Carp Impacts on Waterfowl at Malheur National Wildlife Refuge, Oregon

Gary L. Ivey
U.S. Fish and Wildlife Service
Princeton, Oregon

John E. Cornely
U.S. Fish and Wildlife Service
Denver, Colorado

Bradley D. Ehlers
U.S. Fish and Wildlife Service
Zimmerman, Minnesota

Introduction

Carp (*Cyprinus carpio*) are an exotic fish species which have severe impacts on North American aquatic systems, disrupting food chains and outcompeting native fish and wildlife. Carp were one of the treasures brought to Europe from Asia during trading expeditions to China in the 15th century. They were first imported to the U.S. from Germany in 1877 and were distributed to most states from 1889 to 1897 by the U.S. Bureau of Fisheries. With human help, carp found their way into most U.S. watersheds by the turn of the 20th century. Soon after these introductions, adverse impacts were realized as carp caused reductions of sport fish populations and of waterfowl foods, resulting in lower waterfowl use and production in many wetlands.

Attempted elimination of carp is a common practice to improve marshes for waterfowl, since high carp populations are a detriment to waterfowl habitat. They destroy aquatic vegetation (Threinen and Helm 1954, Robel 1961, King and Hunt 1967, Crivelli 1983), and their foraging, spawning and feeding habits increase water turbidity, decreasing macrophyte and invertebrate production, thus decreasing waterfowl food supplies (Berry 1983). The carp's primary foods are aquatic macroinvertebrates, and they directly compete with waterfowl and waterbirds for those resources. Sigler (1958) found a high percentage of invertebrates in the diets of carp and noted that midge larvae (Chironomidae) were their most important food in Utah. Midge larvae are important foods for breeding ducks and ducklings (Swanson 1984) and have also been shown to be important in the diets of mallards (*Anas platyrhynchos*), northern pintails (*A. acuta*

acuta) and green-winged teal (*A. crecca carolinensis*) during the nonbreeding season as well (Euliss and Grodhaus 1987). Laying females utilize invertebrates to acquire protein for egg production (Krapu 1979, Eldridge 1990). Diets of ducklings are dominated by invertebrates (Swanson et al. 1979). Invertebrates may also be important during molt (DuBowy 1985). Carp directly compete with waterfowl and other fishes for these resources. In shallow wetlands, carp often dominate the aquatic fauna and reduce species diversity. They monopolize the food chain in wetlands, locking up much of the productivity as carp biomass. Reduction or elimination of carp from wetland systems is beneficial to waterfowl and other native fauna.

In 1981, the Malheur National Wildlife Refuge (NWR) staff distributed a questionnaire to the National Wildlife Refuges in the lower 48 states to determine the scope of the carp problem in the National Wildlife Refuge System. Of 162 refuges surveyed, only 54 (32 percent) indicated no carp problems. Nearly half of the stations which reported no problem were either upland or coastal refuges without freshwater impoundments, while more than 80 percent of refuges with impoundments reported carp to be a management problem.

Several methods have been employed by refuges to harvest and control carp with mixed success, but little has been reported in the literature on the effectiveness of these efforts. This paper describes long-term efforts toward carp control at Malheur NWR and the response of waterfowl to those efforts.

Study Area

Malheur NWR is the largest National Wildlife Refuge managed as waterfowl production and migration habitat in the West. Encompassing more than 186,000 acres (75,000 ha), the refuge is the most important waterfowl production area in Oregon, and among the major migratory bird production sites in the Pacific Flyway. Malheur NWR lies within southeastern Oregon's internally drained Harney Basin. Located in the northern Great Basin, the refuge is an oasis in a shrub-steppe desert. A more detailed description of the refuge is provided by Cornely (1982).

