HOW TO OBTAIN BEHAVIORAL AND ECOLOGICAL DATA FROM FREE-RANGING, RESEARCHER-HABITUATED BLACK BEARS

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Abstract: A study was conducted in northeastern Minnesota from 1986-1989 to determine the feasibility of habituating black bears (*Ursus americanus*) to observers for behavioral and ecological research. Of 18 males and 8 females that repeatedly visited an artificial feeding site in the presence of humans, 3 2-year-old females were radio-collared for further habituation away from the site. The 3 females were repeatedly located, fed, and accompanied at various locations in their territories. After 50-100 hours of this additional contact, each bear accepted human presence and mostly ignored observers that followed 1-10 m behind. The bears were no longer fed in their territories except for the feeding of scat markers for digestion studies. The bears were observed for 24- or 48-hour periods approximately weekly as they matured, reproduced, and raised cubs. While being followed, they foraged, napped, slept through nights, showed REM and non-REM sleep, mated, played, nursed their cubs, captured young animals, maintained territories, marked bear trees, prepared dens, and began hibernation. They relied on natural foods and showed activity and movement patterns similar to daily and annual patterns of 103 non-habituated bears that were radio-tracked previously in approximately the same area.

A field computer with an internal clock was programmed to aid in the recording of activities, habitat use, food consumption, and weather. A personal computer was programmed to sort and tabulate the data and calculate 1) time spent in each activity, 2) time spent in each cover type, 3) number of bites taken of each food in each cover type, and 4) time spent in each activity and cover type in each weather condition. The computer calculated these time-activity budgets for single 24-hour observation periods or for any combination of observation periods specified. Problems of excessive hunting loss, habitual nuisance behavior, or appreciable observer injury did not occur. Study results were directly useful to forest managers for identification of opportunity areas for habitat preservation or improvement. Results provided new insights into black bear diet, bioenergetics, foraging strategies, activity patterns, sociobiology, communication, and bear-human interactions. Drawbacks were few study animals and limited study area. Comparative studies are needed in new locations, involving additional age and sex classes, additional physiological data, and additional behavior regimes such as might be exhibited by translocated bears, nuisance bears, or bears whose ranges have been altered by fire, development, insect defoliation, or extensive timber management.

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Ecological studies of elusive, wide-ranging mammals are often hampered by the inability to observe study animals closely for significant periods. Consequently, researchers have studied wide-ranging species in large enclosures (McMahan 1964, Dzieciolowski 1967, Le-Resche and Davis 1973, Stringham 1974, Ozoga et al. 1982, and others), on leashes (Wallmo 1964, Watts 1964, Healy 1967, Neff 1974, Bauer 1977, Crawford 1982, Lautenschlager and Crawford 1983, Thill and Martin 1989, and others), or by temporarily releasing tame animals (Buechner 1950). Other researchers have observed wild, free-ranging animals that were habituated to vehicles (Schaller 1972, Bertram 1973, Douglas-Hamilton 1973) or people (Graf 1955; Brown 1961; Goodall 1965; Geist 1971; Sade et al. 1976; Fossey and Harcourt 1977; Chepko-Sade and Sade 1979; Rogers 1981, 1987*a*; Rogers et al. 1987; Mech 1988). Each study method has its advantages, depending upon the research questions.

During 1985-1989, we developed methods for habituating free-ranging black bears to observers and for using computers to record and analyze detailed behavioral and ecological data rapidly. Areas of study included black bear habitat use, diet, bioenergetics, activity patterns, sociobiology, behavior, communication methods, and bear-human interactions. The objective was a better understanding of black bear environmental requirements and behavior to aid decision-making by forest managers and campground managers and to increase public understanding of black bears. This paper discusses methods, benefits, and shortcomings of the study.

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STUDY AREA

The study was conducted in the Superior National Forest in northeastern Minnesota (47°49' N, 91°45' W). The primary study area was the contiguous territories of 3 principal study animals and was 6 km in diameter. Longer movements during late summer, fall, and estrus increased the overall study area to approximately 24 km by 34 km. The primary study area contained a network of logging roads, a paved 2-lane highway, a 32-unit campground, 24 summer homes, and the research facilities. The homes and research facilities were all located on Kawishiwi River and Birch Lake, a waterway 150-650 m wide that formed the western edge of the study area.

