Use of the Costa Rican Cave, Cueva del Tigré, as a Classroom for Cave Ecology and Conservation by the Organization for Tropical Studies

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I had the good fortune to serve as a guest instructor of biospeleology in Costa Rica during the Organization for Tropical Studies' summer course in tropical biology. This brief report to the Society summarizes this field trip, the survey and bioinventory of Cueva del Tigré, and educational opportunities in such caves.

The Organization for Tropical Studies (OTS) is a non-profit consortium of universities hosted by Duke University and focused upon tropical research and education (www.ots.duke.edu). The University of Arkansas recently joined OTS, facilitating the exchange of faculty and students between host countries. I was invited by the new OTS Ambassador Dr. Cynthia Sagers to join the summer class "OTS-01-3 Tropical Biology: An Ecological Approach" as a guest instructor, or "Resource Person." Resource Persons assist the instructors (in this course, Dr. Deedra McClearn, César Nufio, and Victor Carmona) in leading faculty field projects that provide the students with focused research opportunities, and in my case, the study of tropical caves.

I met the group deep in the middle of their summer research at Palo Verde Biological Station, which is located in Palo Verde National Park (Parqué Nacional Palo Verde). This 20,000-hectare (8,000 acre) park is located on the Tempisqué River in the Guanacaste Province in northwestern Costa Rica. The park has preserved one small portion of a region that is extremely rich in biodiversity and habitats; in particular, the park has unique dry tropical forest growing on limestone outcrops of the Barra Honda formation, a Paleocene-aged, stratified limestone containing some chert, sandstone, and volcanic ash. This tropical karst landscape formed after tectonic plate subduction caused the uplift and rotation of the limestone strata, and then abundant and slightly acidic rainwater dissolved the vertical bedding planes, forming the slot canyons and caves present today (Figure 1). Weathering of the exposed limestone (epikarst) resulted in extremely sharp fluting (rill and karren), and the caves are unmantled, except for odd vegetation growing on the epikarst, such as cactus (Figure 2). Few parts of these caves are completely aphotic, and the multiple cave openings allow copious organic matter and animals to enter. Weakly-developed speleothems, including cave coral and flow stone, are found throughout the caves.

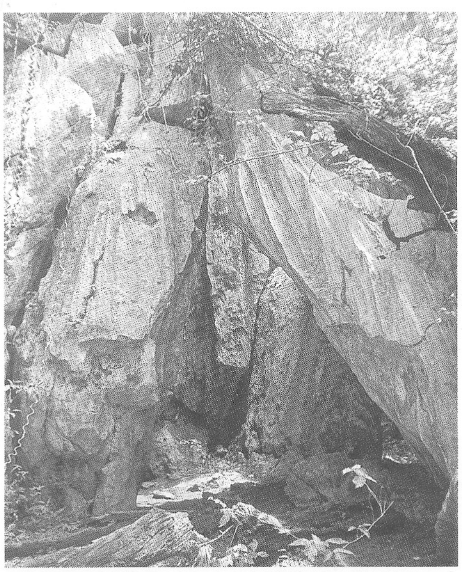


Figure 1. Entrance of Cueva del Tigré, framed in Monkey Ladder vines.

Our faculty field project focused upon the study of the park's most well-known cave - Cueva del Tigré. This project spanned two days (26-27 July 2001) and included the following students and faculty: Joe Bischoff (Rutgers University), Melanie Bateman (North Carolina State University), Shallin Busch (University of Washington), Nathan Muchhala (University of Miami), César Nufio (University of Colorado), Rebecca Rowe (University of Chicago), Scott Solomon (University of Texas), Nicole Turner (OTS Station biologist), and Dr. Robert Timm (Resource Person, University of Kansas). The field report is published in Organization for Tropical Studies' yearbook (2002).

We began by properly outfitting the class, but some equipment differed from that normally used in the USA. We wore surgical masks to prevent inhalation of ubiquitous mold spores (histoplasmosis is easily contracted in tropical caves), and we wore short-sleeved shirts and shorts because the tropical heat and humidity made wearing coveralls unbearable. The class split up into teams to focus upon mapping, biological inventory, or taxonomy. Basic mapping skills were taught and practiced using compass and tape - Figure 3 shows the final map of Cueva del Tigré. Cave habitat categories in relation to daylight (entrance/drip zone, twilight zone, dark zone) were explained and located.

