

CULTURAL HERITAGE RESOURCE PREDICTIVE MODELLING PROJECT:

VOLUME 5 SUMMARY AND RECOMMENDATIONS

**Report Prepared for the Ontario Ministry of Natural Resources
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EXECUTIVE SUMMARY

In Volume 5, the research into the feasibility of applying archaeological predictive modelling to northern Ontario timber management planning is summarized. This summary reflects upon the strengths of the approach, as well as some of the weaknesses that remain to be resolved. This summary section serves as a prelude to a series of recommendations offered to OMNR regarding what is needed in order to strengthen the modelling process, and to facilitate implementation of the approach into timber management planning.



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PROJECT SUMMARY

1.1 INTRODUCTION

In summer of 1991, a memorandum of understanding was signed between the Ontario Ministry of Natural Resources (OMNR) and Lakehead University (Centre for Archaeological Resource Prediction). The intent of the resulting project was to develop a predictive model, or models, which identify areas with a high potential of containing unidentified and potentially significant prehistoric archaeological sites. The six volumes in this report series present the results of that project in which an archaeological predictive model was developed.

In Volume 5, we summarize the research conducted to date and offer recommendations for the future regarding the applicability of archaeological predictive modelling to Timber Management Planning in northern Ontario. The first section of this report summarizes the work presented in Volumes 1 through 4, and discusses the advantages and disadvantages of this approach. The second section offers recommendations stemming from this project regarding the applicability of archaeological predictive modelling to Timber Management Planning in northern Ontario.

1.2 SUMMARY

Archaeological predictive modelling offers a revolutionary new approach to Cultural Resource Management (CRM) in a region that is profoundly unsuited for conventional heritage management techniques. This is due to the large size of the northern forest region, difficulties with logistics and communications, the largely unknown heritage resource base, poor archaeological site visibility due to dense vegetation cover and acidic soils, and also the large scale of contemporary for-

est harvest and regeneration activities. As a result, OMNR is seeking new, more effective, management techniques that can be integrated into the current planning process.

Predictive modelling is a relatively new approach to archaeological inquiry and is a virtually “untried methodology” in a Canadian context, certainly at the scale envisioned for northern Ontario Timber Management. In effect, the feasibility assessment of this new approach could only be carried out by actually developing a prototype predictive model, and then measuring its utility as part of the management process. The research and development efforts to date represent the first goal of developing a prototype model, while the second component of implementing it into routine forest harvest planning represents the next stage of research.

Measuring the feasibility of archaeological predictive modelling as a CRM tool involves many considerations. These can be summarized in the following points.

- 1) What is predictive modelling?
- 2) Why use predictive models?
- 3) What are the cultural phenomena being modelled?
- 4) What sorts of archaeological and anthropological data regarding human land use are necessary to model Boreal forest foraging behaviour?
- 5) What is the time depth and spatial scope of the cultural phenomena being modelled?
- 6) What are the key variables that figure prominently in human foraging in the Boreal forest?

7) Are these variables mapped at sufficient precision and do these important geographic and biotic human behavioural correlates evolve over time?

8) How to effectively implement a predictive modelling approach?

9) How can multi-factorial land use decision-making be modelled in a fashion that is amenable to routine forest harvest planning?

10) What measures of testing and verification are necessary in order to assure that the predictive models used for Timber Management Planning are adequately identifying and ranking heritage resource potential?

These issues have been addressed in the foregoing four volumes of this report series.

1.2.1 What is Predictive Modelling?

Predictive modelling is a technique for anticipating the distribution of archaeological sites in areas where the archaeological database is incomplete. It has traditionally followed two approaches: an inductive strategy and a deductive one. Inductive archaeological predictive modelling of prehistoric activity location requires the identification of mappable phenomena that are correlated with known archaeological sites. Upon identifying such mappable landscape aspects, in theory, we may use them as geographic indicators of archaeological site potential when extrapolating to regions of unknown archaeological site distribution. This presupposes that a representative sample of archaeological sites already exists in the heritage inventory when we use it to seek geographic cues to site distribution. This precondition is not apparent when considering the northern Ontario heritage resource inventory. Furthermore, correlation does not necessarily reflect causation. It is possible that the observed correlation is related to the presence of other, presently unmeasured, variables. If these presently unknown variables are identified, then they may prove to be equally, or more important in the modelling process than those

already known. Independent tests, in other regions of North America, have demonstrated that commonly used indicators of site distribution are, indeed, useful predictors. However, it is probable that such commonly used indicators are insufficient, and additional variables might be necessary to account for the specific situation of boreal forest human land use. This leads us to the second approach to predictive modelling.

The second approach to predictive modelling is deductive in nature. It begins by proposing the general rationale and principles of prehistoric land use behaviour which are thought to underlie the archaeological pattern. With these assumptions explicitly stated, then hypotheses are generated that propose where archaeological site potential should be high if the underlying settlement pattern has been sufficiently and validly deduced. The advantage to this approach is that success in predicting site locations implies an understanding of the underlying prehistoric settlement system. Clearly, understanding the human rationale behind the site distribution results in a more analytically robust predictive model than one which merely identifies “high potential” areas. The disadvantage to this approach is the difficulty in measuring how well the initial model of prehistoric settlement reflects actual site distribution. Such validity measurement is dependent upon the identification and inspection of localities deemed to have both low and high archaeological site potential. The degree to which this is achieved has implications in perpetuating conventional biases with future model applications. These issues are addressed in more detail in Volumes 1 and 3.

1.2.2 Why Use Archaeological Predictive Models ?

Archaeological predictive modelling offers a means of uniformly making heritage resource management decisions across large areas in a timely and cost-effective manner. The rationale behind archaeological predictive modelling is familiar to many archae-

ologists involved in heritage resource management decision-making. Conventional CRM archaeologists routinely examine the current heritage resource inventory to derive expectations regarding the distribution of probable site localities. In addition to such an inductive approach, a CRM archaeologist also uses his/her personal experience and command of the literature to intuitively derive deductive notions of where heritage resources should be expected. These approaches can be viewed as *ad hoc* predictive modelling, and are routinely used in making management decisions. Unfortunately, they are also intuitive and individualistic approaches to anticipating site distribution, and are inadequate to deal with the magnitude of the heritage management challenge in northern Ontario. With neither the time nor the resources to use conventional techniques to make decisions regarding large-scale resource management activities, cultural resource managers will benefit greatly from the use of formalized archaeological predictive modelling.

The manner in which heritage management concerns have been addressed in the current timber management planning process can be summarized by the following generalizations. OMNR timber management planning teams routinely access the existing heritage resource inventory, and integrate the location of *known* sites into the values mapping process. This assures that currently known archaeological sites are integrated into the planning process. However, it does not address the incompleteness and biases in the current heritage inventory. Although the timber management planning process encourages unsolicited input from the interested public, only in very rare situations is additional input from professional archaeologists specifically sought to suggest where presently undocumented sites might be expected (B. Ross 1994: per. comm.). Even if such supplemental information is integrated into the planning process, the archaeologist may define areas with a high archaeological site potential by inductive extrapolation from

where sites have been found in the past. These predictions can be considered inadequate since they are based upon the current biased site inventory. They also have unknown validity since the assumptions underlying site distribution and the predictive process are seldom, if ever, explicitly stated.

