Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

A Century of Managing Fish
Exotics and Ecosystems
Insect Vampires

Volume 4 Number 4

Complacency and Change

Being autumn, change is in the air: change in the color of the aspen, cottonwood, and alder leaves (*yes, even here in Yellowstone)*as they float to the ground...change in the waters of Yellowstone Lake, where the lake trout come to the shallows to spawn as the autumn winds buffet the gillnetters seeking them out...change in the movements of the bighorn, elk, and bison as they move from summer ranges toward the winter ranges before, during, and after their mating seasons...each movement its own kind of migration, be it from the tree to the ground, the depths to the shallows, high elevation to low. Some of these migrations are natural to Yellowstone, and some newly arrived, with or without the assistance or planned forethought of humans. Change, it is said, is the only real constant, and documenting it dominates our research and management efforts. In an interview with *Yellowstone Science*, distinguished conservation biologist Michael Soulé cautions against complacency in the face of exotic invasions and previously unexperienced rates of species' extinctions and invasions on broad geographic scales. On a more local scale, John Burger tells us in sometimes painful detail about the invasions of both exotic and native "bloodsuckers" onto Yellowstone's wildlife—and under our own sensitive skins. And Mary Ann Franke documents the history of fisheries management in Yellowstone as the U.S. Fish and Wildlife Service departs the park, leaving a legacy that spans the spectrum—from the heyday of fish rearing and planting to full-bore efforts to eradicate exotics and restore natives. Our partners in fisheries management leave us a solid, long-term database on aquatic resources that's the envy of many biologists, and with many fond memories of professional work, cheerfully done on behalf of Yellowstone National Park. Their migration elsewhere leaves me saddened, and I wish them well.

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On the cover: Ranger John Jay packing fish to a remote lake in Yellowstone in the summer of 1938. Above: the park service "fish truck" used for stocking fish in more accessible locations. Photo taken in 1935. See the related story on page 2. Photos NPS archives.

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Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Editorial correspondence should be sent to the Editor, *Yellowstone Science*, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.

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A Grand Experiment

100 Years of Fisheries Management in Yellowstone: Part I

Photos courtesy NPS Archives

Park rangers planting fish in a Yellowstone lake, 1922.

by Mary Ann Franke

October 1996 marks another milestone in management of Yellowstone's fisheries, as the U.S. Fish and Wildlife Service Fisheries Assistance Office departs the park after 35 years. The NPS, already responsible for fisheries management policy-setting and enforcement, must provide its own resident fisheries expertise as it does for other natural and cultural resources. To mark this passage, and to summarize for readers the long and complex history of Yellowstone's fisheries, we present the first of a two-part feature by Mary Ann Franke. Part I covers the period from the park's inception to the 1950s; Part II, covering the changing times from the 1950s to the present, will be featured in the January 1997 issue of Yellowstone Science. *Franke is a freelance writer who spent the summer of 1996 researching this and other subjects in Yellowstone. Her piscatory pursuits have also led her to drop lines in Olympic and Virgin Islands national parks.*

In prehistoric campsites by the Yellowstone River, notched stones have been found that are believed to have been used to weight nets for catching cutthroat trout. If this was among the first human alterations of the Yellowstone landscape in pursuit of fish, it was but a tiny harbinger of the changes to come.

Only 17 of the more than 150 lakes in Yellowtone National Park are believed to have contained fish when the park was established. About 40 percent of all the park's waters were fishless, including almost the entire lengths of the Firehole, Gardner, Gibbon, Lewis, and Bechler rivers. Yet the physical character of Yellowstone's waters was found to be generally favorable for fish habitat. A field study in 1890 revealed the presence of abundant insect and crustacean food well-suited for sustaining fish.

Where Geologic and Human History Collide

Yellowstone's relative scarcity of na-

> "It would be an admirable thing if trout and grayling could be planted in these barren waters, but Commissioner McDonald looks at this subject from a broader standpoint, and sees the grand opportunity which the Park offers for experiments on the acclimatization of certain species of fish foreign to these waters. He has expressed himself as desirous of introducing into one of these river systems the brown trout of Europe; the Eastern brook trout might be introduced in another, and the grayling in the third."— *Forest and Stream: A Weekly Journal of Rod and Reel, 1889.*

tive fish is a result of its geologic history. After the last period of glaciation some 12,000-15,000 years ago, fish began to reestablish in those waters to which their passage was not blocked by waterfalls and cataracts. When the park was established in 1872, few fish lived above the falls except in Yellowstone Lake and River. The cutthroat trout there are believed to have used Altantic and Pacific creeks on Two Ocean Plateau to cross the Continental Divide.

Yellowstone's current abundance of non-native fish is a result of its more recent history. Various combinations of native and exotic fish species now inhabit about 40 of the park's lakes and most of its rivers and streams. By 1902 four non-native trout species (brook, brown, lake, and rainbow) that wouldw compete with 12 species of native fish had already been brought in, and for decades afterward such planting seemed a perfectly natural human response to so-called "barren" or otherwise inadequately fish-stocked water. From a modern ecological perspective it was as if, thinking the Hayden Valley looked rather empty, park managers had decided to bring in livestock, or rhinoceri.

How and why the park's particular fish menagerie came about, and what is being done about it now, is a story writ large of wilderness management during the last hundred years, with all of its blunders and revelations. The chapters include subsistence use and commercial sale, import of new species and loss of original ones, catering to recreational interests, learning ecological principles, regulation of humans to permit greater "natural" regulation, and attempts to restore native species.

The Experiment Begins

When the Yellowstone Park Act of 1872 specified that the land be "set apart as a public park or pleasuring ground for the benefit and enjoyment of the people," the idea of a national park as a sanctuary for wildlife was still in the future. Hunting and fishing were regarded as legitimate recreational activities and the only practical way to feed park visitors. But the decimation caused by commercial harvest of fish and game was so extensive that by 1883 fishing was limited to hook and line and hunting was prohibited except for predators. In 1886 the U.S. Calvary was assigned to the park and eventually proved to be adept at protecting the park's resources.

Loch Levan trout from Scotland (originally transplanted to Yellowstone in 1890) displayed by two Mammoth Hotel bellhops in 1930.

Early on, stocking park waters to improve angling opportunities seemed a worthy goal. In his Superintendent's Report for 1889, Captain Frazier Boutelle enthused: "Besides the beautiful Shoshone and other smaller lakes, there are hundreds of miles of as fine streams as any in existence without a fish of any kind. I have written Col. Marshall McDonald, U.S. Fish Commission, upon the subject, and have received letters from him manifesting a great interest. I hope through him to see all of these waters so stocked that the pleasure-seeker in the Park can enjoy fine fishing within a few rods of any hotel or camp."

Colonel McDonald's great interest in this proposal arose from his fledgling organization's need for an outdoor laboratory in which to apply its new science. Yellowstone's waters represented an opportunity to broaden the Fish Commission's activities from concern about the price of shad to the development of a sport fishery in what was then the only wildland under active federal management. The Fish Commission asked eminent scientist David Starr Jordan to catalogue the park's fish, describe their habitat, list the "barren" waters, and advise as to which were suitable for stocking. Jordan's report provided details about Yellowstone's native fish decades before much was known about other park wildlife.

Following Captain Boutelle's recommendation, in 1889 the Fish Commission brought 7,000 yearling brook, brown, and rainbow trout from a Michigan hatchery to plant in the fishless upper waters of the Firehole, Gibbon, and Gardner rivers. The east fork of the Gardner above Osprey Falls also received 1,000 cutthroat trout from the Snake River in Idaho. In 1890, when fewer than 8,000 people entered the park, more than 42,000 yearlings, including Loch Levan brown trout from Scotland and Von Behr brown trout from Germany, went into Lewis and Shoshone lakes, which had been fishless for perhaps 9,000 years. Mountain whitefish from Montana went into Twin Lakes and the Yellowstone River below Yellowstone Lake, to provide "food for the native trout, which appear to be underfed," as urged by *Forest and Stream* in 1889. "If enough of these whitefish escape their enemies to spawn, we are inclined to look for a marked alteration in the character of the trout of the Yellowstone Lake." This was but one of many fish lessons that would be learned by trial and error: the mountain whitefish showed no aptitude for life in the upper Yellowstone and the cutthroat of Yellowstone Lake have shown little interest in eating other fish.

But at the time, all things still seemed possible when it came to man bending nature to his will. At the end of 1890, Captain Boutelle reported that Colonel McDonald "has now hatched and ready for shipment, as soon as I telegraph him that the mountains are passable, 150,000 trout and salmon for the lakes and rivers of the Park. It will probably be the greatest feat in moving large bodies of young

fish ever attempted and will reflect a world of credit upon Colonel McDonald... The streams are full of fishfood and there can be no reasonable doubt of the success of the enterprise. Once stocked and protected, it will be impossible in the short season the Park is accessible to fish them out." Although Captain Boutelle's ambitious goal for 1891 was not met, he had set wheels in motion that would not grind to a halt until more than 60 years later, after 310 million fish had been planted in Yellowstone waters and the possibility of fishing out the native species had been squarely faced.

"Improving on Nature"

> "Within a few years after experienced fish-culturists began to give attention to needs of the park, the hitherto fishless waters began to produce desirable game fish in abundance, and this has continued up to the present time."— Hugh Smith and William Kendall, *The Fishes of Yellowstone, 1921.*

"I believe that it would be better to have Yellowstone Lake stocked with landlocked salmon, which would in time eradicate the wormy trout," Superintendent Young advised the Fish Commissioner in 1908, referring to the native cutthroat trout, which is often infected by a parasitic tapeworm that is harmless to humans when the fish has been cooked.

Fortunately, the Atlantic salmon, rainbow trout, and mountain whitefish planted in Yellowstone Lake failed to survive, as did the black bass that were reportedly put in the Gibbon River and several lakes in the Lower Geyser Basin in 1895. Yellow

Park personnel preparing to poison perch in Goose Lake, 1938.

Fish Past and Present: A Sample of Yellowstone Waters

Extant

Extinct or not viable

Park Location	Native Species	Introduced Species
Firehole River above Firehole Falls	None	Brook trout Brown trout Rainbow trout Yellowstone cutthroat
Gibbon River	Longnose dace Mottled sculpin Arctic grayling Cutthroat Mountain Whitefish	Brook trout Brown trout Black bass Rainbow trout
Lamar River and Soda Butte Creek	Yellowstone cutthroat Longnose dace Longnose sucker Mountain sucker	Rainbow trout
Madison River	Yellowstone cutthroat Longnose dace Mountain sucker Mountain whitefish Arctic Grayling	Brook trout Brown trout Rainbow trout
Shoshone Lake	None	Brook trout Brown trout Lake trout Redside shiner Utah chub
Slough Creek	Yellowstone cutthroat Longnose dace Longnose sucker	Lake chub Rainbow trout
Yellowstone Lake	Yellowstone cutthroat Longnose dace	Atlantic salmon Mountain whitefish Rainbow trout Lake chub Lake trout Longnose sucker Redside shiner
Yellowstone River below Lower Falls	Yellowstone cutthroat Longnose dace Longnose sucker Mottled sculpin Mountain sucker Mountain whitefish	Brown trout Brook trout Rainbow trout

One of the first fish hatcheries at Lake, 1928.