The bioinventory consisted of visual inspection, although bait trapping would be an excellent addition to such studies. Each animal found was counted and identified – the combined taxonomic knowledge of the class made this difficult task much easier. If the species could not be immediately identified, it was assigned to a unique descriptive category (*i.e.* morphospecies), such as "spider species #3, red pedipalps." Approximately 40 species of animals were seen in the cave, and they are listed in Table 1. Also sighted were 16 sac-winged bats (*Blaniopteryx plicata*), 8 woolly false vampire bat (*Chrotopterus auritus*), and 34 common vampire bats (*Desmodus rotundus*), but only their guano input was considered in the foodweb analyses. The detritus on the cave floor included the remains of many animals, including moth wings and snake vertebrae and shed skin. Particularly interesting were the discovery of many animal bones, including some complete skeletons; the class identified them with the help of mammalogist Dr. Timm. The bones belonged to at least five different collared peccaries (*Pecari tajacu*), one agouti (*Dasyprocta punctata*), eight climbing rats (*Ototylomys phyllotis*), and one white-tail deer (*Odocoileus virginianus*), suggesting that this cave served as a lair for a large predator. The cave is named after the Park's largest predator - mountain lion (*Puma concolor*).

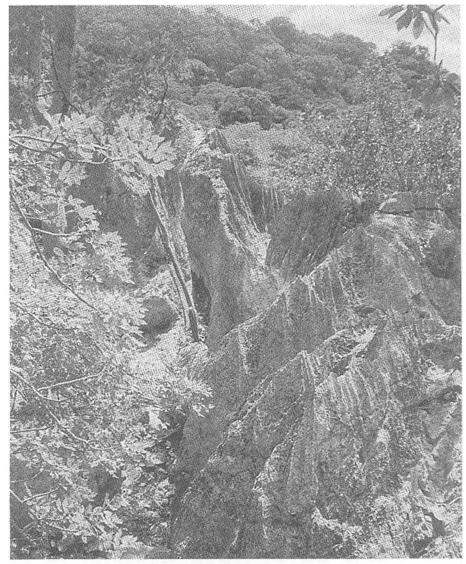
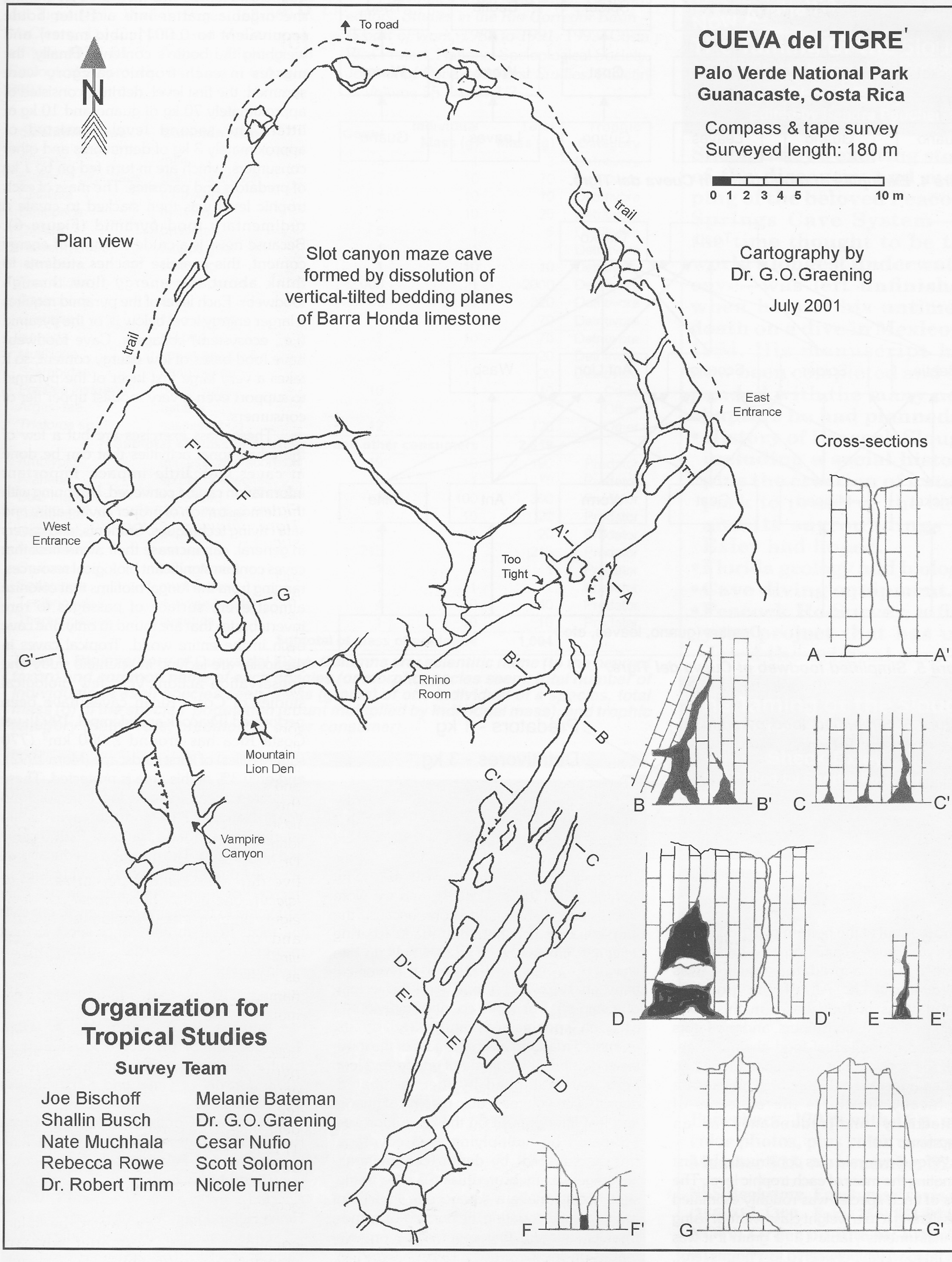


