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Coping with Cold and Other Challenges of the Boreal Forest: An Overview

A. Theodore Steegmann, Jr., Marshall G. Hurlich, and Bruce Winterhalder

10.1. Introduction

Our objectives in this final chapter are to consolidate our observations on one major piece of unfinished business—cold adaptation—and to describe the pattern of general adaptation which we have observed in our studies in boreal anthropology.

Human biology is emerging from a period of narrow technical explorations into one of a generalized search for broad, multifaceted adaptive patterns. The research programs which lie beneath the foregoing chapters reflect that history. We went forth in the beginning expecting to extend our knowledge of biological and behavioral adaptation to cold. Cold and the ecological limits that it sets were assumed to be the essential challenges to human life in northern forests. Anthropological field work, however, is an experience with reality; it rearranges the best armchair theory and is an instructor of the old school.

Gradually, we discovered that illness and death resulting directly from cold are actually rather uncommon now, and were apparently uncommon in the past as well. Both as a threat to survival and health and as a matter of concern in everyday life, low temperature matters little. Although annual weather cycles certainly have profound effects on availability of and ease of foraging for food, they show little direct effect on people.

Intuitively, it is obvious that cold should be a major problem. However, the "obvious" turns out to have dubious support. Where, then, are we left with

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this issue? One explanation for the dissonance could be simply that it is not particularly cold in the northern forest. Winterhalder considered the question in Chapter 2 and laid it to rest. A great band of arctic winter climate drives southward around the lower borders of Hudson Bay. Though the latitude and light/dark cycle there are not those that some high-arctic peoples have to cope with, the climate is nevertheless continental and dominated in winter by arctic air masses of extremely low temperatures. Perhaps, then, dwellers in the northern forests enjoy some extraordinary physiological adaptations which protect them from cold's bite. As we will demonstrate in the next section, they do indeed have special advantages which probably derive from both genetic and acclimatizational foundations. We would not argue, however, that even the maximum physiological adaptations are sufficient to meet challenges of this magnitude. They may be useful, and in some circumstances may even be necessary components of more complex behavioral adaptations. However, most of the survival skills and comforts of life available to the forest native depend on two other dimensions.

The boreal forest itself offers enormous adaptive resources to those who are skilled in its use. Fewer and somewhat different resources are available to the neighboring Inuit (Eskimo) and largely for that reason these people of the far north have long stood at the apex as a model of resourcefulness in their survival techniques. In contrast, the Algonkians have advantages. They are seldom far from trees, which gentle the deadly cold winds, give up their boughs and wood for shelter and fire, and serve to map out living spaces of the multiple animal species available to a proficient forager. Despite these advantages, humans have never found the boreal zone to be a land of milk and honey. Its meager advantages over the arctic cannot be exploited without the use of a complex array of behavioral skills which take years to master and constant self-discipline to maintain. Marano (this volume, Chapter 8) suggests that while the learning in this environment differs little from that demanded of any young human, the latitude of trial-and-error practice may be narrow and the cost of inattention heavy. It is, in short, an effective but demanding adaptive pattern. Like an efficient, well-oiled machine, it does its job so smoothly that it may be taken for granted by the insider and is almost certain to be seen only in occasional glimpses by strangers. It may become most obvious only on those odd occasions when it fails. Consequently, we have doubtless missed a great deal of importance—regarding both cold adaptation and general adaptation—simply because these systems work so well most of the time.

The following sections must, then, be taken as first approximations. Their summary nature cannot do justice to the richness of Algonkian life; they do, at least, give us a framework. Time and change will alter some of what we have reported, but we would stress the observation of Edward Rogers: basic Algonkian adaptations have been remarkably persistent over the last 300 years. The Algonkians may eventually make profound contributions to our understanding of human adaptation. Our present summary will begin with cold.

10.2. Algonkian Cold Adaptation: The Biological Foundation

Reports on physiological response to laboratory and to natural cooling have been published by Steegmann (1977, 1979) and by Hurlich and Steegmann (1979). Although it was demonstrated in those papers that cold-climate peoples maintain relatively high facial temperatures, and even in cases of severe cooling get only mild frostbite at craniofacial sites (Steegmann, 1979), we presented no Indian/non-Indian comparison of hand temperatures. We do that here.

A standardized hand-cooling test was developed in the Physical Anthropology Laboratory at SUNY at Buffalo during the late 1960s; it employed immersion of the left hand (to styloid level) in stirred, 5°C water for 30 min, with a 10-min "recovery period" during which the chilled hand was removed from its cold bath, dried, and warmed in ambient air (23°C). We recorded skin temperatures of midfinger pulp and of the center of the back of the cooled hand and on its uncooled counterpart as well, using highly accurate, dependable thermoelectric monitors. So (1975) applied the test to two populations of non-cold-acclimatized men, one of northern Chinese ancestry and one which was genetically southern Chinese. Though his experiments were conducted in Buffalo and those of Hurlich and Steegmann in northern Ontario, they all followed a single protocol and were as nearly equivalent as possible. Consequently, we can compare cold responses between the two Asian and the one originally Asian populations. The southern Chinese have no evolutionary background of cold exposure, but their northern kinsmen do. The Algonkians are not only a classic example of a cold-adapted people, but also experience both short-and long-term acclimatization; for present purposes, we will employ the data from the Algonkians of Weagamow because they show little European genetic admixture.

After comparing finger temperature means and the overall response curves of the three groups [from So (1975) and Hurlich and Steegmann (1979)], we derive the following conclusions:

1. Native Americans maintained the highest finger temperatures during the 30 min of cooling (a mean of 9.2°C, compared to 7.7°C for north Chinese and 6.8°C for south Chinese).
2. Indian men rewarmed their fingers more rapidly when cooling ceased. In fact, they showed a small rise of temperature after the rapid fall that followed the initial exposure to the cold water. This cooling resistance pattern is typical of such peoples as Inuit (Eskimo), but was not seen in the Chinese. The Indians also showed a more uniform level of response.
3. If one is not highly cold-acclimatized, 30 min of hand chilling in 5°C water is a painful and trying experience. Whereas So's Chinese subjects clearly experienced this distress, the Weagamow Algonkians just as clearly did not.

4. Finally, on strong, if indirect, evidence we argued that white genetic admixture reduces the level of positive cold responses among Indian populations (Hurlich and Steegmann, 1979).

Responses to standardized hand cooling tests, then, suggest that cold-acclimatized Algonkians do maintain higher finger temperatures than those reached by unacclimatized Asians. Reviews of cold response experiments (Steegmann, 1975; So, 1980; Frisancho, 1981) are consistent with that outcome. There is no question that as finger temperature falls, tasks requiring manual dexterity become increasingly difficult. Consequently, Algonkians have a special advantage while working in low temperature. It is not a dramatic differential, but it may be assumed to be a dimension of and contribution to cold adaptation.

Advantageous hand-warming operates only under a narrow range of behaviorally buffered conditions. Steegmann (1977) collected data on Algonkian men working outdoors at low temperatures. When the men were exercising at a steady pace and employing their customary winter clothing and diet, hand temperatures could be maintained at functionally warm levels. When exercise stopped or when they were handling cold materials, some of the men could not maintain finger temperatures above 65°F (18°C), the approximate level at which dexterity loss begins. The other workers kept their hands warm under these conditions. However, when mittens were removed (either at the investigator's request or as part of their task) and in the absence of steady exercise, finger temperatures fell rapidly, of course. However, the critical observation is that much of the sample variation disappeared; at this level of cold exposure (and without behavioral buffers) everyone suffered cooling and loss of dexterity in the hands.

There is a body of evidence which clearly demonstrates that populations native to cold climates have greater weight and relatively shorter arms and legs than those that are ancient residents of warmer zones (Steegmann, 1975; Roberts, 1978). There is less evidence to show that weight and a more robust physique confer thermal advantages, but current experimental and observational data point in that direction (Steegmann, 1975; Frisancho, 1981). When anthropometric data on Algonkians (Hurlich and Steegmann, 1979) are plotted on Roberts' worldwide mean annual temperature/anthropometric regressions, the data fit into the range of cold country populations. Male Algonkian weight (67.0–70.3 kg) is on the world regression line, but is a little greater than we would expect for native American groups. Since most of Roberts' data derive from past surveys, it may be that some of this weight advantage results from recent secular trends in Algonkian growth. Relative sitting height (which gauges what percent of total stature is contributed by head and trunk) is lower in our Algonkian samples (52.0–53.4%) than world or continental standards would predict. Indian men in northern Ontario are fairly big and heavy, but unlike their Inuit neighbors, do not show the northern long-body/short-extremity pattern. To the extent that weight alone confers thermal advantages, then, the Algonkians have that adaptive edge. In fact, it may be considerable in the prevention of hypothermia. Adipose tissue, especially that beneath the skin, is effective in conserving core body heat (Buskirk *et al.*, 1963; Buskirk, 1966) and is of course a component of body weight. The sample of men measured by Hurlich and Steegmann (1979) averaged triceps skinfolds of 6.8 and 6.6 mm and subscapular values of 12.2 and 10.1 mm for two populations. The trunk has more subcutaneous fat than would be expected in groups native to cold (Elsner, 1963) and could be a special advantage for core temperature maintenance. Short legs are not typical, however, perhaps because of the selective disadvantage suffered by a short-legged snowshoer.

Algonkian men have the mass, proportions, and peripheral heat circulation capacity of a reasonably well cold-adapted forest people. Since *Homo sapiens* has remained a unified genetic species which evolved out of tropical roots, there is a limit on how far biological cold adaptation can be taken. No cold-exposed human population has been sufficiently isolated to alter the unity of our species, nor, in our opinion, is biological or physiological divergence really necessary in order for successful cold adaptation to occur. Those who forge an existence in difficult and demanding climates learn their physical capacities and limits, and they come to understand how to work closely with their strengths and weaknesses. The most significant strategies for cold adaptation, then, are composed largely of behavioral rules played out on a robust but narrow band of human biology. The details of these strategies are the real business of the analysis which follows.

10.3. Algonkian Cold Adaptation: Behavioral Factors

The basis for the following observations is our own ethnographic field work, supplemented as indicated by historical records. In this summary we describe mainly normative behaviors, and emphasize those we feel are most contributory to adaptation under subarctic cold-weather conditions. It should be pointed out that individuals vary considerably in their levels of behavioral competence when confronting the subarctic cold. Our observations were made mainly with individuals who continued to brave the rigors of bush life through hunting, trapping, and travel. This is naturalistic research in the sense that the investigators themselves did nothing to bring about the events we recorded. Further, we had no *a priori* definition of what constitutes units of behavior. This research is aimed at discovery through observation.