"Trout have been planted in nearly all streams in the park except those that are tributary to Yellowstone River, and the experiment has been so successful that there are now but few places in this country where better sport can be had by the fisherman... In order that it may never be necessary to make any restrictions it is strongly urged that a small fish hatchery be established here. If this can be done the streams can be kept so full of trout that it will be impossible for the tourists to deplete them." — Captain John Pitcher, Acting Superintendent, 1901

perch were later found there, in Feather and Goose lakes, and it may be that they had been mistaken for black bass, or that the plant was contaminated with perch. In any event, the perch survived in Goose Lake until 1938, when they were poisoned to keep them out of the Firehole River.

But many plantings of non-native fish thrived because of the lack of competition from other species. The Fish Commission's intention had been to keep species separate by putting them in different drainages: this failed due to the ease with which fish passed downstream over waterfalls that prevented fish from going up. As a consequence, species were combined that were either incompatible in some way, competing with each other for food or spawning areas, or too compatible in another— interbreeding to produce hybrids or otherwise diluting the genetic makeup of a native species.

The first decades of the twentieth century brought to Yellowstone both the first private cars—helping push annual visitation from 20,000 in 1914 to 260,000 in 1929—and the improved means by which its waters could be kept stocked for the growing number of anglers. The methods of transporting fish by pack stock were refined, and the practice of planting eyed eggs instead of the more cumbersome fingerlings came into vogue. Consequently, many fishless headwaters and backcountry lakes acquired fish, and some heavily fished waters began to receive almost annual plantings.

Although each new species of game fish was initially introduced through an official stocking program, their increased distribution within the park was sometimes unsanctioned, and some waters therefore have fish of uncertain origin. The non-native lake chub may have arrived through either the authorized stocking of minnows or the dumping of bait by anglers. Outfitters and anglers took it upon themselves to stock for their own use some of the park's smaller, little-known ponds—and apparently, in the case of the lake trout, one large and very well-known body of water.

Authorized or not, enough stocking held to recast the fish populations in many waters. The Gallatin and Madison rivers, where the upper Missouri form of westslope cutthroat once resided with the Arctic grayling and the mountain whitefish, today contain almost exclusively whitefish and non-native brook, brown, and rainbow trout. The Snake River fine-spotted subspecies of cutthroat trout appears to have vanished from the park, and the westslope cutthroat remains in only a hybridized form, because Yellowstone cutthroat were planted in its native waters. Although the Yellowstone cutthroat had its range within the park expanded, it is gone from most native areas where brook trout were introduced, and in some waters it hybridized with introduced rainbow trout. Distribution of the Arctic grayling, once abundant in the larger streams of the Missouri River drainage above Great Falls, Montana, has been reduced to less than 8 percent of its original range. Although grayling are occasionally still found in the Gibbon and Madison rivers, no viable populations exist in any park waters in which the species was native. Grayling are plentiful in three once-fishless lakes where they were introduced, but these lacustrine (lake-dwelling) populations do not play the same role in the ecosystem as their fluvial (river-dwelling) relatives.

As for Yellowstone Lake, "it is interesting to note that native or cutthroat trout are the only specie found anywhere in the lake," the *Salt Lake Tribune* observed in 1928 with more wishful thinking than accuracy. "It is considered the greatest natural reservoir in the United States for cultivation of that specie and the government has no intention of spoiling it by importing other varieties." But by that time Yellowstone Lake had already seen the arrival of the longnose sucker (in about 1923), and it would eventually also accommodate the redside shiner (first reported in 1957), the lake chub (first reported in 1958), and the lake trout (officially confirmed in 1994). The lake chub populations are believed to be inconsequential and, despite some overlap in diet, neither the longnose sucker or redside shiner appear to compete directly with the cutthroat. Spatial separation within the lake and both temporal and spatial separation in spawning streams have apparently led to a stable association of these fishes, with both the redside shiner and the longnose sucker having filled previously vacant niches within the Yellowstone Lake ecosystem.

But the lake trout will be a different

A park ranger harvesting early "blackspotted" spawners at Pelican Creek in May of 1936. Right: Taking eggs for transplantation, 1930.

story. Cutthroat trout will have to compete with juvenile lake trout for the same invertebrate food sources, while adult lake trout eat cutthroat trout themselves. In no body of water do lake trout coexist naturally with cutthroat trout, and they have reduced or eliminated native trout species in places such as Heart Lake in Yellowstone and Jackson Lake in Grand Teton National Park. It has been estimated that they could reduce Yellowstone Lake's cutthroat population by at least 50 percent during the next 20 years. And because they spend most of the year in deep water, lake trout will not replace cutthroat trout for many of the 42 species of birds and mammals that feed on them, including bald eagles, white pelicans, ospreys, loons, otters, andbears. For more information, see "Yellowstone Lake in Change," *Yellowstone Science* 4(2):4-9.

While an increasing number of fish were being disbursed throughout Yellowstone waters, even more fish were leaving, not only on anglers' hooks, but as eggs and fry. The rest of the United States was experiencing the same stocking fervor that filled Yellowstone's waters. Between 1903 and 1953, 818 million trout eggs were exported from Yellowtone, where they were stripped from cutthroat spawners and incubated in hatcheries to improve their survival before shipment.

Eggs of the cutthroat or "black-spotted" trout, as it was then called, were first taken in 1901 from streams in the West Thumb and sent to a South Dakota hatchery, but the park soon built its own operation with four hatchery buildings and fish traps on 14 of Yellowstone Lake's largest tributaries. "Without hatching facilities, it has been necessary to ship out the eggs in a green state and ship back the young, causing rather heavy mortality and considerable extra expense," explained the Fisheries Service Bulletin in 1921, when a hatchery was constructed at Soda Butte Creek near Trout Lake. "It is expected that the new hatchery will serve a very useful purpose in keeping up the supply of trout in one of the most interesting sections of the park."

From Grebe Lake, a once fishless lake that had been stocked with a Montana grayling genotype, about 72 million eggs were collected from 1931 and 1956, and today most western grayling stocks can be traced back there. Both Grebe Lake and Trout Lake, the site of a rainbow trout hatchery, were closed to fishing until 1944 because of their fish culture operations. Today Trout Lake's pure cutthroat trout are gone; it contains only cutthroat and rainbow trout hybrids.

Altogether, more than 50 federal, state, and private hatcheries received eggs from Yellowstone. The annual take increased to about 20 million eggs in 1911 and peaked at 43 million in 1940, making the Yellowstone cutthroat the most commonly introduced cutthroat trout in the world. Only later did it become apparent that the species is suited only to alpine or subalpine lakes that have few or no competing fish. The Yellowstone cutthroat has survived in seven western states and two Canadian provinces in which it was planted, but in only 15 percent of its original range in the Yellowstone and Snake river drainages.

The streams in which cutthroat trout spawn are usually swollen at the time of the run. Some cutthroat go far upstream from the lake and deposit their spawn during high water in places that later may become exposed to the air, resulting in high mortality. Streams that are raging torrents in spring and early summer may by July and August become almost dry, cut off from the lake and reduced to disconnected pools, where the young fish will perish.

The purpose of the hatcheries was to increase the eggs' survival rate by collecting them before they encountered all these perils. To do that, the upstream migrating fish were trapped in weirs and held until their eggs ripened; after the eggs had been taken, the fish were returned to the stream. The hatcheries and traps were supervised by the Rocky Mountain District of the U.S. Bureau of Fisheries under the loose and sometimes contentious guidance of park administrators. Fish culturists were recruited from federal and state hatcheries to assemble in the park during spawning season; each state receiving eggs generally provided one man for 60 days. But the egg collection process posed its own risks. The traps' fishy smell attracted bears, for whom the presence of barbed wire, electric fences, and guard dogs posed little deterrence, and constant vigilance of the

traps was required until the eggs were picked up by the transport crew.

Recreation vs. Preservation

In retrospect, one might ask where were the advocates of wilderness preservation while all of this fish stocking and egg hatching was going on? The prudence of putting some limits on fishing was evident almost from the beginning. A minimum size for keepers recommended by Acting Superintendent Captain George Anderson was formally adopted in the "Instructions to Persons Traveling Through Yellowtone National Park" of 1897: "All fish less than six inches in length should at once be returned to the water with the least damage possible to the fish. No fish should be caught in excess of the number needed for food." Glen Creek was temporarily closed to angling in 1896, and again in 1907 along with Sportsman Lake when evidence of excessive fish catches was found.

By the first decade of the twentieth century, some park managers were beginning to rethink the policy of indiscriminate fish stocking. The first recorded defense of native fish occurred in 1907 when a fisheries employee was reprimanded for trying to plant rainbow trout in Yellowstone Lake. In 1908, the park refused the proposal of the Fish Commissioner to stock smelt in Shoshone and Yellowstone lakes, as it also resisted suggestions to introduce other wildlife, including reindeer, mountain goats, and various game birds. But park managers did not yet realize the extent to which introduced species could be harmful to native species, nor did they stop the spread of nonnative fish already present in Yellowstone to additional park waters.

For most of their early history, national parks treated wildlife as an enticement for visitors and felt little compunction about meddling with it to enhance visitor satisfaction. From 1896 to 1908, bison, elk, and mountain sheep were put on Dot Island for the viewing pleasure of the Yellowstone Boat Company's passengers. The superintendent at Sequoia recommended complete elimination of bears from that park, and noisy woodpeckers near hotels in Yosemite were shot if guests complained. Even after passage of the National Park Service Act in 1916, which called for the conservation of wild animals "by such means as will leave them unimpaired for the enjoyment of future generations," predators that were not an obvious part of the enjoyment continued to be killed. These unwanted predators included the pelicans which ate tons of trout from Yellowstone Lake, competing with people who also did so.

Fishing had become an important part of the national park experience, and most of the concern was about the quality of the angling, not the quality of the resource. The growing number of anglers, the large take of eggs, and the high creel limit (20 fish/day from 1908 to 1920) were having an impact. Nonetheless, Superintendent Albright optimistically reported in 1919 that, as a result of plants made in recent years, the trout in Yellowstone Lake seemed to be returning to their "former abundance before the depredations of the pelicans, gulls, etcetera had made inroads on the stock"—as if it were those pesky birds that had been responsible for the decline.