Figure 2. View from the top of Cueva del Tigré, showing epiphytic vegetation such as cactus.

The class was then challenged with building food chains, a food web, and food pyramid of this small subterranean ecosystem. For each species, a general feeding group, or trophic level (*e.g.* detritivore, carnivore), was assigned (Table 1) and given a classification relative to its adaptation to the cave environment (troglobite, troglophile, trogloxene, or accidental).

Food chains were created by linking consumer to organic matter type and predator to prey (Figure 4). For example,


CUEVA del TIGRE
Palo Verde National Park
Guanacaste, Costa Rica
Compass & tape survey
Surveyed length: 180 m
0 1 2 3 4 5 10 m
Cartography by
Dr. G.O.Graening
July 2001
To road
N
Plan view
Slot canyon maze cave
formed by dissolution of
vertical-tilted bedding planes
of Barra Honda limestone
trail
trail
East
Entrance
West
Entrance
Too
Tight
Rhino
Room
Mountain
Lion Den
Vampire
Canyon
Cross-sections
A A'
B B'
C C'
D D'
E E'
F F'
G G'
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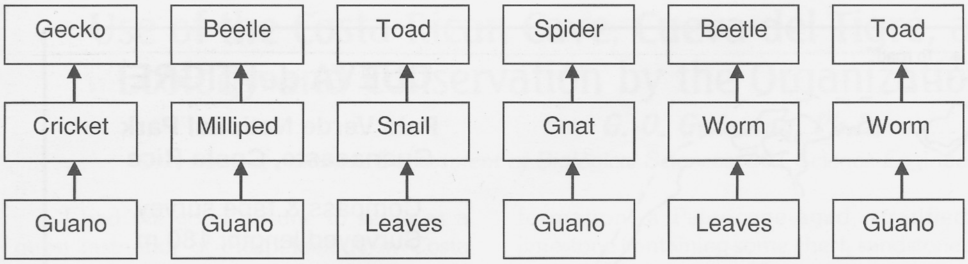


Figure 4. Examples of food chains in Cueva del Tigré.