Unlike the setting of many contemporary societies, neither the forest nor the climate has changed substantially over the last 300 years. Those dimensions of life in northern Algonkian bush communities are something of a constant. Also constant is the fact that a substantial exposure to cold, winter and summer, cannot be avoided by forest natives. Water must be drawn from lake or river, part of the year through holes chopped in the ice. This task is almost universally done by children, and they often see that stove wood is chopped as well. Since wood furnishes domestic heat, men must spend a great deal of time cutting and hauling trees. While in the past most tree-cutting was done in the late fall for the entire winter, with the introduction of the snowmobile, it has now become a year-round activity. Populations in most communities we have studied or visited are sedentary and growing in size, burning expanding amounts of wood, and as a result the outdoor exposure which is part of the woodsman's life increases yearly. Today one can live on imported foods from the Hudson's Bay Company store and from other traders. But fresh game and fish are important supplementary foods, gathered both because of their nutritional quality and for reasons of tradition. Anyone who has had fresh whitefish or trout introduced into a steady diet of oatmeal and canned lunchmeat will support that view. Moose, caribou, fish, and geese come into the larder only at the expense of foraging, and foraging activities involve extended exposure, as shown by Marano (Chapter 8, this volume) and Winterhalder (Chapter 6, this volume). Our position, then, is that behavioral cold adaptation is a living art practiced by most members of remote northern Algonkian communities, simply because no alternative exists.

An important research issue, however, concerns the extent to which behavioral adaptations are predictable from a knowledge of the detailed characteristics of the environment. What aspects of the environment elicit which behaviors? What are the situational constraints imposed by the environment? Here, we will consider just the problem of cold, since our initial assumption was that cold in fact represents a stress requiring adaptive responses. Most simply, the basic strategy which a large nonhibernating homeotherm is able to adopt in a cold climate is to alternate between decreasing heat loss rates and increasing heat production rates (Folk, 1974). Additional complexity occurs when heat production reaches levels which require heat loss rates to increase; but, in a cold environment, increased heat loss mechanisms must be fine-tuned so as not to lead to hypothermia. Decrease of heat loss is accomplished by use of clothing, shelter, and fire, while heat production is raised by exercise and through ingestion of food. As noted, some morphological traits, such as the distribution of adipose tissue and the relative size and shape of various segments of the body, assist these processes. What we describe here is the unique collection of behavioral traits we observed in Ojibwa and Cree communities which serve to maintain homeothermy. One main conclusion is that while the broad outline of the behavioral response patterns were and are predictable from knowledge of environmental conditions, the actual details of the specific behaviors are not.

10.3.1. Situations Producing Cold Exposure

Working at Ft. Severn, Hurlich conducted extensive interviews with men, women, and children about the situations they normally experienced which caused them to feel cold. We may think that exotic events, such as might occur while traveling through the bush, are cold stressful. But even village life with well-heated houses can expose individuals to episodes of cold sufficient to produce

seasonal acclimatization and influence developmental processes which confer an extra margin of cold-adaptive physiology for adults.

A total of 32 children between 6 and 12 years of age in Ft. Severn were asked about what they were doing when their hands, face, and/or feet felt the coldest. Some reported that their hands and feet may sometimes feel cold, but their faces never do. For others, their hands never feel cold, just their faces and feet. Most children said their coldest periods occurred when they played outside (playing in the water in fall or spring; playing in the snow in winter; playing outside when it snows and is windy). Most of their self-reported cases of actual frostbite occurred while riding on a snowmobile sled in the winter, or when doing a chore in winter, such as hauling water from the river. None of the children said they had ever suffered frostbite when in the bush, traveling with their families to and from trapping camps or between villages. This suggests—a suggestion which was confirmed by adults—that while away from the village, adults take greater precautions against the effects of cold exposure on their children.

A dozen women and 15 men were interviewed about their experiences of cold exposure. The most striking thing about their comments is the considerable interindividual variability in reporting which activities were associated with feelings of being cold. Stories about the past were less variable, because few people in Ft. Severn were old enough to recall more traditional practices. In the past, family units would go into the bush for the entire trapping season, with children and, for most of the time, women riding on the dogsled. Men jumped on and off as the trail demanded. Women were responsible for seeing to it that children were warmly dressed and securely attached to the sled, and that they did not get too cold before a halt was called, usually to make a fire and tea. While this does not demonstrate cold stress, it does indicate the women's responsibility in preventing it for children.

For every current activity mentioned, some women reported experiencing cold and some did not. These included cleaning fish, washing clothes, preparing moose or caribou hides, preparing skins of fur-bearing animals, chopping wood, and gathering moss for use as a baby's diaper insulator/absorber.

Comparable variability was apparent in the comments men made, except that some tasks were uniformly described as cold stressful. For example, all men mentioned some activity involving the snowmobile as producing frostbite or numbing cold stress: replacing spark plugs in the bush, driving at night, driving along the coast, driving across open muskegs, and removing ice and slush from boogie wheels (the inner sets of wheels which support the snowmobile's track) during early winter wet-snow conditions. Further, men reported more parts of their bodies feeling cold when driving snowmobiles under certain conditions than were ever reported for activities associated with hunting and trapping. Consequently, snowmobile driving is likely to be associated with whole-body chilling of a kind probably rare under pre-snowmobile conditions. Several men commented that they never "freeze" when they walk, but when they ride a snowmobile they "freeze" easily. Others reported frostbite occurring on their ears, for example, when having to walk into a cold wind. Trapping activities associated with placement of traps and snares under the ice in winter, including removal of animals trapped under the ice, were mentioned frequently as cold stressful. In all communities, we observed that winter net fishing, which required exposure of bare hands to cold water and air for sustained periods, caused severe hand chilling. Steegmann recorded finger skin temperatures of 38°F (3.3°C) from an experienced fisherman following the completion of one such round of activity. Men mentioned their hands more than any other part of their body as becoming cold. If each body part named as cold during various activities is counted as one, then over half the total references to cold stress involved cooling of the hands. This, incidentally, suggests that concentrating our physiological studies of cold stress on individual's hands was appropriate.

Table 1 summarizes this material subdivided by activities, age, and sex, but includes only situations which were claimed by informants to produce real or potential cold stress. This listing does not include all cold stressful events. Note that almost all of the activities mentioned by men relate to what is almost exclusively men's work, namely hunting, trapping, and dealings with snowmobiles. Presumably, it is alright for a man to get cold and admit to getting cold when engaging in these activities; after all, everyone knows that the temperature is low and men must do these things. Nonetheless, it was common to see men and, even more, women shiver as they stood on a cold winter's day by the side of the landing strip to watch the DC-3 land. The point is that while people's comments about cold stress show them to be observant about the cold, the activities they mention do not exhaust the full range of cold-exposure incidents. They do, however, indicate some of the situations which we felt could be productively investigated in our studies of cold-adaptive behavior.

10.3.2. Clothing and the Personal Environment

We tend to think of cold defense on the most obvious level first—protection of hands, feet, faces, and the entire body. For those who spend hours per day at subzero temperatures, no area of adaptive mastery could be more critical. Wherever clothing opens or insulation is compressed, heat is drawn off, and sometimes enough is lost to cause impaired function or tissue damage. Even a second-degree frostbite may become a liability if a wrist, for instance, is affected; continuous flexion retards healing. Older informants told us that in the past strips of rabbit fur were wrapped around vulnerable sites, and fox skins served to protect larger areas such as the neck. Today, cloth scarves have assumed some of those functions, and are used to protect the lower face when temperatures are most dangerous (even if they ice up from breath frost). In earlier days, whole face masks were used during the bitterest cold. Blowing snow and ice crystals cannot reach the face or get into mitten tops as easily, due to the fur ruffs sewn

TABLE 1. Activities Producing Real or Potential Cold Stress, by Age, Sex, and Season: Fort Severn, Ontario[a]

Season and activity	Children	Women	Men
Fall/spring			
Canoe riding			×
Cleaning fish		×	
Getting hands wet, playing	×		
Getting feet wet, playing	×		
Early Winter			
Tending fish net under ice			×
Cleaning fish		×	
Riding on sled pulled by			
Snowmobile	×	×	
Dog team	×	×	
Playing outside	×		
Winter			
Trapping: setting snares and traps under ice			×
Snowmobile maintenance			×
Snowmobile driving			×
Walking during hunt			×
Riding on sled	×	×	
Cutting firewood	×	×	
Going to and from school	×		
Playing outside	×		
Going to landing strip	×		

[a]Information in this table is from interviews, 1973–74.

around the margins of openings. In fact, mittens, of soft, heavy, home-tanned moosehide, are beautifully engineered for the job; they are lined (now with wool duffle cloth, but earlier with rabbit fur) and have a gauntlet which overlaps the coat sleeve halfway up the forearm. Since losing one's mitts has obvious consequences, they are commonly tied together by a cord secured outside the parka at collar back and shoulder front. When bare-handed work must be done, the mitts are simply shaken off with a rearward motion which swings them around the body, crossing cords in the rear. There they remain, out of the way and safe until needed. Euro-Canadian gloves are now popular for some types of manual work, but more for "new" tasks than for traditional hunting and trapping. As noted by Marano (Chapter 8, this volume), whole rabbit skins sometimes serve a rather specialized local insulation role also. Stuffed down the trousers around the groin, they can be used to rapidly rewarm chilled hands, and incidentally, add extra insulation in an area which loses a great amount of heat if unprotected. Inuit cold-weather clothes employ an extra pair of fur shorts for the same purposes. It has long been recognized that an uninsulated head contributes a high percentage of the body's total heat loss (Froese and Burton, 1957; Edwards and Burton, 1960). Hats are consequently universal among cold-climate peoples. Styles come and go, but current fashion in northern Ontario dictates visored caps (usually with ear flaps), some other designs such as "toques" (knitted caps), and an assortment of patterns imported from the south. In contrast to clothing that protects hands and feet, no headwear of aboriginal design and manufacture is still in use.

