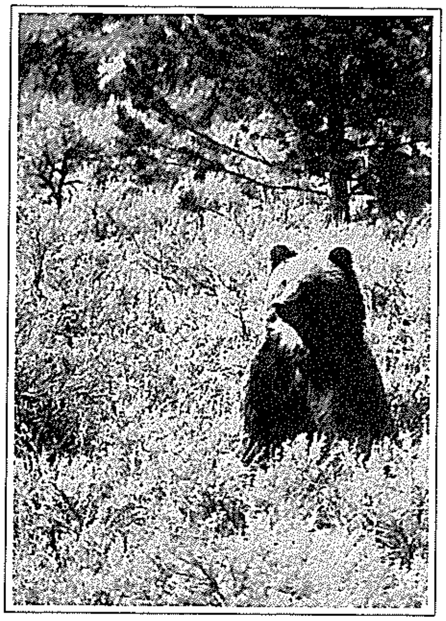

that was just part of your learning curve, or is there something to the notion that bears had forgotten a lot of natural foods in the days of the garbage dumps?

DK: I think they had, for at least summertime. But for a while, we think the only time they ever killed elk was when they were calves or during the rut, when bulls were really easy to catch. Then, sometime in the early 1980s they did start catching elk cows, in the middle of the summer. I can't remember which bear it was—bear #51, one of our big males—killed 13 cow elk one summer. He had a real ambush for them. Had a good time.

YS: Don't we have some that go after bull moose in the same way?

DK: Oh yeah. Moose aren't that much different than an elk, as far as a bear is concerned.

YS: Are bears individuals the way we treat human beings as individuals? You describe an elk predation specialist. I presume there's all different kinds of specialists. How do they discover new things?

DK: I think they've learned by watching other bears. Like fishing—it's something that's got to be learned; they don't just *know* how to fish. It's kind of funny. If you watch a bear that doesn't know how, they can see the fish and just jump right in with all four feet and come up empty. Then they go digging under the banks, and it just doesn't work. When they get the fish crowded, and the stream sort of dammed up, then the bears can get them. It takes a little bit of learning, but once they get it, they're really good at it.

YS: Are you optimistic or pessimistic for the future of grizzly bears?

DK: Sometimes I think they'll be around when we have overpopulated the earth. But I don't know, the way this country is going, the way it's developing...

YS: We hear a lot of concern over global warming and blister rust that will take out the whitebark pine. What about other threats like the lake trout and increasing development across the ecosystem?

DK: I think the worst I've heard for global warming is about a 5° shift, but that is not that much. Besides, you can't forget, we used to have grizzly bears in Mexico and Arizona and New Mexico, too. I think climate change is going to be gradual and the bears will adjust to it, if it's going to happen. That's going to be one of the things they have to cope with. Of course, they cope with no whitebark pine every now and then anyhow. So, it's just like every year is going to be a poor year, and they'd probably adjust. Now they've got the moths they can go on.

As far as lake trout are concerned, if they do cut into the cutthroat spawners significantly, well, that's going to cut into a food source, but then on the other hand, not all the bears in the park are fishing bears, either. There are other things to do.

YS: Do you think the bears can be "delisted" from Endangered Species Act protection?

DK: What I like to say is that I think the bear is recovered in Yellowstone Park and Wyoming, and probably endangered in Montana, and extinct in Idaho. That's the way it is, with the development in Montana...except for the Absarokas and north, it's really tough to see how bears are going to make it there. In Wyoming, I think they've definitely got a huntable population. But it's too bad that delisting removes all the protection of the Endangered Species Act. I can imagine people out there with chain saws and herds of sheep ready to move in when the bear population is delisted, and that scares me. Because I don't know how to protect habitat. We just don't know. You can write some laws, but hell, we couldn't protect the Targhee from widespread clear-cutting and road-building in grizzly habitat, even under the Endangered Species Act. You get an administrator who wants to get around a law, and he'll do it.

YS: If you were talking to the park superintendent right now, parting words on your retirement, what would you tell him to do or not do on behalf of bears?

DK: Just hold on. Hold on with bear management areas and keep developments down. Watch your garbage and indoctrinate new employees about bears—somebody new moves in, you start all over again.

YS: Is the big challenge more related to the bears' habitat than the population itself, in the next 25 years of grizzly bear management?

DK: As far as managing habitat, what can you do? If you can keep the roads out, that is the key. Access is a big thing, access and human development, encroachment on habitat.

YS: A lot of people think that greater Yellowstone will never be big enough, and that the lack of connectivity to another bear population is a concern genetically or demographically. What do you think about that?

