CHILDHOOD FORAGING AS A MEANS OF ACQUIRING COMPETENT HUMAN COGNITION ABOUT BIODIVERSITY

RAYMOND CHIPENIUK *specializes in regional planning and resource development (Ph.D., M.Pl.) and English language and literature (M.A., B.A.). While conducting the studies described in this article, he was an assistant professor in the institute of Urban and Environmental Studies, Brock University, St. Catharines, Ontario, Canada. Most of his research is concerned with how environmental planning should take account of cognitive adaptations to the incommensurability between nature and artifice.*

ABSTRACT: With informants from metropolitan Ottawa and the Niagara Peninsula, Canada, tests were made of the hypothesis that broad foraging for natural things in childhood develops personal competence in assessing the biodiversity of local habitats. Responses from initial groups of informants were used to compile region-specific checklists of natural kinds of things foraged. These checklists then became the basis for questionnaires administered to samples of teenage informants, who were also asked to complete a quiz indexing sense of biodiversity by comparing local habitats. Mean breadth of foraging proves to be around 30 natural kinds, and the hypothesis linking breadth of childhood foraging with sense of biodiversity, tested by analysis of variance, is accepted at modest to fairly high confidence levels. Persons who forage more natural kinds in childhood have a better sense of biodiversity as adults.

There is now a considerable academic literature on what lay members of societies dependent on agriculture, industry, and cities for their livelihood know about the environment or how they think about it (e.g., Hausbeck, Milbrath, & Enright, 1992; Kellert, 1979; Krause, 1993). More still has been published on what members of tribal societies know and think about nature (e.g., Nelson, 1983; Silberbauer, 1981; Toledo, 1991). Yet if anything is critical in the search for solutions to the environmental crisis in wealthy consumer countries, it is to ascertain what lay members of agro-industrial-urban societies know and think about nature as they experience it in their own lives; and research into that subject has not progressed very far.

Typically, recent studies into "environmental knowledge" have concerned themselves with knowledge of social constructions, artifacts, and abstractions rather than knowledge of nature. As indexes of environmental knowledge, Lyons and Breakwell (1994) measured science knowledge and knowledge of industrial pollution. In the tasks they set for their preschool subjects, Cohen and Horm-Wingerd (1993) construe "ecological awareness" as centering on pollution and littering. In their questionnaire, Arcury and Johnson (1987) posed questions about landfill, radioactive waste, institutionally defined wild rivers, the location of oil wells, and the like. Arcury, Johnson, and Scollay (1986) asked informants about waste treatment, water conservation, invisible pollutants, and dam failures. Kellert (1985) probed knowledge of animals among children in Connecticut, but his approach was to inquire about such things as koala bears, whales, penguins, and tigers, which are, from the point of view of membership in the local ecosystems these children dwell in, just media images, as real as Donald Duck.

Correspondingly, with few exceptions (e.g., Harvey, 1989/90), researchers have assumed that lay persons acquire their knowledge about the environment, however that is defined, largely through social intermediation. For instance, as their unique measure of exposure to information about the environment, Lyons and Breakwell (1994) index TV science watching.

The purpose of this article is to report on a study carried on within a somewhat different program of research into lay cognition about the natural environment, one whose perspective is that in appropriate circumstances human beings develop

AUTHOR'S NOTE: For their contributions to my research I thank the students and teachers of Bell High School, Ottawa, and E. L. Crossley and A. N. Myer Secondary Schools, Fonthill and Niagara Falls, respectively; Bert Murphy and John Clipsham, Niagara South Board of Education; Stephen Woodley, Parks Canada; faculty biologists at Brock University, St. Catharines; and my student assistants Mike DiRaddo and Bob MacGregor. For methodological improvements I owe much in particular to Brent Hall and Gordon Nelson, University of Waterloo; John Middleton, Brock University; and two anonymous reviewers for this journal. Some of the expenses of my fieldwork were covered by research seed money from Brock University. Correspondence should be addressed to 1343 Dowler Ave., Ottawa, Ontario, Canada K1H 7R8.

ENVIRONMENT AND BEHAVIOR, Vol. 27 No. 4, July 1995 490-512

some kinds of structured competence in their thinking about nature without any truly cultural intervention at all.

THEORETICAL FRAMEWORK

The theoretical framework is adaptationist (Bernhard, 1988; Tooby & Cosmides, 1992). Certain expectations follow from the well-established anthropological opinion that the human body and mind evolved in adaptation to a hunting-gathering autecology (Cosmides, Tooby, & Barkow, 1992). One of them is that the behavior of children may manifest special cognitive adaptations which would, in environments typical of those human beings evolved in, ensure the development of normal competence in thinking about natural things and natural landscapes (cf. Bell, 1991). Moreover, there should be some expression of these inborn predispositions even when children grow up in contemporary environments affording rather little contact with nature.

In fact, cognitive adaptations involving nature have already been identified. Carey (1985), Gelman (1988), Keil (1989, 1991), and others have demonstrated that cognition involving "natural kinds" of things follows a developmental trajectory quite different from the path taken by cognition involving artifacts. From very early childhood, natural kinds are represented mentally according to theories about their essences. Theory building about the essences of natural kinds produces nature lore that would be of great value to an adult creature that is a broad-spectrum forager by ecological trade. Ideas about artifacts, on the other hand, shift from representation according to characteristic features to representation according to defining features, and do so quite abruptly when the child is about 6, 7, or 8 years old (Keil, 1989). Artifacts are defined principally by human intentions. That is, a chair is something made for people to sit on, not something necessarily made of wood or of steel or of plastic, with four legs or any legs at all. A taxi is a vehicle intended to carry paying passengers over unscheduled short hauls, whether the vehicle is an automobile or a boat.