Because they lie so far from the body's reservoir of core heat, are immersed in a surface layer of supercool air, and repeatedly contact cold surfaces, the feet are probably the part of our anatomy most difficult to defend against cold's assault. The northern Algonkian solution is the winter moccasin, which is in reality a soft, moosehide "pack" functioning mostly to stabilize a heavy layer of insulation evenly and without constriction over the foot and lower leg. Though a moccasin body rises only to ankle level, it is extended upward several inches by an added open-fronted top piece which wraps around, overlapping right and left, and is lashed in place. The design is simple to adjust to variable amounts of insulation and trouser leg, but can also be put on or off rapidly, dries easily, and is very light in weight. Today, wool stockings and wool duffle cloth liners are used instead of rabbit skins, but the insulation design principle is constant. Moccasins are still worn for general use, and especially in winter travel where long distances are to be covered. Because of the constantly low temperatures, waterproofing is not needed. We were told (and in fact discovered for ourselves) that moccasins are easier to use with native snowshoes and bindings, and with their flexibility and lightness, tire the legs less than Euro-Canadian boots. When working around sharp tools, heavy equipment, or other ground hazards, however, heavier rubber-soled boots obtained from the store are favored for protection (despite the loss of some insulative advantage). In addition, when the ground is wet, moccasins sponge up water. In earlier times, one-piece rabbit skin stocking (two pairs) gave some insulation on the "wet-suit" principle, even when the feet were soaked, and an outer shell moosehide "boot" seems to have been used as well. However, most older informants concede that there were times when the feet simply got wet. Foot protection problems had a yearly cycle like everything else in forest life. Deep winter temperatures are so low that the snow is dry and so moccasins do not become wet (except in the case of accidents on insufficiently frozen lakes or streams). During the rest of the year much of the surface is wet. Although most travel is by canoe when the ice is out, a certain amount of foot-sloshing is unavoidable. For that reason, imported waterproof boot packs have become very popular when it is too wet for moccasins.

Our last area of commentary on personal clothing looks at conserving core body heat—keeping the trunk warm. Ethnohistoric data cited in Chapter 7 were reaffirmed repeatedly by our own observations. Traditional and contemporary northern Algonkians depend on the principle of layering; several lighter garments (which trap air between them) covered by a windproof shell provide an optimum insulation package, and incidentally provide layers one can strip off rapidly in case of a fall into cold water. Since earlier clothing often used sleeves and leggings which were tied onto the trunk covering (and because neither were cut to a snug fit) the principle of nonrestrictive clothing was used as well. One can become exhausted just trying to move in heavy clothing, no matter what its warmth, and this is a clothing design feature of first order importance. Now nearly everyone wears the parka over layers of full-length underwear, wool shirts, sweaters, and whatever else is available. This applies to adult men and women alike. However, people do not look like stuffed Teddy Bears; our impression, partly from observing outdoor wear being removed for anthropometrics, was fairly clear: the natives were inclined to wear less insulation than we were.

We have concluded that the way in which outer clothing is worn by northern Indians is in itself a major behavioral cold adaptation. Our own cultural wisdom and that of other groups such as the Inuit recommend that clothing be adjusted for ventilation so that overheating and the sweating it brings are avoided. (sweat lowers the insulative value of clothing). This practice may have been developed because one is inclined to travel from shelter to shelter and to avoid stopping on the way. Likewise, the Inuit have no fire for trail-drying of sweaty clothes, though they do sometimes strip, reverse their parkas, and knock off the instantly frozen sweat. Despite the conventional wisdom, Inuit groups such as the Copper Inuit have been described as perspiring freely from the labor of their winter migration (Jenness, 1922). However, recent physiological work suggests that Inuit differ from Caucasians in the number and responsiveness of sweat glands, with Inuit showing more actively functioning sweat glands in the face and significantly fewer on the body surfaces, which are normally covered by fur in the winter (Itoh, 1980; Schaefer *et al.*, 1976). This may be a true biological adaptation.

We noticed that northern Indians rarely adjust their clothing, keeping parka hoods up, hats on, and everything buttoned up tight. Marano's insightful explanation (Chapter 8, this volume) suggests that this is a deliberate tactic used to increase the body's core heat load as a buffer against hypothermia during periods of inactivity. Even when outdoor work is strenuous and the temperature is low, as when, for example, hunters walked through a depth of 35 cm of newly fallen snow in temperatures hovering about −40°C, Hurlich noticed that the only clothing ever manipulated by whomever broke trail was the parka hood (up or down) and one mitten (on or off). This practice works because these forest people have constant access to fire wood, and in fact will stop to build a fire on the slightest pretext. Once a fire is started, no matter how low the temperature, it is used to dry out sweaty or dampened clothes, if necessary, and to maintain body heat. Preparation of the ever-present cup of tea at this juncture, as Marano has noted, also allows for rehydration. Respiratory water loss in this very dry cold is a problem. There also appears to be a pacing of most heavy physical work in such a way as to avoid excessive sweating whenever possible.

Some exceptions to this general "hyperthermia" pattern were observed. The first was when very heavy work was being done within reach of shelter.

An example is chipping ice on the lake with a heavy iron bar. Even in these cases, the parka was removed for only short periods, and it was not clear whether the removal was for thermal reasons or in order to work with less clothing restriction. A second and very common exception is seen during the final stages of a moose hunt. The men throw off their parkas, which simply drop onto the snow, and step out rapidly after the moving quarry. Moose have excellent hearing and hunters claim the rustle of the coat surface against other surfaces is easily audible; snowshoe webbing is often padded where it crosses wood spars, for the same reason. This, too, is normally a short episode; one either gets one's moose or does not, and returns directly to one's coat. But in one case at Weagamow, discussed by Marano (Chapter 8, this volume), the moose led its hunter farther and farther, with the result of his deepening hypothermia, failure to find his coat, and final escape from death by sheer chance. The following variations may be a product of recent culture change. Younger people will sometimes take off or open coats in very cold weather, not following "the rules," or they may dress fashionably rather than warmly. Perhaps the problem here is the increasing erosion of ancient bush skills as young people become increasingly enmeshed in Canadian schooling and the distractions of the outside world.

In sum, the characteristics and use of clothing for cold protection is one of our clearest examples of cold adaptation. It involves recognition of principles such as layering and deliberate production of core heat loads. Exposed hands are put quickly back into mittens, which are themselves designed for optimum insulation. They are tethered to avoid loss and to keep them just out of the way when off. Deficiencies in materials, and such body features as a linear build and physiological mechanisms relating to sweating, dehydration, and fatigue are balanced beautifully by behavioral compensation. Fire is a constant companion and is used with clothing in cold adaptation; its importance is probably more acute here than in any other anthropological setting.

10.3.3. Nutrition

In the past, late winter/early spring was usually a hungry, trying period. Such suffering is clearly remembered by older people and was only relieved by the appearance of commercial stores well stocked with preserved foods, as noted by Rogers (Chapter 4, this volume). One older man expressed the opinion that people were stronger in earlier times because they ate more meat and fish. As noted in Chapter 7, physiological response to cold depends heavily upon the amount of caloric energy available to burn. Though animal protein is necessary for the repair and maintenance of our tissues and carries fairly high energy, it also requires time and energy for digestion. In fact, a great deal of fish and meat was consumed in earlier centuries simply because that was what was available. We observed what men ate while working outdoors at low temperatures: generally it was not animal protein. In fact, it looked pretty much like what any of us would pack into a lunch box—preserved meats, bread, some dried or fresh fruits,

and concentrated carbohydrates in the form of "bannock," cookies, and candy. The point is that there was a good deal of readily usable energy in these "trail" diets. It was consumed along with large quantities of hot tea or other liquids.

A "calorie/rehydration" pattern, however, is what stands out foremost in our observations concerning cold adaptation. We have noted before the readiness with which Algonkian winter travelers or workers will stop to build a fire—an opportunity to warm the body, dry clothing and equipment, take shelter from wind, replace body moisture lost during respiration of the extremely dry air, and maintain a proper metabolic rate. Åstrand and Rodahl (1970) note that respiratory water loss varies with ventilation and air dryness, that proper rehydration must be learned, and that the whole problem is intensified by the use of dried rations (typically used by winter travelers). Physical work capacity declines during dehydration, and it produces a range of physiological ills. Consequently, we feel that these Algonkian trail customs form a very specific adaptation; both hypothermia and dehydration are avoided. The simplest version involves stopping for "tea." Although brewed tea has some modest thermal gains to offer, it is more important as a source of water intake. It is seldom drunk without being loaded with sugar, canned milk, butter, lard, or oatmeal. The fats, though not as rapidly used as sugars, are highly caloric and break down more readily than do proteins. A secondary issue, but not a trivial one, is that water in the winterscape is frozen, and trying to extract it from snow or ice without fire is not only slow and unpleasant, but also saps body heat reserves. Before Europeans arrived, we suspect that calorie/rehydration demands were met by brewing native herbal teas in bark containers; pemmican (pulverized dried meat, mixed with fat and sometimes with berries) was probably the main source of energy.

10.3.4. Individual Behavioral Adaptations

Proper use of protective clothing, as outlined previously, is certainly the core of individual cold adaptation. In addition, other behavioral features were observed which we interpret as being specific to cold responses. Many of these integrate closely with camping details covered in the next subsection.

The pace of outdoor work is carefully balanced. It appears to be somewhat more rapid than that of Americans in similar settings. Work with the whole body (such as wood cutting or snowshoeing) may be kept at a pace that is fast enough to maintain a high working metabolism for heat, but just below levels that induce profuse sweating and excessive fatigue. Finding that level (which will show individual variation) surely takes considerable experience and its maintenance requires constant attention. Such attention would erode with the failing judgment that accompanies hypothermia; consequently, countermeasures such as the calorie/rehydration pattern are needed to maintain an optimum balance. Exercise is the easiest way to regulate body heat, but can be sustained for only certain periods, as Marano demonstrates (Chapter 8, this volume). Like many of our hypotheses, this could be tested by simultaneous observations of thermal responses and natural levels of work effort relative to an individual's maximal work capacity. Indirect calorimetry would be needed.