DK: I'm not concerned about genetic isolation. It's another field where you've got all kinds of different experts arguing at all times. But we're talking 100, 200 years. Is the human race, civilization as we know it, going to be around that long? I'm not going to worry about 100 years from here, because who knows what will happen in that time.

As long as we can hold on to Yellowstone Park and those wilderness areas, we've got one of the best chances of anyplace in the world to hold on to grizzlies. We are in a lot better position than the NCDE [*the Northern Continental Divide Ecosystem in northwestern Montana*] where everything is broken up by all kinds of roads and people development. We've got a big chunk of habitat that's pretty much *protected* down here, and we've got one of the best shots of anyplace in the world, outside of Alaska.

YS: Do you see in the future real potential for use of such techniques as DNA analysis to help estimate a population or tell us other useful things?

DK: Sure, it's going to help us explain a lot. Whether we ever get to the point where we are going to distantly make a population estimate out of it, I don't know, because the logistics of getting the samples is so great, but small portions of the population we could do.

It would get us lineage—this bear was related to that other bear that did that; okay, that explains that. Some of these things would be interesting; I don't know whether they would be particularly useful to management or not.

YS: Dick, I remember when the satellites were going to tell you everything you needed to know about grizzly bears and were going to count them.

DK: Well, Nat Reed was an ex-U2 pilot and he knew you could see things from 90,000 feet in the air. And Steve Mealey, who was working for me at that time, was an ex-intelligence officer with General Westmoreland in Vietnam. He knew those bears could be seen if they could see the Vietcong from the air, though a lot of the guys that were on the ground would disagree with him! I know these things *could* be done, but I didn't think we'd get the military to do it for us. What the military can do and what we can do are two different things. We hired an air service out of Salt Lake City to take some pictures, and I thought, it's gonna be hard to tell from the air, a long ways in the air, what you've got down there—there are a lot of bison, and I think they'd be hard to tell from bears. We put bear pelts out in Pelican Valley, and we *did* have one grizzly, over by Mary Bay, I think, that came out of the woods and sniffed the hide..."Who was this?"

The whole damn thing just flopped, like I knew it would. We could have spent that money on something *useful.* It was a really expensive little charade.

YS: When you look back at all your years of being in charge of the IGBST, what are your high moments?

DK: Just getting the data. I think the thing I'm most proud of is getting the agencies to cooperate with each other on bear management. Before that, Yellowstone Park would do one thing, Grand Teton another—they might have been on different planets. And every forest did things a different way...everybody was fighting with everybody, and of course, the states never got along with each other anyhow. But then, they had to come together, and the thing that's made it work is the cooperation among the agencies.

"...sometimes I think they'll be around when we have overpopulated the earth. But I don't know, the way this country is going, the way it's developing...we're talking 100, 200 years. Is the human race, civilization as we know it, going to be around that long?...

As long as we can hold on to Yellowstone Park and those wilderness areas, we've got one of the best chances of anyplace in the world to hold on to grizzlies. We've got a big chunk of habitat that's pretty much protected down here, and we've got one of the best shots of anyplace in the world, outside of Alaska."

YS: And this has resulted in tangible benefits to bears?

DK: Yeah, I think so, definitely. Like the IGBC. Everybody's working under the same rules for mortalities, and cooperation in transplanting bears.

YS: Is that telling about the wildlife management business, that the highlight of your long career here would be something that has to do with people?

DK: That's what wildlife management is all about. The animals get along pretty well. We go our way and manage this and manage that, and the animals go their way and survive the best they can.

YS: Maybe wildlife management ought to be populated with sociologists and psychologists and political scientists instead of biologists. Do you think professors are teaching that to wildlife management students? Did you, when you were teaching?

DK: No. You look at what happens out in the field, and what you teach in the classroom, and you begin to wonder, what am I doing? A lot of the stuff you teach them is obsolete. It's different now, you're talking about computers and statisticians; that's all you see in the *Journal of Wildlife Management*—it has very little to do with animals.

YS: Nowadays, whether the schools deliberately do this or the market does it, we've developed a cadre of "bear biologists," and "wolf biologists," and "fish biologists." Are there more specialists today?

DK: It may be. I always felt that a wildlife or fisheries biologist should be an *ecologist.* And the principles are pretty much the same for fish and animals.

YS: So what should your replacement be well steeped in?

DK: Getting along with people. Or at least, dealing with people. You don't especially have to get along with them, but you do have to deal with bureaucrats, politicians...The first five years were pretty tough, but I can look back and laugh now. On the whole, it's been a fairly enjoyable experience, a lot of fun.

YS: Do you think we have as many or more bears now as we had in the 1960s?

DK: I think there are more bears than in the 1960s. We've definitely got them scattered around in Wyoming and in the park.

YS: And we don't need to go back to feeding them? Can you ever see circumstances when we might?