More generally, Heth and Cornell (1985, p. 216) place children's searching behavior in the light of optimal foraging theory. They remark that "search is an adaptive process within the context of finding and using resources."

Adult adaptations to the ecological requirements for thinking about nature are also known. Anthropologists who study folk science have concluded that there is a more or less invariant human manner of classifying wild plants and animals (Atran, 1990; Brown, 1984). If a language lexicalizes just one general botanical category, that category will be trees, despite the fact that in Linnaean scientific classification there is no such taxon as trees. If a language lexicalizes two top botanical categories, one of them will be trees and the other will be either grasses or a combination of grasses and herbs (Brown, 1984). The sequence continues through languages with 3, 4, and 5 highest level botanical categories, and then stops. Similarly with animals, if there is a unique life-form category, it is always birds, fish, or snakes; the class of mammals is never lexicalized before the class of birds; and so on. Field research indicates that languages and cultures never classify abiotic natural things and artifacts in this fashion (Atran, 1990).

As reviewed by Ulrich (1993), scores of studies have attested to the existence of a cross-cultural preference for natural landscapes over those much altered by human beings, other things being equal. In recent opinion, this preference is best explained as reflecting biological provisions for human species-specific habitat selection (Parsons, 1991; Ulrich, 1993; Orians, 1980). It is involuntary, but cognition is entrained through judgments of naturalness (e.g., Kaplan & Kaplan, 1989), which may be a mechanism for evaluating potential productivity of landscapes from the point of view of a hunter-gatherer (Chipeniuk, 1994).

Because of the crucial role foraging for a wide range of wild plants and animals played in early human ecology, and still plays in many contemporary cultures (e.g., Berlin et al., 1983; Toledo, 1991), it is reasonable to suppose that some cognitive adaptations require experience of foraging for their full development (again, cf. Bell, 1991). That is, if adult human beings were (and are) adapted to gathering fruits, seeds, roots, leaves, and stalks that are not easy to find or to process for consumption, and cognitively specialized for the task of capturing a wide variety of elusive animals, then while they are immature they should be inclined to seek out experiences entailing sensory exposure to the phenotypes, autecologies, behaviors, and habitats of potential "resource" species and the ways of living things generally. In such circumstances the immature mind would then develop ecologically suitable knowledge and structures of thought. As Gelman (1991, pp. 314-315) observes, "children's skeletal principles lead them to seek out nurturing data." The importance of early exposure to exemplars is well attested to in the development of other adaptations, such as human language (Lenneberg, 1967).

Here two cognitive adaptations are suggested for human foraging. One is a strong disposition in children to forage for a wide variety of natural things, even in the absence of adult instigation or favorable environments. The other is an ontogenetic reliance on foraging in childhood to develop individual competence in assessing landscapes for their richness in wild plant and animal resources—this richness, because of the breadth of resources encompassed in late Paleolithic human ecology, being all but identical to what biologists think of as *biodiversity.* To test the plausibility of these hypothetical adaptations, a program of research was carried out as described below.

Very little previously published work associates childhood foraging with environmental competence. Ethnographic work in traditional cultures has been hamstrung by the assumption that any knowledge deserving of notice is culturally transmitted (but see Katz, 1989). As for foraging in agro-industrial societies, apart from a single article on "urban foraging" as a teaching device (Curry & Williams, 1978) and occasional passing references to the fact that children do gather wild vegetation (e.g., Harvey, 1989), the subject seems to have escaped the attention of researchers.

METHOD

Field studies were conducted in two locations, metropolitan Ottawa and the Niagara Peninsula, Ontario. About 1 million people live in and around Ottawa, yet the city has a hinterland in which wild or thinly settled land extends almost to the urban doorstep. By contrast, the cities of the Niagara Peninsula have populations of less than 150,000, but the countryside in which they are situated has been almost completely converted to agriculture, residential development, industry, transportation, and closely supervised parks.

Operationally, foraging was taken to be a matter of gathering and putting to some purpose a natural kind of thing. However, what was quantified as the independent variable was not extent of foraging per se but breadth of foraging, because the number of acts of foraging for the same kind of thing could not be reliably ascertained by recall or meaningfully aggregated across various kinds. Furthermore, breadth of foraging should be a better measure of how foraging exposes children to the relative abundance of diverse life forms in different habitats.

Breadth of foraging was measured in two stages. In the first stage, separately in each region, adult informants were given questionnaires asking them to list all the wild plants, wild animals, fungi, and abiotic or nonliving natural materials they could remember foraging for, either by themselves or in the family context. The questionnaire furnished examples, such as pussy willows under *Wild Plants,* toads under *Wild Animals,* and golden chanterelles under *Fungi.* To ensure that informants had in fact foraged for items and not just passively observed them, they were also asked to state uses to which the items were put, with illustrative uses that included "food" and "ornament."

In the second stage, checklists of natural kinds of things foraged were compiled from the responses to the questionnaire just described. The respective checklists were then administered to high school students in Nepean, a suburb of Ottawa, and Fonthill and Niagara Falls in the Niagara Peninsula. Space was available for informants to add new items. Again, informants were asked to state uses for items they reported foraging

Some sorts of places are home to more wild plants, wild mushrooms or fungi, and wild animals, of more different kinds, than other sorts of features. Think back over your travels in the Niagara district. For each of the following pairs of places, please indicate the sort of place you believe would have more wild things, of more kinds, with an *M*, and the sort of place you believe would have fewer wild things, with less variety, with an *L*. Item *0* is an example.

