Wabanaki Traditional Cultural Lifeways Exposure Scenario

Netukulimk refers to the Mikmaq way of natural resource conservation and stewardship. The root words mean getting provisions and making a livelihood from the land, and elders translate it as 'taking only what you need in order to avoid not having enough.' ***Barsh, 2002***

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ABSTRACT

This project was a coordinated effort among the five federally recognized Tribal Nations in Maine and the US EPA. It was produced under a Direct Implementation Tribal Cooperative Agreement (DITCA) awarded to the Aroostook Band of Micmac Indians on behalf of the five Tribal Nations in Maine. A DITCA is a unique funding mechanism authorized by law and developed by EPA for the purpose of awarding Cooperative Agreements to Federally Recognized Indian tribes to assist the US Environmental Protection Agency (EPA) in implementing Federal environmental programs in Indian Territories. EPA is required by law to have sufficient information to protect designated tribal uses when reviewing or approving water quality standards applications and this funding mechanism allowed EPA to work cooperatively with the Maine tribes to collect sound scientific data documenting tribal cultural practices and resource utilization patterns in the form of tribal exposure scenarios.

This project has resulted in the development of the Wabanaki Cultural Lifeways Exposure Scenario ('Scenario'), a numerical representation of the environmental contact, diet, and exposure pathways present in traditional cultural lifeways in Maine. These traditional uses are described as a single best representation of subsistence-traditional lifeways. This project report is intended to reflect the lifeways of people fully using natural resources and pursuing traditional cultural lifeways, not lifeways of people with semi-suburban or hybrid lifestyles and grocery-store diets. Present-day environmental conditions may not allow many people to fully engage in a fully traditional lifestyle until resources are restored, but this is still an 'actual' and not 'hypothetical' lifestyle. This project will help to ensure that exposure pathway information that is collected for the Tribes in Maine will not be biased by contemporary consumption rates.

The Exposure Scenario is presented in a format typically used by regulatory agencies during development of environmental standards and evaluation of baseline environmental risks. This project enables EPA to assess the relation between traditional cultural lifeways (sometimes referred to in the report as the shorthand term 'subsistence') and contemporary applications of this information (development of standards or risk assessment).

Keywords: Native American, exposure, scenario, lifeways, cultural, diet, Maine

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"It is true we have not always had the use of bread and of wine which your France produces; but, in fact, before the arrival of the French in these parts, did not the MicMac live much longer than now? If we have not any longer among us any of those old men of a hundred and thirty to forty years, it is only because we are gradually adopting your manner of living, for experience is making it very plain that those of us live longest who, despising your bread, your wine, and your brandy, are content with their natural food of beaver, of moose, of waterfowl and fish, in accord with the custom of our ancestors and all of the MicMac Nation."

Anonymous, MicMac, 1676.



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EXECUTIVE SUMMARY

This document presents the Wabanaki Cultural Lifeways Exposure Scenario, a numerical representation of the environmental contact, diet, and exposure pathways present in traditional cultural lifeways in Maine. This project was a coordinated effort among the five federally recognized Tribal Nations in Maine and the US EPA. It was produced under a Direct Implementation Tribal Cooperative Agreement (DITCA) awarded to the Aroostook Band of Micmac Indians on behalf of the five Tribal Nations.

In order for this project to be awarded as a Direct Implementation Cooperative Agreement by US EPA, a number of EPA offices needed to concur that the work conducted under this agreement constituted Direct Implementation activities and the Maine Tribal Governments needed to pass Tribal Council Resolutions to participate in this project. Each Tribal Nation passed a Tribal Resolution to participate in this project and reviewed and approved the document after it was completed.

The DITCA is significant in the following ways:

a. It is a unique funding mechanism authorized by law and developed by EPA solely for the purpose of awarding Cooperative Agreements to Federally Recognized Indian tribes to assist the Agency in implementing Federal environmental programs in Indian Territories.
b. It recognizes that EPA is required by law to have sufficient information to protect designated tribal uses when reviewing or approving water quality standards applicable to Indian territories in Maine.
c. It allows EPA to work cooperatively with the Maine tribes to collect sound scientific data documenting tribal cultural practices and resource utilization patterns in the form of tribal exposure scenarios.
d. These exposure scenarios will ensure that tribal cultural practices and resource utilization patterns are addressed, no matter who develops water quality standards.

The purpose of this report is to describe Maine tribal traditional cultural uses of natural resources, and to present them in a format that can be used by EPA to evaluate whether or not tribal uses are protected when they are requested to review or develop water quality standards in waters that include Indian territories in Maine. These traditional uses are described as a single best representation of subsistence-traditional lifeways. Present-day environmental conditions may not allow many people to fully engage in a fully traditional lifestyle until resources are restored, but this is still an ‘actual’ and not ‘hypothetical’ lifestyle.

Water quality standards are adopted by Tribes, states, and the federal government to protect public health or welfare and provide for the protection and propagation of fish, shellfish, and wildlife and for recreation in and on the water. The development of numeric or narrative water quality standards requires information regarding the uses of water resources, and about potential exposure pathways and impacts to humans and plant and animal species. This report will enable EPA to understand Tribal use of the water resource for food, medicine, cultural and traditional practices, and recreation so that EPA can evaluate whether or not those uses are protected regardless of who develops water quality standards. The next steps in actually developing water quality standards are beyond the scope of this report.

In addition, the scenario will also support other cumulative exposure and risk assessments reflecting tribal uses of natural resources. This document is not a risk assessment, which would require knowledge of contaminants in various media. However, information presented in this scenario about environmental exposure pathways (inhalation, water and soil/sediment ingestion, and diet) may be combined with information about contaminants in air, water, soil/sediment, or natural resources used as food, medicine, or materials to answer specific questions about risk. For example:

a. Baseline risks may be estimated by coupling contamination information with the scenario presented in this document. This would answer the question, "What would risks be if people used resources (with their current contaminant levels) in their traditional manner?"
b. Environmental standards and cleanup levels can be derived by asking, "How clean do the resources need to be in order to ensure that traditional resource utilization patterns are safe?"

This report provides EPA with scientifically sound data that describes traditional uses, not contemporary uses that are suppressed or distorted for many individuals by lack of access, resource degradation, or knowledge of contamination. In other words, this report enables EPA to evaluate and protect Traditional Tribal uses of natural resources This report does not reflect lifeways of people with semi-suburban or hybrid lifestyles and grocery-store diets, but the lifeways of people fully using natural resources and pursuing traditional cultural lifeways.

An advisory board consisting of technical representatives from each of the five Maine Tribes guided this project, and the Cultural Departments from each Tribe reviewed the information periodically throughout the development process. Subject matter experts were also consulted during the development of the report. The entire process of developing the scenario included many iterations of consultation with Maine Indian tribal elders, tribal councils, tribal cultural resource experts, and tribal natural resource departments on the accuracy and relevancy of the historical data and the draft conclusions concerning natural resource utilization patterns and traditional Native American lifestyles.

The basic process for developing the diet and direct exposure factors was to:

(a) Develop ecological descriptions for Maine;
(b) Conduct a literature search of credible historical records concerning the traditional lifeways and foods of Native Americans in Maine;
(c) Gather pertinent archeological and anthropological information;
(d) Develop an understanding of the major categories of subsistence activities (such as hunting, fishing, gathering, basket making, and so on);
(e) Identify the major human activities that contribute to environmental contact, and identify the major dietary staples;
(f) Evaluate the relative proportion of major food groups, and evaluate nutritional information, total calories and quantities of foods;
(g) Iteratively crosswalk between activities and conventional exposure factors to develop exposure factors for inhalation rates and soil and water ingestion

Because there are no databases with statistical food consumption data or time-activity data for Native Americans, the scenario is essentially a reconstruction from the literature. Information from several types of literature (ethnohistorical, ecological, nutritional, archaeological, and biomedical) was reviewed to develop a description of Wabanaki traditional subsistence lifestyles and diets through the lens of natural resource use and activities necessary to survive and thrive in Maine environments. Although the information used to develop a nutritionally complete diet is taken from literature that describes diets from the 16th, 17th, 18th, and 19th centuries, this information is still relevant today even if that diet is eaten by fewer people at present. Again, the purpose is to describe the lifestyle that was universal when resources were in better condition and that some tribal members practice today (and many more that are waiting to resume once restoration goals and protective standards are in place). We recognize that the Wabanaki homelands extended further west and south into areas with different plants and climate and where farming was possible, but the scenario itself covers only areas most heavily used by Tribal members at present, and where farming is marginal due to climate.

Based on the ecological habitats present in Maine, we concluded that three ecologically-derived lifestyles encompass the range of natural resource utilization patterns:

a. Inland bands generally inhabited large permanent villages at waterway confluences or large lakes because those sites provide:
    - ease of travel up and down river to seasonal specialty camps with seasonal occupation that reflect resource diversity and local microclimate conditions,
    - stable and reliable resources, particularly fish, deer, moose, and beaver,
    - good sources of fresh water,
    - locations on trade and communication routes,
    - protection in winter with water, shelter, and firewood,
    - known location of some inland villages at sites of anadromous fish runs and other villages at sites without such access; therefore two dietary variants are developed for this report:
        1. a diet including anadromous and resident aquatic resources
        2. a diet including only resident aquatic resources

b. Coastal bands moved along the littoral zone and within an estimated 50 miles of the coast with seasonal inland (upriver) forays to acquire other resources and to trade. The permanent villages were typically located at the heads of estuaries because those sites provide:
    - ease of travel upriver
    - stable and reliable resources, particularly shellfish and anadromous fish
    - good sources of fresh water
    - sheltered winter sites and open summer sites
    - a single coastal diet

Scenarios and diets are presented in a way to allow mix-and-match variations, proportional to the amount of time spent inland or along the coast, and adaptable to local microclimate conditions.

1. INTRODUCTION

1.1 Purpose

This document presents the Wabanaki Cultural Lifeways Exposure Scenario ['Scenario'] for the five Maine Tribes. This scenario includes three regional diets that are applicable to Maine's three primary habitat types east of the Kennebec River. It describes subsistence lifestyles that Maine's indigenous societies pursued in order to survive and thrive in its inland and coastal ecologies, and the lifestyle characterized by hunting, gathering, and fishing. We recognize that the Wabanaki homelands extended further west and south into areas with different plants and climate and where farming was possible, but the scenario itself covers only areas most heavily used by Tribal members at present, and where farming is marginal due to climate.

The goal of the DITCA was to collect scientifically sound data with a high degree of quality control, consistent with Section 104 of the CWA and with general risk assessment guidance to document tribal cultural practices and resource utilization patterns. For each of the five federally recognized Tribes in the State of Maine, Tribal culture is inextricably linked to water resources, including the food, spiritual, medicinal, economic, and recreational resources that are derived from the water and associated natural resources. Protection of water resources and other natural resources is therefore vital for the sustenance and cultural survival of the Tribes and for the health and well being of Tribal members who are dependent upon the water resources.

1.2 Process and Quality Assurance

In order for this project to be awarded as a Direct Implementation Cooperative Agreement by US EPA, a number of EPA offices needed to concur that the work conducted under this agreement constituted Direct Implementation activities and the Maine Tribal Governments needed to pass Tribal Council Resolutions to participate in this project. Each Tribal Nation passed a Tribal Resolution to participate in this project and approved the document after it was completed. The following EPA offices concurred that this project consisted of Direct Implementation activities on behalf of the US EPA:

1. American Indian Environmental Office in Head Quarters;
2. Office of Water in Head Quarters;
3. Region 1 Office of Water
4. Office of General Counsel;
5. Office of Regional Counsel;
6. Standards and Health Division in the Water Quality Standard Branch of Head Quarters;
7. Water Quality Standards Division in Region 1; and
8. Region 1 Indian Program.

Upon completion of the draft "Wabanaki Traditional Cultural Lifeways Exposure Scenario", either a presentation was made or the document was shared with the Maine Indian Tribal Councils i.e. The Aroostook Band of Micmacs, the Penobscot Indian Nation, the Passamaquoddy Tribe at Pleasant Point, the Passamaquoddy Tribe at Indian Township and the Houlton Band of Maliseet Indians, and was approved by each Tribal Nation. In addition, EPA Region 1 Office of Ecosystem Protection approved the scientific peer review conducted for this study. (See APPENDIX 3 for a list of peer reviewers)

Figure 1. Scenario development process

An Advisory Board composed of tribal and EPA representatives guided the entire process of developing the scenario. This Board approved the overall process (Figure 1) used to produce this document. To ensure the highest quality and reliability, a process of internal and external peer review by both cultural and technical experts was followed before, during, and after the preparation of the Scenario. The first step was a thorough literature review, particularly of the ethnohistorical literature related to the Maine Tribes and Wabanaki (referred to as Abenaki in some of the literature) peoples. Information on natural resource use was extracted and evaluated for credibility. Information about the ecology was also collected from ecological and anthropological literature and compared to reports of natural resource use. After the information was collated, it was reviewed by project advisors and other technical and cultural experts during the internal review process. This part of the process also included the anthropologist traveling, by car, to each Wabanaki community and vetting the literature and some very initial drafts of the exposure scenario with tribal historic preservation or natural resources personnel and other community cultural experts and elders. This process created the opportunity for better science, as community-based experts had the opportunity to create a critical dialogue regarding the scientific evidence already in the public domain

After tribal consultation on the initial anthropological and ecological data, the information about resource use was extracted and put into a format used in regulatory applications (‘exposure pathways’ and ‘exposure factors’). A review draft was prepared for scientific peer review. EPA scientific peer review is intended to uncover any technical problems or unresolved issues in a preliminary (or draft) work product through the use of independent experts. This information was used to revise the draft product so that the final work product reflects sound technical information and analyses. Peer review is a process for enhancing a scientific or technical work product so that the decision or position taken by the Agency, based on that product, has a sound, credible basis. Peer review was conducted because the goal of peer review is to obtain an independent, third-party review for ensuring scientific integrity and technical credibility of the work product that supports a policy or decision. Accordingly, this Exposure Scenario study was extensively peer reviewed, by a diverse cross section of 12 different external peer reviewers including Toxicologists, Tribal risk assessors, EPA risk assessors, Ecologists, Anthropologists, State of Maine representatives and Tribal Cultural experts to ensure the scientific integrity and technical credibility of this project. All comments gathered during the peer review process were addressed and the final report was accepted by EPA as a scientifically peer reviewed work product. In addition, all the Maine Tribal Nations approved the final work product.

The Maine Tribes developed a process through Tribal legal counsel to ensure that the conclusions reached through this process satisfy appropriate court rules for admissibility of expert testimony, since the data presented in this Exposure Scenario are intended to provide information regarding Tribal uses of water bodies to assist EPA regulators in determining if designated uses meet the requirements of the CWA and its implementing regulations at 40 CFR 131.10. This process was also developed so that the data could be used to assist EPA to ensure that water quality standards applicable to waters within Indian Territories of Maine are protective of Tribal cultural practices and resource utilization patterns. A set of technical, ethical, and procedural rules were followed (adapted from Harris and Harper, 1997; Harper et al., 2002). They were intended to ensure quality, objectivity, utility, and integrity of information, and also to ensure that truly informed consent was obtained.

1. Principles of objectivity and the scientific method were followed.[1] This criterion has been satisfied by obtaining peer review from qualified colleagues ("the relevant scientific community").

    - "Objectivity" involves both the presentation and substance of information. In order for information to be considered objective, it must be presented in an accurate, clear, transparent, complete, and unbiased manner. The information must be presented in the proper context, and the source and data or models must be identified so that the reader can evaluate the objectivity of the sources.
    - The technical substance of the report must be accurate, reliable and unbiased. Agencies must identify the data sources, the results or conclusions, the methods used to produce the results or reach a conclusion, and provide full, accurate, and transparent documentation. In order to make this process as transparent as possible, this scenario primarily relied on open peer-reviewed literature and ethnographic documents and reports concerning traditional lifestyles and practices. Thus, all the source information is available and reviewable.
    - Sound research methods must be used to generate original and supporting data and development of analytical results. Research that is not statistical in nature, such as the development of this scenario, should rely on other accepted methods such as expert elicitation to develop best professional judgments. The development of the Wabanaki scenario included an internal review process which included extensive interactions with tribally-recognized cultural experts. This latter expertise derives from their traditional or indigenous environmental knowledge, and from their acknowledged expertise and standing. Further, oral history is a hallmark of Tribal knowledge and education, so direct interaction with elders is very important. To the extent possible, discussions in the native language are very important since immersion in the language and eco-cultural lifeways reveal many concepts about identity and interrelationships that do not translate into English in a linear one-to-one manner. A simple example is the function of native foods as simultaneous nutritional, medicinal, and spiritual nourishment – a simple English listing of foods would miss these added dimensions.
    - Data subjected to formal, independent, external peer review, is presumed to be of acceptable objectivity. The thought process must be explained clearly enough that the validity of the judgment can be evaluated. Development of the Wabanaki scenario also included external peer review.
    - Information also must be reproducible to demonstrate its objectivity. "Reproducibility" means that the information is capable of being substantially reproduced, subject to an acceptable degree of imprecision. Multiple lines of evidence should lead to the

[1] Modified from: http://library.findlaw.com/2003/Jan/14/132464.html

same general conclusion. The scenario should be accepted by colleagues as reasonable. The external peer review process included this consideration.

2. In addition to being scientifically relevant and reliable, the scenario must also be culturally relevant and reliable. The process must be culturally sensitive, respectful, draw on traditional environmental knowledge (such as the observational expertise of elders), and must be developed in partnership with tribal cultural and technical experts. Collaboration with the cultural and natural resources programs among the Maine Tribes provided this assurance. The Wabanaki scenario with three diets was developed through a community-based participatory process, which provided an avenue to foster a strong, communicative relationship. It was based on the principles of meaningful consultation, in which all players come to the table and have equal parts in the decision-making process, establishes cultural credibility, obtains truly informed consent, and reflects the local the knowledge system and customary means of exchanging materials and information. The methodology used to reach the conclusions of this study incorporated information from a variety of disciplines, including cultural and traditional environmental knowledge. Specifically, tribal staff indicated which literature sources were considered to be the most accurate. They also aided in the refinement of the dietary components by identifying natural resources and their relative importance that the anthropological literature may have generalized too much. Additionally, this process ensured that present-day information and relevance was also included and not just older information from the literature.

3. The principles of informed consent must be followed. Even though human subjects research was not a part of the scenario development, the consequences of underestimating exposure rates could have such an adverse impact on tribal health and sovereignty that an extra level of effort was made.

   - Because tribal leaders are not trained in risk assessment methodology, an additional effort was expended in discussing the overall approach and assumptions with tribal leaders and cultural departments. Each Tribe (through designated representatives) included under the Wabanaki scenario gained a basic understanding of the process and methods and reviewed both the technical merits and cultural relevancy.
   - Informed consent includes a requirement for full disclosure, including the risks, benefits, and uncertainties, as well as the requirement for transparency. The risk of underestimating exposure rates and the risks of an external agency misusing the information were considered internally before proceeding with the project.
   - The tribal technical staff that provided direct oversight were also involved at every step, and feedback was continually requested. A variety of discussions and presentations were made, and questions were encouraged.

2. CONTEXT OF THIS SCENARIO

Traditional cultural lifeways did not fade away as settlements intruded; they are alive and vibrant, albeit often adversely impacted by natural resource degradation. When this scenario is used in a regulatory process or risk assessment, the intention is to develop standards to ensure that traditional subsistence uses are safe, or to evaluate risks that would occur if resources were fully used in traditional ways. This section describes the information that risk assessments or standards development require, and describes what the term 'subsistence' means in this report (briefly, subsistence simply means full resource use in an exposure assessment context).

2.1 Regulatory Context

The report is not a risk assessment, but the information on exposure pathways presented in this report may be combined with contaminant information to create a risk assessment. The development of numeric or narrative water quality standards and the evaluation of risks require information regarding the use of water and other resources and about potential exposure pathways in order to evaluate impacts to humans and plant and animal species. Unfortunately, detailed and accurate information about activity, food, and water usage patterns for the Maine Tribes and other indigenous communities does not currently exist. One seemingly quick way to collect exposure pathway information is to conduct surveys of current consumption or natural resource usage. However, there are several important concerns associated with this approach. Since the Indian Tribes in Maine have only recently begun to regain a sufficient land base to support natural resource utilization activities and to restore depleted natural resources, current natural resource utilization rates are, on the average, lower than historical consumption rates. The relationship of this factor to several other important factors, including social oppression, economic factors, and current fears about the safety of consuming natural resources (i.e. fish advisories, etc), severely compromises the effectiveness of a consumption survey to accurately characterize the exposures that would occur during fully traditional use. Furthermore, consumption surveys do not typically evaluate other potentially elevated exposure risks associated with practicing a subsistence lifestyle, such as increased incidental ingestion of sediment and soil or increased respiration rates.

In addition to concerns associated with suppressed consumption, there is also a danger that current consumption data may be unintentionally misinterpreted by regulatory agencies to make regulatory decisions about acceptable levels of pollutants in the environment. Specifically, a regulatory agency might assume that Tribes want to use natural resources only as much as they are doing so today. In other words, evaluating only today's tribal exposures and risks, and then setting standards or risk levels based on today's risks could prevent safe uses at higher usage rates (i.e., as restoration improves resource availability, resource cleanliness must increase in parallel).

Under the paradigm used by the federal government (NRC, 1983), risk derives from the combination of human contacts with natural resources, contamination data, and the toxicity of the contaminants (Figure 2). Exposure scenarios are used in the human health risk assessment process to describe how people come into contact with natural resources (e.g., air, water, soil, food) (Figure 3). The particular format used in this report assumes that it will be used in a risk-based decision process at some point.

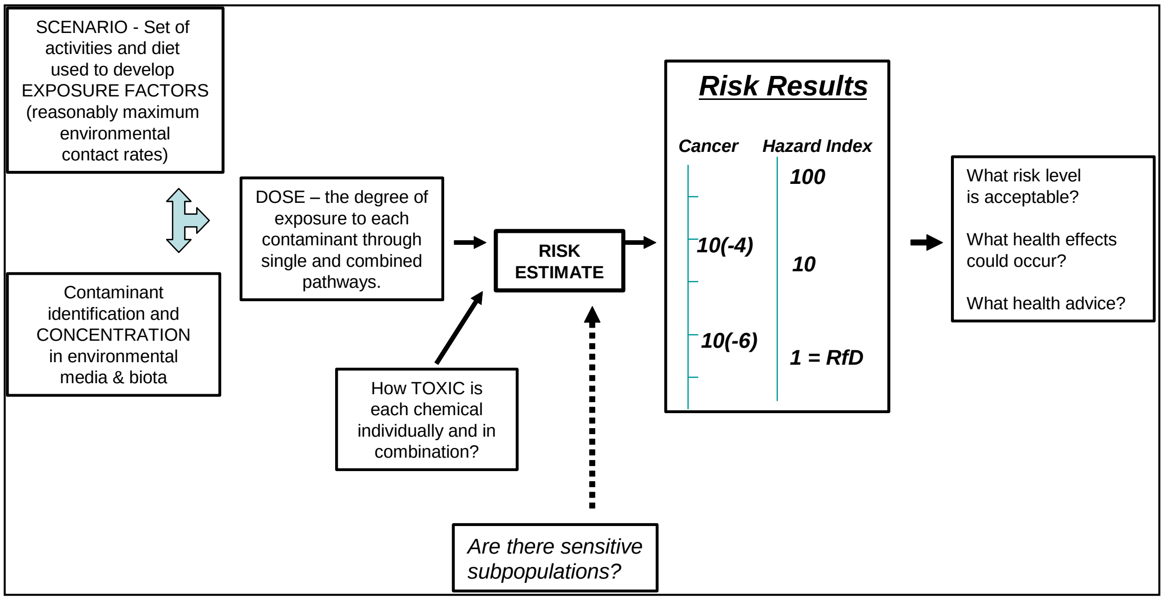


Figure 2. Risk assessment process

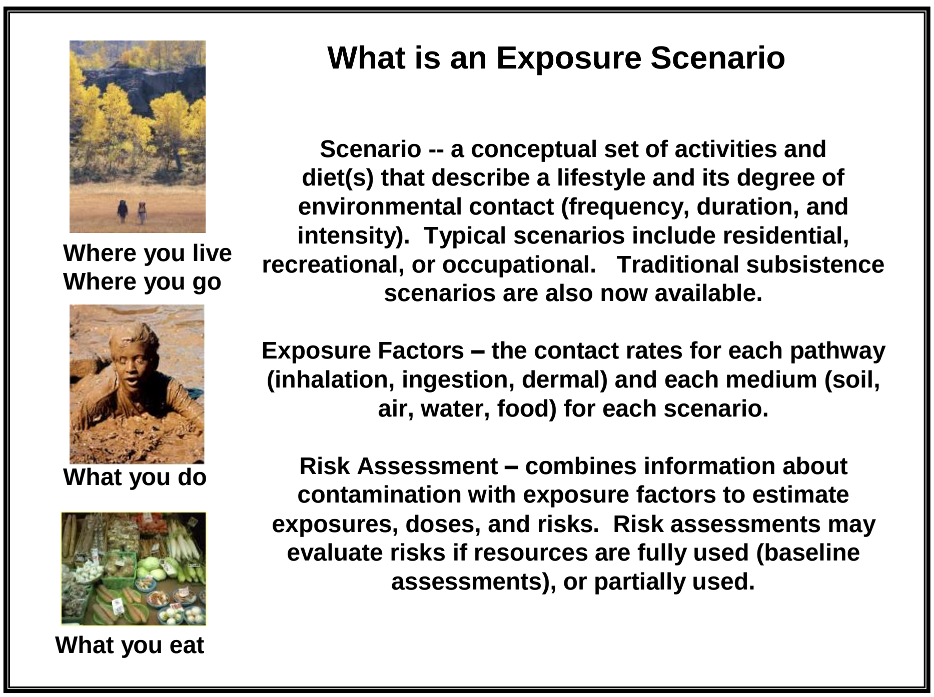


Figure 3. Basic Elements of an Exposure Scenario

The basic tool used to evaluate contact rates with natural resources is the exposure scenario (Figure 3). The Maine Tribes' scenario reflects full traditional resource uses. Because statistical food consumption and time-activity survey data are not available for describing traditional cultural lifeways, the scenario is essentially a reconstruction from the literature.

In order to most accurately describe the traditional lifestyle that was (and is) fully integrated into the ecology, the primary sources of information were the anthropological and ethnohistorical literature, and confirmation by interviews with tribal cultural departments. This reconstruction reflects the objective of many Tribes to regain land, restore resources, and encourage more members to practice healthier (i.e., more traditional) lifestyles and eat healthier (i.e., more native and local whole) food.

