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COMMENTARY

Wilderness Fish Stocking: History and Perspective

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ABSTRACT

The stocking of trout in wilderness lakes of the western United States began in the 1800s. This practice was followed for nearly a century with the singular goal of creating and enhancing sport fishing and without any consideration of its ecological ramifications. Following the advent of a new environmental awareness in the 1960s, and thanks to new research that revealed negative impacts on the biota attributable to introduced fishes, traditional fish-stocking practices came under question first at federal land management agencies and later at their counterparts within the states. The highly utilitarian ethic that drove resource management until well into the 1960s was gradually replaced by one that acknowledges the value of all life forms and their ecological complexity, a view currently supported even by many anglers. The necessity for wilderness fish stocking is now the subject of widespread debate, especially in view of changing social values and priorities. Options for future generations cannot be preserved if introductions continue to erode the biodiversity of mountain lake ecosystems.

Key words: biodiversity; wilderness lakes; trout stocking; research; history; government resource agencies; user groups; ethics; future direction.

INTRODUCTION

As I was writing this history of fish and wildlife agencies and considering the perspectives of various user groups on the matter of fish stocking in wilderness lakes, the following quotation, attributed to Stephen Jay Gould, pervaded my mind: "We are trapped in the ignorance of our own generation."

During my 50 years of studying and managing about 700 wilderness lakes in California's High Sierra, first with the US Fish and Wildlife Service as a research biologist, and later with the California Department of Fish and Game as a hands-on manager, I have witnessed a major revolution in the philosophies and programs that direct such things. Enormous changes occurred during the second half of the 20th century, and fortunately they have led us in the right direction in terms of maintaining biological integrity and diversity. Unfortunately, during the latter part of the 19th century and the first 60 years of the 20th, very little thought was given to biodiversity and ecosystem issues. When trout planting was first implemented, the nation was gripped with a highly utilitarian resource management ethic that placed short-term human interests above virtually any other consideration. No one even thought about its impact on other organisms. The only criterion employed by state fish and wildlife agencies in lake stocking was whether or not a given water would sustain a fish population. In other words, "If it stays wet all year, plant it!" An ethic of concern about the effects that such stocking might exert on a lake and its surrounding ecosystem had not yet been developed and incorporated into management planning.

Curiously, concern over such matters was not forthcoming from within the Ivory Tower, not even from ecologists and aquatic entomologists. Following my departure from graduate school in 1952 and during my early affiliation with the Bureau of Sport

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Fisheries and Wildlife (now the US Fish and Wildlife Service), queries from my graduate committee members at Berkeley (Robert L. Usinger, A. Starker Leopold, and Paul R. Needham) focused primarily on which wilderness lakes had been most recently and heavily stocked and therefore (presumably) were most likely to provide good fishing. No ecological concerns were registered. The impact of fish stocking on aquatic invertebrates and other taxa only began to be questioned after the dawn of the era of environmental awakening, prompted by the publication of Rachel Carson's monumental *Silent Spring* in 1962. This concern was further reflected in the passage of the Wilderness Act of 1964, then underscored by the National Environmental Policy Act in 1969, the Endangered Species Act in 1973, and related state laws.

History of Wilderness Lake Stocking

The vast majority of western mountain lakes were historically barren of fish life. Due to their glacial origin in the late Pleistocene epoch, there were physical barriers that prevented any invasion from downstream sources. As the West was settled by Europeans in the second half of the 19th century, trout were gradually introduced into these waters, but without structured management plans. Initial introductions were made by cattlemen, miners, and sportsmen, followed by rudimentary and sporadic governmental activity in the late 1800s and early 1900s. The first trout hatcheries were constructed throughout the western states during this same period, but fish were dispensed from them without much prior thought. "Management" was driven primarily by the availability of trout; little thought was given to biological or ecological considerations (Smith and Needham 1942).

