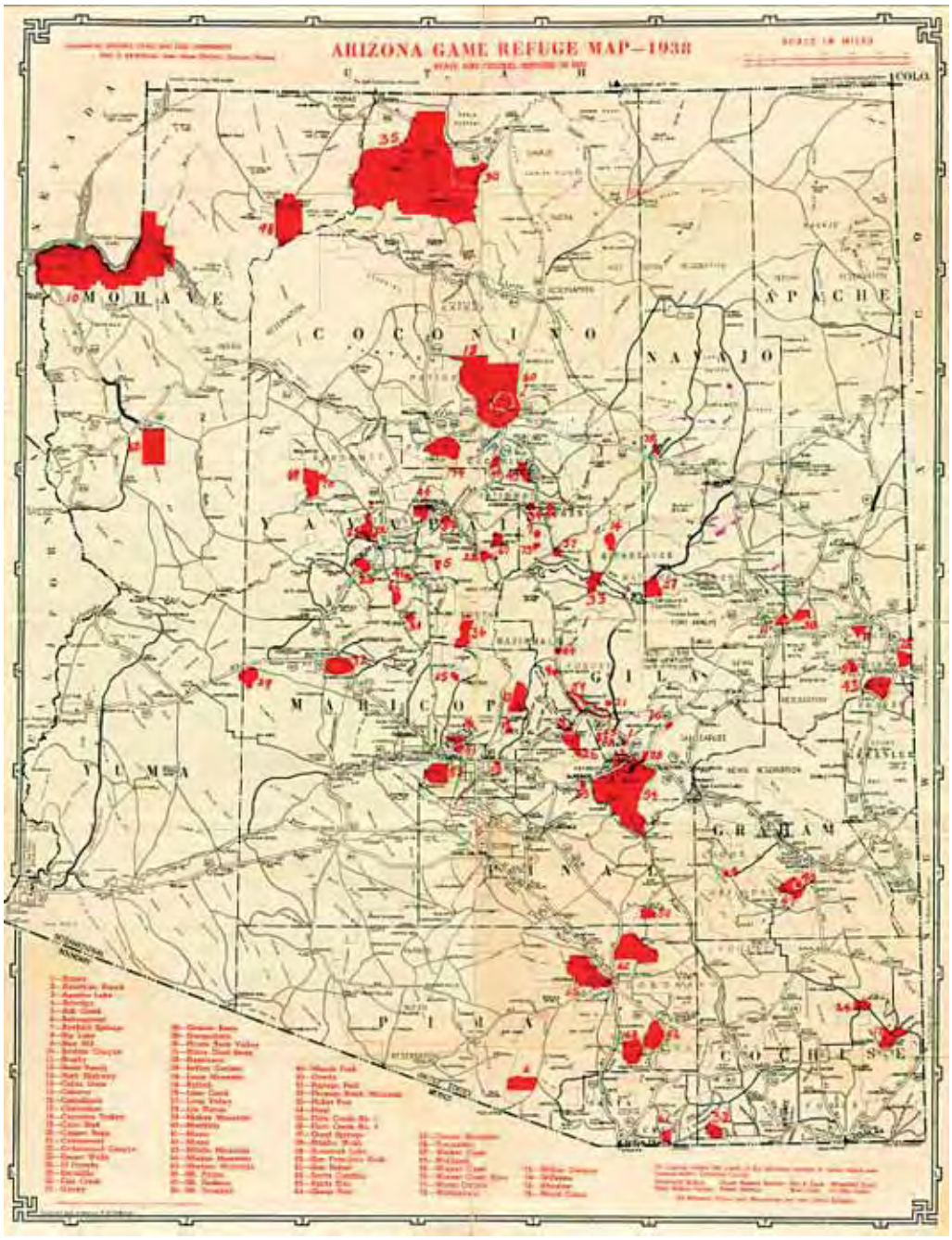

Fig. 1. Arizona State Game Refuges in 1938.

a debilitating factor. That the percentage of young in the 1942 check station bags was considerably lower than observed on July surveys was additional cause for concern. Much of the annual crop had been lost before the season began, and there was a fear the hunt had reduced brood-stock needed for the coming year. The length of the 1943 season was halved to 15 days.