Manual tasks (such as setting traps or clearing fish from nets) are not normally accompanied by general bodily exercise. We were all struck by the rapidity with which bare-handed work was done in the cold, sometimes interrupted by periods of hand-rewarming. It became something of a little in-group joke, in fact, that such tasks were done so fast that we could not separate the sequence of steps. The point, confirmed in cooling experiments (Steegmann, 1977), is that bare fingers cool very fast. Any practice that reduces exposure time is valuable. Rapid rewarming requires high body core temperature and highly vascularized extremities, for which Hurlich and Steegmann (1979) found some evidence. The core heat reservoir used in rewarming is maintained by exercise–clothing combinations (Keatinge, 1957; Wyndham and Wilson-Dickson, 1951). Other practices include use of sticks in lieu of hands where possible, and use of the teeth as a "third hand" to speed up manual tasks. For instance, when fish are stuck in gill nets, older men will sometimes grip the fish snout with their incisors, and rapidly work the tangled fish out of the net with both hands. Most of the men in our sample of experimental subjects retained enough of their anterior dentition to use their teeth in that way if they choose. We asked most of them how they warmed their hands when they did get too cold. The general response was simply to put their mitts back on, though we expected something a little more exotic. For that reason we were also cautioned more than once not to wet our mittens or moccasins. One distinctive variation came out of Marano's field work, however; when working near water (trapping or fishing), dangerously cooled hands were sometimes dipped in water (water at least has the virtue of being above the freezing point of flesh), but this, too, is a behavioral adaptation that works only in tandem with good peripheral heat circulation.

Though there are doubtless individual or idiosyncratic "tricks" to enhance cold survival (and these could be extremely critical in differential survival), these will not always be easy to observe or to separate from general social practice. The following practices were seen or described more than once, and seem to have sufficient importance to be included here. When a northern Algonkian is working in the cold, he or she does not sit on anything that is not insulated—especially the ground—because heat drains rapidly out of the body core if one does. The normal outdoor resting posture is to "sit on your heels," relaxed, but minimally in contact with the surface. Extremely low temperatures, which occasionally hover around −40 to −50°C, may require special coping measures. Of those, simple avoidance is the easiest. Hurlich noticed that hunters and trappers avoid the coldest pockets when traveling or camping. Most men said that daytime temperatures seldom were so low as to keep them inside, but severely cold nights were another matter. Women and especially children spend less time outside than do men and due to the nature of their activities are probably able to voluntarily limit exposure on the most taxing cold days. Men, however, must

sometimes go after fire wood or carry out other essential duties during low temperature periods. Other tasks may be self-limited in severe cold; game animals do not move much when temperatures hit the bottom, impeding the ability of a forager to locate them, and ice may be frozen to depths so great that chipping through to set nets or traps is more work than returns justify.

Another form of avoidance, and an obvious one, centers on cold water. Falling through ice produces a deadly combination of initial exposure to numbing water and, if one survives that, of loss of the insulative value of clothing due to wetting. Jack London's short story, "To Build a Fire," carries a chilling reality to those who have faced this prospect. Drowning and water hypothermia dangers are taken very seriously—they are major causes of accidental death (see Chapters 6–8). Although most areas of lakes freeze over safely, wherever water currents run beneath the ice, there may be danger. Winterhalder (Chapter 5, this volume) reports his guide tapping the ice on a stream with his axe handle to sound its thickness. The danger is also diffused somewhat by weight-distributing characteristics of snowshoes and snowmobiles, but vigilance must be constant. These observed actions are doubtless only a small sample of a much larger body of cold-buffering behavior.

10.3.5. Camping and Shelter

The nature of a winter camp depends on its permanency and the tasks to be performed there. Permanent trapping camps removed from the village are today often substantial log cabins with stoves. These may differ little from their village counterparts. They offer excellent shelter. In the recent past, the standard winter field dwelling was a wedge-shaped or conical tepee with walls composed of vertically laid sticks chinked against the cold and wind with moss. Snow was banked around the lower perimeter for insulation. From all reports, the central fire kept this shelter very warm; problems arose only from smoke which accumulated during windy periods. The disadvantages, however, were mainly related to the large amounts of time and energy required to build the moss lodge, and not to its utility. It has been replaced by permanent cabins or wall tents using small "air-tight" wood stoves. Cabin walls are still banked with snow, and may be insulated inside with sheets of paste board from boxes or chinked on the outside with moss or fiberglass insulation. At Ft. Severn, Hurlich noticed that a few cabins both in the village and at trapping camps were completely covered outside with thick clear plastic, no doubt a recent practice.

When a group is working, for instance, on a clearing or building project, a fire is often built up to fairly large proportions and is often sheltered behind brush, banked snow, or in a sort of excavated barrow pit floored by spruce boughs. Heat from the fire is great enough to warm the surrounding area quite well, and workers can enter these cocoons of heat to rest, dry off, eat, and talk. Both in these instances and with more permanent camps, shelter is always arranged to avoid wind if possible.

If one or two people are traveling and stop for a tea break, arrangements are simple, but use of natural windbreaks and spruce bough carpets are constants, even when the fire is rather small; fires are not built directly beneath trees, so as to avoid snow drop. Tents, of course, are normally employed for trail sleeping. However, on occasion (especially when moose or caribou hunting) people are caught out unprepared for an overnight camp and must get through the night. As Marano notes (Chapter 8, this volume), the hunter can survive by skinning the moose and using the fresh hide as a makeshift sleeping robe. Using the principles of insulation by evergreen foliage and snow, as well as finding a spot sheltered from the wind, one can apparently sleep well enough "in a snow bank" to use shelter this way for some time if necessary.

The principles of insulation and wind protection, supplemented by heat from fire, are pretty much commonsense. With the possible exception of the moosehide-robe technique, they were what we had expected, and what peole in our culture and others have done from Pleistocene times forward. Frisancho (1981) describes sleeping adaptations used by several aboriginal groups, and many patterns contain these same elements. They point up the importance of being able to recoup strength with undisturbed sleep. This is especially important under stressful conditions, as any winter camper can attest.

10.3.6. Children and Cold

Children are hard to manage as a rule, and seem to be extremely resourceful in finding dangerous things to do. Consequently, we are treating child care under cold conditions as a special problem.

Little and Hochner (1973) review infantile cold adaptation in some detail, and conclude that human infants are born with a low degree of cold resistance. Being fairly vulnerable to cold, they require unusual care. There is also indirect evidence that they may enjoy some special defenses, such as pads of brown adipose tissue—an important biological adaptation (Aherne and Hull, 1966; Dawkins and Scopes, 1965; Barnard, 1976). Brown fat is specialized to produce great amounts of heat, by chemical thermogenesis, and is nested in a circulatory net which transfers heat rapidly to organs of the body core.

Though northern Algonkians are no longer nomadic, they retain some of the technical and psychological paraphernalia of former times. Babies get their own well-insulated sleeping bags. Cabins or tents cannot be kept safely warm throughout most winter nights, and so the infant's microenvironment is maintained separately. While babies sleep close to the parents, there is a considerable danger that they will be smothered if they are actually in the same bed; it happens often enough that people are aware of the danger. A solution is to put the infant's bedding on a raised platform (as noted in Chapter 8) or in a hammock constructed of rope and overlapping wool blankets.

In order to assess the immediate winter thermal conditions in which native children sleep, Steegmann ran a series of tests during late January and early February at Weagamow. This was the period of coldest weather. In each of ten households, 24-hr ambient thermal records were collected (PTC Recording Thermometer Model 615F). The recorders were placed close to the children's beds, at between 3 and 5 ft (92–152 cm) above the floor. Thermal layering in cold-climate houses is great, but these sites were in all cases fairly close to the youngest child's sleeping place, and if they err, give slightly higher temperatures than the true ones. Results are illustrated in Fig. 1. For every hour, a dot represents the mean, and vertical lines above and below the dot show a single standard deviation. Lines connecting the limits of standard deviations convey an impression of the limits within which most temperatures remain. The highest mean at 8 p.m. was 73.0 ± 4.22°F (22.8 ± 2.34°C), and the 6 a.m. low was 35.0 ± 8.79°F (1.7 ± 4.88°C). The 7 a.m. and 8 a.m. variation was high because some people rise earlier than others to start their fires. The lowest temperature recorded was 10°F (−12.2°C) at 8 a.m. It is very clear than an infant or young child without special thermal protection would be endangered under these conditions in every household.

During the day, infants are a common sight around villages in northern Ontario in all but the very coldest periods. After swaddling in blankets (once rabbit fur, now wool), they are laced into a *tikinagan* (cradle board). Only their eyes and nose peer out from beneath the many layers. We were told that this system works quite adequately. It brings to mind words from the old nursery rhyme, "Bye baby bunting, daddy's gone ahunting, to get a little rabbit skin to put his baby bunting in." It may be that Europeans of the past found soft, warm hare fur to be as good an insulator as did native Americans. As its own multi-layered support system, the cradle board has another major thermal defense function. Summer travel is mostly by canoe, but northern waters are usually so cold that one can live no more than a few minutes after a canoe goes over or after ice breaks under one. A cradle board, however, will float and may save an infant's life with its buoyancy and warmth; although no recent case of this was reported, it appeared in historical accounts (Chapter 7).