The most prominent feature on Malheur NWR is Malheur Lake, the largest relatively unaltered freshwater marsh in the western U.S. The lake is fed by the Silvies River which flows south from the Blue Mountains, and the Blitzen River which flows from Steens Mountain, north through the refuge-owned Blitzen Valley. Malheur Lake has been important to migratory birds since prehistoric times. In addition to providing nesting habitat for waterfowl and a wide variety of waterbirds, the lake is important as a migrational staging area for several hundred thousand waterfowl. Historically, the lake was famous for dense stands of sago pondweed *(Potamogeton pectinatus)* and other submergent plants (U.S. Fish and Wildlife Service 1957). Sago pondweed is a preferred food of the canvasback (*Aythya valisineria*) and other waterfowl. Canvasback numbers on Malheur Lake peaked at more than 10,000 during spring in the mid-1940s (Erickson 1948).

Carp were introduced into the Silvies River in the late 1920s, but were not apparent in Malheur Lake until the early 1950s. Apparently, large numbers of adult carp were flushed into the lake by high flows in 1952 (U.S. Fish and Wildlife Service 1957). Refuge biologists noted concerns about large numbers of carp which apparently caused an 80-percent decline in sago pondweed between 1953 and 1954. By 1955, no sago pondweed was evident in the lake and carp were abundant. These conditions prompted the U.S. Fish and Wildlife Service to undertake a major carp control project in the Malheur Lake drainage in 1955 (U.S. Fish and Wildlife Service 1957). Since then, several other carp control projects have been completed.

Carp clogging the mouth of the Blitzen River after 1961 rotenone treatment at Malheur National Wildlife Refuge. *Photo by E. Kridler, U.S. Fish and Wildlife Service.*

Methods

The first major carp control project was conducted in 1955 using the piscicide, rotenone. This chemical was applied to the Silvies and Blitzen rivers and to Malheur and Boca lakes in an effort to exterminate carp from the system. Several drip stations were established on the rivers and tributaries. Malheur Lake (12,000 acres [4,858 ha]) and Boca Lake (700 acres [283 ha]) were treated by aerial spraying of rotenone. A total of 5,445 gallons (24,792 l) of rotenone was used on Malheur Lake, while another 1,982 gallons (9,008 l) were applied to rivers, streams and Boca Lake combined. An estimated 1.5 million carp were killed (U.S. Fish and Wildlife Service 1957).

Less extensive carp control programs were conducted in 1959 through 1961. In 1959, only the lower 16 miles (26 km) of the Blitzen River and Sodhouse Spring Pond were treated with just more than 50 gallons (227 l) of rotenone which killed about 58,000 carp. In 1960, rotenone was applied with several drip stations along the Blitzen River beginning 40 miles (64 km) upstream. Malheur Lake contained about 4,000 surface acres (1,620 ha) and 105 gallons (477 l) of rotenone were used, killing an estimated 400,000 carp. In 1961, Malheur Lake (650 acres [263 ha]) and 45 miles (72 km) of the Blitzen River were treated using drip station, boat and aerial applications. A total of 325 gallons (1,477 l) of rotenone was applied and an estimated 150,000 carp were killed.

In 1968, Malheur Lake (870 acres [352 ha]) was aerially sprayed with rotenone and 59 miles (95 km) of the Blitzen River and tributaries were treated using drip stations and boats. A total of 850 gallons (3,863 l) of rotenone was used and an estimated 240,000 carp were killed. In 1969, additional wetlands in the Blitzen Valley were treated from a boat and drip stations were used along 40 miles (64 km) of the Blitzen River, using 244 gallons (1,109 l) of rotenone.

In 1977, rotenone was aerially applied to Malheur Lake and applied to the Blitzen River from a drip station located 2 miles (3 km) upstream. A total of 12,000 gallons (54,540 l) of rotenone was used, killing 50,000 carp in the river, plus "thousands" more in Malheur Lake. Malheur Lake contained about 15,000 surface acres (6,073 ha).

In 1992, drought reduced Malheur Lake to about 400 surface acres (162 ha) and about 2 inches (5 cm) in depth. Carp had moved from the lake into the Blitzen River. Fifty miles (80 km) of the Blitzen River and Sodhouse Spring Pond were treated using rotenone drip stations. A total of 180 gallons (818 liters) of rotenone was used, killing an estimated 100,000 carp.

