Tribal Consumption of Plants and Animals in EPA Superfund Risk Assessment Methodology

Research and Presentation by Grace Maley

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Prepared for the US Environmental Protection Agency (EPA).

The project aims to supplement EPA risk assessment models for the consumption of biota by incorporating produce items that are found in Native American diets. The goal is to create more comprehensive and inclusive risk assessment models.

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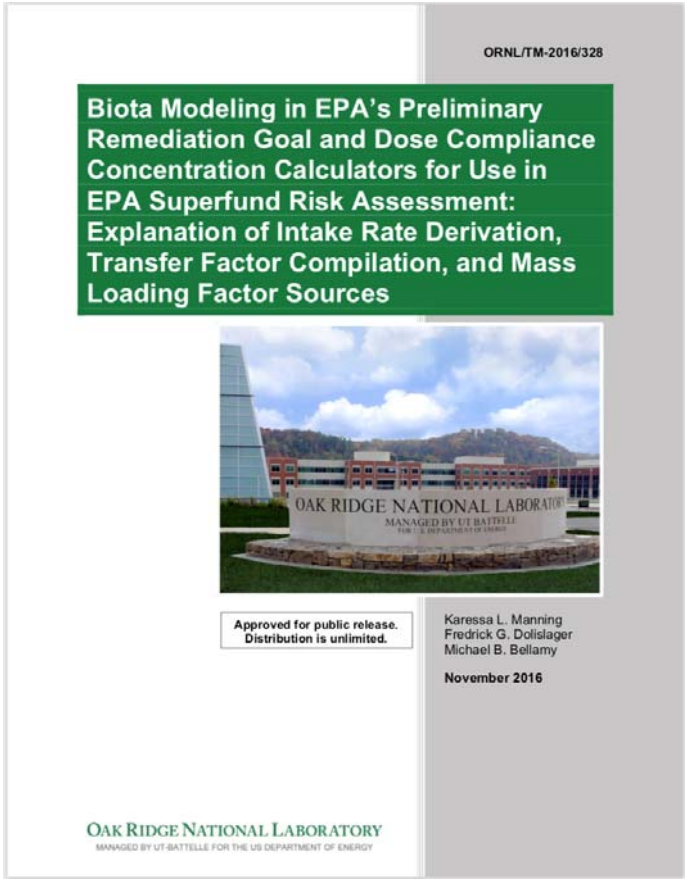
Study Basis - Manning et al (2016)

- EPA and ORNL report on hierarchal selection process of biota modeling in the Preliminary Remediation Goal (PRG) and Dose Compliance Concentration (DCC) Calculators.
  - Intake Rate Derivation
  - Transfer Factor Compilation
  - Mass Loading Factors (for plants)
- This report updated the accuracy of risk assessment modeling for the consumption of produce and animal products sourced from contaminated land and/or land irrigated with contaminated water



Summary of New Study

- Goal:

  Supplement the Manning et al. (2016) report by incorporating produce items and animal products that have been found in Native American diets.

- Components of Study
  - Plant-specific mass loading factors (MLF)
  - Transfer factors (TF) of radionuclides to produce and animals
  - Source hierarchies for TFs and MLFs
  - Ingestion rates

Ingestion Rates

- New data adds over new 30 produce items
- Produce items are based on food consumption surveys and reports by the following
  - Environment International Ltd. for the Confederated Tribes of the Colville Reservation (2012)
  - Harper and Ranco in conjunction with five federally recognized Tribal Nations in Maine for the EPA (2009)
  - New York State Energy and Development Administration (NYSERDA) (2015)
  - CB&I Federal Services LLC for the EPA (2017).
  - Harper (2008) for the Quapaw Tribe in Oklahoma
  - Harper (2006) for the Elem Pomo tribe at Clear Lake, CA
  - Integral Consulting Inc. (2007) for International Paper at a St. Regis Paper company site
  - Garvin et al. (2015) of Tribal Environmental Management Services LLC for the Six Treaty Tribes of Oklahoma

Ingestion Rates

- New data adds over new 30 produce items and over 20 animal products
- The new additions are based on food consumption surveys and reports by the following
  - Various reports by Harper et al. for the Spokane Tribal Cultural Resources Program (2002), the Washoe Tribe of Nevada and California (2005), Elem Pomo tribe at Clear Lake, CA (2006), the Quapaw Tribe in Oklahoma (2008), and the Tribal Nations in Maine (2009)
  - Integral Consulting Inc. (2007) for International Paper at a St. Regis Paper company site
  - Environment International Ltd. for the Confederated Tribes of the Colville Reservation (2012)
  - Garvin et al. (2015) of Tribal Environmental Management Services LLC for the Six Treaty Tribes of Oklahoma
  - New York State Energy and Development Administration (NYSERDA) (2015)
  - Polissar et al. (2016) for the EPA, Nez Perce Tribe and Shoshone-Bannock Tribe
  - CB&I Federal Services LLC for the EPA (2017)