Low quail numbers persisted through the mid-1940s. Some quail restoration plots in Cochise County showed improvement in range conditions, but little if any increase in quail numbers was discernable (Kimball 1942a; Eicher 1943, 1944). Quail management focused on expanding and standardizing summer brood counts, trapping and transplanting excess birds from agricultural areas (e.g., Arrington 1942, Kimball 1943), and implementing conservative hunt regulations. Water developments were given new impetus by Glading's (1943) 'gallinaceous guzzlers' in California, and water catchments specifically constructed to benefit quail were constructed in the Superstition Mountains, Paradise Valley, and other quail hunt areas (Fig. 3, Kimball 1946a).

Midsummer quail surveys in 1945 showed another year of poor quail production, and some populations were deemed the lowest in recorded history (Kimball 1946b).

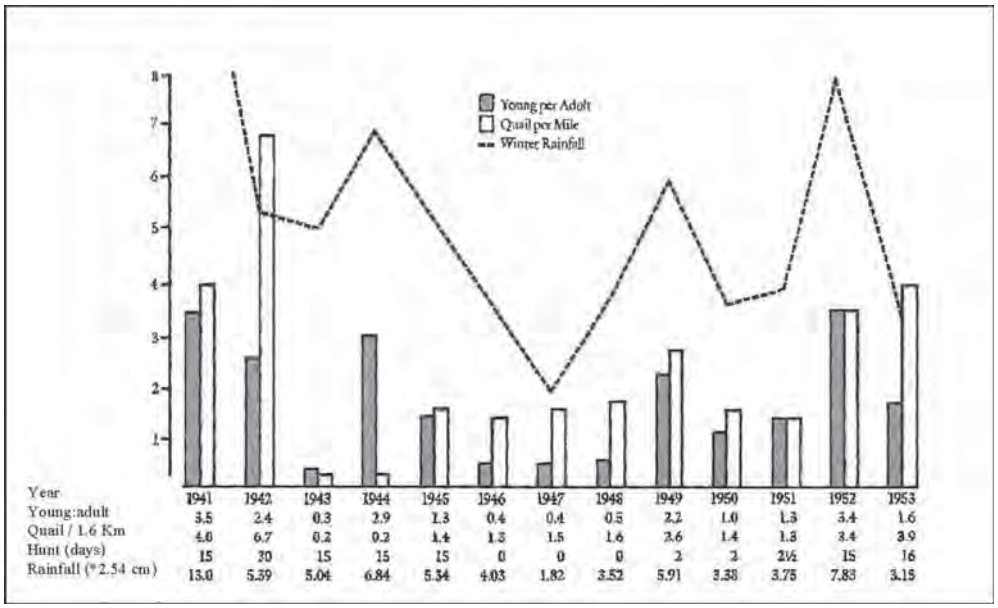

Fig. 2. Standardized Gambel's quail survey and rainfall information in Arizona, 1941–53.

Even the Yuma area, the perennial source of crop depredation complaints and the source for quail stocking attempts, showed a marked decline. Hunting was thought to be additive to natural mortality, and Kimball (1946a) calculated that a ratio of 2.1 young to one adult was needed to justify a hunt. This number was based on Emlen and Glading's (1945) mean annual monthly mortality rate for California quail (*Callipepla californica*), and on past survey and check station data for Gambel's quail in Arizona. Summers having ratios of young to adults above 2.1:1 (1940, 1941, 1944) had been followed by fair to good quail seasons; those years when the young-to-adult ratio was $<$ 2.1:1 were succeeded by poor or decreased hunt success. The statewide young-to-adult ratio observed in 1945 was 0.4:1; there would be no quail season in 1946, 1947, and 1948 (Fig. 2, Table 1; Brown 1989).

A 7-year drought broke in January 1949. Summer quail counts that year showed a statewide young-to-adult ratio of 2.16:1, and a 2-day season was authorized in 2 areas of southwest and east-central Arizona where ratios exceeded the 2.1 minimum (Lawson 1949). The bag and possession limit was 5 quail. The return to quail hunting was short-lived, however. Midsummer surveys in 1950 showed a Gambel's quail young-to-adult ratio of only 1.04:1 and the number of quail seen per 1.6 km of survey reached a new low.