(0) A town *M*	A grain farm *L*
(1) A field in crop	A pasture
(2) A forested valley	A forested hilltop
(3) The middle of a lake	Parts of a lake near the shore
(4) A pure hardwood bush	A bush with a mixture of hardwoods and evergreens
(5) A big stream	A small stream
(6) Flat farm country	Hilly farm country
(7) The middle of a large woodlot	The edge of a large woodlot bordering a field
(8) A pond with a stream flowing in and out	A pond with no stream flowing in or out
(9) A small woodlot	A large woodlot
(10) A lake with lots of points and bays	A lake with a few points and bays
(11) A patch of forest	An old pine plantation
(12) A pond that is mostly very deep	A pond that is mostly shallow but that has one deep area
(13) A lakeshore or river bank with no cottages on it	A lakeshore or river bank with a few cottages on it
(14) Forest that has never been logged	Forest where loggers made a few clearings a few years ago
(15) A field abandoned a year ago	A field abandoned five years ago
(16) A cattail marsh	A cornfield

[*Correct answers:* (1) L M; (2) M L; (3) L M; (4) L M; (5) M L; (6) L M; (7) L M; (8) M L; (9) L M; (10) M L; (11) M L; (12) L M; (13) L M; (14) L M; (15) L M; (16) M L]

Figure 1: Biodiversity Quiz *(Niagara Version)*

for. The rationale for choosing teenagers as informants for the second stage of the study was that they would have concluded cognitive development and they would be mature enough to understand the questionnaire, yet their memories of childhood foraging would be fresh.

Another section of the second survey instrument was a quiz to assess informants' sense of biodiversity in their home bioregion. Informants were asked to consider 16 pairs of local habitat types, such as "a bay of a lake" versus "the middle of a lake," and to indicate which they felt would be home to more wild plants and animals of more different kinds (Figure 1). "More wild plants and animals of more different kinds" renders in a common sense way the two dimensions technical indexes of biodiversity strive to measure, namely variety of species and relative abundance of individuals in species (Magurran, 1988). Characterization of habitat types was deliberately expressed in universal terms to force the informant to abstract from all the memories he or she could command. However, the habitat types were specific to local ecosystems and the quiz for the Niagara region therefore differed in several habitat pairs from the quiz for the Ottawa district.

One local ecologist, a Ph.D., reviewed the quiz for the Ottawa region. Five local ecologists, all Ph.D.s, evaluated drafts of the quiz for the Niagara region. Only habitat pairs on which there was unanimity or near unanimity were included.

For the Niagara region, information was also elicited on childhood gathering of artifacts. In a procedure exactly parallel with that employed for foraging for natural kinds, informants responded to a checklist of "sorts of artifacts (things made by people)" they could remember having searched for and collected or used. Instructions emphasized that the sorts checked off should not include those bought or received from someone else. Space was again provided for a description of uses.

The purpose of an index to breadth of artifact gathering was to provide a control for the foraging of natural kinds. Both sorts of activities entail curiosity, spontaneous searching, collecting, and use. Both sorts of self-reports involve memory, intelligence, and no doubt other shared psychological characteristics. Hence any apparently meaningful statistical relationship between foraging and sense of biodiversity could more confidently be attributed to uniquely potent developmental properties of natural kinds if no similar relationship obtains between gathering of artifacts and sense of biodiversity. Two other control procedures, applied in minor collateral studies, are treated briefly in the results section of this article.

Ottawa informants were allowed to take protocols home to fill out at their leisure over a period of 2 to 4 weeks. Niagara informants completed the protocols in the classroom in the space of approximately 1 hour, with the same research assistant administering the exercise in each case.

RESULTS

In the less rigorous and less extensive Ottawa round of the study, conducted in April 1993, 39 students in two classes of Grade 10 students returned questionnaires in which the foraging checklist had been completed with accompanying uses; 32 also did the biodiversity quiz. Mean age of the 39 was 14.8 years, the range was 13 years to 16 years. The two participating classes included students from the full range of academic abilities. Females in the sample outnumbered males 31 to 8, purely because of response rates. All but one of the informants had lived in the Ottawa area for at least 4 years; about three quarters had lived there all their lives. Students at the school where the survey was administered are drawn from outlying towns and farms as well as urban and suburban areas.

The checklist these informants worked with comprised 211 natural kinds, more or less; a few categories were subsets of others and the use of popular rather than scientific names sometimes made it difficult to be certain two kinds were not really the same kind. As individuals, the teenagers reported a respectable breadth of kinds foraged: mean 33.5, range 3 to 82, standard deviation 20.0.

For the 32 informants who completed the Ottawa biodiversity quiz, the mean score was 11.7 correct responses out of the 16 possible, or 73%. Standard deviation was 1.4, the range 8 to 14.

Finally, to test for the hypothesis that childhood foraging develops a sense of biodiversity, nonparametric ANOVAs were performed on foraging and quiz results. When scores were converted to ranks according to standard deviations from the mean and analyzed with the Kruskal-Wallis (K-W) one-way analysis of variance, the hypothesis was supported at the 99% confidence level (corrected for ties, $\chi^2 = 11.9$). Subsequently, for the sake of consistency with the later Niagara study, foraging totals were divided into those above and those below the median and the Mann-Whitney (M-W) rank-sum test was performed on variance with raw quiz scores, as discussed below. Results fell just below significance.