Produce Additions

Roots

- Root Vegetables*
- Indian Carrot
- Leek
- Wild Potato Vine
- Wild Onion

Fruits

- Oregon grape
- Chokecherries
- Plantain
- Pawpaw
- Mayapple

Other vegetables

- Beans
- Buckbrush
- Cattail shoot
- Peas
- Squash
- River Birch
- Wild Rose

Greens

- Leafy Greens*
- Herbaceous flowering plants*
- Wild lettuce
- Lichen
- Buckbrush
- Wild Mint
- Sage

Seeds and Nuts

- Tree Nuts
- Acorns
- Sunflower
- Chia seeds
- Wild rice

Other

- Wild mushrooms

*Encompasses a wide range of vegetables that use the same MLF and TF. These are vegetables are listed out in the document.

Animal Product Additions

Aquatic Biota

- Freshwater fish
- Marine fish
- Invertebrates
- Mollusk
- Reptiles

Large Herbivorous Mammals

- Deer
- Moose
- Elk
- Caribou
- Horse
- Big Horn Sheep

Small Mammals

- Rabbit
- Squirrel
- Beaver
- Muskrat

Large Mammals

- Bear
- Wild cats

Birds

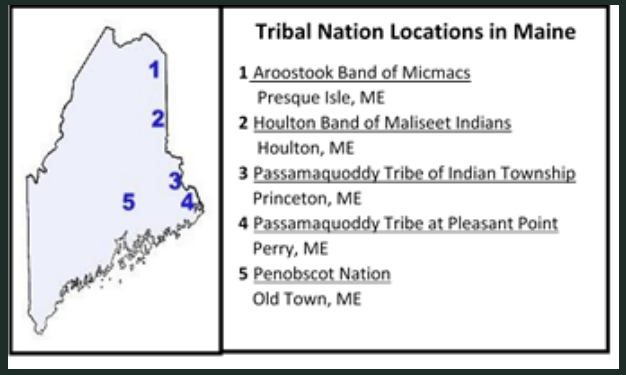
- Duck eggs
- Turkey
- Duck
- Quail
- Pheasant

*Encompasses a wide range of vegetables that use the same MLF and TF. These are vegetables are listed out in the document.

Wabanaki Cultural Lifeways Exposure Scenario (2009)

By the Harper and Ranco

- Coordinated effort among the five federally recognized Tribal Nations in Maine and the US EPA
- Report describes traditional uses, not contemporary uses
- Uses historical and anthropological information



Source: MIT CEHS

Food category	% of 2000 kcal	Equiv. kcal day	Rep kcal/100g	Grams per day
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

Wabanaki Cultural Lifeways Exposure Scenario (2009)

By the Harper and Ranco

Food category	% of 2000 kcal	Equivalent kcal day	Rep kcal/100g	Grams per day
Inland - anadromous				
Resident fish and other aquatic resources	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
Inland – non anadromous				
Resident fish and other aquatic resources	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
Coastal				
Resident fish and other aquatic resources	5	100	175	57
Anadromous & marine fish, shellfish	40	800	175	457
Game (large and small)	25	500	175	286
Fowl & eggs	12	240	200	120

Human Health and Ecological Risk Assessment(2007)

By Integral Consulting Inc.

- Prepared for International Paper at a St. Regis Paper company site
- Evaluates risks associated with the Paper Company Site in St. Regis, MN
- Pulls from many sources to create intake rates
- Focuses on fish and wild rice exposure in the Chippewa National Forest

Food Category	Adult Consumption Rate (g/day) Uncooked	Child Consumption Rate (g/day) Uncooked
Fish	74	31
Recreational Fish	15	7.8
Wild Rice	0.41	1.4

Source: EPA

Food Questionnaire Data Report: Upper Columbia River Resources Survey (2012)

By Environment International Ltd.