The study area was almost entirely forested and had gently rolling terrain with occasional rock outcrops. Mixed coniferous-deciduous forest predominated (Rogers 1987*b*). Stands ranged in age from newly clearcut to

virgin stands >100-years-old. Wetlands included streams and beaver impoundments, scattered bogs and marshes, and a 2.5-ha lake, each typically bordered by alder (*Alnus rugosa*) swamps.

Bear foods available in season between May and September included wild fruit, beaked hazelnuts (*Corylus cornuta*), digestible vegetation, and Hymenopteran insects (Rogers 1987*b*). Wild fruit was available from July to early September, if crops were successful, and included wild strawberry (*Fragaria* spp.), dwarf red raspberry (*Rubus pubescens*), serviceberry (*Amelanchier* spp.), lowbush blueberry (*Vaccinium angustifolium*), sourtop bilberry (*V. myrtilloides*), pin cherry (*Prunus pensylvanica*), choke cherry (*P. virginiana*), wild sarsaparilla (*Aralia nudicaulis*), red raspberry (*R. strigosus*), red-osier dogwood (*Cornus stolonifera*), roundleaf dogwood (*C. rugosa*), highbush cranberry (*Viburnum trilobum*), and mountain-ash (*Sorbus* spp.). The only hard mast was beaked hazelnuts, which were available in August and early September in occasional years. Acorns (*Quercus* spp.) and other fall mast species were essentially nonexistent. Bears entered dens in October and emerged in April. Snow was present from late October or November to April.

METHODS

Habituating Black Bears To Observers

To habituate bears to human presence, researchers established a beef fat feeding site, which was visited repeatedly by 18 males and 8 females. Within 4 bear visits, each bear became accustomed to the presence of a reclining person within 30 m. Within 8 visits, most readily took food from, or within 5 m of, an immobile or slowly moving person. Personality, wariness, and time required for habituation varied with individuals. Very few became accustomed to being touched. All became accustomed to talking. Two adults, a male and a female, remained defensive after 2 and 10 weeks of occasional encounters and were not studied closely. Three other females (401, Patch, and Terri), all 2-years-old, were more receptive and were captured and radio-collared for further study away from the feeding site.

These 3 females were initially timid when they were approached in new areas. They retreated, usually unseen, for up to 2 hours before circling downwind and stopping 40-80 m away to smell the person and the beef fat he carried and to listen to his voice. After <30 minutes, the bears approached, often demonstrating their uneasiness by lunging, blowing, and slapping vegetation before calming down and resuming their familiar feeding routines. Over the next 50-100 hours of contact, each bear became accustomed to being approached, fed, and accompanied in the forest. Supplemental feeding was then stopped. The bears continued to approach observers for food but readily learned that open, empty hands meant no food. After a food-check, the bears typically resumed foraging and ignored observers. However, if food was hidden in pockets or backpacks, the bears often continued their attention or returned repeatedly to observers. Therefore, no food was brought during data collecting sessions.

Observers followed <10 m behind foraging bears. At greater distances, the bears sometimes lost track of observers and became wary of their rustlings. Bears also sometimes became wary when observers approached to within a few meters, although this wariness waned as bears became more habituated. An intent look from a bear indicated its concern over an observer's proximity or actions. Bears sometimes gave "threat" displays (lunging, slapping vegetation, blowing) when observers got in their way in unusually food-rich areas. Most startled or defensive reactions (jumping away, whirling around, starting up trees) were due to sudden, seemingly aggressive acts by observers (sneezing, tripping, falling, accidentally hitting the bear) or by the sudden appearance of an extra observer in dense brush or on an overhead ledge. Therefore, data collecting sessions were conducted by lone observers.

"Threat" displays were actually expressions of fear or uneasiness rather than threats. No bear attacked, and bears retreated if an observer acted aggressively. Bears were calmed by giving them more room and by talking. Although difficult to describe, it became easy to read bears' expressions and anticipate their movements. Thus, observers avoided causing "threat" or defensive behaviors. With time (100-150 hours), mutual trust developed, "threats" all but disappeared, and the fully habituated bears foraged, slept, and appeared to be comfortable with a single observer 1-5 m behind or occasionally closer to see certain foods. Sensitive, experienced observers saw <1 "threat" per 100 hours of observation, with most of the threats occurring in dusk or darkness when it was more difficult to anticipate bears' movements.