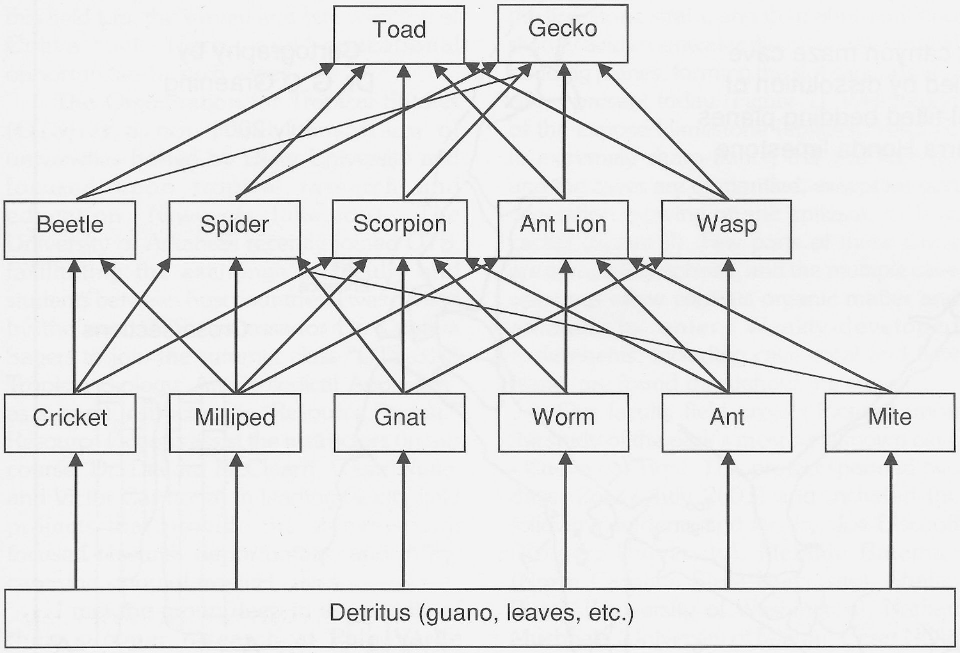
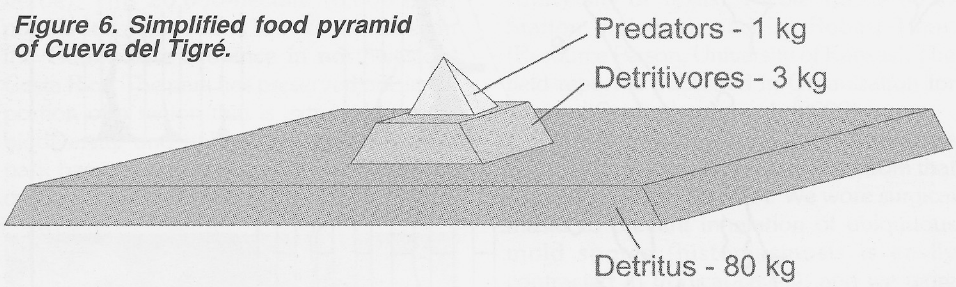


Figure 5. Simplified foodweb of Cueva del Tigré.

Figure 6. Simplified food pyramid of Cueva del Tigré.



guano was put at the bottom of a food chain, then a consumer—camel cricket—was linked above it, then a predator—gecko—was linked above it. All of the possible permutations of food base (in this case, guano or leaves), consumers, and predators are linked in individual food chains. Then, of all the food chains were linked together, creating a foodweb (Figure 5). This exercise graphically illustrates the concepts of connectivity and redundancy in an ecosystem.