- Prepared for the Confederated Tribes of the Colville Reservation
- Located in Washington State
- Uses food consumption questionnaires and interviews of reservation residents
- Provides the most detailed produce item list of all the sources found

Food category	percent of population consuming	Average consumption frequency (times per year)	Consumers sourcing from local area
Huckleberries	75.0%	16	86.00%
Wild Strawberries	27.0%	9	89.00%
Camas	23.0%	14	74.00%
Wild Raspberries	22.0%	10	90.00%
Bitterroot	21.0%	11	83.00%
Wild Blackberries	19.0%	15	78.00%
Wild Mushrooms	17.0%	11	92.00%
Sarvisberries	16.0%	14	89.00%
Chokecherries	14.0%	17	87.00%
Lomatiums	14.0%	14	89.00%
Spring Beauty	14.0%	13	84.00%
Indian Carrot	12.0%	12	88.00%
Wild Thimbleberries	11.0%	8	89.00%
Wild Rose	10.0%	21	87.00%
Hazelnuts	10.0%	32	36.00%
Balsamroot	9.0%	22	95.00%
Pine Nuts	8.0%	14	37.00%
Soapberries	8.0%	18	84.00%
Blue Elderberries	7.0%	17	89.00%
Sage	7.0%	37	65.00%
Lichen (Moss)	7.0%	10	78.00%
Oregon Grape	3.0%	9	95.00%
Walnuts	3.0%	53	100.00%
Red or Black Hawthorn	2.0%	21	100.00%
Valerian	1.0%	44	84.00%
Cattail	1.0%	19	100.00%
Huss Huss	1.0%	12	100.00%
Buckbrush	1.0%	8	86.00%
Bunchberries	<1%	6	57.00%

Source: EPA

Food Questionnaire Data Report: Upper Columbia River Resources Survey (2012)

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- Prepared for the Confederated Tribes of the Colville Reservation
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Species type	Percent of population consuming	Average consumption frequency (times per year)	Consumers sourcing from local area
Fish			
Salmon	73%	15	74%
Trout	46%	13	92%
Walleye	12%	9	91%
Smallmouth Bass	11%	21	93%
Crawfish	9%	13	85%
Mussels	8%	9	12%
Largemouth Bass	7%	22	85%
Panfish	6%	25	79%
Burbot	4%	9	30%
Sturgeon	3%	40	68%
Lake Whitefish	2%	9	91%
Mountain Whitefish	1%	8	69%
Lamprey	1%	12	13%
Aquatic animals (turtles, snakes, frogs)	1%	18	100%
Northern Pikeminnow	1%	7	87%
Sucker	<1%	6	100%
Other	<1%	6 (meat) 52 (head/skins/ organs/eggs)	0%
Wild animals			
Deer	76%	38	90%
Elk	46%	22	84%
Moose	28%	14	90%
Bear	4%	19	81%
Small animals	2%	7	84%
Bighorn Sheep	2%	8	100%
Wild cats	1%	6	89%
Other Wild animals (horse)	<1%	6	100%
Beaver	0%	N/A	N/A

ANALYSIS OF HEAVY METALS (Pb, Zn, Cd) IN CULTURALLY SIGNIFICANT PLANTS WITHIN THE GRAND LAKE WATERSHED OF NORTHEASTERN OKLAHOMA (2015)

By Garvin et al. of Tribal Environmental Management Services

- Prepared for the Six Treaty Tribes of Oklahoma
- Mining district of Ottawa County, OK
- Provides hypothetical weekly consumption scenarios along with approximate serving sizes of various produce items found within the Tribal communities

Food Category	Child Serving Size (g/d)	Adult Serving Size (g/d)
wild onion	25	50
green dragon	25	50
jack-in-the-pulpit	50	100
wild ginger	25	50
common milkweed	50	100
pawpaw	75	150
river birch	75	150
pecan	60	120
wild carrot	50	100
strawberry	75	150
jewelweed	25	50
wild potato-vine	50	100
wild lettuce	50	100
duckweed	75	150
peppergrass	25	50
spicebush	25	50
white mulberry	75	150
wood-sorrel	50	100
wild mint	50	100
poke	50	100
common plantain	50	100
mayapple	25	50
solomon's seal	25	50
bracken fern	50	100
buttercup	50	100
blackberry	75	150
curly dock	50	100
arrowhead root	50	100
black willow	25	50
elderberry	75	150
greenbrier	25	50
buckbrush	25	50
dandelion	50	100
mullein	25	50
violet	50	100
wild grape	75	150

A Fish Consumption Survey of the Nez Perce Tribe (2016)

By Polissar et al.