Observers used dim flashlights to aid observations and computer entries at night. The bears typically slept or nursed from 1-2 hours after sundown to 0.5 hours before sunrise. Observers spent nights in sleeping bags 1-8 m from the sleeping bears.

To begin a new year of observations, researchers reinforced the previous year's habituation by resting near dens and day beds before extensive movement began. This presence was especially important with newborn

litters because cubs developed wariness of strangers in late March and early April around the time of emergence (Rogers 1989). Prolonged handling of cubs during that time (the third month of life) further habituated them to people (Rogers 1989 and unpublished data), making them less likely to distract their mothers with distress calls when observers accompanied them later.

The artificial feeding site was essentially discontinued in 1988 and 1989. Bear use of the feeding site had waned by then, and observers were concentrating on obtaining data from habituated bears rather than on habituating new ones. Only 1 habituated female (Terri) visited the site in 1988 and 1989 because Bear 401 had been thrown from a tree by another female and killed on 10 June 1987, and Patch had shifted her territory 3 km away by the end of 1987 and did not return in 1988. She was killed by a hunter 16 km away on 5 September 1988. Terri's use of the site in 1988 and 1989 was limited to a few visits each year in late May (after spring forbs became unpalatable but before ant pupae became abundant) and in early fall (after berries and hazelnuts disappeared). On each visit, she was given a few grams of food to entice her onto a platform scale, and she was given more food during the fall 1988 hunting season to divert her from any hunters' baits and to increase the chance of her producing cubs (which she did) for study of mother-cub interactions.

Data Collection Procedures

Field equipment (Table 1) included a Husky Hunter field computer (Husky Computers, Inc., Sarasota, FL 34236), which is a small, immersible, shock resistant computer worn in a harness that leaves both hands free. The computer was programmed to accept entry codes for describing activity, food consumption, habitat, and weather (Rogers et al. 1989*a*). A clock in the computer automatically recorded dates and times of entries. Activities recorded included walking, sitting, standing, reclining, running, sleeping, climbing, defecating, urinating, digging, grooming, scent-marking, nursing, vocalizing, playing, drinking, bathing, wading, and eating. For eating, number of bites of each food was recorded.

Data were recorded continuously during observation periods of 24 or 48 hours. Twenty-four-hour observation periods provided natural, around-the-clock time frames for collecting data on activity, food consumption, habitat use, and weather and were repeated approximately weekly to keep pace with changes in phenology. Forty-eight-hour observation periods were used when digestibility data were collected in addition to the above data. The longer observation period was needed to collect fecal droppings containing foods observed eaten during the first 24 hours. Passage time typically was 4-12 hours. Foods eaten during the first 24 hours of observation were identifiable in scats because a colored scat marker was fed at the beginning of an observation period and a different colored marker was fed at 24 hours. Scats collected between passage of the markers contained the first 24 hours' consumption. Scat markers included colored beads, corn, peanuts, pieces of colored balloon, or combinations of these items. After it was determined that passage rate was essentially the same for all these materials, pieces of colored balloons were used because they were most easily obtained and most easily seen in scats. Approximately 10-20 balloon pieces, each 1-2 cm^2, were fed in a 50-gram piece of fat.

The 48-hour observation periods were conducted in 4 consecutive 12-hour shifts. The 24-hour observation periods were conducted in 2-3 consecutive shifts of 8-12 hours each or in 1 24-hour shift. The latter was possible because observers rested while the bears slept at night or napped in daytime. Longer shifts were precluded by

Table 1. Equipment needed for extended bear observations.