In the worst weather, children are defended from cold by being kept inside, but under most conditions, children are seen spending time in the open, either doing their endless chores or playing with friends. Younger children always appeared to have been warmly dressed and, of course, were watched carefully. The only old-fashioned, heavy moosehide coat Steegmann saw at Weagamow was worn by a child about 4 or 5 years old, and Hurlich saw none used at Ft. Severn. When asked about the clothing children wore in the past, all informants noted, somewhat wistfully, how warm rabbit-fur clothing was and that all children were dressed that way until fairly recently. However, we noticed that older children, starting at perhaps 8 years, often seemed to go outside without adequate protection. They seem most susceptible to southern fashions—leather cowboy boots, tight denim jeans, and short jackets—none of which were designed for the northern climate. This was especially true during cold, wet summer days which are in some ways more dangerous than the deepest of the winter. In the

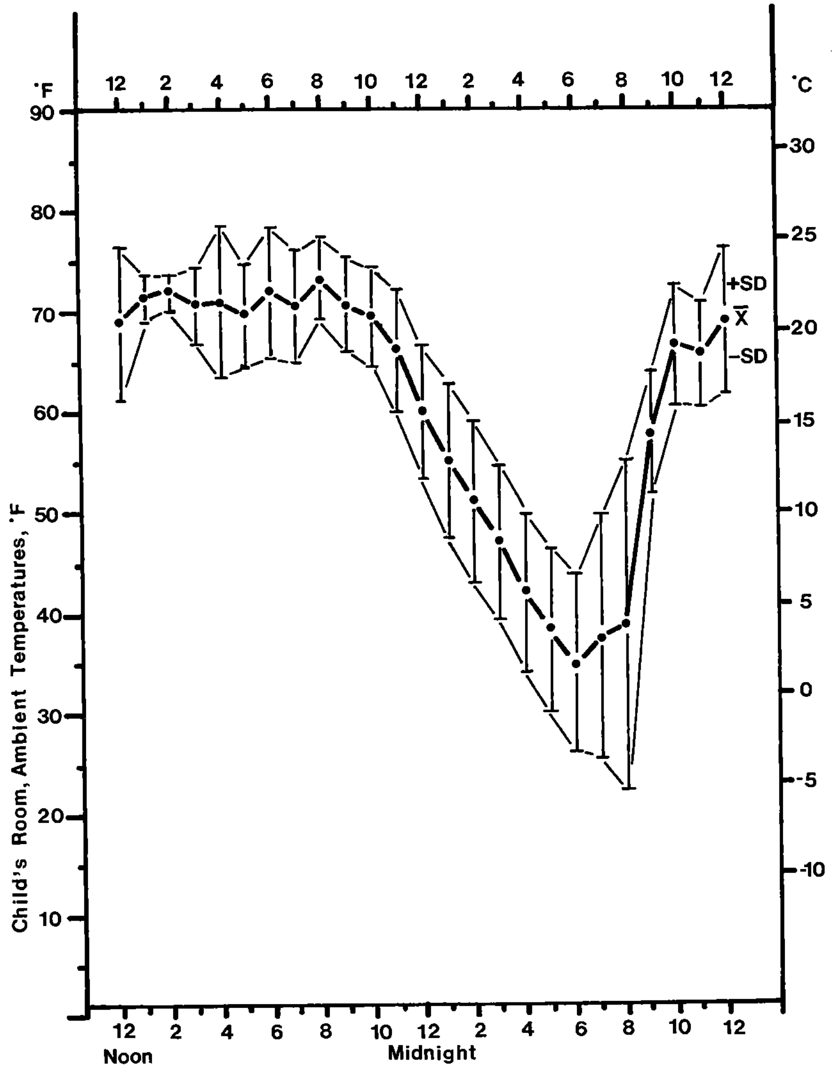

FIGURE 1. Ambient temperatures were recorded for one 24-hr period in each of 10 households in Weagamow, Ontario. Records were made during the coldest period of the winter of 1974, the recording thermometers being stationed near the sleeping places of the youngest children. Dots are means and vertical bars equal single standard deviations.

absence of thermal testing (and since those children were better acclimatized than we), we cannot prove, but did suspect, that children sometimes get fairly severe cold exposure, as Table 1 suggests. In recognition of special problems protecting children in winter, an adult in at least one village was employed on the school playground to supervise winter play—not to keep order, but as a sort of insulation and frostbite inspector.

The highest actual morbidity and mortality risk to children from cold, however, is probably for toddlers and younger children, at a time in their lives when they can move fast, but have little sense of what situations are dangerous. Women noted, for instance, that youngsters would occasionally scamper off over the hard crust of late winter snows, which would support children but which are very difficult for an adult to cross. Hurlich documents (Chapter 5, this volume) several cases of children's deaths due to their getting lost in the bush, an ever-present danger heightened by low temperatures. That which is easily avoided by following rules may be a grave danger to those who have not yet learned them.

Marano (Chapter 8, this volume) discovered an example of what appears to be deliberate induction of developmental cold acclimatization in children. A game was played, the object of which was self-application of snow to the child's wrist for as long as is tolerable. Steegmann was told (by a less reliable informant) about children being encouraged to run barefooted in snow. In either case, these games could push vascular developmental patterns in the right direction. Not only could these be seen as a special case of protecting children from subsequent cold damage, but would of course confer lifetime advantages as well.

10.3.7. Cold Injury

We have already noted the scarcity of reports of any but superficial cold injury. Typically, physicians and nurses, after years on northern service, will say that they have seldom seen and never treated a serious cold-induced injury in unimpaired adults. Aside from the obvious explanation—infrequency of such problems—there are other operative elements here. We suggest that cold injuries either lead to hypothermia and death, or are not sufficiently serious as to require medical care. If fatal, they almost inevitably occur when people are alone, and the actual cause of death may be other than cold-induced. At the other extreme, minor cold injury (which is as universal as is sunburn in warmer climates) is simply not seen as a medical problem. In fact, we suspect that people who get frostbitten under routine circumstances are a little embarrassed about it; it shows that they have failed to follow the rules or use common sense. On the other hand, some men did discuss their cases of frostbite, but, as noted earlier, the frostbite was the result of great effort associated with masculine tasks. Perhaps in these groups a man's success can be subtly emphasized by indication of his difficulties. The main preventative, however, is to have one's senses intact. Sad to say, alcohol- and drug-related freezing deaths are an increasing problem (Knox, 1980).

As facial skin starts to freeze (especially that of the nose), one often feels a slight "ping" at the site. The sensation is similar to a mild electric shock. If one is paying attention, the spot can be rapidly rewarmed by hand. Through warnings of this sort, recognition of stiffness and numbness when one voluntarily moves one's facial muscles or when someone else sees white spots forming on the skin, facial frostbite can be systematically avoided. Fingers and toes are better equipped with pain and numbness sensors, and themselves tend to give a person fair warning of impending trouble. If utilizing warm spots on one's body or exercise are not enough to reverse the chill, it may be necessary to build a fire or seek shelter if it is near.

As noted earlier, snowmobile riding has introduced a new wrinkle into problems of cold injury avoidance. The driver is simultaneously exposed to strong headwinds and low exercise levels, and employs a throttle–handlebar grip which constricts finger circulation. We saw numerous healed frostbite scars on the face and neck, and some recent second-degree frostbite lesions. In response to questions about them, the universal culprit was the snowmobile. It not only presents northern peoples with a useful tool which can be injurious, but offers us a precise illustration of how finely this biological–behavioral system is balanced. Second-degree frostbite, despite its newness, like any thermal injury, presents its victim with problems only when it becomes infected.

Hurlich and Steegmann (1979) noted that frostbite in general was less common in the deep forest community of Weagamow than among those who lived on the much more exposed Ft. Severn lowlands. Though none of the frostbite was especially serious, it presents us with a puzzle. Fort Severn not only lacks some of the classic forest defenses, since the area is rather barren, it is also somewhat colder and is windier, and contains a population with a higher admixture of genes of European origin. People there also must depend much more on the surfaces of Hudson Bay and the Severn River for travel, and both are more hazardous than lakes. Their danger, however, runs more to falling out of canoes (and subsequent hypothermia) than to cold alone (Hurlich, Chapter 5, this volume, Tables 8–11). We predict a somewhat higher environmental mortality there as a result.

During our field work, we collected only one (uncorroborated) story of an unimpaired adult freezing to death. Across all northern communities, both Algonkian and Euro-Canadian, a gossip and information network of remarkable richness is in constant operation. It brought reports of drownings, fires and burns, hunting accidents, airplane crashes, and other traumatic events (as well as a great deal which was funny and cheerful). Because of its uncommon and in fact almost unexpected nature, a freezing death is a major news item. It was news we simply did not often hear, and the winter of 1973–1974 was a severe one even by boreal forest standards. The point is that neither cold injury nor low temperature death are significant problems. In the preceding pages, we have

outlined some of the behavioral mechanisms which Algonkians use to work with and support the frailties and strengths of their bodies. Cold is held at bay with remarkable resourcefulness and a deep understanding of the principles of heat exchange. The same is true among the Athapaskans studied by Nelson (1973: 206).

10.3.8. Algonkian Cold Adaptation: Summary

The price of survival in the boreal forest was and is great physical effort and a deep knowledge of the behavioral rules by which success can be achieved. The game will be lost only if one's body is so hypothermic that wise judgments are hard to make or if hands and feet are too cold to obey. Those conditions generally require a mistake not directly related to cold. Section 1 has outlined a few of the routine measures employed by northern Algonkians to facilitate life in a deeply frozen winterscape. A major objective in any treatise on thermal biology is how deep-body (core) temperature is maintained (Folk, 1974). Below that narrow band of temperature at which human metabolism and organ function operate, the very ability of metabolic processes and nervous system required for coping fade. The first objective of our cold adaptation study, then, has been to examine how natives of the northern forest maintain core body temperatures.

Figure 2 sketches our conclusions about what has turned out to be a fairly complex process. Deep-body temperature is both the center and the goal of the entire process, and is maintained by both biological and behavioral supports. Biological factors are in the upper central part of the diagram (between the two dashed lines). A heavy trunk, reasonably well insulated by subcutaneous fat, has more thermal inertia than a lighter equivalent; exercise is judiciously used to fill the heat reservoir. Careful pacing of work–energy expenditure appears to be the key to avoiding insufficient or excessive heat gain, and equipment such as snowshoes makes smoother progression over deep snow possible.