Systematic biases affect the heritage inventory whereby sites are sought (and sometimes found) in areas where our preconceptions lead us to expect them. However, archaeologists seldom deliberately search for archaeological sites in areas where they don't expect to find them. Such 'low potential' areas are seldom systematically examined and, therefore, the validity of these preconceptions are rarely tested. If an invalid notion of site distribution becomes entrenched as part of the conventional wisdom of the prehistoric settlement system, then it takes on a 'deemed reality' in heritage management decision-making. In many circumstances, archaeologists may not be able to explain why they expect sites in specific localities aside from resorting to past experience. That is, they may not be able to explicitly identify the geographic or biotic cues that are subjectively used as indicators of site potential. Under such circumstances, if an explanation of the site location is offered, often the cues cited reflect an "after the fact" rationalization. This is not true prediction, nor does it measure how consistently the selected cues are correlated with site presence. Thus, without "ground truthing" or testing of the "null hypotheses", we have no means of assessing the validity and predictive strength of our expectations. All techniques for measuring archaeological site potential, short of intensive inductive field reconnaissance, are vulnerable to these sorts of failings and risk rendering presently unidentified types of sites vulnerable to impact. We emphasize that archaeologists using conventional CRM approaches are vulnerable, and are more susceptible to this problem than those using formal predictive modelling approaches. Admittedly, in the context of archaeological predictive modelling, determining high po-

tential areas utilizes the current site inventory and some preconceived notions of site distribution. As is discussed in previous volumes and summarized below, these weaknesses can be effectively addressed by the explicit enunciation of modelling assumptions and processes. With these difficulties in mind, the benefits of adopting formalized archaeological predictive modelling for timber management planning purposes are clear. The only conventional alternative to a formalized predictive modelling approach involves intensive archaeological field reconnaissance. This approach clearly involves overcoming logistical obstacles, the problematical issue of site visibility, difficult sample design problems, as well as the enormous time investment and expense that would be required to engage in such efforts. This is particularly the case in light of large-scale land disturbances resulting from forest harvesting, road construction and related infrastructure activities. Clearly, development of a heritage inventory by physical inspection of all land surfaces prior to developmental impact is not a viable alternative. We propose that formal archaeological predictive modelling, which includes ongoing testing and refinement, offers the best means of effective heritage management.

In our view, the benefits of applying predictive modelling to the timber management planning process are significant, and offer the only viable alternative to current practise. We emphasize, however, that the premature implementation of untested predictive models could be problematical. Clearly, the issue is not whether to engage in predictive modelling. Rather, how does one follow this approach in a robust and valid fashion, and in ways that are amenable to testing, refutation and refinement? We reiterate that, given the current pace of land and resource development in northern Ontario, responsible heritage resource management requires the refinement and implementation of archaeological predictive modelling.

1.2.3 What are we modelling?

The prototype predictive model introduced in Volume 4 identifies and measures prehistoric archaeological site potential. It does this by using two discrete approaches that have resulted in the cultural model and the archaeologist's model. The *cultural model* is based upon generalizations about Boreal forest foraging derived from the ethnographic literature, and is expressed in cartographic representations. In order to predict where people conducted activities in the past, an understanding of the people and their activities is needed. The cultural model contributes to a better overall predictive model because it uses analogy to integrate direct observation of Boreal forest land use into the modelling process rather than relying solely upon inductive logic. While this approach offers advantages by addressing directly observable human behaviour, the ethnographic record focuses upon early to middle 20th century groups who have successfully adapted to at least 400 years of contact with European culture. During this time period, there was a collapse in specific strategic resources (i.e. caribou, moose, beaver), and a shift in focus to rapidly reproducing smaller game or fur-bearers of economic value as trade commodities. This has significant implications for any effort to use ethnographic analogy for modelling prehistoric human mobility, land use and land tenure. The relationship between historic and prehistoric reality remains the subject of intense scholarly debate. These issues are addressed in Volumes 1 and 2. While questions over the antiquity of the ethnographic model remain, we have chosen to consider them moot for the current modelling purposes. These problems aside, it is clear that ethnographic syntheses offer valuable insight. By examining variation in the nature of ethnographically documented land use across the Boreal forest, and exploring the attendant causes, some of the important variables affecting land use can be isolated. As discussed in Volume 1 and 2, these variables include adaptations to seasonal fluctuations in resource potential,

localized and large-scale variability in biotic productivity, forest succession, plus a wide range of socio-economic and political considerations that might be unrelated to mappable landscape considerations.

The second approach, called the *archaeologist's model*, involves the derivation of site indicators from a review of general foraging strategies. These generic considerations reflect, among other things, the physical characteristics and attractiveness of a landscape for human habitation and are expressed as mapped variables. This latter approach also contributes to the development of deductively derived predictive models.

1.2.3.1 The Cultural Model

The synthesis of Boreal forest ethnography, presented in Volume 2, emphasizes the importance of seasonal flexibility in land use among foragers. For example, during spring and summer, several autonomous hunting bands may aggregate in localities where predictably clumped food resources can be expected. In this season of relative plenty, people engage in a range of social, political and religious activities, including personal interaction, planning future activities and general recreation. These aggregation zones are often associated with localities where large quantities of fish may be harvested to support the human population. These central places to a larger catchment area may be repeatedly used for thousands of years, thereby creating large, complex and highly visible archaeological sites. With the approach of fall and winter and the associated decline in resource productivity, the larger group subdivides into smaller ones, who disperse into habitats suitable for wintering foraging. In this circumstance, well-sheltered uplands accessible to a range of diffuse resources are often sought out as temporary winter encampments. These short term, perhaps never reused, localities are severely under-represented in the current heritage inventory and are very difficult to locate archaeologically. A third category of human habitation site consists of short-term camps used in the

spring and fall while in transit between the winter and spring habitation zones, and can also include short-term winter hunting and kill sites. These temporary camps are virtually invisible upon the landscape and are also under-represented in the heritage inventory. Using the ethnographic information base in this way offers significant insight into the detail of northern forest forager behaviour that might otherwise have been overlooked. These generalizations, and critical issues regarding their valid use, are addressed in Volumes 1 and 2. By explicitly addressing ethnographically defined seasonal land use, the Cultural model emphasizes the incompleteness of the current site inventory by drawing attention to activity zones not associated with shoreline areas that have been the primary focus of archaeological reconnaissance.

1.2.3.2 The Archaeologist's Model

Land use considerations on a more generic level figure prominently in the archaeologist's model outlined in Volume 4. These reflect land use considerations that might be held as common among many forager cultures throughout the world. Interestingly, these common considerations are seldom explicitly mentioned in the ethnographic literature because, on first light, they might appear obvious. Some such issues include the availability of flat, well-drained land, access to water, or shelter from adverse weather conditions. However, such landscape characteristics have a profound affect upon how humans consciously or unconsciously use the land. These generic and unmentioned variables often figure prominently, although silently, in intuitive models used by archaeologists in interpreting the landscape and its site potential. By rendering such variables explicit and manipulating them uniformly across space, they can be highly effective in assigning site potential.

When used independently of each other, each of these approaches offers an incomplete perspective of prehistoric land use choice. The cultural model integrates an understand-

ing of land use based upon direct observation, while the archaeologist's model integrates an understanding based upon derived observation and collective professional experience. By combining them, a much more complete and explicitly defined predictive model of activity location can be achieved.

1.2.4 Complexities in understanding the past.

Prehistoric sites are the cumulative archaeological record of hunting and gathering cultures who utilized the region over about the last 9,500 years. Upon deglaciation, human populations moved northwards and, over many thousands of years, developed highly flexible and efficient land use strategies that are generally described as 'high latitude foraging'. The key characteristics of this adaptation are seasonally fluctuating subsistence pursuits coupled with high mobility, fluid social organization and small group size. This social system and economy is highly efficient given the ecology of the Boreal forest noted for its fine grained habitat patches. In fact, the heterogeneity of forest conditions demands flexibility in land use and resource harvest techniques.

When attempting to understand the past, it becomes clear that human culture and land use changed through time and across space in response to a complex interplay of factors. Given that land use changed, modelling human behaviour at various times in the past must involve a diachronic perspective. To address this complex interplay in a coherent fashion, we will first discuss the evolution of the physical landscape, and then turn to cultural considerations affecting human land use.