The information obtained from the ethnohistorical literature is generally qualitative or semi-quantitative, yet risk assessments require deterministic or probabilistic numerical inputs in the form of exposure factors. This scenario provides a reasonable representation (central tendency) of the traditional cultural lifeways. Due to the semi-quantitative and professional judgment approach, ranges or distributions for the exposure factors were not developed. Therefore, single best-professional-judgment estimates for direct exposure pathways (inhalation, soil ingestion, water ingestion) are presented along with the three diets that reflect the three major Maine habitat types.

2.2 Traditional Cultural ("Subsistence") Context

This document focuses only on the human exposure component of a risk assessment. The shorthand label 'subsistence' is often used to refer to all Tribal risk assessments and all aspects of Tribal culture. However, traditional cultural lifeways are more than simply obtaining calories. In the larger context, tribal health and well-being are also part of the risk framework because they are also at risk from contamination of natural resources. Tribal members associate the loss of culture, language, education, identity, and heritage directly with the practices that are unavailable as a result of contamination. These cultural losses adversely affect all tribal members due to impacts to the health and well-being of the entire community.

A public health approach to risk assessment naturally integrates human, ecological, and cultural health into an overall definition of community health and well-being that is widely used in public health but not in risk assessment. The combination of subsistence lifeways and public health is adaptable to indigenous communities that, unlike westernized communities, turn to the local ecology for food, medicine, education, religion, occupation, income, and all aspects of a good life (Harris, 1998, 2000; Harper and Harris, 2000).

"Subsistence" in the narrow sense refers to the hunting, fishing, and gathering activities that are fundamental to the way of life and health of many indigenous peoples. An explanation of "subsistence" developed by the Tribal Science Council is as follows.[2]

> "Subsistence is about relationships between people and their surrounding environment, a way of living. Subsistence involves an intrinsic spiritual connection to the earth, and includes an understanding that the earth's resources will provide everything necessary for human survival. People who subsist from the earth's basic resources remain connected to those resources, living within the circle of life. Subsistence is about living in a way that will ensure the integrity of the earth's resources for the beneficial uses of generations to come.

[2] Tribal Science Council (2002). "Subsistence: A Scientific Collaboration between Tribal Governments and the USEPA." Provided by John Persell (jpersell@lldrm.org).

> Tribal cultures assign great value to being thankful for the earth's resources, as well as to learning and utilizing the traditional environmental knowledge that emanates from resource use and observation. Traditional knowledge is an integral part of subsistence and is passed down from generation to generation. Subsistence is concerned with the inter-relationship of water, air, fish, wildlife, plants, and soils on a time scale pertinent to traditional knowledge."

The more concrete aspects of a subsistence lifestyle are important to understanding the degree of environmental contact and the ways that subsistence is practiced in contemporary times. Also, spiritual connections are sometimes based upon observation, and traditional knowledge can be learned directly from nature. Subsistence utilizes traditional and modern technologies for harvesting and preserving foods as well as for distributing the produce through communal networks of sharing and bartering. The following is a useful explanation of "subsistence," slightly modified from the National Park Service:

> "While non-natives tend to define subsistence in terms of poverty or the minimum amount of food necessary to support life, native peoples equate subsistence with their culture. Among many tribes, maintaining a subsistence lifestyle has become the symbol of their survival in the face of mounting political and economic pressures. It defines who they are as a people. To Native Americans who continue to depend on natural resources, subsistence is more than eking out a living. While it is important to the economic well-being of their communities, the subsistence lifestyle is also the basis of cultural existence and survival. It is a communal activity. It unifies communities as cohesive functioning units through collective production and distribution of the harvest. Some groups have formalized patterns of sharing, while others do so in more informal ways. Entire families participate, including elders, who assist with less physically demanding tasks. Parents teach the young to hunt, fish, and farm. Food and goods are also distributed through native cultural institutions. Most require young hunters to distribute their first catch throughout the community. Subsistence embodies cultural values that recognize both the social obligation to share as well as the special spiritual relationship to the land and resources. This relationship is portrayed in native art and in many ceremonies held throughout the year."[3]

In economic terms, a subsistence economy is one in which currency is limited because many goods and services are produced and consumed within families or bands, and currency is based as much on obligation and respect as on tangible symbols of wealth and immediate barter. It is well-recognized in anthropology that indigenous cultures include networks of materials interlinked with networks of obligation. Together these networks determine how materials and information flow within the community and between the environment and the community. Today, there is an integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors.[4] For example, subsistence in an Arctic community includes the following:

> "The modern-day subsistence family depends on the tools of the trade, most of which are expensive. Snowmobiles, gasoline, guns, fishing nets, and sleeping bags are necessities. Subsistence households also enjoy many of the modern conveniences of life, and are saddled with the economic demands which come with their acquisition. Today's subsistence family generates much-needed cash as wage-laborers, part-time workers and trappers, professional business people, traditional craft makers, and seasonal workers. A highly-integrated interdependence between formal (cash-based) and informal (barter and subsistence-based) economic sectors has evolved."[5]

[3] National Park Service: http://www.cr.nps.gov/aad/cg/fa_1999/Subsist.htm
[4] http://arcticcircle.uconn.edu/NatResources/subsistglobal.html
[5] http://arcticcircle.uconn.edu/NatResources/subsistglobal.html

3. METHODS

Development of the Wabanaki scenario starts with a general description of baseline natural resources that are or could be available to the Tribes in Maine. It then describes the activities that Wabanaki people undertake, including hunting, gathering foods and medicines, fishing, collecting firewood, making material items, and various other cultural and domestic activities. Once the activities comprising a particular lifestyle are known, they are translated into a form that is used for risk assessment. This translation captures the degree of environmental contact (frequency, duration, and intensity) that occurs through activities and diet, expressed as numerical “exposure factors.” Exposure factors for direct exposure pathways allow the estimation of exposure to any contaminants in abiotic media (air, water, soil, and sediment), via inhalation, soil ingestion, water ingestion, and/or dermal exposure. Indirect pathways refer to contaminants that are incorporated into biota and may subsequently reach people who ingest or use them.

The basic process for developing the direct exposure factors is to:

a. Start with an understanding of the major categories of subsistence activities (such as hunting, fishing, gathering, basket making and so on),

b. Describe enough of the sub-activities that the complexity and interconnection of resources and activities can be appreciated,

c. Identify the major activities that contribute to exposure, and then

d. Iteratively crosswalk between activities, frequency, intensity, and duration of environmental contact to develop exposure factors.

For the direct exposure factors, each of the major activity categories includes activities that result in exposure to each medium. For example, by estimating the relative amount of time spent in activities that result in high, medium, or low soil contact rates for each activity category, an overall soil ingestion rate was estimated. However, we did not attempt to be overly quantitative in enumerating the myriad of activities and resources in each category because this implies more precision than is warranted. Thus, each crosswalk is a systematic estimate but not a statistical exercise.

When developing an exposure scenario for the general U.S. population, there are national databases available for exposure factors (e.g., contemporary diets and human activity data) that have been summarized in EPA guidance. For the general suburban population the exposure scenario used in risk assessments is well defined in EPA guidance (EPA, 1992, 1997)[6]. However, there are no tribal-specific databases of subsistence activities, resources, or diets as there are for the general U.S. population. Cross-sectional surveys of most contemporary tribal populations will not generate that data because much resource use is currently distorted due to loss of land and access, awareness of contamination, and other reasons. Further, tribal communities often include people who rely largely on the natural environment as well as people who partake in the western economic system to varying

[6] U.S. EPA. Exposure Factors Handbook (1997) http://www.epa.gov/ncea/efh/ *and*
Guidelines for Exposure Assessment. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, 600Z-92/001 (1992) http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=15263

degrees. Together, this means that large statistical distributions for subsistence exposure factors are not available and cannot be developed. Finally, targeting the most traditional members of Tribal communities with computerized survey tools is intrusive and generally unwelcome. Rather, a multidisciplinary ethnographic and eco-cultural approach was taken to describe the Wabanaki lifestyle with confirmatory interviews with Tribal cultural and natural resource departments (Figure 4).

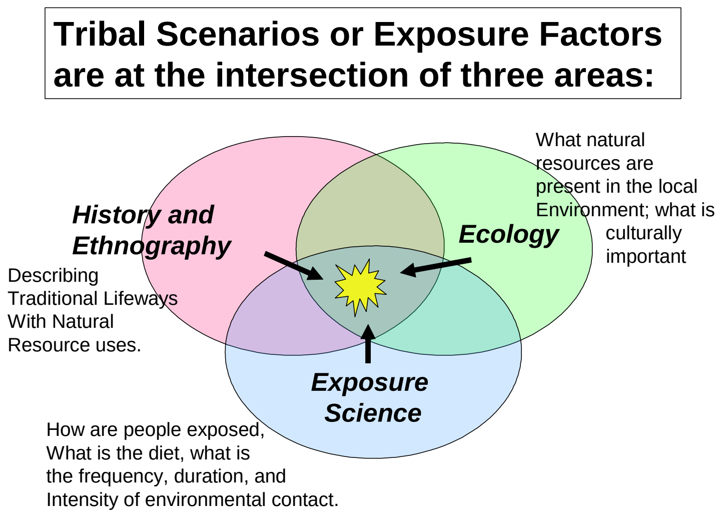


Figure 4. Multidisciplinary Information Base for Describing Traditional Lifeways

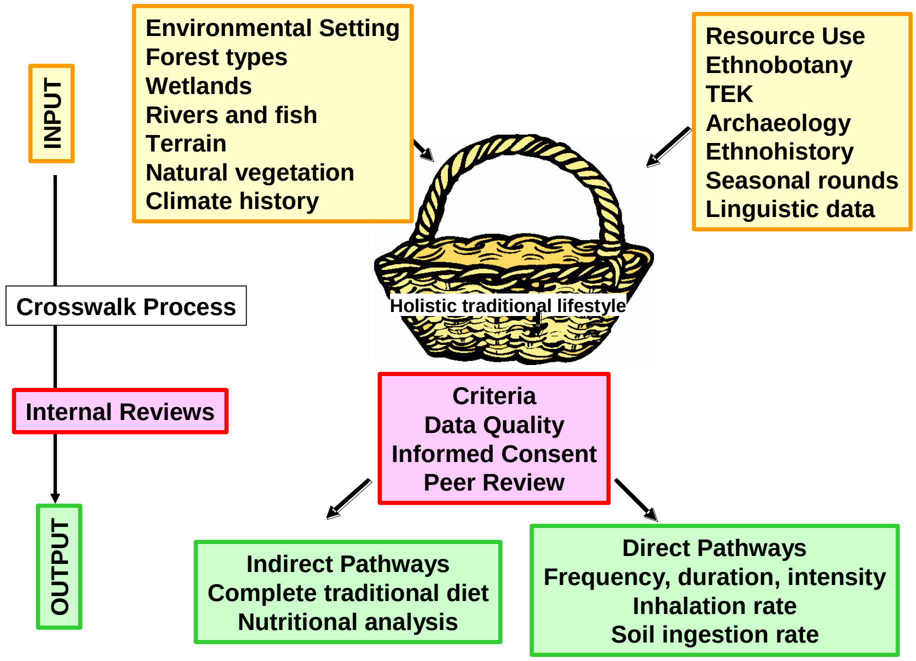


Figure 5. Input and output information

A variety of information is used to understand the degree of environmental contact and support the derivation of numerical exposure factors (Figure 5). The chapters in this report are organized around the input data and output requirements.

- Tribal history
    - The section on Tribal history describes factors such as whether Tribes have moved or have been consolidated on reservations, what happened as a result of contact with settlers and incoming governments, historical reports, and linguistic and oral history that describes how Tribes identify with and use natural resources.
    - This information is needed to understand lifeways as they existed prior to significant resource degradation. This is often quite recent, and is not regarded as irreversible.

- Environmental Setting.
    - The ecological and climatological description provide information about plants, animals, biodiversity, relative proportions of different habitat types, seasonality, and physiographic features of the environment.
    - This information is needed to support estimates of dietary staples (the resources that are most abundant and reliable), and environmental characteristics that affect contact rates with soil, sediment, and water (for example, proportion of wetlands versus dry upland habitats).

- Natural Resource Use
    - Ethnobotanical and ethnohistorical literature describes the general diversity of plants used for food, medicine, or materials in various regional ecotypes and helps derive dietary intake values.
    - Traditional ecological knowledge (TEK) combines anthropological and environmental knowledge with tribal knowledge, teaching, and observation. This type of information was contributed by Tribal cultural resource departments to identify the most important resources used by the Tribes, and the importance of various ecological functions and services, as well as refinement of estimates of frequency, intensity and duration of major activity types.

- Diet
    - In some cases, a complete diet may have been identified in the foraging theory literature, but more often the major dietary staples are identified but not fully quantified within a nutritionally complete diet.
    - Information about natural resources and their uses is used to estimate relative importance of the major food categories. This is combined with nutritional information to estimate a nutritionally complete subsistence diet (for as many major regional habitat types as are appropriate). Tribal staff reviewed diets and recommended refinements based on their knowledge of their individual locales.

- Direct exposure factors (soil, sediment, water, and air pathways)
    - There is little data directly relevant to environmental contact rates with abiotic media for indigenous styles other than the foraging theory literature, which tends to be non-specific, and some individual studies (see Appendices).
    - The crosswalk between major activities (hunting, fishing, gathering, and so on) and the abiotic exposure pathways (soil ingestion, sediment ingestion, water intake, and inhalation) is based on estimates of activity levels and the frequency, duration, and intensity of each activity category.
    - Physiological information adds knowledge of activity levels, and the relation between inhalation rates and calorie needs to ensure a reasonable and physiologically coherent set of exposure parameters.

4. HISTORY OF WABANAKI IN MAINE

This section presents a short history of several climatic and anthropological phases that the Indigenous Wabanaki people experienced. An understanding of how people have come to rely on certain resources is useful for identifying the resources that must be evaluated within the exposure scenario.

The pre-contact sequence of phases is often seen as cultural responses to climate change and to the natural environment (Bourque, 2001). In the broadest terms, people survived the immediate post-glacial era by large game hunting. As the huge herds declined due to climate changes, people began to rely more on riverine and coastal resources, eventually developing ceramics, agriculture, and a variety of environmental management practices.

This section describes the anthropological perspective on the history of habitation in Maine, including major sites identified with various phases, and some well-known sites that span multiple phases.

4.1 Introduction to the Wabanaki

Wabanaki (Dawnlanders or People of the Dawn) is the collective name of the Algonquian Indian Tribes of the sub-St. Lawrence and northern New England area called Wabanakis (Dawnland). Their ancestors include the Abenaki, Penobscot, Passamaquoddy, Maliseet, and Micmac[7] peoples speaking Algonquian languages as well as a number of tribes who 'disappeared' because of disease, warfare and emigration, such as the Kennebec Indians at Norridgewock, whose descendents can be found in a number of Wabanaki communities today (Prins, 1994) (Figure 6). In the 17th Century, the Eastern Abenaki controlled an area that is almost entirely contained within the modern state of Maine (Snow 1968; Snow 1976). Oral traditions, ethnography and archaeology all show deep interconnections and exchanges between Wabanaki tribes and their neighbors. Of particular note are the connections between Wabanaki and Ojibway (Anishnaabe) tribes in the great lakes area which are detailed in oral histories. One migration story places the origins of some Ojibway with the "Daybreak People" of the east coast (most likely the Wabanaki) (see Benton-Benai, 1988).

The larger Abenaki geographic region approximates the former French territory of Arcadia, now including Provinces of Nova Scotia, New Brunswick, Prince Edward Island, a small portion of Quebec, and the portion of Maine east of the Kennebec River (Whitehead, 1980; Prins, 1994). This area has been inhabited since the end of the last ice age about 12,000 years ago. Mastodon, mammoth, musk-ox, and large herds of caribou roamed the area. As the glaciers retreated, they left numerous lakes and many rivers running into long harbors. The post-glacial tundra gradually transformed into woodland habitats that continued to slowly change over time. By 5,000 years ago a modern heavily forested ecological system had developed with warm summers, cold winters, and northern hardwoods and conifers. Near-modern environmental conditions have been present for about 4000 years.

[7] For this report, we use various spellings of Micmac, including MicMac, Mikmaq, Miqmaw, Mi'qmaq, and others. All of these terms refer to the same group of Algonquin speakers indigenous to northeasten North America and the terms themselves reflect various histories of usage in English, French and Lnuisimk, the native language of the Mi'gmaq. We use the terms identified by the authors we cite and the groups we have consulted during the writing of this report.

The Wabanaki knew the precise location of every natural feature of their homeland. They knew where each resource was plentiful when they were wanted and roughly in what quantities. Major inland resources included white-tailed deer, moose, and caribou, beaver, black bear, other fur-bearers (fox, lynx, bobcat, fisher, marten, otters, skunks), muskrat, porcupine, rabbit, fowl, berries, seeds, roots, tubers, nut trees, resident and anadromous fish, wild grasses, bark, maple sap, and plants for medicinal purposes. Upland game birds were plentiful – turkey, pigeon, and grouse (partridge) – along with raptors and birds of prey. The coast was abundant with lobsters, clams, oysters, and sea mammals such as seals, porpoises, and whales. Multitudes of water fowl such as loons, ducks, cormorants, herons, and geese were seasonal inhabitants.

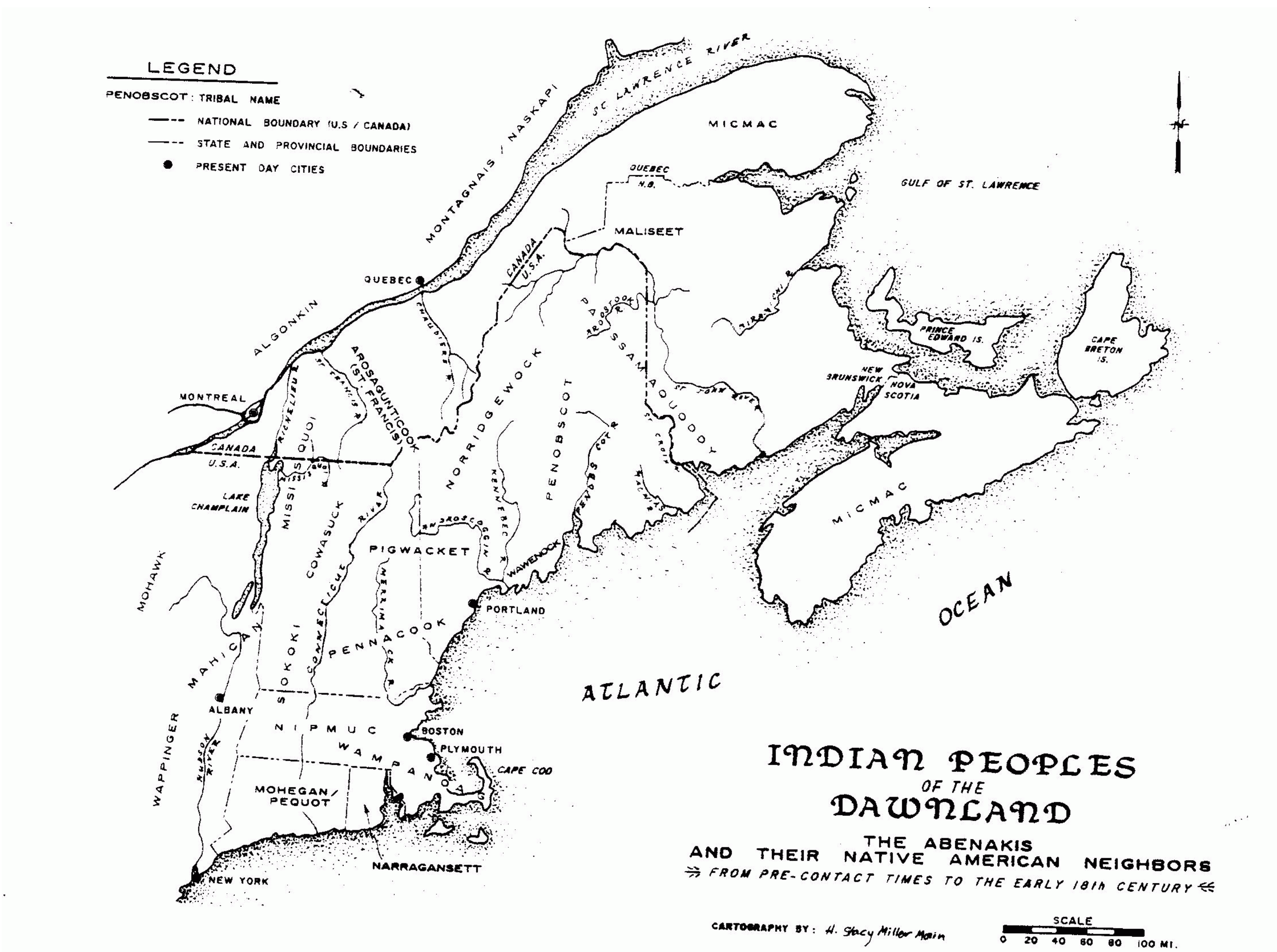


Figure 6. Wabanaki Territories in New England and the Maritimes

Many differences of the Wabanaki Indigenous people's material culture and social organization can be understood as the result of their"tradition of governing their tribal members according to natural law"(J. Sappier, personal communication) and adaptations to variations in ecologies.[8] In the centuries before the arrival of the first Europeans, the Wabanaki had mastered techniques which enabled them to manufacture the necessities of life from animal bone, ivory, teeth and claws, shells, quills, hair and feathers, fur and leather, clays and native copper, stone, wood, roots, bark, and a variety of plants. Every member had a specific role in the community based on the family tradition, e.g., hunter, gatherer, fisher, canoe maker, basket maker, or medicine person. Many of the basic Wabanaki traditional cultural practices were focused around creating useable resource for the tribal community. The techniques that the Indigenous people developed were highly complex and diversified. For example, variations in weaving methods were developed which allowed the utilization of an enormous range of raw materials: cedar bark, basswood bark, rushes, cattails, nettles, Indian hemp, sweet grass, spruce roots, wood fibers, rawhide and tendon thread, and porcupine quills. Conversely, the availability of a single raw material often gave rise to numerous techniques: for example, there were six major methods or working with porcupine quills alone, and each of these techniques had variations. (Whitehead, 1980; Bock, 1978)

4.2 Paleo (Post-Glacial) Period

Ecologically, this period is known as the Holocene, and extends up to the present. Anthropologically, the first phase of the period is known as the Paleo period, just after the glaciers retreated.

Numerous paleoecoogical investigations over the last several decades allow mapping of temporal distribution and abundance of selected plant taxa in eastern North America supported by a database of fossil pollen from lake sediments. Data from studies of prehistoric plant communities show that modern plant assemblages have generally not existed for more than a few thousand years and that even the major forest types we recognize today were not present through much of the last 10,000 years (Jacobson and Dieffenbacher-Krall, 1995). Methods for reconstructing ecological history include soil and sediment coring with characterization of carbon dating, macrofossils, microfossils, organic content, charcoal and soot stratification, pollen (referencing a national pollen database), soil or sediment structure, mineral grain size, and soil chemistry. Together, these methods can provide a picture of climate, vegetation, and hydrology of the site and/or region (Schauffler and Jacobson, 2002; Dieffenbacher-Krall and Nurse, 2005; Almquist et al., 2001; Jacobsen and Dieffenbacher-Krall, 1995).

Temporal variations in distribution and abundance of one indicator species, white pine, mirror major changes in climate during the past 12,000 years. White pine reached northern New England 10,000 years ago as the glaciers retreated (Jacobson and Dieffenbacher-Krall, 1995). Extensive regions of white pine in the early Holocene (10,000 to 5,000 years ago)

[8] Natural law is law that is understood to be derived from nature and is therefore valid everywhere, and to every being.

coincided with climates that were consistently drier than today, somewhat warmer, and with a fairly high frequency of fire.

After the glaciers retreated (10,000 to 12,000 BP), during what is known as the Paleo-Indian period, early hunters hunted mastodons and other large game with spears and gathered roots and plants. Archaeologists have noted that Paleo-Indian settlement patterns were much different than later patterns that favored rivers and lakes. Paleo-Indians favored sandy soils in wind-blown dune areas, often located near bogs or other wetlands (Bourque, 2001). Wilson and Spiess have suggested that the Paleo-Indian period in Maine could be represented by three-phases of occupation categorized by different fluted point styles (Wilson and Spiess, 1990). These styles and occupations are closely related to specific sites, with the Dam site representing the earliest period, the Michaud site the middle, and the Vail site representing the latest Paleo-Indian period.

Anthropological data and coastal sites from 12,000 to 6,000 BP are scarce because the coast has subsided while the sea level has risen, and preservation of physical evidence in moist inland soils is problematic. For example, oysters are not present today in Penobscot Bay, but oyster shells from 6,000 years BP are present in 25 feet of water, along with flaked tools.

4.3 Archaic Period

The Archaic period spanned 10,000 BP to 3,000 BP. The decrease in abundance of white pine in northeastern North America during the past 4,000 years took place as cooling allowed the boreal taxa to move southward. The abundant stands of white pine today largely result from abandonment of farms over the last century. For example, the limits of spruce and Balsam fir spread southward over the past 1500 years and coincide with the general decrease in abundance of white pine that has continued to the present day (Jacobson and Dieffenbacher-Krall, 1995). During the early (10,000-7,500 BP) and middle (7,500-6,000 BP) Archaic phases, nut bearing forests appeared in the southern half of Maine, along with atlatl[9] hunting, fishing with nets and spears, shellfish gathering, and on-shore seal hunting.

During the Late Archaic period (6,000-3,000 BP), there was a steadily warming climate, and evidence of deep sea fishing and hunting, fishing with hooks, lines, nets, weirs, and of shaping stone and wood (Braun and Braun, 1994). Also, after 6,000 BP, environmental historians suggest that changes in sea level and changes in water temperature affected marine organisms, especially those at either end of the temperature tolerance spectrum such as swordfish, which are found in older sites (they require warmer water), and soft shell clams (they require cold water). Related to this is the route of the cool Labrador current; after 3,500 BP the Labrador current grew stronger and water temperature declined (Spiess 1983). Rising water levels in recent centuries likely drowned any Archaic-period

[9] An **atlatl** or **spear-thrower** is a tool that uses spring-action leverage to achieve greater velocity in spear-throwing. It consists of a shaft with a handle on one end and a spur or cup on the other, against which the butt of the spear or dart rests. The dart is thrown with the same action as throwing a rock, holding the shaft and letting the dart fly. It has been used worldwide for tens of thousands of years, making it the longest-used weapon in the history of mankind. It preceded the bow and arrow. Atlatl use continues to be a tribal and international sport as well as a hunting technique.

archaeological sites situated on the edge of a lake, unless the site was perched on a high landform (Sanger, et al., 2003).