Assuming basic Algonkian capacity to build and conserve heat by metabolic and morphological means, clothing then plays a critical role. In fact, it performs the same two functions. Layered, nonconstrictive clothing is kept closed, often building body heat, or at least retarding its loss when conditions are at their worst. Dry clothes work more efficiently toward these goals than do wet or sweaty ones, and so clothes are dried by fire with some frequency. Thus, the basic biological wherewithall as well as insulation work best in the presence of a trail institution known as "tea." Queen Victoria would have been pleased. The break in routine offers rest, food, heat, a chance to dry clothes, and, perhaps above all, rehydration. A canteen (water bottle), after all, cannot be used at low temperatures. While on the trail and in the village home, the principles of insulation (undisturbed layers of air) are applied to everything in the living space. Core heat will slip away, especially from people who have a high energy/dissipation or "metabolic" adaptive pattern (Hammel, 1964). But it is not wasted. Finally, infants have neither a mature cold physiology nor culturally prescribed

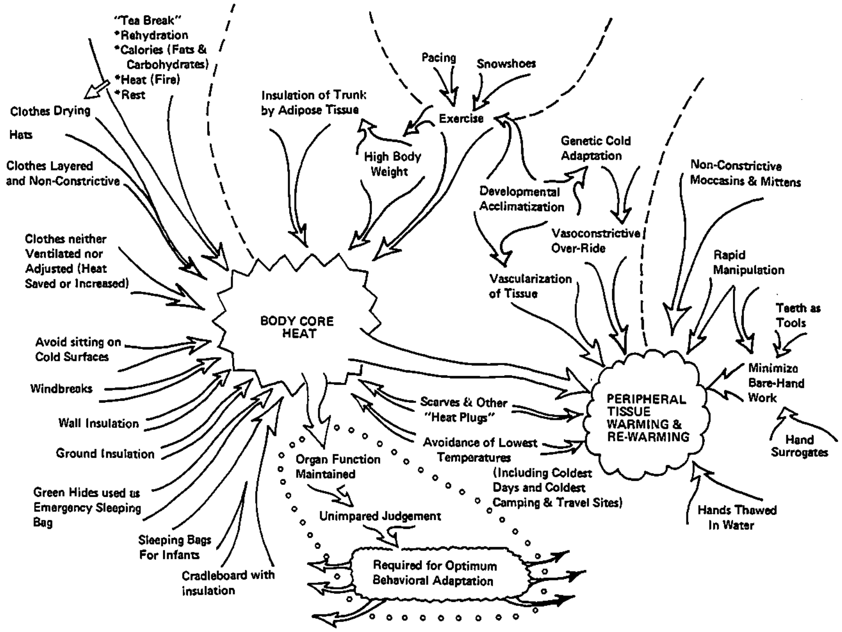

FIGURE 2. Essential elements of Northern Algonkian cold adaptation. Those of a biological origin are within the dashed lines (upper central area) and the remainder are behavioral. The maintenance of deep (core) body heat and of peripheral tissue temperatures are focal results. Arrows show direction of effect or causation.

self-defenses. Their garments, sleeping gear, and behavioral guidance are consequently specially developed and carefully attended to.

Body core heat, maintained with some effort but with general success under most conditions, is "invested" in two ways of relevance to this discussion. Foremost, of course, is that the brain and other organs will not function properly if only a few degrees of core temperature are lost. The entire complex of behavioral adaptations will be executed with uncertainty once higher cerebral function begins to waiver. This is not an all-or-nothing situation, as Marano suggests (Chapter 8, this volume). At least some heat conservation practices are learned in childhood and probably operate without conscious attention. Mistakes may nevertheless weaken or kill someone already faltering from hypothermia. A second use for core body heat is for peripheral rewarming. There must be a ready source of warm blood, which is the main vehicle of heat exchange between the body and its extremities. Lowered core temperature will soon inhibit peripheral rewarming, simply because the body considers hands and feet to be more expendable than are central organs (Folk, 1974). The complex of biology and behavior that keep the hands and feet warm, in other words, will be useless without core-temperature backup.

Developmental acclimatization (those adaptive changes that require "growing up" with a stress) offers several advantages. Genes for an advantageous condition may require lifelong influence of an environmental pressure to be fully functional. Cold-adapted hands and feet, for instance, may have genes for a larger network of blood vessels, but will only produce them if people's hands and feet *are* cold during youth, and the same may be true for factors which override the normal tendency in our species toward vasoconstriction of peripheral blood vessels when chilled. Regular, disciplined exercise, so useful in core heat maintenance, may also benefit from years of acclimatization to the work load.

Starting from an assumed base of good thermal protection by nonconstrictive well-insulated mittens and moccasins, several additional techniques are used to protect the hands. Mostly, they simply involve exposing the hands to stressful cooling for periods absolutely no longer than necessary. The teeth or pieces of wood may be used to hasten a task or buffer its performance from cold. The main principle is speed.

Cold adaptation to the boreal forest environment, in short, contains few elements which were a real surprise. However, the tapestry is woven in a complex, skillful pattern. Though cold appears, superficially, to be something which is almost ignored, it may be ignored with only part of one's mind. In a sense, the strength of this adaptive pattern is what broader adaptative strategies rest upon.

10.4. Adaptation to Boreal Forests: Algonkian Patterns

An advantage to analyzing the boreal forest as a setting for human activities lies in its relative simplicity. Despite the fine-grained complexity discussed in preceding pages, this is an ecosystem which seems to offer its native occupants relatively few options. Because alternatives are limited, patterns may also be somewhat predictable. Here we synthesize conclusions reached during the research which led to this book.

Figure 3 represents directions and interactions of forces applied to and by forest Algonkians. It has descriptive as well as predictive dimensions and consequently should be seen as a model. However, it is certainly a preliminary model and is better at this stage for identifying interactions than for quantifying them. It is also somewhat mechanistically (or naturalistically) oriented, and does not pretend to be a reflection of the entire fabric of northern Algonkian lifeways. We have attempted to determine forest–human interactions and to detect causation of specific activities insofar as is possible. Arrows on the diagram, then, represent consequences. The model should also be able to reflect temporal change. At the expense of further graphic complexity, major cultural and adaptive shifts appear in parallel with traditional patterns. Hatchured barriers (innovation) are sometimes seen to block or modify older pathways. The figure "flows" from upper left, which represents maturation of the original adaptive pattrn, to lower

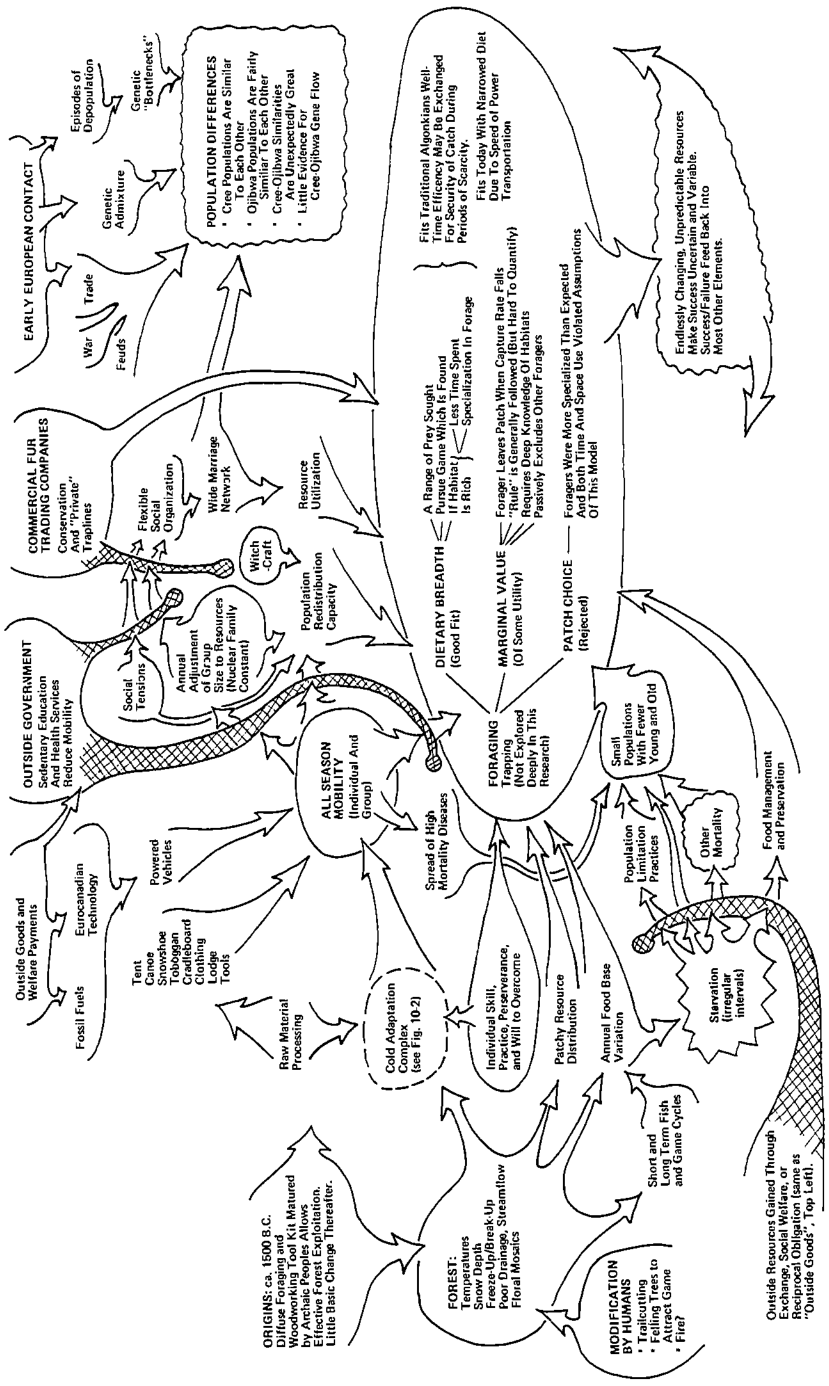

FIGURE 3. Our preliminary understandings of Northern Algonkian adaptations to the boreal forest. Arrows show direction of causation, and hatchured bars represent modification or blockage of aboriginal patterns by historical or recent intrusion.

right. Many points are obviously simplified. For example, both governmental agencies and commercial fur companies have contributed to animal conservation schemes, but only the effects of commercial efforts are represented in Fig. 3 (top right). Foraging patterns, if we are correct, emerge as the crux of forest adaptation, and their successful application, of course, feeds back (by channels not shown but self-evident), fueling the entire process. We begin with mastery of the forest by Archaic foragers.

10.4.1. Origins

Dawson (Chapter 3, this volume) argued that many elements essential to survival in the boreal forests were developed outside its boundaries—very likely in the more temperate deciduous regions to the south. Among the most important was a pattern typical of Archaic cultures generally—diffuse foraging (in contrast to the specialized big-game hunting of earlier times). Resources were no longer so concentrated, and human exploitation had to respond. The northward shift of milder climatic patterns (*ca.* 3000 B.C.) was apparently not adequate to promote permanent, widespread human occupation of northern Ontario. It appears that not until about 1500 B.C. was an adaptive complex available which would lead to constant inhabitation. Sophisticated woodworking tools (and the canoes, snowshoes, and toboggans they can produce) are central to that adaptation, in our opinion. An effective, year-round foraging strategy simply cannot be executed in boreal forests unless there are ways to overcome travel barriers such as deep snows of winter and the extensive areas of swamp and lake during summer (Winterhalder, Chapter 2, this volume). In the same sense, maturation of an adaptive pattern, based on raw materials available to nonindustrial peoples, can follow a limited number of channels. There is no obvious technologically simple way, aside from snowshoes (North America) or skiis (Scandanavia), to move through deep soft snow. Consequently, once basic technical inventions appeared, they showed little change until European intrusion. Many, in fact, persist to this day.