1.2.4.1 Addressing Variability in the Physical Environment

Examination of Volume 2 reveals that contemporary foraging strategies vary in response to a number of physiographic, climatic and biotic conditions, and it is probable that similar variability affected prehistoric land use. At a macro-scale of ecologi-

cal variability, land use strategies vary with the geographic position of the cultural group within the Boreal forest biome. For example, the Mistassini of northern Québec and the Caribou-eater Chippewyan of southern Keewatin rely heavily upon the seasonal migration of caribou herds between the closed coniferous forest and the open tundra. The biology and behaviour of this key resource profoundly affects the seasonal land use behaviour of humans preying upon the herds. Perhaps the utilization of this clumped resource might lead to archaeological sites at good river and lake crossings, or upon eskers and end moraines where the animals might have established travel corridors. In contrast, more southerly groups of foragers may have relied more heavily upon seasonal abundances of aquatic resources such as beaver, wild rice and fish, or upon moose who exhibit quite different behaviour and habitat choices from caribou. In such situations, the aggregation sites might be expected in quite different locations from those in the more northern areas. These sorts of distinctions in the ecological nature of the northern forest may result in the need to develop regionally based archaeological predictive models. This is particularly the case when we consider that the territory subject to Timber Management Planning includes portions of the Hudson Bay Lowlands, the Boreal forest and the Great Lakes-St. Lawrence forest (see Figure 1.1 in Volume 1).

At a finer and more dynamic micro-scale, variability in land use can also be expected in terms of local habitat patches and forest succession. For example, Volume 2 draws attention to the variable character and biological productivity of different forest patches. Depending upon the patch composition in specific regions, human groups occupying those regions might engage in subtly different behaviour on the basis of local conditions. Thus, as yet unmeasured variability in human land use can be proposed between contemporaneous populations across space. Additional micro-scale variability is introduced by the successional state of each

group's home range. For example, endemic cycles of forest fire, disease and wind and snow damage assure that the Boreal forest is in a constant state of dynamic flux. These disturbances result in forest patches that contain a range of pioneer species that are highly productive for, and attractive to, foragers.

When we consider the occurrence of forest disturbances (i.e. fire, wind damage, disease, etc.) over the long term, they have a randomizing affect upon human land use. For example, overlapping patches of upland forest will have been destroyed at irregular intervals throughout the history of human occupation. Subsequent forest regeneration likely attracted foragers, resulting in resource extraction sites being established to harvest short-term and transitory resources. Forest fire history is not directly measurable or mappable except perhaps within the past two hundred years where forest stand aging has been conducted. However, it is clear that upland non-littoral zones can be expected to contain archaeological sites deriving from the human use of disturbed forest patches. The occurrence and periodicity of forest fires throughout the Holocene might be treated as a "random" variable that affects virtually all of northern Ontario in ways that are presently unmeasurable. It may not be possible to use these variables to predict sites, but they may be valuable in explaining site distribution. While recognizing that such considerations affect land use, because we are unable to account or control for them as yet, we have chosen to not address them directly. Some possible approaches to land use variability related to fire ecology are offered in the Recommendations section.

It is clear that the nature and structure of the subarctic forest has been profoundly affected by long term processes such as recovery from deglaciation, and continental-wide climatic change. The implications of these and other phenomena have great significance for archaeological predictive modelling. For example, the process of Pleistocene

deglaciation was time-transgressive, freeing the land for biotic regeneration much earlier in the south than in the north (for example see Figure 1.1). As soon as the physical environment regenerated to support a human population, people moved in. The nature of these early adaptations to a comparatively short-lived tundra-steppe or lichen-woodland environment is not archaeologically well documented, and may exhibit significant differences from Boreal forest foraging behaviour. In addition, the physiographic and hydrological nature of the land underwent significant evolution even after the northern coniferous forest was well established (see Julig, McAndrews and Mahaney 1990; Phillips 1993). Since these variables profoundly affected where specific favoured habitat patches were located, then there transformation through time greatly affected where and how people used the land. These issues are addressed in more detail in the Recommendations section offered below.

At a very coarse scale the deglaciation sequence is documented, and the major proglacial and peri-glacial lakes and outwash channels are known. However, virtually no detailed reconstructions are currently available regarding the small drainage systems and minor meltwater lakes which dotted the emerging landscape. Detailed reconstructions of the evolution of hydrological systems and biotic productivity are also yet to be generated. The nature and long-term effect of soil development and isostatic rebound are equally tentative. Perhaps one exception to this are the late Pleistocene and early Holocene reconstructions that have been conducted in the Thunder Bay area (Burwasser 1977; Farrand and Drexler 1985; Julig 1984; Julig, McAndrews and Mahaney 1990; and Phillips 1988, 1993). These ongoing changes in the physical environment had a profound effect upon human land use and therefore, have important implications to predictive modelling. These issues are substantively addressed in an paper to be included in Volume 6

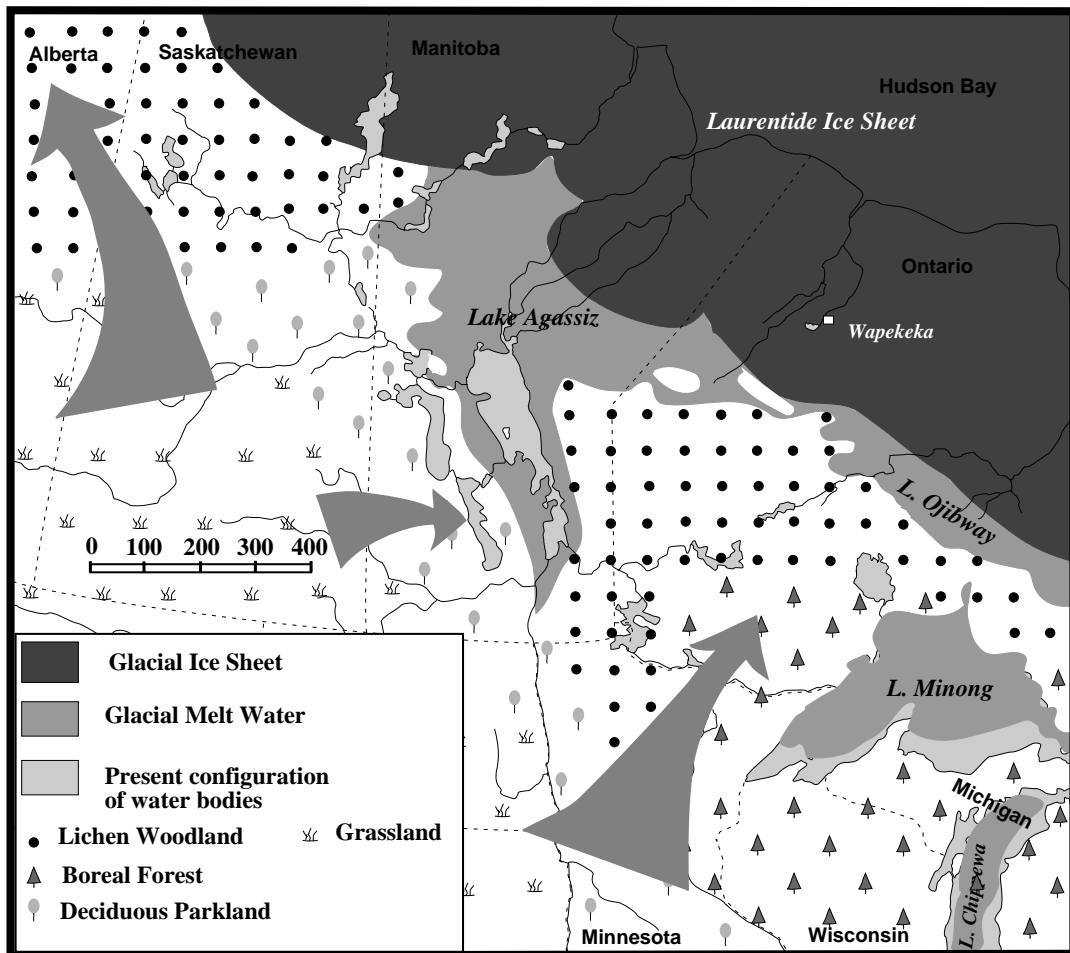


Figure 1.1. Probable routes of movement of people into northern Ontario following deglaciation.