In the Niagara round, conducted in April 1994, seven classes of high school students participated, most of them in Grade 11. Two were unlike the others in that students in them were taking a course in urban and environmental studies and had received several periods of instruction in biodiversity. Hence the returns were divided into a main sample (Classes 1 through 5) of 84 informants and a by-sample (Classes 6 and 7) of 28.

Of the 84 students in the Niagara main sample, 80 included personal data. Among the 80, 44 (55%) were female, 36 (45%) were male. Mean age was 16.6 years, mean number of years resident in the Niagara region was 13.6 years.

Classes 1 through 3 and 5 were in a school drawing students from the fringes of St. Catharines, a city of about 130,000. Classes 4, 6, and 7 were in a school serving residents of a large and prosperous town and rural families in outlying areas. However, in this heavily humanized landscape, the distinction between town and country is not very meaningful. When results from classes were analyzed separately, Class 4 closely resembled the other classes of the main sample, though it was "rural" and they were "urban."

The checklist of natural kinds for the Niagara region, compiled from 15 adult primary informants as opposed to 50 as in the Ottawa case, included only 136 items. The checklist for artifacts, similarly compiled, included 38 kinds. Informants wrote in about a dozen additional natural kinds and three or four artificial kinds.

Results for Niagara, displayed in Table 1, resembled those for Ottawa. Mean number of natural kinds foraged by the main sample ($N = 84$) was 31.6, the range 11 to 81. Mean number of artifacts was 9.8, range 1 to 35. Mean score on the biodiversity quiz was 11.5 (72% correct), range 7 to 16. Some idea of a modal foraging repertory can be had from Figure 2.

Scores were dichotomized as above or below the medians. When the M-W ANOVA was applied to the hypothesis that broad foraging for natural kinds helps produce sense of

TABLE 1
Foraging for Natural Kinds and Gathering of Artifacts, Sense of Biodiversity, and Analysis of Variance

Sample	N	*Natural Kinds Foraged (Mean)*	*Artificial Kinds Gathered (Mean)*	*Biodiversity Quiz Scores (Mean)*	*M-W ANOVAs (Biodiversity Quiz Score With Natural or Artificial Kinds [Kinds Above vs. Below Median])*
Ottawa, Classes 1-2	32	33.5	—	11.7	natural random artificial N/A [K-W natural < .01] [K-W artificial N/A]
Standard deviation		20.0	—	1.4	
Niagara, Class 1	18	31.2	8.6	11.7	
Niagara, Class 2	16	31.5	8.1	10.9	
Niagara, Class 3	14	32.6	14.2	10.9	
Niagara, Class 4	16	35.4	9.7	12.1	
Niagara, Class 5	20	27.8	9.2	11.8	
	==	==	==	==	
Niagara main sample	84	31.6	9.8	11.5	natural < .01 artificial random
Standard deviation		13.6	6.2	1.9	
Niagara by-sample Classes 6-7	28	38.5	10.8	11.1	natural random artificial random
Standard deviation		16.3	5.9	2.1	
Niagara total sample	112	33.2	10.0	11.4	natural < .05 artificial random
Standard deviation		14.5	6.1	2.0	

biodiversity, results were significant at a two-tailed probability of .027. That is, broad foragers do better than narrow foragers on the biodiversity quiz (mean rank 48 vs. 38, $W = 1955$, $U = 669$) more often than chance predicts. Because of low dispersion on the quiz scores, exaggerating the consequences of small distances from the median, an M-W ANOVA was also performed on dichotomized foraging scores but raw quiz scores. Results were significant at a two-tailed probability of .009 (mean rank 50 vs. 36, $W = 2030$, $U = 595$).

Kind of wild plant	*Use*	*Foraged in Niagara?*
Acorns	To throw	X
Apple	To eat	X
Cattails	Decoration	X
Clover	Four leaf—luck	X
Crab apples	To throw	X
Dandelions	Picked for Mom	X
Driftwood	Carved for a sculpture	X
Pinecones	Crafts	X
Pussy willows	Gave to Mom	X
Raspberries	To eat	X
Roses	Gave to Mom	X
Strawberries	Ate	X
Violets, yellow	Gave to Mom	X
Kind of wild mushroom or fungus		
Puffballs, common	Puffed	X
Kind of wild animal	*Use*	*Foraged in Niagara?*
Ants	Ant farm	X
Bass, rock	Fishing	X
Bass, smallmouth	Food	X
Caterpillars	Keep as pets	X
Catfish	Fishing	X
Crayfish	Used for bait	X
Daddy longlegs	Pulled off legs	X
Earthworms	Used for bait	
Fireflies	Caught in jars	
Frogs and tadpoles	Used as bait	X
Mice	Brought home	X
Perch, yellow	Fishing	X
Pickerel (or walleye)	Fishing	
Pike	Fishing	
Potato bugs	Played with	X
Praying mantises	Made them fight	X
Snakes, garter	Kept for pet	X
Sunfish	Fishing	X
Turtles, snapping	Kept for pet	X
Other natural kinds	*Use*	*Foraged in Niagara*
Birds' nests	Brought home	X
Feathers	Acted as Indian	X
Artifacts	*Use*	*Foraged in Niagara*
Arrowheads	Used as necklace	X
Bottle caps, beer	Collected	X
Bullet casings	Collected	X
Coins, old	Collected	X
Golfballs	Collected from driving range	X
Popsicle sticks	Crafts	X
Tennis balls	For hockey	X
Tinfoil (from cigarettes)	Foil ball	X

Figure 2: "Modal" Example of Childhood Foraging and Gathering: Class 3, #46

When ANOVAs were performed in the same fashion on the variance between foraging for kinds of artifacts and sense of biodiversity, results were random.