Trout stocking in California's Sierra Nevada began in the latter part of the 19th century. Ironically, among the first practitioners was the Sierra Club. Will Colby, who assumed leadership of the club from John Muir following the turn of the century, would utilize packstock for trout planting after the stock had served their purpose of carrying the camping equipment and other gear that sustained club members during their legendary trips into the high country (Farquhar 1965). The California Fish and Game Commission (Colby was a commissioner), predecessor to the present Department of Fish and Game, did not begin its activities on a regular basis until well into the 1920s. However, the commission had been involved in significant if sporadic planting since the early 1900s, primarily by moving golden trout (*Oncorhynchus aguabonita*) northward from their evolutionary Kern River habitats (Ellis and Bryant 1920; Vore 1928). The Cottonwood Lakes golden trout spawning facility was not established until 1917, concurrent with completion of the Mount Whitney state fish hatchery. By the time the Department of Fish and Game and its predecessor agencies began their programs, many high-country waters already harbored trout populations (Ellis and Bryant 1920; Christenson 1977).

In the early years, sportsmen's clubs and private citizens often conducted their own planting programs. During his frequent visits to the Bishop Department of Fish and Game office during the 1950s and 1960s, legendary mountaineer Norman Clyde spoke glowingly of planting "brookies" into certain of his favorite and theretofore barren lakes (USDA–Forest Service 1999). Although he (and others) were warned that this practice was illegal, it was of no avail. In any case, there was no practical means of enforcing the law. In his highly popular book *Waters of the Golden Trout Country*, McDermand (1946) also condoned this practice.

At this point, it seems appropriate to include an anecdote that was related to me nearly 50 years ago by Earl Leitritz, who for many years supervised California's fish hatchery system. Stories like this one help to explain the almost totally disorganized way in which hatchery trout were initially distributed. During the early days (1800s), much of California's trout distribution emanated from the Sisson (now Mount Shasta) Hatchery in northern California. Production consisted largely of fingerling steelhead rainbow trout (*Oncorhynchus mykiss*), which were often transported in railroad cars. As the "fish cars" pulled into railroad sidings along the way, they would be met by different groups (sportsmen and so on) who would ask for (as an example) two cans of eastern brook (*Salvelinus fontinalis*) two of brown trout (*Salmo trutta*), and two of rainbow. The hatchery personnel would dutifully procure six cans of steelhead, label two of them "eastern brook," two of them "brown," and two of them "rainbow," and the sportsmen would take it from there, happier but never the wiser. This example may be a bit extreme, but it is true and underscores the chaos of early-day trout distribution. No one really knew what went where, when, or why. To put this lamentable situation in its proper context, we should note that during this same period California and other western states were importing and distributing carp (*Cyprinus carpio*) into many of their waters (Dill and Cordone 1997).

With the advent of the 20th century and more formal organization of state fish and wildlife agen-

cies, more hatcheries were built and distribution became better organized. Nevertheless, it remained highly utilitarian. Increased angler success was the goal relentlessly pursued, and it seemed that the best way to achieve this was to plant as many trout as possible into as many lakes as possible. This thinking prevailed past World War II and continued until newly implemented limnological research began to effect a gradual change (Reimers and others. 1955).

After World War II, when airplanes and helicopters again became generally available for civilian use, wilderness trout stocking was shifted from packstock to aircraft, thereby allowing greater efficiency at reduced cost and, initially, greater reliability in trout distribution. In California, early flight crews were extremely well informed and accurate in their placement of fish, but as experienced pilots retired and were replaced by pilots who were unfamiliar with the many lakes involved (and who found it very difficult to identify the lakes accurately when flying less than 100 meters above them at speeds approaching 200 knots), the wrong lake was occasionally planted. Although global positioning system (GPS) technology is now employed, until this new equipment was installed, a number of serious errors were made. As one who has been in the business of lake management for many years, I can testify that it is far easier to plant a lake than to unplant it.