DK: No, I don't see that. We're trying to keep things as natural as we can. And these ungulates are a big food source, especially the elk, for bears. Especially in the early spring, the "overpopulation," so to speak, of elk that die and are so weak that they can't get away, are a big food source. No other bear population I know of has that particular food source. It's important to this group of bears.

YS: Do you ever see yourself writing the book on grizzlies or your life with them? You've laid low compared to a lot of the personalities that deal with endangered species.

DK: I just don't have that kind of personality. I'm not without an ego, but I don't have the kind that wants to write a book. And I'm tired of writing. I told Bonnie, [*Blanchard, his wife and co-worker, who also left the IGBST in 1997*], when I retire, the checks are deposited—she has a checkbook; I'm not even going to write my name!

YS: You haven't always secretly thought,

Grizzly bear sow feeding on a five-point bull elk carcass.

I'm going to write the exposé when I'm retired and don't work for the government anymore—"kiss and tell?"

DK: No. I really have some strong feelings about some of the things that happened to me in the early times, and I don't have a very objective view of it, so I probably shouldn't write about it.

YS: That hasn't stopped lots of authors from writing!

DK: I know. If I ever wrote a book, I'd like to write about "Bears I Have Known"—just about fun bears; there have been a lot of those.

The one bear I liked, we call "Big Red." We never were able to trap him. He was in the Gallatins; the first time I ever saw him was on Fawn Pass. You could see him 'cause he was really reddish, his coat. We had a trap set up south of the pass in the meadow, and we used to pre-bait him. After about three times, here comes Old Red zooming out of the trees—the food plate is here! We did that a couple of times. Bonnie and I went up there to start trapping, and we got the horses, and the bait was all on the ground. I was in the trap putting the trigger bait on, and Bonnie says "here comes a bear!" So I came out of the trap and here comes Old Red, just ambling by—it's time he's going to have lunch. I shot a couple of times in the air. Bonnie said, "Let's get out of here." The horses were skittish, and I got on my horse, but then I said, "He's got all our trigger bait! All our bacon!" And so I ran back and I charged *him*, and grabbed the bait, and he ambled over and took the rest of it and ran for the woods.

I finished setting the trap and thought, boy, we'll have him in the morning! Nah, we caught some other little bear. We trapped several days in a row. Old Red, we never did catch him. We see him from the air now and then; he's still out there, at least as of a couple years ago. He's a big, big bear, one of the biggest bears we've got around.

YS: I'd like to go back and find some of bear #38's progeny. She was the bear that was purported to do everything—she was, as I recall, the most productive bear in the ecosystem at that time.

DK: Bear #38 lived over north of West Yellowstone, right where they want to put the golf course *[laughs]*, in the Fir Ridge area. She was really a good bear. Horse Butte and Cabin Creek, that was her area. One year, it was a great huckleberry year; I myself could smell the huckleberries at Two Top from Fir Ridge (and I was still smoking at that time.) She ended up taking her two kids over there to Two Top; I'm sure they went over there for the berries—but what did they find? Sheep! And it was great; they'd never had sheep before. But they did learn in a hurry, and we finally had to catch her and the kids, and she died on the way out. While she was tranquilized, her collar cut off the windpipe. That was a bad deal.

The first litter we knew she had was three cubs, and the next one was two, and she had another one before that, too; she was productive.

YS: Did other individual bears stand out, like the bear that disappeared for 20 years and then reappeared?

DK: That was a bear that we caught as a yearling over in Cabin Creek and just ear-tagged her; we couldn't put collars on then. About 20 years later we picked her up at Indian Creek. She'd been around all that time. We had another one that was killed over in Wyoming, in Mormon Creek. She had two cubs we ear-tagged and transplanted up in the south Absarokas, and we saw them the next year. We didn't see them for 17-18 years and then caught one down at Open Creek.

YS: Put yourself in the mindset of thinking you were just starting today and designing what you'd like to do in the next ten or twenty years. Would there be new and different things you'd suggest people research? Unanswered questions that you'd like to know about a grizzly bear, if you had more time and an unlimited budget?

DK: There are all kinds of things that I would like to know that you're never going to get money for and nobody is interested in studying—like moths. Bears feed on moths in high-elevation sites. Everybody wants to work on bears, but what is the life cycle of the moths? Where do those moths come from?

A lot of other supposedly insignificant species are kind of important to bears, and it'd be nice to know more about them. Why don't bears eat camas roots? Maybe they just haven't discovered them yet. And melica bulbs—we've got fields of melica bulbs out there, and the bears get them in pocket gopher caches, but they don't dig up melica bulbs. I had my troops go down and dig camas bulbs and melica bulbs, big bunches of them, and we sent them over to Charles Robbins *[professor of animal nutrition at Washington State University]*, and his bears just gulped them right down. Maybe it's something they haven't learned yet. And ladybug beetles—in other places those are a big deal. We've got them in the park, but bears haven't discovered where they congregate.