By the 1920s, some wildlife ecologists were alarmed by the damage that had been done to national parks as a result of misinformation and misguided management. The Ecological Society of America and the American Association for the Advancement of Science announced their opposition to the introduction of any more new plants or animals to national parks. But although Yellowstone fishing was not as good as it had been, it became more famous as park visitation increased. Even with the reduction of the daily limit to 10 fish in 1921, Yellowstone offered better sport fishng than many places.

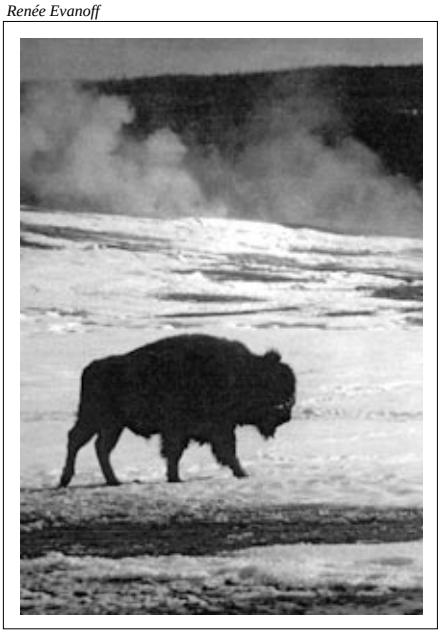
Limited understanding of fish ecology, pressure to maintain Yellowstone's sport fishery, and bureaucratic stalemate combined to continue fish culture operations. While the National Park Service (NPS) was awakening to the need to preserve native fish species, the U.S. Fish and Wildlife Service (descendant of the U.S. Fish Commission) continued to mass produce trout. No written agreement existed between the two agencies until 1939, when a Memorandum of Understanding was drawn up that described in general terms the extent of fish culture operations in the park. Although often mutually beneficial, the relationship between the two federal agencies was occasionally strained, and on several occasions Yellowstone officials tried to force the fish culturists out altogether.

A typical days catch of the 1920s.

> "The National Park Service wildlife policy is consistent with the general theme of national park administration, i.e., that the areas will be maintained unimpaired for the benefit of future generations... In view of the fact that fishing is permitted in certain national park waters, a modification of the general wildlife policy is necessary... In waters where native and exotic species now exist, the native species shall be definitely encouraged, unless exotic species are better suited to the environment and have proven of higher value for fishing purposes than native species."— *General Policies of the National Park Service Governing Fish Planting and Distribution*, 1941.

Concern about both Yellowstone's native fish and the quality of its sport fishing did lead to the establishment of a formal NPS stocking policy in 1936 which prohibited planting exotics in waters where only native fish resided. It also suggested that, "It might be advisable to leave barren waters as such," but it did not entirely ban stocking. At the time, any curtailment of fish stocking was considered a radical idea, as was the reduction in the daily limit from 10 to 5 fish in 1949. Thus the new policy did not change the "put-grow-and-take" maintenance of fish in many roadside waters, nor did it end "put-and-take" stocking of immediately catchable size, hatchery-raised rainbow trout to increase the likelihood that anglers would leave the park satisfied. ❧

Renée Evanoff



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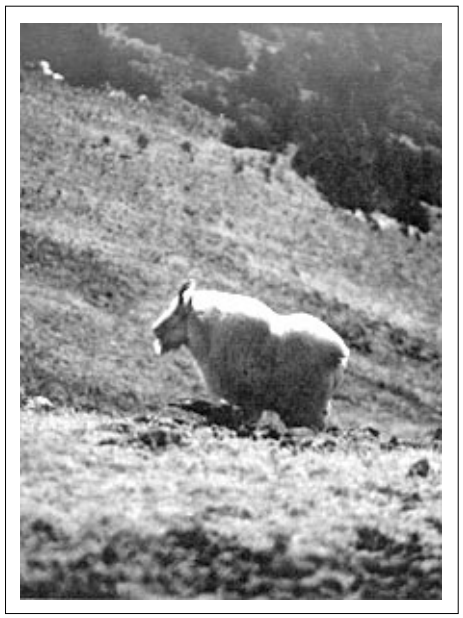
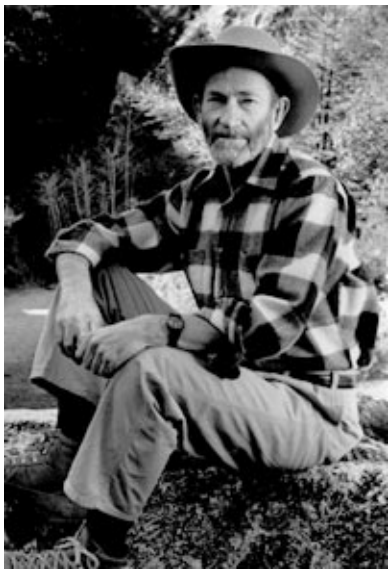


Natives Versus Exotics

Coming to Terms With Non-native Species Invasions and Rates of Change

Michael Soulé was the founder and first president of the Society for Conservation Biology. He is a fellow of the American Association for the Advancement of Science, serves on the National Research Council, and is a founding member of the Wildlands Project. His research interests include morphological and genetic variation in natural populations of animals, island biogeography, population viability, consequences of habitat fragmentation, and the analysis of policy conflicts. His field work has taken him to Africa, Samoa, Australia, Yugoslavia, Mexico, and the West Indies. He recently retired as Chair and Professor Emeritus of Environmental Studies at the University of California, Santa Cruz.

Soulé has published on a wide range of topics and is well known for his edited books, Conservation and Evolution, Conservation Biology: The Science of Scarcity and Diversity, Viable Populations for Conservation, and Reinventing Nature: Responses to Postmodern Deconstruction. *He has defined conservation biology as a crisis discipline, saying that "its relation to biology, particularly to ecology, is analogous to that of surgery to physiology... In crisis disciplines, one must act before knowing all the facts; crisis disciplines are thus a mixture of science and art, their pursuit requires intuition as well as information."*



Yellowstone was delighted to have Dr. Soulé visit in September 1995, when he was invited to speak at the symposium "Carnivores and Ecosystems" following the park's third biennial science conference. Paul Schullery and John Varley conducted this interview at that time.

YS: One of the things that the National Park Service (NPS) wrestles with constantly in many of its areas is the problem of exotic species. Over the course of the past three-quarters of a century, we have built up a powerful institutional compulsion to fight exotic invasions as hard as we can. But when we take the long view, we have to wonder if we're just temporarily holding off the inevitable. We know that new species have been colonizing Yellowstone for 10,000 years and we can't prevent that. That isn't to say that the accelerated rate of invasion by exotics that humans have caused here is somehow "natural," but it is to suggest that invasions are truly unpreventable. What with the high cost of running parks and the decreasing budgets, we are forced to

wonder if we can afford this kind of work.

MS: Lots of things are inevitable. Death and corruption come to mind. So, yes, invasions are inevitable. The question is, how aggressive should we be in combatting them so they don't become lethal. Like diseases, some invasions are more serious than others.

YS: Why has this become such an urgent problem in recent times?

MS: We've seen an extraordinary increase in the numbers of invasions over the last century. It has to do with the increase in human population and the modern technology of travel and transportation. For example, the first time I went to Europe I went on a boat. Nobody goes to Europe by boat anymore. But if you cross the ocean by ship, you have time to wash your clothes and get the seeds out of them. If you're traveling by plane, however, you can bring insects and seeds across the ocean or from Mexico to Colorado.

YS: You said that some invasions are more serious than others. How does one go about judging such things?

MS: You can't. You never know which species will become invasive. It's getting to the point where you need some kind of a triage system in places like Yellowstone. One approach is to develop a list of all exotics in the park and decide which you can live with and which you can't, and then spend your money on those that are unacceptable.

What is a "Native" Species?

YS: The national parks have been dealing with that decision-making process for a long time, and it has led us in some unusual directions. In the 1970s, there was a movement to institutionalize the recognition that we couldn't get rid of some exotics, especially sport fish that had been introduced in a lot of parks back before we knew better. It was proposed that we declare brown, rainbow, and eastern brook trout "naturalized."

MS: Honorary natives.

YS: Right. That was hotly debated for a while, and the people who opposed it won out at the time. There seemed no real need to do it, and there seemed a risk of giving managers an easy way out of tough management situations that shouldn't be susceptible to resolution by surrender. Are you proposing anything like that? Can we arbitrarily decide what is native?

MS: I wouldn't go that far. Aquatic systems are the most susceptible to invasion, and they are also the ecosystems where invaders are likely to be the most popular; a lot of people like rainbow trout, even if they cause the local extirpation of native amphibians. And of course a lot of sportsmen don't know or don't care about the difference. Nowadays, commerce is introducing a new set of aquatic invaders. Zebra mussels are a good example of the complexities of these invasions. They originated in warm seas like the Caspian and Yellow seas. But as the climate warms, species that we thought couldn't survive in colder regions might become invasive. So climate warming and invasions are inseparable processes that are both caused by humans, and are complexly interrelated.

As plants, animals, and diseases are moved with increasing rapidity between continents, humans are reversing more than 100 million years of continental isolation. Some are calling this period the "Homogocene." I prefer the "Catastrophozic."

YS: One objection that we hear to all this concern over invasions is that they have always happened; they're just happening faster now, so what's the big deal?

MS: That is, indeed, a common response. I refer to it as the "Rush Limbaugh response" because it overlooks something very important—differences in rates. When rates undergo a large increase, we need to pay attention. Examples include the increases in human death rates attributable to smoking and drunk driving. As a society we can't afford to dismiss these large increases in rates just because death is nothing new.

The Increasing Rate of Invasion

YS: Yes, it appears to reveal an extraordinary anthropocentrism to say "so what?" in the face of the ecological changes that are now occurring. One doesn't have to be an alarmist to sense that something is wildly out of control.

MS: I agree. Civilization is running amok, and ecosystems are victims. By the way, another example of the "Rush Limbaugh fallacy" is the claim that "extinctions of species have always occurred, so what is all the shouting about." Again, those who make this claim want to gloss over the huge increase in the *rate* of extinction. The rate is thought to be approaching 1000 times the normal background rate in the world. And unless your definition of "natural" is distorted, this amazing rise in the rate of extinction isn't natural. I think that there have been, perhaps, one or two natural extinctions of vertebrate species in the last several hundred years, but during the same period there have been hundreds of human-caused extinctions.

Returning to the subject of invasive species: as plants, animals, and diseases are moved with increasing rapidity between continents, mankind is reversing more than 100 million years of continental isolation. Some are calling this period the "Homogocene." I prefer the "Catastrophozoic." The practical problem is that a lot of these alien species are quite aggressive, and are significantly degrading the invaded ecosystems, the way that cheatgrass is changing the Great Basin and affecting its productivity for native species as well as for cattle.