Consequences of Trout Introductions

Research in which I was deeply involved has revealed that the impact of introduced trout on a heretofore fishless lake is devastating to its invertebrate fauna (Reimers 1958, 1979). Yet the majority of lakes that the Department of Fish and Game (and others) had been planting for the previous 50-odd years had already been impacted, and there seemed little reason not to continue planting to sustain a population of trout. Besides our research, there were other clues indicating that the trout had a deleterious effect on invertebrates. Initial trout introductions were followed by rapid growth, but ensuing year classes grew less rapidly until stunting occurred, usually within a few years.

In 1951, at Convict Creek Basin's previously unplanted Bunny Lake (Mono County, California), we introduced approximately 1800 eastern brook trout measuring around 6.6 cm in length, after carefully studying the lake's invertebrate populations. In their 1st year, the trout tripled in weight and nearly doubled their length, virtually eliminating much of the invertebrate fauna in the process. Growth then approached a standstill. The last fish that we recovered, identified by a fin clip applied in 1952, lived to 24 years, at which time it measured less than 24 cm. It had grown less than 12 cm in 22 years (Reimers 1979). It has been our observation that this is typical of trout (especially brook trout) in high lakes. In the meantime, these trout (while virtually starving to death) essentially eradicated the existing invertebrate populations while in the process of stunting. The effects of introduced trout on native aquatic fauna have been demonstrated repeatedly throughout western North America (Reimers 1958, 1979; Hall 1991; McNaught and others 1999).

Along with their known impact on invertebrates, recent studies have implicated introduced trout in the still poorly understood phenomenon of depleted amphibian populations (Bradford 1989; Bradford and others 1993; Corn 1994; Drost and Fellers 1996; Knapp and Mathews 2000), lending credibility to the common observation that if a lake contains trout it will have very few (or no) frogs, and vice versa.

Current Practices and Policies

During the environmental awakening that began in the 1960s, and with the Forest Service and National Park Service showing increased concern over the management of waters on federal lands (Hall 1977; Wallis 1977), western states began to take a more cautious approach in their management direction, even rearranging priorities within the state agencies themselves. In some respects, this new approach reflected the increasing influence of ecologists and environmentalists who questioned the ethics of past practices. To them (and to responsible agency biologists), a native planktonic or amphibian taxon deserved more consideration than a nonnative trout and virtually all of them are nonnative species (Pister 1977, 1992, 1993, 1995). This position was more in line with the letter and intent of federal and state laws addressing the need for biodiversity and ecosystem conservation. One manifestation of this new thinking can be found in the current mutual efforts of federal and state agencies to maintain populations of mountain yellow-legged frogs (*Rana muscosa*) by eliminating introduced salmonids in selected waters.

State Programs

While I was preparing this paper, I spoke at length with representatives of the fish and wildlife agencies of Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah,

Washington, and Wyoming. I also reviewed relevant documents prepared by several states. With the exception of Alaska and Arizona, which are anomalous—Alaska due to the enormity and remoteness of its lake resource and Arizona because it contains no natural mountain lakes—the management histories and current practices of most western states are remarkably similar (Cordone 1977; Wiltzius 1985; Alvord 1991; Bahls 1992; Wiley 1993; Green 1995; Dill and Cordone 1997; Erickson and others 1997; Johnston 1977; USDA Forest Service 1999; B. Hooton and C. Puchy unpublished.)

Following the same general plan, fingerling trout are stocked in lakes by aircraft on a rotational basis, some annually, some biennially, some less frequently, and some not at all. In many instances, stocking policies have been established over a period of years simply by trial and error (Bahls 1992). All of the states have critical manpower problems, and when hundreds of lakes fall under the jurisdiction of one or two biologists, there is simply not enough time to make adequate surveys (or even to see) their lakes more than once every several years. As a California biologist entrusted with the management of about 700 such lakes, even after 40 years I have yet to see all of them.

Alaska deserves special mention here, inasmuch as it contains an enormous resource of approximately 100,000 lakes, of which an estimated 50%–75% remain free of fish life. In Alaska, lakes range from fishless tundra ponds in places like the Yukon-Kuskokwim Delta and on the North Slope to much larger bodies of water. An example of the latter is Lake Teshekpuk, a huge but shallow lake about 10 m deep, with at least seven species of resident fish and a connection to the Beaufort Sea. That single lake comprises a substantial proportion of the total surface area and volume of the lakes on the Arctic coastal plain. There are a number of such big lakes in Alaska.