I really like bears. I think there should be a little bit unknown, a mystery about them, too.

Hidden Biodiversity

The Benefits of Large Rotting Carcasses to Beetles and Other Species

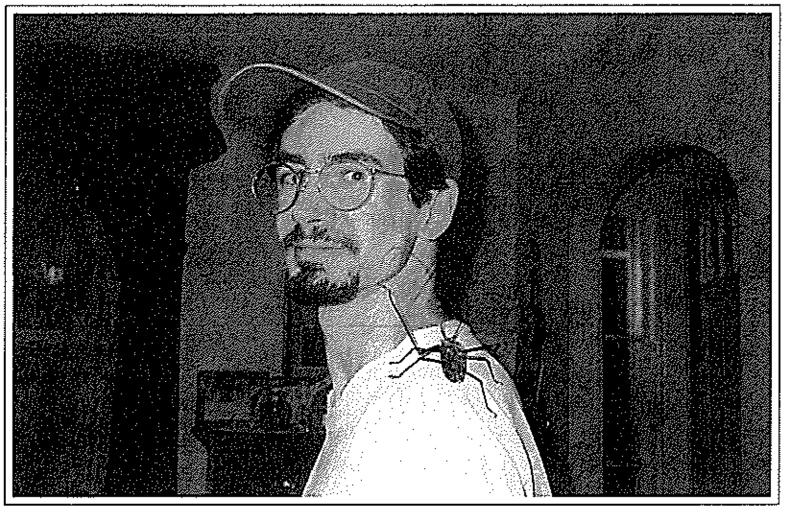

Photo courtesy of Derek Sikes.

by Derek S. Sikes

One late summer day in 1993, I was in the Lamar Valley as an alpine thunderstorm swept down toward me from the Absarokas. Like many other researchers, I was in Yellowstone because of my interest in its charismatic megafauna—its herds of elk and bison. But the three-month-old bison beside which I knelt was a carcass, little more than bones and yet teeming with life. As a graduate student at Montana State University, I had chosen for my master's thesis the task of describing beetles, a large portion of the Lamar Valley megafaunal food web. This project was based on two field seasons of data gathering, 1978 and 1993, and was completed in late 1994.

When considering all the species that constitute an ecosystem, it appears that some act as hubs of biodiversity, and have a disproportionate impact on the ecosystem's structure and functioning. Ecologists refer to these as keystone species. I like to think of them as representatives for hidden biodiversity—for the myriad often poorly known species whose abundances would change if the keystones were to disappear. Large mammal herds are obviously a significant component of the Yellowstone ecosystem. They consume large quantities of vegetation, produce large quantities of dung and carrion, and cause researchers to generate large quantities of data on mammalian ecology, behavior, and physiology. Although we may know what these animals eat, we know very little about what eats them.

How many species are linked to the megafauna found in the Lamar? We can list the 10 or so species of vertebrates that feed on ungulates there, but what about the hundreds of invertebrates? A complete list, you may be surprised to learn, would take years of research to finish. Conducting such research would improve our understanding of the Lamar Valley ecosystem by identifying some of the players. Managers of the Yellowstone ecosystem are interested in maintaining native biodiversity, so it is important to understand the values of having large rotting carcasses lying about.

My objective was to determine the effect megafaunal carcass communities have on the ecosystem of the Lamar by measuring changes in the beetle communities associated with them. Beetles are an especially diverse group of organisms and megafaunal carcasses are some of the largest, and in my opinion, the most exciting communities of ecological systems. It's possible that some of the same beetle species that I encountered during my study could have been found on a mastodon or glyptodont carcass 20,000 years ago. Although such speculation was beyond the scope of my research, by studying the beetles of the carrion community I could at least investigate a large portion of the species linked to Yellowstone's current megafauna and a largely unknown component of North American megafaunal biology.

Why Study Beetles?

The background for my thesis research began in 1978, when there was a large winter die-off of elk on Yellowstone's northern range. Dr. Robert Moore of

Montana State University initiated a project to understand the arthropod fauna associated with elk carcasses by sinking cups into the ground (called pitfall traps) around the carcasses to catch arthropods for later identification. He also set control traps 40 meters from the carcasses to compare the carrion-associated arthropods with those of the background habitat and to quantify the degree of association between beetle species and the carrion.