By itself, the Niagara by-sample of Classes 6 and 7 resulted in ANOVAs random for both foraging of natural kinds and gathering of artifacts. However, if Classes 6 and 7 are added to the main sample to create a single overall Niagara sample ($N = 112$), the ANOVA on foraging for natural kinds and sense of biodiversity is significant at probability less than .05, broad foragers scoring higher than narrow ones on the biodiversity quiz, rank by rank; on foraging for artifacts and the biodiversity quiz, the ANOVA is random.

Numerical differences between males and females were negligible.

DISCUSSION AND CONCLUSIONS

Clearly, most informants in the study groups have sought out and used a fairly broad range of natural kinds of things, sometimes spontaneously, sometimes because of their parents, in a few instances because of teachers. When informants report foraging few kinds, it is perhaps for lack of opportunity: there is a substantial correlation between number of kinds foraged and years of local residence. If nothing else, foraging must therefore be an important means by which children come into contact with instances of local natural kinds.

Second, by the standards of the quiz, most informants in the study groups have acquired a quite competent sense of biodiversity concerning the various habitats of the bioregion they live in. What is more, they have evidently done so without formal instruction about biodiversity. Because only the Niagara by-sample are known to have had such instruction and they obtained a lower mean score on the biodiversity quiz (11.1) than did the Niagara main sample (11.5), informal learning about the biodiversity of real habitats may be more effective than formal.

Third, it would appear that foraging is an important avenue by which children obtain learning experiences involving natural kinds and relative biodiversity of local habitats. For the study samples, roughly, the wider the foraging, the better the sense of biodiversity. It may be that childhood foraging experiences trigger an intuitive sense of biodiversity in much the same way as linguists believe early exposure to speech triggers the development of grammar, or it may be that they provide learning opportunities through repeated and vivid exposure to examples of the biodiversity of various habitats; or it may be both. Whatever the case, an adaptationist interpretation remains viable.

Alternative explanations for the relationship between breadth of foraging and sense of biodiversity are available but not very convincing. That some underlying variable such as diligence, strength of memory, or intelligence accounts for it is rendered less likely at the outset by the consistently random results from ANOVAs testing variance of biodiversity quiz scores with breadth of foraging for artifacts.

Data from one of the collateral studies mentioned earlier has a bearing on whether intelligence is an underlying variable in these results. When a sample of 18 adult Niagara region Rotary Club members completed the standard foraging questionnaire and biodiversity quiz in May 1994, the ANOVA on foraging for natural things was significant at a two-tailed probability of less than .05. Although the ANOVA on gathering artifacts was random, as usual, there were low correlations between years of education and both quiz scores (Kendall's tau-c = .16) and foraging (tau-c = .28). Consequently, to the extent that years of education reflect intelligence, greater intelligence may indeed issue in both broad foraging, or at least good recollection of kinds foraged, and high scores on the biodiversity quiz. But which intelligence: verbal, mathematical, spatial, or some other? If intelligence is modular and sense of biodiversity is a component in some poorly known module of natural-kind intelligence, then this explanation may not differ from an adaptationist one.

Another possibility is that mere interest in nature might produce an impulse to forage at the same time as it stimulates a child's desire to observe the relative biodiversity of habitats. In May 1994, as a limited test of this competing "curiosity" hypothesis, 20 students in a Niagara high school performed an exercise like the standard one in all respects other than that they were additionally invited to check off natural kinds they could recall having "just observed or paid attention to." "Just observed or paid attention to" was elaborated as meaning the informant had just looked at the wild kind close up, or listened to or smelt it, without keeping it or making use of it in any way. Further comment made it clear that "just observed" was a possible answer even for kinds the informant could recall having also foraged for. For natural kinds foraged, the ANOVA on biodiversity quiz scores had a two-tailed probability of less than .1, with high-ranking foragers scoring high on the quiz. For natural kinds "just observed" but exclusive of kinds also foraged, the probability was less than .3, with opposed ranks. For natural kinds just observed and inclusive of kinds also foraged, the probability was .9. In other words, mere interest in natural kinds, if the just observing index does it justice, was associated with less competence in thinking about biodiversity, so if anything, it counteracts the effects of foraging.

A factor definitely shared between childhood foraging and sense of biodiversity is parental influence. As illustrated by the modal foraging list of Figure 2, parents can elicit foraging behavior in their children. Informants often cite giving instances of a kind to their mother as a use (seldom to their father). In welcoming the gift, parents may both reinforce the behavior and communicate their attitudes towards nature. In a study reported in Chipeniuk (1994), a large proportion of informants mentioned their parents in self-reports on where they believed their attitudes to nature had come from, especially if the attitudes toward nature were positive, as most of them were.

It is true that even in hunter-gatherer societies adults make little deliberate effort to teach young children to differentiate among wild plants and animals, and children show a strong inclination to participate in family foraging and to forage on their own without their parents requiring it of them (e.g., Lee, 1979; Marshall, 1976; Shostak, 1981; Wentzel, 1991). Katz (1989, p. 49) comments that when she asked Sudanese children where they learned about the plants they foraged for, "it appeared to them that their knowledge was not so much learned as taken in with the air." But parents may control learning opportunities by determining whether certain types of foraging will take place at all, such as fishing for lake trout, hunting moose, or picking mushrooms, where travel or skill are required.

