guideline

VOL. 3 No. 3 MAY/JUNE 1973

RECREATIONAL CARRYING CAPACITY OF THE NATIONAL PARKS

Dr. Theodore W. Sudia is presently Chief of Ecological Sciences in the National Park Service. Prior to entering the Service in 1969, Dr. Sudia was Associate Executive Director of American Biological Sciences.

James M. Simpson entered the National Park Service in 1967 and served as a park ranger in Great Smokies, Everglades, and the Virgin Islands. He is presently stationed in Washington, D.C. as a biologist.

The increasing congestion and overuse in parks and recreation areas in the United States and the concomitant deterioration of natural features and of developments has brought management agencies and visitors to the realization that it may ultimately be necessary to schedule park use. A more equitable distribution and some restriction of visitors at peak periods must be seriously considered as alternatives if we are to halt the adverse effects of overuse and to restore the ecological balance in our parks.

The problem is widely discussed as the "carrying capacity" for recreational lands, i.e. the number of persons for which an area can provide recreation while maintaining the conditions that originally made it desirable for that purpose. This definition implies that the natural characteristics of the area are of primary importance and form the basis for its management. The objectives and the policies of the managing agency are to determine the type of use appropriate to the area, the proper intensity of use, the degree of impact which can be considered reasonable, and the seasonal distribution of visitors. These factors are also important in assessing the maintenance effort required to improve conditions or to increase capacity without risk of loss of natural and aesthetic values. Thus, many of the major factors that determine the use of a park are contained within its enabling legislation and within the mandate of the agency's administration.

But the concept of carrying capacity for the National Park System implies to many persons an *a priori* decision process that takes into account the size, the character, and the significant natural features of an area, and allows the judgment to be made as to the number of people that can see or interact with it on the basis of the natural features alone. There is a desire to discover something inherent within each type of area that would allow this judgment to be made, such as a true "park" experience, or large crowds of people enjoying themselves, or some other aesthetic criteria of the people-park interation that does not significantly damage the resource.

How many people can be accommodated in a park before the park begins to deteriorate? This question is invariably preceded by descriptions of overcrowding in Yosemite, automobile traffic in Yellowstone and the Great Smokies, and campground congestion in Grand Teton. And the

(Continued on page 27)

guideline A PUBLICATION OF THE PARK PRACTICE PROGRAM

NATIONAL RECREATION AND PARK ASSOCIATION

CONTENTS

speaker might add that roads are crumbling under continuous use, campsites are wearing out, and larger areas of wilderness are showing the depredations of frequent trampling; that back-country lakes are increasingly polluted and the impact of garbage and trash in remote areas is reaching the acute stage. Sewage disposal is critical in highly developed areas and a worsening problem in wilderness. "Will success spoil the National Parks?" is a significant question that induces emotional overtones and the not-so-subtle suggestion that visitations to parks must be limited or the parks will be destroyed.

The problem of carrying capacity is significant to the future of the parks. It applies to the present use of the parks, the repair of damage already done, and the development of areas as yet undeveloped and in most cases untrammeled. In the face of increasing pressure, how can the commitment to public use be honored without further jeopardizing the resource that the Park Service is charged with maintaining for the use of all people for all time? Above all, how can use be made of the parks by the greatest number of people without detriment to the environmental qualities of the parks? Can the experience still be translated into environmental awareness and appreciation of our American heritage and be a satisfying aesthetic experience as well, replete with safe and exhilerating adventure?

Although the concept that every park has carrying capacity is generally accepted, there is some question whether the limit can be quantified in terms of number of visitors per hour or per day or whether the same formula can be applied to more than one area. Objective guidelines are needed so that a park manager will know that his area has reached its full capacity and that additional visitors will result in unacceptable deterioration. Such a guideline would be a valuable tool for any land-managing agency responsible for maintaining a resource and providing for its use, whether that resource is a wilderness preserve, a multiple-use recreation area, or a historic site or building in an urban setting.

Throughout the world there are myriad examples of the results of excessive use of preserves and natural areas in developed countries. Wherever shorter working hours, increased incomes, and improved roads and access have become available to the majority of citizens, the subsequent increase in tourism has taken its toll of the most precious of that nation's scenic and historic resources.

Widespread park deterioration has led to extensive research into carrying capacities but only now are we making progress in accumulating quantitative data. Many studies describe a complex array of biological, physical, social, and aesthetic factors interacting to influence the source and nature of impact and its effect on the resource, while others cite the lack of standards by which to measure biological alterations as an obstacle to quantitative guidelines. Moreover, the aesthetic qualities in nature are not amenable to quantitative measurement by resource economists and equally intangible are the complex relationships and the vagaries of human behavior that further effect the natural biota, the developed facilities and the enjoyment of other visitors.

Although the study of total park impact is formidable, many clues have long been available in the journals of agriculture, forestry, and ecology. Bates (1935) documented the effects of human use on the vegetation of "footpaths, sidewalks, cart-tracks, and gateways" and earlier Meinecke (1926, 1929) studied the impact of tourist travel in Sequoia National Park and California redwood parks. Subsequent studies have described the effects of touring, boating, camping, picnicking, hiking, skiing, or snowmobiling on coasts, lakes, back country, landscapes, ski-slopes, watersheds, caves, or tundra. Considerable data is available on the effects of trampling and other compaction on meadows, pastures, and woodlots (Steinbrenner, 1951; Lull, 1959; Free et al., 1940).

Detailed information provided by soil scientists has aided in documenting that the impact of continual campsite use extends far beyond the immediate evidence of exposed tree roots and reduced canopy. Knowledge of infiltration moisture regimes, organic decomposition, and nutrient take-up demonstrates the physical and chemical changes brought about by soil compaction. Soil condition effects the reproduction, growth, and vitality of vegetation at the site, which in turn effects the campsite's appearance, susceptibility to further impact, and its response to rehabilitation (Paparnichos, 1966; Jolliff, 1969).

Corresponding to the wide range of factors influencing park use, information from many non-biological fields is cited in the literature dealing with impact and capacities. Resource economics, land use planning, and landscape architecture are related disciplines that have provided data relating to problems of special concern to the park manager. The determination of visitor preferences and satisfaction relies heavily on the contributions of social scientists, and some recreational surveys have provided pertinent data in that area. Smith et al., (1969) conducted a survey of recreational boating populations aimed at learning the preferred activities of that group and Brewer and Gillespie (1967) compared indices useful for estimating satisfaction levels of recreationists for their preferred vis-a-vis actual activities. Willard and Marr (1962) examined effects on tundra in Rocky Mountain National Park and recommended that carrying capacities be established for the major ecosystems in the National Park System.

Wilcox et al., (1969) considered the sociological factors as determinents of impact and outlined areas where further work would be required, but failed to define the parameters by which such determinations could be made. Other park studies have examined specific instances of visitor impact. Hartesveldt (1963) reported that the effects of visitors on *Sequoia dendron giganteum* included significant changes in organic matter, nitrogen content, saturation percentage and potash in severely trampled soils. Witson (1970) studied the impact of human use on the Chisos Basin in Big Bend National Park, examining in particular the effects of horses and stock on trailside vegetation and on areas surrounding buildings and concessions. He found significant alterations in plant distribution and succession. Studies aimed at determining what controls are needed on the more popular lakes in the back country of Sequoia - Kings Canyon

National Park, are uncovering useful evidence related to human impact. Limitations have been imposed on river floats in Grand Canyon and remote campsite use is held to a fixed number in those areas in the inner canyon that have been damaged by too many hike-in campers (Arron 1971). These restrictions are similar to those imposed by the U.S. Forest Service in New Hampshire's White Mountain Forest, where increased camper impact at trail shelters has required special regulations and limits on users.

The variety of needs and objectives of different environmental agencies and the broad range of interests motivating individual and groups of conservationists are reflected in the diversity of research now being conducted in land use planning and environmental impact. Significantly, much of the accumulating data is basically useful to all natural resources management. Recent advances in biological simulation and modeling; computer mapping; remote sensing; technical information systems; and improved monitoring methods in air and water quality and other environmental parameters are particularly helpful.

Continuing efforts are producing quantitative criteria with which to measure even some of the less tangible factors such as the individual's personal satisfaction with natural values. The difficult problem is to apply these accumulating data to the objectives of the agencies that administer public lands. The problem is compounded by what may be called a "floating baseline." The personal satisfaction an individual derives from a "park experience" will depend to a great extent on his first experience. Each generation "rediscovers" the parks, wilderness, and natural areas, and the condition in which they are found will influence their appreciation or lack of it. Thus it is important for park managers to retain the continuity of experience and skills to preserve and maintain areas, and to regulate use in order to provide the authentic environmental circumstance in which a satisfactory park experience can occur.