The oldest known site on the central Maine coast is at Turner Farm on North Haven Island, in Penobscot Bay (approx. 5000 BP). The oldest stratum (referred to as Occupation 1) includes soft shell clam shells and bone fragments from deer, sea mink, and swordfish. The next stratum (referred to as Occupation 2; 4500 – 4000 BP) includes many more and more varied tools and bone fragments.

Occupation 2 at the Turner Farm site is also associated with one of the most celebrated issues in Maine archaeology, the so-called Red Paint people. This time segment, named the Moorehead Phase (5,000 to 4,500 BP) after archaeologist Warren Moorehead, shows the importance of marine hunting by bone technology, marine faunal remains, and bone isotopes. The Nevin shell midden at Blue Hill Falls has the highest marine isotopic signature (probably due to swordfish and cod), and Turner Farm the lowest of this phase (Bourque, 2001, Bourque and Krueger, 1994).

Occupation 2 also suggests that there was year-round occupation of coastal sites by Archaic period Indians. During the same time period, at the Hirundo site on Pushaw Stream, there appears to be some relation between inland sites and year long coastal occupations (Sanger, 2000). Bourque suggests that this site on Pushaw Stream might have been a seasonal camp for populations otherwise living on the coast (Bourque, 2001). Other seasonally occupied sites include the Stanley site on Monhegan Island and the Goddard site on Naskeag Point in Brooklin, both coastal sites.

The Red Paint people of the Moorehead phase disappear quite abruptly around 3800 BP and are replaced in the archaeological record with people representing the Susquehanna Tradition, which has a shorter phase in Maine in comparison with other places in the Northeast (Sanger et al., 1977; Speiss, 1983). The Susquehanna tradition in Maine represents more refined artifacts and a diet that relied more on deer and anadromous fish and less on marine and shellfish, with the swordfish completely falling out of the archaeological record (Bourque, 2001). There is also evidence that the forest changes to a more southern character that also allowed populations to rely much more on nuts (Bourque, 2001).

The diet of the Susquehanna phase is revealed as quite diverse in the archaeological record. Seals and birds were taken twice as often than in the previous phases, and deer and bear were primary protein staples (Speiss, 1983). Isotopic ratios in human bones indicate that the coastal sites supported protein rich diets as well as individuals who had primarily been eating herbivore, terrestrial based sources of protein, which suggests possible migration (Bourque and Krueger, 1994).

Burley associates the Susquehanna phase people with climate changes, rising sea levels, an increased conifer density and changes in marine ecology in the Gulf of Maine that eventually stabilize in the Ceramic Period (Burley, 1983).

4.4 Woodland or Ceramic Period

The Woodland or Ceramic Period spans 3000 BP to contact. The early and middle ceramic periods are characterized by a stabilized climate, the infusion of pottery, bows, arrows and the dugout canoe, with wampum and the birch bark canoe (most likely) appearing in the late Ceramic period.

There is a general consensus that the transition from the Archaic to the Ceramic phases roughly coincided with a downturn in ocean temperature in the Gulf of Maine (as well as a southward deflection in the Labrador Current) and a shift in species from oysters, quahogs and bay scallops to soft shell clams (*Mya arenaria*) (Yesner, 1983). Sanger (1979, 1982, 1988) noted similar shifts away from swordfish to various modern species at this time. This temperature shift is corroborated by pollen cores. Also, changing ocean currents affect coastal salinity and sedimentation, which in turn affects which species are present, abundant, and utilized as staples.

The Ceramic Period was also marked by substantial population growth in the area. Moose became more important, especially in coastal areas (Bourque, 2001). Climate cooling is revealed in the increased amount of spruce pollen at archaeological sites, and strong year-round reliance on marine fish west of Passamaquoddy Bay. Swordfish are not found at all and cod are limited, but other fish became more abundant during this period, especially seals and flounder. Clams were a staple during late winter and early spring.

The Turner Farm site (Occupation 3) once again is a primary source of information about this period. Here, resource use increases in moose, flounder, birds, seals, beaver and sturgeon, with a drop in reliance on deer and cod (Spiess, 1983). After 900 BP another increase in moose, seal, and flounder occurs. Finally, the plow zone contains evidence of an even greater proportionate reliance on seals and another relative increase in moose over deer (Spiess, 1983).

4.5 Contact Era

The contact era is defined as the initial period when an indigenous population first comes into contact with outsiders such as explorers, traders, or settlers. Their writings are often useful to scenario development since some explorers were trained naturalists. On the east coast of North America, contact was made before modern anthropological methods with systematic observational methods were developed, but most species were recognized by the Europeans who were surveying for potentially valuable resources. As long as the tendency of some explorers to romanticize and exaggerate their observations is recognized, these early written accounts are an important part of the literature.

Beginning with the voyage of Giovanni de Verrazzano in 1524, European explorers started documenting the cultures and lifestyles of indigenous people in Maine. While potentially biased, these reports provide important insights into the subsistence lifestyles of Wabanaki in the 17^{th} century, in particular, which scholars have referred to as the ethnohistoric baseline of Indians in Maine (Bourque, 1973; Snow, 1976). This 17^{th} century ethnohistoric baseline clearly had been influenced by earlier trade and contact with Europeans, especially the summer European sailing schedule along the coast (Sanger, 2000). In the spirit of our approach to use as many sources of information through multiple lines of evidence, we also believe that both English and French sources provide important insights into subsistence diets and lifestyles.

While there may have been contact (most likely indirect) between Norse sailors and indigenous people in what is now Maine between the 11th and 14th centuries (see McGhee 1984), the ethnohistoric baseline reflects the earliest decades of European settlement in Maine, roughly 1605 to 1675. The year 1605 marks the year when Champlain made his exploratory voyage along the New England coast, and 1675 marks the outbreak of King Philip's War, which resulted in a great diminishment of independent Indian society in New England, though not in Maine (Bennett, 1955). Biard, a French Jesuit Priest, provided some of the best early descriptions of the seasonal patterns of Wabanaki people in southern Nova Scotia during the early part of the seventeenth century. He pointed out three modes of subsistence based on different periods of the year. From fall to late winter, he gave a list of mammals hunted by Indians primarily inland. After winter ice had receded, he described a subsistence lifestyle based on riverine fish runs and bird hunting. Beginning at the end of May, he describes movements to the coast where Indians relied more on birds, clams and other marine resources. He also mentions that as Indians returned upriver in September, fish and eels provided important sources of protein (Biard, as cited in Thwaites 1896-1901). While others have used this to compare with possible subsistence patterns in Maine (cf. Bourque 1973), we remain more skeptical because the resources and their availability are different in the two areas, although it remains a useful guide to Wabanaki subsistence patterns and many of his observations have been corroborated by archaeology and other observations for resources in Maine as well.

In addition to Champlain and Biard, we have consulted other early written sources, including: Rosier (1605), Lescarbot (1606), John Smith (1614), Denys (1632-1672), and LeClerq (1675-1687). Both Cowie (2002) and Christianson (1979) give excellent overviews of contact era subsistence lifestyles, although slightly to the east (Christianson) and west (Cowie) of our primary area of study. For example, Rosier's account of arriving in the St. George Islands in 1605 contains an example of fragment artifiacts that is typical of such sources: "Upon this Iland [sic], as also upon the former, we found (at our first comming [sic] to shore) where fire had beene [sic] made; and about the place were very great egge shelles bigger than goose egges, fish bones, and as we judged, the bones of some beast. Here we espied cranes stalking on the shore…" (Rosier, reprinted in Burrage 1930). Most compelling about this observation is the sense that places such as St. George Island had been continuously inhabited for some time, as well as what it may say about reliance on bird eggs along the coast.

Beginning in 1616, epidemics wiped out as much as 75% of the Wabanaki population in Maine, and many coastal villages were entirely abandoned (Prins 1995). The primary impacts of these epidemics were on more coastal, sedentary villages to the west and south of our primary area of study, where arriving Europeans witnessed already plowed and cleared fields with nobody inhabiting them (Bourque 2001; Prins 1995). Prins and Bourque point out that the primary impact of these impacts were in the ability of Wabanaki groups to resist European incursion into their territory (Bourque 1989; Prins 1995). Most analysts agree epidemics impacted individual communities in often dramatic ways, but the overall subsistence lifestyle, especially east of the Kennebec River, was not greatly impacted, as Wabanaki leaders routinely regrouped families in familiar territory after such dramatic events (Snow 1976; Ghere 1997).

How indigenous people reacted to changes resulting from the preferences of early traders (e.g., for pelts or salted fish for European Friday meals) is also revealing. We recognize that there may be a variety of seasonal rounds as some people responded to traders, while other people did not, resulting in inconsistency among early observers and among the archaeological data from the Ceramic Period. The ecology could clearly support a variety of seasonal rounds. Thus, the reports of individual observers, even if they vary, could all be true within ecological parameters. We have developed a model that is flexible enough to account for this variety. The next section in this report explores the environmental setting in more details.

5. ENVIRONMENTAL SETTING

5.1 General Approach

A general description of Maine's ecology and climate is presented in order to identify the major habitat types and to support the development of diets associated with each one. Future risk assessments may take this state-wide description as a starting point and modify it for more localized assessments.

The description of the environmental setting is based on natural ecological zones or ecoregions. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components (Bryce, Omernik, and Larsen, 1999). They are also used for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernmental organizations that are responsible for protecting different types of resources in the same geographical areas (Omernik et al., 2000).

In North America, seven broad climatic zones are recognized, roughly corresponding to temperature (especially winter minimum temperature) and moisture gradients. North American vegetation types roughly track these same zones. Because these zones are defined by dominant vegetation types, the composition of plant and animal species is fairly predictable for the dominant species. Local differences in geology (soils and deeper substrates), elevation, climate (light, temperature, precipitation and wind), and water (streams, wetlands) affect individual plant associations.

A hierarchical scheme has been adopted for different levels of ecological regions, and is being used by the US Environmental Protection Agency[10] (Figures 7 and 8). Level I is the coarsest level, dividing North America into 15 ecological regions. Level II divides the continent into 52 regions. At level III, the conterminous United States has 84 regions. Level IV ecoregions are further subdivisions of level III ecoregions, but are not yet completed for Maine. Methods used by the U.S. Environmental Protection Agency to define the ecoregions are explained in Omernik (1995, 2004), Omernik et al. (2000), Gallant et al. (1989); and Bailey (US Forest Service)[11]. The approach used to compile these ecoregion maps is based on the premise that ecoregions can be identified through the analysis of the spatial patterns and the composition of biotic and abiotic characteristics that affect or reflect differences in ecosystem quality and integrity (Wiken, 1986; Omernik, 1987, 1995). These characteristics include physiography, geology, climate, soils, land use, wildlife, fish, hydrology, and vegetation including "**potential natural vegetation,**" defined by Kuchler as vegetation that would exist today if human influence ended and the natural vegetation and natural processes were restored (including the earlier fire regime of mixed natural and indigenous origin, and natural flooding).

[10] http://www.epa.gov/wed/pages/ecoregions.htm and http://www.cec.org/files/PDF/BIODIVERSITY/eco-eng_EN.pdf
[11] USFS Bailey province ecology: http://www.fs.fed.us/land/pubs/ecoregions/intro.html

Figure 7. Level 1 and 2 Ecoregions of North America

from: http://www.epa.gov/bioindicators/html/usecoregions.html

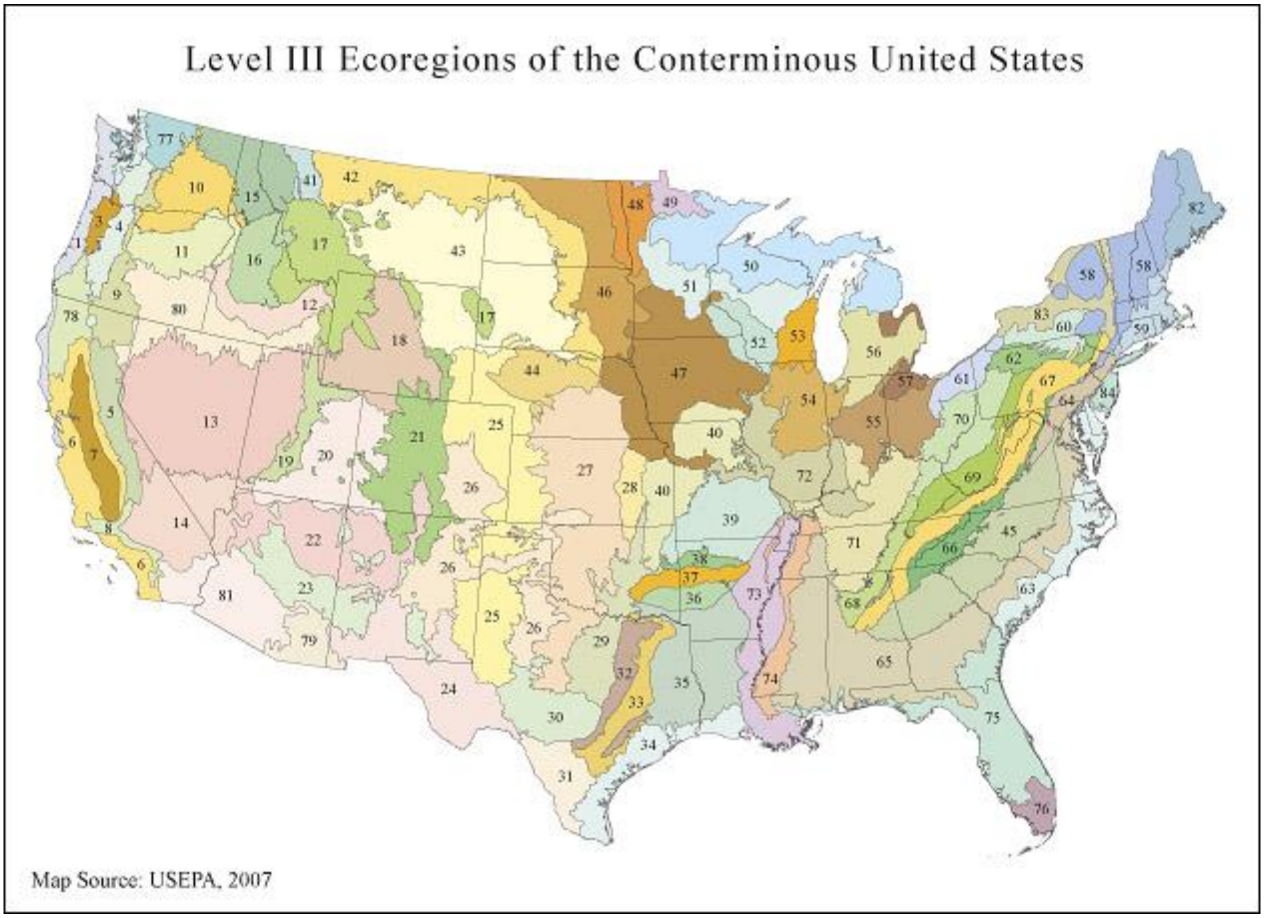


Figure 8. Level 3 Ecoregions of North America

ftp://ftp.epa.gov/wed/ecoregions/us/useco/pdf

5.2 Maine

Most early descriptions of vegetation types focused on forests and marketable trees. More recently, many conservation efforts have expanded the focus into natural community types. For example, the Maine Natural Areas Program (MNAP) has classified and distinguished 98 different natural community types that collectively cover the state's landscape.[12] These include such habitats as floodplain forests, coastal bogs, and many others. It also describes the 24 broader ecosystem types within which these natural communities typically occur, and it provides cross-walks to other classification systems, including those used by the National

[12] http://www.mainenaturalareas.org/docs/publications/

Vegetation Classification System, Society of American Foresters, and New Hampshire Natural Heritage Inventory. Other ecological mapping efforts also exist.[13]

For this scenario, a description of general vegetation types is adequate for supporting the development of general inland and coastal diets. For example, the information about the extent of wetlands is used to support the estimates of aquatic-based dietary components, and the composition of forests supports the percentage of nuts in the diet.

5.2.1 Maine Climate and Weather

Information about Maine's climate and weather sheds light on indoor-outdoor activities, personal hydration needs, soil adherence to skin versus inhalation as dust, and similar environmental contact rates.

Maine is divided into three climatological divisions: Coastal, Southern Interior, and Northern Interior. The Coastal Division, which extends for about twenty miles inland along the length of the coast, is tempered by the ocean, resulting in lower summer and higher winter temperatures than are typical of interior zones. The Southern Interior Division extends in a longitudinal belt across the southern portion of the State, and encompasses about 30% of Maine's total area. The Northern Interior Division occupies nearly 60% of the State's area and has a continental climate. It is furthest from the ocean and contains the highest elevations. Peak temperatures, normally occurring in July, average about 70°F throughout the State. In the Southern Interior Division during a very warm summer, temperatures may reach 90° for as many as 25 days, and in the Coastal Division, two to seven days. Summer nights are usually comfortably cool. Winters are generally cold, but very prolonged cold spells are rare. Northern Interior weather stations may record as many as 40 to 60 days of sub-zero temperatures annually, while coastal stations report 10 to 20 sub-zero days per year. Annual precipitation in Maine averages 40 inches in the Northern Division, about 42 inches in the South and 46 inches in the Coastal Division. Although Maine is rarely subjected to ice storms, hurricanes and tornadoes, 10 to 20 thunderstorms occur annually in the Coastal Division and 15 to 30 elsewhere. Heavy ground fogs often appear in low-lying inland areas, but occur most frequently along the coast, for 25 to 60 days annually. The southern portion has 80 to 120 clear days per year when there is no fog or other precipitation, and northern regions somewhat less. The percentage of possible sunshine varies from 50% in Eastport to about 60% in Portland. Average annual snowfall in Maine is 50 to 70 inches in the Coastal Division, 60 to 90 inches in the Southern Interior and 90 to 110 inches in the Northern Interior. The Coastal Division rarely has more than 15 to 20 days annually with snowfall of one inch or more, although a "Northeaster" may occasionally drop 10 or more inches of snow in a single day. The Northern Interior may have up to 30 days a year with a minimum of one inch. January is normally the snowiest month, with an average of about 20 inches [14]

[13] http://eros.usgs.gov/LT/regions/eco58.html; http://www.biosurvey.ou.edu/duckflt/dfhome.html; http://www.fws.gov/northeast/gulfofmaine

[14] http://www.mainetourism.com/content/4004/Maine_Weather/

5.2.2 Forest Types

Because Maine lies between the northern boreal zones, the southerly mid-Atlantic zones, and the westerly hardwoods, there are examples of species characteristic of each of these zones, resulting in a high level of biodiversity in the flora and fauna. The southernmost outliers of arctic vegetation in eastern North America occur here, numerous Atlantic coastal plain plant species are at their northern limits, and the northeastern limits of several deciduous tree species and forest communities with southern affinity can also be found within the ecoregion. In addition, this ecoregion contains several rare ecological or evolutionary phenomena including major areas of serpentine rocks and associated rare vegetation, raised peat bogs, ribbed fens, and coastal raised peatlands.[15]

Glacial processes shaped the entire ecoregion, creating numerous lakes and wetland areas. Starting approximately 15,000 years ago, the late Wisconsin Laurentide ice margin began to recede northward across the Gulf of Maine, and was finally gone by 12,000 years ago. The crustal rebound, as the weight of the glaciers declined, caused the land to rise (or sea level to fall), followed by a slow rise in sea level to present levels. Glacial erosion and deposition, followed by deposition of silt and clay produced a landform characterized by shallow lake basins and poor drainage (Sanger 1979). Over time, the pollen record at several lakes and ponds show the general progression (depending on moisture and other parameters) of:

1. Deglaciation
2. Tundra
3. Spruce-fir, Spruce-birch-poplar woodland
4. Conifer-hardwood forest types at first (white pine-oak; white pine-spruce; white pine-birch-oak) and then other types (hemlock-birch-beech; hemlock-white pine-birch-northern hardwoods).
5. Hardwood-conifer forest types (northern hardwoods-hemlock; birch-northern hardwoods-hemlock) and slightly later up to present (increasing spruce-decreasing hemlock-beech, with alder, fir, and grass).

Vegetation types in Maine since the Woodland-Ceramic eras through the contact era include two major ecozones (Figure 8), and a small portion of a coastal zone. Vegetation types in Maine since the Woodland-Ceramic eras through the contact era include two major ecozones, and a small portion of a coastal zone.[16]

[15] http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0410_full.html
[16] http://www.hort.purdue.edu/newcrop/cropmap/maine/maps/MEeco3.html

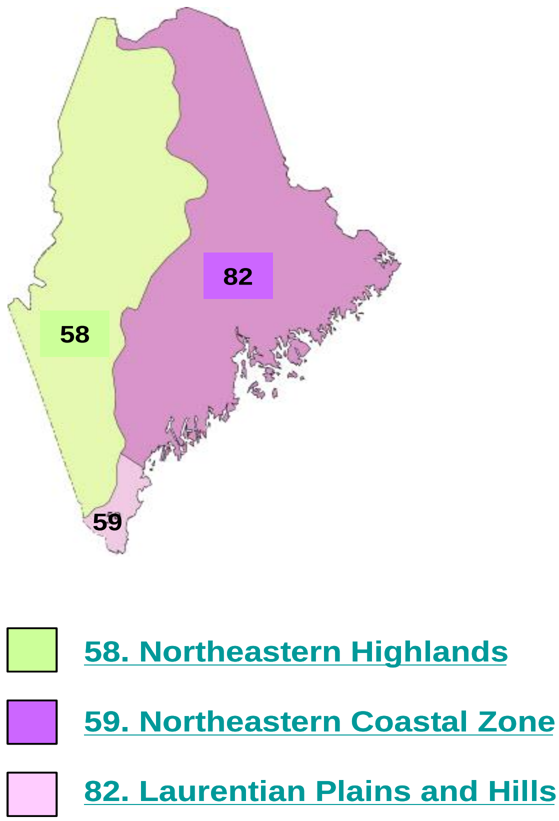


Figure 9. Primary Forest Types in Maine

(http://www.hort.purdue.edu/newcrop/cropmap/maine/maps/MEeco3.html)

58. NORTHEASTERN HIGHLANDS (western half of Maine)

The Northeastern Highlands ecoregion shows many remnants of glaciation, including rocky soils, glacial lakes, and wetlands. It is characterized by nutrient-poor soils blanketed by northern hardwood and spruce fir forests. Land-surface form in the region grades from low mountains in the southwest and central portions to open high hills in the northeast, with numerous glacial lakes. This region extends westward with numerous mountain ranges, including the White Mountains in New Hampshire, the Green Mountains in Vermont, and New York's Catskills and Adirondacks. Annual average rainfall varies from 940 to 1,397 mm (37 to 55 in), with significantly higher amounts in mountainous areas. Bailey's forest type term for Northeastern highlands is Adirondack-New England Mixed Forest (Bailey, 1994).

59. NORTHEASTERN COASTAL ZONE

The Northeastern Coastal Zone contains relatively nutrient poor soils and continental glacial lakes; however, this ecoregion contains considerably less surface irregularity. The forests in this zone are mostly white, red, and jack pine and oak-hickory.

82. LAURENTIAN PLAINS AND HILLS (eastern half of Maine)

> This region is mostly forested, with dense concentrations of continental glacial lakes. It is less rugged than the Northeastern Highlands. Vegetation is mostly spruce-fir with some patches of maple, beech, and birch. . The average annual precipitation ranges from 1,041 mm (41 in) in the northern areas to about 1,168 mm (46 in) further south. Bailey's forest type term is Laurentian Mixed Forest (Bailey, 1994).

In addition to being at the transition between three forest zones, Maine has many fast-flowing, cold water rocky rivers with highly fluctuating water levels that give rise to interesting floral and faunal communities.[17] According to the World Wildlife Fund, the mosaic of forest types and habitats support 225 bird species, making these forests the second-richest ecoregion within the temperate broadleaf and mixed forests, and among the 20 richest ecoregions in the continental United States and Canada.

Characteristic mammals include moose (*Alces alces*), black bear (*Ursus americanus*), red fox (*Vulpes vulpes*), snowshoe hare (*Lepus americanus*), porcupine (*Erithyzon dorsatum*), fisher (*Martes pennanti*), beaver (*Castor canadensis*), bobcat (*Lynx rufus*), marten (*Martes americana*), muskrat (*Ondatra zibethica*), and raccoon (*Procyon lotor*). White-tailed deer (*Odocoileus virginianus*) have expanded northward in this ecoregion and displaced the woodland caribou (*Rangifer tarandus* ssp. *caribou*) from the northern parts of the ecoregion.

5.2.3 Wetlands

This section is taken from http://www.state.me.us/dep/blwq/wetlands/life.htm. Fully 25 percent of Maine's land area is wetlands, four times the wetland area of the other five New England States combined. Over five million acres of Maine's wetlands are resident types (wooded swamps, shrub swamps, bogs, resident meadows, resident marshes and floodplains). An additional 157,500 acres are tidal types (tidal flats, salt marsh, brackish marsh, aquatic beds, beach bars and reefs). Wetland types are described as follows:

"Resident wetlands" means resident swamps, marshes, bogs and similar areas that are inundated or saturated by surface or groundwater at a frequency and for a duration sufficient to support, and which under normal circumstances do support, a prevalence of wetland vegetation typically adapted for life in saturated soils; and, not considered part of a great pond, coastal wetland, river stream or brook.

"Coastal wetlands" means all tidal and subtidal lands, including all areas below any identifiable debris line left by tidal action; all areas with vegetation present that is tolerant of salty or brackish water and occurs primarily in a salt water or estuarine habitat; and any swamp, marsh, bog, beach, flat or other contiguous lowland which is subject to tidal action during the maximum spring tide level as identified in tide tables published by the National Ocean Service. Coastal wetlands may include portions of coastal sand dunes.

Coastal Marshes

> Tidal marshes provide vital habitat for clams, crabs and juvenile fish, as well as providing shelter and nesting sites for migratory waterfowl. Plant communities can include smooth cordgrass, spike grass and black grass.

[17] http://www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0410_full.html

Inland Marshes

Resident marshes are one of the most productive ecosystems on earth, sustaining a myriad of plant and wildlife communities. Lily pads, reeds and bulrushes provide habitat for red-wing black birds, great blue herons, otters and muskrats. Many species, including wood ducks, muskrat and swamp rose will only be found in inland marshes. Other common species found here are loons, snapping and painted turtles, woodpeckers, warblers and other songbirds, osprey, and many types of dragonflies and damselflies.