Another miserable quail year followed in 1951, but Kimball's 2.1 young-to-adult criterion was now being scrutinized more closely. Gallizioli (1951a), on the basis of past survey and hunt data, questioned the rationale for closing the season in poor years. Most of the variation in quail hunt success appeared solely due to reproductive performance, population levels showed little relationship to previous hunt regulations and harvests. Sportsmen were also questioning the validity of brood counts, contending the surveys missed counting many young of the year. Additional surveys were conducted at their request, and substantial increases in young quail were noted on many of the routes. Short, local hunts of 2 ½ days each were then authorized in several areas. Survey route procedures were revised and the number of routes expanded (Gallizioli 1951a). Most importantly, a research study was instituted to examine the actual effects of hunting on quail populations (Gallizioli 1951b, 1952, 1953, 1954; Webb 1953).

QUAIL RESEARCH AND MANAGEMENT

Quail were abundant in 1952. Statewide young-to-adult ratios increased from 1:3.1 in 1951 to 3.4:1 – within 0.1 of the 1941 high. A 1–14 December season was approved with a bag limit of 8 quail. The data generated from this and the 1951 hunt, coupled with preliminary research findings, showed how overly conservative past hunt recommendations had been. Swank and Gallizioli (1953, 1954) were now able to show quail populations were heavily dependent on winter precipitation and the success of the hatch. Hunting had little if any effect. The 2-week hunt in late fall with an 8-bird bag limit was continued (with local exceptions). Previous management practices were questioned and either eliminated or modified. Trapping and transplanting practically ceased, refuges were abolished, and the value of water catchments was investigated.

Summer survey routes were modified in 1956, and a test made of a new call-count survey technique pioneered by Senteny (1957) and Gallizioli (1957a). A November-December season was recommended in 1957 as banding studies had shown that no more than 25% of the population would be removed by hunting, the percentage of quail removed was proportional to the density of birds,

Fig. 3. Tom Kimball showing one of the first quail water catchments in the Superstition Mountains, Arizona, ~ 1946. The apron of this 'gallinaceous guzzler" is of asphalt and the water capacity of the catchment is limited to a few hundred liters.

and that hunting mortality was compensatory to natural mortality (Gallizioli 1957b).

Banding studies by Griner et al. (1941) and Swank and Gallizioli (1953) had shown a high loss of young quail between the midsummer brood count and late fall hunting seasons; thus a split 40-day season from mid-to late October and from mid-December through early January was adopted in 1958 to harvest those juveniles 'that were going to die anyway'. The daily bag limit was increased to 10. Management efforts now concentrated on improving survey techniques, developing an annual statewide harvest estimate, and establishing a standardized season.

Harvest questionnaires were providing reliable hunt success estimates by 1965 on a statewide basis and a split quail season during the month of October and from 1 December through the end of January was in effect. The closed season during the month of November was to allow cattle growers to conduct round-ups without interference. A 15-bird bag-limit was established as the norm. A major change in survey procedures occurred in 1962 when call-count surveys proved able to predict fall population levels as measured by hunt success with 97% accuracy (Kufeld 1962, 1964, 1965; Smith and Gallizioli 1965; Fig. 4).

November was included in the quail season in 1971 without objection from stockmen and, in 1979, the season was extended to mid-February to coincide with closing of the increasingly popular Montezuma quail season. A standard small-game season opening on the second Friday in October was adopted that year, and this generous season of ~125 days remained in effect to the present time.

MANAGEMENT PRACTICES

Water Development

The practical aspects of water developments on quail populations were resolved by a Department study in the Paradise Valley-Pinnacle Peak area north of Phoenix that began in 1958 and concluded in 1962. Nine rainwater catchments were sealed from use in the study area from January 1961 through the end of the 1962 quail season, effectively drying up 81,000 ha of quail habitat with the exception of one intermittent stock tank. Despite the fact that 1961 was a drier than average year, quail call-counts and hunt success during the 1961 and 1962 seasons was slightly higher in the study area than in the adjacent control area where several rainwater catchments supplied quail with water throughout the spring and summer. It thus appeared water developments served to concentrate birds within certain portions of a covey's range but had little effect on quail numbers and overall distribution (Gallizioli 1961, 1965).

Effects of Grazing

Gorsuch (1934), Griner et al. (1941), Kimball (1946a), and others considered heavy grazing to have a deleterious effect on Gambel's quail. They reasoned the resulting reduction in forage and ground cover contributed to an increased mortality of adults and chicks and was an important cause of low quail numbers. These early suppositions were somewhat discredited by the knowledge that Gambel's quail numbers fluctuated as markedly on grazed ranges as on ungrazed allotments, but the influence of livestock grazing on population carryover remained a concern.