Several historic sets of data are available to assess the beneficial effects of carp control at Malheur NWR. Aerial and ground surveys of waterfowl were conducted to assess waterfowl use of the refuge. Waterfowl use-days were derived from these surveys by multiplying the number of waterfowl observed by the number of days in a census period. Duck production has been estimated based on ground surveys of pairs and broods. Sago pondweed acreage on Malheur Lake has been mapped annually since 1955. We used the "T" test (SAS Institute, Inc. 1989) to compare duck production between the 1940s (before carp) and the 1950s (after carp introduction). We also correlated acres of sago pondweed and dabbling and diving duck use throughout the period of major carp control programs. Acres of sago pondweed were also correlated with waterfowl use of Malheur Lake for different species and species groups.

Results and Discussion

Carp have been recognized as a serious problem, limiting waterfowl production and use since their invasion of Malheur Lake. Before carp invaded the refuge, duck production averaged more than 101,000 ducks annually in the 1940s, and peaked at 139,000 ducks in 1946. During the 1950s, with carp established in Malheur NWR wetlands, duck production was significantly lower ($P < 0.0001$), averaging less than 38,000. Due to the presence of carp in Malheur NWR wetlands, the refuge's potential for waterfowl production and maintenance has been lowered to about 25 percent of its historical capability. If carp could be eradicated, the refuge could potentially produce an additional 80,000 ducks a year, at least in years of abundant water. If these data are extrapolated to other carp-infested wetlands in North America, carp could be reducing continental waterfowl production by several million ducks each year.

The carp control programs at Malheur NWR were unsuccessful in eliminating carp, but resulted in low carp populations for two to four years following treatment. Carp numbers were so high prior to the treatment projects, very few individuals of other fish species remained. Very low numbers of other fish species were killed during rotenone treatments and no native species were completely eliminated as native fish survived in the upper reaches of the Blitzen River which was never treated with rotenone. Although carp control projects failed to eliminate carp from Malheur NWR, they were successful in enhancing habitat for waterfowl for a few years, until carp populations rebounded.

Sago pondweed acreage in Malheur Lake increased substantially after each major carp control project (Figure 1). In both 1955 and 1992, no sago pondweed was found in Malheur Lake, compared with an estimated 16,900 and 10,000 acres, respectively, in years following the carp control project. Substantial increases in sago pondweed were also documented after the other major carp control programs.