Whether parental influence is a dominant factor in the relationship between childhood foraging and sense of biodiversity remains to be seen. A quite different methodological approach will be necessary to settle the question.

To continue with discussion of results, the fourth point is that some sorts of foraging may be more effective than others in developing sense of biodiversity. With the Niagara main sample, ANOVAs done on breadth of animal kinds foraged are almost an order of magnitude more significant than those for plant kinds. On the other hand, foraging for fungi shows no significant relationship with sense of biodiversity. One might expect that foraging done across habitats ranging from highly disturbed to nearly undisturbed would be more heuristic than foraging, for however many kinds, restricted to purely urban habitats.

Fifth, whereas broad foraging for natural kinds is usual, broad gathering of artificial kinds is not. Not only is the mean for artificial kinds low, at about 10 versus 33 for natural kinds, but many informants report little or no artifact scavenging behavior. Of course, in contemporary agro-industrial societies, children or their parents can satisfy a desire for intimacy with artifacts, such as toys, by buying them. But people can also buy pets or house plants or garden seeds, which are natural kinds with some artificial features.

Sixth, the fact that informants who have been formally instructed in biodiversity do no better on the biodiversity quiz than those who have not (mean score for main sample 11.5, for by-sample 11.1) is surprising only at first sight. Formal instruction is on the principles of biodiversity, not on the intuitive reading of local landscapes. To read the biodiversity of landscapes with real insight takes years of personal acquaintance, not a few hours in a classroom.

Seventh, although the Ottawa and Niagara samples are small, they reveal what seem to be some peculiar regularities. The coincidence in mean number of natural items foraged, 33.5 as compared with 31.6, is striking, especially in view of how results for individual classes also fluctuate around means of about 32. Possibly related is the fact that most of the variance in biodiversity quiz scores is used up in the step from foraging scores below 20 kinds to those above. It is as if children are unsatisfied until they reach a certain minimum breadth of foraging, that point also being the one at which gains in competence in thinking about local biodiversity level off, as measured by the quiz.

On the other hand, regional differences in the content of foraging repertories are pronounced. A detailed comparison has not yet been made, but one can say, by way of illustration, that although high percentages of informants in both groups report foraging for pussy willows, many other kinds are region specific in how commonly they are foraged, or in whether they are foraged at all. Nearly everyone in the Ottawa sample, but not the Niagara, has foraged for wild blueberries. Only informants in the Niagara sample have foraged for sassafras. Herein lies one of the sources of bioregional identity.

Some regional comparisons are worrisome. Every human settlement presents children with a unique set of environmental conditions. Situated between farm country and the still fairly intact ecosystems of the Canadian Shield, metropolitan Ottawa-Hull affords children who grow up in it some unusually good opportunities for foraging and for comparing the richness of wild plant and animal life of various habitats. The drastically degraded Niagara Peninsula may be more typical of the ecological settings in which most North American children now find themselves. Yet Niagara does not represent the extreme intensity of land use of Toronto, Chicago, or New York, where foraging is hard to do or out of the question near home, and getting well out of the influence of a city is something increasing numbers of children seldom do. In these places urban environments may be so "unnatural" in the sense explained by Symons (1979) that children growing up in them cannot engage in foraging to the extent necessary for them to acquire a basic competence in biodiversity.

Megalopolitan children will preponderate in the societies among which future constituencies for nature must be found. To throw light on whether some environments are too artificial to develop children's sense of biodiversity properly, foraging and sense-of-biodiversity studies need to be carried out among informants who have grown up in giant conurbations, among other, less extreme environments.

Should further studies bear out the apparent relationship between childhood foraging and competence in assessing biodiversity, the implications will be considerable. For the past generation, environmental education has been based on the premise that "a general understanding of the basic principles of ecology, the principles that govern the relationship of all living things to their environment, is the key to an understanding of environmental problems, whatever they may be" (Kupchella & Levy, 1975, p. 3). Results from the present study, as well as reviews casting doubt on the idea that children learn much besides economic technique from conscious instruction (Jahoda & Lewis, 1988), suggest that teaching abstract ecological principles may not be the best way to promote environmental competence in lay citizens. Instead, perhaps the emphasis should be on certain critical cognitive abilities which arise spontaneously and inevitably so long as conditions are conducive to children's seeking out appropriate sorts of experience on their own.

The trouble is that increasingly, planning institutions create conditions that are not suitable. Urban densities are deliberately intensified; more and more, provincial and state jurisdictions frown upon or actually forbid foraging and other sorts of direct contact with nature (Ontario Wildlife Working Group, 1991); educational materials convey the oblique message that it is wrong for an individual to make use of wild plants or animals unless someone else has first processed and packaged them.

Wilson (1992, p. 15) has described biodiversity as "the key to the maintenance of the world as we know it." If in fact children do much of their learning about biodiversity and about the effects people have on biodiversity by making use of natural resources, then societies pursuing the goal of sustainability might do better to encourage childhood foraging. Obvious ways in which they might do so are by providing and designating urban areas where children are free to forage; by permitting and promoting foraging on public land in hinterland areas; and by cultivating traditions of family foraging of the sort prevalent in Scandinavia.