In addition to the effects of deglaciation, continental climatic fluctuations throughout the Holocene had profound effects upon the biotic communities found in what is now northern Ontario. For example, palynological data indicates that subtle shifts in the composition of the northern forests occurred in response to episodic climate changes (Julig, McAndrews and Mahaney 1990; McAndrews 1982). One such warming and drying trend occurred between ca. 8,000 and 4,000 years ago and had a significant effect upon the mid-continental portion of North America, most notably the Great Plains (Frison 1978; Vickers 1986; Doll 1982; Buchner 1980). Archaeologists refer to this as the Altithermal or Atlantic stage, and still debate the significance of this extended drought. It appears to have had an affect upon the Boreal forest in southeast Manitoba, northern Minnesota and the southwestern portion of northwestern Ontario (Pettipas 1983; Shay 1971; Buchner 1980; Steinbring 1980). The boundaries between the grassland and forest biotic provinces shifted north and east, perhaps resulting in grassland and parkland habitats becoming established as far northeast as the Lake of the Woods region. Other climatic episodes affected the biological composition and spatial position of the Boreal forest at other times in the past. As yet, the implications for shifts in human land use have not been substantively addressed in the archaeological literature. However, it is clear that changes in the physical environment had an effect upon culture change, perhaps land use, and will figure in the refinement of predictive modelling in some portions of northern Ontario.

1.2.4.2 Addressing Variability in the Cultural Environment

In order to adapt to seemingly continual changes in the physical environment through time and across space, human land use decisions were constantly readjusted to accommodate and take advantage of variable resource productivity. For example, in the Archaic period, archaeological sites yielding bison remains are reported in northern

Minnesota at Itasca (Shay 1971) and in northern Wisconsin associated with tools of the Old Copper culture (Kunsman 1937; Palmer 1954). Additionally, skeletal remains of an extinct form of bison were discovered in a peat bog near Kenora (McAndrews 1982; Rajnovich 1980). These latter remains have been radiocarbon dated to $4,850 \pm 60$ years B.P. (Beta-3779) (McAndrews 1982:43), and yield fossil pollen that is indicative of an open “pine-poplar woodland” with a warmer and drier environment than is presently apparent. This suggests that the warmer conditions supported an open forest mosaic that sustained bison throughout the early and middle Holocene period until about 3,600 years ago, at which time cooler and wetter conditions favoured the development of current boreal forest conditions. Clearly, these now-extinct biotic communities offering habitats for human exploitation that are different from those apparent in the ethnographic review. These habitats could have been exploited by local populations as well as newcomers moving into the areas from regions such as the northern plains. Such cultural incursions are exemplified by the discovery of Oxbow projectile points (commonly associated with the northern plains) in the Lac Seul, Lake of the Woods and Winnipeg River regions (Lambert 1982; Pettipas 1983; Steinbring 1980). This is important to predictive modelling because, through time, we should expect shifts in land use in response to changes in the physical environment, which may be reflected in the composition and distribution of archaeological sites.

In addition to the continental wide responses of human populations to environmental changes, there is variability in land use at more finely spaced time intervals. The ethnographic data presented in Volume 2 indicates that Boreal forest foragers used their land according to schedules of past land use and biotic recovery. This land use variability has formerly been interpreted as an opportunistic subsistence strategy designed to cope with unpredictable resources. Recent re-evaluation of Boreal forest foraging be-

haviour indicates that long-term foraging success is dependent upon both the ability to efficiently harvest resources, and the ability to schedule appropriate land uses to assure sustained resource availability. The term ‘informed forager’ aptly describes the process by which land and resource information is collected, analysed and processed to ensure sustainable resource yields in a variety of habitats. These strategies are reflected in the archaeological record by shifting resource catchment areas, and rapid turnover of habitation locales. Therefore, the pattern of archaeological sites may be widely dispersed rather than appearing as long-term concentrations and occupations of specific attractive areas. Repeatedly used seasonal aggregation locales, as discussed above, are notable exceptions.

1.2.5 Given all this, how do we model human land use?

Given the complexities of human land use, and in light of the many variables to be considered, how is an effective predictive model operationalized? The development and application of a predictive model involves a multi-stage process which includes the selection of variables that represent prehistoric human land use that, ultimately, serve as indicators of archaeological site location. The manipulation of the variables first requires that they be represented as thematic elements of maps. Once in this form, variables can be evaluated individually or as a group, and their eventual contribution to the modelling process can be addressed. In our view, the only effective means of incorporating the number and variety of variables required, over large regions and in a uniform and standardized way, involves computerized data management and analysis using geographic information systems (GIS) software. The predictive modelling process benefits from a computerized approach because the variables being modelled are explicitly identified, and an unlimited number of variables can be simultaneously considered.

An integral part of the CARP research approach has been the use of a GIS as a tool for cartographically representing human land use variables, and manipulating them within the predictive model. An examination of Volume 4 reveals that, in theory, the structure of the model could be applied without the aid of computers. However, it is clear that these analyses are more effectively carried out using automated data management techniques, particularly in light of the scope of Timber Management Planning over thousands of hectares. The variables used in the prototype predictive model introduced in Volume 4 include ordinal measurements of slope, aspect, elevation and orientation. Deriving these variables by means other than with computers and GIS software is time-intensive, error prone and unrealistic in light of Timber Management Planning schedules. For all intents and purposes, the generation of these types of variables is beyond the capabilities of conventional cartographic techniques. When using a GIS approach to archaeological predictive modelling, the variables must be explicitly defined, and the structure of the GIS program assures clear and consistent representation across the study area.

A second benefit of employing a computerized approach is the speed at which model results can be calculated, and the ease with which revisions, refinements and new variables can be incorporated into the modelling process. Slight adjustments can be made to variables with each iteration until the ‘best’ result is achieved. Continued applications of the model may generate new information, rendering previous ‘best results’ obsolete. This new information may identify new variables which can be integrated into the existing model. Additionally, a regionally-applicable model can be generated with comparative ease by the adjustment of existing variables. Repeatedly undertaking such fine adjustments by non-computerized methods would be prohibitively expensive in terms of time and money. As a result, fine tuning

of such a model may not take place and initial results become final results by default.

For the production of a predictive model using a GIS system, the clear definition of the decision-making process is required. As a result, critical evaluation of the variables selected, their ranking, prioritization, and manner of manipulation can be achieved. The value of this external input cannot be overstated. Since the underlying assumptions in the model are rendered explicit, critics can more effectively evaluate the appropriateness of the variables used, offer how to refine existing variables, and suggest new variables to be added. Additionally, refinement of the modelling process can be expedited because weaknesses are easier to identify. Again, it is the interactive nature of a GIS-based approach which enables easy integration of any suggested modifications.

Another fundamental benefit of a GIS-based approach is the ability to simultaneously manipulate an unlimited number of variables to derive a measure of archaeological site potential. This simulates the reality of how people evaluate the suitability of a location for a specific activity by using multiple criteria. For example, when seeking a campsite, a forager might consider the following issues:

- 1) is the land reasonably flat, with dry, well drained sediment;
- 2) is an adequate supply of potable water conveniently at hand;
- 3) are there sufficient supplies of firewood and construction materials;
- 4) is the location suitable in light of seasonal weather conditions;
- 5) is the site convenient given the mode of transportation and technology available; and
- 6) are food supplies, or other needed resources conveniently at hand.

Using conventional cartographic techniques, the integration of more than two or three separately mapped variables is not realisti-

cally achievable. Using a GIS-based modelling approach, if the variables can be expressed in map form, they can be manipulated together to reflect their co-occurrence on a landscape.

During the course of this project, a micro-computer-based GIS system was used to develop, test and produce a prototype predictive model. We rejected the use of dedicated minicomputer/mainframe GIS systems (i.e. ArcInfo) because the cost of acquiring the hardware, software and services were prohibitive. The associated costs of data entry, processing, correction and manipulation were also beyond the means of the project. These considerations led us to develop and implement the predictive model using GIS software written for personal computers. Specifically, we used Macintosh microcomputers to operate Map II GIS software which met all our needs. As discussed in Volumes 3 and 4, we were able to train new staff quickly and inexpensively, existing data were imported from outside sources, new data were created in-house, and resulting data were exported for our purposes and those of others. Most importantly, we were able to conduct all the necessary tests, trials, manipulations and procedures related to this project's terms of reference.