If the archaeological "beginning" date of 1500 B.C. is sound, it is hard to avoid the conclusion that carriers of that culture were "Proto-Algonkians." Szathmary and Auger (Chapter 9, this volume) cite a linguistically estimated date for Proto-Algonkian origins of 1200 B.C. The initial Archaic cultural patterns may later have been overlaid by Woodland intrusions, but whether any of these were major movements of biological populations rather than cultural diffusions has yet to be proven. Dawson concluded (Chapter 3, this volume) that between A.D. 700 and 1200 new people did arrive. They may have been ancestors of historic Cree and Ojibwa. What did *not* occur was a basic change in adaptive pattern. It seems that the forest channeled outside cultures into convergence with the previously established modes.

Figure 3 shows "raw material processing" leading out of the basic adaptive set; it divides into two major activity patterns. Both must have reached a high proficiency before humans could permanently occupy boreal lands. While cold adaptation (discussed in Sections 2 and 3) has biological and behavioral components, the processing of animal skins, bone, and wood is the base on which they rest. Taken together, clothing design, transport (snowshoes and canoes), and shelter (tents and lodges) were developed by early northern Algonkians and allowed them to overcome winter hazards and impassable conditions. These technologies provide the protection and mobility so critical to forest exploitation. Mobility is one of the primary themes of Algonkian existence and its centrality is reflected in our diagram. We have entitled this "all season mobility," although there may be periods (when the waterways, bogs, and muskegs are either freezing for the winter or thawing afterward) which make movement a hazard and a trial.

10.4.2. The Forest

The left side of Fig. 3 is dominated by the forest and its peculiarities. This should be taken to include climate and geography as well as biotic communities. Winterhalder (Chapter 2, this volume) described the basic environmental characteristics of the Ontario boreal forest. Fire, wind, and snow maintain floral/faunal mosaics and give this zone its character of mixed, diffused riches. North American and Eurasian boreal forests in fact share those features, but recent continental glaciation and low relief surrounding Hudson Bay have left a legacy of poor drainage and, consequently, difficult overland travel for humans. Neither has human activity resulted in large-scale modification of the basic ecology, although people did cut bush trails and create small cutover patches to attract game. While it is possible that deliberate burning was occasionally practiced for its ecological benefits (Lewis 1977, 1980), the incidence of lightning-ignited fires in this region made such a practice largely redundant.

The forest is regionally homogeneous, but locally highly varigated (Winterhalder, Chapter 2, this volume, and Dawson, Chapter 3, this volume). Striking variability occurs annually (seasonally) and on longer time scales (such as the recurrence of disturbance and succession); it has intimate relationships to faunal populations, and those in turn determine human welfare. Even during the better years, late winter/early spring brings a crisis—animal populations are diminished to their smallest yearly numbers. Extraordinary weather conditions, such as extreme cold or drought, or extreme fluctuations in secondary climatic conditions, such as deep snow or low stream flow, take heavy tolls of fish, fowl, and game (see Chapters 2–4). For these and other reasons, such times work unusual hardships on humans. At the worst, people starved to death. Hard years could not really be predicted, nor provisioned for even if they could have been anticipated.

Our analysis of human adaptation in this environment has produced two conclusions with broader relevance to studies in ecological anthropology. First, it is difficult to anticipate which environmental features or which configurations of features will have the greatest impact on human adjustment. A sense of the effective environment emerges only with detailed study of the adaptations themselves; environmental analysis, field work, and inference are linked and recurrent, not sequential, activities. Second, characterization of these effective features by averaging or normative statistics cannot capture what is important about them. Ecological anthropologists are faced with the need to devise parameters which can characterize pattern and deviation from pattern in time and space, parameters which capture unlikely events as well as they do the predictable and expected.

10.4.3. Demography

Occasional starvation, then, was an historical and probably ancient fact of life for boreal foragers (Chapters 4, 5, and 7), and had rather general consequences. Most probably, it removed the young and old from populations, and sometimes took healthy adults. It also weakened survivors so that they were more vulnerable to other causes of mortality. We propose that Algonkian cultures devised some active countermeasures; elaborate food management and preservation techniques lead the list, but a case was also made (Chapter 7) that several population control techniques were used, including birth spacing, infanticide, and killing of the aged. These practices are not unique to Algonkians, and may in fact be responses to general pressures on nomads who must live in unpredictable foraging environments.

The result of such practices would be that small populations, lightly encumbered with young children and the infirm, would have a relatively large proportion of active foragers, and would have enhanced group mobility. Foraging strategies should be influenced by both relative number of foragers and group mobility. However, as soon as food from outside of the forest ecozone was made generally available through trading companies, starvation was no longer such a serious threat. We suggest that not only were food management practices modified (including decline in both native preservation and, possibly, in sharing) but so were population limitation customs. Missionary encouragement would have had the same apparent effect (through infanticide reduction), but was probably not as influential in relaxing population control as was food security. The many other sources of mortality, which acted in concert with starvation and population control methods, were at first intensified by European intrusion; this is particularly true for epidemic disease. The long period between those early contacts (mostly 17th and 18th centuries) and the appearance of dependably available imported food (20th century) was one of death and hardship which almost certainly exceeded anything seen in prehistoric times. General population expansion is a recent phenomenon. It has brought with it a higher number of dependents and has been concurrent with reduction of group dependence upon foraging as the only livelihood. Demographic trends are discussed in detail in Chapter 5.

10.4.4. *Mobility, Adaptation, and Change*

Flexibility of response to a resource base ever changing in the details of its distribution is a mode which probably best typifies Algonkian adaptive tactics. At its core lies mobility; not only must individuals be able to adjust their location and movement patterns, but so must social units, from the nuclear family on up. Lee (1976) has argued that mobility may be a general adaptation of foragers, given resource uncertainty and localized depletion. We have already discussed the cold adaptation complex and several major items of technology which are prerequisites for mobility (upper left quadrant of Fig. 3). Recent cultural influences by Euro-Canadians have thus far done little to change the forest environment, but they have dramatically altered the rate of movement. First, powered canoes and more recently airplanes and snowmobiles have transformed the speed of travel. What were once long hunts on snowshoes, initiated from small, scattered family bush camps, have been replaced by long-distance radial travel from a village base. Most of these trips involve no more than a day or two. However, unless trails are cleared and packed in advance, an arduous undertaking, movement within the forest is still accomplished on snowshoes. Snowmobiles excel on the hard-packed, shallow snows of ice-covered lakes and rivers, but the working technology for hunting and other activities is still the ancient one. Summer stream and lake surfaces are seldom free of the racket of outboard motors, carrying foragers or visitors over distances and at velocities which would have astonished their grandparents. Again, however, leaving the waterways involves slow and difficult travel by foot. The brush is often dense and much of the landscape is bog or muskeg, a bone-wearying substrate for human passage. In that sense, mobility, which was once great, has been increased. In other ways, modern technology has not supplanted old patterns.

However, as Rogers so clearly illustrated, recent government services in the area of health and education have precipitated the formation of sedentary communities, and we would judge that increased dependence on goods of all sorts imported by trading companies has been a major influence in this new demographic pattern. So, despite increased individual mobility, social groups have become increasingly consolidated, localized, and identified with a specific piece of geography (usually small government reserves). Certain freedoms have been lost. It is no longer easy for groups to fission as a relief from social tensions or in order to find new territory for economic use. Nuclear families, though still the basis of this society, now find it more difficult to control their setting or to ply the ancient choice of location which was their birthright. The old flexibility of social organization resists constraint, but must inevitably become more static. However, Fig. 3 attempts to illustrate both modern and previous patterns.

Individual foragers in traditional Algonkian society required freedom of movement, but this also had consequences for populations and social groups (see Rogers, Chapter 4, this volume). There was a yearly cycle of group size, dependent largely on how many people in one place could be supported by local

food resources. Typically, nuclear family groups (possibly with aged dependents)—the "family hunting group" (Rogers, 1963)—scattered widely to try to survive the severest winters, but groups of 40 people or more might gather at summer fishing stations. Populations were free to distribute themselves in response to annual food cycles, as well as to long-term resource changes such as those produced by large forest fires or drought. Rogers (1969) has suggested that witchcraft—a very real part of Algonkian perception—may have been an additional stimulant to the maintenance of group spacing. Social nets may thus have been made even more flexible by the propensity to simply move away from people who generate tensions. Though that option may be less open to groups with fixed residences in communities, there is still a great deal of social travel, and in one extreme case (murder), people fled from the site, to trapping camps or to relatives in other places.

In the face of constantly changing resources and movements of people, a flexible kinship and social structure would be most adaptive. Rogers (1962: B10) observed that the northern Algonkians reckon kinship bilaterally with fairly broad collateral inclusion, and that people on both sides of the family are depended upon for aid. Traditionally, hunting groups were nuclear families, extended families, or sets of families, and marriage customs made a fairly wide range of potential partners available. As Hurlich discovered (Chapter 4, this volume), loss of mobility produced by modern sedentary community patterns appears to have raised the number of unmarried women in Ft. Severn; men often leave the village for wage employment, but women are less inclined to leave. That is probably true everywhere, as is a rising rate of community endogamy and consequent reduction of widespread (and environmentally adaptive) kinship networks of former times. Certainly diffused kinship relations, produced by flexible marital customs, would make it easier to distribute people to achieve a good and constantly adjusting fit with a variable resource base.

It would also tend to promote gene flow, at least within the boundaries of major language areas. As suggested in the upper right-hand corner of Fig. 3, biological differences between populations within the northern Algonkian domain derive from historical forces as well as from marriage customs. Harpending (1976) concluded that genetic boundaries were hard to verify among shifting foragers such as the San; Szathmary and Auger (Chapter 9, this volume) have found evidence for a parallel pattern in boreal Indian groups. Despite their far-flung distribution, from east of James Bay to west of Lake Winnipeg, Cree populations appear to be rather homogeneous, and the Ojibwa show lesser but still strong similarities among themselves. Since the Cree do not carry a distinctive Ojibwa marker gene (an indication of little admixture since the time that the allele originated) and since Cree–Ojibwa similarities are unexpectably high, it would appear that these two peoples share a fairly close common ancestry. However, it does not support the suggestion (see Rogers, Chapter 4, this volume) that they are really just one continuous population. Separation could certainly go back as far as the A.D. 700–1200 dates suggested by Dawson (Chapter 3, this volume) as a period of broad population movement.