My advisor, Dr. Michael Ivie, has been conducting a larger but similar study using more than 800 beetle species to assess the effects of the 1988 fires in Glacier National Park. Beetles are frequently chosen as a focus of study because of their enormous numbers and diversity. Beetles are the largest order of life on Earth, outnumbering in described species even nematodes, bacteria, and the entire plant kingdom, and include one-third of all animal species that have been described on our planet. Coleopterists have named between 350,000 and 400,000 beetle species since 1758, at an average of about 2,300 new species each year during the last decade. However, that is only a small portion of the recent estimates, based on studies conducted in the tropics, of perhaps as many as 2.4 million beetle species that may occur on Earth. At the current rate of description, coleopterists will need another 870 years of exploring, discovering, and describing before the job will be complete!

Beetles feed on virtually everything and live virtually everywhere, from the bottom of lakes to the tops of trees, feeding on fungi, rotting wood, living wood, living vertebrates, leaves, stems, seeds, pollen, arthropods, dung, and, of course, carrion. Some species are generalists and feed on a wide variety of resources, while others have a strict diet, often specializing on a single species of plant or animal. Because of this ecological diversity, beetles are proving to be excellent indicators of environmental change. Mike Ivie has stated it nicely: "It's almost impossible for an ecosystem to be disturbed and not have an effect on the beetles that are in it."

The combined influence of Dr. Moore's initiative, my advisor's support, and my fascination with beetles led to my predicament that summer day—the storm and its lightning were approaching, and it had begun to get dark. I carefully poured the trapping preservative through a filter to extract the beetle specimens, trying not to spill any in my anxious haste. I knew grizzly bears commonly fed on carrion and was little comforted by either the anti-bear pepper spray in my pocket or the words of my advisor: "You must label your specimens promptly; that way, if you die, you will not compromise their scientific value."

Nature's Clean-Up Crews

My study focused on decomposition ecology, nature's clean-up crews. The decomposers, known as detritivores, channel more energy flowing through ecosystems than do herbivores and predators (Fig. 1). This makes sense when you consider that the decomposers consume all the dead plants, dead herbivores, dead predators and all of their wastes—that's a lot of consumption! Yet little research has been done on decomposition ecology in comparison to herbivore and predator ecology.

The grass emerging from beneath the bison carcass before me was both taller and greener than that surrounding it. The most obvious life-form using the energy stored within the remains of the bison was the immature form of *Thanatophilus lapponicus*, the northern carrion beetle. These small, six-legged creatures, protected by an exoskeleton composed of chitinous armor plates, were visible on every portion of the bison remains. As I knelt there collecting a sample of organisms that had blundered into the four pitfall traps placed around the carcass, I thought about bison and the connectivity of life. What percentage of Yellowstone's bison biomass is annually converted into beetle biomass? How many visitors or rangers realize that the molecules that make up a beetle they see

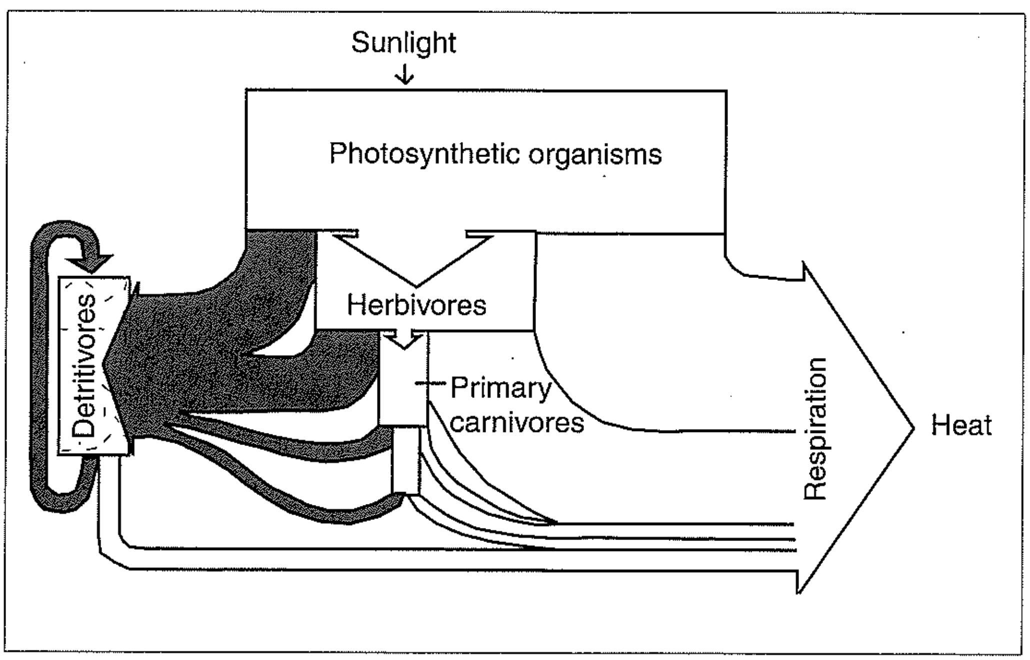

Figure 1. Energy flow through a typical terrestrial ecosystem. The darkened areas represent death (necromass) and waste products, all of which are processed by the detritivores.

may have recently been part of a bison?