YS: Are these changes uniform across a landscape? Are some parts of a continent more vulnerable than others?

MS: Indeed, some kinds of ecosystems appear to be more vulnerable than others, though we are still trying to understand the reasons. In terrestrial ecosystems, those habitats that are subject to soil disturbance and that lack a canopy of trees appear to be the most easily invaded. High-elevation habitats appear to be less vulnerable, possibly because of the severity of the climate and lower probability of aliens arriving from colder regions of Eurasia and South America. The exception, of course, is fresh water. Rivers and lakes appear to be the most vulner-

able regardless of latitude, and I note that some of the most serious alien problems in Yellowstone, such as lake trout, are aquatic.

By the way, the natural dynamics of an invasion can lull us into complacency. For example, a new colonist may double its population size and the area it occupies each year, but this kind of growth may appear to be negligible in the first few years as the alien expands, say, from 1 meter of land to 2, then 4, then 8, then 16, 32, 64, and so on. But if this continues, during the twentieth year the alien will gobble up a square kilometer of territory, and people will think that it has undergone a sudden increase in growth rate when in fact they are witnessing a normal geometric expansion.

YS: So the key is to find these invasion sites as early as possible?

MS: Yes. I don't know what NPS policy is on this, but if I were in charge, I would develop four or five regional exotic teams, each of which was familiar with a particular ecosystem. Maybe twice a season those teams would patrol the roads in the camp areas and pulloffs, find new sites of infection of particular exotic plants or animals, and put a lot of effort into getting rid of them before they spread, and then train local personnel in their management.

Potential Impact on Yellowstone

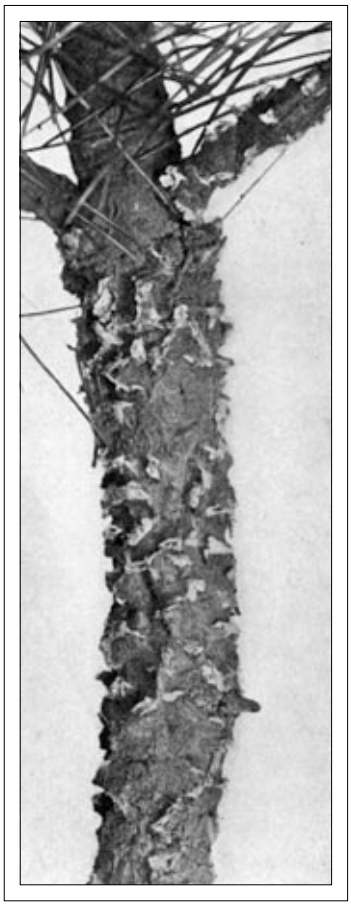
YS: One interesting twist on the Yellowstone situation, at least with terrestrial plants, is that science has never shown that the exotic plants are actually replacing native plants. And so the argument goes, what's the big deal? Of course, this doesn't apply to areas where the native vegetation and soil have already been disturbed by human activity; we have a number of sites near the park and in the park that were massively altered, say by a feedlot, where exotics take over and essentially create monocultures.

MS: While it may be true that there is no evidence that a species has gone extinct in Yellowstone because of an alien introduction or colonization, there is no question that it's happening in other places, and I think eventually it will happen here. Also, don't forget that many new diseases are exotic species. And if a disease is affecting a native tree that is an important source of food mast for the ungulates or the carnivores, then the lower productivity or abundance of that species as a result of the disease can have a profound effect on the ecosystem even without causing herbivores to go extinct. The demise of the American chestnut due to chestnut blight was such an event. So, local extinction of native species is not the only criterion by which you should judge whether an exotic species is having a significant impact. I understand that you have a tree species that is being affected by a disease.

YS: Right. The whitebark pine is suffering to some extent from an exotic disease, blister rust. So far we don't seem to be as hard hit as areas farther north of here with a different climate. Glacier National Park, in northern Montana, is apparently going to lose virtually all of that species of tree over time. But you're absolutely right about the effects of an exotic disease, because several of our fauna including grizzly bears, red squirrels, and Clark's nutcrackers are ecologically tied up with the fate of the whitebark pine.

But there is another side to the exotic question. Say that an exotic grass invaded the park, one that animals like to eat. Over time, it might fill in places between native plants, or even to some extent replace the natives. It may have increased the nutritional potential of a range. The result could be that the animals "benefit" by having more food, but at the same time the system has been altered, and of course the greater number of animals could have effects on other plants or other parts of the system. Philosophically, even if the plant has some short-term effects that don't seem harmful, we must be very careful how we define such things as "harm" and "benefit."

MS: I think what the argument boils down to is the difference of opinion on what's an acceptable rate in change. The ecological system in Yellowstone has never been a stable equilibrium system; it's only been in existence a few thousand years, which is no time at all biologically and ecologically. So the system is always in flux. Besides, ecologists no longer accept the paradigm of ecosystems as homeostatic. And in the face of global warming, ozone thinning, and other changes such as the return of the wolf, there will continue to be an increase in the rate of change.



Blister-rust on the trunk of a young white pine.

So we are selecting among possible scenarios. Where we have control, we should probably exercise that control by eliminating the invading factors that cause a grievous effect to the system. We don't have the resources to eliminate everything that we may not like. So some exotic species might out of necessity be tolerated, including a species that comes in but does not displace any native species, or does not have significant effects on the system's productivity, or doesn't serve as host for a more noxious species. We might even decide we can tolerate an exotic species that increases productivity. But again, each time it's a judgment call; it's a matter of degree.

Alien Disease Organisms

YS: Most of us were raised on the "balance of nature" concept. But as you

pointed out, ecologists have abandoned that simplistic view of how natural systems work. The extent to which wild ecosystems change without any obvious cause or direction is largely unknown to the public—which still implicitly expects these places to be managed to arrest the changes that have always been characteristic of wild systems. Look how worked up people got over the fires. But we'd like to return to the issue of introduced disease organisms, and get your impression of what Yellowstone has to face in that regard.

MS: Look at it this way. Suppose we could pick Yellowstone up and drop it into Asia or Manchuria or Southern Africa. The result would be thousands of invasions. That is obviously farcical, but the point of thinking about it is that Asia and Africa are coming here, in the form of many species of plants, many species of animals, and many, many diseases. And as the climate changes, in particular if the climate warms as nearly all climatologists predict it will, the rate of movement of pests and pathogens, including animal pathogens and parasites, will be greater than it is now. Already in the warmer parts of the United States we're seeing increasing populations of tropical mosquitoes and other insects that harbor a variety of diseases, some of which will pose very serious human health threats such as malaria, yellow fever, and chagas disease in the future.

This is not to say that we're going to be seeing bananas and oranges growing in Yellowstone in the next ten to twenty years, but it will become warmer. That means that organisms that live in more moderate climates will have a higher probability of showing up here. Besides that, with the importation of exotic wildlife to North America for the enjoyment of hunters and game ranching, there is always the possibility of increasing the movement of African and Asian diseases to this continent, affecting our native fishes, waterfowl, and ungulates. So, I'm very concerned for the well-being of our wildlife.

I don't know what we can do to plan for these eventualities, but quarantine is certainly an issue that we are concerned about in the conservation and wildlife community. I'm one of the most vocal supporters of the concept of linking up our wilderness areas and national parks and roadless areas through the use of interconnecting wildlife corridors, so that the populations of wildlife will be viable. But the other side of the coin is that if everything is highly connected, pathogens will move more easily too. Perhaps we need to have choke points within our wildlife corridors.

Deciding Which Alien Species to Fight

YS: The NPS is struggling with a lot of questions relating to nativeness. Olympic National Park has gone through the political and emotional equivalent of World War III over their desire to get rid of non-native mountain goats that were introduced years ago. Olympic's managers weren't just concerned about philosophical purity; those goats have tremendous impacts on native vegetation. And other parks have big problems, like the feral burro populations in the Southwest. Here in Yellowstone, we're being invaded by populations of mountain goats that were artificially established on public lands outside the park and are now moving onto park lands.

MS: Those are important issues, but if there were a simple answer to this, it would have been thought of a long time ago. Nativeness is one of those concepts that is always open to debate. By various definitions, there are countless degrees of nativeness or pristineness and, as you suggest, the definition depends on where you draw your line, and the line is always somewhat arbitrary. For instance, I could argue that everything that was here prior to the arrival of Columbus is native, and everything that came later is not. Or I could say that everything that was here before humans arrived from Asia 10,000 or 12,000 years ago, is native. All definitions are arbitrary to some extent, but that doesn't make them less necessary for some purposes.

I sometimes think that the issue of nativeness is a red herring that distracts us; an alternative approach in this era of massive biotic invasions from continent to continent is to look at the problem ecologically. My personal litmus test for determining whether an alien should be dealt with or ignored is based on whether it's likely to cause the endangerment or extinction of native species that were part of the pre-European fauna of North America. But it always comes down to difficult management decisions, and nobody is going to provide the NPS or any other land management agency with simple guide-lines or rules of thumb about how to deal with these problems.

YS: Actually, there is a whole world of position takers and opinion holders out there who are trying to do precisely that. There is an extraordinarily large group of people who are certain they know what to do, and equally certain that science will back them up. The trouble is, from a manager's perspective, none of them are persuasive enough to win the debate. Perhaps that is what saves parks from having too narrow a view of their mission.

MS: In these situations, your best hope is to gather together the best minds and sit down and say, "Okay, we have a problem. This group says this, another group says that, the public is saying this, the managers are saying that. What should we do?" Somebody is going to have to make a decision and it's never going to be clear-cut.

My personal litmus test for determining whether an alien should be dealt with or ignored is based on whether it's likely to cause the endangerment or extinction of native species that were part of the pre-European fauna of North America.

National Parks as Preserves for Exotic Animals

YS: Another interesting idea that pops up now and then, and not always out on the lunatic fringe, is that national parks are good places for stockpiling species, even if those species are not native to the park

in question. At its most reasonable (which is giving more credit than it usually deserves), this position would say, for example, that we would have a better chance of saving the giant panda if we established "wild" populations in Great Smoky Mountains National Park. Pandas are exotic, but if it were shown that they could thrive there, maybe it would be worth the compromise of park values to save this species.

MS: Well, I don't think that national parks should be botanic gardens or outdoor zoos for exotic species. There are other agencies and other organizations that should provide those services. National parks should not be all things to all people. When an agency or a facility tries to do that, then they don't do anything well. Besides, it is impossible to predict all the consequences of introductions.

I think it's important that the administration and Congress and other policymakers within the NPS bite the bullet and say that this is our mission and those things are outside of our mission; somebody else must take care of them. Let's say that some temperate species of ungulates in southern Africa has become endangered. Maybe they could survive in Yellowstone. But they might also carry diseases, and their presence could have a lot of other unknown consequences for the carnivores and herbivores in the system. Stockpiling exotics opens a Pandora's box.