In view of the significant implications of carrying capacities, the diversity of present thinking and research, and the complexity of man's activities in our parks there is need to institute practical means to minimize the impact. The

NPS Photo

concern of the National Park Service relates to national parks, monuments, and historic sites but the principles are applicable to other agencies and to any park situation. Some of the national parks already have areas suffering from overuse, and these are appropriate places to develop the necessary controls. Secretary of the Interior Morton took the first step on March 1, 1972, when he announced a temporary, experimental program aimed at dispersing visitors over a wider region and limiting their numbers in remote areas of Great Smokey Mountain, Yosemite, and Sequoia-Canyon National Parks.

The concept of carrying capacity as it is sometimes used gives the false impression that there is an *a priori* method of determining the capacity for any given parcel of land or natural resource. However, carrying capacity is not a primary factor in the interaction of people and a resource, but is a derived or dependent factor which is subject to precise definition after the parameters of park development have been determined. The primary factors or parameters of carrying capacity are those elements of park planning and development that determine how people are to be *accommodated* and *contained* within the park.

To illustrate carrying capacity at its two extremes, first consider a true wilderness – in reality a trackless forest, desert, mountain fastness, or prairie – where the only trails are animal trials. The carrying capacity of a true wilderness is zero or a very low number.

By definition, it is the number of human beings that could occupy the land, either temporarily or permanently, without disturbing the ecosystem in any way. They would take little or nothing into the wilderness, remove nothing from it, and nothing would be rearranged. If the wilderness is to be preserved, man must function in it as an intimate part of the ecosystem and without benefit of technology. His actions would not be discernable from the ecological events of the area so that he would, in effect, be integrated into the natural system.

At the other extreme, Times Square in New York City represents the ultimate in development for human use; hundreds of thousands of people use Times Square every day. It is the epitome in urbanization with its concrete, steel, and glass-hardened surface; quite the opposite from the wilderness. But as soon as the first improvement is made in the wilderness – the first trail cut or the first stream bridged – the urbanization of the wilderness begins. From trails to roads and from campsites to motels is only a matter of degree of urbanization that progresses from the primitive to the highly technical.

When man makes improvements in the environment he is usually accommodating the environment to himself. The cutting of a trail in the wilderness is an accommodation to man; roads are a further accommodation to man and his animals and machines. This is the beginning of total urbanization of the environment that only ends when the entire complex is given over to man and his machines and activities, as exemplified by Times Square or the downtown of any city. If we are to understand carrying capacity, we must first understand that when man shapes the environment to his own purpose he is fashioning containers or compartments for his activities, and it is the capacity of these containers or compartments that are the ultimate parameters of carrying capacity.

Carrying capacity is the ability of the developed landscape or park to contain people in compartments. The simplest compartment is a trail. How many people can use a trail? The answer depends upon a number of factors. If the trail is long and broad the number is quite large, but its capacity also will be influenced by the rate of travel of the individuals using it, whether they are on foot, bicycles, or horseback; the number of places people will wish to stop; and whether the trail is circular or whether the return must be made in the opposite direction on the same trail. If the trail is hazardous, its limit will depend upon the number of people that can travel it under supervision. From trails to roads with pullouts and overlooks, and from campgrounds to hotels, visitors centers, golf courses, and museums is merely a matter of degree, with each new development increasing the capacity for visitation and creating its own limitation parameters. Each facility in a national park has a certain size, potential filling and emptying rate, and a certain population restriction when maintenance is in progress. If maintenance is not possible during use, the facility will degrade faster than it can be maintained and a reduction in capacity will result.

From each developed facility within a park, there flows a transition of disturbance from the center of the facility to some place in the natural environment. The simplest example is a road. The center of disturbance is the center of the road and the transition occurs through the berm, the roadside, and into the surrounding vegetation. In all park development it is desirable to minimize the transition of disturbance from the developed facility to the natural vegetation, and to a large extent this will depend upon the design of the facility itself.

A campground located behind an amphitheater demonstrates the problem. Let us assume that access to the campground is on roads parallel to the sweep of the amphitheater. The main foot traffic flow from the campground will not be along the roads, for that is the long way, but through the wooded area between the campground and the roads. If regular pathways had led to the amphitheater, the zone of disturbance would have been minimized by being channeled and absorbed within fixed corridors that can be hardened to resist wear and be easily maintained.

Each developed facility in a park will have a potential maximum capacity. For a motel it depends upon the number of rooms; for a parking lot it is the number of parking spaces. We do not usually think of a road or highway as a container but, nonetheless, there is a maximum capacity for any road. For trails, the concept is even more elusive but it exists. The crowds at the C&O Canal National Historical Park at Great Falls, Maryland, are an indication of the capacity of the canal towpath for it is bounded by a high wall on one side and the canal on the other. A wilderness trail in the high country may have other features that define its limits.

NPS Photo

In addition to the maximum capacity for each developed facility there is an optimum capacity. The optimum capacity is reached when the degradation of the facility does not outpace its maintenance. If the facility is a road or path or trail, its optimum capacity keeps the zone of disturbance to a minimum and hazards to life at a minimum. If the facility is a wilderness campsite, the optimum capacity may be that level of use that does not cause the pollution of streams or lakes in the area; or that does not significantly alter the appearance of the wilderness site by trash disposal, use of firewood or bathing or washing clothes; or does not cause the deterioration of vegetation in the vicinity.

It is safe to predict that as visitors to national parks increase, the frequency of maximum capacity for the developed facilities in the park will increase at a similar ratio. This will make maintenance difficult and facilities will deteriorate. It is the degradation of the developed facilities, as much as the disturbance of the surrounding area, that leads to degraded visitation.

Although the view in Glacier National Park along Going-to-the-Sun Road will never wear out, the condition of the road, the congestion at the pullouts, and the inconvenience created by large numbers of visitors at the Logan Pass Visitor Center may lessen the enjoyment of the trip. How many road repair crews, stalled cars, and full turnouts are required to significantly reduce the capacity of the road to handle cars and to diminish the enjoyment of an otherwise magnificent mountain drive? How can the interaction of people and tundra be manipulated to reduce to an absolute minimum the zone of disturbance between the developed facility and the tundra itself? Tundra is no more fragile than a grass lawn – the rate of growth of grass and its rapid recovery from abuse are what make it different from tundra. Tundra sod strips placed on the upslope side of road cuts at Trail Ridge in Rocky Mountain National Park have not grown appreciably since their placement in the 1930's.

The construction of a path, instead of permitting visitors to roam at will is a start to containing the crowds at Logan Pass. The erection of walls, some attractive fences and other devices will also work. An elevated boardwalk is a nearly perfect container because it completely separates the people from the resource without inhibiting their enjoyment of it, and is in sharp contrast to the multiplicity of trails and paths that form when people traverse the tundra at will. Only a boardwalk through Anhinga in the Everglades makes it possible to traverse an otherwise impassable swamp and the boardwalks at Logan Pass and Anhinga provide "windows on the wilderness." A boardwalk in Bird Park at Hawaii Volcanoes National Park would prevent the destruction of undergrowth and of the magnificent Koa trees.

Before additional facilities are introduced into the parks, care must be taken in assessing their impact upon the area. At the general development concept of planning stage it should be possible to predict within certain limits what the capacity of any given area will be. We know from experience that areas that are developed only to the extent of a trail are little used unless the area is a lawn or lawn-like, such as tundra and that areas that are highly developed such as the village at Grand Canyon attract high visitor use. It is or should be obvious that planners are in part estimating use when they design facilities.

Moreover, in considering the alteration to the vegetation it is equally important to consider the response of the animals, especially if they are large and potentially dangerous. The carrying capacity of certain areas – Canyon Campground in Yellowstone, for example – is reduced during those times of the year when grizzly bear activity is a potential hazard to human occupancy. Multiple use of such areas is possible, but in order to maintain the natural fauna the carrying capacity is reduced because the seasons for visitors must begin later and end earlier and the circumstances require a closed vehicle for camping. The Camus Creek Road in Glacier National Park poses similar problems because the road sides are seeded to timothy and clover and the early spring green-up of these plants attracts grizzly bears. The potential hazard to visitors along this road may have repercussions similar to those of campgrounds built in prime bear habitat.

The optimum capacity for any developed facility in a park is related to its maintenance. If the rate of degradation exceeds the rate of maintenance, only two alternatives are available: maintenance must be increased or visitors must be decreased. The first alternative is only a temporary solution because usually the number of visitors increases at the same rate as the size and convenience of the facility. Optimum use is not a single-factored phenomenon, nor is any ecological relationship, and carrying capacity is an ecological relationship of people to facilities and resources.