Douglas B. Houston, a researcher familiar with the northern range of Yellowstone, found that during a period of three winters (1974–1978), about 75 to 80 percent of the total necromass (between 19,000 and 35,000 kg [77,161 lbs.] of meat) from 1,084 elk carcasses was eaten by vertebrate scavengers: coyotes, bears, and birds. Ten bird species (ravens, black-billed magpies, golden eagles, bald eagles, chipping sparrows, Audubon's warblers, western tanagers, mountain bluebirds, robins, and Brewer's blackbirds) were observed to feed on ungulate carcasses or the insects associated with them. These vertebrate scavengers, although consuming the majority of the necromass, are only the tip of the species-diversity iceberg. The majority of the diversity, perhaps as great as 90 percent, is composed of organisms that are often overlooked due to their small size. It was this hidden biodiversity on which I focused my research. Somehow these seemingly barren bones in front of me were producing pounds of beetle larvae—and I was capturing only those that fell into my traps.

As it turned out, I completed the collection rounds, got very wet from the storm, heard some of the loudest thunder in my life, and later successfully changed the numerous small beetles, carefully stored and labeled, into one sample period of thesis data. Each sample represented the catch of one trap, active for one period (*ca.* seven days). In total there was an effort of 194 days of trapping and the equivalent of 6,832 trap-days (one trap-day = one trap open for one day). Along with many other sample periods, including Dr. Moore's 1978 data, these data were subjected to statistical tests and analyses to quantitatively describe some of the puzzle pieces of the Lamar Valley carrion community.

Winterkilled bull elk.

Carrion Beetles' Abundance and Diversity

In Dr. Moore's 1978 field season, six elk carcasses were studied. Because of that winter's large die-off, the scavenger community had been sated and the carcasses lay virtually intact throughout the summer. In 1993, conditions were at the extreme opposite end of the spectrum; those few carcasses that were available had been stripped to bones within a week. I found one elk carcass and one bison carcass. From the beetles collected during these two seasons, I counted and identified a total of 23,365 adults of 445 species. Of the 445 species, there were 385 that were part of the quantitative data set and were thus available for statistical analysis. These were used to determine the effect of carcasses on beetle communities. Of the 385 species, 37 were strongly associated with carcasses in 1978 (Table 1), and 42 were strongly associated with carcasses in 1993. When both years' data were combined there were 57 carcass-associated beetle species. Eleven species were strongly associated with the control traps (apparently avoiding the carcasses), and 317 species showed no preference.

Thanatophilus lapponicus was the most common beetle in my samples, but it was only 1 of 57 species found in association with carcasses that can be considered the core of the Lamar Valley carrion-associated beetle community. However, not all of these species feed directly on carrion; the adults of many species prey on other arthropods. One such species, *Aleochara verna*, is a type of predator called a "parasitoid" that is not found among vertebrate species. It has an unusual life cycle that strongly resembles that of the monster in the science fiction movie *Alien*: the female adults pierce the skin of living fly larvae (maggots) and deposit their eggs within the larval tissues, where they quickly hatch into beetle larvae (grubs) that slowly consume the living maggot from the inside out, eventually causing its death. Also common in the carcass samples were beetles of the family Ptiliidae that are so small (less than 2 mm long [0.08 inches]) that they are thought to feed on fungal spores and other microscopic organic matter.

I was puzzled by the abundance of an herbivorous weevil species, *Otiorhynchus ovatus* (the strawberry root weevil, introduced from Europe), in the carcass traps. Could the great flush of nitrogenous compounds leeched from the carcasses that fertilized the surrounding plants have increased the survivorship of this weevil's larvae at the site? Or perhaps the abundance was a result of the higher humidity of the microhabitat, or a combination of both factors. Such an explanation doesn't require the weevil to prefer carcasses—the observations of abundance may have simply resulted from the fact that more individuals survive on carcasses than elsewhere. It would be a remarkable discovery if it could be shown that this plant-feeding weevil does actively choose carcass sites for breeding—an unlikely but interesting hypothesis because, to my knowledge, none of the 60,000 known species of weevils are carrion-associated.

Table 1. Carcass associated beetle species, 1978. Total abundances of 37 beetle species. The P-value represents the likelihood of obtaining such results if there were no differences between the carcass and control traps (i.e., if carcasses did not affect the beetle's behavior).