Wet Meadows

Water loving grasses, sedges, rushes and wildflowers can be found in the highly fertile soils of wet meadows.

Fens

Grasses, sedges, rushes and wildflowers often cover these habitats.

Bogs

Bogs, or peatlands, support some of the most interesting plants in the U.S., including the carnivorous sundew and pitcher plant, the northern pitcher plant, cotton grass, cranberry, blueberry, pine, Labrador tea and tamarack. They also provide habitat for lots of animal species, like moose, deer, lynx, cranes, the sora rail and the great gray owl.

Shrub Swamps

Shrub swamps are dominated by woody vegetation such as buttonbush, willow, dogwood and swamp rose. Beaver and yellow warblers are found in shrub swamps.

Forested Swamps

Red maple, sugar maple, birch, white ash, alder, swamp rose and elderberry dominate the vegetation in forested swamps. They provide habitat for wood ducks, beaver, mink, fisher, the red-spotted newt, eastern wild turkey, barred owl, pileated, downy and hairy woodpeckers and the black-capped chickadee.

Vernal Pools

Vernal pools, which are seasonally wetted, are critically important spawning areas for amphibians, such as the spotted salamander, the blue-spotted salamander and wood frogs. The resident crustacean, fairy shrimp, spend its entire lives in vernal pools and are found no place else.

5.2.4 Watersheds

As with most indigenous cultures, the Wabanaki cultures are strongly riverine oriented. Territory boundaries tend to be at ridgelines rather than rivers. Entire river valleys are considered single territories with the river being the center feature rather than the peripheral boundary. Modern environmental management is likewise returning to a watershed basis.

Biard (1610) noted that the Sagamores divided up the country according to bays or rivers. More recently, Speck described family territories as fixed tracts of country whose boundaries are determined by certain river reaches, ridges, lakes, or other natural landmarks.[18] Watersheds are shown in Figure 10.

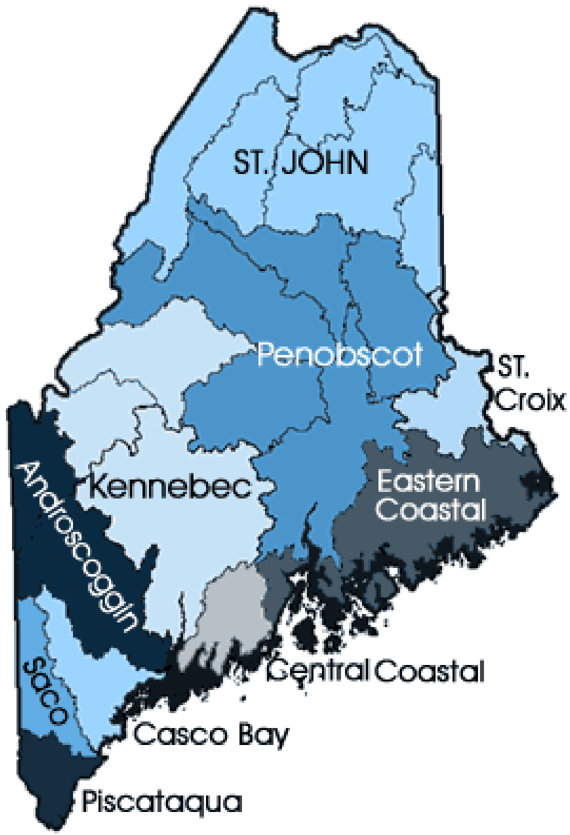


Figure 10. Watersheds in Maine

(http://www.mainerivers.org/water_profiles.html)

[18] Penobscot Nation historian James Eric Francis Sr, quoted in http://bangordailynews.com/news/t/penobscot.aspx?articleid=141008&zoneid=183 and http://www.bangordailynews.com/news/articlefiles/PenobscotPage1secure.pdf

Penobscot Watershed.

Most of the following information is taken from http://www.mainerivers.org/penobscot.html. The Penobscot Rivershed spans the middle third of the state. New England's second largest river system, the Penobscot, drains an area of 8,570 square miles. Its West Branch rises near Penobscot Lake on the Maine/Quebec border; and the East Branch at East Branch Pond near the headwaters of the Allagash River. The river's total fall from Penobscot Lake on the South Branch is 1,602 feet. Tidal movement reaches as far inland as Bangor. Terrain ranges from steep mountains including Maine's highest, Mt. Katahdin, rolling hills and extensive bogs, marshes and wooded swamps. The Penobscot River is currently home to many fish, including native brook trout, landlocked salmon, smallmouth bass (non-native), white perch and chain pickerel are prevalent resident species. Sea-run species include Atlantic salmon, alewives, American shad, American eel, sea lamprey, striped bass, tomcod, rainbow smelt and occasional Atlantic sturgeon. Many place names and family names reflect fish, such as the translations 'shad place,' 'clam place,' 'place of overgrown eels', and 'abundance of eels' (Kenduskeag, or Bangor) (Penobscot Nation 2001; Prins, 1994; Speck, 1997). Most sea-run species are found in numbers far below historic levels because of non-existent or inadequate fish passage facilities on main-stem and tributaries, past pollution, and loss of habitat due to dam construction. The Penobscot is best known for its large historic salmon run (50,000 or more adults) and its much smaller contemporary run, which is nevertheless the largest Atlantic salmon run remaining in the United States.

St. John Watershed

One of the largest river basins on the East Coast, the St. John drains over 21,000 square miles of land. Its upper portions are some of the most remote stretches of river in all New England. Its length is 410 miles, and its discharge at the mouth is 25.5 billion gallons/day.

Kennebec Watershed

Originating from Moosehead Lake and the Moose River, the Kennebec flows gently for much of its course. The river had perhaps the most magnificent runs of anadromous fish on Maine's coast. Atlantic salmon, alewives, shad, sturgeon and striped bass all swarmed far upstream to spawning grounds. Its length is 230 miles, it drains an area of 5,870 square miles, and its discharge at Merrymeeting Bay is 5,893 million gallons/day.

Central Coastal Watershed

These rivers along the central coast of Maine are relatively short and drain much less of an area than the northern rivers. Several, like the Sheepscot and Ducktrap, still support small runs of anadromous fish.

Eastern Coastal Watersheds

The rivers along the Eastern coast of Maine are gentle- flowing and relatively undeveloped. These rivers are some of the last to support wild Atlantic salmon runs.

St. Croix Watershed

The St. Croix forms the eastern boundary between Maine and Canada. It has been heavily developed for electric power, reducing once prolific runs of anadromous fish. However, the river still claims the second largest Atlantic salmon run in the state.

5.2.5 Atlantic Salmon (*Salmo salar*) Rivers

Due to the importance of anadromous fish in the subsistence diet, a brief description of salmon rivers is included. Historically, Atlantic salmon occurred in abundance in eastern North America: in Canada from Ontario eastward, and in the United States in all the New England states, and the State of New York. In all, 875 rivers historically supported large populations of wild salmon.

“Unheard-of quantities” of salmon were taken at Indian Island each year (Speck, 1997; Barsh, 2002). All early observers recorded abundant anadromous fish.

> In 1633, the young French merchant Nicholas Denys arrived in Nova Scotia where he eventually married into a Mikmaw family and spent the rest of his life with them. The land “abounds in trout and salmon, and the smelt are present there in spring in great quantity.” Fishing in deep pools in rivers after dark with torches and spears, a single Mikmaq could land 150 to 200 salmon or trout in a single night; large harvests were also attained using tidal weirs. There were “great quantity of bass, which is a very good fish of two or three feet in length. ... in an hour they load a canoe with them, which means about two hundred of these fish.” He observed “salmon, the smallest one was 3 feet long.”
>
> Biard lived in Maine from 1611 to 1613. He reported that in mid-March, Micmac moved to streams where they could harvest successive runs of smelt, herring, salmon and sturgeon, as well as waterfowl and their eggs. “Any one who has not seen can scare believe it.”
>
> LeClercq was a missionary who spent a decade with the Mikmaq just after Biard’s book was published. “Wildlife and fish are abundant and everything necessary for life can be found there without much effort.” Mikmaq landed “a prodigious quantity of all sorts of fish” such as cod, salmon, sturgeon, herring, trout, mackerel, catfish, shad, bass, carp, pike, bream, eels, whitefish, and skates, in addition to hunting sea lions and collecting oysters.

More recent historical documents on the abundance of salmon and other species have been collected [19] For example, a 1790s document cited for the Penobscot River says,

> “The streams were full of them - salmon, shad and alewives were taken under Lover's Leap, at the mouths of the Mantawassuck, Segeunkedunk, and Sowadabscook Stream and at Penobscot Falls.... Game was found in great abundance along the banks of this river. There are those living who had the fine sport in hunting moose and the larger animals of the forest, as well as birds and smaller game. Besides the fish mentioned, bass were plenty in the Penobscot, and sturgeon...“

Another document from 1860 says,

> "Salmon, shad and alewives were very plentiful, and in their season many people came here to catch them -- bass were also plenty, and in the fishing season, we could fill a bateau with

[19] http://www.kennebecriverartisans.com/kennebec.org/fks/historicrecords.html

> fish at Treat's falls in a short time; we would sometimes take forty salmon in a day, and I think as many as five hundred were taken some days, in all. My father had a large seine in the eddy, just above the Bangor bridge, and we had much trouble with the sturgeon."

Currently the number of rivers supporting Atlantic salmon runs is greatly reduced, and the runs are primarily supported through stocking with hatchery fish.[20] In eight rivers - all in Maine (Sheepscot, Ducktrap, Cove Brook, Pleasant, Narraguagus, Machias, East Machias and Denys) the salmon are considered still wild (i.e. genetically correspond to historic populations), but endangered. The greatest remaining Atlantic salmon river in New England is the Penobscot. The recovery of Atlantic salmon on the Penobscot River likely depends on a return of healthy populations of alewives, blueback herring, American shad and other sea-run species (http://penobscotriver.org/)

Atlantic Pollock *(Pollachius virens)* is another important (non-anadromous) marine fish. The word Passamaquoddy is derived from "peskotomuhkatiyik" or people of the Pollock. Pollock is "peskotom." Pollock are predatory and chase schools of fish such as herring, and would arrive in great numbers along the coast at Pleasant Point. A watcher would report to the community that the Pollock were there, and the community would participate in pulling the pollock out by hand or with spears[21].

[20] http://www.mainerivers.org/atlantic_salmon.html
[21] Personal communication from Passamoquoddy cultural department.

The Maine legislature recognized the national significance of this fish and in doing so reestablished the Atlantic Salmon Commission in 1998. The Commission's mission is to protect, preserve, enhance, restore and manage Atlantic salmon and their historical habitat in all (inland and tidal) waters of the State of Maine. Many local, state, national and international organizations and agencies are working to restore and manage the wild Maine Atlantic salmon population (Figures 11 and 12 and http://www.maine.gov/asc/).

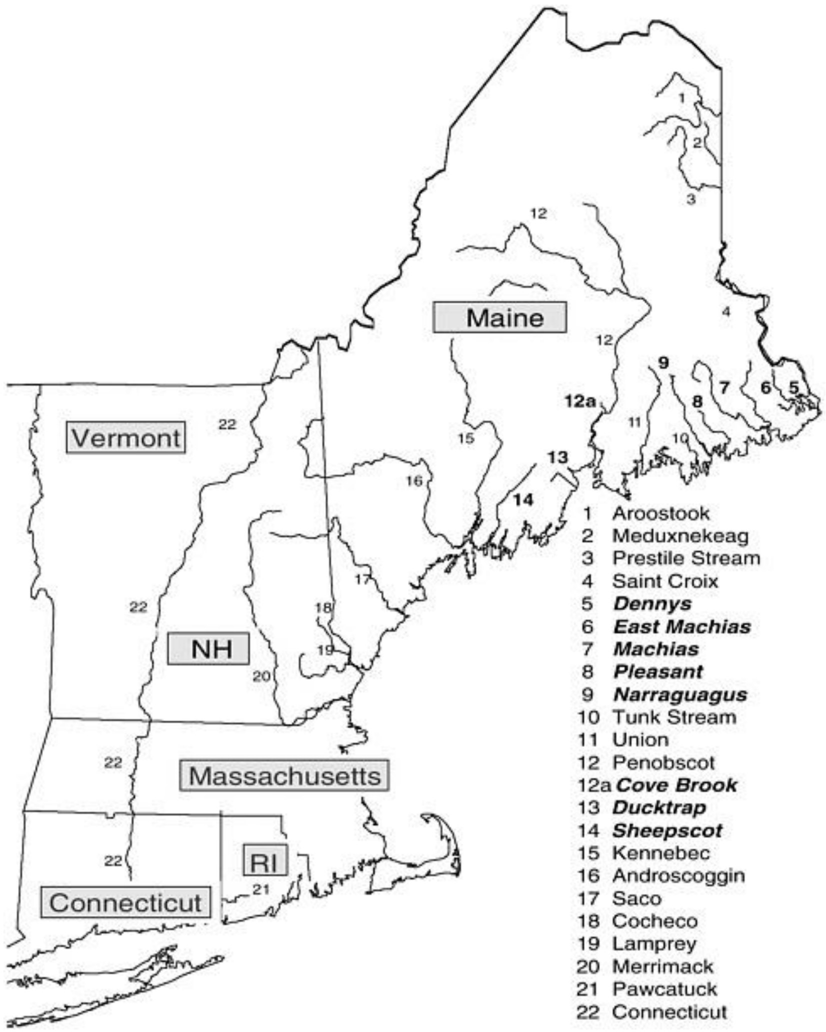


Figure 11. Salmon Restoration Rivers in Maine

Sources: http://books.nap.edu/openbook/0309091357/html/17.html
http://pearl.maine.edu/windows/salmon/images/salmonwatersheds.gif and
http://www.nmfs.noaa.gov/pr/pdfs/recovery/salmon_atlantic.pdf
A more detailed map of historic Atlantic salmon rivers is posted on a NOAA website[22]. Note that rivers 2 and 3 are reversed.

[22] http://www.nefsc.noaa.gov/USASAC/ 2006%20 USASAC%20 Report/HistoricNESalmonRiversMap11x17.pdf

The third edition of the *Maine Atlantic Salmon Habitat Atlas* is available digitally by staff of the Maine Atlantic Salmon Commission and the U.S. Fish and Wildlife Service. These surveys were conducted to identify important spawning and rearing areas. The maps also include information on habitat categories, composition, length, width, depth, canopy and other vegetation variables.[23]

Maine Watersheds with Atlantic Salmon Habitat Surveys

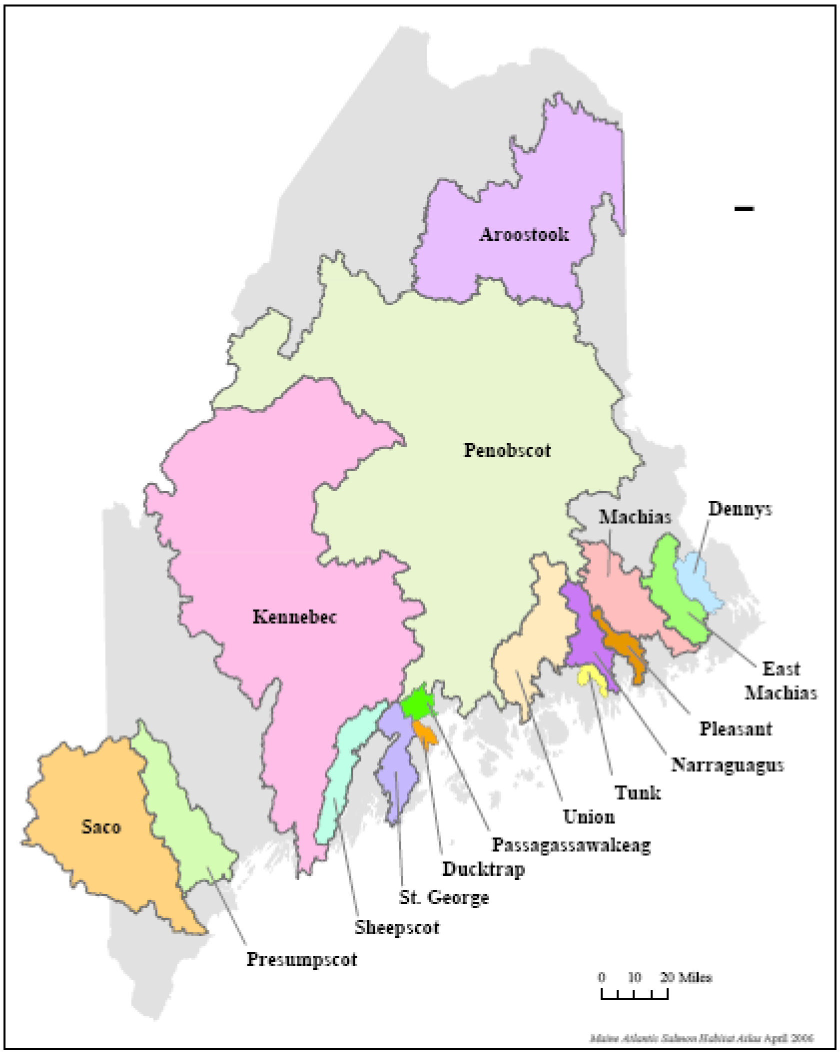


Figure 12. Maine Waterways with Atlantic Salmon Habitat Surveys.

[23] http://apollo.ogis.state.me.us/maps/ASHAB3/AroostookAtlas.pdf.

6. WABANAKI RESOURCE USE

6.1 General Foraging Theory

Kelly (1995) described the concept of systematic evaluation of eco-cultural lifestyles for efficiency and resource use patterns, also known as foraging theory. This concept includes labels for people such as hunter-gatherers and foragers, which unfortunately leads to mental images of people barely surviving by randomly foraging around the landscape for something to eat, rather than the reality of living within an informed educational system based on traditional environmental knowledge, systematic observation, rich languages, exquisite crafts, and adaptability.

In the 1960s to 1980s the “Man the Hunter” concept of subsistence lifestyles (with males providing most of the provender) prevailed due to a previous archaeological emphasis on hunting and warfare artifacts (Lee and Devore, 1968). This gave way in the 1990s to a more balanced foraging model that recognized the importance of plants as much as meat (and equality of genders in contributing to survival), and a relatively peaceful and secure “original affluent society” (Sahlins, 1972). The latter concept is supported by data (Kelly, 1995; Winterhalder, 1981; Steegman, 1983) on the amount of time required to obtain survival necessities and to raise children, and the typically abundant amount of time available for socializing, education, ceremonies, material items, leisure, oratories, and so on. Winterhalder (1981) further elaborated this view by evaluating information about ecotypes, biodiversity, abundance, patchiness, species abundance, and travel times to various resources in the boreal zone to confirm that indigenous traditional environmental knowledge is intimately informed through general knowledge and constant observation for efficient recovery of resources.

In foraging theory, efficiency or return rate for specific resources obtained from specific habitats is estimated by evaluating the amount of calories expended in getting food (search costs) by means of hunting, gathering, or fishing relative to time spent or calories obtained. Foraging information is typically presented as return rates, or net calories obtained per hour of effort. Depending on the evaluation methods used in a study, this return rate data may include (1) time and calories spent in preparing to hunt, fish, or gather (e.g., making nets), (2) time and/or calories spent in the actual activity, and (3) time spent in the processing of the resource after obtaining it. Several submodels have been proposed:

> Diet breadth. In this model, resources are ranked by their caloric value to the forager. Foraging is divided into two phases: search costs (time or energy) to encounter each unit of potential resource species, and the pursuit costs for each unit. An optimal diet is one that adds resources to those pursued in decreasing rank order until search costs for a resource start to exceed energy return.
>
> Patch Selectivity. Since most resources are unevenly distributed, the forager must randomly move over the environment and allocate time and effort to travel to various patches of various quality, according to which resources are needed, until the travel time exceeds the caloric value of the resource gained.
>
> Movement among Habitats. The marginal value model assumes that the forager pre-selects the patches to be visited, using the resources that are closest and best first, and gradually moving to lower quality patches farther away until the travel time is so great that the residence is moved and/or the forager switches to different resources.

The drawback of oversimplifying foraging solely to caloric efficiency is that micronutrients (vitamins, minerals, specific amino acids, and fatty acids), medicinal or pharmacologically active compounds, other nutritional requirements, and non-nutritional attributes such as aroma or dye or material uses may not be considered (Lindstrom, 1992). Similarly, many plants and animals have multiple uses or are co-located with other resources; therefore, caloric calculations must not ignore the way that people actually make decisions about where to go or what to gather, or the reasons they seek to obtain particular resources.

The following are the steps developed to reconstruct the Wabanaki diet:

1. Review ecological and foraging information specific to the Tribe, and the local ecosystem(s),
2. Review interviews and other archaeological and ethnographic sources for supporting information of species and abundance, habitat types, human activity levels, and methods of obtaining, preparing and using resources;
3. Develop overall percentages of major food categories and major staples within the total diet;
4. Estimate calories provided by the diet, and compare estimates of percentages of quantities and percentages of calories;
5. Refine estimates of major staples and food categories after considering information about medicines, sweeteners, and other often-overlooked food/medicine types; macronutrients, and other factors.

For the Wabanaki, Sanger (1988) points out that developing a foraging picture based solely on archaeological evidence is inadequate because the ratio between marine and terrestrial remains in sites, and between plants and fish and bone among middens does not paint a coherent picture if considered individually. Consideration of the entirety of the data is needed, including the amount of hunting and fishing gear in evidence, the seasonal natural resource cycle, the settlement pattern relative to known resources, human bone isotope ratios, pollen profiles over time, and so on, gives a fairly accurate picture of the overall diet (Sanger, 1988). For some sites across the continent other data may also lend important such as early data on fish catches, fish buying records, trading records, early commercial records, and early explorers and naturalists, and so on.

6.2 Historical Seasonal Patterns

This section presents information on the seasonal uses of natural resources. Resources are obtained from different locations throughout the year, and this cycle is often referred to as a ‘seasonal round.’ Unfortunately, this may lead to an impression that entire villages were constantly on the move, whereas it is probably the case that permanent villages served as home bases and different sized groups of people went to different hunting and gathering grounds to bring back resources for the entire family, band, or community.

The scenarios presented in this report are based on permanent villages with seasonal acquisition of regional resources. The ethnohistorical literature reviews indicate that game and fish were both important. Further, the literature reviews and the locations of larger permanent village sites indicated that fresh water was a primary criterion both for drinking and for aquatic resources, either anadromous or resident. Thus, it did not appear that a purely upland terrestrial diet without fish would be logical for Maine.

This information was then used to derive "bounding cases," or lifestyles and diets derived solely from each major ecotype. For risk assessment, the preferred approach is to develop these types of bounding cases in order to evaluate 'reasonable maximum' situations. After extensive review, we concluded that there are three reasonable lifestyle models in Maine, each with its own diet:

1. Permanent inland residence on a river with anadromous fish runs,
2. Permanent inland residence with resident fish only,
3. Permanent coastal residence.

These three dietary models can be tailored to individual tribal locations in a 'mix-and-match' fashion, as appropriate to the specific location or application. In addition, local application may substitute locally-grown livestock or produce so that the exposure pathways from the specific site or waterbody are assessed as a baseline risk assessment (i.e., all resources are obtained locally whether gathered or grown, and hunted or raised.

The three diets (Figure 13) are the "pure" diets that would be reasonable if a person lives solely within one of the three local ecosystems and obtains most of his/her food locally. In reality, diets and movement are probably comprised of variable ratios among two or all three diets.

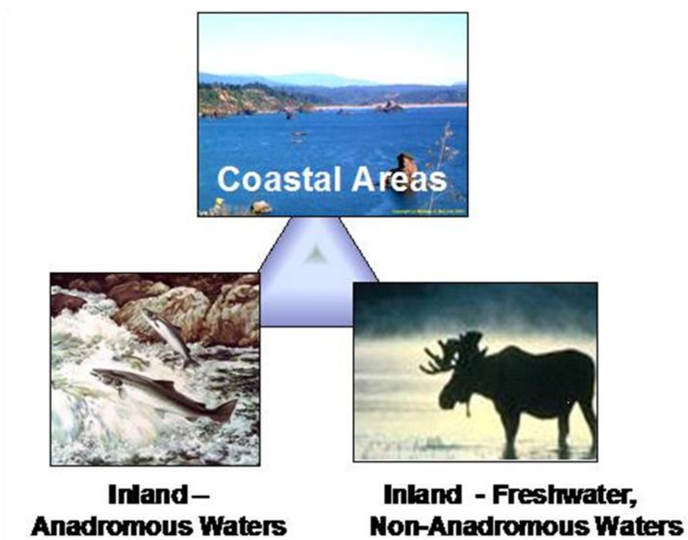


Figure 13. Three Maine Diets

The supporting information for the Wabanaki diets include (1) the availability of particular resources in known sequences and locations reflecting ecological information, (2) the tangible remains of particular resources at individual archaeological sites, and (3) the seasons in which those resources are known to have been obtained. For example, individual shellfish sites can be demonstrated to be warm season or cold season, or both, by virtue of the particular shellfish and their growth patterns, and when considered as a whole they provide a picture of an overall coastal diet (Sanger, 1996).

Within Maine, some early authors suggest that summers were spent on the coast while winters were spent along inland waterways (Willoughby, 1906). Other authors suggest the opposite, or that the summer-winter pattern shifted at the time of contact because traders plied the coast during the summer, thus drawing people there to trade. This might have shifted the pattern from an earlier pattern that drew people to the coast in winter where shellfish were a reliable winter resource.