Best judgment decisions have to be made regarding the optimum capacity for each facility and these decisions must be soundly based on reasonable maintenance of developed facilities and of the related natural resource. A bear attack on a visitor using the Camus Creek Road in Glacier must be attributed to road maintenance because the practice of seeding the road-slopes with timothy and clover attracted the bear to that location. Similarly, bear attacks in the vicinity of garbage dumps must be attributed to the efficiency of garbage disposal, another maintenance cost.

Based on developed facilities of known capacity, known rates of movement into and out of these developed facilities (roads, trails, buildings, etc.), and established optimum use levels the actual numerical carrying capacity of any park can be determined. The carrying capacity will not relate to the number of acres of natural area within the park boundaries, but will relate to the population capacity of the developed areas of the park. The determination of the carrying capacity of a park, however, requires some qualification. For example, if the 800,000 acres of Yosemite were developed like Disneyland, the carrying capacity would be very large indeed and conversely, Yosemite with no development at all, not even roads or trails, would have very little capacity. When Stephen Mather prepared his road plan for Yosemite he did not visualize it being gridironed with a road system that would make every part accessible; Mather's plan included large portions that would be accessible only on foot or on horseback (National Park Service Road Folder). This decision limited the overall carrying capacity for Yosemite, and rightly so since only through limited access can the wilderness aspect be maintained.

The carrying capacity of a park, then, is determined by the capacity of the developments and facilities, and whether occupation will be maximum or optimum is determined by the extent to which occupancy affects maintenance, including maintenance of the natural resource. The decision to limit occupancy, while soundly based vis-a-vis maintenance costs, will nevertheless be a best judgment decision. Good maintenance is not compatible with a stream of cars and campers entering a park when an entrance sign says, "All campgrounds full." Placed in this context, we can recognize that carrying capacity is largely a systems analysis problem. There may be many variables, with a consequently large number of equations, necessary to solve the problem, but it remains a straightforward analysis problem. Maintenance and engineering personnel can supply maintenance estimates for roads, trails, and structures and these, together with noticeable effects on the natural vegetation will form the basis for establishing optimum usage. The role of the ecologist in determining the equation will focus on the unacceptable degradation of the natural environment. There is no magic formula for determining the carrying capacity of a natural area and for a park the determination can be made only after the developments are incorporated into it, for without them the concept of carrying capacity has no practical meaning.

Finally, then, carrying capacity is dependent upon master planning, which must in turn, be based on fundamental ecological principles. Assurance of this consideration has been stated in two of the criteria for an adequate park master plan (NPS Service and Planning Standards) which:

1) describes the overall concept for the preservation and use of the area, including the role and degree of development; and
2) identifies and describes ecological and developmental limitations of visitor use which provide the framework for park capacity.

One of the most costly mistakes in master planning is failing to realize that most developments are merely downpayments. Over the long haul, maintenance of the facility and restraining the degradation of the concomitant natural areas will be far costlier. Poor judgment left uncorrected will cost not only the initial investment, but also will require excessive maintenance upkeep and perhaps corrective measures at a later date. The failure to abandon a campground that is plagued by problems with bears or the subsequent necessity for a floating breakwater for a marina that could have been built in a lee cove are examples of a poor understanding of all the environmental costs associated with development.

The key to establishing carrying capacity lies in recognizing its relation to environmental degradation and in limiting the use of a facility when an imbalance between degradation and maintenance is reached. Maintenance costs include repair of physical damage to the facility or to the surrounding natural area, e.g. bear attacks or law enforcement problems; highway accidents or the pollution of back country lakes. The maintenance of any ecological situation implies the ability to regenerate, restore, rehabilitate, or reequilibrate the community. When this ability is lost, the vigor and vitality of the community are lost with it and degradation and destruction follow.

To maintain the parks unimpaired for future generations, the interrelated concepts of park development, carrying capacity, and cost of maintenance must be thoroughly understood. Sound planning based on ecological principles, determination of optimum use, and the techniques of systems analysis should speedily produce the needed answers for any present or contemplated development. Since carrying capacity is so obviously a systems analysis function, it should be no problem to construct mathematical models of park developments and apply systems analysis to the master plan prior to construction. Such a system should do much to enlarge the horizons of planners, ecologists, and engineers alike, and should ultimately lead to the most efficient patterns for park usage.

While many factors interact to affect the capacity of a natural area for recreational use, one of the most critical problems facing the National Park System is determining when the number of visitors exceeds the point where developments are no longer adequate or efficient or desirable.

The mandate to provide for public use and preserve our parks has continually tested the training and dedication of men and women of the National Park Service who are responsible for the traditionally high standards of the parks, and resolution of the dilemma has long relied on the soundness of their personal judgments. Many park managers know approximately how many persons their park can accommodate, and as visitation increases at a linear rate the attendant problems can be solved by adding seasonal personnel or by intensifying maintenance. But at some point the problems and incidents associated with visitors increase at a rate disproportionate with the number of persons or cars, and may even approach logarithmic proportions. Experience shows that enlarging picnic grounds or designating overflow camping areas does not solve the problem. When by-pass roads are built in the parks, traffic increases and still is unable to move freely. As with an ungulate range, a campground may resist moderate use and be able to renew its vegetation for the next season, but if perpetually "overbrowsed" the reproductive base is killed and may require years to repopulate and regenerate. When the cost of maintenance outweighs its effectiveness acceptable capacity has been exceeded and the decision to limit visitation or to institute other controls must be made in time to forestall damage to the park. It is essential therefore, to adopt a realistic capacity for use; one that provides the necessary margin for carrying out maintenance without shutdowns or impairment of service and that can adapt to feedback from any of the physical, biological, or aesthetic indicators of overuse.

The primary elements of carrying capacity center on a few important concepts, the most essential of which is that *carrying capacity* is a function of development. *Minimum capacity* is an economic concept, i.e. if the cost-benefit ratio is such that the development is precisely justified by its use, it is operating at minimum capacity; if fewer than the minimum capacity use the facility there is reason to question the merit of its inception.

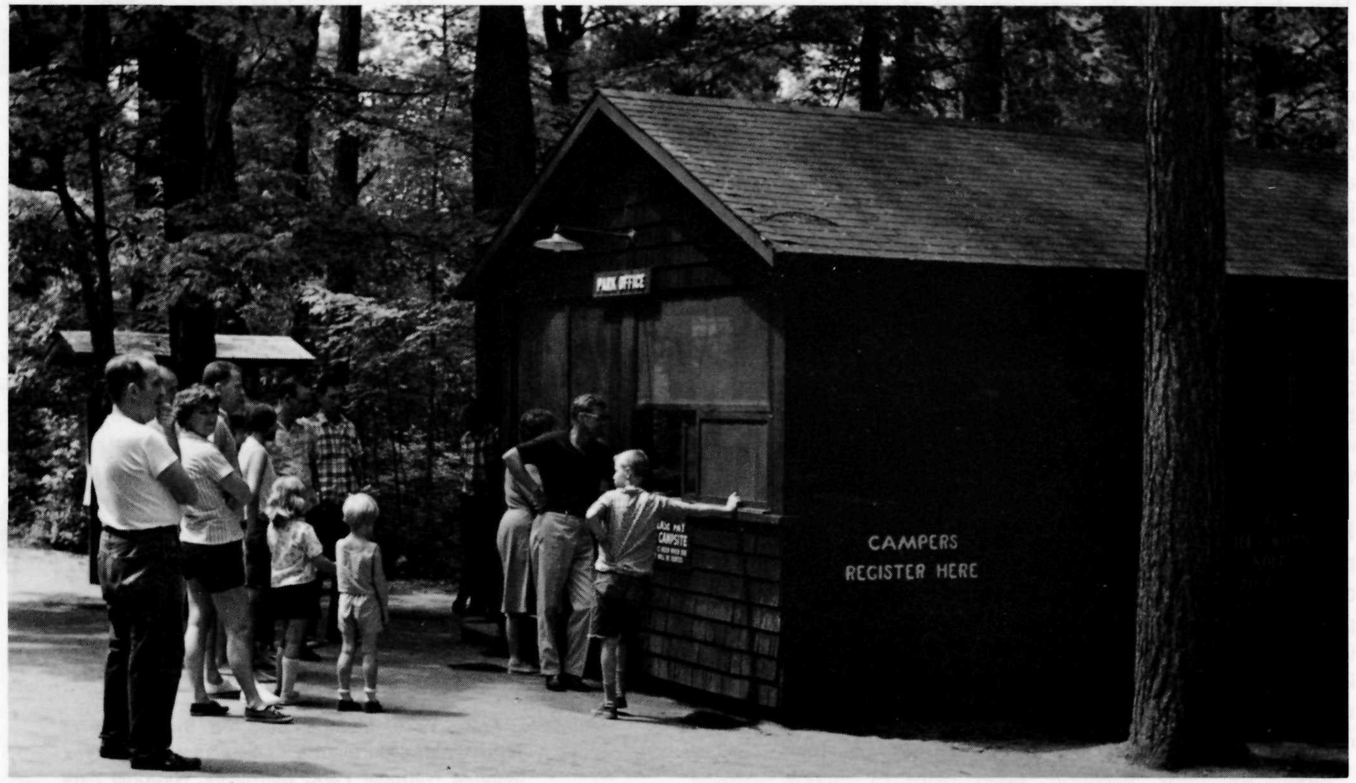
The *design capacity* reflects the master planner's concept of "best use" of the area in question. The initial considerations of master planning must take into account the character of the resource and its natural properties and the best manner in which the resource can be enjoyed. Design capacity must be based upon engineering considerations for construction, utilities placement, access, circulation of vehicles and people and adequate water supplies and garbage and sewage disposal. The design capacity is the absolute number of spaces allotted for people in the master plan. It includes the total number of campsites, trailer and camper sites, parking spaces, motel rooms, etc. The design capacity will determine to a large extent the actual use but will not be congruent with actual use.