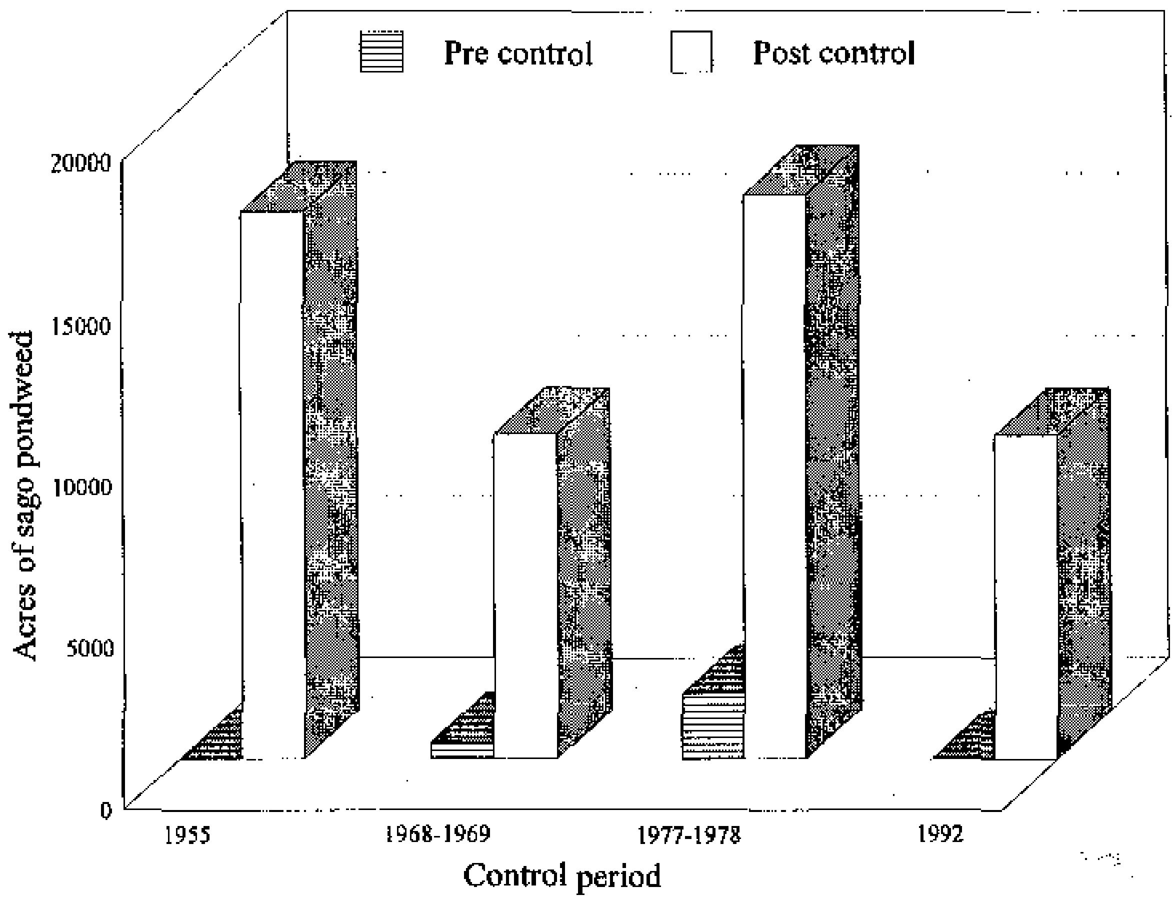

Figure 1. Comparisons of sago pondweed acreage in Malheur Lake for the years before and after major rotenone treatment projects at Malheur National Wildlife Refuge, Oregon.

Concurrent with increases in sago pondweed following carp control efforts, waterfowl use increased (Figure 2). Diving ducks showed the greatest response to increased sago pondweed following carp control. Diving duck use increased from 50 to 70 percent after carp control, while dabbling duck use increased from 1 to 116 percent. Significant positive correlations were found between breeding pairs of diving ducks and acres of sago pondweed in Malheur Lake from 1972 to 1984 ($r = +0.81$, $P < 0.01$, 11 d.f.), and between diving duck use and sago pondweed acres since 1975 ($r = +0.89$, $P < 0.01$, 8 d.f.). Canvasback use also showed a significant positive correlation with sago pondweed from 1955 through 1979 ($r = +0.72$, $P < 0.01$, 23 d.f.). We also found a significant correlation between sago pondweed and redhead (*Aythya americana*) production 1955 to 1979 ($r = +0.51$, $P < 0.01$, 23 d.f.) and canvasback production ($r = +0.46$, $P < 0.05$, 23 d.f.) during the same period.

Implications

Although rotenone is the traditional treatment for carp control, it is very expensive and can have adverse impacts on native species. The 1955 rotenone