Of the forces that may have molded Algonkian genetic patterns, several could have promoted genetic exchange across social boundaries (especially within language or dialect "tribes"). We have already identified the wide marriage networks to be one of those. In fact, anything that puts people on the move, such as feuds, military raiding, or trade, would enhance genetic exchange among native groups. Likewise, infusions of European genes would tend to make all groups that received them genetically more similar to one another. Between-population differences also have some obvious causes. Gene flow between groups may have been too slow to overcome differences produced by genetic bottlenecks, and genetic drift could further enhance dissimilarities. Bottlenecks may occur as a result of starvation, military action, or epidemic mortality, but may appear following any other depopulation. Northern Algonkian history is full of junctures with potential genetic consequences. Overall, however, data presented in Chapter 9 lead to the conclusion that forces of homogenization were more powerful than those causing distance.

10.4.5. Foraging

It would not take years of research on boreal forest adaptations to make a general prediction that foraging must be a central factor in an environment of this character. Rather, we have attempted to assess which aspects of the environment were specifically hazardous, and how native foragers worked with woodland resources and difficulties to secure their welfare. The patterns of complexity and constraints that operated and still operate were not evident when we began; Fig. 3 attempts to outline our first assessment of these. It is an attempt to identify major pressures and tracks of causation. Foraging inevitably emerged as the endpoint of the several currents, and trapping (largely a product of the fur trade) is a subset of foraging, with similar techniques but different economic and ecological objectives.

Foraging tactics are conditioned from the start by the nature of a forager's hunting group. Where there is a large number of dependents (children and oldsters), group mobility cannot be as high as that for a group of young adults. Hurlich (Chapter 5, this volume) proposed (following Laughlin and Harper) that the presence of numerous dependents is by itself an index of adaptive success. But that is only partially applicable, because successful avoidance of starvation (under traditional conditions) may have involved deliberate reduction of dependents by behavioral means. Similarly, epidemic diseases introduced by Europeans were often spread by the very mobility that is a keystone of successful foraging. Any environmental stressor tends to eliminate the young and old with a harsher hand, and these new diseases for which the Algonkians were unprepared were no exception.

A profound knowledge of what the lands and waters offer is characteristic of foragers generally; the boreal forest varies in its yield, not only from year to year, but also from patch to patch at a given time. Floral and faunal progressions keep patches changing throughout one person's lifetime. In essence, unpredictability must be made regular by foraging knowledge and tactics. We would not expect any foraging strategy to be homogeneous or monotypic. It now appears that the powerful individuality and self-reliance of the Algonkian personality is an additional element of decision-making which must also be included in a predictive equation. Both free choice and some remarkable accounts of seemingly major handicaps overcome (Marano, Chapter 8, this volume) make the casting of reliable models considerably less simple than we would have once thought.

Presently, family hunting group mobility has declined, but this is heavily offset by widespread use of powered canoes, snowmobiles, and even small aircraft to expand individual mobility. Winterhalder (Chapter 6, this volume) worked both traditional and recent modes of transport into his foraging discussion; resource utilization may consequently now have less dependence on demography (and more on technology) than in former times.

10.4.6. Foraging Models

Rogers (Chapter 4, this volume) and Winterhalder (Chapter 6, this volume) both offered a considerable amount of information necessary for the analysis of foraging tactics. These fall into at least three areas; scarcity, distribution, and efficiency. In hard times, the range of foods sought or taken should expand. Rogers noted that the 19th century impoverishment of traditional game resources produced that pattern, with fish, hare, and a range of plant foods becoming staples. Use rights to territory may also have arisen in response to economic pressures (after 1820) despite the fact that the forest with its diffuse unstable resource array was probably not a habitat which encouraged defense of territory. Efficiency or optimal use of forager energies was another obvious modeling element; after all, Algonkians today, although pursuing fewer species than did their ancestors, go about the task with considerable economy of motion. Finally, patchy distribution of resources should produce a patch-oriented set of exploitation techniques. Solitary, dispersed prey in particular, should produce dispersion of human foraging groups; relatively long periods spent searching for prey should lead to pursuit of most of those that are found. Size of individual patches of forest should also modify foraging choices, particularly as to the variety of patches used at any one time.

Winterhalder (Chapter 6, this volume) used hare and moose distribution as illustrations. Hare live in highly predictable places, and may be snared with only modest energy investment. Each take is in itself a rather small return, and snare lines must be checked with regularity. In addition, peak populations of the hare cycle are many times larger than those when the hare are scarcest; dense hare populations yield reliable and easily obtained food. Trapping hare is not surrounded by the aura, difficulty, or challenge of a moose hunt; moose must be tracked carefully and the final stages of a hunt are not predictably successful. Despite the meat and valuable hides to be gained (not to mention the honor), moose hunting could be too great a risk if people are in immediate need of food. Consequently, a hunt that makes sense in one circumstance may be risky in another; the conditions informing such a choice are quite dynamic.

Winterhalder was able to illuminate foraging models that seem to fit circumstances of Cree foraging; he was not able to give them thorough testing. The latter would require much more data than could be gained in a year of field work. For the moment we have attained a sense of the systematic or strategic aspects of Cree foraging and a more certain knowledge of the types of data we will ultimately need to answer certain questions. The dietary breadth model predicts that a range of prey will be pursued if found. Diet breadth ranges would be expected to be narrower (fewer species sought) if the habitat is relatively rich. Foragers would, in times of plenty, spend less time foraging and also be more specialized. In view of both Rogers' and Winterhalder's findings, this model gives a reasonable description of traditional Algonkian foraging. During scarcity, it may be that a minimum catch is the goal, even if a good bit of time must be spent to attain it. Survival and avoidance of short-term failure, rather than time efficiency *per se,* are the objects. Given human resourcefulness and our relatively great physiological endurance, that goal makes sense. The diet breadth model predicts much more specialized foraging in modern circumstances, due to higher velocities gained by motorized transport and to lessened dependence on forest resources for short-term food requirements. Scarcity has diminished, but the material and personal (or cultural) rewards of skilled and productive hunting still motivate the efficient pursuit of game.

The marginal value theorem predicts that the forager abandons a patch when its productivity falls below the average level attained for all patches used. It is clear by observation and anecdote that extraction efforts are often dropped abruptly in order to move to the next, not recently depleted patch. Whether the breakoff point is related closely to a mean productivity was not established; the same pattern would result from a more or less conscious conservation effort. It did appear to us all that our informants were acute observers of the prey behavior and had a "sense" of each patch. We found that the marginal value theorem is a useful adaptive concept, but less easily assessed for empirical fit to evidence than the dietary breadth hypothesis. Finally, hypotheses from the "patch choice" model were not especially useful. Although their environment is certainly patchy, and although this patterning influences their foraging, Algonkian hunters (with cooperation from the boreal forest) violate assumptions of the model. They are choosy about patches, to be sure, but they also know patch locations in advance and use between-patch areas to cue behavior. Thus, in many instances, an alternative interstice model would be more applicable.

Foraging, later combined with trapping, supplies the energy and raw materials that allowed the northern Algonkians to use the boreal forest. Foraging success during periodic minima provided survival and little else; at other times it probably allowed some relative prosperity. Failures were largely idiosyncratic, or products of chance elements of weather or foreign interference. Though the Algonkian world has certainly undergone a good bit of buffeting recently, most of the people we encountered continue to use resources in their environment in a way which reflects ancient styles.

These foraging models produced some interesting insights, and led to fascinating field observations on hunting choices and efficiency, but they did so at the cost of ignoring a great deal. Thomas et al. (1979) have discussed the virtues and limitations of such middle-level, simple models. Here a primary limitation (Winterhalder, Chapter 2, this volume) was that of overlooking the effects and impact of the fur trade. Fuller comprehension of Cree–Ojibwa ecology and foraging behavior necessarily will reach into that area (Ray, 1974; Bishop, 1974; Ray and Freeman, 1978). We are confident that the adaptive understandings reached in this work will provide a secure base for examining that more complex realm of interaction between ecological adaptations to the boreal forest and economic adaptations to the fur trade, the latter so important in the historical and present periods.

10.5. Conclusions

Our original intention was to study cold. We assumed that it was a major hazard. Work in Ontario led us to the conclusion that compared to many other factors, cold was not very threatening. A major reason is the high level of cold-coping behavior which has evolved in boreal cultures. Other hazards are more threatening; in the past, disease took a heavy toll of life, and starvation was an occasional, if unpredictable, threat. Cold indirectly exacerbated some traditional problems, such as mishaps leading to drowning, and dwelling fires and other environmental accidents. These cause as many difficulties today as they ever did. As we looked at hazards and responses to them, we were increasingly led into an interest in trying to define broader adaptive patterns and mechanics.

We concluded that elements that lead to foraging success may be seen as the supporting timbers of Algonkian adaptation. These we have reviewed in this chapter, along with observations on cold adaptation and other conclusions. Foraging starts with an understanding of the distributions and uncertainties of forest resources and their climatic settings. However, with even the deepest native insights into the mechanics of forest ecosystems, only a small number of people could live on those resources. Variability in resources could be buffered to a degree by careful food preservation and management, but ultimate success may have consisted in controlling population size and regulating the distribution of small groups in congruence with changing availability of food stuffs. Consequently, the first focus of the entire adaptive scheme centers upon mobility. We have repeated observations, both historical and contemporary, in support of that. A second focus is the control of population size. Since that conclusion is drawn from historical evidence, and since we lack data on the actual number of people living in a given area, this conclusion is less firm. However, a remarkably large number of population control mechanisms, such as birth spacing, infanticide, and suicide, were reported by reliable observers; this conclusion, too, is quite strong. A native technology well crafted to coping with forest challenges, and a complex of cold adaptations with both biological and behavioral components, were developed to ensure that mobility could be maintained during all seasons. Those elements all lead to flexibility of social organization and the successful application of foraging "rules." Foremost among the conceptual sets that regulate foraging is the acceptance of a broad range of food resources, together with considerable foresight into their probable distribution. Finally, it is clear that life in the boreal forest is a hazardous business. Those hazards, now centered on travel accidents and extending to starvation as we look back in time, are intrinsic to the forest itself.

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