The *maximum capacity* is the upper limit of people who can be accommodated in the developed areas of the park if the threat to the development or to the surrounding natural resource is ignored. Maximum capacity under some circumstances can exceed the design capacity, as when rooms designed for double occupancy are occupied by more than two persons. When people spill out of the developed areas of the park and spontaneous development occurs in unplanned areas, the park is *over capacity*. Parking, camping, viewing and other activities conducted at unauthorized locations are all symptoms of over capacity, as are excessive traffic accidents or law enforcement problems that are beyond the ability of the regular staff to handle.

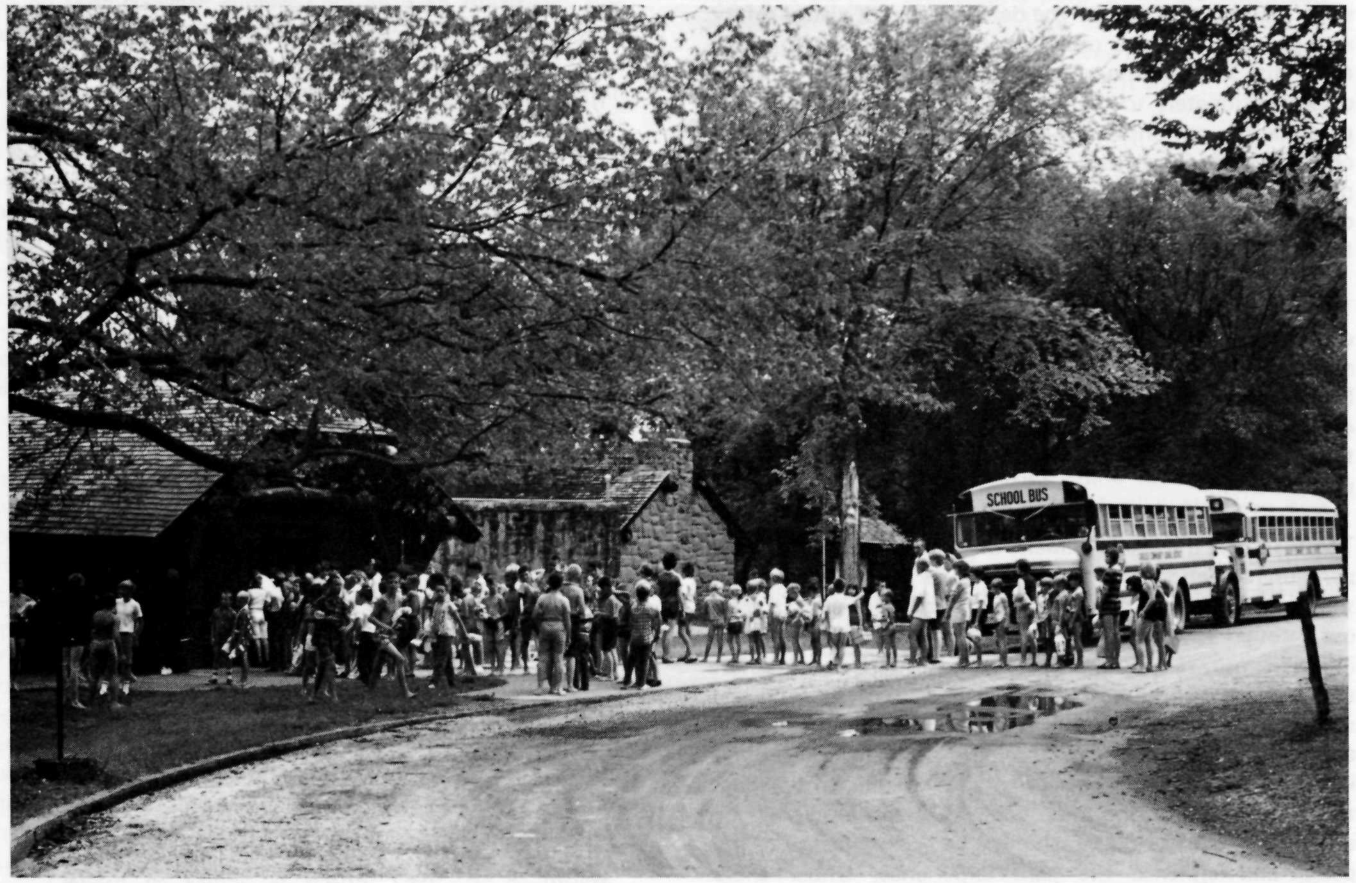
The *optimal capacity* for park areas centers on two concepts: (1) that under conditions of optimal capacity the natural resource adjacent to developed facilities does not degenerate faster than it can regenerate itself or be regenerated (by planting, seeding, fertilizing slope stabilization, etc.); and (2) that the development is not deteriorating faster than it can be maintained given the economic resources available.

Acceptable cost is a necessary modifying condition. Optimal carrying capacity is the use level of a park area at which the natural resource does not deteriorate faster than it can be regenerated and where maintenance of the development is at a reasonable level and for which the dollar value is either remaining constant or diminishing.

The use of a facility sometimes contributes to its maintenance and, conversely, nonuse of an area, particularly a building, may quickly cause the deterioration of the facility. Adequate maintenance will halt the deterioration of a facility but it may not be economically justified if use is deficient.



BOR Photo



BOR Photo

The arbitrariness of the establishment of optimal carrying capacity focuses on several factors. One is the judgment of the park planning and design staff in the initial concept for development. It is here that the binding decisions of the circumstance of the "park experience" are made and they must be based on enlightened ecological, environmental, and engineering judgment. The second point of arbitrary judgment is the determination of what constitutes acceptable change in the natural environment. The definition of change as deterioration will automatically evoke the concept of overuse. The extent to which change is detrimental is a well-informed ecological and environmental opinion based upon adequate baseline data for the area. Thirdly, the park manager must judge which human behavioral attributes fall within the prescribed uses of the park or recreation area, and his sound judgment can prevent law enforcement problems from getting out of hand.

Each of these factors are warning indicators that tell the park manager that optimal capacity is being exceeded. Of course, part of the concept of development is related to park staff, which, in turn, is related to the number of visitors, the services expected and the nature of the area involved. When the demands for service exceed the capabilities of the park staff, optimal capacity is being exceeded regardless of other factors.

The available evidence is subtle and elusive, but there are indications that deterioration of facilities and resources may be a geometric function of the number of people. The same may be true also of the deterioration of visitor safety and protection. At a certain point the incidents of auto accidents, lost or strayed children, thieving, etc., increase disproportionately to the increase of people. This seems to preclude the notion that to increase either the development or the staff is an easy solution to carrying capacity problems, and also reinforces the view that scheduling for optimal use, with perhaps an increase in the total recreational park system, is a valid concept.

The systems analysis approach augmented by defining and delineating arbitrary parameters based upon sound judgment is the answer to the carrying capacity problem. Finally, it must be added that when the park is operating at optimal capacity it will also be operating at standard, for these concepts represent two manifestations of the same phenomenon.