Species	Abundance in carcass traps	Abundance in control traps	Chi²	P
Thanatophilus lapponicus (Hbst)	467*	1	360.0	0.000
Dermestes talpinus Mannerheim	144*	2	106.4	0.000
Anaspis rufa Say	188	18	102.5	0.000
Creophilus maxillosus (L.)	129*	0	100.0	0.000
Saprinus oregonensis LeConte	133*	2	97.9	0.000
Ptiliid sp. 4	126*	5	84.8	0.000
Trachypachus holmbergi Mann.	201	33	83.4	0.000
Omaliinae sp. 8	84*	0	65.3	0.000
Catops basiliaris Say	78	1	57.9	0.000
Trox sonorae LeConte	70*	0	54.4	0.000
Notoxus serratus LeConte	70	1	51.7	0.000
Necrobia violacea L.	58*	0	45.1	0.000
Staphylinidae sp. 65	66*	3	43.5	0.000
Dermestes fasciatus LeConte	50*	1	36.1	0.000
Staphylinae sp. 7	46*	0	35.7	0.000
Otiorhynchus ovatus (L.)	213*	79	33.0	0.000
Aphodius fimentarius (L.)	42	0	32.6	0.000
Oxytelus sp. 18	37	0	28.7	0.000
Saprinus lugens Erichson	36*	0	28.0	0.000
Staphylinidae sp. 80	28	1	19.1	0.000
Staphylinae sp. 5	24*	0	18.6	0.000
Anchicera sp. 2	23*	0	17.9	0.000
Omosita inversa LeConte	20	0	15.5	0.000
Borboropora quadriceps (LeC.)	19*	0	14.8	0.000
Encimus mimus Fall	19*	0	14.8	0.000
Corticarina cavicollis (Mann.)	22*	1	14.5	0.000
Staphylinidae sp. 63	17	0	13.2	0.000
Staphylinae sp. 4	13*	0	10.1	0.001
Staphylinidae sp. 72	16	1	9.9	0.002
Anotylus sp. 17	10	0	7.8	0.005
Tachinus basalis Erichson	9	0	7.0	0.008
Staphylinidae sp. 64	9	0	7.0	0.008
Cryptopleurum minutum (Fab.)	8*	0	6.2	0.013
Syntomus americanus Dejean	14*	3	4.7	0.030
Xantholininae sp. 43	6	0	4.7	0.031
Apteroloma tenuicorne LeConte	25	9	4.1	0.043
Falagria dissecta Erichson	5*	0	3.9	0.049

* 22 of 37 species that were also found to be significantly associated with carcasses in 1993.

Another puzzling find was that certain beetle species common in the 1978 sampling were not found in 1993 at the same sites. This may have resulted from changes that occurred during the interim, such as those due to the 1988 fires, but I cannot rule out other possibilities. Some species do show tight association with particular sites. For example, a small rove beetle (family Staphylinidae) in the genus *Bledius* (Fig. 2) that occurs in saline environments was found only at a site near Trumpeter Lake; these beetles dig burrows into the shoreline mud in which to rear their young. There were also beetles about which virtually nothing was known, such as those in the family Scraptiidae, that were shown to be carrion-associated.

Research Implications

I clearly demonstrated that a significantly larger abundance and diversity of beetles can be trapped adjacent to carcasses than are found 40 meters (131 feet) away (Fig. 3). For those who would ask "So what?" there are two reasons why these findings are important. First, previous carrion ecology studies had not quantitatively described the strengths of associations for the species studied. This novel and more rigorous approach has proven to be a powerful way to understand these systems in great detail. The second reason, perhaps of greater importance, is that to understand an ecosystem's biodiversity you must know its components. Currently, we are famil-

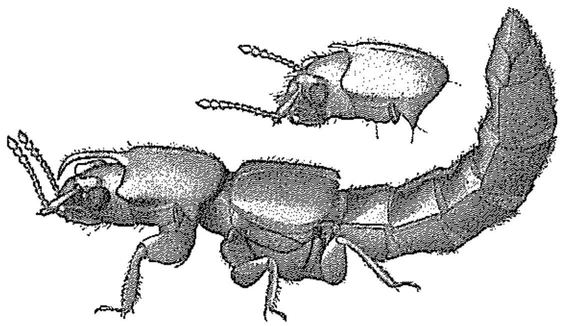

Figure 2. Bledius susae. *A close relative of 1 of the 445 beetle species found in the Lamar Valley.*

iar with very few of the components of the Lamar Valley megafaunal community.