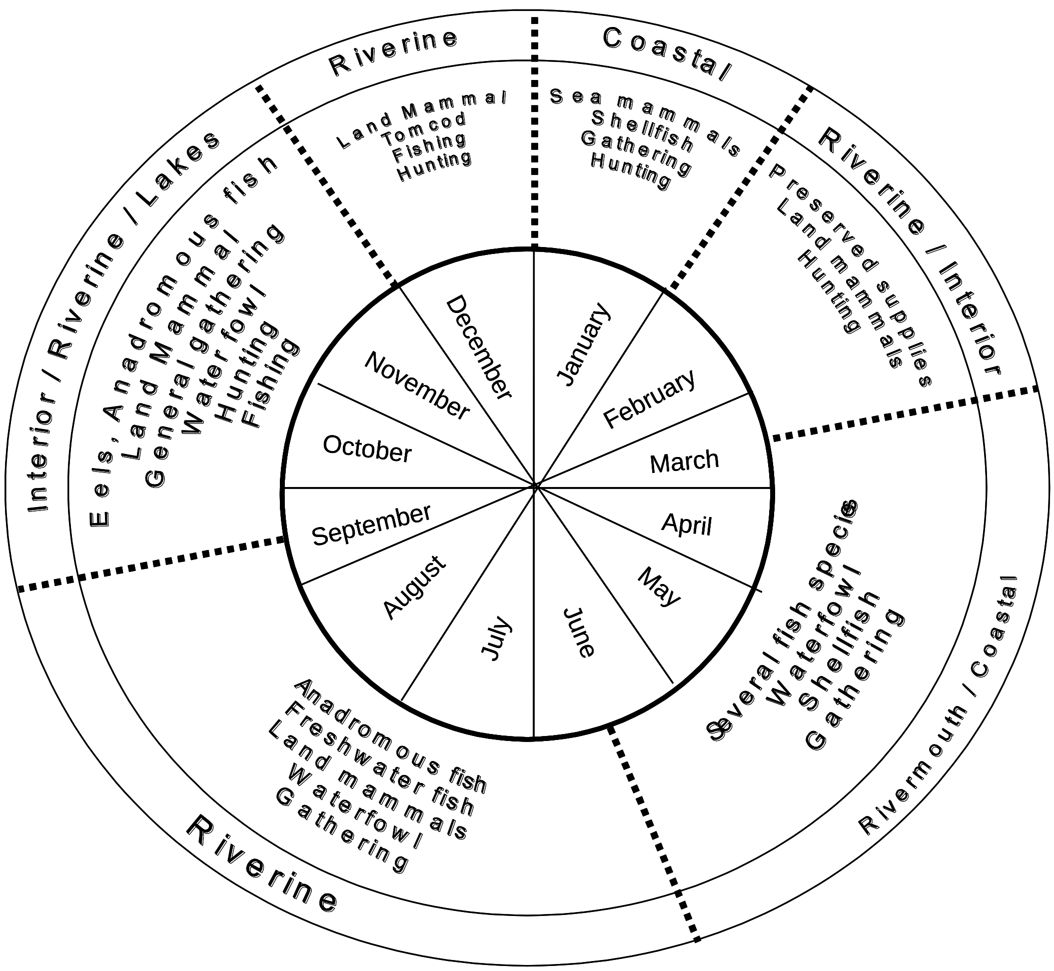
Sanger (1996, 2000) and Borque (2001) have shown that some coastal sites are warm season, some are cold season, and some are year-round according to the fish and shellfish species that were obtained at each. Sanger combined evidence across multiple sites into winter and summer assemblages of species. He suggests that coastal people moved back and forth along the shoreline from open to sheltered sites, more than from the coast to inland and back. The demonstrably winter sites are generally protected from the north winds and have access to winter food and fuel.

Other authors have also suggested similar seasonal patterns vary according to the local ecology. For example, McBride and Prins (2003) and Christianson (1979) suggested that marine resources could be exploited most of the year. They suggested that coastal people spent the winter in small bands along the coast and estuaries harvesting smelt, tomcod, seals, beaver, moose, bear, caribou, and other small game. During the spring, summer, and early fall people congregated in large coastal villages where people could collect anadromous salmon, seafoods, migratory birds, berries, and nuts. Fall hunting trips were pursued by small bands or families moving up and down the rivers.

All peoples living along anadromous rivers would have to match their schedules to the sequential spawning runs and migratory bird schedules. At least 8 anadromous fish species are present in Maine (salmon, alewife, shad, smelt, sturgeon, striped bass, and white and yellow perch), along with one that is partially anadromous (tomcod) and one that is catadromous (eel). Three of these (tomcod, eel, and smelt) are available in cold weather. Spring runs of smelt and spring waterfowl migration begin shortly after the ice has left the waterways (March-April). These are followed by herring, sturgeon, alewife, bass, and geese (April-May-June). In September to October the eel fishery was ready (Biard, 1616; Thwaites, 1901; Borque, 1973; Burley, 1983).

Sanger (1996) suggests that inland people also inhabited permanent villages with forays to specialty camps and the coast. However, data are sparse because inland soils do not preserve materials well and because prime sites near water, deer meadows, and anadromous harvest locations are largely obscured by modern development. Burley (1983) also suggests that inland population were highly attuned to resource diversity with a greater emphasis on riverine ecosystems but also used estuarine and coastal resources.. Burley's seasonal round for the Micmac is shown in Figure 14. Again, this does not necessarily mean wholesale migration of entire villages, but a combination of permanent base villages and specialized exploitation of seasonal resources.

Figure 14. A Micmac Seasonal Round (Burley)



6.2.1 Dietary Breadth, Abundance, and Food Storage

The diets presented in this report are presented at the level of food categories. The general abundance of resources supports the conclusion that an average of 2000 kcal per day was available throughout the year. In addition, the diversity of resources is used to support conclusions about the proportional size of each food category. For example greens are not preserved in archaeological sites, yet around one hundred plants are recorded by cultural experts and ethnobiologists as used for food or medicine. Therefore, a larger intake of plants is included in the diet than archaeology alone would indicate.

There appears to have been relatively little overall food insecurity. In addition to the observations of abundance made by early explorers and traders in the 1600s, other documentation is available for the 1700s, such as journals kept by settlers, traders, or records of captives who spent time in Indian villages. So productive were forest, field and stream that large stores of smoked fish, dried meat, nuts, and dried berries could be set aside in root cellars lined with birch bark or mats. Migrating flocks of ducks, geese, along with partridges, and wild turkeys added to the spring and fall larders. There was an "incredible variety of plants and animals that were available..." (Calloway, 1991; Raine, 1997).

Nevertheless, periodic scarcity was clearly known. Early Europeans, from coast to coast, make the point that aboriginal people often survived through feast or famine situations. In order to survive for millennia, native peoples must have had reasonably balanced diets, but stresses did occur and the wide-spread oral histories of famines are present in most societies. Human skeletons from archaeological sites across the continent show clear evidence of these dietary stresses in some skeletal remains. In fact, human physiology evolved the "thrifty genotype" to account for periodic famine and wide fluctuations in the availability of food. The Eurocentric emphasis on continual and constant food supplies over the winter may reflect contemporary concepts of food adequacy (and the lack of the thrifty genotypes that may have made shortages less tolerable).

Some early observers of the Wabanaki did not observe much food storage, and noted periodic winter food shortages, although they did not report starvation deaths. However, early observers also mentioned caching smoked meats, roots, acorns, as well as imported dry beans, peas, and prunes (obtained through trade). Tribal staff confirm that tribal members habitually smoke and preserve the meat of bears, eels, fish, and fowl, and use the meat over the winter. Oral history teaches that this is routine. Roots, shellfish, eggs, and fats and oils were also stored. Biard referred to stored seal oil, bear oil, caribou oil, and moose grease, which "serves them as sauce throughout the year" (cited in Barsh, 2002). The oil was stored in seal or moose bladders. Moose grease or moose butter was obtained from bone marrow in boiling water, where fats floated to the top and could be skimmed off and stored in cakes (Christianson, 1979). Meat was dried by sun, fire, or smoke; fish (eels, shad, alewives) were more commonly dried or smoked than eaten fresh. Lobsters and 'oysters' (probably clams) were also dried, and hard boiled eggs were minced and dried. Vegetable products were also dried, including corn (where grown), berries, and grapes. Bennett (1955) suggests that many more things were also dried. Sanger suggested that little food was smoked along the coast because he did not find many sites indicative of fish drying racks. However, Black and Whitehead (1988) suggest that Sanger underestimates storage of smoked foods, especially seafood.

The Wabanaki scenario attempts to reconcile these models by considering the archaeological observations along with information about ethnobotany (the breadth of plants used), ethnohistory (sociological and demographic information), early explorers and settler accounts, and nutrition, and conclude that reliance on dried or smoked foods was higher than Sanger estimated. For the regulatory applications of this scenario, a single constant intake is used, even though we recognize that the availability of food may vary throughout the seasons, and also the resources themselves can be quite seasonal in nature.

SIDEBAR

Sammy Louis, Micmac, Born 1923 on the Deer River Reserve, Nova Scotia.

Sayres (1958) described the life of Sammy Louis. His mother made baskets ("piles and piles" of them), sold or traded for food and necessities. Sammy's father was an expert fisherman, canoeist, and hunter. He also made baskets and axe handles. His father considered hunting [which includes fishing in this text] the "alpha and omega of life." Other families trapped for pelts. Some people were good hunters and knew woods lore. Sammy's family gardened on a small scale (potatoes, with some beans, peas, and carrots) and they had a "fair amount" of moose meat from his father's hunting. "*We ate pretty good, you know. We ate just about everything. We had all the vegetables from the garden, and a lot of meat either bought by my mother or shot by my dad. And we had a lot of fish, too. We bought some things that we ran out of or didn't have handy, like butter. We ate pretty good, three meals every day*." "*Another thing I used to do with my uncle was dig clams. We would go down to the beach and spend the day digging for clams. We used to get a lot of them because there were a lot of them around*." "*Another thing we used to get down at the beach was dulce. You get it from the water. It looks a lot like seaweed. We spread it out on the beach to dry. It was green when picked and red when dry. You could eat it right there after it dried, without cooking*." Sayres (1958).

Figure 15. Sidebar – Sammy Louis

This sidebar (Figure 15) is included to demonstrate that subsistence lifestyles did not disappear two or three hundred years ago. Even in the populous northeast, a fully subsistent lifestyle and intimate knowledge of their surroundings is within the memory of today's elders or their parents. Subsistence in this context means being self-sufficient, including a home garden and wild foods.

6.3 Inland Hunting and Fishing

This section briefly describes inland resource use. Later sections (below) describe fishing and plant gathering. Inland groups that did not have access to rivers supporting large anadromous runs depended largely on moose and beaver. In addition they hunted muskrat, deer, caribou, bear, rabbit, raccoon, porcupine, partridge, and turtle. Birds and resident fish are likely underrepresented in archaeological sites due to poor preservation (Speck, 1997; Snow, 1968; Cox, 2000). Beaver was especially important in non-anadromous areas, as abundant and not fluctuating as much as some of the other megafauna (Snow, 1968). Some archaeological sites near wetlands have >90% beaver bone fragments. Beaver dams in small tributaries create a series of stepped ponds, each only a meter or so higher than the previous one. Muskrat, an important food, was also prevalent since beaver dams create an ideal muskrat habitat. In addition, the ponds provide habitat for a wide variety of fish, amphibian, reptile, bird, and plants (Sanger et al., 2003) and are a vital part of the ecology. When beaver dams washed out, fertile margin soil was left. When beaver ponds filled in, meadows were created. From this review, we conclude that upland and wetland resources were roughly equal in importance to inland diets.

One research data gap is the question about a few resources that were greatly altered during the early contact era. In particular, it is well-known that beaver were hunted almost to extinction. It may be that beaver became a dietary favorite only after hunting for pelts resulted in a larger amount of beaver meat being available. On the other hand, pre-contact sites also contain many beaver bones. Eels may be another example of a forgotten resource due to a combination of availability and contamination with lipophilic contaminants, which may be reflected in contemporary times as an actual change in preference. Anecdotally, new oral history arises around known sources of contamination as a teaching tool and a way of protecting young families.

6.4 Coastal (Bays, Islands, Estuaries)

Due to the existence of more coastal sites with shell middens, more information is available on coastal sites than for inland sites. The general conclusion of this information is that the lifestyle of the Central Maine coast is characterized as a combination of littoral foraging, land mammal hunting, and in-shore fishing (Spiess et al., 2006).

Denys provided descriptions of the coast for the time period 1632-1672. “During the spring and the autumn this cove is quite covered with wild geese, ducks, teal and all other kinds of game. Their number is so great that it cannot be imagined.” In some bays, oysters [clams] are “a great manna for the winter when the weather does not permit going on the hunt.” There were also walrus, seal, salmon, shad, sea-going trout, lamprey, smelt, sea-eel, mackerel, herring, anchovy, sardine, and “many other sorts of little fish,” skates, and sole, although “they are frequently too large to land.”

Examples of reports for archaeological sites in Maine are presented below, although several reporting methods have been used for different sites and there is much variation between sites. For instance, some reports count bone and shell fragments and report percentages of fragment types; some convert fragment counts to numbers of whole animals; and some convert whole animals to an estimate of protein percent. Further, some sites are winter and some summer; and the species mix changes from strata to strata as sea level changed (Spiess et al., 2006).

Different archaeological sites have different ratios of animal remains, which is sometimes assumed to reflect the exact proportions of what people ate while they were in residence at the site. However, historical and cultural information suggests that many sites were located where certain resources were concentrated and were gathered for consumption elsewhere as part of a more balanced diet. Coastal sites range from 2% to 35% large and small game species, but this does not necessarily mean that some diets averaged only 2% game. As Sanger points out, groups of sites must be evaluated regionally to derive average diets. Therefore, species lists are presented below in rough order of abundance across a variety of archaeological coastal sites, from most to least abundant (Yesner, 1988; Barsh, 2002; Sanger et al., 2003; Christianson, 1979). It may be noted that some of these species may not be present currently:

> <u>Fish</u>: herring, smelt, cod, flounder, sculpins, shad, sturgeon, striped bass, eels, salmonids such as whitefish, plaice, trout, capelin, gaspereau/alewife, mackerel, redfish, saltwater sunfish, silver hake, skates, spiny dogfish, suckers, tomcod, and white perch.
>
> <u>Marine mammals:</u> walrus, grey seal (hunted; some pups taken), harbor seal, harp seal, hooded seal, white whale (when found beached; sometimes hunted and harpooned), porpoise.
>
> <u>Shellfish:</u> Shell middens are predominantly soft-shell clam (*Mya arenaria*), along with hard-shell clam (*Spirula solidissima*) and quahog (*Mercenaria mercenaria*) and a wide variety of other shellfish such as whelks, mussels, sea urchins, limpets, lobster, squid, scallop, horse mussel, crab, oyster, razor clam, shrimp, and other species. Oysters could be taken through the ice (some European authors appear to be referring to clams or mussels, not true oysters). Shellfish such as crab and lobster have thin shells that do not survive, so they are under-counted.
>
> <u>Land mammals:</u> beaver, white-tailed deer, black bear, caribou, fisher, squirrels, lynx, marten, mink, moose, muskrat, otter, porcupine, raccoon, red fox, skunk, show shoe hare, weasel, white-tailed deer, wolverine, woodchuck.
>
> <u>Birds:</u> puffin, owls, crow, gulls, murre, gannet, merganser, ruffed grouse (partridge), bittern, plover, scooter, woodcock, baldpate, black-crowned night heron, bufflehead, geese, loon, dowitcher, curlew, teal, guillemot, scaup, mallard, dove, osprey, grebe, auk.

6.5 Gathering Plant Foods, Medicines, Materials

A brief survey of vegetal resources is presented to gain an understanding of diversity, importance, and relative proportion of various plant families in the diet. This is particularly important since plant remains do not preserve well in archaeological sites and are easy to underestimate.

Some 200 native medicinal plants are known and were widely used until recently across America. Botany (the study of identity, classification, growth, and uses of plants) and medicine were practiced as interrelated arts until the 17th century when they emerged as two distinct areas of study in universities (Chandler et al., 1979). Most authors present lists of species rather than quantitative estimates because plants other than seeds or nuts are not preserved well in archeological sites and are difficult to identify. Some information on pollen is available. Seeds that were stored in a ground form are difficult to identify. Most earlier (and many modern) excavations did not identify small and/or carbonized flora remains. Horticulture is therefore generally underestimated, as are most plant portions of the diet. Additionally, since many cultivars were grown in seasonal floodplains, rather than less-frequently disturbed upland sites that are relatively less attractive to modern settlements; virtually every village was located at the very places most favored by Europeans (Petersen and Cowie, 2002).

Information on the breadth of flora usage is presented below in order to indicate the diversity of plants used. The intent is not to list every species and quantify their use, but to provide general support for the amount of the vegetal intake included in the food pyramids. For instance, if only the archaeological data is used, one might conclude that the diet consists of only a few percent of plant foods. However, the diversity of species and breadth of uses, the vitamin and mineral contribution of plants, and the cultural information together support a higher vegetal intake rate than the archaeological record alone would indicate.

Manuals on edible, medicinal, and useful plants list hundreds of species used in the northeast. Some of the Maine-specific citations include the following:

- McBride and Prins (2003) list 132 plant species used for food, medicines, and materials in Acadia National Park (Islands in Penobscot Bay), a few are introduced species.

- Speck (1915) lists hundreds of herbal remedies in Maine.

- Chandler et al. (1979) reviewed writings of early settlers and missionaries and compiled a list of 128 local plants used to treat about 70 ailments.

- At least 40 food plants in Maine have been listed by various authors (McBride and Prins, 2003; Asch Sidell, 1999a, b; Braun and Braun, 1994; Waugh, 1916; Speck, 1997).

The most often-used plants and some of their uses and methods of preparation are listed below. This list is not exhaustive, but is provided in order to gain a general idea of the diversity and importance of plants in the diets.

Nuts

Nuts were powdered for flour, bread, gravy, soups, as well as roasted or eaten whole. Fourteen nut species are found in the state. Red oak, hazelnut, and beech are widespread in Maine, and the rest are localized in the more southerly areas. Other Maine nut trees include shagbark hickory, chestnut, beaked butternut, white oak, swamp white oak, scarlet oak, bear oak, bur oak, chestnut oak, black oak.

Fleshy fruits

Strawberries (*Fragaria virginana* and *vesca*), raspberries (*Rubus idaeus* and *triflorus*), blackberry (*Rubus occidentalis*), thimbleberry (*Rubus ordoratus*), wild gooseberry (*Ribes* spp), wild black currant (*Ribes floridum* and *triste*), blueberry or huckleberry (*Vaccinium pennsylvanicum* and *corymbosum*), cranberry (*V. oxycoccux* and *macrocarpa*), juneberry (*Amelanchier canadensis*), elderberry (*Sambucus canadensis*), nannyberry (*Viburnum lentago*), viburnum (wild raisin; *Viburnum cassinoides*). tree cranberry (*Viburnum opulus),* wintergreen (*Gaultheria procumbens*), partridge berry (*Mitchella repens*), wild grape (*Vitis vulpina*), mulberry (*Morus rubra*), wild red or pin cherry (*Prunus pennsylvanica*), chokecherry (*Prunus virginiana*), wild black cherry (*Prunus serotina*), wild plum (*Prunus americana*), haws (*Crataegus pruinosa, submollis* and others), crab apple (*Pyrus coronaria*), mandrake (*Podyphyllum peltatum*), ground cherry (*Physalis spp*).

Medicinal/beverage.

Berries in honey-water, corn coffee, roasted sunflower seeds, nut broths, mints. Teas and various infusions of leaves, roots, barks, flowers – Bayberry, bedstraw, bristly sarsaparilla, wild sarsaparilla, buttercup, common lousewort, lily family, sumac, sweetfern. hemlock, birch twigs, sassafras roots, spicewood twigs, wintergreen leaves, witch hazel, raspberry twigs, sumac seed clusters, Monarda (horse-mint or Oswego tea), pennyroyal.

Seeds

Pigweed or Chenopod (*Chenopodium album* and *berlandieri*), hog peanut (a legume; *Amphicarpa bracteata*), tick-trefoil (a legume, *Sedmodium spp.*), wild sunflower (*Helianthus spp.).* Lamb's quarters (*Amaranthus retroflexus*), mustard (*Brassica spp*), and other seeds have been occasionally identified, along with dogwood, sedges, smartweed, and spruce. Grass and rye seeds appear in increasing quantities after 1000 BP but are not speciated (Asch Sidell, 1999b). Some squash or gourd seeds appear in the central part of the state fairly recently. Giant ragweed seeds are found repeatedly in situations that implicate giant ragweed as a cultivated species or utilized garden weed. Tick-trefoil was the most abundant and ubiquitous seed at the Tracy Farm site. "The great variety of Late Woodland/Contact food remains at Tracy Farm indicates that [perennial] nuts and fruits were an important part of the diet and that there were thickets and openings in the vicinity" (Asch Sidell, 1999a, b)

Greens

Fiddlehead ferns, marsh marigold shoots, cattail shoots, milkweed shoots, Jerusalem artichokes, wild leeks, milkweed flowers, rose hips, milkweed young plants; waterleaf; marsh marigold; yellow dock, Purslane (*Portulaca oleracea*), burdock, nettle, skunk cabbage, leek and wild garlic, wood betony, sensitive fern, water cress, peppermint, oxalis, grapevine shoots, cattail (shoots, roots and pollen), sumac shoots, red raspberry, corn silk, maple bark (dried and pounded into flour), and various buds, barks, seaweed, and flowers (Braun and Braun, 1994).

Roots, tubers, bulbs, corms, rhizomes

There was a sense among cultural experts that tubers were always eaten, although the names and species are not always clear. Among them are wild potato or ground nut (*Apios tuberosa*), Jerusalem artichoke (*Helianthus tuberosus*), pepper-root (*Dentaria diphylla*), lilies (yellow pond-lily, white lily, bullhead lily, cowlily), burdock (*Arctium lappa*), Solomon's seal, Indian turnip or jack-in-the-pulpit (medicinal only), skunk cabbage, Claytonia (*Claytonia virginica*).

Fungi

Meadow mushroom (*Agaricus campestris*), morrel (*Morchella*), puffball (*Lycoperdon*), polyporus fungi - various species.

Other

Maple syrup and honey. Other sweeteners include rose hips and berries.

Salt

Salt (sea salt) was not used much, but salt was present in natural broths such as from clams, and in natural fluids such as blood. Wood ash was used as a salt ash. Seaweed (dulce) was also dried. Sodium is not always easily obtained; for example, the quintessential image of moose eating aquatic vegetation has been linked to sodium hunger (Belovsky, 1981; McCracken et al., 1993).

One of the major archaeological sites is Norridgewock or Naragooc in the Kennebec River drainage basin (Cowie, 2002; Demerett, 1991; Petersen and Cowie, 2002; Bennett, 1955). In contrast to many other archaeological sites, floral remains at Norridgewock have been carefully studied. This location is at the southwesterly edge of the area that the Wabanaki scenario covers, and is within the zone that supported a reliable maize crop and other domestic cultivars.

The native plants identified at Norridgewock are present in many more sites across Maine. Floral remains at Norridgewock include corn, beans, squash, and wheat, along with amaranth (*Amaranthus*), hog peanut (*Amphicarpa bracteata*), big bluestem (*Andropogon geradi*), bristly sarsaparilla (*Aralia hispida*), chenopod or goosefoot (*Chenopodium berlandieriand other species),* dogwood (*Cornus alterniforlia*), bunchberry (*Cornus canadensis*), hawthorn (*Crataegus spp.),* tick trefoil (*Desmodium* spp.), wild rye (*Elymus* *spp.),* strawberry (*Fragaria spp.),* sunflower (*Helianthus spp.),* smart weed (*Polygonum spp.),* cherry (*Prunus spp*.), chokecherry (*Prunus virginiana*), sumac (*Rhus spp.),* bramble (*Rubus spp.),* elderberry (*Sambucus spp.),* blueberry (*Vaccinium spp.),* and grape (*Vitis spp*.). Brambles include raspberry, blackberry, and dewberry. Nuts include butternut, acorn, beechnut, and hazelnut, in order of commonness (Cowie, 1999).

6.5.1 Baskets, cordage, and material plants

There are at least 100 different categories of baskets woven in Maine, utilizing a wide range of raw materials: cedar bark, basswood bark, rushes, cattails, nettles, Indian hemp (dogbane), sweet grass, spruce roots, wood fibers, raw and treated hide, tendon thread, and porcupine quills. Innumerable variations on the style and method of craftsmanship exist among the indigenous Wabanaki tribal communities due to the enormous abundance of natural resources available for traditional tribal resource utilization. The most common weaving rush was the reed, *Scirpus lacustris*, which is found throughout Maine, growing to a height of two meters in shallow water along the edge of lakes and rivers. Cattail (*Typha)* and the reed *Juncus effusus*, which is smaller in diameter, may also have been used. Mats were woven tightly enough to be waterproof for shelter. Rushes are gathered in the late summer or after the first frost, immersed in hot water, then bleached and dried in the sun for a few weeks. They may then be dyed prior to weaving (Whitehead, 1980).

In northern Maine, brown ash (the basket tree, *Fraxinus negra*) grows in moist rich soil along the banks of streams. It is an important natural resource for the Wabanaki and is deeply rooted in Wabanaki culture. Basketmakers particularly prize the brown ash for its flexibility and strength. The tree is felled in winter, and the trunk is pounded to cause the wood to separate along its growth rings. That can then be spliced into strips for weaving baskets (Prins and McBride, 1983; Maine Indian Basketmakers Alliance, *A Wabanaki Guide to Maine*).

The inner bark of the white cedar, *Thuja occidentalis*, was gathered in the spring and used in strips in twill or checker weave in baskets. Thicker splints of witherod, yellow birch, elder, willow, ash, maple, cedar, poplar, and spruce were made into baskets and other items. Wicker materials were from shoots of Red Osier dogwood (*Cornus stolonifera*), alder (*Alnus crispa*, *Alnus rugosa*), elder (*Sambucis pubens*), witherord (*Viburnum cassinoides*), yellow birch (*Betula allegheniensis*), and numerous species of willow (Whitehead, 1980).

The Micmac and other Tribes used the bark of the white birch (*Betula papyrifera*) to make an incredible range of objects, including baskets, containers, canoes, and housing. It can be cut and sewn, and is waterproof and rot resistant.

Cordage was made from the inner bark of the basswood (*Tilia americana*) gathered in the spring when the inner bark separates easily form the tough outer bark. The inner bark is soaked in water for two to four weeks, to rot away all but the coarsest fibrous strands, which are then twisted into very strong cord. Cordage was also made from Indian hemp (dogbane *Apocynum cannabinum*) and some members of the nettle family (*Labiatae)*. Other fibrous materials were also used, such as yellow birch, beach grasses, and others (Whitehead, 1980).

The following is a list of some of the other plant materials that were utilized by the Wabanaki Indian Tribal members

Bayberry – wax
Witch hazel – hunting bows
White pine – canoes
Red cedar wood – dishes
Sweet flag – roofing and caulking
Sphagnum moss – absorbent
Cattails – thatching and weaving, absorbent
Hickory wood – bows
White oak wood – canoes, dishes

6.5.2 Environmental Management

There was less active environmental management in Maine than in the Mid-Atlantic and other regions. Asch Sidell (1999) suggests that burning was not common since transportation on water was easy so forest lanes did not need to be cleared, and northern trees such as beech, maple, black birch, white pine cannot sprout from the roots as oak, chestnut and hickory can. Some meadows were burned occasionally to maintain them for deer, and berry patches were burned periodically (Prins, 1994; Calloway 1991). Early explorers reported that in southerly parts of New England tribes maintained "much park like upland forest, wherein the undergrowth was burned off annually in order to provide grazing for deer and open ground for winter hunting."