The fear that the establishment of a carrying capacity for a park or recreation area will lead to its reduced use is not supported by the evidence. The increased efficiency of park use through scheduling will, in most instances, bring about increased use. It is optimization of use that is the criterion and this means the seasonal distribution of use and the reduction of peak loads that are the cause of most damage and present the greatest management problems. By supplying the information necessary to allow people to schedule their park visits during times when they can efficiently be accommodated we will increase the carrying capacity of the parks and enhance the park experience. Under these conditions the parks can be maintained unimpaired for the enjoyment of future generations.

LITERATURE CITED

Anon., 1971. Conservation backtracking- White Mountain National Forest. Prairie Club Bulletin, No. 605 March p. 5.

Bates, G.H., 1935. The vegetation of footpaths, sidewalks, cart-tracks and gateways. J. Ecol. 23:470-487.

Brewer, D. and G.A. Gillespie, 1967. Estimating satisfaction levels of outdoor recreationists. J. Soil and Water Cons. 22(6):248-249.

Free, G. R., et al. 1940. Relative infiltration and related physical characteristics of certain soils. U.S.D.A. Tech. Bul. 729 52 pp.

Hartesveldt, R.J., 1964. Sequoia-human impact analysis. Memorandum to Regional Director, National Park Service, San Francisco Feb. 10, 1964.

Jollif, G.D., 1969. Campground site-vegetation relationships. Ph.D. Dissertation, Colorado State University, Fort Collins, Colorado.

Lull, H. W., 1959. Soil Compaction on forest and range lands. U.S. Forest Service Misc. Pub. 768. 33 pp.

Meinecke, D.P., 1928. Memorandum on the effects of tourist traffic on plant life, particularly Big Trees, Sequoia National Park, California. National Park Service Report. 19 pp.

Meinecke, D.P., 1929. A report upon the effect of excessive tourist travel on the California Redwood Parks. Calif. State Printing Office, Sacramento, Calif. 20 pp.

National Park Service, 1968. Road Standards. Sup Doc.

National Park Service, undated. Planning Standards. GPO, 780-495. Washington, D.C.

Papamichos, H. T., 1966. Light, soil and moisture conditions in areas of heavy recreational use. M.S. Thesis. Colorado State University, Fort Collins, Colorado.

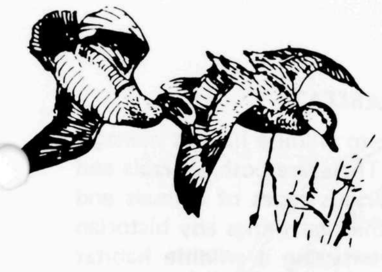
Smith, Gorman, and H. Linsert, no date. A recreational boating-population-statistical information system. Vol 1. Undated Executive Summary. Information Concepts, Inc. 1501 Wilson Blvd., Arlington, Va. 22209. Typed 1 page.

Steinbrenner, E.C., 1951. Effects of grazing on floristic compostion and soil properties of farm woodland in Southern Wisconsin. J. For. 49:906-910.

Whitson, P.D., 1970. The impact of human use upon the Chisos Basin and adjacent lands. Univ. of Okla. Res. Instit. Norman, Okla. National Park Service Report. 120 pp.

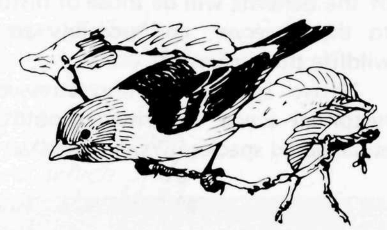
Wilcox, A.T., R. B. Held, and S. K. Brickler, 1969. A study to develop criteria for determining the carrying capacity of natural areas in the National Park System. Center for Research and Education, Estes Park Colorado. National Park Service Report.

Willard, B. E., 1962. Effects of visitors on natural ecosystems in the Rocky Mountain National Park. Institute of Artic and Alpine Research University of Colorado. National Park Service Report.



WILDLIFE MANAGEMENT
for the Historical Area

Lloyd M. Pierson is presently an Archeologist with the Bureau of Land Management in Denver. Mr. Pierson entered the National Park Service in 1948 at Aztec Ruins and served at Tonto, Montezuma Castle, Arches, Natural Bridges, Shenandoah, DeSoto and Appomattox Courthouse, until he transferred to BLM in 1966.



By Lloyd M. Pierson

The accent in historic preservation in recent years has tended toward preservation of the total environment and the preservation of the entire historic period scene. To do a job on the natural environment worthy of the already fine jobs being done on building preservation, the historian today finds himself in a position of having to have some knowledge of natural history and of wildlife management in particular. He finds his history, his historic building, and his historic site did not float in space - it was a part of a landscape altered and used by both man and animals. At the same time the historian may control many acres in his historic preserve, many of which have little to do directly with the historic events with which the area is concerned. Whatever the reason for having these acres, the historian is finding that they are becoming more and more valuable because they are open space, natural areas, or park land which has value as high as, if not higher in some cases, than the historical values for which it was acquired.

If the historian is to be true to the tenet to reproduce the historical scene as faithfully as possible, then one of the things he must do to enhance the value of the acreage he controls and still retain or enhance the historical scene is to encourage the maximum production of wildlife on these acres. It is difficult to ascertain in many cases just what the wildlife situation was at the time of the historic event being preserved; but an over-abundance of wildlife today usually will not detract from the historic scene. Even if the area is developed to the point today, for instance, that deer are seen on the historic area quite frequently and they were rarely seen back in the historic time, it is not warping the historic scene too much, for the important thing in making the observation of deer in a natural setting easier for the visitor so he realizes that deer were a part of the history. The visitor to most historical areas rarely stays very long as he does in natural areas so that what he carries away with him is a small vignette of that historic scene. If he does not see birds and animals—they remain out of his memory.

There is, of course, a danger of over-emphasizing the wildlife and the natural scene to the detriment of the historic scene. In most cases, however, they are highly complimentary if given forethought. It is a rare historical area that is not deficient in many species that are an important part of the historic past. There are also many species that are gone and cannot ever be substituted, as with the passenger pigeon, so that even at best we can only reproduce most of the original scene - not all.

MANIPULATED SCENE

Most historical areas have the natural and historical scene manipulated in some way. The grass is mowed, the bushes trimmed, the weeds and shrubs along the roadways cut down, and in general, a parklike atmosphere prevails in most historic areas. This is true even in the most accurate of our historic period restorations. There are no mudholes or broken fences or shutters hanging on one hinge, or piles of dung in the streets, or weed patches - all are usually maintenanceman perfect.

Unfortunately for both history and wildlife, this is not always the best or the accurate thing to do. There is a better balance than the sterile perfection that we now frequently have; balance that will tell it more "like it was" and with the addition of wildlife types that were there during the historical period—a balance that will also help to preserve wildlife that would not otherwise be preserved.

In many of our urban situations and even some of the rural ones, the historic areas provide the only sanctuary for many of the smaller species of animals. This situation cannot help but become more acute as time passes and the historical area, if it does not plan to get involved now and on its own terms, may find itself forced into a much less desirable position in the future. Hunting organizations and wildlife conservation organizations all are looking for ways and places to increase the wildlife they deem most desirable. These species are not always those of value to the historic area. Our object here is to present to the historian

and the historical area manager some of the basic principles of wildlife habitat management and how he can apply these principles to an historical area to provide for enhancement of both the historic scene and the natural scene through better wildlife production. Because most historical areas are too small to allow for significant production of many big game species for hunting purposes and the concentrated people—use of the area in addition to a normal anti-hunting policy does not allow for hunting within most areas, the emphasis in the habitat management here is primarily for wildlife observation purposes. Some benefits will undoubtedly accrue to the hunter cruising the boundaries of the historical area but these will be secondary or minor. Most of the benefits will be those of historic scene enhancement, to the observer, and possibly to the scientist and the wildlife themselves.

Native species are also stressed in deference to the historical scene. Priorities should be given to rare and endangered species. *(See Checklist on page 40)*

A brushy fence line -- good habitat for small animals and birds.