A food pyramid was constructed by first estimating the mass of each trophic level. The mass of each species was roughly estimated by assigning it to a weight class without using any instruments (Table 1): 1 gram if it was thought to weigh between 0 to 1 grams (*e.g.*, the weight of a paper clip); 10 grams if it weighed between 1 to 10 grams (*e.g.*, the weight of a pencil); or 100 grams if it weighed between 10 to 100 grams (*e.g.*, the weight of a stapler). Then, the count of individuals of each species was multiplied by its estimated mass. To estimate mass of the food base, detritus, the volume of guano and leaf litter was multiplied by their estimated density. The volume (cubic meters) of guano and leaf litter present on the cave floor was estimated by multiplying area coverage (meters squared) by depth (centimeters); coverage was measured using a wire frame stretched to make a square one meter on each side and counting the number of frames (meters squared) that covered the organic matter on the cave floor. Density (g/m^3) of guano and leaves was measured by stuffing the organic matter into a 1-liter bottle (equivalent to 0.001 cubic meter) and weighing the bottle's contents. Finally, the masses in each trophic category were summed: the first level, detritus, consisted of approximately 70 kg of guano and 10 kg of litter. The second level consisted of approximately 3 kg of detritivores and other consumers, which are in turn fed on by 1 kg of predators and parasites. The mass of each trophic level was then stacked to create a rudimentary food pyramid (Figure 6). Because mass is a crude estimate of energy content, this exercise teaches students to think about the energy flow through foodwebs. Each level of the pyramid requires a larger energy level below it, or the pyramid (i.e., ecosystem) collapses. Cave foodwebs have food bases of low energy content, so it takes a very large first layer of the pyramid to support even a very modest upper tier of consumers.

These class exercises are but a few of the educational activities that can be done in caves with little impact. Important information can be conveyed, beginning with the demonstration of proper caving attire and safe caving techniques. Students, and cavers in general, can increase their awareness that caves contain significant biological resources, ranging from the fungal biofilms that colonize almost every surface of passages to rare invertebrates that are found in only one cave each in the entire world. Tropical caves in particular are lacking in scientific study and conservation action. Very few biological studies of Costa Rican caves have been performed (Peacock and Hempel, 1993); yet Costa Rica has around 2,000 km^2 (770 square miles) of karst landscape (Mora 1992), and only 3% of this area is protected. These protected areas include the karst of Palo Verde National Park and the caves within nearby Barra Honda National Park (Kueny and Day, 2002). The insertion of educational activities during recreational caving trips in tropical (or temperate) caves can not only add value to the caving experience, but shift the focus from an endurance sport to total immersion into the subterranean environment.

Literature Cited

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Scientific Name	Common Name	Count	Individual Mass (g)	Total Mass (g)	Trophic Category
Acarina	mite	3	1	3	Detritivore
Blaberus giganteus	giant cockroach	7	10	70	Detritivore
Clitellata	earthworm	1	10	10	Detritivore
Diplopoda	millipede	2	10	20	Detritivore
Diplura	bristletail	5	1	5	Detritivore
Heleomyzidae	fungus gnat	1	1	1	Detritivore
Hemiptera	bark bug	1	10	10	Detritivore
Formicidae	ant, 3 species	2,000	1	2000	Detritivore
Gastropoda	snail	32	10	320	Detritivore
Gryllidae	cave cricket	7	10	70	Detritivore
Isopoda	pill bug	7	10	70	Detritivore
Mutillidae	velvet ant	20	1	20	Detritivore
Scarabidae	dung beetle	2	10	20	Detritivore
Polistes instabilis	paper wasp	10	1	10	Other
Argasidae	bat tick	2	1	2	Other
Triatoma sp.	assassin bug	12	10	120	Other
Subtotal of mass of detritivores and other consumers				**2,619**	
Amblypigi	tail-less whip scorpion	19	10	190	Predator
Araneae	spider, 9 species	75	1	75	Predator
Bufo marinus	cane toad	3	100	300	Predator
Carabidae	ground beetle	2	10	20	Predator
Gekkonidae	gecko	2	10	20	Predator
Neuroptera	ant lion	215	1	215	Predator
Opiliones	harvestman	1	1	1	Predator
Sphecidae	mud dauber	1	1	1	Predator
Tenibrionidae	darkling beetle	4	10	40	Predator
Theraphosidae	tarantula	1	10	10	Predator
Subtotal of mass of predators				**1,004**	

Table 1. Bioinventory of Cueva del Tigre. Columns are: scientific name (to the nearest taxon) and common name of each species (or morphospecies seen), total number of individuals of each species seen, mass (grams) of one individual of a species, total mass (g) of the species' population (count multiplied by individual mass); and trophic category (detritivore, predator, or other consumer).