YS: But you can understand how tempting it must sound to some people, especially those whom we describe as having an especially strong husbandry gene. Let's say, for example, that we could easily gather up all the different strains and species of endangered pupfish that live in tiny isolated warmwater ponds and springs in the desert southwest. We have hundreds of warm pools here where we could give them additional homes, broadening their population bases and improving their odds of survival if a disaster destroyed one pond.

MS: But you know there are always unpredictable ecological consequences of doing things like that. By establishing new populations of these fish, you would then provide a new food source for some species of birds that specialize in feeding on small fish and prawns, but which don't exist here now. Suddenly an entirely new suite of bird species might over-winter, bringing new diseases or parasites that could infect other birds. They could also bring in seeds and spores of aquatic plants that don't exist in the park. You never know what can happen. That is why the rule of thumb is that no exotic species should ever be consciously introduced.

NPS Photo

*The wooly mullein (*verbascum thapsus*) a bienniel that is exotic to Yellowstone.*

What Distinguishes Yellowstone

YS: But we'd like you take a broader look at Yellowstone. In the world of conservation, we have the impression that Yellowstone serves many purposes. A lot of theory gets tested here, and a lot of new management ideas are tried out, criticized, revised, and tested again. We always have about half a dozen big controversies simmering along, and a lot of smaller ones, about the best way to manage Yellowstone. From your global perspective, what is it that distinguishes Yellowstone as a site of conservation in action?

MS: One thing that distinguishes Yellowstone is that it contains virtually a complete array of its native carnivores and herbivores. The completeness of this system, and its scale, can't be found in any other place in the lower 48 states. The sense of wilderness and wildness here is incomparable. If you're walking into a forest and you know that there might be mountain lions, grizzlies, or wolves nearby, it makes you that much more aware of your surroundings. You're more alive and alert than you are in almost any other kind of environment. To suddenly realize that one is a prey species helps us to appreciate our lives, particularly if a helicopter isn't hovering overhead. In other words, wilderness teaches us lessons of humility and self-reliance.

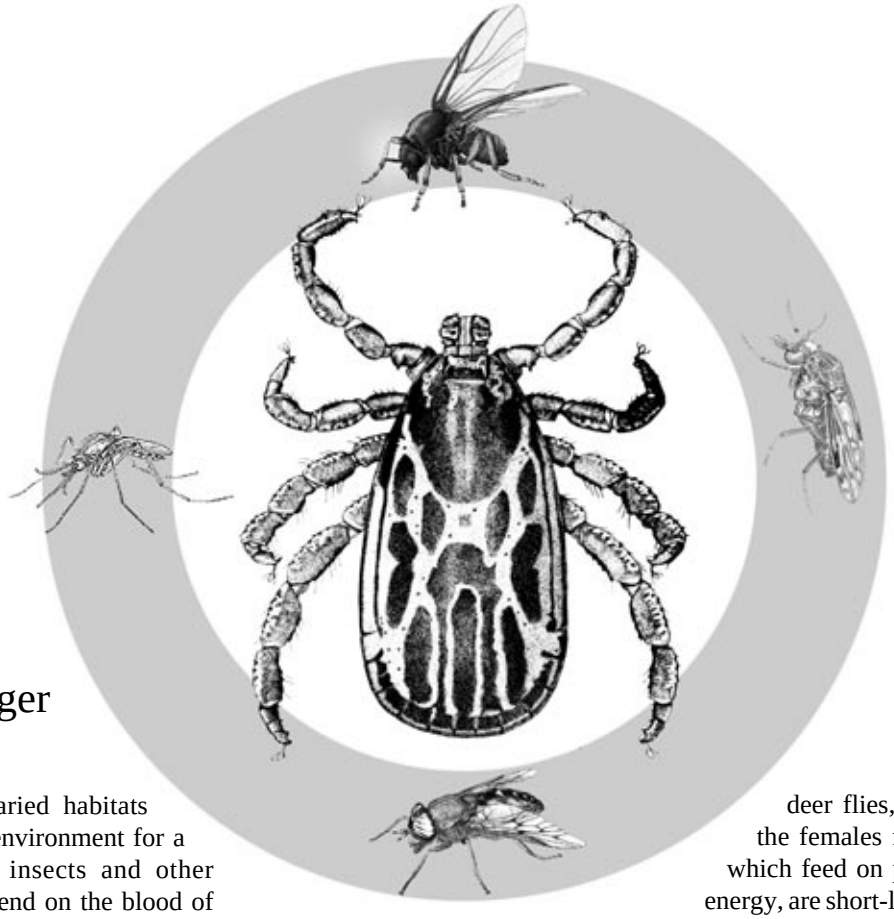
Unfortunately, though, we're coming to the end of the era when you were on your own as soon as you left your car at the trailhead. Soon most hikers in the woods will carry a cellular or satellite phone. Such postmodern, backcountry ecotourists will be able to down-load the Wall Street Journal, phone their baby sitter, or call in a helicopter rescue if their Gore-tex boots get damp. I'm saying that communications technology means the end of the wilderness experience of its users. In a real sense, it means the end of wilderness, period. Who wants to hear a phone ringing from the other side of the lake in a so-called wilderness?

YS: So maybe we should ban cellular phones in the wilderness?

MS: Indeed, but the government liability lawyers won't permit it. They're already issuing phones to climbers in Denali. The best we can hope for is that grizzlies or wolves develop an irresistible fondness for the taste of these evil instruments.

Yellowstone's Insect Vampires

Biting to Survive



by John Burger

Yellowstone's varied habitats provide a suitable environment for a great diversity of insects and other arthropods that depend on the blood of birds and mammals for their survival and reproduction. While often regarded as pests, these organisms are important components of their ecosystems. As larvae, they contribute to nutrient cycling in aquatic and semi-aquatic habitats, and as both larvae and adults they provide food for a variety of predators and parasites.

This article summarizes the biology and habits of each group of blood-feeding flies and ticks that inhabits the park, where it is possible to study populations that have not been affected by large-scale pest control projects and habitat alteration. Much of the general information on biting flies was gathered during the summers of 1966 and 1967, while I was studying the association between insects and bison, elk, and moose at the Lamar Ranger Station. I made direct observations of these host animals and of horses kept at Lamar for backcountry work, collected insect specimens with standard insect nets as they fed from animals and humans, or reared the insects from the droppings of host animals.

My detailed field notes on insect activity during this period were supplemented by observations and daily activity logs kept during 1959-1961 and from 1990 to the present. Most of my observations were of large ungulates in the northern half of the park. Additional and often vivid comments were provided by park personnel on the blood-feeding insects that made their lives more than a little uncomfortable. Little or no information seems to be available on the effects of blood-feeding insects on other park animals such as bears, coyotes, pronghorn antelope, and bighorn sheep.

All of the flying insects in Yellowstone that feed on the blood of vertebrates are true flies (order Diptera). In mosquitoes, buffalo gnats, biting midges, horse and deer flies, and snipe flies, only the females feed on blood; males, which feed on plant sugars for flight energy, are short-lived and die soon after mating. In horn flies, stable flies, and moose flies, both sexes feed on blood. For most blood-feeding flies, blood is needed for egg development. A few species can complete the first ovarian (or gonotrophic) cycle using nutrients stored from the larval stage, but subsequent cycles require a blood meal for egg maturation.

Mosquitoes

Of all Yellowstone's blood-feeding insects, mosquitoes (family Culicidae) are the most diverse and familiar to visitors. Most of the 33 species recorded in the park are in the genus *Aedes;* species in the park's other three mosquito genera are infrequently seen. The informa tion in this article focuses on the 12 species of *Aedes* that are responsible for most of the annoyance to humans and other animals in the park.

Life cycle. The females deposit their eggs in soil depressions where water will collect during the spring and summer. The eggs remain dormant until they are flooded by water during snow melt or flooding in spring. The larvae, which hatch in ground pools, feed on suspended particulate organic matter that they sweep into their mouths with specialized mouth brushes. They pass through four molts (instars), followed by an active pupal stage from which the adults emerge. The length of this part of the life cycle depends on water temperature, but usually takes about 4-6 weeks. After adult emergence, both males and females feed on plant sugars for flight energy, and mating soon occurs.

After mating, females search for available hosts, primarily large mammals. They are attracted by movement, CO_2, heat, moisture, and volatile compounds on a host animal's skin surface. Following a blood meal, the eggs mature in the ovaries and are deposited in a suitable habitat. *Aedes* produce only one generation per year, and overwintering occurs in the egg stage. The other three genera of mosquitoes occurring in Yellowstone overwinter as larvae or adults.

Feeding. Although the onset of biting activity may vary by up to two weeks depending on weather, it usually begins during the first week of June at lower elevations. Generalizations about biting activity duration are difficult to make, partly because species tend to be typical of either open sagebrush-grasslands (*Aedes idahoensis*) or forested areas (*Aedes communis*). In open sagebrush-grasslands in the northern part of the park, biting peaks during the last half of June and in early July, while in forested areas and at higher elevations where larvae can be found in mid-July or later, biting may not commence until late July and may continue until early September.

Host-seeking mosquitoes tend to be most active in the evening and on cool, cloudy days, and less active during the middle of the day or during warm, dry, or windy weather. Activity tends to be stimulated after wet weather. The habits of each species are quite distinct. Some forest species are very elusive, approaching a host cautiously and flying off quickly in response to any sudden movement. These mosquitoes, while persistent, are hard to catch. In contrast, species inhabiting the northern sagebrush-grasslands tend to be very aggressive.

Distribution. Mosquito populations can be relatively local or more generally distri buted. Although biting populations can be very large almost anywhere in Yellowstone at a particular time, some areas such as the Lamar Valley, Soda Butte Creek, and Slough Creek are notorious for mosquitoes because of extensive breeding habitat, especially in low spots where water accumulates after snow melt and spring flooding. Biting populations can be so dense that they drive anglers and hikers indoors or to the refuge of their vehicles. In early July, *Aedes idahoensis* can attack in dense clouds in Lamar and near Soda Butte. On one early evening, dark horses being loaded at the Soda Butte trailhead appeared gray because of the light reflecting from the wings of feeding mosquitoes. In spring and early summer, Bechler Meadows has large flooded areas where mosquitoes can become pestiferous until the wet spots dry up in August. Spring flooding along the Yellowstone River in the Thorofare area also produces large mosquito populations.