Lake stocking for recreational fishing in Alaska is strongly influenced by proximity to population centers and road systems, primarily in the Tanana Valley and in south-central Alaska around Anchorage, Palmer, Soldotna, and Kodiak, but not in the Yukon-Kuskokwim Delta or on the Alaska Peninsula. Some stocking is also done in the southeastern area. Over 300 lakes are presently stocked with rainbow trout, chinook salmon (*Oncorhynchus tshawytscha*), silver (coho) salmon (*O. kisutch*), arctic grayling (*Thymallus arcticus*), arctic char (*Salvelinus alpinus*), and lake trout (*S. namaycush*) (M. Doxey personal communication).

In a review of high-lake fishery programs, survey methods, and stocking criteria employed by the western states, Bahls (1992) noted:

> [1] Most regions [of the western United States] stock mountain lakes with nonnative trout species and with limited or nonexistent survey data upon which to make basic stocking decisions, such as the identification of wild trout lakes (self-sustaining) that do not require further stocking. [2] Most regions appear to have little concern for protection of native fish species in lakes or downstream systems, no evident concern for maintaining representative pristine lakes, and no consideration of the effects of trout stocking on indigenous fauna, aquatic ecosystems, and lakeshore recreational impacts.

Bahls's first point remains largely true today, although at least one state utilizes objective criteria, and others are refining techniques upon which to base stocking decisions. However, in the ensuing 8 years since Bahls made these observations, most states have begun to show a higher degree of sensitivity for their native species (vertebrate and invertebrate) and retain personnel to study and perpetuate them. Stocking programs are often designed accordingly. Rehabilitation of native trout species remains a primary goal of all state fish and wildlife agencies in the West.

Progress is being made by state fishery managers in recognizing the value of a broader spectrum of biota. In discussing the development of an ecological conscience and a code of decency for human-to-land conduct, Aldo Leopold (1947) advised that in such matters we should not worry too much about anything except the direction in which we travel. That direction now seems clear and inexorable. The only thing that remains unclear is how quickly this revolution will occur. It may come about more quickly than we imagine, because the law and public opinion are shifting strongly in the direction of this change.

Jurisdictional Conflicts

During the 1970s, a Park Service policy of no stocking in California parks was opposed by the California Department of Fish and Game, which wished to continue its longstanding programs within the national parks (Cordone 1977; Wallis 1977; USDI National Park Service 1991). The passage of time has revealed the wisdom of Park Service policy, although numerous park lakes were planted in the early years and still (and will likely always) retain fish. Ironically, many of Yosemite's lakes were initially planted from the Yosemite Hatchery, con-

structed in 1927 on the floor of Yosemite Valley at Happy Isles on the Merced River. Yosemite Hatchery was operated by the (then) California Division of Fish and Game in cooperation with the National Park Service until 1956, when it was abandoned (Leitritz 1970). The Park Service no longer condones stocking within California national parks, but under certain circumstances stocking may occur in parks in other states.

These examples help to illustrate the conflicts inherent within the legislative mandates of the agencies involved. State fish and wildlife agencies, operating until rather recently under an almost singular mandate to provide good angling, and under perhaps greater political pressure than their federal counterparts, pushed for a continuation of stocking. The Forest Service, bearing a broader responsibility, including that of maintaining habitat health and integrity, began to require interagency discussion and approval prior to implementing a wilderness stocking plan for a given year. A common practice started during the 1970s, this procedure in now a formal provision of a 1995 Memorandum of Understanding between the California Department of Fish and Game and the Regional Foresters of the Pacific Southwest, Intermountain, and Pacific Northwest regions of the Forest Service (USDA Forest Service 1995). It has proved helpful in resolving such conflicts, although they still exist in some western states. Duff (1995) discusses the federal/state relationship; and Landres, Meyer, and Matthews 2001 give detailed descriptions and histories of applicable laws, policies, and their implementation.