1.2.5.1 Data Quality and Standards

A review of GIS-based predictive modelling outlined in Volume 3, and the substantive example of the prototype model discussed in Volume 4, reveals that specific types of mapped data form the core of the modelling approach. The primary sources of information for this model are derived from 1:50,000 NTS topographic maps and 1:100,000 NOGETS surficial geology maps, with some supplemental information coming from the 1:20,000 OBM topographic map series. These conventional maps yield a wide range of information regarding elevation, relief, hydrology, current road systems, some Pleistocene landscape features, surficial geology and drainage, among others. From

these data themes, an even wider range of data can be generated including digital elevation models, slope, aspect, transportation corridors, stream order, ‘distance from water’ measures, soil drainage capabilities, and so on. Other data sources exist for some parts of northern Ontario, but these data are not consistently available throughout the north. For example, the NOGETS surficial geology map series covers only parts of the southerly portion of northern Ontario. Therefore, both by necessity and in consideration of the future applications and users of the predictive model, we have limited ourselves to widely available information sources. When map coverage in northern Ontario improves and when new data sources become available, the modelling process outlined in Volume 4 is flexible enough to incorporate this new information.

The quality and nature of original data sources is a fundamental issue that affects the entire predictive modelling approach, and is addressed in more detail in Volume 3. For northern Ontario, the best widely available maps are the National Topographic Series (NTS) maps. While there is a continual program of map updating, it is not unusual to purchase a map that was published 25 years previously. Additionally, errors and omissions were detected when comparing NTS maps with other maps, or when field checking topographic data. However, NTS maps maintain a consistent standard of accuracy on all map sheets and, thus, form a base level of accuracy against which all other data can be evaluated. Other information sources may be useful to supplement the data existing on NTS maps. For example, large scale “forest resource inventory” maps produced by the major forestry companies often record small tributary streams, bogs and small lakes that are not reported on the 1:50,000 maps. Aerial photographs may also be used to identify wetlands, topographic highs, or unreported rapids or falls. Selectively enhancing the quality of the base data using these larger scale sources can be problematical. It is

important to the modelling process to ensure that the base level of data used in all models is of consistent quality. For example, errors are introduced if a model for one area uses enhanced hydrological data, while the model for a second area uses a different data standard. By adopting and making use of data that are available now, such as the NTS map series, and by adhering to a base level of accuracy and consistency, user-introduced variation among models can be controlled.

The representativeness of a map to the actual landscape is also an important consideration. The NTS 1:50,000 map series represents elevation at 50 foot intervals (15.5 metres). While this provides a relatively accurate topological description of the landscape, many landscape features important in understanding archaeological site placement are not always apparent. These might include undulating surfaces that are mapped as being flat, or the occurrence of old river terraces which ‘fall between’ arbitrarily assigned contour lines. Even the new OBM map series at 1:20,000 scale has been produced with a contour interval of 30 feet (10 metres), a degree of improvement in relief representation that is not consistent with the increase in map scale. Furthermore, throughout significant portions of northern Ontario the OBM maps have not yet been published. The NOGETS surficial geology map series offers a good example of the dilemma involved in evaluating thematic mapped data, and making decisions how to validly use it. This 1:100,000 map series sometimes exhibit inconsistencies with the 1:50,000 NTS series in terms of the location and spatial relationship between landscape features. The analytical value of a GIS-based approach is readily apparent with the ability to ‘warp’ one map series to match the spatial configuration of the second. The NOGETS map series must be used with some measure of caution based upon its level of precision. This thematic map series was derived primarily through air photo interpretation, with only limited field verification of the

Pleistocene landscape features. Pleistocene geomorphologists have observed that the precision of detail and identity of mapped features is sometimes suspect (B. Phillips 1993: per. comm.). While these thematic maps may be sometimes problematical, they are far superior to alternative representations of surficial geology and Pleistocene geomorphology. Indeed, in much of northern Ontario, no alternative data source is available, and they are highly informative provided they are used with due caution. This issue of data quality and precision confronts all aspects of Timber Management Planning. As new thematic data is derived, its integration into archaeological predictive modelling will continually enhance the quality and validity of the results.

Hamilton's field survey report in Volume 6 presents an example of how topographical information, supplemented by field survey, aerial photos, thematic maps, and remotely-sensed data can be used to identify geomorphological features which are associated with archaeological site location. In this case, post-glacial landscape features, not represented on available topographic maps, were identified by combining several different data sources. This research did not follow a predictive modelling orientation. Rather, upon discovery by conventional field reconnaissance, the sites, their distribution, and their association with landscape features was examined. This is of value since it independently addresses what landscape characteristics are useful indicators of site location, and whether these indicators are apparent upon the standard maps used in constructing the predictive model. This was not intended to measure the validity of the prototype model, but rather, to examine what standardized cartographic data enhancement might be most useful for refining the model in the future.

The digital data generated in this project used NTS 1:50,000 maps and OBM maps as a supplemental source, resulting in a database resolution of one grid cell of information

representing 30 x 30 metres on the ground. Compared to the vast majority of predictive models already published, the level of accuracy employed in this model is ranked at or near the top. Ironically, this scale of map resolution has evoked conflicting comment that it is either too precise given the scale of the source data, or too generalized to reflect variables useful for predicting human land use. We counter this by pointing out that the concerns over 'false precision' is irrelevant given that the GIS used in modelling is capable of coping with the large data sets generated to date, and that new data suited to this level of precision can be seamlessly integrated into the modelling process at a later date. By establishing a high standard of data precision, less 'retrofitting' of the prototype models will be needed in the future. As noted in Volume 3, selecting a suitable scale of data resolution should be viewed as seeking a compromise between over-generalization of the data, and overly precise data resolution that will result in large and cumbersome data files. In our view, the 30 metre data resolution standard is an appropriate compromise given the current capabilities of computers, the goals of predictive modelling, and the territorial expanse to be subjected to timber management planning. It must be emphasized that the level of data quality will, in large measure, dictate the quality of a predictive model. When the quality and precision of mapped data improves, there should be a corresponding improvement in the predictive strength of the model. The modelling process developed in this project is flexible in that, as new data arise and as map standards and quality improve, this new information can supplant other data of lesser quality, resulting in an improved overall product.

1.2.6 The Predictive Model

The prototype predictive model developed as a result of this project, may eventually contribute to managing cultural resources in areas subject to Timber Management Planning. The underlying premises upon which the model is based are consistent with those

routinely used by archaeologists in cultural resource management. This model differs from others previously published or currently in use in the following regards.

- 1) The decision-making process that results in a predictive model is clearly defined and presented for comment and discussion.
- 2) Each variable used to determine archaeological potential is identified and the degree or manner in which the variable contributes to potential is clearly established.
- 3) The clear establishment of the modelling process encourages critical commentary from others. This commentary is important in assisting in the clarification and justification of existing modelling assumptions, introducing and incorporating new variables, and evaluating the model with the aim to refine its precision.
- 4) The use of geographic information system (GIS) software and computer hardware allows larger areas to be subjected to predictive modelling than could be achieved through conventional cartographic means.
- 5) The use of computerized techniques results in the uniform and consistent application of a model across the entire study area, rather than at a detailed level in some selected locations and a cursory level over the balance of the study area.
- 6) The use of computerized techniques facilitates existing data to be updated or refined, enables the inclusion of new data sources, or the removal of redundant data sources.
- 7) The combination of computerized techniques and the open nature of the modelling process results in a model which is most applicable to the area in which it was developed, but also flexible enough to be transposed to other regions where, with additional testing and refinement, it can be applied.
- 8) The predictive model and the predictive modelling process also produces information that is useful to a wider audience than those involved in the Timber Management Planning process. The model is useful for archaeologists and others involved in researching the prehistoric past.

PROJECT RECOMMENDATIONS

2.1 RECOMMENDATIONS

The prototype predictive model outlined in Volume 4 represents a major research and development effort over the past four years. In our view, it also reflects a significant advance in archaeological predictive modelling in Canada, and represents a good foundation for future refinement. We conclude this volume by offering recommendations that address how to further test and refine this particular model, how to expand its spatial applicability beyond its current scope, and suggest what is needed to facilitate its eventual implementation as a tool for Timber Management Planning.