Effect on Animals. Deer, elk, bison, and other large mammals are suitable hosts for many mosquito species, but little is known about whether these animals' behavior or health is seriously affected. Mosquitoes probably remove significant quantities of blood, but animals may avoid the most severe attacks by moving to areas where mosquitoes are less abundant. Dense pelage on bison may limit mosquito attacks to areas of the body where hair is short, sparse or absent. Mosquitoes are known to transmit avian haematozoa (blood parasites) to birds and probably do so to at least some extent in Yellowstone. One species of *Culex* known to occur in Yellowstone feeds exclusively on frogs.

Horse Flies and Deer Flies

After mosquitoes, horse flies and deer flies (family Tabanidae) are the most diverse and conspicuous biting flies in Yellowstone. Of the 31 species recorded in six genera in the park, the most abundant and widespread are in the genus *Chrysops* (deer flies) and the genus *Hybomitra* (horse flies). Deer flies are smaller (6-8 mm long), and in Yellowstone are either black or yellow and black. All deer flies have a conspicuous dark crossband on the wing. They often are confused with snipe flies, which are gray, brown, or black and have unpatterned wings. Horse flies are larger, heavy-bodied flies (12-18 mm long) that are gray, reddish brown, or black.

Life Cycle. Masses of 100-400 horse fly and deer fly eggs are laid on emergent vegetation near the edges of ponds and other areas of standing water such as marshes and sloughs. When the eggs hatch in 3-4 days, the larvae drop into the water, burrowing into the soil beneath it. The larvae pass through 6-8 molts before moving to drier adjacent soil to pupate. The larval stages of deer flies last about a year, while those of larger horse flies may last one to three years, depending on food availability. Both horse fly and deer fly larvae prey on soft-bodied organisms, and will generally consume any organism they can overpower, including each other. The pupal stage lasts about 8-14 days, followed by adult emergence. Overwintering always occurs in the larval stage.

Studies have shown that only about 40 percent of the deer flies that survive to pupation emerge as adults; the remainder are killed by parasites or pathogens such as viruses, bacteria, microsporidia, and fungi. Adult emergence usually begins the last week of June, but may be advanced or delayed by a week or more depending on the weather. The flies rapidly become more abundant and peak in many areas of the park by the third week of July, starting at lower elevations. Although the flies may remain locally abundant at higher elevations, activity gradually begins decreasing by mid-August, and usually ceases by the first half of September, depending on weather conditions.

Deer flies appear to alternate annually between high and low populations in Yellowstone, perhaps because predators or parasites are favored by particular environmental conditions, or because deer

fly pathogens are more common in some years.

Feeding. Horse flies and deer flies are most active on warm, sunny days between 10 a.m. and 4 p.m. and less active on cloudy or cool days or during rainy periods. These flies are strongly visually oriented, and usually depend on host movement for long-distance attraction, and on host odors, color, and CO_2 for close attraction. Their blade-like mouthparts for piercing and cutting through skin can produce very painful bites. Deer flies tend to be most common in meadows or along trails, where they perch on vegetation and fly out and around objects moving on the trail. They usually circle once or twice while determining whether to land and attempt to feed. Horse flies also rest in vegetation and fly out after moving objects, particularly in open areas. Trails and large meadows are prime locations for *Chrysops ful vaster*, a vicious biting deer fly that is extremely abundant in large meadows and near some thermal areas.

Effect on Animals. Little is known about the effect of horse flies and deer flies on Yellowstone's wildlife populations. Although the fierce bite of *Tabunus punctifer*, which has a large black body with a gray thorax, can cause horses to spook, the species is not common in the park. Deer fly bites have been known to occasionally transmit tularemia to humans, and horse fly bites have transmitted anaplasmosis to Wyoming mule deer. In the Southwest, horse flies transmit elaeophorosis, a serious filarial worm disease of elk, but it has not been reported in Yellowstone.

Horse flies can cause significant blood loss in livestock, resulting in a reduction in weight gain of up to a kilogram a day, and this probably occurs in park ungulates as well. If not "fly doped" several times a day or kept in the barn, horses corralled at Lamar Ranger Station had blood oozing from multiple bites, which attracted other flies that feed on blood. Bison may use dust wallows to reduce attacks of biting flies, but this is probably secondary to other reasons for wallow use. Elk will sometimes bunch together with heads pointing inward, or line up with heads facing in opposite directions in what appears to be a kind of collective response to attacks of horse flies, but this could also be to avoid parasitic nasal bot flies. Yellowstone's large mammals undoubtedly experience considerable annoyance during the horse fly season which can be mitigated by moving to a higher elevation or seeking shelter in dense forested areas during the day.

Snipe Flies

Biting snipe flies (family Rhagionidae) are slender-bodied, gray, brown, or black flies with long, unpatterned wings and short piercing mouthparts. All the biting species in Yellowstone belong to the genus *Symphoromyia*. Their attack behavior is similar to that of deer flies, with which they are often confused, and they are sometimes referred to as "deer flies" or "buffalo flies." The most common species inhabit either open sagebrush-grassland areas (*Symphoromyia flavipalpis*) or forested areas (*Symphoromyia pachyceras*).

Feeding. Snipe flies are not as generally distributed or as consistently abundant in the park as horse flies, deer flies, and mosquitoes, and they tend to be extremely local in distribution. They are most common in northern Yellowstone and in large, open expanses such as Hayden Valley. They may be abundant in a particular small area for only a few days. The factors governing the occurrence of these flies and their abundance during outbreak years are not known. When very abundant, snipe flies can be severely annoying to humans, attacking in large numbers around the head and arms, with a particular predilection for wrists and fingers, resulting in painful bites. In certain years, such as 1994, adults have been extremely abundant, with 25 or more flies attacking simultaneously. They attack silently, often going unnoticed until a sharp stab heralds their penetration of the skin.

Effect on Animals. When especially abundant, snipe flies may cause large animals to move. Snipe flies that are active in open areas tend not to move into forested locations, and forest species do not often attack in large meadows, so animals can avoid the most severe attacks by moving to areas where the flies are less active. The extent to which snipe flies may transmit diseases or parasites to wildlife is not known.

(For a more detailed account of snipe flies in Yellowstone, see *Yellowstone Science* Spring 1995 3(2):2-5.)

Buffalo Gnats or Black Flies

Buffalo gnats (family Simuliidae) are small, heavy-bodied flies with piercing mouthparts similar to those of horse flies and biting snipe flies. "Buffalo gnat," which is the name used commonly in the West, refers to the humped appearance of the thorax. Many species are predominantly black with some paler markings. Extensive surveys of buffalo gnats in the park during the past four years have recorded 30 species in four genera, mostly in the genera *Prosimulium* and *Simulium*. Except for those originating in thermal areas, every stream examined in Yellowstone has been found to support at least a few species.

Life Cycle. Females deposit their eggs singly or in groups in running water, either by scattering eggs over the water surface or attaching them to vegetation or rocks in a stream. Species of *Prosimulium* may overwinter as larvae or eggs, while *Simulium* species overwinter only as eggs. The elongate larvae, which attach to rocks or vegetation in streams, have head "fans" that filter particulate organic matter from the water column. Pupation occurs on the same substrates that are inhabited by the larvae. Emerging adults ride a bubble of air to the water surface and fly to shore. Mating usually occurs near the larval habitat.

Adults begin emerging in late June and rapidly increase in abundance through July and early August. Because some species may have several generations per year, large populations can be found even in early September. A CO_2-baited canopy trap in the upper pasture at Lamar collected thousands of female *Simulium arcticum* on September 6-9, 1966. Fortunately for humans, buffalo gnat populations in the park tend to be quite local. Some species inhabit large rivers such as the Yellowstone and the Lamar, while others live in cold springs and tiny water trickles running down hillsides. Some

species occur in dense populations while others are widely scattered over large areas of stream bottom. The most favored areas for adults seem to be in tall grass adjacent to streams; they are rarely abundant in upland areas away from streams.

Feeding. After mating, females search for suitable hosts. Particular species tend to feed on either birds or mammals, but not on both. The females usually crawl on the host before biting. When attacking humans, they often burrow beneath trouser legs, socks, and shirt cuffs, or bite at the back of the neck at the hair line. Host-seeking females are most active on cool, humid days during late morning and late afternoon to early evening; biting activity increases during and just after wet weather. Some species have relatively painful bites, while others produce no initial reaction at all. Often a spot of blood remains where a fly has pierced the skin. Bites can cause severe allergic reactions in some people, but this is unusual.

Effect on Animals. Buffalo gnats can be serious pests of humans and large mammals, especially in northern areas and in the mountains of the West. Some species known from Alberta and Saskatchewan, Canada, can cause severe allergic reactions in cattle, which may die from a large number of bites. Observations of horses at Lamar in the 1960s showed that adults of *Simulium arcticum*, one of the park's most abundant species, burrow under the hair of the animal, particularly on the neck, chest, and between the front legs. Running a hand over the chest of a horse can cause a hundred or more feeding buffalo gnats to drop out of the hair. The insect bites form large bloody welts that turn into swollen scabby patches. Although horses do not seem to try to avoid them, possibly because of the gnats' small size and quiet approach, some horses are known to be especially sensitive to them. Large mammals are presumably heavily exposed to biting buffalo gnats where species such as *Simulium arcticum* are abundant, but effects on the health and behavior of the host animals are not known. Buffalo gnats can transmit a blood parasite (*Leucocytozoon*) to waterfowl, but the presence of this parasite in Yellowstone is undetermined.

Biting Midges

Biting midges (family Ceratopogonidae), commonly called punkies or no-see-ums, are minute flies whose painful bites are wildly disproportional to their size. They generally have dark-colored chunky bodies and faintly mottled wings with pale spots. The genus *Culicoides* is responsible for most biting activity in Yellowstone. These are the least studied of Yellowstone's blood-feeding insects, and little is known about the number of species present or their life cycle. The larvae, which are slender and elongate with a well-developed head capsule, occur in wet or damp soil, usually where muddy areas persist for considerable periods. Larvae are carnivorous as far as is known. The mouthparts of the adults are similar to those of buffalo gnats, horse flies, and snipe flies.

Feeding. Biting female midges are active from early July to early September. Large populations tend to be rather local, and adults probably do not disperse far from their breeding sites. The midges are most active at dusk, and large numbers may suddenly attack when decreasing light intensity reaches a critical level for activity, causing considerable annoyance. Biting activity usually lasts until about 9 p.m., when the air temperature begins to drop rapidly. I have observed 150-200 midges attacking horses when pastured in or near wet areas in tall grass at dusk. Feeding midges, which appear as dark or pale grayish specks on the skin, are not capable of penetrating clothing but pass readily through screened windows. One of the most common biting species in Yellowstone is *Culicoides cockerelli*.

Effects on Animals. Serological evidence suggests biting midges transmit bluetongue virus, a serious disease of domestic sheep, to elk, mule deer, and pronghorn in Wyoming. They also transmit epidemic haemorrhagic disease, which has been recorded in white-tailed deer and pronghorn antelope. Some species are known to transmit filarial worm parasites to large mammals.