1.	Shock resistant, immersible, field computer with harness that leaves hands free. AA batteries for change at 24 hours.
2.	Backpack with no frame structure to catch on vegetation.
3.	Lightweight receiver (in ziploc bag to prevent rain damage) and a folding mini-antenna.
4.	Two-way radio.
5.	Small transmitter for locating the observer in case of injury.
6.	Scat marker (if doing digestion studies—see text).
7.	Pocket-sized notebook.
8.	Habitat forms for describing habitat.
9.	Two dozen gallon-sized, prelabelled, dated ziploc bags for collecting unknown foods and (if doing digestion studies) scats.
10.	Two ballpoint pens with waterproof ink for taking notes, filling out habitat forms, and writing collection times on scat bags.
11.	Compass, laminated topographic map, and laminated aerial photo.
12.	Two quarts of drinking water in collapsible goatskin containers. (As the water is used, more room becomes available for scats).
13.	Insect repellent.
14.	Light sleeping bag in a compression sack; waterproof shell for the sleeping bag (if observing overnight).
15.	Dry socks and t-shirt in a ziploc bag (if observing overnight).
16.	Flashlight with fresh batteries and an extra bulb.
17.	Plastic trash bag for keeping the above items dry in backpack when swimming across streams.
18.	Rain suit (optional).

hunger and the weight of collected scats.

Observation periods were begun, and shift-changes made, only when bears were awake, so sleep-activity cycles were not disturbed. Activity was detectable from telemetry signals. The incoming observer located the bear by telemetry and then waited 200-300 m away until telemetry signals indicated activity or the observer already with the bear informed him by 2-way radio that the bear was active. The incoming observer talked the last 100-200 m to identify himself.

Habitat Description

A goal in collecting habitat use data in this study was to provide national forest managers with information useful in habitat management decisions. For that reason, habitats were classified in U.S. Forest Service terms—by forest type, tree size, and tree density. In addition, Ecological Land Type (ELT), silvicultural history, and natural disturbances (such as insect defoliation, wind damage, fire, old-growth forests breaking up) were recorded to determine factors that influence habitat quality. However, not all of this information was immediately evident upon entering a new forest type. Consequently, observers recorded only the time when entering a stand and recorded descriptive parameters while moving through it.

To understand fully why bears used particular forest types, it was necessary to describe not only the forest type in general but the microhabitats (or forest components) that were used within that type. To record microhabitat use, computer codes were created to denote common microhabitats (e.g., the different types of forest openings, rock crevices, thickets, certain tree species, old dens, game trails) and were used to denote microhabitats associated with recorded activities. Thus, each activity entry had an accompanying microhabitat entry if the microhabitat differed from the general forest type. For example, if an important component of a forest type was blueberries growing on patches of shallow, sunlit soil at edges of rock outcrops, computer entries would indicate, in code, that the bear, e.g., ate 234 bites of blueberries from edges of rock outcrops. An objective was to understand why bears used particular habitats at particular times (time of day, time of year, time of life), considering food, water, security, weather, insects, reproductive status, social constraints, and recent events.

Post-observation Handling of Data

After an observation period was completed, the data were uploaded from the field computer to a personal computer for viewing, correction of entry errors, and printing. The computer was programmed to sort and tabulate the data and create the following time-activity budgets (Rogers et al. 1989*b*):

1. Amount of time spent in each activity,
2. Amount of time spent in each vegetative cover type,
3. Number of bites taken of each food in each cover type, and
4. Amount of time spent in each activity in each weather condition. (Weather was classified by temperature range, humidity range, and sky condition.)

The computer calculated these time-activity budgets for single 24-hour observation periods, for 48-hour periods, or for any specified combination of observation periods so changes in activity that accompany changes in physiology, food distribution, food abundance, weather, or other factors could be discovered. Observers wrote narratives to describe play, social interactions, vocalizations, predation, and other unusual observations that did not easily fit the computer format. Routes of bears were mapped, including resting locations, intensive feeding locations, and hourly progress. Uncertainties about routes and locations were resolved by checking an aerial photo of the study area.

Supplemental Studies

In the days following an observation period, follow-up studies were conducted to determine amounts ingested of each food and the nutritional values of those foods. After seeing hundreds of bites during an observation period, observers used their knowledge of bite size to collect 100 bite-sized samples of each current bear food and weigh them fresh and oven-dried (48 hours at 48 C). For each food, the weight per bite (fresh and oven-dried) was multiplied by the number of bites the bear had eaten of that food in 24 hours to estimate daily consumption of each food. This information was also calculated by cover type to determine feeding efficiency in the different cover types. The oven-dried samples were then sent to Washington State University for determinations of gross energy (by bomb calorimetry), percent protein (Kjeldahl method), digestible protein (Pritchard and Robbins 1990), and digestible energy (Pritchard and Robbins 1990). Bodyweight changes were determined by enticing the bears onto a platform scale whenever they visited the artificial feeding site.