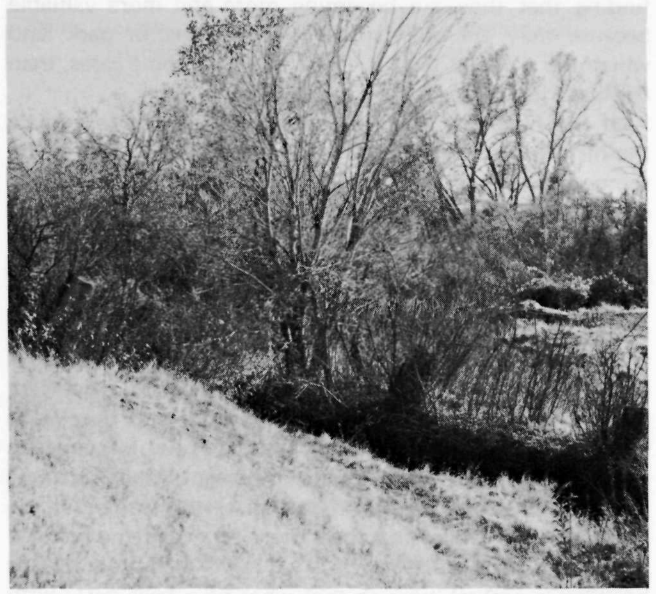
Rush covered shallow lake bed -- good for ducks and other bird life.

A BASIC HABITAT

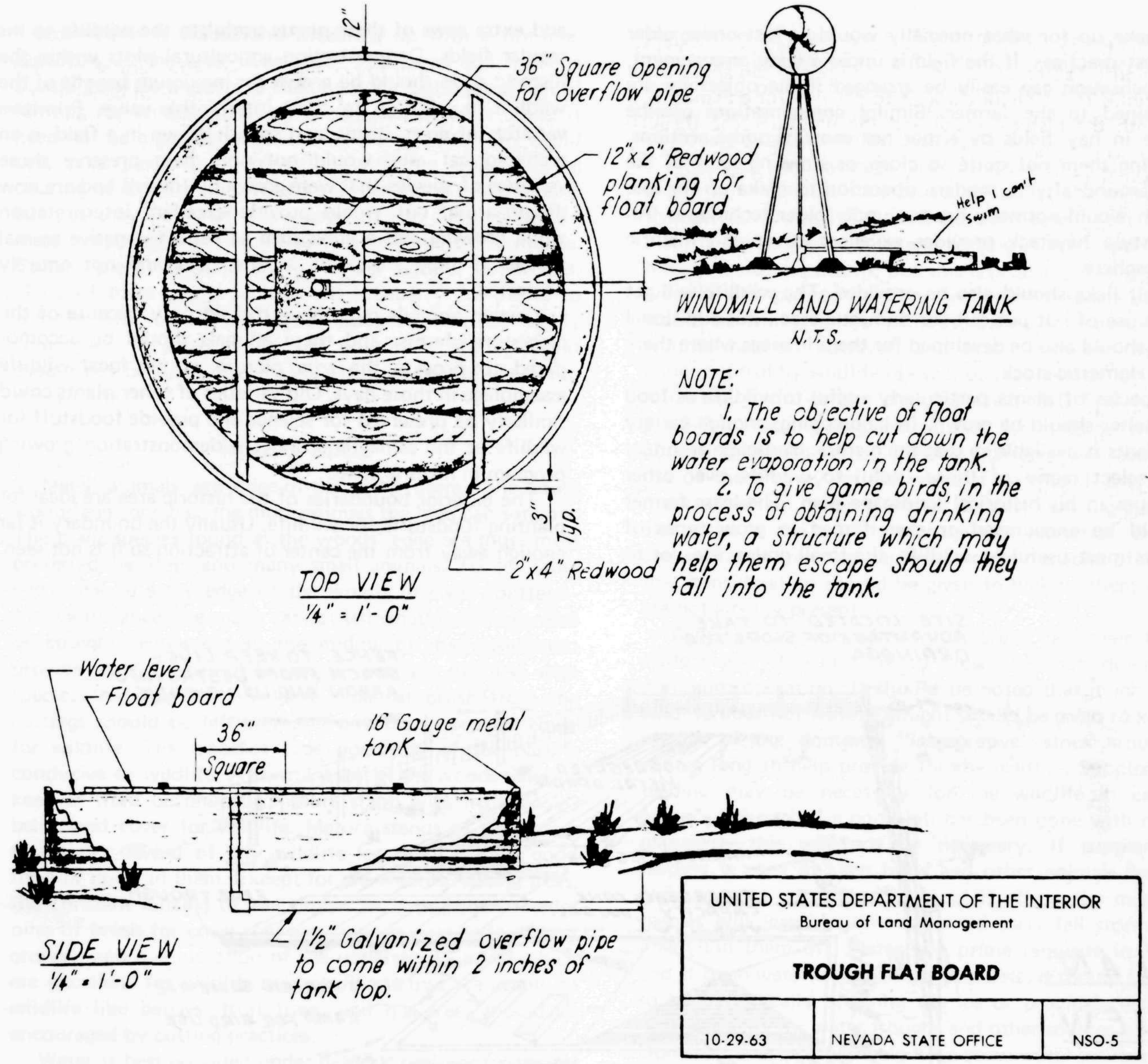
There are three things basic to wildlife habitat management: food, cover, and water. There are both generals and specifics as to the needs of various types of animals and species in these areas. One of the first things any historian should do in contemplating initiating a wildlife habitat management program in his area is to contact the nearest state game technician or Bureau of Sport Fisheries and Wildlife technician and the county farm agent to get sound detailed advice. What is given here can only indicate general direction and some of the possibilities that exist.

The biggest detriment to wildlife in historic areas is the tendency to manicure: to produce a parklike appearance of the area which shows the staff to be doing an excellent job. Actually our ancestors were much more sloppy in many of their practices than we would admit them to have been. Many of their practices in agriculture and village life were ideal to the production of wildlife—even though not intentionally done.

A good example is the old-fashioned mudhole. In old towns, villages and countrysides, most of the streets and roads were dirt, and mudholes were a common occurrence. The mudhole is important to a wide variety of animals including birds, small mammals, and insects who depend on the mudhole for water and for mud to build their homes. The mud dauber wasp, the robin in spring, the skittering chipmunk, all have some dependence on the mudhole. It is difficult to defend the mudhole today but there are substitutes. If part of the historic scene involves water troughs or domestic animals, the watering area should be allowed to get somewhat muddy to compensate for the lack of mudholes in the street. Rather than draining the gutter spout into a cistern as in the old days, or into a sewer system as we do now, let a few mudholes develop by some of them as did also occur in the past. A domestic pig or two under historic conditions will not only provide mudholes, but smells that are frequently missing from the historic scene. Domestic animals in general provide much for the wild ones, especially if the domestic animals are kept under



Small areas of trees with heavy undergrowth are excellent wildlife habitat.



conditions similar to those our ancestors used rather than "cleaning" up the process. Broadcast feeding of chickens was standard and provided enough food also for a good-sized flock of sparrows and other birds. The horse and the English sparrow had a symbiosis going, based on horse droppings, that was close enough so that when the horse was replaced by the motor car, the English sparrow went the way of the horse. Any domestic animal kept for the historic scene aspect will contribute greatly to reproduction of wildlife that naturally associates with them if raising conditions of the domestic stock are kept primitive.

Because of tort claims from falling trees, most maintenance crews pay careful attention to the removal of rotting or hollow trees. In heavily visited areas this is necessary and wise, but if carried too far it is detrimental to species needing hollow and rotting trees. Woodpeckers, squirrels, titmice, and others need this type of situation for food and shelter. These trees should be preserved wherever and whenever possible in and about the village, in out-of-the-way places and in the woods and along the highways where they endanger no one. If they are not available, artificial nesting should be provided.

Bird houses are ideal for keeping numbers of birds within observation areas. Certain types are historically correct and should be made part of the historical scene. Wren houses and purple martin houses have had a close association with historical scenes for some time. Other species like bluebirds and wood ducks need housing because of the destruction of natural nesting situations by modern developments. Houses for these species can be placed in inconspicuous locations—the backside of posts in fence lines. Birdhouse building projects and upkeep can also contribute to public relations if the project is given to a local conservation-minded group like Scouts or natural history clubs.