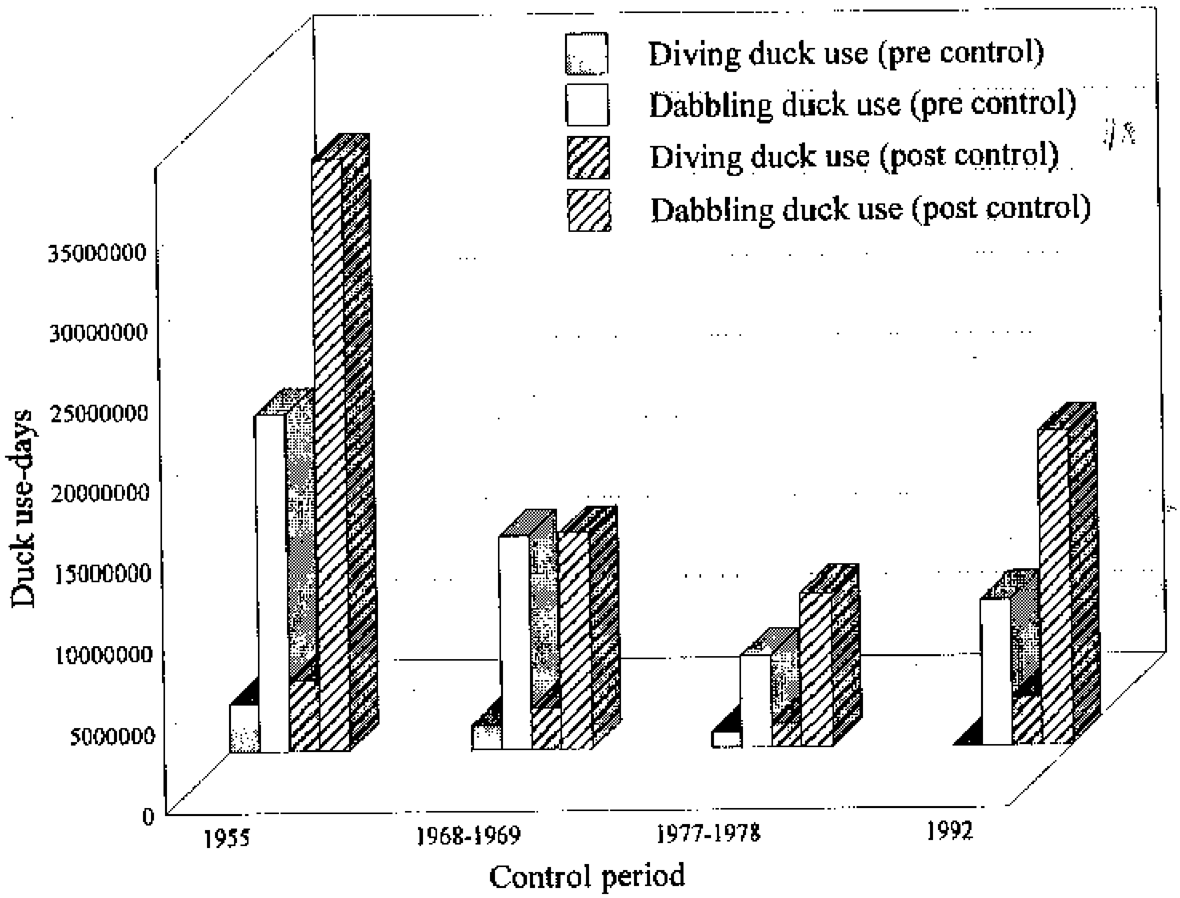

Figure 2. Comparisons of diving and dabbling duck use-days for the years before and after major rotenone treatment projects at Malheur National Wildlife Refuge, Oregon.

project treated both rivers and the 12,000 surface acres of Malheur Lake at a cost of $37,000, while the 1977 project treated only the Blitzen River and 15,000 surface acres of Malheur Lake for $129,000. Since 1977, chemical and application costs have increased substantially. In addition, because of environmental concerns, it is much more difficult to acquire permits to conduct rotenone projects than it used to be. The refuge can only afford to conduct rotenone projects during periods of extreme drought, when water acreage is very low. In recent years, Malheur NWR staff have resorted to a more integrated approach to carp control. Impoundments have been redesigned to allow complete drawdowns. Fish screens have been installed to slow carp invasions to selected wetlands. Traps have been used to trap carp in fish ladders and at other sites where they congregate. Large pumps have been used to drain deeper wetland areas, and biologists have used electroshocking to remove carp from springs and areas which cannot be drained completely.

Based on what has been learned at Malheur NWR, traditional rotenone treatments are not the long-term solution to carp problems. Improvements in existing strategies (i.e., toxicants, barriers, traps, water management) aimed at reducing carp problems would be beneficial and would lead to improved habitat for waterfowl. They should continue to be applied until a better solution to carp problems is developed. However, these strategies will likely never eliminate the problem which will continue to require action and funds for years to come.