The first four recommendations relate to the need to conduct further field testing and verification, as well as conducting research into

additional variables that are useful in the predictive modelling process. Additionally, the need to evaluate existing data types for use in archaeological predictive modelling is also discussed in Recommendation 4.

Recommendation 5 through 7 refer to the need to effect technology transfer between the predictive model as a product of research and development and its implementation in an applied context.

Recommendations 8 and 9 discuss the capability of the predictive model to be applied in contexts other than the prediction of pre-historic archaeological sites.

Recommendation 10 discusses the need to constantly and continuously audit applications of the model.

RECOMMENDATION 1

The prototype predictive model should be subjected to pilot studies to more fully 'field evaluate' its predictive strength prior to routine implementation as a timber management planning tool. As the model was developed for application in the Thunder Bay area, this testing should be continued in this region, or in areas that match the biotic, cultural and physiographic character of the region.

While attempting to maintain widespread applicability throughout northwestern Ontario, the prototype model was constructed, in part, using the results of archaeological survey in four areas located within a two hour drive of Thunder Bay. These test blocks are located in the southerly Boreal forest, and the northern extreme of the Great Lakes-St. Lawrence forest. The physiographic composition of these test regions includes bedrock controlled tills and outwash of the Port Arthur Uplands, deep accumulations of palaeo-lacustrine sediments of the Lake Agassiz and Lake Minong basins, and stony sediments derived from lag deposits in a high velocity spillway between Lakes Agassiz and Minong. Some areas evince dramatic relief and poor localized drainage, some are gently rolling tills associated with small lakes, and some are characterized by well-drained fine sediments bisected by meandering streams.

The field survey component of the project focused upon examining non-littoral zones that are currently being subjected to forest harvesting and preparation for regeneration. These exposed and disturbed land surfaces were sought out in order to overcome the poor site visibility apparent in the Boreal forest. These upland regions are consistently under-represented in the current heritage resource inventory. Over the past two years, CARP survey crews (12 people in 1992 and 9 people in 1993) have examined over 5,000 hectares. Through these intensive survey efforts, several sites were encountered in areas that are generally deemed to have low potential for containing archaeological sites.

In spite of this effort, the size of northern Ontario and the labour-intensive nature of archaeological survey, assures that this coverage represents a minute sample of the range and diversity of landscapes found within the region. Part of measuring the validity of the prototype model involves expanding the sample size and breadth of diversity represented in the survey coverage. These issues of sample size and representativeness are discussed in more detail below.

A number of important issues remain to be addressed before the validity of the prototype model can be adequately evaluated. Specifically, it must be determined how well it succeeds in predicting prehistoric activity locations. Addressing this question will determine the validity and precision of the predictive model. One means of measuring this is to continue the archaeological reconnaissance within the Thunder Bay region where the model was initially developed. The prototype predictive model should be applied to a series of test regions to identify localities with high, medium and low potential for containing archaeological resources. This prioritization of the landscape will be explicitly based upon the assumptions underlying the prototype model. Testing how well the predictions are borne out provides a means of measuring whether the assumptions are appropriate, and whether the chosen variables and their weighting effectively reflects site distribution.

At this stage in the modelling process, we suggest that the model be judged successful if it predicts sites in three zones of potential

(high, medium, low) in accordance with the following ratio - 6:3:1. That is if the three different zones of potential are surveyed, sites should be expected in each of the zones according to a ratio of 6:3:1. It is impossible to describe the success of the model in terms of the percentage of sites it predicts. Predicting a percentage of the total site database implies that the total number of sites is known. Since this can never be known without complete archaeological survey of all areas, expressing the success of the predictions in terms of the ratio 6 (high potential): 3 (medium potential): 1 (low potential) is a more effective means of evaluating the success of the model.

Successful predictions of where prehistoric human activity *did and did not occur* provides a means of independently measuring the precision and validity of the prototype model. Conversely, this field testing also aids in identifying model weaknesses, and how to improve its predictive strength by identifying more effective indicators of prehistoric activity location.

Such critical evaluation of the prototype model should be undertaken at a scale that will generate a statistically significant sample within the region. Determining what sample size is sufficient to appropriately test the model predictions is a complex issue that is beyond the scope of this discussion. One approach to sample design involves stratifying the “research universe” into a series of distinctive subareas, each of known aerial extent. In this circumstance, one might stratify the area on the basis of the prototype model’s predictions of site potential. That is, divide the test area into a series of zones

of specific archaeological site potential based upon the projections offered by the prototype model. The next stage would involve selecting an appropriate sample of each subarea to be subjected to field reconnaissance. Usually this involves random selection of a specific percentage of the land mass making up each sample subarea. In the context of archaeological survey in the Boreal forest, this standard procedure may be confounded by the fact that the survey areas are, in effect, “pre-selected” by the timber harvest and scarification priorities of the forest companies operating in the area. In this circumstance, close coordination of the archaeological research with both OMNR and timber company foresters is necessary. It also results in a divergence from some aspects of the traditional stratified random sample survey, and the potential for systematic biases in survey coverage to creep into the model verification process. These problems aside, the validity testing exercise is important to generate a more complete understanding of prehistoric land use, and also gain important information for refining the prototype model. These issues are discussed more fully in the context of recommendation 3.

This process of model verification begs the question who decides when a predictive model has received enough testing, and what level of robusticity is acceptable to allow implementation as a planning tool. Given the pioneering nature of archaeological predictive modelling in the Boreal forest, we are not in a position to address such issues now. In the short term, such decisions will likely be driven by consensus among all interested parties.

RECOMMENDATION 2

The prototype model was designed and tested in Thunder Bay District. Its predictive applicability outside of this district is presently unknown. Therefore, prior to applying the model outside the test region, it should undergo testing in those other regions. It also should be evaluated with regard to the need to develop regional or temporal models.

Once it has been demonstrated that the prototype model adequately predicts prehistoric activity locations within the region where it was developed, the next issue is whether it can be applied without modification to other portions of the Boreal forest. The ‘goodness of fit’ of the prototype model to other regions in northern Ontario has yet to be measured. The Thunder Bay region encompasses considerable diversity in biotic structure and productivity. However, it does not exemplify the range of diversity found within the lands subject to timber management across northern Ontario. Clearly, an important precondition of routine model application is the exploration of how adequately it reflects local conditions in the various Timber Management Units. If the prototype model proves inadequate in these new geographic contexts, then new variables must be identified to refine it to reflect regional variability in archaeological site distribution. This second round of testing should be conducted in ways similar to that proposed above. That is, the model should be applied to sample regions, and the resultant predictions should be field tested to determine how well prediction matches reality.

In the context of the broad applicability of the prototype model, it may be necessary to develop regionally based predictive models that reflect both macro-scale and micro-scale variability in human land use. In the context of macro-scale variability, we can expect differences along a north/south gradient which reflects differences in climate-induced biotic capacity. There might also be differences around the fringes of the subarctic

forest where different ecotonal boundaries are encountered. For example, the grassland-parkland in the southwest, the forest-tundra in the north, and the coniferous-deciduous hardwood forest in the southeast will each have offered different ecological options for local human populations in the past. Additional regional variation in prehistoric land use might be apparent in response to localized variation in the nature of the sediments, relief, and hydrological system. The implications of this variability can only be adequately measured by validity testing the prototype model in a wide range of geographic contexts. As was noted earlier, such testing will clearly be a long-term enterprise. Much of the discussion within this report series reflects a strong cultural-ecological focus whereby past human land use is assumed to be strongly affected by the physiographic, climatic and biotic structure of the land. These are not the only considerations that affected how prehistoric foragers likely used the land. All human groups may selectively incorporate ideas, personnel, technology, religious ideology and social organization from adjacent groups. Therefore, widely separated subarctic foragers who were exposed to different neighbours may display cultural variability that is not directly related to their particular ecological setting. For example, in the Rainy Lake and Lake of the Woods regions we can expect prehistoric aboriginal groups to have been influenced by adjacent populations of sedentary horticulturists in the headwaters of the Mississippi River valley and migratory big game hunters from the northeastern Plains. The most obvious example of such external in-