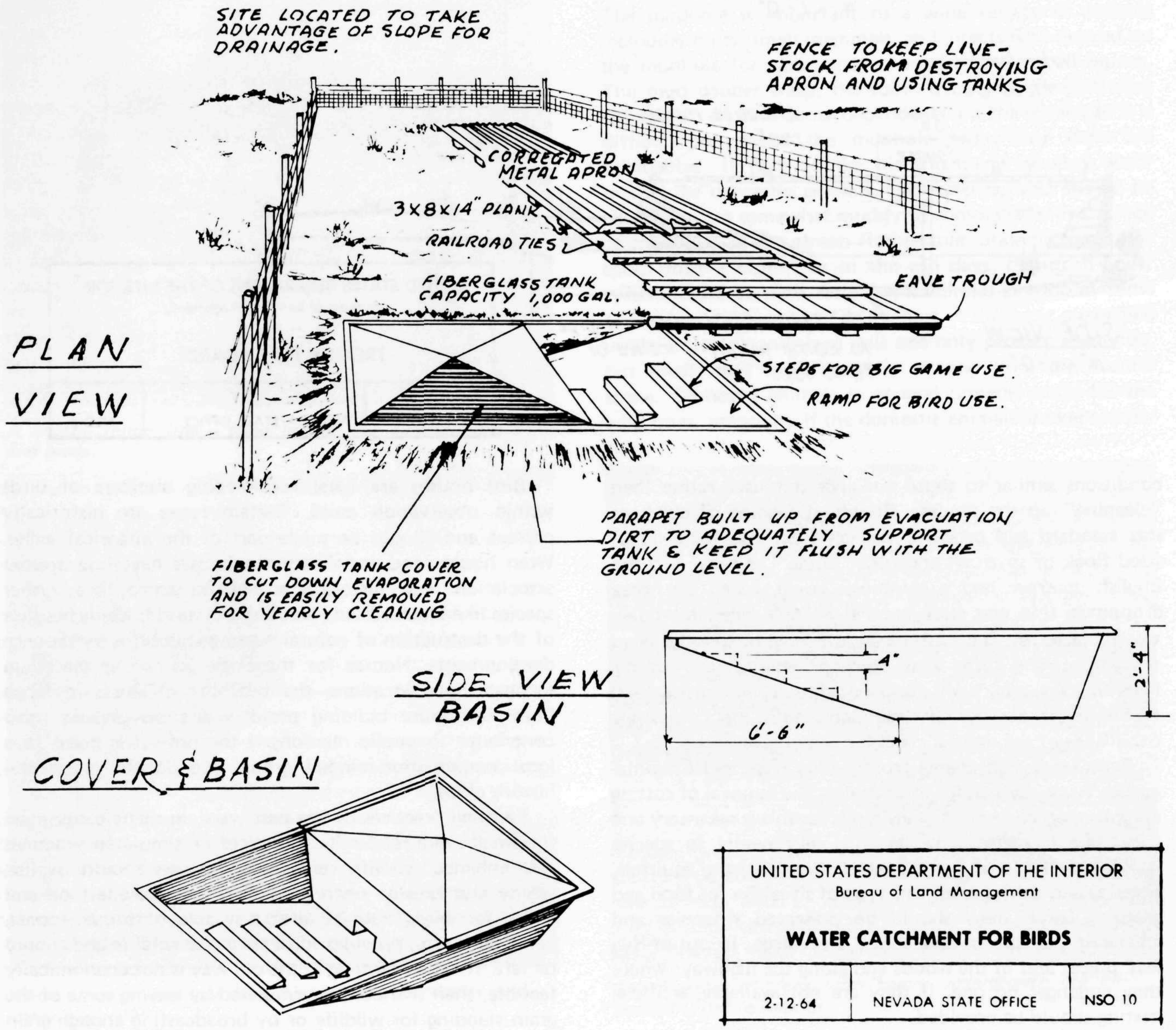
Farming practices of the past were, in many cases, ideal for small wildlife. Similar practices or simulated practices will enhance wildlife values. Fence rows should be left weedy and brushy wherever possible to provide food and cover for birds, rabbits, etc. Any pile of brush, weeds, cornstalks, etc., provides ideal cover for wildlife and should be left. If actual farming in the old way is not economically feasible, then it should be simulated by leaving some of the grain standing for wildlife or by broadcasting enough grain to make up for what normally would be lost under older harvest practices. If the field is under a lease arrangement, compensation can easily be arranged if the objectives are explained to the farmer. Similar compensations can be made in hay fields by either not mowing some sections, mowing them not quite so close, or strewing some of the hay around after a modern operation to make up for loss which would normally happen under older techniques. An old style haystack provides excellent cover and historic atmosphere.

Salt licks should also be provided. The wildlife will get some use of salt put out for domestic stock but additional licks should also be developed for them in areas where there is no domestic stock.

Species of plants particularly useful to wildlife as food or shelter should be grown. In landscaping, enough variety of plants is available so that the historic landscape architect can select many of those useful to wildlife over other varieties in his historical landscape plan. The lease farmer should be encouraged or even forced to grow types of plants most useful to wildlife, the small grains, etc., or to add extra rows of these plants useful to the wildlife to his regular fields. Demonstration agricultural plots within the historic areas should be grown for maximum benefit of the wildlife in addition to their interpretive value. Primitive varieties of corn, beans, and squash grown in a field in an archeological area would not only help preserve those varieties of species that were grown by Indians and are now disappearing, but would provide excellent interpretation while growing and a great deal of food for native animal species if they were left in the field and not entirely harvested.

Certain animals must have thrived only because of the prehistoric farms, and these animals should be accomodated to provide the true picture of the local wildlife assemblage in those days. Old varieties of other plants could similarly be preserved for science and provide foodstuff for wildlife at the same time under a demonstration growing program in historic areas.

The exterior boundaries of the historic area are ideal for planting foodstuffs for wildlife. Usually the boundary is far enough away from the center of attraction so it is not seen.



Frequently it is fenced and often set up with a fire line, especially if the area is wooded. The fence and fire line should be wide enough so that a crude planting program of farming for wildlife palatible species can be done there. It need not be a professional farming job and probably could best take place in coordination with the annual spring clearing of the fire line. Wildfire in general is not desirable but you may find that it is a good tool to clean up certain areas temporarily and at the same time benefit the wildlife. Certain plants respond to fire under natural conditions. Many of these plants such as the blueberry are useful to wildlife. Use of fire in these respects should be highly controlled, in small doses, and only after study, but it should not be ruled out as a management tool of benefit to the wildlife.

WOODS' EDGE

Many animals are edge-of-the-wood users. The more woods'edge one has, the more animals the land can support. The plant species found at the woods' edge are those most preferred by deer and many small animals. To get more edge, one cuts the edge of the woods in a wavy pattern—from a distance one really cannot tell whether it is crooked or straight. Holes cut in the middle of the woods also provide edge. These holes can be partially planted with species that appeal to wildlife. Piles of brush from the cuttings should be left wherever possible to provide cover for wildlife. The woodlot type operation of the past is conducive to wildlife. A constant use of the woods helps to keep it from becoming a mature stand with little underbrush and cover for wildlife. Mature stands of timber are essentially devoid of any wildlife for there is little good food or cover in them. Except for old wildlife nesting trees, the constant cutting of the timber as it matures provides piles of brush for cover, old logs to encourage certain plant growth, and a stimulation of the understory - all of which are excellent for wildlife habitat. Plants that are usable to wildlife like berries, fruit trees, and nut trees should be encouraged by cutting practices.

Water is best provided under natural conditions. Streams should be left as primitive and unpolluted as possible to provide not only water but also cover and food from the stream side plant life. Natural springs should be developed to provide water in a mudhole-swampy setup. Old millponds were excellent waterfowl, fish, and wildlife areas, particularly if, again, not too much attention is paid to the weeds along the edge which provided cover for a great many animals. Care has to be taken with millponds and other similar impoundments so that a balance is maintained and the pond is not contaminated with too much algae, pollutants, or silted up. Old windmills can provide water and be an asset to the historic interpretive program by being a working mill. Open tanks and troughs may need wood floats or ramps to allow small wildlife to extricate themselves.

In drier areas consideration should be given to providing guzzlers — small underground reservoirs filled by rainwater and protected from evaporation by a cover open to small bird and mammal life. Artificial ponds can also be developed if no natural ones exist. Most historic scenes included some sort of stock watering, beaver, mill, or other type of pond and these should be prime efforts in the restoration of the scene. Even modern sewage disposal ponds can be utilized for either domestic or wild animals or both with proper handling - and it saves answering some embarrassing questions if the pond, to the visitor, is obviously a duck pond because ducks are on it.

Wetlands and swamps are always suspected of being places where mosquitoes breed. Actually—the mosquitoes themselves probably should be considered part of the historic scene, the swatting and cursing of them apart of the historic cultural pattern, but this is probably one species of wildlife that purist historians and wildlife specialists both would be willing to do without. Swampy areas are prime wildlife habitat, however, and mosquitoes can be kept under control by wildlife use without the need of forbidden, saturated, hydro-carbon chemicals (e.g. D-D-T, 2-4-D, and 2-4-5-T.). Planting of gambusia fish, for instance, will help control mosquito larvae. Nesting platforms will encourage use of the area by various types of waterfowl. Encouragement of certain native plants or actually planting them will also assist in the wildlife management attraction. Swamps and wetlands are so important to certain species of wildlife that consideration should be given to making them if they are not already present.