Two similar areas were compared in an attempt to obtain some insights into the impact of grazing on Gambel's quail populations: the Three-Bar Wildlife Area and a Tonto Basin study area. The former area had not been grazed since ~1944 whereas Tonto Basin was heavily grazed. Both areas were good quail habitat, about the same size, and possessed precipitation stations. Call-count and hunter collection data showed no significant differences in the percentage of young quail in the bag between the 2 areas for the 5 years from 1977 through 1981, even though the call-count index was higher on the non-grazed Three-Bar in all years but one, and hunt success was greater on the Three-Bar (Brown 1989). Hunters averaged almost a bird more per day on the Three-Bar than on Tonto Basin despite the same hatching success in both areas. It could be argued that quail hold better when more ground cover is present, and are thus more susceptible to the gun, but the fact that the call-count index was higher on the non-grazed area 4 of 5 years suggests population carryover was also usually greater on the Three-Bar than in Tonto Basin.

Virtually no field studies of Gambel's quail have been done since 1981, the species of concern having switched to Montezuma quail and, to a lesser extent, scaled quail, both of which were shown to be impacted by livestock grazing and plant succession.

Table 1. Quail hunt information from statewide hunt questionnaires and Oracle Junction check station, 1940–2010.

Year	No. Quail Harvested	Quail/trip	Quail @ check sta.	Quail/trip check sta.	Year	No. Quail harvested	Quail/trip	Quail @ check sta.	Quail/trip check sta.
1940			3,858	6.7	1976	1,233,308	3.2	1,574	2.1
1941			6,794	5.9	1977	872,471	2.8	782	2.0
1942			8,497	5.0	1978	1,580,309	4.2	2,590	4.4
1943			1,529	3.9	1979	2,903,804	5.0	6,021	6.7
1944			no check sta.		1980	1,987,103	4.5	3,756	5.8
1945			no check sta.		1981	1,317,406	3.1	1,518	3.4
1946			no hunt	no hunt	1982	1,303,570	3.4	2,141	3.5
1947			no hunt	no hunt	1983	1,459,580	3.6	1,894	3.3
1948			no hunt	no hunt	1984	1,181,450	3.1	1,133	2.3
1949			no hunt	no hunt	1985	1,357,998	3.2	921	2.1
1950			no hunt	no hunt	1986	1,540,736	3.5	372	2.0
1951			3,234	2.0	1987	996,517	2.9	822	2.4
1952			4,303	3.9	1988	707,252	2.7	348	1.2
1953			4,997	3.3	1989	443,111	2.0	139	0.6
1954			6,658	3.3	1990	342,952	1.6	278	1.1
1955			3,365	2.5	1991	728,038	2.9	1,084	3.5
1956			1,407	1.7	1992	1,121,746	3.5	1,802	3.3
1957			1,767	2.0	1993	1,463,669	3.4	1,556	3.4
1958				2.6	1994	1,031,285	2.7	1,511	2.9
1959			3,567	2.5	1995	1,389,639	3.1	1,394	2.6
1960			10,395	5.9	1996	833,780	2.1	474	1.2
1961	303,980	3.2	1,916	2.6	1997	554,832	2.0	373	1.3
1962	320,865	2.6	9,358	6.0	1998	840,258	2.9	1,113	3.0
1963	557,327	4.3	6,928	4.9	1999	794,230	2.5	921	2.6
1964	711,826	4.1	1,421	2.9	2000	537,202	2.2	365	1.1
1965	715,007	4.7	5,600	4.9	2001	814,559	2.8	1,383	3.1
1966	1,223,243	5.8	3,467	4.3	2002	383,453	2.1	256	1.2
1967	1,006,519	4.0	885	3.1	2003	759,889	2.7	569	2.1
1968	1,541,978	5.3	2,115	4.6	2004	654,977	2.5	393	2.0
1969	1,351,429	4.2	896	3.3	2005	1,566,849	3.9	614	2.9
1970	1,026,276	3.3	580	4.3	2006	778,798	2.9	219	0.9
1971	551,289	2.7	1,017	1.7	2007	618,982	2.0	162	1.0
1972	468,347	2.5	1,888	2.9	2008	362,306	2.4	270	2.1
1973	1,108,330	3.8	5,623	4.5	2009	442,102	2.3	264	1.8
1974	969,270	2.8	1,221	2.0	2010			371	2.7
1975	1,334,195	3.6	2,435	3.7					

WERE QUAIL MORE ABUNDANT IN THE PAST?