Mere foraging experience and mere possession of a strong sense of biodiversity are not enough to render a person unwilling to destroy the richness of nature. Deliberate undertakings to promote foraging should therefore be accompanied by an ideology of conservation and preservation. Needless to say, some species, for instance North American wild orchids, ought never be foraged. However, many other species can withstand quite intensive foraging without sustaining significantly harmful effects. For example, the widespread gathering of wild mushrooms in Europe seems to have made no impression on the survival of mycelia (Arnolds, 1991).

Concerning the possibility that foraging might instill exploitive habits of mind in children, Harvey (1989) has concluded that the more varied children's contact with vegetation, the less likely they are to believe people can manipulate the environment with impunity. Historically, it is striking that many, if not all, of the great literary prophets of love of nature were foragers in their youth or as adults. Of the father of the English Romantic movement, which some would say commenced the chain of events leading to modern environmentalism, De Quincy (1834-40/1961) states that "Wordsworth, like his [boyhood] companions, haunted the hills and the vales for the sake of angling, snaring birds, swimming, and sometimes of hunting. . . . It was in the course of these pursuits, by an indirect effect growing gradually upon him, that Wordsworth became a passionate lover of nature. . . ."

In *The Prelude* Wordsworth tells how ". . . 't was my joy/ With store of springes o'er my shoulder hung/ To range the open heights where woodcoks run. . . . " Henry Thoreau picked berries, fished for pickerel at Walden Pond, and ate woodchuck. John Muir hunted birds' nests in Scotland (Teale, 1954). Ernest Thompson Seten hunted wolves in North Dakota, as did Aldo Leopold in Arizona. In fact, by his own account (Leopold, 1949, p. 130), it was hunting wolves that taught Leopold it was unwise to hunt wolves to extinction. Loren Eiseley (1970) speaks of how,

when he was a child on the American prairie, boys played with sunflower spears in wild sunflower forests; that image becoming transmuted into a metaphor for "love of earth." A close reading of Reiger (1986) reveals that virtually all leading actors in the early American conservation movement were enthusiastic foragers in their youth.

Ethnobiologists Nabhan and Trimble (1994) worry that children deprived of extensive direct contact with natural things, including foraging, may grow up with what they call a "politically correct" but ungrounded conservation ethic. Plainly, they fear dissociation from nature more than they do the imprinting of bad habits of exploitation.

Many indigenous societies are highly regarded for their wisdom concerning right relations between human beings and nature (Durning, 1992). Westerners especially, and properly, admire hunter-gatherer people in this respect, at the same time as they imagine they themselves can somehow live without making use of natural things (Wentzel, 1991). Results from the present study indicate agro-industrial-urban cultures might gain in understanding of nature and of themselves if they were to recognize the advantages of providing ample foraging opportunities for their children.

REFERENCES

Arcury, T. A., & Johnson, T. P. (1987). Public environmental knowledge: A statewide survey. *Journal of Environmental Education, 18*(4), 31-37.

Arcury, T. A., Johnson T. P., & Scollay, S. J. (1986). Ecological worldview and environmental knowledge: The "new environmental paradigm." *Journal of Environmental Education, 17*(4), 35-40.

Arnolds, E. (1991). Decline of ectomycorrhizal fungi in Europe. *Agriculture, Ecosystems and Environment, 35*, 209-244.

Atran, S. (1990). *Cognitive foundations of natural history: Towards an anthropology of science.* Cambridge: Cambridge University Press.

Bell, W. J. (1991). *Searching behaviour: The behavioural ecology of finding resources.* London: Chapman and Hall.

Berlin, B., Berlin, E. A., Patton, J. L., O'Neill, J. P., McDiarmid, R. W., & Swift, C. C. (1983). Adaptation and ethnozoological classification: Theoretical implications of animal resources and diet of the Aguaruna and Huambisa. In R. B. Hames & W. T. Vickers (Eds.), *Adaptive responses of native Amazonians* (pp. 301-325). New York: Academic Press.

Bernhard, J. G. (1988). *Primates in the classroom: An evolutionary perspective on children's education.* Amherst: University of Massachusetts Press.

Brown, C.H. (1984). *Language and living things: Uniformities in folk classification and naming.* New Brunswick, NJ: Rutgers University Press.

Carey, S. (1985). *Conceptual change in childhood.* Cambridge, MA: MIT Press.

Chipeniuk, R. (1994). *Naturalness in landscape: An inquiry into means of rendering the concept serviceable for purposes of planning.* Unpublished Ph.D. dissertation, University of Waterloo, Waterloo, Ontario.

Cohen, S., & Horm-Wingerd, D. (1993). Children and the environment: Ecological awareness among preschool children. *Environment and Behavior, 25*(1), 103-120.

Cosmides, L., Tooby, J., & Barkow, J. H. (1992). Evolutionary psychology and conceptual integration. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 3-15). New York: Oxford University Press.

Curry, A. D., & Williams, R. A. (1978). Living off the land—An urban foraging experience. In C. B. Davis & A. Sacks (Eds.), *Current issues in environmental education — IV: Selected papers from the Seventh Annual Conference of the National Association for Environmental Education,* 219-224. Columbus, OH: ERIC Clearinghouse for Science, Mathematics and Environmental Education, Ohio State University, College of Education and School of Natural Resources.

De Quincy, T. (1961). *Reminiscences of the English lake poets.* London: J. M. Dent & Sons. (Originally published in 1834-40)

Durning, A. T. (1992). *Guardians of the land: Indigenous peoples and the health of the earth.* Worldwatch paper 112. Washington, DC: Worldwatch Institute.