Biting Muscoid Flies

Stable fly

Although these flies belong to the same family (Muscidae) as the house fly, their mouthparts are modified for piercing and feeding on blood. Yellowstone has three species of biting muscoid flies (subfamily Stomoxyinae): the horn fly (*Haematobia irritans*), the stable fly (*Stomoxys calcitrans*), and the moose fly (*Haematobosca alcis*). The horn fly and the moose fly are host-specific to bison and moose, respectively, in Yellowstone while the stable fly is a generalist, feeding on many large mammals.

Horn Fly. This blood-feeding fly from the Old World spread rapidly throughout most of North America after its introduction here around 1885. Dark brown and about half the size of a house fly, adult horn flies have a slender, elongate piercing proboscis. This fly and its relatives in Eurasia and Africa feed on Bovidae such as cattle and buffalo. The name horn fly was given to this species because of the mistaken impression that they cluster around the horns of cattle.

Adult horn flies live on Yellowstone bison, primarily on the animals' backs, where they feed on blood frequently. If disturbed from the bison, they immediately fly back to it. Up to 200-300 flies can be found on a single domestic animal, but whether they reach this density on wild bison is not known. As soon as a bison defecates, the females fly onto the dropping, each stabbing 5-10 eggs beneath the surface. After five minutes when the dung is no longer attractive to the females, they return to the host. Larvae develop in the droppings for about 2-3 weeks, then migrate to the soil to pupate. When adults emerge, they search for a suitable host or wait until the animals visit the area.

Adult horn flies are of considerable economic significance to ranchers because they lessen weight gain in cattle. They may occasionally feed on a horse or land on other animals, including humans, but they rarely attempt to feed on unsuitable hosts. Their numbers gradually increase starting in late June, and probably

peak in late August or early September.

Stable Fly. This biting fly, which has relatives in Asia and Africa, was probably introduced into North America sometime after the arrival of European immigrants. It is sometimes called the "biting house fly" because it resembles the house fly except for its slender, elongate proboscis. Immature stages live in moist decaying vegetable debris, including mats of dead grass or animal droppings mixed with vegetable debris. The larval stages last 2-4 weeks, depending on temperature. Mature larvae move to drier substrates for pupation. After emergence, adults mate and then search for a suitable host.

Stable flies tend to attack the lower part of the body, especially the legs and ankles of horses and other large mammals. Because their approach is silent, stable flies often remain undetected until they penetrate the skin. Close observation reveals the black proboscis searching for a likely feeding spot. The elongate mouthparts can readily penetrate clothing. The bites are quite painful, and animals react by stamping their feet. As with the horn fly, stable fly populations gradually increase during the summer months and are most abundant in August and early September. Adults are active during daylight hours until dusk.

Moose Fly. I conducted the only definitive study of this fly in Yellowstone in the 1960s. This fly is similar in many respects to the horn fly, except it is native to North America. It depends on a single animal species for its entire life cycle, which is unusual for a blood-feeding fly. While its Eurasian relatives are associated primarily with cattle and their relatives, in North America it occurs wherever moose are found. Adults remain on the moose's hindquarters, feeding frequently except when females leave to lay their eggs. When a moose crosses a stream, the flies hover over the animal until it emerges from the water, then they immediately land on it again.

When a moose defecates, the females immediately leave the animal and walk across the dung surface, stabbing eggs into crevices. About 5-10 flies will lay 50-75 eggs on a dropping. The flies return to the moose to resume feeding after 2-3 minutes, as other dung-inhabiting insects begin arriving at relatively specific intervals, thus partitioning access to the resource. Moose flies may complete up to three generations a year under favorable environmental conditions, but only the softer droppings characteristic of late spring and summer will support their development. The larvae pupate after about 3-4 weeks. Adult flies emerge from the pupa about 4-5 weeks after the eggs have been deposited and then rest in vegetation until moose move into the area. Larvae present in September pupate and remain dormant until the adults emerge the following June and early July.

I have not noticed any adverse effects on moose, which do not seem to be especially bothered by the flies, even with 200-300 flies per animal in mid-summer, although blood loss must be considerable in such cases. I have occasionally collected adult moose flies on horses, and once a male bit me on the arm, producing a sensation like a mild pinprick. These flies were probably seeking a suitable host animal and were attracted by movement.

Ticks

winter tick

The two most commonly encountered species of ticks (family Ixodidae) are the winter tick *(Dermacentor albipictus)* and the Rocky Mountain wood tick (*Dermacentor andersoni)* although other species likely appear in the park.

Winter Tick. Active during winter and early spring, the winter tick is a "one-host" tick, remaining on its host as it develops from larva to nymph to adult. It occurs on many large mammals, including elk, deer, moose, bison, and antelope, but not on humans. Unlike most ticks, the winter tick can occur in very large numbers on a host. Some hosts that carry hundreds or even thousands of ticks are almost invariably in poor condition and are likely to die during the winter. Although the relationship between the physical condition of the host animal and the number of winter ticks present has been observed for many years, no explanation has been documented. Because animals in poor condition are more sedentary, they may be apt to pick up more questing ticks from vegetation.

The winter tick is not known to transmit any diseases to wildlife, but its large numbers on elk, antelope, deer, and other large mammals that are physically stressed in winter would undoubtedly contribute to their mortality.

Rocky Mountain Wood Tick. As a "three-host" tick, the Rocky Mountain wood tick has a very different life cycle. After hatching, the larva feeds on a small mammal such as a ground squirrel, then drops off and molts to the nymph stage. The nymph feeds on another small mammal the following year, then leaves that host and molts to the adult stage. The following year, it seeks a large mammal, which could be a human, although such ticks seem to be relatively rarely encountered. After feeding, the female lays up to several thousand eggs and then dies. In Yellowstone, adults are active from mid-April to mid-May and are most prevalent in large meadows and in sagebrush-grasslands.

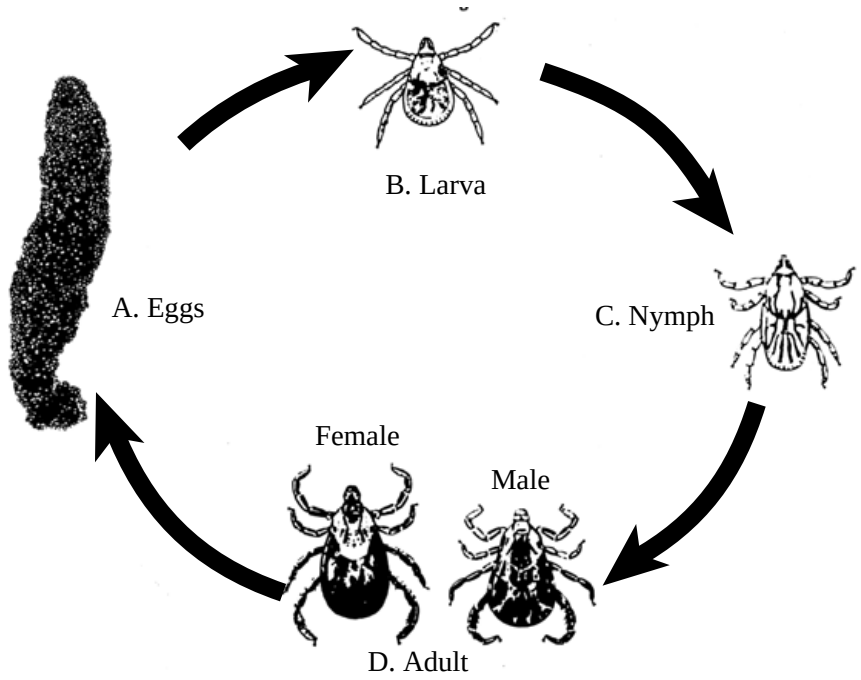
Rocky Mountain tick

The Rocky Mountain wood tick transmits several diseases, including tularemia and Rocky Mountain spotted fever, which was once common in Flathead Valley and the Bitterroot Mountains of Montana but is now much less so because of changes in land use and a shift in the pathogen's virulence. The Rocky Mountain wood tick has been implicated in the biological transmission of anaplasmosis to mule deer in Wyoming. *Brucella* organisms have been detected in ticks, but no evidence of transmission to animals has been demonstrated. This wood tick can cause a slow-spreading paralysis that is a reaction to the saliva of a feeding tick when it bites on the scalp or back of the neck; the paralysis disappears when the tick is removed.

Lyme Disease. Currently the most serious tick-borne human disease in North America, Lyme disease has not yet been reported in Montana. Thirty cases have been reported in Wyoming since 1989, but the presumed western vector (*Ixodes pacificus*) has not, raising the possibility

Yellowstone's Biting Flies and Ticks

Insect	Larvae	Peak Activity	Habitat	Host Animals
Mosquitoes	Hatch in standing water and mature in 4-6 weeks; one generation a year for most species	From mid-June to early September, depending on elevation and habitat; most active in evening and cool cloudy days	Specific to sagebrush-grasslands or forested areas depending on species.	Primarily large mammals; impact on wildlife includes blood loss and transmission of avian haematozoa parasites.
Horse flies and deer flies	Burrow into soil beneath standing water and mature in 1-3 years, depending on food availability	Early July to mid-September; most active on warm sunny days from 10 a.m. to 4 p.m.	Along trails and in meadows	Primarily ungulates; may cause significant blood loss.
Snipe flies	Develop in vegetated soil in about 1 year	July to mid-August; most active on warm sunny days from late morning to early evening	Usually specific to sage-brush-grasslands or forested areas.	Humans and ungulates; may cause significant blood loss
Buffalo gnats	Attach to rocks/ vegetation in streams and mature in 3 weeks to 3 months; may overwinter and have several generations a year	Late June to early September; most active on cool humid days from late morning to early evening	Near streams, especially in tall grass	Specific to birds or mammals; cause severe allergic reaction in cattle and some humans; impact on wildlife unkown, but may transmit *Leucocytozoon* to waterfowl
Biting midges	Develop in damp or wet soil and are probably carnivorous	Early June to early September; most active at dusk	Near wet areas	Humans and other large mammals; may transmit filarial worm parasites and bluetongue virus but impact on wildlife is unknown
Stable fly	Develop in animal droppings mixed with vegetable debris; mature in 2-4 weeks	July to early September; active during daylight hours	Widespread	Humans and other large mammals, especially on legs; no known impact on wildlife
Horn fly	Develop in bison droppings; mature in about 3 weeks	Late June to early September	Adults live on host animal except when laying eggs	Primarily cattle and bison, occasionally horses; may limit weight gain in cattle but impact on bison unknown
Moose fly	Larvae develop in moose droppings; mature in 4-5 weeks; may have 3 generations a year	June to September	Adults live on host animal except when laying eggs	Primarily moose; on rare occasions may bite humans or other animals in search for suitable host
Winter tick	Larvae develop on host animal	Winter and early spring	Spends entire life on single host animal	Large mammals; not known to cause any diseases but may stress animal enough to contribute to winter mortality
Rocky Mountain tick	Larvae develop on small mammal; nymph feeds on another small mammal; adult feeds on large mammal	Mid-April to mid-May	On host animal or in host animal's habitat	Small and large mammals; may transmit several diseases including tularema and Rock Mountain spotted fever, but rarely encountered by humans



The developmental stages of the tick.

that these cases were contracted elsewhere. The species of ticks known to occur in Yellowstone have not been implicated in Lyme disease transmission.