In 1994, ecologist Truman Young reviewed the literature on large mammal die-offs applicable to wildlife conservation. (A die-off was defined as a rapid peak-to-trough decline of 25 percent or more in estimated population numbers). According to Young's analysis, these large die-offs should be considered a natural part of the species' population dynamics. Given the potential biomass and energy made available by a large mammal die-off, such as a 30 percent loss in a herd of bison, it seems reasonable to assume that such die-offs would play a role in many aspects of ecosystem functioning. No carrion study has directly compared a large die-off with the normal background density of carrion input, or compared the impact of large vertebrate carcasses (> 50 kg [110 lbs.]) to that of small ones. However, a reasonable hypothesis would seem to be that the greater the mass of carrion, the greater the richness, diversity, and ecological impact.

It has been estimated that during the Pleistocene, North America may have had densities of large mammals similar to those that can be found in the Serengeti of modern day Africa, which would mean that megafaunal carcasses were available in much greater numbers then. However, the Yellowstone ecosystem is probably as close as any researcher can get to studying the Pleistocene megafaunal ecology of North America without conducting paleontological research.

If a complete ecological understanding of the large mammal food web in the Yellowstone ecosystem is to be achieved, the list of species that are linked to the presence of these large animals needs to be completed. Houston's 1978 observations demonstrated that birds and bears were eating insect larvae from the skeletal remains of elk carcasses, indicating that the insects were a link in the chain between vertebrate scavengers and the carcasses (elk → carcass beetle → bear). My own research showed that many predaceous beetles are attracted to these carcass feeding frenzies, so the benefits of the dead elk and bison in the park can be traced through many links of an as yet little-understood food web. The trickle-down effects of dead ungulates are certainly greater than we currently recognize.

After all the parasites (ticks, lice, fleas, tapeworms, nematodes), dung-feeders (beetles, flies, fungi), predators (wolves, bears, cougars), and carrion-community members have been identified we will be prepared to determine their roles in this system in greater detail. Although to many it is a strange concept, we may someday look at these large mammals from a different, more complete perspective: that they are perfect habitat and resources for the many other (mostly invertebrate) species that together represent a greater portion of the total ecological value of the mammals themselves. How much biodiversity would vanish if the park lost its herds of megafauna? The herds themselves are composed primarily of fewer than five species; however, I can name 57 beetle species that might be greatly affected by such a loss. We must wait for future researchers to supply the remaining hundreds of species' names.

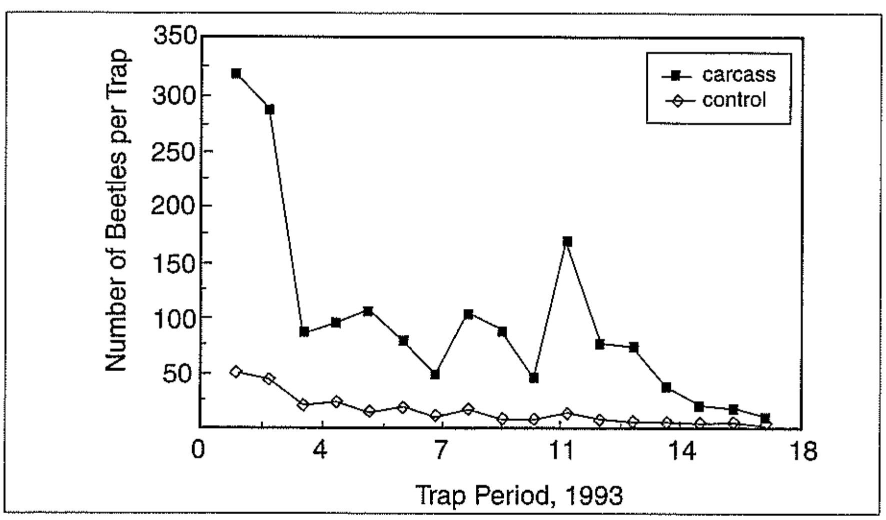

Figure 3. Distribution of beetle abundance over time, carcass and control trap data from 1993. Note that the final abundance of the carcass trap data is 12.7 beetles per trap and 5.8 beetles per trap for the control trap data.

Derek Sikes completed his master's degree in Entomology at Montana State University in 1994. He is currently working toward a Ph.D. at the University of Connecticut, revising the taxonomy of a behaviorally unique group of carrion beetles—the burying beetles. His interest in detritivores stems from undergraduate research he conducted on the natural history of a west coast species of burying beetle during 1991. Derek's research interests combine aspects of ecology, systematics, and conservation biology. In 1996, Derek fused research in these often disparate fields into a World-Wide-Web site, based on research conducted for the Connecticut Nature Conservancy (http://viceroy.eeb.uconn.edu/ctb/home.html), which includes taxonomic, ecological, and conservation information on Connecticut tiger beetles.