Eiseley, L. (1970). *The invisible pyramid.* New York: Scribner's.

Gelman, R. (1991). Epigenetic foundations of knowledge structures: Initial and transcendent constructions. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: essays on biology and cognition* (pp. 314-315). Hillsdale, NJ: Lawrence Erlbaum.

Gelman, S. A. (1988). The development of induction within natural kind and artifact categories. *Cognitive Psychology, 20,* 65-95.

Harvey, M. R. 1989. Children's experiences with vegetation. *Children's Environments Quarterly, 6*(1), 36-43.

Harvey, M. R. (1989/90). The relationship between children's experiences with vegetation on school grounds and their environmental attitudes. *Journal of Environmental Education, 21*(2), 9-15.

Hausbeck, K. W., Milbrath L. W., & Enright, S. M. (1992). Environmental knowledge, awareness and concern among 11th-grade students: New York State. *Journal of Environmental Education, 24*(1), 27-34.

Heth, C. D., & Cornell E. H. (1985). A comparative description of representation and processing during search. In H. M. Wellman (Ed.), *Children's searching: The development of search skill and spatial representation* (pp. 215-249). Hillsdale, NJ: Lawrence Erlbaum.

Jahoda, G., & Lewis, I. M. (Eds.). (1988). *Acquiring culture: Cross cultural studies in child development.* London: Croom Helm.

Kaplan, R., & Kaplan, S. (1989). *The experience of nature: A psychological perspective.* Cambridge: Cambridge University Press.

Katz, C. (1989) Herders, gatherers and foragers: The emerging botanies of children in rural Sudan. *Children's Environments Quarterly, 6*(1), 46-53.

Keil, F. C. (1989). *Concepts, kinds, and cognitive development.* Cambridge, MA: The MIT Press.

Keil, F. C. (1991). The emergence of theoretical beliefs as constraints on concepts. In S. Carey & R. Gelman (Eds.), *The epigenesis of mind: Essays on biology and cognition* (pp. 237-256). Hillsdale, NJ: Lawrence Erlbaum.

Kellert, S. R. (1979). *Public attitudes toward critical wildlife and natural habitat issues.* Washington, DC: Superintendent of Documents, U.S. Government Printing Office.

Kellert, S. R. (1985). Attitudes towards animals: Age-related development among children. *Journal of Environmental Education, 16*(3), 29-39.

Krause, D. (1993). Environmental consciousness: An empirical study. *Environment and Behavior 25*(1), 126-142.

Kupchella, C. E., & Levy, G. F. (1975). Basic principles in the education of environmentalists. *Journal of Environmental Education, 6*(4), 3-6.

Lee, R. B. (1979). *The !Kung San: Men, women, and work in a foraging society.* Cambridge: Cambridge University Press.

Lenneberg, E. H. (1967). *Biological foundations of language.* New York: Wiley.

Leopold, A. (1949). *A Sand County almanac and sketches here and there.* Oxford: Oxford University Press.

Lyons, E., & Breakwell, G. M. (1994). Factors predicting environmental concern and indifference in 13- to 16-year-olds. *Environment and Behavior 26*(2), 223-238.

Magurran, A. E. (1988). *Ecological diversity and its measurement.* Princeton, NJ: Princeton University Press.

Marshall, L. J. (1976). *The !Kung of Nyae Nyae.* Cambridge, MA: Harvard University Press.

Nabhan, G. P., & Trimble, S. (1994). *The geography of childhood: Why children need wild places.* Boston: Beacon Press.

Nelson, R. K. (1983). *Make prayers to the raven: A Koyukon view of the northern forest.* Chicago: The University of Chicago Press.

Ontario Wildlife Working Group. (1991). *Looking ahead: A wild life strategy for Ontario.* Toronto: Ontario Ministry of Natural Resources.

Orians, G. H. (1980). Habitat selection: General theory and applications to human behavior. In J. S. Lockard (Ed.), *The evolution of human social behavior* (pp. 49-66). New York: Elsevier.

Parsons, R. (1991). The potential influences of environmental perception on human health. *Journal of Environmental Psychology, 11,* 1-23.

Reiger, J. F. (1986). *American sportsmen and the origins of conservation.* Norman: University of Oklahoma Press.

Shostak, M. (1981). *Nisa: The life and words of a !Kung woman.* Cambridge, MA: Harvard University Press.

Silberbauer, G. B. (1981). *Hunter and habitat in the Central Kalahari Desert.* Cambridge: Cambridge University Press.

Symons, D. (1979). *The evolution of human sexuality.* New York, Oxford: Oxford University Press.

Teale, E. W. (Ed.). (1954). *The wilderness world of John Muir.* Boston: Houghton Mifflin.

Toledo, V. M. (1991). Patzcuaro's lesson: Nature, production, and culture in an indigenous region of Mexico. In M. L. Oldfield & J. B. Alcorn (Eds.), *Biodiversity: Culture, conservation, and ecodevelopment* (pp. 147-171). Boulder: Westview.

Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. H. Barkow, L., Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 19-136). Oxford: Oxford University Press.

Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes. In S. R. Kellert, & E. O. Wilson (Eds.), *The biophilia hypothesis* (pp. 73-137). Washington, DC: Island Press.

Wentzel, G. (1991). Animal rights, human rights: Ecology, economy, and ideology in the Canadian Arctic. Toronto: University of Toronto Press.
Wilson, E. O. (1992). *The diversity of life*. Cambridge, MA: The Belknap Press of Harvard University Press.