fluences is the prehistoric tradition for construction and use of burial mounds in the Rainy Lake/Boundary Waters region that is somehow related to similar cultural developments throughout the Mississippi River headwaters, and across the northeastern plains. These non-local contacts are also indicated, by exotic archaeological specimens such as the recovery of a Hopewell-derived pipe and projectile points from the Rainy River and Lac Seul areas (Kenyon 1970, 1986; Lambert 1982), and Wyoming obsidian artifacts from several sites across northwestern Ontario (Godfrey-Smith and Haywood 1984; Hamilton 1981). Late prehistoric foragers located in northeastern Ontario may have been exposed to completely different cultural pressures derived from contact with Huron horticulturists in the Georgian Bay region. Other non-ecological considerations affecting land use will include now-lost religious prohibitions against the use of specific resources or areas. Political and military considerations can also figure prominently in land use decisions. For example, Dene habitation sites have been reported to be located well back from exposed and visible shorelines to avoid confrontations

with their enemies (V. Petch 1994: per. comm.). Similar considerations likely affected land use in northwestern Ontario where there is a long standing oral tradition of warfare and contested land use between Algonkian-speakers and their allies, versus their Souian-speaking neighbours to the south.

While archaeologists and anthropologists make sweeping generalizations about the nature of subarctic hunting and gathering, it is important to point out that many discrete ethno-linguistic groups with unique cultural traditions animated the historically known past, and similar patterns of cultural diversity existed in the prehistoric past. From the discussion in Volume 2, some differences in land use across the subarctic were noted in the ethnographic record. It remains to be seen whether diversity between contemporaneous populations can be expected between, for example, Shield Archaic and Laurentian Archaic populations occupying different parts of northern Ontario. These and other issues is more fully addressed in relation to recommendation 3.

RECOMMENDATION 3

New variables should be developed and tested in order to improve the predictive strength of the prototype predictive model. This refinement process should focus upon presently unaddressed variables that are already identified as important, and also incorporate new data derived from the field testing process outlined in recommendations 1 and 2.

During the development of the prototype model, a number of possibly valuable lines of investigation became apparent. In order to maintain research focus, certain of these were not addressed fully. Further, as part of the process of prototype model testing, a number of new indicators of archaeological site distribution may come to light. This may include the identification of new mappable landscape variables that are associated with archaeological sites discovered as part of the validity testing process. Additional refinement may involve adjustment of the weighting associated with existing variables, and also the identification of variables that may be used to address land use considerations that we were not in a position to consider during the prototype modelling process. As these new considerations come to light, there should be a formalized feedback process whereby new information, critical commentary, and experimental models are integrated into succeeding generations of the predictive model(s). Some such considerations are offered for example purposes.

A recurring issue in the development of the prototype model is whether one predictive model is sufficient to address the entire temporal span of human history in the Boreal forest. This issue reflects several considerations. The first is the validity of using the ethnographic record of Native land use to develop analogies to be applied to the prehistoric situation. Is the seasonally-based settlement system that was so important in the historic period applicable to the Woodland cultural eras encompassing the past 2,500 years, and is it also useful to explain

human settlement in the Plano (9,500 and ca 7,000 BP) and Archaic (ca 7,000 and 2,000 BP) eras? The implications of this uncertainty has been addressed in Volumes 1, 2, and in earlier portions of Volume 5. If it is accepted for the moment that significant elements of prehistoric land use and tenure can be modelled by analogy from the historically known past, several considerations must be addressed.

One such issue is related to placing the ethnographic and ethnohistoric data in a proper temporal context. A critical examination and synthesis of land use in the early historic period is required in order to examine what relationship exists between the situation in the 1600s versus that in the late 1800s and early 1900s. Such a process of contextualization may reveal developmental trajectories of Native populations in response to the fur trade experience and, more importantly, offer insight into the nature of land use in the late prehistoric and early historic periods. Such an examination of the ethnohistoric record was beyond the scope of the current project. Future research could address uncertainties over the applicability of the ethnographic data summarized in Volume 2, and expand the utility of the 'cultural model' described earlier. Such an information base would also be of great value when OMNR turns to the task of addressing historic heritage values and the issue of 'contemporary traditional' land use.

Another issue is how do we account for the significant evolution of the physical landscape that has occurred throughout the post-

glacial period. While the magnitude of these changes have not been fully explored, presently available studies reveal that the landscape has changed dramatically over the past 10,000 years. Perhaps one of the best examples of this phenomena is apparent with the initial palaeo-hydrological reconstructions in the Lake Agassiz and Minong basins. In the Thunder Bay area, very large and culturally significant Plano age archaeological sites have been encountered associated with the relict shorelines of glacial Lake Minong (see Julig 1984, 1988; Julig, McAndrews and Mahaney 1990; Phillips 1988, 1993; Ross nd; Dawson 1983; and Fox 1975, 1979). These sites have been interpreted as shoreline aggregation camps that were repeatedly reused because they offered access to highly valued lithic quarrying locales, and a seasonally rich and reliable littoral habitat. These active shorelines of 8,000 years ago may now be located many kilometres from the current shoreline of Lake Superior, and might not be in any way associated with current hydrological systems. Because of their current upland context many such localities might potentially be within zones subject to current forest harvest activities. This situation is addressed in more detail in Hamilton's field survey report in Volume 6.

If the documentation of these ancient shorelines and stream systems has not been done, then these indicators of site potential may not be available for integration into a predictive model. As the prototype predictive model, by necessity, does not address landscape evolution, the importance of measuring the validity of the model is readily apparent. This situation should not be construed to suggest that the modelling approach is invalid. Rather, it emphasizes the importance of more testing, field validation and refinement before the predictive modelling approach is implemented as part of timber management planning. For example, let us suppose that during the field testing of the prototype model, archaeological sites are discovered in areas where it was predicted that a low potential for prehistoric human

activities existed. In such a situation, the first stage of predictive model refinement would involve a systematic examination of these sites to place them in a temporal and cultural context, and then determination of what landscape features are spatially associated with them. This contextualization of the sites is important to aid in determining whether they might, for example, represent late prehistoric hunting activities carried out at a distance from a base camp. Most of the sites discussed by Dalla Bona in Volume 6 likely represent these sorts of activities. Alternatively, the site contextualization process might indicate that a proportion of the newly discovered sites appear to be "base camps" that yield large assemblages of artifacts. Several archaeological sites reported by Hamilton in Volume 6 appear to be of this sort. In this latter circumstance, examination of the site(s) in terms of their local environment may reveal consistent patterns of association with landscape features that indicate the original rationale underlying site placement. If such contextualization leads to the identification of mappable landscape variables associated with the sites, then new inductively-derived variables might be identified to account for these sites which are presently not predicted by the prototype model. If these indicators can be mapped, then they can be integrated as a new series of variables in the next model generation.

Another consideration perhaps warranting the development of new variables is the fact that temporally transitory variables affect human land use over the broad span of time herein considered. As noted earlier, this reflects successional pressures that are constantly at work upon the structure and composition of the Boreal forest biome. For example, one such transitory variable is the affect of forest fires upon human land use. As discussed earlier, one means of dealing with this constantly occurring phenomenon is to treat fire as a random variable, and not address it. Another alternative might be to seek variables that might be indirectly or probabilistically related to the development

and spread of natural forest fires, and which are also currently mappable. Examples of some such possible variables might include reduced surface moisture (i.e. lower density of lakes and bogs), well-drained as opposed to water-saturated sediments, enhanced exposure to strong drying conditions, or greater probability of violent lightning storms. Considering the long history of human occupation of the subarctic, we might choose to ignore the short-term affect of inordinately wet versus dry years. Mapping variables that might predispose specific zones to repeated fire disturbance might offer a means of probabilistically predicting archaeological site potential. Because these areas have a higher probability of being burned, there may also be a greater probability that people were repeatedly attracted to them due to an enhanced biotic productivity. By extension, this will result in an enhanced probability for the presence of archaeological sites.