What is needed is development of a technique to eliminate carp totally from wetlands. Creative methods such as genetic manipulation, introduction of sterile hybrids, or development and introduction of disease agents which could kill carp or interfere with their production should be explored. Developing techniques targeted to impact only carp while safeguarding native and sport fishes would be important. Because Malheur NWR is within a closed system, it would be an ideal, yet challenging area to design and test experimental carp eradication schemes. A successful project at Malheur could serve as a model for carp control in other wetlands across the continent.

Acknowledgments

We thank Kevin Kilbride for his comments on the content of this paper and Caroline Herziger for helping format the figures. Malheur NWR biologists Dave Marshall, Eugene Kridler, Eldon McLaury, Larry Napier and Richard Vetter documented past rotenone projects.

References

Berry, C.R. 1983. Effects of carp control on a waterfowl marsh. Proc. Utah Chapt. The Wildl. Soc. Meet., Utah St. Univ., Logan. 12 pp.

Cornely, J.E. 1982. Waterfowl production at Malheur National Wildlife Refuge, 1942-1980. Trans. No. Am. Wildl. and Natur. Resour. Conf. 47: 559-571.

Crivilli, A.J. 1983. The destruction of aquatic vegetation by carp. Hydrobiologia 200(201): 177-185.

DuBowy, P.J. 1985. Feeding ecology and behavior of postbreeding male blue-winged teal and northern shovelers. Can. J. Zool. 63: 1,292-1,297.

Erickson, R.C. 1948. Life history and ecology of the canvas-back, *Nyroca valisineria* (Wilson), in southeastern Oregon. Ph.D. thesis, Iowa St. Coll., Ames. 324 pp.

Eldridge, J. 1990. Aquatic invertebrates important for waterfowl production. Fish Wildl. Leafl. No. 13.3.3, U.S. Fish and Wildl. Serv., Washington, D.C.

Euliss, N.H. and G. Grodhaus. 1987. Management of midges and other invertebrates for waterfowl wintering in California. California Fish and Game: 238-243.

King, D.R. and G.S. Hunt. 1967. Effect of carp on vegetation in a Lake Erie marsh. J. Wildl. Manage. 31(1): 181-188.

Krapu, G.L. 1979. Nutrition of female dabbling ducks during reproduction. Pages 59-70 *in* T.A. Bookhout, ed., Waterfowl and wetlands—An integrated review. Proc. 1977 Symp., North Central Sect. The Wildl. Soc., Madison, WI.

Robel, R.J. 1961. The effects of carp populations on the production of waterfowl food plants on a western waterfowl marsh. Trans. No. Am. Wildl. and Natur. Resour. Conf. 26: 147-159.

SAS Institute Inc. 1989. SAS\STAT user's guide. Vers. 6, 4th ed. SAS Instit. Inc., Carey, NC. 934 pp.

Sigler, W.F. 1958. The ecology and use of carp in Utah. Bull. 405, Utah St. Univ. Ag. Exp. Sta., Logan. 63 pp.

Swanson, G.A. 1984. Invertebrates consumed by dabbling ducks (Anatinae) on the breeding grounds. J. Minnesota Acad. Sci. 50: 37-40.

Swanson, G.A., G.L. Krapu and J.R. Serie. 1979. Foods of laying female dabbling ducks on the breeding grounds. Pages 47-57 *in* T.A. Bookhout, ed., Waterfowl and wetlands—An integrated review. Proc. 1977 Symp. North Central Sect. The Wildl. Soc., Madison, WI.

Threinen, C.W. and W. T. Helm. 1954. Experiments and observations designed to show carp destruction of aquatic vegetation. J. Wildl. Manage. 18(2): 247-251.

U.S. Fish and Wildlife Service. 1957. Carp control program at Malheur Lake-Oregon. U.S. Fish and Wildl. Serv., Portland, OR. 49 pp.