Gorsuch (1934), Leopold (1977), and Brown (1989) speculated that quail numbers, although fluctuating in response to the vagaries of winter precipitation and the hatch, were greater in the 19th century than in the 20th. The historic accounts on which these assumptions are based are too numerous and too detailed to be dismissed out of hand. The argument that this decline is based on long-term habitat alterations is persuasive and cannot be ignored. Mesquite (*Prosopis* spp.) bosques and other riparian habitats in particular have been much altered and Gambel's quail have undoubtedly suffered from years of grazing during times of drought, cessation of wheat farming, onset of industrialized agriculture, and the invasion of saltcedar (*Tamarix* spp.) and other exotic vegetation (Brown 1989).

The big question is whether this decline continues to occur and, if so, what are the actual causes, and, if identifiable, can anything be done to remedy the situation? Check station records show quail hunters at Oracle Junction in 1940, a dry year following prolonged drought, averaged 6.6 quail per hunter day—a success rate not attained now even in the best years. It would appear that quail hunting is less productive now than in the 1940s and 1950s unless one accepts the premise that hunters were formerly more dedicated. Fortunately, due to the monitoring programs implemented in the 1950s and 1960s, we now have the means to track quail hunt success, and fall population levels for the past half century.

The earliest of these monitoring methods were check stations and wing boxes (Brown 1989; Table 1). Provided one accepts the dictum that number of birds bagged per hunter trip is a function of population density, the trend at Oracle Junction, one of the state's premier quail hunting locales, indicates a population decline from 1940 through 2010 ($r^2 = 0.27$; $P < 0.0001$; Table 1, Fig. 5).

A more representative picture for Arizona can be obtained by examining the numbers of quail claimed and bagged per hunter trip as measured by small game hunt

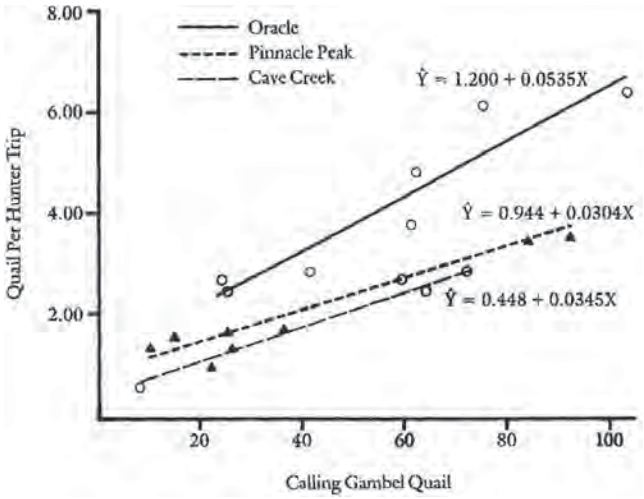

Fig. 4. Quail call count and hunt success information in 3 areas in Arizona. Data from Smith and Gallizioli (1965).

questionnaires. These data, while showing no significant change ($P < 0.10$) in numbers of quail claimed, show that hunt success has also declined since 1962 when questionnaire surveys were initiated ($r^2 = 0.35$; $P < 0.001$; Table 1, Fig. 6).

So, what is happening? Are quail hunters less avid in their pursuit of quail or are quail numbers in long term decline? One argument confounding the later conclusion is that Christmas Bird Count data collected by the Audubon Society in Arizona, while showing large annual fluctuations, show no long-term change in Gambel's quail populations between 1962 and 2010 (Fig. 6: $r^2 = 0.01$: n.s; http//audubon2.org/cbcist/Fig. 7). Thus, the phenomenon of declining quail hunt success may only apply to those public lands open to quail hunting. There are several hypotheses to possibly explain a long-term decline in hunt success.

1. *Quail hunters are less dedicated to their sport than formerly; do not exert themselves as much and quit hunting earlier in the day.*

This assumption is difficult to test and there is little reason at present to assume its validity. Personal observation shows that quail hunters appear as dedicated to their sport as formerly, and more likely to use bird dogs. Nor is there any evidence of an increase in the percentage of novice quail hunters, nor any data to support a decrease in hunter interest or hours spent afield. One must accept the premise that either a higher commitment to hunt success existed in the past or quail are now less easy to obtain, unless further exploration into this phenomenon is forthcoming.