Boundaries of territories and annual ranges were estimated from the maps of 24-hour bear movements and from interim radio locations. Territories were considered to be areas of exclusive or nearly exclusive use by a female and her offspring. Annual ranges included all

areas known to be traversed in a year, including the sallies made during estrus and the extraterritorial foraging movements made during late summer. The availability of different cover types within territories and annual ranges were determined from aerial photos, U.S. Forest Service and Minnesota Department of Natural Resources compartment exam records, private timber company inventories, and a U.S. Fish and Wildlife Service Geographic Information System (GIS) data base. Use and availability were compared to determine habitat preferences in different seasons and years.

EVALUATION OF METHODS

Data Collected

The habituated bears provided over 2,000 hours of observation data, including 6 24-hour periods in 1987, 23 24-hour periods in 1988, and 20 24-hour periods in 1989.

Human Influences on Bear Behavior

Gross behavior of the 3 habituated females was similar to that of 103 bears previously radio-tracked in northeastern Minnesota (Rogers 1987*b*) with no differences in territory size, nuisance behavior (see below), food habits, social relationships, daily activity patterns, seasonal travel patterns, or denning habits. Habituated bears further appeared to behave normally in that they nursed their cubs periodically through the day and night and defecated at fairly regular intervals that varied seasonally with food type and abundance. Bears pursued and captured young animals, marked small trees with urine, marked larger trees by rubbing, and investigated the marks of other bears. Sleeping bears showed apparently normal sleep that included both REM and non-REM sleep. REM sleep is seldom seen in poorly habituated animals (Allison and VanTwyver 1970). The bears also prepared dens and became lethargic in preparation for hibernation while being accompanied. A prehibernating female cub that fell asleep with an observer's hand on her femoral artery outside her den on 12 October 1989 showed a pulse rate of only 22 beats/minute.

Mothers ran to distress cries of cubs 1-2 m from observers but seemed to discount observers as possible sources of danger. Habituated bears chased or fled from wolves (*Canis lupus*) or other bears, and they remained aware and responsive to distant, unidentified sounds but apparently ignored the rustlings of nearby observers because the focus of bears' ears and eyes was usually in directions other than toward the observer. The direction of their muzzles while doing the special breathing that accompanied intense scenting also was usually directed away from observers. Observations of the ways bears sensed their environment gave insight into the kinds of stimuli that most influenced their actions.

However, some aspects of growth and behavior were influenced by the study. Habituated bears reproduced earlier (at 3, 4, and 4 years of age) than most other bears of the region (Rogers 1987*b*) due to supplemental food given to them during habituation efforts and September hunting seasons. Bears' foraging was sometimes interrupted briefly when observers got in the way. Mating activity was slightly disrupted by observers in that 4 strange males that approached habituated females were initially apprehensive until observers stood back 15-20 m. The males then courted, copulated with, and rested with the females and within 1-2 hours tolerated closer (10-15 m) observation. A habituated adult (Patch) and several habituated cubs occasionally involved observers in play, especially when they awoke from naps. This was remedied by stepping back a few meters.

Potential Problems

Problems of excessive hunting losses, habitual nuisance problems, and appreciable injury to observers did not occur. No one was bitten. Habituated mothers were as tolerant of observers as were other bears. One bear occasionally slapped if she was teased with food or was eye-to-eye with a person on her level within 0.5 m. Slaps that were apparently full power created only welts or scratches with no appreciable injury due to the dullness of adult black bear claws. No threat behaviors were of types used before fights (deep-throated, pulsing vocalizations; bellowing, open-mouthed threats; stiff approaches with backs arched and noses nearly touching the ground). We recognize that some danger exists in working closely with large animals and that sensitivity and good manners are required to avoid provoking defensive behaviors. However, the bears in this study showed restraint and no propensity to seriously injure.