7. THE WABANAKI DIET

The intent of this section is to explain the thought process used to reconstruct diets that are nutritionally complete and reflective of the three habitat types and resource utilization patterns in Maine. This explanation will allow readers to evaluate whether the conclusions are reasonable. Because this process was a best professional judgment and not a statistical exercise, the goal was to derive reasonable estimates of food groups. We recognize that another professional might reconstruct slightly different diets, but not so different that a different risk assessment result would be obtained.

The basic premise of dietary reconstruction is that the original 'potential natural vegetation' and other natural resources will support the subsistence lifestyle. Current environmental conditions may or may not be adequate to support many people in full subsistence at present, but the underlying assumption is that they will be restored so subsistence use can be regained by more people. Information about current uses of existing natural resources is part of the consideration, but contemporary dietary surveys are not useful in answering the question of what the diet was and will be once natural resources are restored.

The general steps were to:

1. Review information about ecological settings and natural resources, ethnohistorical and contemporary natural resource use, archaeological evidence, tribal history and interviews;
2. Review databases of contemporary foods and diets for comparability, native foods currently eaten, ethnic data, regional data, and contemporary quantities;
3. Identify dietary staples and develop overall percentages of major food categories including medicinal plants for a completely subsistent diet(s);
4. Estimate total calories and quantities of food provided by the diets;
5. Refine estimates of major staples and food categories, macronutrients, and other factors. This is a reasonable estimate, not a statistical estimate with ranges.

7.1 Dietary Components of Risk Assessment

While there is general guidance on how to evaluate dietary exposures, individual risk assessments can be quite variable. For example, some risk assessments simply divide plant foods into above-ground or below-ground foods if airborne deposition is the primary focus. Water quality standards might be developed based on drinking water alone, water plus fish, water plus all aquatic resources, or all water-based pathways including irrigation of food crops and domestic use. In order to make this report most useful, nutritionally complete diets are presented by major raw food categories, which can be grouped during specific applications.

Several approaches to selecting food categories were considered. EPA's Exposure Factors Handbook (EPA, 1989)[24], which is the EPA guidance that risk assessors follow for CERCLA

[24] http://www.epa.gov/nceawww1/efh/pdfs/efh-front-gloss.pdf *and* http://www.epa.gov/oswer/riskassessment/ragsa/pdf/preface.pdf

risk assessments, originally suggested using food ingestion factors for fruits and vegetables, fish and shellfish, meat and dairy, grain, 'various home-produced products' and breast milk. However, there is no overall guidance for ensuring that a nutritionally complete diet is evaluated in CERCLA risk assessments, or for matching food categories with ecological niches.

The USDA-HHS Food Guide Pyramid is the least detailed presentation of an average American diet, using five basic food groups. These groups are (1) bread, cereal, pasta, and rice; (2) vegetables; (3) fruits; (4) milk, yogurt and cheese; and (5) meat, poultry, fish, dry beans, eggs, and nuts. A sixth group (fats, oils and sweets) consists mainly of items that are "pleasing to the palate but high in fat and/or calories." This grouping does not support evaluation of native resources according to their different habitats.

The federal government tracks national consumption, which is used in regional or national risk assessments and is applied to risk assessments for the general population. The same level of data is not available for ethnic subgroups. Foods tracked by federal government (USDA, FDA) include both raw food categories and prepared foods (Egan et al, 2007). The basic raw food groups used by FDA[25] are dairy, eggs, baby foods, meat/poultry/fish, legumes (legumes, nuts, seeds), vegetables and their juices, fruits and their juices, mixtures (soups, stews), fats and oils, grains and flour, other beverages, snacks, and sweets. The total quantity of food across all adult age groups is about 2000 grams per day[26]; the total calories averages 2195 kcal/d across the US in 2003-2004. This approach is somewhat more useful because it is based on raw food groups, but would have to be modified to support habitat evaluations.

The Total Diet Study[27] (TDS) conducted by FDA is based on USDA's 1994-96 and 1998 "Continuing Survey of Food Intakes by Individuals" (CSFII) (USDA 2000). The TDS food lists and diets are compiled from national consumption survey data through a process of aggregating survey foods and consumption amounts. During the food consumption surveys, detailed information is collected on the types and amounts of food consumed by each survey participant. Over 5,000 different foods were reported in each of the USDA surveys that were used for compiling the 1990/91 and 2003 food lists and diets. Although there are many fewer TDS foods (~ 280) than survey foods (> 5,000), the goal of the TDS diets is to account for total food consumption.[28] However, these databases cannot easily be converted into raw food categories.

Because databases for subsistence diets do not exist, and because food categories tracked by the federal government are not directly applicable to ecological niches, a modified approach for selecting food groupings is presented in the next section.

[25] www.cfsan.fda.gov/@comm/tds-toc.html
[26] http://www.ars.usda.gov/Services/docs.htm?docid=14958
[27] http://www.cfsan.fda.gov/~comm/tds-hist.html. (2003 version)
[28] http://www.usda.gov/factbook/chapter2.htm

7.2 Nutritional Analysis

The combined consideration of raw food groups, habitats, plant families, lists of utilized species, and caloric similarities led to selection of the following food groupings (Table 1):

- fish and other aquatic resources (divided into resident and anadromous groups),
- large and small game (may be separated based on homerange, feeding guild, or other factors)
- fowl and eggs,
- bulbs (Allium family),
- berries and fruits,
- above-ground vegetables including legumes,
- greens (including tea, medicinal leaves),
- roots/tubers,
- nuts/grain/seeds,
- sweeteners and miscellaneous foods.

One consideration when applying this diet to risk assessment is the crosswalk between human health risk assessment and ecological risk assessment. This may be important if an approach is taken of integrating omnivorous subsistence consumers into an ecological risk assessment, or when using the output of the ecological risk assessment as input into the dietary component of the human health risk assessment.

After the major food categories and representative foods were determined, the representative species were identified and caloric information was retrieved from the USDA database[29] for either the exact species, a member of the same or nearest plant family, and the exact animal or other animal from a similar habitat and feeding guild (e.g., wetland omnivore or upland browser). The data for fresh or cooked foods matches the form of native foods eaten as closely as possible. The USDA data was derived from recent studies on contemporary domesticated and wild foods, including some information on different methods of food preparation. Some of the information was obtained by USDA in response to requests from Indian Tribes and is appropriate as to species and cooking method (e.g., roasted beaver). In other cases nutrient data are not available (such as for wild tubers or bulbs), so data for the nearest domesticated species was used. In most cases this would probably not alter the high-level food pyramid or food circle, even though native peoples recognize that flavor, texture, and “strength” differ between wild species and domesticated cultivars.

Each food category represents many other species. For example, in the discussions with the Tribes during the development of these diets, there was a general sense that tubers were always eaten, such as Jerusalem artichokes, and arrowroot. Bulbs were also mentioned frequently, including several kinds of lilies, as were greens and berries. These two categories, therefore, are accorded separate categories and a greater role than the archaeological information alone would indicate.

Fish and shellfish are grouped together due to their caloric similarity. When applying the coastal scenario to a specific site, it may be beneficial to separate fish from shellfish to reflect resource management goals or other site-specific applications.

[29] http://www.ars.usda.gov/main/site_main.htm?modecode=12354500

Table 1 shows information from the USDA database for 100 gram portions of representative foods. This information is used when evaluating caloric content of the diets that are suggested for the Wabanaki scenario.

Table 1. Nutritional Data for Representative Species

Food Category	*Kcal per 100g (Representative species)**	Food Category	*Kcal per 100g (Representative species)**
Resident fish and other aquatic resources	Mixed trout, cooked – 190 Crayfish, wild cooked - 82 Turtle, raw - 89	***Bulbs***	Leek, onions and other bulbs (bulb & leaf) – 31
Anadromous and marine fish and shellfish	Salmon, cooked – 180 Shad, cooked - 252 Herring, dry cooked – 200 Pollock, dry cooked - 118 Eel, dry cooked – 236 Oyster, dry cooked – 70 Clam, moist cooked – 148 Lobster, moist heat cooked - 98 Seal, raw – 142 Beluga, raw - 111	***Berries, fruits***	Raw elderberries – 73 Raw strawberries - 70
		Other vegetables (above-ground)	Beans, cooked pinto, kidney or white – 143 Peas, boiled pigeon or split - 120 Squash, cooked winter – 37 Squash, cooked Navajo - 16
Game, large and small	Deer, roasted – 158 Moose, roasted – 134 Moose liver, braised - 155 Rabbit, wild, roasted – 173 Beaver, roasted – 212 Muskrat, roasted - 236	***Greens, Tea (includes leaves, stems, medicinal plants, flavorings)***	Raw dandelion greens – 45 Raw watercress – 11 Fiddleheads, raw - 34
		Honey, Maple syrup, other	Honey – 304 Maple syrup - 261
Fowl and Eggs	Quail, cooked – 234 Duck, cooked - 200 Duck eggs – 185 Pheasant (for wild turkey) - 247	***Seeds, Nuts, Grain***	Corn, Navajo strain steamed - 386 Raw dried sunflower seeds – 570 Chia seeds – 490 Hazelnut, dry roast – 646 Butternuts, dried - 612
		Roots, Bulbs, Tubers	Raw chicory root – 73 Boiled burdock root – 88 Potato, baked tuber - 200

The basis for the Wabanaki diets is an assumption of 2000 kcal/day. This amount of energy intake is much less than athletes in training require, but is adequate for a mix of 2 hours of high activity, 6 hours of moderate activity, 8 hours of low and sedentary activity and 8 hours of rest (the same activity used for estimation of inhalation rate). Basic nutritional and energy requirements (Stipanuk, 2000) were compared to information on resource abundance to evaluate overall adequacy of the initial diets. The initial estimates were then refined based on information on paleonutrition (Wing and Brown, 1979; Sobolik, 1994), exercise physiology (McArdle et al., 1996; 1999), and suggestions from the Tribes' Culture Departments.

Additionally, methods from other authors was also evaluated for relevance and compared to the results reported in this report (Delorimer and Kuhnlein, 1999; Egeland, 2004; Kuhnlein et al., 1996; Kuhnlein et al., 2006; White, 1999; Brand-Miller, 1998; Eaton and Eaton[30]). In

[30] http://www.cast.uark.edu/local/icaes/conferences/wburg/posters/sboydeaton/eaton.htm

particular, the literature describing complete and traditional food systems (for example, 3000 kcal; Brand-Miller, 1998) is very limited; most reports examine contemporary hybrid natural-western diets rather than describing the baseline fully subsistent diet.

The following pages show the nutritional information for the three Maine diets. Information is presented for average adults, and may be scaled up (athletes) or down (elders, children). As mentioned, iteration between estimated percent of calories and estimated quantities for each food category resulted in our best judgment of the complete diets. These estimates are based on a general consideration of resources present and reported to be used combined with nutritional information, but are not derived as statistically-derived calculations with ranges because that level of precision would not be warranted.

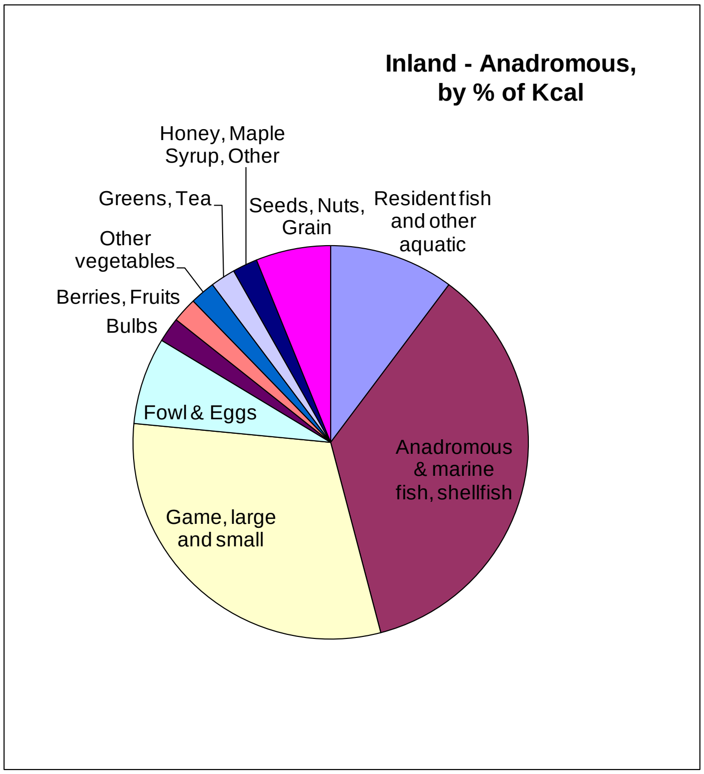
These diets are reasonable representations across locales within a general ecoregion, genders, seasons, and age groups (excepting children's diets, which were not estimated). The terminology for the three Maine diets is:

- "Inland-Anadromous" refers to inland communities living on rivers with anadromous fish runs;
- "Inland Non-Anadromous" refers to inland communities without access to anadromous fish runs;
- "Coastal" refers to communities living where coastal resources are available.

Table 2. Inland-Anadromous Diet

Inland - ANADROMOUS				
Food Category	***% of 2000 kcal***	***Equivalent kcal day***	***Rep kcal/ 100g***	***Grams per day***
Resident fish and other aquatic	10	200	175	114
Anadromous & marine fish, shellfish	35	700	175	400
Game, large and small	30	600	175	343
Fowl & Eggs	7	140	200	70
Bulbs	2	40	30	133
Berries, Fruits	2	40	100	40
Other vegetables	2	40	100	40
Greens, Tea	2	40	30	133
Honey, Maple Syrup, Other	2	40	275	15
Seeds, Nuts, Grain	6	120	500	24
Roots, Bulbs, Tubers	2	40	100	40
TOTALS	***100***	***1960***		***1312***

Figure 16. Foodwheels for Inland - Anadromous Diet



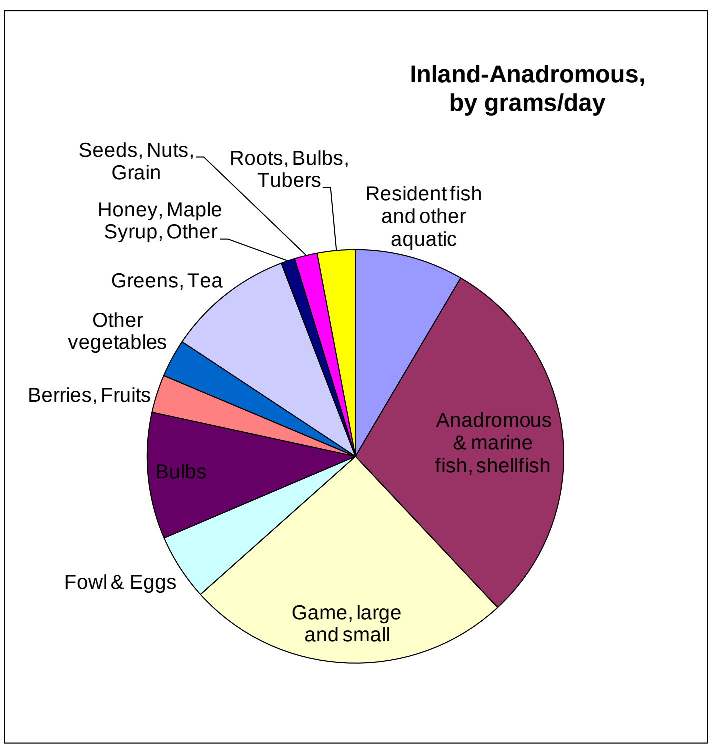
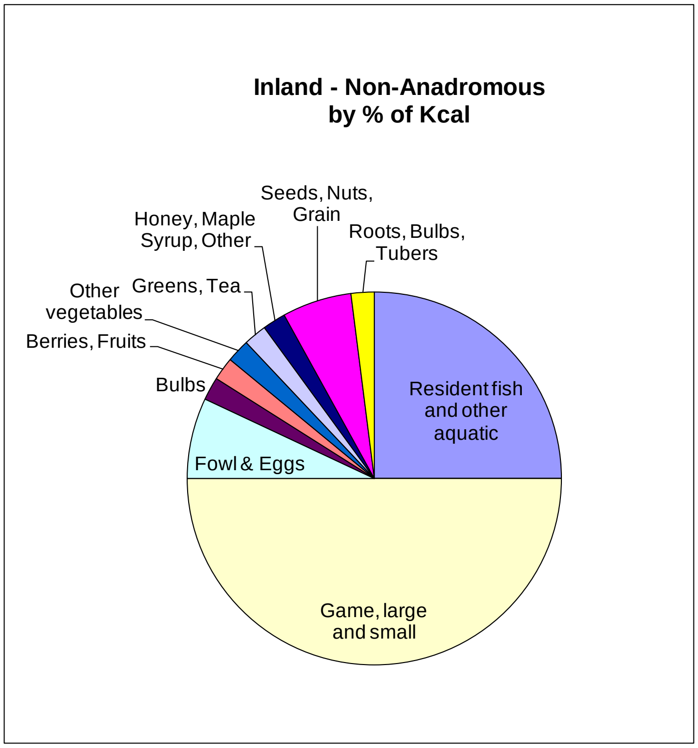


Table 3. Inland Non-Anadromous Diet

Inland NON-ANADROMOUS				
Food Category	***% of 2000 kcal***	***Equiv. kcal/ day***	***Rep kcal/100g***	***Grams per day***
Resident fish and other aquatic	25	500	175	286
Anadromous & marine fish, shellfish	0	0	175	0
Game, large and small	50	1000	175	571
Fowl & Eggs	7	140	200	70
Bulbs	2	40	30	133
Berries, Fruits	2	40	100	40
Other vegetables	2	40	100	40
Greens, Tea	2	40	30	133
Honey, Maple Syrup, Other	2	40	275	15
Seeds, Nuts, Grain	6	120	500	24
Roots, Bulbs, Tubers	2	40	100	40
TOTALS	***100***	***2000***		***1352***

Figure 17. Foodwheels for Inland Non-Anadromous Diet



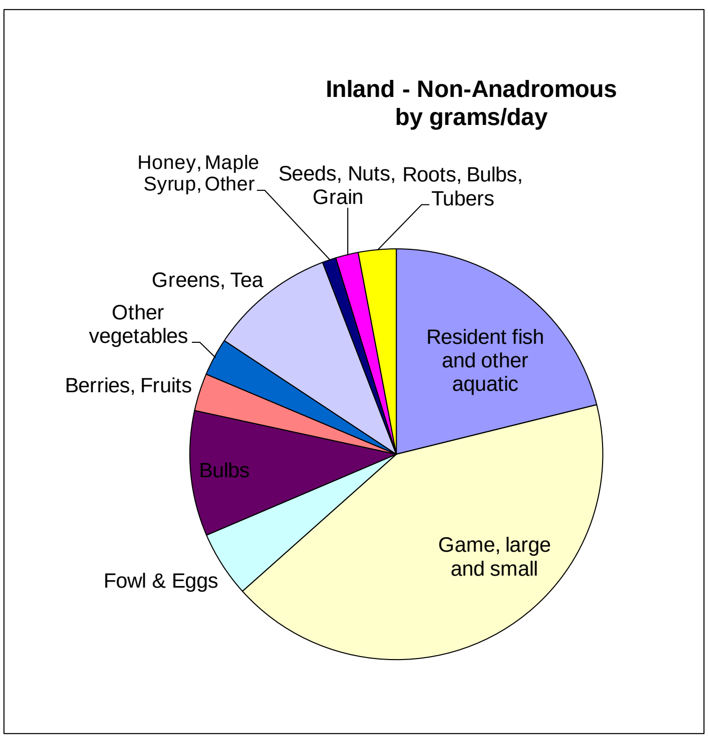
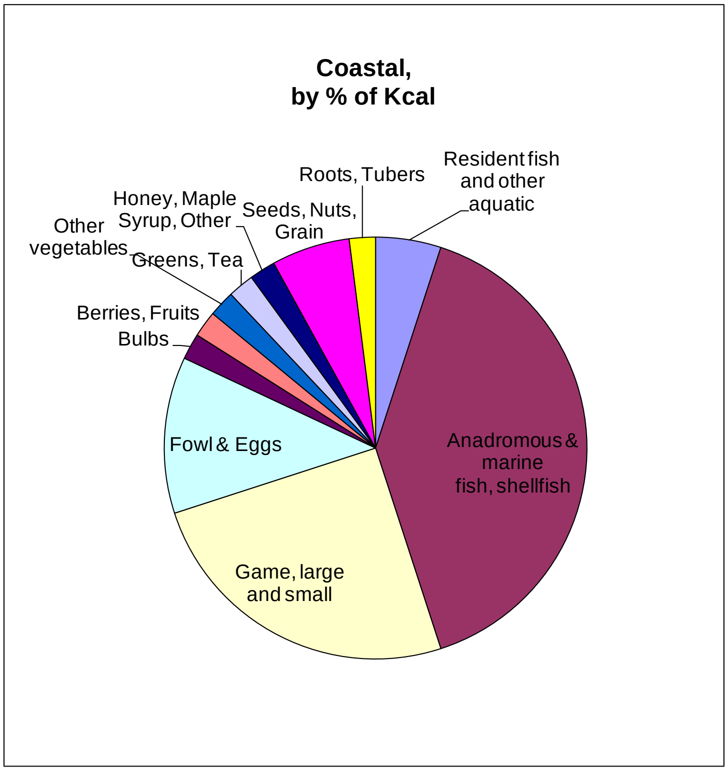
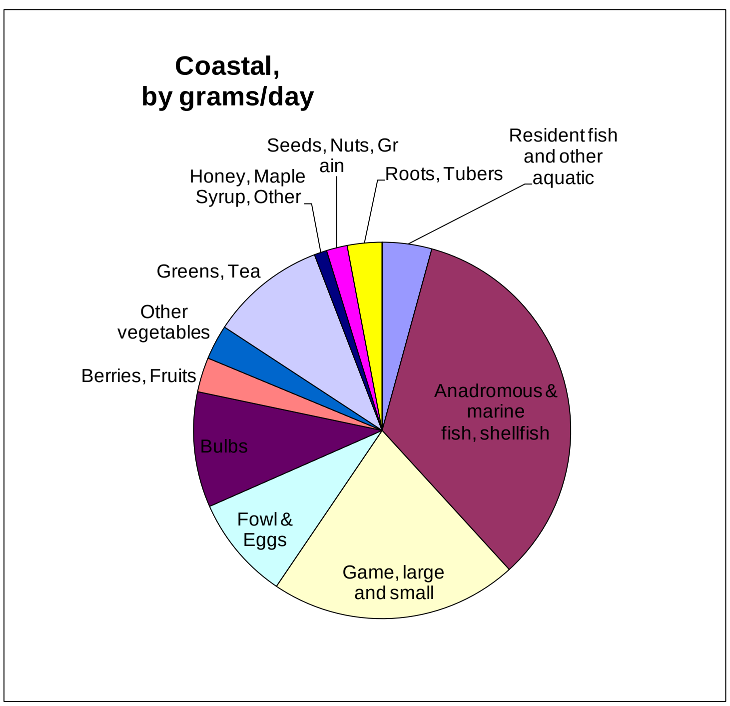


Table 4. Coastal Diet

COASTAL				
Food Category	***% of 2000 kcal***	***Equiv. kcal/ day***	***Rep kcal/100g***	***Grams per day***
Resident fish and other aquatic	5	100	175	57
Anadromous & marine fish, shellfish, marine mammals	40	800	175	457
Game, large and small	25	500	175	286
Fowl & Eggs	12	240	200	120
Bulbs	2	40	30	133
Berries, Fruits	2	40	100	40
Other vegetables	2	40	100	40
Greens, Tea	2	40	30	133
Honey, Maple Syrup, Other	2	40	275	15
Seeds, Nuts, Grain	6	120	500	24
Roots, Tubers	2	40	100	40
TOTALS	***100***	***2000***		***1345***

Figure 18. Foodwheels for Coastal Diet





8. DIRECT EXPOSURE FACTORS AND PATHWAYS

8.1 Approach

This section focuses on direct exposure pathways: ingestion of water, sediment, soil (including residual soil on the outside of food) and inhalation. This information will be useful when conducting cumulative (multi-pathway) risk assessments as well as for media-specific assessments or standards development.

Default exposure factors have been developed for conventional suburban, urban, occupational, and recreational scenarios based on national statistics and assumptions about the activity patterns that comprise those situations. The approach for developing a tribal scenario is similar, except that large statistical databases are not available. Therefore, we rely on existing literature and professional judgment.

The conceptual steps in this process are:

1. Understand the lifestyle and the activities that comprise the lifestyle, and are required to obtain necessities and engage in the community culture.
2. Describe the day, the year, and the lifetime of Maine Indian men and women to identify any significant differences in activity levels between genders or ages.
3. Cross-walk activities with exposure pathways on the basis of frequency and duration of major activities, activity levels, and degree of environmental contact.
4. Estimate cumulative exposure factors.

8.2 Major Activities

As with other indigenous communities, traditional Native American lifeways in Maine are active outdoor lifestyles that are moderately physically demanding, even with some modern conveniences. This scenario is intended to represent a central tendency or average culturally active and subsistence person, but information about especially active individuals is also considered; for example, young Indian bachelors ("pure men" or "runners") would run down game and serve as messengers (Speck, 1979).

Wabanaki indigenous subsistence foragers (both genders) perform a combination of aerobic (high pulse and ventilation rates), strength, endurance, and stretching-flexibility daily activities, as well as more sedentary work and resting. Table 5 and Figure 20 show the thought process for considering the wide range and numerous activities associated with the major activity categories (hunting, fishing, plant gathering, wood gathering, and sweatlodge purification). In actuality, many activities are sequential – for example, a resource might be gathered in one location, used in a second location to make an implement or basket, and taken to a third location for use in hunting or fishing[31]. The activities shown in Figure 20 are

[31] This is similar to the Cultural Ecosystem Stories concept developed Terry Williams (Tulalip Tribes) with the associated software, ICONS (see, for example, http://www.epa.gov/owow/watershed/wacademy/ wam/comresource.html).

so interconnected that it is virtually impossible to separate a lifestyle into distinct categories, but they are presented as separate for illustration purposes. Figure 20 presents examples of the wide variety of tasks that occur within major activity headings. There are many educational and preparatory tasks, as well as many post-activity tasks that must be considered with respect to environmental contact.

The activities shown below reflect original activities, whereas most are now modulated by modern conveniences. The direct exposure factors have taken this into consideration.