2. *Hunter intensity has increased and more late winter hunting has resulted in increased mortality rates and fewer birds available to breed and nest the following spring.*

This hypothesis, although rejected by most game managers (e.g., Guthery et al. 2004), is testable and needs investigation if for no other reason than to assure the public that prolonged hunting is not depleting breeding stock. Most studies in Arizona and elsewhere have shown hunt mortality in small game populations is compensatory, but there may be situations where intense, prolonged hunting pressure impacts quail numbers—at least locally (e.g., Williams et al. 2004, Rolland et al. 2010). The extension of quail hunting seasons from January to mid-February in Arizona was instituted *after* studies had shown hunting did not result in additive mortality and

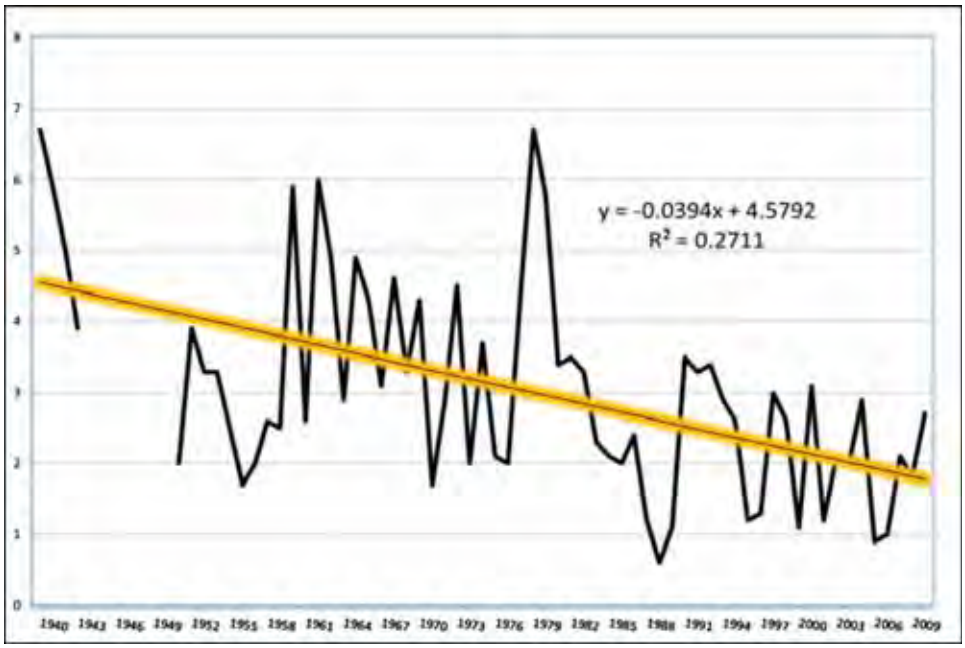

Fig. 5. Quail/hunter trip at Oracle Junction, Arizona check station, 1940–2010.