Views of User Groups

To gain insight into public views on stocking of wilderness lakes, officials of the nationwide organization Trout Unlimited, as well as Oregon Trout and California Trout (angler advocacy groups) were contacted because they are generally representative of the organized angling public. The philosophies of the three groups are essentially the same: Do not stock historically fishless, barren lakes, especially if the overall aquatic biota might be damaged by so doing. This is meant to include any indigenous life form. Where no harm will result from trout stocking, consumer groups favor its continuation. These views generally reflect those of the resource management agencies (with the exception of the National Park Service) and the public as a whole, and they are meant to include any water, either within or without wilderness boundaries per se (May 1977). Trout Unlimited's North American Salmonid Policy (1997) states: "Our focus on salmonids must not be so narrow as to exclude the broader ecosystem and its constituent species." It continues:

> Conflicts between nonnative salmonids and native threatened or endangered non-salmonid species already occur. . ., and Trout Unlimited recognizes that harm can be caused to freshwater ecosystems by human-assisted range expansions of trout or salmon. Trout Unlimited advocates that naturally fishless waters of natural diversity value not be stocked with non-native species at present or in the future. Further, where a body of scientific evidence shows that stocking in historically non-salmonid waters adversely affects native biodiversity, such stocking should cease. In all cases where stocking occurs, the burden of proof should lie with the state or federal agencies (or other proponents) to demonstrate that stocking does not cause ecological harm. (Trout Unlimited 1997).

However, it would be naïve to assume that the policies of the larger trout organizations are shared by all user groups, or even unanimously within their own memberships. There are many individuals who remain unsympathetic to the more sensitive and altruistic philosophies of their leadership and place angling success per se as their ultimate objective. Other users with similar views include pack station operators, outfitters, and groups that resist any change in the status quo and, usually with no apparent concern over ethical or ecological principles, place short-term consumptive interests above higher considerations.

Surely the largest user group comprises the vast number of anglers, unaffiliated with established organizations, who simply tie a rod onto their pack and head into the backcountry. Although angling may not be the primary reason for their trip, it is often an important one. If fishing is good, they will generally attribute it to a successful stocking program; if it is poor, their feeling will likely be that the water "needs stocking." For whatever reason, there remains a common assumption that equates good angling with regular stocking, even though in fact there may be little (or no) relationship between the two (Bahls 1992).

One of the more responsible user groups is the Trail Blazers organization in Seattle, Washington, a group of highly motivated and focused outdoorsmen who have assisted the Washington Department of Fish and Wildlife in wilderness lake stocking for nearly 70 years (M. D. Swayne unpublished). But even here one detects a distinctly utilitarian view of stocking, with little concern for those indigenous life forms that are inevitably im-

pacted and often extirpated by the introduction of nonnative trout species (Reimers 1979; McNaught and others 1999). Although the intent and energy of such groups are generally admirable, in terms of the big picture their programs tend to be shortsighted and overlook the long-term direction of society. Such groups may be generally supportive of wilderness concepts, but their primary aim remains one of creating and maintaining quality backcountry fishing, a goal not in accordance with the generally accepted definition of "wilderness." Such utilitarian programs are perhaps better characterized as "economically or politically expedient," since enlightened self-interest, the hallmark of utilitarianism, if carried to its logical limits, must lead to a policy of basic resource integrity and protection (Pister 1987).

Discussion: Is Wilderness Trout Stocking Worth the Effort and Cost?

It has never been apparent that stocking wilderness lakes really accomplishes much, other than perhaps in those very rare cases where it is impossible for natural spawning to occur. Even under the worst of spawning conditions, it seems that a few redds will occur somewhere. And inasmuch as the average allotment for a California lake might range from 2000 to 3000 fingerlings, only a very few (perhaps two or three) redds would be needed to produce this number of young. I have observed successful spawning of rainbow trout along windswept beach areas, in the absence of flowing inlet or outlet streams, and it seems likely that cutthroat trout (*Oncorhynchus clarki*) would do the same. I remain fully confident that if a nuclear holocaust should eliminate most of Earth's life forms, survivors would include not only cockroaches but brook trout as well.