Table 5. Descriptions of Major Activities

Activity Type	***General Description***
Hunting	Hunting includes a variety of preparation activities of low to moderate intensity. Hunting occurs in terrain ranging from flat and open to steep and rugged. It may also include setting traplines, waiting in blinds, climbing, etc. After the capture or kill, field dressing, packing or hauling, and other very strenuous activities occur, depending on the species. Subsequent activities include cutting, storing (e.g., smoking or drying), returning the remains to the ecosystem, and so on.
Fishing	Fishing includes building weirs, hauling in lines and nets, gaffing or gigging, wading (for shellfish), followed by cleaning the fish and carrying them to the place of use. Activities associated with smoking and constructing drying racks may be involved. Remains are returned to aquatic ecosystems.
Plant Gathering	Women gather plants, bark, and kindling up to a day or two distant from the camp or village using a variety of tools such as digging stick, knife, and basket or other means for carrying resources back to camp. A variety of activities is involved, such as hiking, bending, stooping, wading (marsh and water plants), digging, bundling, carrying, and climbing over a wide variety of terrains.
Wood Gathering	Gathering wood for firewood (domestic and sweatlodge) and splint basketry materials is a frequent and vigorous activity. Activities include felling, skidding, bucking, splitting, and stacking. Ash splints require lengthy pounding to loosen the bark from the core.
Ritual Purification (Sweatlodge)	Sweatlodge building and repairing is intermittent. Willoughby (1906) and McBride and Prins (1983, citing Denys) suggest that the sweatlodge was used weekly or monthly, either in a cave or in a small structure covered with mats or skins.
Materials Use and Food Preparation	Many activities of low to high intensity are involved in preparing materials for use or food storage. This category includes basketmaking, which is an example of a very important activity with its own set of prescribed activities, meanings, and cultural ethics.

Figure 19. Examples of Wabanaki Indigenous Subsistence Activities

Hunting ⟺	***Purification/ Sweatlodge*** ⟺	***Gathering*** ⟺	***Fishing***
Learn skills	*Learn skills, songs*	*Learn skills*	*Learn skills*
Making tools	*Build lodge from natural materials*	*Previous gathering*	*Make nets, poles, tools*
Ritual bathing	*Gather rocks*	*Make baskets, bags*	*Travel to location*
Vigorous activity in hunting	*Chop firewood*	*Hike to areas*	*Catch fish, haul out*
Pack meat out	*Prepare for use, get water*	*Cut, dig, harvest*	*Clean, can, hard dry, soft dry, smoke, eat whole fish or fillet or liver or soup*
Process meat	*Use Lodge, sing, drink water, inhale steam and smudges*	*Carry out items*	*Return carcasses to ecosystem, use as fertilizer*
Scrape hides	*Close area & fire*	*Wash, peel, process, split, spin, dye*	
Tan, use other parts		*Cook and eat or make product or make medicine*	
Cook, smoke, dry, eat meat and organs			

Table 6 shows the cross-walk between tribal activity categories and exposure pathways, showing how exposure factors are derived from knowledge about activities, and interlinked resources and ecosystem stories, and the technical literature. This is an iterative process that relies on multiple lines of evidence. This is not intended to be a complete listing of activities; for example, details related to wood gathering are spread among several categories although it could warrant its own category. It shows an example of the thought process used to iteratively cross-walk exposure pathways and categories of subsistence activities. The last column ("totals") shows how exposure pathways (such as soil ingestion) are evaluated by estimating across activity categories. This is not a statistical summation but rather a judgment based on multiple lines of evidence such as ethnohistorical, archaeological, nutritional, and experimental information.

Table 6. Considerations During Integration of Activity Categories with Exposure Factors

	Hunting and associated activities	***Fishing and associated activities***	***Gathering and associated activities***	***Ritual purification and associated activities***	***Material and food use and processing***	***<u>Totals</u> for major exposure factor categories***
Food, Medicine, Tea, other biota ingestion (diet)	*n* deer /yr diet; Total large-small game, fowl. Organs eaten	*n fish* /yr diet; Total pounds or meals/day-wk-yr; Organs eaten.	Includes foods, medicines, teas, etc.	No food, but herbal particulates are inhaled.	Both as-gathered and as-eaten forms; cleaning and cooking methods.	Must account for all calories, breadth of plant species; parts eaten
Soil, sediment, dust, and mud ingestion	Terrain types such as marsh with more mud contact.	Sediment contact, dust and smoke if drying; weir construction, tide flats	External soil on plants; cooking method.	Includes building the sweat lodge and getting materials.	Includes incidental soil remaining on foods.	Must consider living area, unpaved roads, regional dust and mud.
Inhalation rates	Days per terrain type; Exertion level; hide scraping; load & grade.	Exertion level – nets and gaffing methods; cleaning effort.	Exertion level for load and grade; or gardening. Include making items.	Includes building the lodge, chopping firewood, singing.	Exertion level for pounding, grinding, smoke from fires.	Must account for exertion levels; smokes and smudges.
Groundwater and Surface water pathways	Ritual bathing, Drinking water; wash water; water-to-game and plants pathways.	Drinking water; incidental ingestion, washing and cooking.	Drinking water, cooking water, soaking in mud or water.	Steam in lodge; drinking water during sweat.	Soaking, washing, leaching tannins, other uses.	Must account for climate, sweat lodge, ritual bathing.
Dermal pathways	Soil, air and water pathways, plus pigments and exposure to microorganisms	Immersion considerations.	Same as hunting.	Immersion with open skin pores.	Includes basketmaking, wounds.	Must consider skin loading and habitat types.

Seasonality. The changes in activity patterns over the annual seasonal cycle has been modified in modern times, but the ecological cycle has not, so people must still gather plants according to when they are ripe, hunt according to game and fowl patterns, and fish when the spawning runs occur. While specific activities change from season to season, they are replaced by other activities with a similar environmental contact rate. Many items are gathered during one season for year-round use. For instance, a particular plant may be gathered during one month, while another month may be spent hunting, and a winter month may include cleaning and using the items obtained previously.

For the purposes of this study, we are assuming that all activities throughout the seasons are roughly equal in terms of energy expenditure, and that there is no decrease in environmental contact rates during winter months. In reality, winter is a less active season, which might reduce caloric intake and inhalation rate, so the diet and inhalation rate are moderate and are intended to be central tendency rather than upper bounds. The report recognizes that late winter or early spring could be times of hardship when supplies were exhausted and the spring resources were not ready.

The main winter foods were fresh, dried and frozen meats and fish, dried berries, seeds, dried root and seed cakes, and teas and medicines. Modern methods of storage (canning, pickling, salting, and so on) extend the availability of preserved foods throughout the year.

Gathering firewood was required year-round. There was also winter fishing and hunting, as well as an emphasis on making tools, baskets, and other material items. Food and material preparation were constantly required regardless of the season. Similarly, Wabanaki Indigenous people were always scouting, tracking game, monitoring areas to determine what resources were ready for harvest, looking for good stands, or visiting neighbors.

8.3 Exposure Factors for Direct Exposure Pathways

For the purposes of developing these exposure factors, the description of tribal activities focused on:

- Frequency of activity (daily, weekly, monthly)
- Duration of activity (total years)
- Hours at a time
- Intensity of environmental contact and intensity of activity

8.3.1 Drinking Water

For the Maine climate, the drinking water ingestion rate is assumed to be the conventional 2 liters per day as recommended by the Exposure Factors Handbook. That rate is an upper bound for the general population based on relatively recent national surveys of urban and suburban populations and general fluid needs. The Spokane and Umatilla scenarios (Harper et al., 2000; Harris and Harper, 1997) recommended 3 L/d for the hot arid climate of the Columbia Basin plus an additional liter for rehydration during daily sweatlodge use. However, the Maine climate is cooler and moister, so a lower rate is recommended even considering the frequency of active and/or outdoor subsistence activities.

8.3.2 Soil and Sediment Ingestion

Soil ingestion includes consideration of direct ingestion of dirt, mud, sediment, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. Generally soil ingestion rates are poorly quantified, so a qualitative estimate based on the literature and the environmental conditions and environmental activities has been made. Higher or lower rates could also be supported, so a moderate value was selected as generally representative. This is a source of uncertainty, but is unlikely to be amenable to further refinement because the methods are intrusive and complex.

The recommended Wabanaki soil ingestion rate of 400 mg/day is the same as the authors of this report recommend for all indigenous communities. It is based on a review of EPA guidance, soil ingestion studies in suburban and indigenous settings, and dermal adherence studies (see Appendix 2 for more detail). It is also based on knowledge about tribal subsistence lifestyles with their higher environmental contact rates and local climatic and geologic conditions. It reflects a variety of soil exposure pathways activates such as cooking, wild foods harvesting and/or gathering (or gardening), residual soil or dust on foods and medicine, holding natural materials in the mouth while processing or using the materials, driving on unpaved roads, and other activities. It also considers the frequency of higher contact events such as sports, pow-wows, days in wetlands or forests, and similar activities. There are also likely to be many intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).

The soil ingestion rate of 400 mg/d for all ages is also the published upper bound for suburban children (EPA, 1997), and is within the range of outdoor activity rates for adults but lower than the typical 480 mg/d applied to intermittent outdoor occupations such as construction, utility worker or military soil contact levels. The US military assumes 480 mg per exposure event[32] or per field day. The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[33]. Anecdotally, US forces deployed in Iraq report frequent grittiness in the mouth and food, reflective of soil grain size of 50-75 microns, the size threshold between sand and silt or clay in various soil texture classification scales. Haywood and Smith (1990) also considered sensory reports of grittiness in their qualitative estimate of a soil intake rate of 1-10 g/d in aboriginal Australians.

Simon (1998) reviewed soil ingestion studies from a perspective of risk and dose assessment. Because of their high dependence on the land, Simon recognized that indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Based on his qualitative judgment, Simon recommended using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommended using 3 g/d for all indigenous children.

[32] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.
[33] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

For the Wabanaki climate and lifestyle, the soil ingestion rate for all ages is assumed to be 400 mg/day for 365 days/year. This is higher than the prior EPA default value of 200 mg/day (USEPA, 1989). This rate reflects both indoor dust and continuous outdoor activities analogous to gardening or camping (Van Wijnen, 1990), but it is less than a single-incident sports or construction ingestion rate (Boyd, 1999). More detail is presented in Appendix 2.

Application of a soil ingestion exposure factor should consider whether the ingestion rate of 400 mg/d should be applied to each location and soil or sediment type separately, or whether the soil ingestion rate should be apportioned among all locations within an assessment area. Development of exposure point concentrations is not within the scope of this report. Specific recommendations for soil, sediment, and dust are a data gap at present.

8.3.3 Inhalation Rate

The inhalation rate in the Wabanaki scenario reflects the active, outdoor lifestyle of traditional tribal members. Traditional tribal communities had no sedentary members except the frail elderly, whereas one-quarter of modern American adults of all ages report no leisure time physical activity at all.[34] This report recognizes that contemporary tribal communities are striving to regain this level of activity,

Unlike most other exposure factors, which are upper bounds, the inhalation rate is a median rate, and is conventionally 20 m^3/day in EPA risk assessments based on activity levels in the general population. The activity levels associated with the traditional lifestyle and diet based on published anthropological studies, ethnographic literature on foraging theory, hunting-gathering lifestyles, and interviews with Tribal members were evaluated (see Appendix 1). Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is a median rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. This is rounded down to 25 m^3/day based on the relation of oxygen utilization to caloric intake. More detail is presented in Appendix 1.

8.3.4 Dermal Exposures

The dermal pathway has not been fully researched for this scenario, but EPA methods[35] for dermal exposure can be used. Two relevant papers are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats in a study of dermal adherence. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes, et al. (1999) studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2). In the future, a more refined approach that considers numbers of days or hours in

[34] http://www.cdc.gov/brfss/pdf/ 2001prvrpt.pdf and http://www.cdc.gov/brfss/pubrfdat.htm.
[35] http://www.epa.gov/superfund/programs/risk/ragse/

various habitats and activities and matches that information with soil ingestion rate could be used. For example, the soil ingestion rate and dermal adherence rate should both consider the number of mud event-days and the proportion of wetlands present in the region of the location where the scenario is being applied. In the interim, the Wabanaki scenario provisionally recommends that a rate of 0.1 mg/cm^2 be used to account for averaging among outdoor activities with moderate to high dermal adherence and indoor activities with a lower adherence rate.

9. APPLICATIONS

The goal of this report is to deliver a compendium and summary of tribal exposure scenarios that are indicative of freshwater and marine natural resource utilization patterns so that appropriate designated uses, including the use of the water resource for food, medicine, cultural and traditional practices and recreation can be adopted along with water quality criteria that are protective of those uses. The data and exposure scenarios in this report have been presented in a manner which will enable EPA to understand Tribal use of the water resource for food, medicine, cultural and traditional practices, and recreation. The mechanics of actually developing water quality standards are outside the scope of this report. Those steps may include designation of waterbody uses, developing human health criteria using one or more exposure pathways or portions of the diet (e.g., how much is obtained locally), determinations of how water is actually used in specific settings (e.g., irrigation), and/or how contaminants might affect different exposure pathways at different concentrations.

Another goal is to reduce the uncertainty associated with lack of knowledge about tribal exposure pathways. A number of uncertainties still remain, such as a degree of uncertainty about the soil ingestion rate or a site-specific diet. However, these same uncertainties also exist in risk assessments for the general population. One of the ways that uncertainty is addressed in risk assessments for the general population is to take a probabilistic approach, and develop ranges for the primary exposure factors. For the general population this is possible because there are large data sets from which distributions can be derived. These are not and probably will never be available for Tribal populations, so the exposure scenario is presented as a single reasonable representation (central tendency) of traditional cultural lifestyles.

This exposure scenario has been developed to apply to all of Maine (east of the Kennebec River), and will provide a reasonable approximation of environmental exposures to tribal members using natural resources. If it is applied to tribal settings in the Kennebec River or westward, the authors recommend that irrigation and cultivation be added; however, tribal lands today are all located more eastward.

Several research data gaps have been identified. Among these are the needs for (1) more nutritional information about native foods, (2) better data about physiologic intensity of traditional activities, and (3) better data about soil-based exposures during traditional activities. Beyond this, sensitivity analyses within specific risk assessments are likely to reveal other data gaps that are related to particular contaminants, such as (1) metals uptake into native plants, (2) bioaccumulation within various ecological niches, (3) uptake of contaminants into fungi and lichens used as food or browse, and (4) total exposures associated with basket making (from field gathering through processing, crafting, and using).

Another data gap is the well-known but unquantified vulnerability of tribal members to adverse health and cultural stressors. Pre-existing clusters of stressors are typically much higher in tribal communities than in the general population. These stressors include lower access to and lower quality of health care, poverty, attacks on sovereignty and other culturally-important attributes, underlying disease rates, safety and violence issues, housing and educational issues, and others. This vulnerability is typically not addressed in risk-based decisions.

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APPENDIX 1 – Inhalation Rate

INHALATION RATE

Inhalation Rate = 25 m^3/d (adult)

SUMMARY

The inhalation rate in the Wabanaki scenario reflects the active, outdoor lifestyle of traditional tribal members, including youth who are learning traditional subsistence skills, adult outdoor workers who also hunt, gather, and fish, and elders who gather plants and medicines, and prepare and use them (e.g., making medicines or baskets, etc.) and who teach a variety of indoor and outdoor traditional activities. As with the dietary component, this report focuses on traditional lifestyles – we recognize that current activity levels and current health are not the healthier traditional activity patterns that most tribes are trying to regain.

We have estimated the activity levels associated with this lifestyle and diet using published anthropological studies, ethnographic literature on foraging theory, hunting-gathering lifestyles, and interviews with Tribal members. Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is an average rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. Unlike most other exposure factors, which are upper bounds, the inhalation rate is an average rate. However, to be consistent with national methodology, we have rounded the rate to 25 m^3/day.

1.0 Population-specific physiology

Perhaps the most relevant factors associated with ethnic specificity of metabolic and inhalation rates are the thrifty genotype(s), insulin use, and oxidation and adiposity patterns (Goran, 2000; Fox et al., 1998; Muzzin et al., 1999; Rush et al., 1997; Saad et al., 1991; Kue Young et al., 2002), as well as ethnic differences in spirometry (Crapo et al., 1988; Lanese et al., 1978; Mapel et al., 1997; Aidaraliyev et al., 1993; Berman et al., 1994). Research on the thrifty genotype suggests that there may be several stress response genes that enable indigenous populations to respond to environmental stresses and to the rapid transition between extremes, including feast and famine, heat and cold, disruption in circadian rhythms, dehydration, seasonality, and explosive energy output or rapid transitions between minimum and maximum exercise and $VO2_{max}$ (Kimm et al., 2002; Snitker et al., 1998). These genes "uncouple" several energy expenditure parameters (Kimm et al., 2002), which allows more tolerance of extremes with less adverse physiological consequences.

2.0 Short-term versus long-term inhalation rates.

Most federal and state agencies either use the EPA default value of 20m^3/d or use activity levels to estimate short-term and long-term inhalation rates. For this exposure scenario, activity levels were evaluated through anthropological data (foraging theory and activity descriptions in the anthropological literature) and confirmatory interviews with Tribal elders, and used the CHAD-based EPA recommendations for ventilation rate for the different activity levels. Several examples of similar approaches are:

- EPA's National Air Toxics Assessment (homepage: http://www.epa.gov/ttn/atw/nata/natsa3.html) uses the CHAD database in its HAPEM4 model to estimate national average air toxics exposures even though "the lack of activity pattern data that extend over longer periods of times presents a challenge for HAPEM4 to predict the long-term (yearly) activity patterns that are required to determine chronic exposures." Therefore, "an approach of selection of a series of single day's patterns (from CHAD) to represent an individual's activity pattern for a year was developed."
- The California Air Resources Board (CARB, 2000) reviewed daily breathing rates based on activity levels and measured ventilation rates for many activities in the CHAD database. The average hourly rate for sleeping was 0.5 m^3/hr, light activities at 0.55 m^3/hr, moderate activities at 1.4 m^3/hr, and heavy rates of activity levels at 3.4 m^3/hr. The CARB concluded that 20 m^3/d represents an 85th percentile of typical adult sedentary/light activity lifestyles. This is based on 8 hours sleeping and 16 hours of light activity with no moderate or heavy activity, or 1 hour day of moderate and heavy activity each.
- In their technical guidance document, "Long-term Chemical Exposure Guidelines for Deployed Military Personnel," the US Army Center for Health Promotion and Preventive Medicine (USACHPPM) recommended an inhalation rate of 29.2 m^3/d for US service members. Deployed personnel were assumed to spend 6 hours sleeping at an inhalation rate of 0.4 m^3/hr, 4 hours in sedentary activities (at 0.5 m^3/hr), 6 hours in light duties (at 1.2 m^3/hr), and 8 hours in moderate duties (at 2.2 m^3/hr).[36]
- EPA used 30 m^3/day for a year-long exposure estimate for the general public at the Hanford Superfund site in Washington state, based on a person doing 4 hours of heavy work, 8 hours of light activity, and 12 hours resting.[37]
- The DOE's Lawrence Berkeley Laboratory also used 30 m^3/d: "the working breathing rate is for 8 hours of work and, when combined with 8 hours of breathing at the active rate and 8 hours at the resting rate, gives a daily equivalent intake of 30 m^3 for an adult."[38]
- The Rocky Flats Oversight Panel recommended using 30 m^3/d.[39]

3.0 The use of population-specific information rather than national averages.

EPA instructs risk assessors to identify the receptor population and their activities or land use.[40] "Assessors are encouraged to use values which most accurately reflect the exposed

[36] http://www.gulflink.osd.mil/particulate_final/ particulate_final_s06.htm and http://www.gulflink.osd.mil/pm/pm_en.htm.

[37] "Report of Radiochemical Analyses for Air Filters from Hanford Area" Memorandum from Edwin L. Sensintaffar, Director of the National Air and Radiation Environmental Laboratory to Jerrold Leitch, Region 10 Radiation Profram Manager (http://yosemite.epa.gov/R10/AIRPAGE.NSF/webpage/Hanford+Environmental+Perspective). *Note:* EPA removed this link immediately after we first cited this reference.

[38] www.lbl.gov/ehs/epg/tritium/TritAppB.html

[39] RAC (Risk Assessment Corporation). 1999. *Task 1: Cleanup Levels at Other Sites. Rocky Flats Citizens Advisory Board, Rocky Flats Soil Action Level Oversight Panel.* RAC Report No. 3-RFCAB-RFSAL-1999. http://www.itrcweb.org/Documents/RAD-2.pdf

population."[41] The OSWER Land Use Directive[42] requires the identification of land uses for the baseline risk assessment; when the affected resources are on reservations or areas where tribes retain usury rights, a subsistence/residential land use must be assumed if the Tribe so indicates. Executive Order 12898[43] requires the identification of subsistence consumption of natural resources, and for Indian Tribes this includes the activities required to obtain those resources.

EPA recognizes that inhalation rates may be higher in certain populations, such as athletes or outdoor workers, because levels of activity outdoors may be higher over long time periods. "If site-specific data are available to show that subsistence farmers and fishers have higher respiration rates due to rigorous physical activities than other receptors, that data may be appropriate."[44] Such subpopulation groups are considered 'high risk' subgroups.[45] EPA (1997) recommends calculating their inhalation rates using the following average hourly intakes for various activity levels (in m^3/hr): resting = 0.4, sedentary = 0.5, light activity = 1, moderate activity = 1.6, heavy activity = 3.2. EPA's average rate for outdoor workers is 1.3 m^3/hr, with an upper percentile of 3.3 m^3/hr, depending on the ratio of light, moderate and heavy activities during the observation time. Other EPA risk assessments typically use 2.5 m^3/hr for groundskeepers.[46]

Using EPA guidance on hourly inhalation rates for different activity levels, a reasonable inhalation rate for an average tribal member's active lifestyle is an average rate of 26.2 m^3/d, based on 8 hours sleeping at 0.4 m^3/hr, 2 hours sedentary at 0.5 m^3/hr, 6 hours light activity at 1 m^3/hr, 6 hours moderate activity at 1.6 m^3/hr, and 2 hours heavy activity at 3.2 m^3/hr. The resultant 26.2 m^3/d is rounded to 25 m^3/day.

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[40] http://www.epa.gov/superfund/programs/risk/ragsd/table4instructions.pdf.

[41] Exposure Factor Handbook, Volume 1, page 5-23

[42] OSWER Directive 9355.7-04, "Land Use in the CERCLA Remedy Selection Process" (May 25, 1995)

[43] White House, 1994. Federal Actions To Address Environmental Justice In Minority Populations And Lowincome Populations: Feb. 11, 1994; 59 FR 7629, Feb. 16, 1994.

[44] EPA (OSWER) "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Support Materials Volume 1: Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities" page 6-4, at (http://www.epa.gov/earth1r6/6pd/rcra_c/protocol/volume_1/chpt6-hh.pdf)

[45] Exposure Factors Handbook, 1997, Volume 1. page 5-24

[46] For outdoor workers, see U.S. EPA 1991a. U.S. Environmental Protection Agency (U.S. EPA). Human health evaluation manual, supplemental guidance: "Standard default exposure factors". OSWER Directive 9285.6-03. An example of use is http://epa-dccs.ornl.gov/radionuclides/equations/outdoor_guide.shtml. Oregon uses 3.66 m^3/hr for penitentiary workers; http://64.233.167.104/search?q=cache:uQII54d5ioYJ:www.doc.state.or.us/fiscalservices/facilities/existing/osp_groundwater/tables/2000/table_5_4.pdf+%22construction+worker%22+%22inhalation+rate%22+epa&hl=en.

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APPENDIX 2 – Soil Ingestion Rate

SOIL INGESTION RATE

Soil Ingestion Rate = 400 mg/d (all ages)

SUMMARY

Soil ingestion includes consideration of direct ingestion of dirt, mud, or dust, swallowing inhaled dust, mouthing of objects, ingestion of dirt or dust on food, and hand-to-mouth contact. Soil ingestion rates are generally poorly quantified, and are difficult and intrusive to study. Therefore, a purely statistical derivation was not possible. Instead, the Wabanaki soil ingestion rate is an estimate based on a review of EPA guidance, quantitative soil ingestion studies in suburban and indigenous settings, qualitative recommendations in indigenous and other settings, pica (excessive non-nutritive ingestion of soil and other materials) and geophagia (high ingestion of soil for nutritive or medicinal reasons) to explore high end situations, and dermal adherence studies.

The soil ingestion rate of 400 mg/d for all ages is the upper bound of federal guidance for suburban children (EPA, 1997), and is within the range of outdoor activity rates for adults. Subsistence lifestyles were not considered in the EPA guidance, but those lifestyles are generally considered to be similar in soil contact rates to construction, utility worker or military soil contact levels. The recommendation for Wabanaki traditional cultural lifestyles, however, is lower than the 480 mg/d that is often used for construction or excavation workdays. The overall consideration included some low-contact days and balanced with many “1-gram” days and events such as root gathering days (or home gardening), tule and wapato gathering days, pow wows, rodeos, horse training and riding days, sweat lodge building or repair days, grave digging, and similar activities. Residual soil on wild or home-grown food was considered (but not measured). There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).

1.0 EPA Guidance

EPA has reviewed the studies relevant to suburban populations and has published summaries in its Exposure Factors Handbook (1989, 1991, and 1997). In the current iteration of the Exposure Factors Handbook[47], EPA reviewed the available scientific literature for children and identified seven key studies that were used to prepare recommended guidelines for evaluating the amount of soil exposure. The mean daily values in these studies ranged from 39 mg/day to 271 mg/day with an average of 146 mg/day for soil

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[47] Environmental Protection Agency. 1997. Exposure Factors Handbook. Volumes I, II, III. U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/P-95/002Fa.

ingestion and 191 mg/day for soil and dust ingestion. Based on these studies, EPA originally recommended a value of 200 mg/day for children. EPA now recommends 100 mg/d as a mean value for children in suburban settings, 200 mg/day as a conservative estimate of the mean, and a value of 400 mg/day as an “upper bound” value (exact percentile not specified). Most state and federal guidance uses 200 mg/d for children.

For adults, the USEPA now suggests a mean soil ingestion rate in suburban settings of 50 mg/day for adults (USEPA, 1997), which has been decreased from 100 mg/d as recommended in earlier guidance based on consideration of typical housing and occupational settings. However, EPA says that this rate is still highly uncertain and has a low confidence rating due to lack of data. An adult soil ingestion rate of 100 mg/day is most commonly used for residential or agricultural settings.