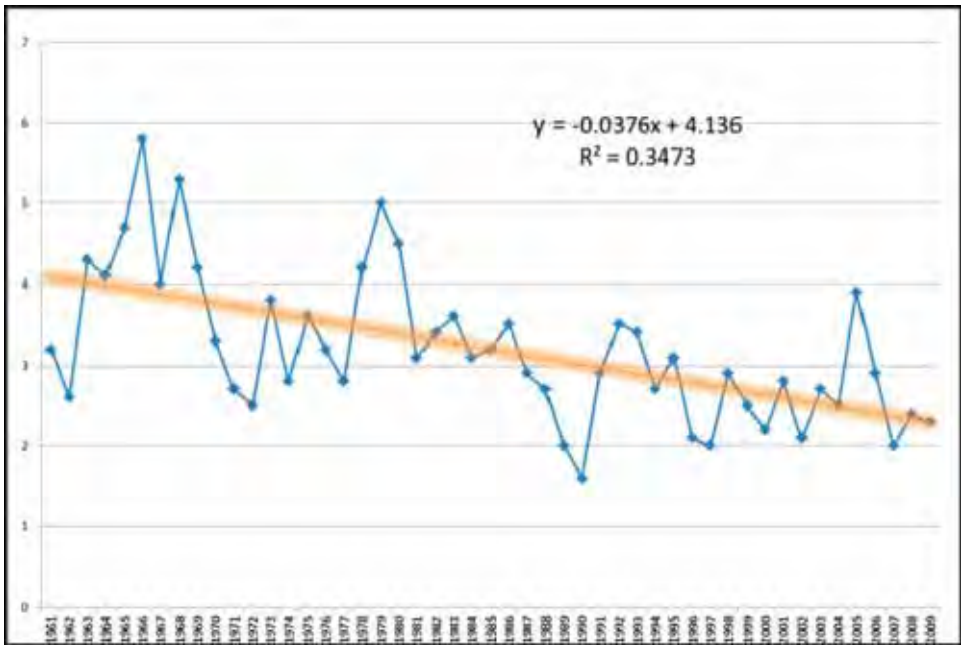

Fig. 6. Quail/hunter trip from mail questionnaires, Arizona, 1961–2009.

subsequent reduced quail population levels. Even though the large expanses and nature of quail habitats in Arizona make an additive mortality hypothesis unlikely, such a situation in local areas could reduce hunt success over time. Whatever the reason, this hypothesis can be tested by comparing quail populations in areas closed to late season quail hunting with those in similar or adjacent areas open to such hunting.

3. Precipitation totals are in a long-term decline and/or rainfall patterns have changed.

Most biologists and some hunters are prone to subscribe to this rationale as the reason for a decline in quail numbers despite a lack of statistical documentation. The problem with this explanation is there is little or no evidence to show a long-term decline in either winter or summer rainfall amounts in Arizona's quail habitats after 1960 (Turner et al. 2003). There appears to have been instead an increase in precipitation albeit of a higher variability (McClaran 2003). There has also been an increase in minimum temperatures since 1962, attendant with a continued increase in woody vegetation of tropic-subtropic origin (McClaran 2003, Turner et al. 2003). It is thus possible the overall increase in shrubby vegetation has reduced hunt success, however slight. If so, such a time-sensitive change would be difficult to measure.

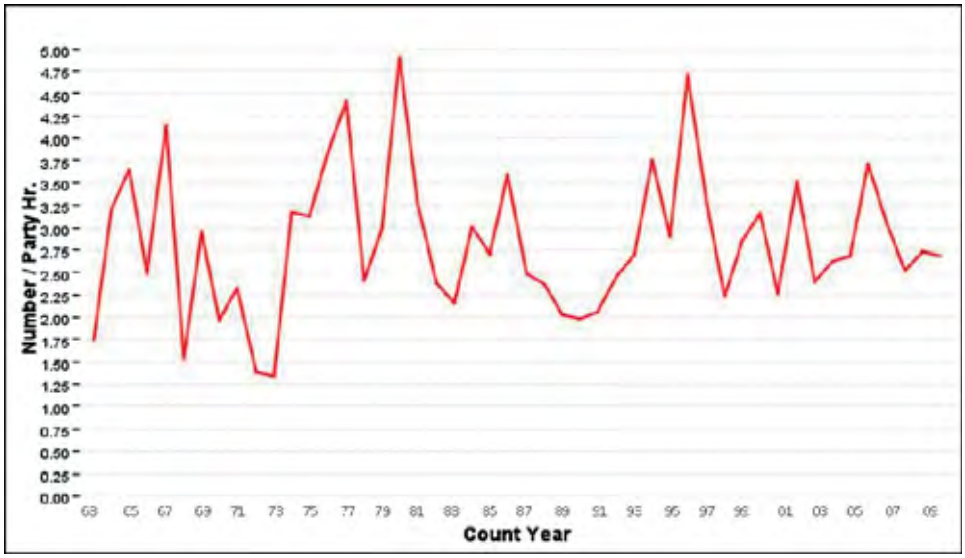

Fig. 7. Number of Gambel's quail seen/party/hr in Arizona on Audubon Christmas Bird Counts, 1962–2010.