However, entrenched bureaucracy is highly resistant to change. When it was suggested in the 1970s to Department of Fish and Game fisheries leadership that research was badly needed to evaluate effectiveness of the aerial stocking program, the proposal was summarily rejected. Although no good reason was given at the time, one can surmise the department's underlying rationale.

Following World War II, wilderness stocking was highly popular among the angling public. With strong political support, the department purchased expensive aircraft and structured its fish hatchery system to provide the desired fingerling trout. Motivated by a politically astute program administrator, movies extolling the virtues and methods of wilderness fish stocking by aircraft were widely distributed throughout the nation. Concrete information that served to question the effectiveness of this procedure would therefore have involved a lot of eating crow, the awkward (and politically difficult) position of disposing of expensive aircraft and crews, and downsizing of the overall fish culture program. It is also likely that the department was fearful of related reductions in angling license sales, one of its major revenue sources.

This type of blind, head-in-the-sand retention of the status quo is scarcely admirable to a scientist, but this is the way politics often works. Administrators and politicians remain fearful of any change that might affect popular programs. There are still many department employees (and employees in other states) who staunchly defend the wilderness stocking program in the absence of supporting data, but their reasons for doing so derive more from self-interest and politics than from actual necessity. We can always expect a somewhat negative reaction from those who would shoot the messenger. To end on a more positive note, the wilderness fish planting program now appears less popular than it was during its heyday in the decades following World War II.

Changing times

Another basic assumption that must be questioned is that sport fishing will continue indefinitely into the future as a major American pastime, especially in wilderness areas. California, with its huge population (currently in excess of 35 million) and its remarkable biodiversity and ecosystems, serves in a bellwether capacity here. It is highly significant that more Californians purchased angling licenses in 1965 that in 1995, although the state's population more than doubled during this period (Pister 1992). The question might well be asked, then, if managers have any defensible justification to continue the current practice of wilderness lake stocking when the future will almost certainly present a very different set of values and interests. The only way to prepare for an uncertain future is to make biodiversity and ecosystem preservation our highest priority.

Conclusion and Future Direction

Based on the management practices and policies currently in use in the West, Bahls (1992) made 12 recommendations that constitute a desired future direction for state agencies. To his paramount ob-

servation concerning the need for greater funding support for lake surveys and biotic inventories, I would add another highly important item. Research into the value (in terms of contribution to the angler) of backcountry lake stocking badly needs to be conducted. The western states are collectively involved in a massive and expensive wilderness stocking program, the value of which has never been conclusively demonstrated, and which is known to be destructive to native fauna and not in accordance with generally accepted wilderness values. Such a program should never be conducted in perpetuity without a proven scientific basis. The status quo therefore remains indefensible.

I have found through the years that when such controversies as wilderness fish stocking come under discussion, application of a corollary to Aldo Leopold's famous land ethic provides a very good answer: "A thing is right when it tends to preserve the beauty, integrity, and stability of the biotic community. It is wrong when it tends otherwise" (Leopold 1949). The question at hand obviously becomes fully as much a matter of ethics as biology. Inevitably, good ethical practice translates into good biological practice.

The philosopher George Santayana observed with great accuracy that those who cannot remember the past are condemned to repeat it. This thought may then be combined with a reconstruction of John F. Kennedy's famous admonition: Ask not what your biota can do for you; ask what you can do for your biota. Future management of waters that already contain introduced trout must be directed toward overall ecosystem health and stability, with biodiversity and ecosystem integrity as a paramount objective. Waters that have heretofore been spared from the introduction of trout must be vigorously protected, along with endemic life forms that exist in a complexity that will continue to transcend our absolute comprehension. Options for future generations cannot be preserved if introductions continue to erode the biodiversity of mountain lake ecosystems. This should be our greatest concern.

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