Other EPA guidance such as the Soil Screening Level Guidance[48] recommends using 200 mg/d for children and 100 mg/d for adults, based on RAGS HHEM, Part B (EPA, 1991) or an age-adjusted rate of 114 mg-y/kg-d.

A value for an ingestion rate for adult outdoor activities is no longer given in the 1997 Exposure Factors Handbook for adults as “too speculative.” However, the soil screening guidance recommends 330 mg/d for a construction or other outdoor worker, and risk assessments for construction workers typically use a rate of 480 mg/d (EPA, 1997; Hawley, 1985).

Other soil ingestion rates are also used by risk assessors. For example, some states recommend the use of 1 gram per acute soil ingestion event[49] to approximate a non-average day for children in the general population, such as an outdoor day. We assume that tribal children have many more outdoor days as they are learning about and assisting with traditional activities.

2.0 Military Guidance

The US military assumes 480 mg per exposure event[50] or per field day. For military risk assessment, the US Army uses their Technical Guide 230 as the tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures.[51] No database is available to estimate incidental soil ingestion for adults in general or for military populations either during training at continental U.S. facilities or during

[48] EPA (1996) Soil Screening Guidance: Technical Background Document, EPA/540/R-95/128, July 1996 (http://www.epa.gov/superfund/resources/soil/toc.htm#p2), and EPA (2002) Supplemental Guidance For Developing Soil Screening Levels For Superfund Sites. OSWER 9355.4-24 (http://www.epa.gov/superfund/resources/soil/ssg_main.pdf),

[49] MADEP (1992). Background Documentation For The Development Of An "Available Cyanide" Benchmark Concentration. http://www.mass.gov/dep/ors/files/cn_soil.htm

[50] http://www.gulflink.osd.mil/pesto/pest_s22.htm, citing US Environmental Protection Agency, Office of Research and Development, Exposure Factors Handbook, Volume I, EPA/600/P-95/002a, August 1997 as the basis for the 480 mg/d.

[51] USACPPM TG 230A (1999). Short-Term Chemical Exposure Guidelines for Deployed Military Personnel. U.S. Army Center for Health Promotion and Preventive Medicine.
Website: http://www.grid.unep.ch/btf/missions/september/dufinal.pdf

deployment. Department of Defense (2002)[52] recommendations for certain activities such as construction or landscaping which involve a greater soil contact rate is a soil ingestion rate of 480 mg/day. This value is based on the assumption that the ingested soil comes from a 50 µm layer of soil adhered to the insides of the thumb and the fingers of one hand. DOD assumed that the deployed military personnel would be exposed at both the high ingestion rate and a mean ingestion rate throughout the year. The two ingestion rates were averaged (half the days were spent at 480 and half at 50 mg/d) for a chronic average rate of 265 mg/d. The UN Balkans Task Force assumes that 1 gram of soil can be ingested per military field day[53].

3.0 Studies in suburban or urban populations

Written knowledge that humans often ingest soil dates back to the classical Greek era. Soil ingestion has been widely studied from a perspective of exposure of people to the eggs of soil parasites and other infectious agents. More recently, soil ingestion was recognized to be a potentially significant pathway of exposure to contaminants, and risk assessments initially used a high rate of inadvertent ingestion, based on studies of pica children (e.g., Kimbrough, 1984). This triggered a great deal of research funded by industry (e.g., Calabrese) or federal funds (e.g., the DOE-funded studies of fallout and bomb test contamination).

Some of the key studies are summarized here. Other agencies (including the EPA[54] and California OEHHA) have reviewed more studies and provide more detail. To quote from OEHHA:

> "There is a general consensus that hand-to-mouth activity results in incidental soil ingestion, and that children ingest more soil than adults. Soil ingestion rates vary depending on the age of the individual, frequency of hand-to-mouth contact, seasonal climate, amount and type of outdoor activity, the surface on which that activity occurs, and personal hygiene practices. Some children exhibit pica behavior which can result in intentional ingestion of relatively large amounts of soil."[55]

In general, two approaches to estimating soil ingestion rates have been taken. The first method of involves measuring the presence of (mostly) non-metabolized tracer elements in the feces of an individual and soil with which an individual is in contact, generally in controlled (largely indoor) situations. The other method involves measuring the dirt adhered to an individual's hand and observing hand-to-mouth activity. Results of these studies are associated with large uncertainty due to their somewhat qualitative nature, but some studies include specific activities relevant to outdoor lifestyles.

[52] Reference Document (RD) 230, "Exposure Guidelines for Deployed Military" A Companion Document to USACHPPM Technical Guide (TG) 230, "Chemical Exposure Guidelines for
Deployed Military Personnel", January 2002. Website: http://chppm-www.apgea.army.mil/desp/; and http://books.nap.edu/books/0309092213/html/83.html#pagetop.

[53] UNEP/UNCHS Balkans Task Force (BTF) (1999). The potential effects on human health and the environment arising from possible use of depleted uranium during the 1999 Kosovo conflict. www.grid.**un**ep.ch/btf/missions/september/dufinal.pdf

[54] http://www.epa.gov/ncea/pdfs/efh/sect4.pdf.

[55] California Office of Environmental Health Hazard Assessment, Technical Support Document for Exposure Assessment and Stochastic Analysis, Section 4: Soil Ingestion. http://www.oehha.ca.gov/air/hot_spots/pdf/chap4.pdf

3.1 Studies in Children

Early studies in children focused on pica (see below) and unique food-related events. Early studies were estimates rather than direct measurements. In particular, one study of soil ingestion from "sticky sweets" was estimated at 10 mg to 1 g/d (Day et al, 1975). Hawley (1985) estimated that the amount ingested by young children during outdoor activity between May and October is 250 mg/d. For outdoor activities from May through October in Niagra Falls, NY, Hawley estimated the ingestion amount as 480 mg per active day for older children, assuming that 8 hours is spent outdoors per day, 2 d/week. Chronic averages for indoor and outdoor dust via inhalation and surface contact were estimated to be 160 mg/d for young children, 30 mg/d for older children, and 66 mg/d for adults.

Early tracer studies in American children (Binder, et al., 1986) resulted in large ranges of estimates of soil ingestion for several reasons. In the Binder study (as in subsequent studies), the particular tracer element makes a large difference in soil ingestion estimates. Clausing et al. (1987) followed basically the same approach for Dutch rather than American children. Neither studies included the trace minerals from food or medicine and were not mass balance studies and in addition included hospitalized children. A third study (Van Wijnen et al., 1990) used the same approach, and was the first to include a consideration of camping and the presence or absence of gardens.

Thompson and Burmaster (1991) reanalyzed the original data on children from Binder et al. (1986) to characterize the distribution of soil ingestion by children. In studies with large numbers of children, pica children may be present, but most studies did not try to diagnose pica. On the other hand, not all children with high ingestion rates are pica children, so caution must be exercised when identifying pica children merely on the basis of high soil ingestion. The reanalysis indicated a mean soil ingestion rate of 91 mg/d, and a 90th percentile of 143 mg/d.

Davis et al. (1990) provided another evaluation of food, medicine, and house dust as an approximation of a total mass balance in 101 children. As with the earlier studies, using titanium (Ti) as the tracer results in estimates of large ranges of soil ingestion rates, while aluminum (Al) and silicon (Si) tracers resulted in a narrower range of soil ingestion rates. However, Ti is problematic because of its variability in food, Al is difficult to control since it is the third most abundant soil mineral and present in many household products, and Si is widespread and an essential trace element for plants and animals (although apparently not for humans). During the study weeks, soil ingestion ranged up to 6 grams, depending on the tracer. The medians were an order of magnitude lower, and the means were 40 (for Al), 82 (for Si), and 245 (for Ti) mg/d.

Calabrese et al. (1989) based estimates of soil ingestion rate in 64 children in a home and university daycare setting on measurements of eight tracer elements (aluminum, barium, manganese, silicon, titanium, vanadium, yttrium, and zirconium). The study population consisted of 64 children between one and four years old in the Amherst, Massachusetts.
Stanek and Calabrese (1995a, b) reanalyzed their 1989 data several times, with somewhat different conclusions. When extended to an annual estimate, the range of average daily soil ingestion in the 64 children was 1 – 2268 mg/d; the median (lognormal) was 75 mg/d, the

90^{th} % was 1190 mg/d, and the 95^{th}% was 1751 mg/d. The range would have been even larger if the known pica child and other "outlier" data had not been excluded. They also estimated that 16% of suburban children are likely to ingest more than 1 gram of soil per day on 35-40 days of the year. In addition, 1.6% would be expected to ingest more than 10 grams per day for 35-40 days per year. Stanek and Calabrese (1995b) published a separate reanalysis combining the data from their 1989 study produced much lower estimates, but they still conclude that the large standard deviation indicates that there are still large problems with the methodology.

3.2 Studies in Adults

Only a few soil ingestion studies in adults have been done because the attention has been focused on children, who are known to ingest more soil and are more vulnerable to toxicity of contaminants. Stanek, Calabrese and co-authors (1997) conducted a small adult pilot study (n = 10) to compare tracers. This study was done as a method validation, and was "not designed to estimate the amount of soil normally ingested by adults."

4.0 Studies in Indigenous Populations

Studies of soil ingestion in indigenous populations have largely centered on estimates of past exposure (or dose reconstruction) of populations affected by atomic bomb tests such as the Marshall Islands (tropical island) and Maralinga (Australian desert) evaluations.

Haywood and Smith (1992) estimated potential doses to aboriginal inhabitants of the Maralinga and Emu areas of South Australia, where nuclear weapons tests in the 1950s and 1960s resulted in widespread residual radioactive contamination. The most significant radiological dose pathways were inhalation of resuspended dust and ingestion of soil by infants. Haywood and Smith constructed a table showing hours per week sleeping, sitting, hunting or driving, cooking or butchering, and other activities. The authors state that in this climate

> "Virtually all food, whether of local origin or purchased, has some dust content by the time of consumption due to methods of preparation and the nature of the environment. A total soil intake in the region of 1 gpd was estimated based on fecal samples of non-aboriginals during field trips. This must be regarded as a low estimate of soil ingestion by aboriginals under camp conditions. In the absence of better information, a soil intake of 10 gpd has been assumed in the assessment for all age groups."

They noted a "very high occurrence of cuts and scratches with a high percentage being classified as dirty...puncture wounds on the feet were frequent. "

The Marshall Island indigenous peoples have also been studied. In a study of the gastrointestinal absorption of plutonium, Sun and Meinhold (1997) assumed a soil ingestion rate of 500 mg/d. This was based on the primary work of Haywood and Smith who estimated "an average soil intake of 10,000 mg/d in dose assessments for the Emu and Maralinga nuclear weapons testing sites in Australia." The authors state that:

> "Haywood and Smith specifically discussed the effects of lifestyle on plutonium ingestion for the Australian aboriginal people: an average soil intake of 1,000 mg/d was established from the fecal samples of the investigators who made field trips to the affected areas." We note that these are estimates, not direct measurements.
>
> "It is difficult to quantitatively compare the amount of soil ingested by the Marshall Islanders and the Aboriginal people because of their different lifestyles. However, both societies live in close contact with their natural environment, although the Australian aboriginal people are nomadic, while the Marshallese have a lifestyle nearly like to that of industrial nations. LaGoy (1987) reported an estimated maximum intake of 500 mg/d for adults in developed nations who do not exhibit habitual pica. This value, then, was taken to be a reasonably conservative average for the Marshallese people. Therefore, this work adopts 500 mg/d as the average life-time intake of soil by the Marshallese."

Simon (1998) reviewed soil ingestion estimates from a perspective of risk and dose assessment. He concluded that certain lifestyles, occupations, and living conditions will likely put different individuals or different groups at risk to inadvertent soil ingestion. Because of their high dependence on the land, indigenous peoples are at highest risk for inadvertent ingestion, along with professions that may bring workers into close and continual contact with the soil. Most of the studies that Simon reviewed were related to geophagia (intentional soil ingestion; see below), which is relatively common worldwide. Simon recommends using a soil ingestion rate for indigenous people in hunters/food gathering/nomadic societies of 1g/d in wet climates and 2 g/d in dry climates. He recommends using 3 g/d for all indigenous children. Geophagia is assumed not to occur; if geophagia is common, Simon recommends using 5 g/d. These are all geometric means (lognormal) or modes (triangular distribution) of estimates.

These estimates are supported by studies of human coprolites from archaeological sites. For instance, Nelson (1999) noted that human coprolites from a desert spring-fed aquatic system included obsidian chips (possibly from sharpening points with the teeth), grit (pumice and quartzite grains from grinding seeds and roots), and sand (from mussel and roots consumption). Her conclusions are based on finding grit in the same coprolites as seeds, and sand in the same coprolites as mussels and roots. She concludes that "the presence of sand in coprolites containing aquatic root fibers suggests that the roots were not well-cleaned prior to consumption. Charcoal was present in every coprolite examined."

5.0 Geophagia

This section on geophagia presents information on intentional soil ingestion for nutritive or medicinal reasons. It is presented in order to show how high soil ingestion rates are in some cultures, but is not directly used in the recommendations for the Wabanaki ingestion rate.

Despite the limited awareness of geophagia in western countries, the deliberate consumption of dirt, usually clay, has been recorded in every region of the world both as idiosyncratic behavior of isolated individuals and as culturally prescribed behavior (Abrahams, 1997; Callahan, 2003; Johns and Duquette, 1991; Reid, 1992). It also routinely occurs in primates (Krishnamani and Mahaney (2000). Indigenous peoples have routinely used montmorillonite clays in food preparation to remove toxins (e.g., in acorn breads) and as condiments or spices (in the Philippines, New Guinea, Costa Rica, Guatemala, the

Amazon and Orinoco basins of South America). Clays are also often used in medications (e.g., kaolin clay in Kaopectate). But the most common occasion for eating dirt in many societies, especially kaolin and montmorillonite clays in amounts of 30g to 50g a day, is pregnancy. In some cultures, well-established trade routes and clay traders make rural clays available for geophagia even in urban settings. Clays from termite mounds are especially popular among traded clays, perhaps because they are rich in calcium (Callahan, 2003; Johns and Duquette, 1991).

There are two types of edible clays, sodium and calcium montmorillonite[56]. Sodium montmorillonite is commonly known as bentonite; the name is derived from the location of the first commercial deposit mined at Fort Benton, Wyoming USA. Bentonite principally consists of sodium montmorillonite in combination with 10 to 20% of various mineral impurities such as feldspars, calcite, silica, gypsum, and others. Calcium montmorillonite, the second type of montmorillonite, is also known as "living clay" for it principally consists of nutritionally essential minerals.

Geophagia has long been viewed as pathological by the western medical profession. However, this practice is so widespread and physiologically significant that is presumed to be important in the evolution of human dietary behavior due to its antidiarrheal, detoxification, and mineral supplementation potentials (Reid, 1992; Krishnamani and Mahaney, 2000). They propose several hypotheses that may contribute to the prevalence of geophagy:

(1) soils adsorb toxins.
(2) soil ingestion has an antacid action.
(3) soils act as an antidiarrheal agent.
(4) soils counteract the effects of endoparasites.
(5) geophagy may satiate olfactory senses.
(6) soils supplement nutrient-poor diets. Some clays release calcium, copper, iron, magnesium, manganese, or zinc in amounts of nutritional significance (Johns and Duquette, 1991). This is especially important in pregnancy and at high altitudes.

Several studies of geophagia in pregnancy have been done. In countries such as Uganda where modern pharmaceuticals are either unobtainable or prohibitively expensive, ingested soils may be very important as a mineral supplement, particularly iron and calcium during pregnancy (Abrahams, 1997). One widely held theory suggests that craving resulting from iron deficiency is a major cause of geophagia[57]. Several reports have described an extreme form of geophagia in individuals with documented iron deficiency, although there has been uncertainty as to whether the iron deficiency was a cause of excessive ingestion or a result of it. Because some substances, such as clay, are believed to block the absorption of iron into the bloodstream, it was thought that low blood levels of iron could be the direct result of geophagia. Some studies have shown that soil cravings in individuals with iron deficiency stop once iron supplements are given to correct the deficiency, suggesting that iron deficiency induces geophagia (and other) cravings during pregnancy. In addition, low blood levels of iron commonly occur in pregnant women and those with poor nutrition, two populations at higher risk for pica.

[56] http://www.the-vu.com/edible_clay.htm
[57] http://www.ehendrick.org/healthy/001609.htm

Edwards et al. (1994) studied 553 African American women who were admitted to prenatal clinics in Washington, D.C. Serum ferritin concentrations of "pica" women were significantly lower during the second and third trimesters of pregnancy; the average values for three trimesters of pregnancy for both ferritin and mean corpuscular hemoglobin were significantly lower in pica women than their non-pica counterparts. Although not significantly different, the iron (66 vs. 84% RDA) and calcium (60 vs. 75% RDA) contents of the diets of pica women were less those of non-pica women. Again, low ferritin and hemoglobin are hypothesized to result in pica. In this paper, the term pica was used although geophagia may be the more appropriate term.

A further hypothesis is presented by Callahan (2003). Regular consumption of soil might boost the mother's secretory immune system. Monkeys that regularly eat dirt have lower parasite loads. In some cultures, clays are baked before they are eaten, which could boost immunity from previous exposures. For decades aluminum salts, like those found in clays, have been used as adjuvants in human and animal vaccines because they amplify immune response. Aluminum compounds make effective adjuvants because they are relatively nontoxic; the charged surfaces of aluminum salts absorb large numbers of organic molecules. Note that Al was one of Calabrese's preferred tracers due to the assumption that it is not adsorbed and inert at trace levels (it is quite toxic at high levels).

6.0 Acute Soil Ingestion and Pica

There can also be a relation between geophagia and pica, and there is not a clear distinction between the conditions. Pica is an obsessive-compulsive eating disorder typically defined as the persistent eating of nonnutritive substances for a period of at least 1 month at an age in which this behavior is developmentally inappropriate. The definition also includes the mouthing of nonnutritive substances. Individuals presenting with pica have been reported to mouth and/or ingest a wide variety of nonfood substances, including, but not limited to, clay, dirt, sand, stones, pebbles, hair, feces, lead, laundry starch, vinyl gloves, plastic, pencil erasers, ice, fingernails, paper, paint chips, coal, chalk, wood, plaster, light bulbs, needles, string, and burnt matches.

Pica is generally thought of as a pediatric condition, but pica diagnoses include psychiatric conditions like schizophrenia, developmental disorders including autism, and conditions with mental retardation. These conditions are not characterized by iron deficiency, which supports a psychological component in the cause of pica.

Pica is seen more in young children than adults. Between 10-32% of children aged 1 to 6 may exhibit pica behavior at some point[58]. LaGoy (1987) estimated that a value of 5 gpd is a reasonable maximum single-day exposure for a child with habitual pica. In June 2000, the U.S. Agency for Toxic Substances and Disease Registry appointed a committee to review soil pica. The committee settled on a threshold of pathological levels as consumption of more than 5000 mg of soil per day but cautioned that the amount selected was arbitrary[59]. With this criterion, studies in the literature estimate that between 10 and 50% of children may exhibit pica behavior at some point. While this threshold may be appropriate in relatively

[58] http://www.nlm.nih.gov/medlineplus/ency/article/001538.htm#Causes,%20incidence,%20and%20risk%20factors
[59] Summary report for the ATSDR Soil-Pica Workshop, Atlanta, Georgia, 2000. Available from: URL: http://www.atsdr.cdc.gov/NEWS/soilpica.html

clean suburban settings, it may not be appropriate for defining the pica threshold in rural settings where average soil ingestion is likely to be higher.

The occurrence of pica has been discussed with respect to risk assessment, especially for acute exposures. Calabrese et al. (1997) recognized that some children have been observed to ingest up to 25-60 g soil during a single day. When a set of 13 contaminating chemicals were evaluated for acute exposures with a pica exposure rate, four of these chemicals would have caused a dose approximating or exceeding the acute human lethal dose.

Regulatory guidance recommends 5 or 10g/d for pica children. Some examples are:

(1) EPA (1997) recommends a value of 10g/d for a pica child.

(2) Florida recommends 10g per event for acute toxicity evaluation[60].

(3) ATSDR uses 5 g/day for a pica child[61].

7.0 Data from dermal adherence

Dermal adherence of soil is generally studied in relation to dermal absorption of contaminants, but soil on the hands and face can be ingested as well. Although this body of literature is not typically used to estimate a quantitative contribution to soil ingestion, it can give relative estimates of soil contact rates between activities.

Two relevant papers are summarized here. Kissel, et al. (1996) included reed gatherers in tide flats. "Kids in mud" at a lakeshore had by far the highest skin loadings, with an average of 35 mg/cm^2 for 6 children and an average of 58 mg/cm^2 for another 6 children. Reed gatherers were next highest at 0.66 mg/cm^2 and an upper bound for reed gatherers of >1 mg/cm^2. This was followed by farmers and rugby players (approximately 0.4mg/cm^2) and irrigation installers (0.2mg/cm^2). Holmes et al. (1999), also from Kissel's laboratory, studied 99 individuals in a variety of occupations. Farmers, reed gatherers and kids in mud had the highest overall skin loadings, up to 27 mg/cm^2. The next highest skin loadings on the hands were for equipment operators, gardeners, construction, and utility workers (0.3 mg/cm^2), followed by archaeologists, and several other occupations (0.15 – 0.1 mg/cm^2). Since reed gatherers, farmers, and gardeners had higher skin loadings, this is supporting evidence that these activities also have higher than average soil ingestion rates.

One factor that has not received enough attention is the grain size of adhering and ingested soil. Stanek and Calabrese (2000) stated that variability in estimating soil ingestion rates using tracer elements was reduced when a grain size less than 250 um were excluded in order to reduce variability. Driver et al. (1989) found statistically significant increases in skin adherence with decreasing particle size, with particles above the sand-silt size division (0.075 mm) adhering less than smaller sizes. Average adherences of 1.40 mg/cm^2 for

60 Proposed Modifications To Identified Acute Toxicity-Based Soil Cleanup Target Level, December 1999, www.dep.state.fl.us/waste/quick_topics/ publications/wc/csf/focus/csf.pdf .

61 For Example: El Paso Metals Survey, Appendix B, www.atsdr.cdc.gov/HAC/PHA/**elpaso**/epc_toc.html.

particle sizes less than 150 µm, 0.95 mg/cm^2 for particle sizes less than 250 µm and 0.58 mg/cm^2 for unsieved soils were measured (see EPA, 1992[62] for more details).

Soil samples should be sieved and concentrations should be evaluated various size ranges. A consideration of grain size could affect the estimation of soil ingestion rates because the mineral and organic composition within a particular soil sample can vary with particle size and soil granule pore size. If soil adherence studies are conducted in a manner wherein sand is brushed off the hands while smaller grain sizes remain adhered, then tracer ratios could be altered, and would be different from the original unsieved soil.[63]

Figure 20. Digging wapato (water potatoes)

(photo courtesy of the Coeur d'Alene Tribe).

8.0 Data from washed or unwashed vegetables.

Direct soil ingestion also occurs via food, for example from dust blowing onto food (Hinton, 1992), residual soil on garden produce or gathered native plants, particles on cooking utensils, and so on. However, there is very little quantitative data about soil on vegetation as-gathered, as-prepared, or as-eaten, which is a separate issue from root uptake of soil contaminants into edible materials. However, there is information on interception rate of dust particles deposited onto leafy surfaces, and information on soil ingestion by pasture animals. For example, Beresford and Howard (1991) found that soil adhesion to vegetation was highly seasonal, being highest in autumn and winter, and is important source of radionuclides to grazing animals. Palacios et al. (2002) evaluated lead levels in the aerial part of herbage near a Superfund site. A water washing pre-treatment of the vegetal samples considerably diminished the concentration of lead.

[62] EPA (1992). Interim Report: Dermal Exposure Assessment: Principles And Applications. Office of Health and Environmental Assessment, Exposure Assessment Group. /600/8-91/011B

[63] Soils are classified according to grain size (1mm = Very coarse sand; 0.5mm = Coarse sand; 0.25mm = Medium sand; 0.10mm = Fine sand; 0.05mm = Very fine sand; 0.002mm = Silt; <0.002mm = Clay). The Wentworth scale classifies particle sizes as ranges: sand = 1/16 to 2 mm; silt = 1/256 to 1/16 mm; clay = <1/256 mm.

Kissel et al. (2003) evaluated concentrations of arsenic and lead in rinsed, washed, or peeled garden vegetables. He found that concentrations of lead and arsenic in washed or peeled potatoes or lettuce were generally lower, as expected, although the concentration of lead in peeled potatoes was higher than in rinsed or washed potatoes.

9.0 Subsistence lifestyles and rationale for soil ingestion rate

The derivation of the soil ingestion rate is based on the following points:

- The foraging-subsistence lifestyle is lived in close contact with the environment.
- The original indigenous lifestyle includes processing and using foods, medicines, and materials.
- The Maine ecology has many wetlands, and moist soils adhere to skin and products more than dry soils.
- The house is assumed to have little landscaping other than the natural conditions or xeriscaping, some naturally bare soil, a gravel driveway, no air conditioning (more open windows), and a wood burning stove in the winter for heat.
- All persons participate in day-long outdoor group cultural activities at least once a month, such as pow-wows, horse races, and seasonal ceremonial as well as private family cultural activities. These activities tend to be large gatherings with a greater rate of dust resuspension and particulate inhalation. These are considered to be 1-gram events or greater.
- 400 mg/d is based on the following:
    1. 400 mg/d is the upper bound for suburban children (EPA); traditional or subsistence activities are not suburban in environs or activities
    2. This rate is within the range of outdoor activity rates for adults (between 330 and 480); subsistence activities are more like the construction, utility worker or military soil contact levels. However, it is lower than 480 to allow for some low-contact days.
    3. The low soil-contact days are balanced with many 1-gram days and events such as root gathering days, wetland gathering days, pow wows, and similar activities. There are also likely to be many high or intermediate-contact days, depending on the occupation (e.g., wildlife field work, construction or road work, cultural resource field work).
    4. This rate is lower than Simon estimate of 500 mg/d and lower than the recommendations of 3 g/d for indigenous children and 2 g/d for indigenous adults in arid environments. It is also lower than the 5 or 10 grams he estimated for purely aboriginal lifestyles. For original housing conditions a higher rate would be clearly justified; for today's housing conditions, a lower rate is adequate.
    5. This rate does not account for pica or geophagia.
    6. Primary data is supported by dermal adherence data in gatherers and 'kids in mud'.
    7. This rate includes a consideration of residual soil on roots (a major food category) through observation and anecdote, but there is no quantitative data.
    8. This rate includes a consideration of the number of windy-dusty days, but without further quantification of air particulates.

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