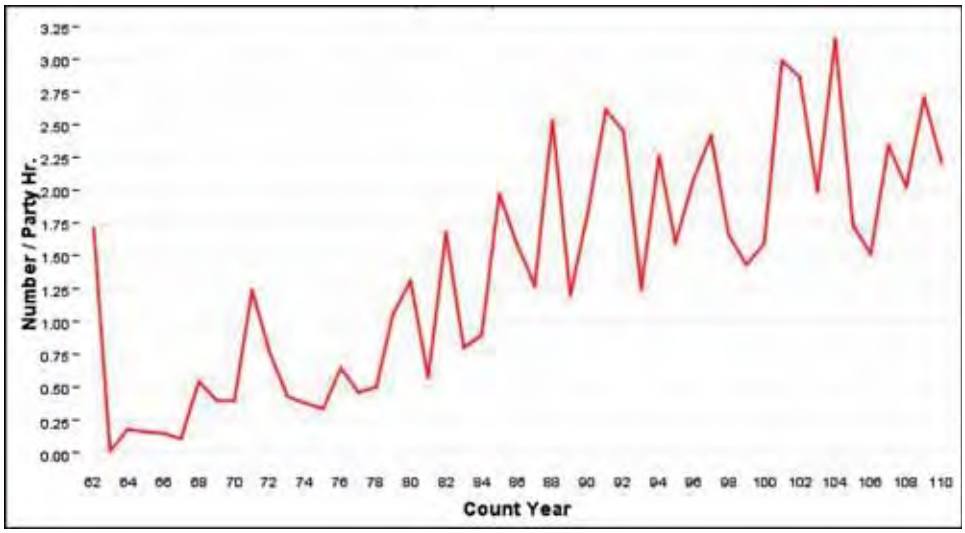

Fig. 8. Number of ravens seen/party/hr on Audubon Christmas Bird Counts, Arizona, 1962—2010.

4. Habitat conditions have continued to gradually deteriorate due to inappropriate grazing and other land uses.

This rationale is another favorite explanation for declining quail numbers and appears to have merit. Studies by McAullife and Van Devender (1995) and McAullife 1998) have shown the construction of stock tanks and other improvements concentrate livestock and result in long-term vegetation changes and desertification on public lands. The resulting increased evapotranspiration rates facilitate wind and sheet erosion that results in lower soil productivity. The corresponding changes in vegetation from semi-desert grassland and other vegetation communities of high value to quail populations are gradually replaced by desert-scrub communities with depauperate understories that lower quail numbers and hunt success. This hypothesis can be tested using paired areas, one of which is closed to livestock grazing, over a set period of time.

5. Predation rates have increased due to increased water developments, more road kills and other ecological changes.

A major cause of concern by earlier wildlife biologists (e.g., Ligon 1927), predation has long been considered a factor in game bird population dynamics (e.g., Gorsuch 1934, Potts 1986). Even now, some sportsmen continue to relate predation to quail population declines—a hypothesis rejected by most wildlife managers (e.g., J. R. Heffelfinger, personal communication 2012). There are, however, no studies indicating an increase in predation despite a curtailment in the use of predacides and evidence of increases in small carnivore populations and egg predators such as the common raven (*Corvus corax*) after 1972 (Fig. 8; $r^2 = 0.813$; $P<0.001$; Audubon Christmas Bird Count (http//audubon2.org/cbchist/graph.html). Hunt success on coyotes (*Canis latrans*) and foxes (*Urocyon cinereoargenteus* and *Vulpes velox*) in Arizona has also increased since 1991 with a reduction in fur prices and a ban on leg-hold traps (e.g., Arizona Game and Fish Department 2011). It thus appears, at least to some, that increased predation on breeding birds and their eggs could possibly explain a decrease in quail hunt success. Either way, no remedial measures should be taken unless further investigation demonstrates these concerns are justified.

Of the above 5 possible explanation for the decline in quail hunt success, only #'s 2, 3, 4, and 5 can be developed into testable hypotheses and only # 2 can be addressed by regulation changes. However, comparative studies need to examine if late hunt mortality is a factor in decreasing hunt success before any hunter restrictions are made. If # 3 is the cause, nothing can be done and the decline in hunt success will continue. If issues 4 or 5 are involved, only major management changes, difficult to implement, would stop the progression toward lower hunt success.

ACKNOWLEDGMENTS

I am much indebted to Jim Heffelfinger and the Game Branch of the Arizona Game and Fish Department for locating and providing all of Arizona's hunt questionnaire and check station data. Also of great help to this effort were Roger D. Applegate, Robert M. Perez, and an unknown reviewer who provided important references on the impacts of hunting on quail mortality in other states and additional Arizona data.

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