No habituated bear became a habitual nuisance at any of the 24 homes within the study area or at the 32-unit campground, which was less than 500 m from the feeding site. In fact, the feeding site diverted bears from the campground and reduced nuisance problems (Rogers, unpublished data). Two bears briefly ate dandelions and 1 bear licked grease from a disposal area in yards of the homes. Nuisance behavior appeared to be more a function of home range location and natural food scarcity than familiarity with people. When fruit, nuts, or ant pupae were abundant, habituated bears sometimes foraged within 200 m of homes, the campground, or the feeding site without checking for food or being seen. Most of the

homeowners developed a protective interest after seeing the bears and being informed (whenever possible) about new findings.

Mortality of habituated bears during hunting season (1 Sep-mid-Oct) did not exceed mortality in the overall population, possibly due to partial protection by researchers. Habituated bears were studied through 7 bear-years of hunting seasons with only 1 hunting death, showing a slightly lower mortality rate than the 16% hunting mortality reported for other radio-collared females in Minnesota during the same period (D. Garshelis, Biologist, Minnesota Dep. Nat. Resour., pers. commun. 1989).

Of the 3 radio-collared bears, 1 is still alive, 1 was killed by a larger female and 1 was killed by a hunter 16 km outside the bear's territory. In 1989, observers accompanied the last surviving habituated adult during most daylight hours of the hunting season until she and her cubs entered prehibernation lethargy in late September.

Benefits of Habitat Studies

Diet and habitat use data from the habituated bears were directly useful to local forest managers in identifying opportunity areas for black bear habitat preservation or improvement. On a broader scale, the new information aided development of a habitat suitability index model for black bears of the region (Rogers and Allen 1987) and, hopefully, will aid in refining the model. Some of the information provided by habituated bears has proven difficult to obtain in other ways. For example, a commonly eaten succulent, jewelweed (*Impatiens capensis*), has not been identified in scats in this or previous studies due to its high digestibility. Grasses in spring diets have not previously been identified as to species or source cover types because grasses without seed heads cannot be identified in scats. In a previous study in this region (Rogers 1987*b*), intensive spring use of black ash (*Fraxinus nigra*) swamps and alder swamps by bears feeding on bluejoint grass (*Calamagrostis canadensis*) was missed because feeding in those cover types is so efficient and brief that bears were seldom radio-located in them. Habituated bears also revealed the importance of large refuge trees (e.g., *Pinus strobus* >50 cm dbh) to mothers and cubs in spring, confirming an earlier finding by Elowe (1987). Habituated bears provided the first information on amounts eaten in the wild and how consumption differs between years and with phenological progression within years.

Research Needs

Major drawbacks of this study were few study animals and the limited study area. Comparative studies using habituated bears in ecologically different areas across the continent are needed. Such studies should provide new insights into bear behavior and habitat needs and may explain regional differences in black bear growth and reproduction due to possible regional differences in feeding efficiency or diet quality.

Another shortcoming of the present study was the lack of intensive study of males. Few males remained at the artificial feeding site long enough for thorough habituation. Males born in the study area dispersed despite abundant food at the feeding site, and other subadults moved on after a few days or weeks. Mature males that visited the feeding site during mating season appeared more interested in estrous females than food and did not return later. There is a need to determine differences in foraging strategies of large-bodied, wide-ranging males compared to smaller bodied, territorial females. Studies of bears that might exhibit additional or altered behavior regimes such as translocated bears, nuisance bears, and bears whose ranges have been extensively changed by fire, development, insect defoliation, or extensive timber management are also needed. Studies of habituated bears with implanted physiological transmitters (to determine heart rate, body temperature, etc.) are needed for a better understanding of bioenergetics and the factors that influence habitat selection.

Studies of habituated bears do not eliminate the need for extensive studies of large samples of radio-collared bears to learn age-specific and sex-specific movement patterns and survival rates. Habituated bear studies are best used for habitat use studies and to add details to data patterns obtained by more extensive methods. Nevertheless, in some situations and locations (e.g., the cloud forests of South America) habituated bear studies (e.g., studies of spectacled bears [*Tremarctos ornatus*]) may be more immediately feasible than more extensive and expensive studies (B. Peyton, Bear Specialist, International Union for the Conservation of Nature and Natural Resources [IUCN], pers. commun. 1989).

Habituated bear studies are labor intensive but can be accomplished at relatively low cost with few radio-collars and minimal flying time. Computer programs developed in this study are available to researchers interested in similar studies of any species. Researchers are welcome to visit the study area and accompany the habituated bears to become acquainted with field techniques and computer programs.

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