Success in generating new data layers, and refining the resolution of the prototype predictive model is conditioned largely by the development of more detailed and extensive thematic maps which address Pleistocene geomorphology, surficial geology, sedimentology, relief and so on. It is also dependent upon continued financial commitment to cultural heritage values mapping as part of timber management planning. These costs might be significantly reduced by establishing symbiotic research partnerships between OMNR and various universities and other public institutions that employ geomorphologists, sedimentologists, historians, historical geographers, anthropologists and archaeologists who are interested in linking their academic research interests to applied research problems. By contributing financially to the ongoing research interests of such academics, OMNR can gain a great deal of information without increasing its own staff levels. The relationship between the Centre for Forest Ecosystem Research and Lakehead University serves as a useful example of such productive collaboration.

RECOMMENDATION 4

A wide variety of digital data already exist. The Ministry of Natural Resources not only uses many of these data sources, but creates new data ‘in-house’. A program should be implemented that evaluates the full range of data available within MNR. This includes assessing its applicability to archaeological predictive modelling, evaluating its integrity, and coordinating its accessibility.

In conjunction with Recommendation 3, the refinement and eventual implementation of archaeological predictive modelling should include seeking out and evaluating existing data sources that might be valuable in generating established or new indicators of pre-historic human activity locations. This proc-

ess should begin by reviewing the existing digital data currently held by OMNR, and well as conventional analog data. This review will be valuable to aid in coordinating the process of data compilation, and identification of digital data sources will greatly reduce data production costs.

RECOMMENDATION 5

The process of technology transfer of the prototype predictive model from its current configuration as a research tool into an applied heritage management tool must be initiated. This involves evaluating how to fit archaeological predictive modelling into the process of Timber Management Planning.

The predictive modelling research summarized by this report series must be considered as the culmination of a research and development project. In conjunction with the process of model validity measurement and refinement, the next step involves implementing it as part of routine timber management planning. In fact, this implementation process is the primary subject of a one year study to be conducted during the 1994-95 fiscal year by Luke Dalla Bona (Pictographics, Ltd) under subcontract to

Lakehead University. This study will focus on applying predictive models within two timber management plans to evaluate how the predictive modelling process works within a timber management planning cycle. This pilot project will provide an indication to OMNR regarding the process of implementing archaeological predictive modelling, and an estimate of the time, finances and personnel levels needed to adopt this approach as a routine part of Timber Management planning.

RECOMMENDATION 6

Part of the process of “technology transfer” must involve the hiring and/or training of new kinds of planning staff within OMNR. This involves staff members who have professional training in Cultural Resource Management, and who have the necessary expertise in archaeological predictive modelling method and theory.

According to the *Timber Management Guidelines for the Protection of Cultural Heritage Resources* (Annon. 1991:6), “a heritage planner will be assigned to each timber management plan being prepared”. Review of the predictive modelling report series reveals many of the issues that are important for undertaking archaeological values mapping as part of Timber Management Planning. This discussion makes it clear that the heritage planners must have expertise in subarctic archaeology and anthropology and cultural resource management issues. Fur-

thermore, since archaeological predictive modelling is viewed as the only effective means of undertaking such heritage planning at a large scale, specialized skills in predictive modelling using GIS are also essential. Few archaeologists in Canada currently possess this range of skills. In order to first test and refine the prototype model, and then implement it as part of the Timber Management planning process, OMNR should begin clarifying the requisite skills needed, and identify the personnel to carry out these tasks.

RECOMMENDATION 7

Educational materials should be developed for OMNR planning staff that summarizes the culture history of northern Ontario, and also discusses the range and importance of cultural values introduced in the Guidelines for Heritage management. This education program will be particularly valuable if it is extended to include all workers within the forest industry since valuable information regarding site distribution may be generated from their informed observations.

This training process is necessary to address the fact that most OMNR timber management planning staff are not professionally trained heritage planners, are not aware of the nature, complexity and history of Aboriginal culture, nor heritage values from the post-contact era. Such training might involve development of documents that synthesize cultural heritage, or more innovative approaches using video or interactive computer applications.

Most of the people working within the forest regions of northern Ontario have minimal understanding and exposure to the nature, breadth and value of cultural heritage resources. Ironically, these are the same individuals most likely to encounter archaeological and other heritage values. Part of the training process should involve the development of well-illustrated handbooks which identify the range of archaeological re-

sources. Such a document could of great value for expanding the heritage resource inventory if people working in the forests are informed about the nature of archaeological remains. Part of this educational process could also involve establishing a reporting procedure whereby archaeologists attached to various ministries of the provincial government or public institutions could expedite the process of identifying recovered specimens, and integrating “site leads” into the heritage inventory. However, such educational processes must be taken with all due care given the vulnerability of heritage resources to looting. That is, the education process must also point out that excavating and removing archaeological specimens from their original context without a permit is an offence under the Ontario Heritage Act, and has a significant detrimental effect upon heritage resources.

RECOMMENDATION 8

The predictive model resulting from this project is designed to address prehistoric archaeological resources. There are other cultural heritage values yet to be addressed as part of timber management planning. The predictive modelling process outlined in the project may be useful in predicting and/or managing these other resources. This should be investigated further.

According to the “Timber Management Guidelines for the Protection of Heritage Resources” (Anon. 1991), four general categories of heritage values have been identified for consideration as part of Ontario Timber Management planning. These values include designated and undesignated archaeological sites (prehistoric and historic), heritage landscapes, historic properties and traditional land use practices by contemporary Aboriginal people. The current research initiative has exclusively focused upon the

prehistoric archaeological values. This has involved assessing the feasibility of applying archaeological predictive modelling to the Boreal forest of northwestern Ontario. While a predictive modelling approach is not always directly usable or appropriate for these diverse heritage values, the data management techniques discussed in this report series may prove useful in mapping and managing them as part of a values-mapping exercise.

RECOMMENDATION 9

The predictive modelling process developed as a result of this research project is applicable to a wide variety of cultural resource management situations including the planning and development of pipeline corridors, transmission lines, hydroelectric reservoirs, urban development, cottage development, among others. OMNR, in consultation with other interested regulatory and planning agencies should collaborate in refining the approach for information management, or land and resource planning. The predictive model should be used to address heritage resource management outside the scope of timber management planning.

Large-scale environmental impact assessment has become a major issue for public regulatory agencies and private development projects. As an increasingly wide range of values are integrated into such impact assessments, major problems are encountered in managing the data base, and coordinating it to facilitate informed decision making. Many of these land management and development projects are gradually moving towards large scale information management. Inevitably this results in a great deal of expensive replication of effort as each agency

initiates development of a methodology. Coordination of effort, and collaboration in research and development would greatly facilitate the eventual refinement of predictive modelling and computerized information management. The current effort at archaeological predictive modelling should be used as a catalyst for such coordination in order to maximize the return on the expenditure of public financial resources. Serious consideration of the marketability of the predictive modelling approach for cost recovery should also be made.

RECOMMENDATION 10

As the process of predictive model refinement proceeds and as it is gradually integrated into timber management planning, a process of “auditing” should be initiated to assure coordinated and appropriate use of the modelling process.

The timber management planning process engaged in by OMNR is a complex exercise that integrates a wide range of values. It is also carried out by small planning teams operating at the OMNR District level. While this approach offers significant advantages, the potential for poor coordination of effort, and inconsistent standards is also very real. To combat this potential problem, particularly during refinement and initial implementation of predictive modelling, OMNR should initiate an auditing process by external advisors. This external audit should focus both upon the process of heritage resource management, and the methods used. That is, how much variability occurs from one Timber Management Plan to the next with regard to heritage values mapping? How

much of the process is standardized throughout Ontario, and is variability in the predictive modelling technique reflecting; 1) regional variability in the heritage resource base, 2) regional variability in the composition, resources and expertise of the planning teams, 3) differing opinions regarding the importance, range and weighting of variables used in applying a predictive model. This process of auditing is important in order to control the conflicting priorities of maintaining a province-wide consistency of standards within the planning process, the need for long term experimentation and refinement in the modelling process, and regional flexibility to reflect variation in the cultural phenomena being modelled.

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