Winter is a time when most areas lose their human visitors and it is a time to close the shop down to a minimum operation. It should be noted that much of the wildlife does not leave. Thought should be given to keeping certain of the domestic "interpretive" stock around all winter long to help provide for the wildlife. Supplemental feeding may be necessary for the wildlife in extreme winters although if a good job has been done with natural plantings, this will not be necessary. If supplemental feeding is used to keep birds and other animals near the high-use area, remember to taper it off so the migratory species will leave in time to avoid early fall storms that might kill them off. Water is a prime requisite in winter, and if open water is not readily available, it should be made so by periodically breaking the ice or providing electrical heat elements for water troughs and other sources of water. Domestic livestock will help keep some water sources open.

To initiate a wildlife habitat management program in an historical area, the historian or historical area manager should first consult with a wildlife technician and a map of his area. He needs to develop a basic plan which will coordinate with all the other various resource management needs and provide the best wildlife habitat management possible for the area. The plan will enable the manager to balance his habitat management to avoid over-concentration of plant or animal varieties, and keep the proper interspersion of various types of habitat. The plan will also provide a working tool which will show present status, needs and priorities for accomplishment. It will also point up areas of conflict where problems may need to be ironed out in concert with several specialists.

A good wildlife management program in a historic area will result in better utilization of all resources there and will complement historic area aims, produce more realistic historic scenes (or restoration of past landscapes), generate an increased interest by visitors in preservation and conservation (through greater opportunity to sight wildlife species in a natural setting) and present a better public image for aiding wildlife.

U.S. LIST OF ENDANGERED NATIVE FISH AND WILDLIFE

MAMMALS

Hawaiian hoary bat–*Lasiurus cinereus semotus.*
Indiana bat–*Myotis sodalis.*
Delmarva Peninsula fox squirrel–*Sciurus niger cinereus.*
Morro Bay kangaroo rat–*Dipodomys heermanni morroensis.*
Salt-marsh harvest mouse–*Reithrodontomys raviventris.*
Eastern timber wolf–*Canis lupus lycaon.*
Red wolf–*Canis rufus.*
San Joaquin kit fox–*Vulpes macrotis mutica.*
Black-footed ferret–*Mustela nigripes.*
Florida panter–*Felis concolor coryi.*
Florida manatee (sea cow)–*Trichechus manatus latirostris.*
Key deer–*Odocoileus Virginianus clavium.*
Columbian white-tailed deer–*Odocoileus virginianus leucurus.*
Sonoran pronghorn–*Antilocapra americana sonoriensis.*

BIRDS

Hawaiian dark-rumped petrel–*Pterodroma phaeopygia sandwichensis.*
California least tern–*Sterna albifrons browni.*
Hawaiian goose (nene)–*Branta sandvicensis.*
Aleutian Canada goose–*Branta canadensis leucopareia.*
Laysan duck–*Anas laysanensis.*
Hawaiian duck (koloa)–*Anas wyvilliana.*
Mexican duck–*Anas diazi.*
Brown pelican–*Pelecanus occidentalis.*
California condor–*Gymnogyps californianus.*
Florida everglade kite (snail kite)–*Rostrhamus sociabilis plumbeus.*
Hawaiian hawk (io)–*Buteo solitarius.*
Southern bald eagle–*Haliaetus leucocephalus leucocephalus.*
American peregrine falcon–*Falco peregrinus anatum.*
Arctic peregrine falcon–*Falco peregrinus tundrius.*
Attwater's greater prairie chicken–*Tympanuchus cupido attawateri.*
Masked bobwhite–*Colinus virginianus ridgwayi.*
Whooping crane–*Grus americana.*
Yuma clapper rail–*Rallus longirostris yumanensis.*
California clapper rail–*Rallus longirostris obsoletus.*
Light-footed clapper rail–*Rallus longirostris levipes.*
Hawaiian gallinule–*Gallinula chloropus sandvicensis.*
Hawaiian coot–*Fulica americana alai.*
Eskimo curlew–*Numenius borealis.*
Hawaiian stilt–*Himantopus himantopus knudseni.*
Puerto Rican plain pigeon.–*Columba inornata wetmorei.*
Puerto Rican parrot–*Amazona vittata.*
Ivory-billed woodpecker–*Campephilus principalis.*
Red-cockaded woodpecker–*Dendrocopus borealis.*
Hawaiian crow (alala)–*Corvus tropicus.*
Small Kauai thrush (puaiohi)–*Phaeornis palmeri.*
Large Kauai thrush–*Phaeornis obscurus myadestina.*
Molokai thrush (olomau)–*Phaeornis obscurus ruttra.*
Nilhoa millerbird–*Acrocephalus kingi.*
Kauai oo (oo aa)–*Moho braccatus.*
Crested honeycreeper (akohekohe)–*Palmeria dolei.*
Hawaii akepa (akepa)–*Loxops coccinea coccinea.*
Maui akepa (akepuie)–*Loxops coccinea ochraceu.*
Oahu creeper (alauwahio)–*Loxops maculaia maculata.*
Molokai creeper (kakawahie)–*Loxops maculata flammea.*
Akiapolaau–*Hemignathus wilsoni.*
Kauai akialoa–*Hemignathus procerus.*
Kauai and Maui nukupuus–*Hemignathus lucidus.*
Laysan and Nihoa finches–*Psittirostra cantans.*
Ou–*Psittirostra psittacea.*
Palila–*Psittirostra bailleui.*
Maui parrotbill–*Pseudonestor xanthophrys.*
Bachman's warbler–*Vermivora bachmanii.*
Kirtland's warbler–*Dendroica kirtlandii.*
Dusky seaside sparrow–*Ammospiza nigrescens.*
Cape Sable sparrow–*Ammospiza mirabillis.*

REPTILES AND AMPHIBIANS

American alligator–*Alligator mississippiensis.*
Blunt-nosed leopard lizard–*Crotaphytus silus.*
San Francisco garter snake.–*Thamnophis sirtalis tetrataenia.*
Puerto Rican boa–*Epicrates inornatus.*
Santa Cruz long-toed salamander–*Ambystoma macrodactylum croceum.*
Texas blind salamander–*Typhlomolge rathbuni.*
Houston toad–*Bufo houstonensis.*

FISHES

Shortnose sturgeon–*Acipenser brevirostrum.*
Longjaw cisco–*Coregonus alpenae.*
Lahontan cutthroat trout–*Salmo clarki henshawi.*
Piute cutthroat trout–*Salmo clarki seleniris.*
Greenback cutthroat trout–*Salmo clarki stomias.*
Gila trout–*Salmo gilae.*
Arizona (Apache) trout–*Salmo sp.*
Humpback chub–*Gila cypha.*
Mohave chub–*Siphateles mohavensis.*
Pahranagat bonytail–*Gila robusta jordani.*
Moapa dace–*Moapa coriacea.*
Woundfin–*Plagopherus argentissimus.*
Colorado River squawfish–*Ptychocheilus lucius.*
Kendall Warm Springs dace–*Rhinichthys osculus thermalis.*
Cui-ui–*Chasmistes cujus.*
Devil's Hole pupfish–*Cyprinodon diabolis.*
Comanche Springs pupfish–*Cyprinodon elegans.*
Tecopa pupfish–*Cyprinodon nevadensis calidae.*
Warm Springs pupfish–*Cyprinodon nevadensis pectoralis.*
Owens River pupfish–*Cyprinodon radiosus.*
Pahrump killfish–*Empetrichthys latos.*
Big Bend gambusia–*Gambusia gaigei.*
Clear Creek gambusia–*Gambusia heterochir.*
Pecos gambusia–*Gambusia nobolis.*
Unarmored threespine stickleback–*Gasterosterus aculeatus williamsoni.*
Gila topminnow–*Poeciliopsis occidentalis.*
Fountain darter–*Etheostoma fonticola.*
Watercress darter–*Etheostoma nuchale.*
Maryland darter–*Etheostoma sellare.*
Blue pike–*Stizostedion vitreum glaucum.*

–from Bureau of Sport Fisheries and Wildlife, 1/1/71.

BIBLIOGRAPHY

Bureau of Land Management, "Water Development; Range Improvements in Nevada for Wildlife, Livestock, and Human Use", Nevada State Office, Reno, 1964.

Bureau of Sports Fisheries and Wildlife, "Rare and Endangered Fish and Wildlife of the United States", Resource Publication No. 34, Washington, 1968.

Shomon, J. J., B. L. Ashbaugh, C. D. Tolman, "Wildlife Habitat Improvement" National Audubon Society, Nature Centers Division, 1130 Fifth Avenue, New York, N.Y. 10028, $2.50. 1966.