The Peculiar 1996 Season

The summer of 1996 proved to be an extremely unusual one for blood-feeding insects in Yellowstone, when heavy snowpack and rains in late winter and spring produced record water levels and floods. Mosquitoes in the Lamar and Slough Creek drainages were exceptionally scarce, less than 1 percent of "normal" nuisance populations, and this apparently occurred in other areas as well. Snipe flies were absent from all investigated areas, including those where they are usually moderately to extremely abundant, and horse flies and deer flies appeared to be much reduced. Trail crews in the Lamar backcountry reported a near-absence of the usual plague of biting flies that can make their work so uncomfortable.

In the case of mosquitoes, it seems likely that high water may have flushed out their usual breeding sites near rivers and larger streams. Although predators may also have had greater access to the ordinarily isolated pools in which mosquitoes breed in large numbers, this would not be the case for mosquitoes in isolated snowmelt pools in forested areas that are not as subject to flooding and other disturbances. Very wet soil conditions may have reduced the survival of horse flies and snipe flies in some areas. Buffalo gnats breeding in the Yellowstone River hatched much later than usual and grew very slowly, possibly reducing the adult population and the number of generations emerging this year. The respite from the annual onslaught of blood-feeding insects, while welcome to most of us, is probably temporary, and we can look forward to healthy populations of these insects in future years.

Reducing Annoyance by Blood-Feeding Insects

Three strategies can be used to minimize exposure to blood-feeding insects: using protective clothing, using repellents, and avoiding places when and where pesky insects are active. Avoidance is easiest for snipe flies, deer flies, and buffalo gnats, which tend to be locally abundant during certain times of the year. For insects that are more generally distributed, protective clothing and repellents are more effective, keeping in mind that snipe flies, deer flies, and horse flies are most active during dry periods, and on warm, sunny days during daylight hours, while buffalo gnats, mosquitoes, and biting midges are most active during late afternoon and evening hours and on cool, cloudy, or humid days.

Protective clothing, which works best against mosquitoes, buffalo gnats, and biting midges, includes shirts with long sleeves, broad-brimmed hats, long pants, and heavy socks. A bandanna behind the head tucked into a hat will keep buffalo gnats and deer flies from attacking around the head and neck.

Commercially available repellents can be used to eliminate or reduce attacks by blood-feeding flies. A bewildering array of these products claim to work, but different formulations and concentrations of a particular repellent can vary widely in their effectiveness. Length of protection is related to the concentration of the active ingredient in the product. While convenient and useful for treating clothing, sprays are generally not as persistent as lotions. Repellents containing "DEET" (diethyltoluamide) are effective against mosquitoes, biting midges, and to some extent, buffalo gnats, but not against horse flies, deer flies, and snipe flies; for these, repellents containing citronella seem to work better but must be applied more frequently.

It is well to remember that despite their unpleasant traits for humans, Yellowstone's insect vampires were here long before humans arrived and are likely to still be here long after humans have passed from the scene. Perhaps one can at least appreciate their role in nature, if not their predilection for blood.

Dr. John Burger is professor of zoology at the University of New Hampshire, where he specializes in blood-feeding flies. Since 1990 he has been documenting the growth and succession of post-fire vegetation and selected insect populations at sites in northern Yellowstone, sacrificing much blood in his quest for knowledge.

President Announces Settlement on New World Mine

With a backdrop of Barronette Peak in Yellowstone, on Monday, August 12, President Bill Clinton announced an agreement between Crown Butte Mines, environmental groups, and federal agencies that would stop a massive gold, silver, and copper mine just outside park boundaries. Leaders of conservation groups and agencies battling the proposed New World Mine hailed the settlement as a major victory for the environment and a way to forever protect Yellowstone from mining pollution in this area. President Clinton gave his speech to nearly 300 persons saying that the agreement "proves that everyone can agree that Yellowstone is more precious than gold. We are all protected from years of and years of expensive and bitter litigation. And while there is still work to do, and work in which members of the general public must and will be involved, we are going to move forward. And this signing today means that it will come the way so many of you have worked for, for so many years. I also want to say that the way this was done should become a model for America's challenges, not only in the environment but in other areas as well."

Environmental groups that had sued Crown Butte over pollution draining from the companies mining lands agreed to drop their lawsuit, while federal and state agencies will suspend work on an environmental impact statement assessing the effects of the mine, and Crown Butte must cease all exploration and other mining activity. Crown Butte will also place $22.5 million into a special account that will pay for the company's continuing cleanup of historical mine waste on its holdings. In turn, federal agencies will give Crown Butte $65 million worth of property yet to be identified through a process which will include public comment. The agreement was designed to compensate shareholders for their investments, provide strict protection for park resources and, in doing so, respect both private property rights and the sanctity of Yellowstone National Park.

NPS photo

Wolf Population Continues to Grow

On August 29, three female pups and one male pup from the Sawtooth wolf pack near Augusta, Montana, were transferred to and temporarily penned in the park. On September 8, six more pups were captured and joined their siblings at the Rose Creek pen. Adults from this pack had killed livestock and were the removed according to wolf management guidelines for the Rocky Mountain Front area. The pups were placed with the two Nez Perce yearlings being held in the Rose Creek pen. It is hoped that the yearlings and pups will form a new pack. Plans currently call for these wolves to be held for the winter and released in spring.

Two wolves penned temporarily at Nez Perce were released on September 17 when a yearling female began to frequent the area outside the pen, possibly forming a bond with the older male inside. The penned wolves, a young adult male originally of the Soda Butte pack and a male pup from the Nez Perce pack, had been captured and relocated from private property near Nye, Montana. Neither wolf had preyed on livestock, but it was believed that relocation to the park would provide the wolves better habitat. Unfortunately, the younger male was found dead on September 21, apparently the result of a roadkill.

The wolf pair originally penned at Nez Perce separated upon their release in spring, and never reunited. The alpha female settled north of the park with five pups born this spring and, when she began preying on livestock, repeated attempts were made to capture her. Though these efforts were unsuccessful and were terminated in August, one of her male pups was injured during capture operations. The pup subsequently had a leg amputated and was placed into captivity at the Wildlife Science Center in Forest Lake, Minnesota.

The Soda Butte pack has been penned all summer due to concerns about potential livestock predation on private lands where they had denned this spring. On September 3, one of this year's pups was found dead by biologists during a scheduled feed; the cause of death is yet to be determined. The five remaining wolves were penned at Trail Creek south of Yellowstone Lake from August until October 7, when sections of their pen were removed to permit their release.

Wolves in the Druid Peak, Leopold, Chief Joseph, Rose Creek, and Crystal Bench packs continue to roam in and outside park boundaries, and have picked up some new wolves from other packs, while two sets of wolves who ranged as loners during summer have newly paired and at last report were in the Thorofare area. Free-ranging wolf packs and loners have not been involved in any livestock depredations and continue to provide occasional opportunities for visitors to see or hear them.

Record Year for Grizzly Bear Cubs

Grizzly bear reproduction, as evidenced by annual counts of unduplicated females seen with cubs across the greater Yellowstone ecosystem, was at record levels in 1996. Through October 1, biologists had observed a total of 33 sows with 70 cubs-of-the-year (average 2.1 cubs per litter). The highest number of grizzly bear sows with cubs previously counted

was 25 in 1986. The highest number of cubs of the year previously counted was 57 in 1990. Whitebark pine nuts were very abundant in most areas of the ecosystem this year, holding bears at higher elevations away from most human activity and developments. There was only one grizzly bear-human conflict reported in the park in 1996 and no bears have had to be trapped and translocated within or removed from the park.

Record Fire Season in West Comparatively Quiet in Yellowstone

Wildfire activity throughout the western United States was reported to have burned more acreage in 1996 than even in the record year of 1924 (1988 being a record for Yellowstone National Park), but Yellowstone experienced only 13 prescribed natural fires that burned a total of 3,264 acres, and 10 wildfires that were suppressed and burned a total of 3 acres. The largest single fire in Yellowstone was the Coyote Fire, which started June 26 in the northern part of the park. Jointly managed by the National Park Service and the Forest Service, the fire was allowed to burn across agency boundaries, and as of September 17 had burned 1,169 acres inside the park and 2,594 acres in the adjacent Gallatin National Forest. The Pelican Fire burned 1,570 acres and provided good viewing opportunities for visitors driving along the East Entrance Road and those hiking around or boating on Yellowstone Lake. By late September, a few fires were still smoldering, but cold weather and precipitation had reduced the fires to minimal activity.

Visiting Scholar Todd Fuller Works with Wolf Project

Dr. Todd Fuller of the University of Massachusetts arrived in Yellowstone in September to spend six weeks as a Visiting Scholar. Fuller is at the forefront of research on wolf population dynamics, and during several decades of wildlife research has also had the opportunity to study carnivores in Africa and South America. Biologists are honored to have Dr. Fuller in the park collaborating and assisting with the wolf project, and he also presented several talks for park staff on carnivore conservation in other ecosystems of the world.

PEOPLE AND PLACE:
THE HUMAN EXPERIENCE IN GREATER YELLOWSTONE

Fourth Biennial Scientific Conference on the Greater Yellowstone Ecosystem
September 28-30, 1997
Mammoth Hot Springs Hotel, Yellowstone National Park

"No place is a place until things that have happened in it are remembered in history, ballads, yarns, legends, or monuments." —*Wallace Stegner*

The next in a series of conferences to feature the presentation of research on the region's cultural and natural resources will be held on September 28-30, 1997 in Mammoth Hot Springs. *People and Place: The Human Experience in Greater Yellowstone* invites proposals for papers and panel sessions from the disciplines of American studies, anthropology, archeology, cultural and historical geography, economics, ethnography, history, literary and art criticism, philosophy, political science, and sociology on topics related to greater Yellowstone. One-page abstracts (hard copy and disk) and requests for more information should be submitted to Joy Perius, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190. Or look for the World Wide Web site at http://www.nps.gov/yell/ycr.htm.

Yellowstone Science
Yellowstone Center for Resources
P.O. Box 168
Yellowstone National Park, WY 82190

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