- Prepared with the EPA and Nez Perce Tribe
- Based on Food Frequency Questionnaire data

Species group	Mean consumption (gpd)
All finfish and shellfish	123.4
Near coastal/ estuarine/freshwater/ anadromous finfish and shellfish)	104
Salmon and steelhead	79
Resident trout	13.5
other freshwater finfish and shellfish	14.3
marine finfish and shellfish	51
unspecified	8.1

Source: Columbia River Inter-Tribal Fish Commission

Land Use Survey (2015)

By NYSERDA

- Seneca Nation Territory
- Effort by NYSERDA to determine potential health impacts from radioactive contamination
- Responses are estimates made by technical team without comment from Seneca community

Source: eSpatially New York

	Quantity consumed (g/day)	
Food Category	Adults	Children
Fruit, grains, and non-leafy vegetation	453.59	194.40
Leafy vegetation	323.99	129.60

	Quantity consumed (g/day)	
Food Category	Adults	Children (1-5y/o)
Fish	64.80	194.40
Crustacean	0.00	0.00
Deer	121.50	N/A
Turkey	74.78	N/A

Carson River Human Health Risk Assessment (2017)

By CB&I Federal Services LLC for the EPA

- Evaluates risks associated with the Carson River Mercury Site in Nevada
- Traditional tribal food intake exposure factors from EPA (2007) and Harper (2005)
- Fallon Paiute-Shoshone Tribe

Food Category	Quantity consumed (grams per day)
Small Game	180
Waterfowl	40
Freshwater game fish	200

Food Category	Quantity consumed (grams per day)
Pine nuts	80
Roots, Tubers	300
Bulbs	300
Berries, fruit, and garden vegetables	333
Greens	833
Seed and grain	50
Honey, tea, etc.	40
Total plant intake	1936

Source: EPA

Plant-Specific Mass Loading Factors (Appendix A)

- MLF Sources:
  - Hinton (1992)
  - Environment Agency (EA) (2009)
  - Pinder and Mcleod (1989)
- Moisture content conversion factor sources:
  - EA (2009)
  - Stuckel & Low (1996)
  - Ixtaina (2008)
  - International Atomic Energy Agency (IAEA) (2010)
  - IAEA (2014)
  - Soil Screening Guidance (EPA)
- Other table components:
  - Initial MLF
  - Units
  - Unit conversion (to obtain g dry soil/g dry plant)
  - Moisture content conversion factors

Plant-Specific Mass Loading Factors (Appendix A)

Example:

Produce	Initial MLF	Initial MLF units	Initial MLF source	Unit conversion	Units after conversion	Moisture content conversion factor	Moisture content conversion factor sources	MLF	Final MLF units
Root Vegetables									
Balsamroot	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.103	EA (2009)	1.03E-04	g dry soil / g fresh plant

The full table contains 30 produce items

Transfer Factor Source Hierarchy (Appendix B)

Transfer factors model radionuclide transfer to produce before human consumption

Table components

- Primary, secondary, and tertiary transfer factor categories
- Sources
- Number and list of transfer factors

Example:

Produce	Primary Transfer Factor Category	Primary Transfer Factor Source	Number of Transfer Factors from Primary Source	Secondary Transfer Factor Category	Secondary Transfer Factor Source	Number of Transfer Factors from Secondary Source	Tertiary Transfer Factor Category	Tertiary Transfer Factor Source	Number of Transfer Factors from Tertiary Source
Bulbs and roots									
Balsamroot	Root	IAEA TRS 472	34-Ag, Am, Ba, Ce, Cl, Cm, Co, Cr, Cs, Fe, I, La, Mn, Mo, Na, Nb, Np, P, Pb, Pm, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zr	Root Vegetable	EA	15- Au, Br, Ca, Er, Eu, Ga, In, Lu, Ni, S, Se, Sm, Tl, V, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

The full tables contains 30 produce items and 24 animal products

Transfer Factor Source Hierarchy (Appendix B)

1. IAEA Technical Report Series no. 472
   - Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments
2. EA
   - Initial radiology assessment methodology
3. NCRP-123
   - National Council on Radiation Protection and Measurements
   - Screening models for releases of radionuclides to atmosphere, surface water, and ground Vol I and II
4. RADSSL
   - EPA Radionuclide Soil Screening Level Users Guide
5. RESRAD
   - US Dept of Energy
   - User's Manual for RESRAD Version 6
6. Baes et al.
   - Oak Ridge National Laboratory
   - Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture

Animal intake Rates(Appendix C)

Food, Water, Soil

	Food Intake Rate (g/day)	Water Intake Rate (L/day)
Reptiles and Amphibians		
Herbivores	$0.019Wt^{0.841}$(g)	Not identified
Insectivores	$0.013Wt^{0.773}$(g)	Not identified
Mammals		
All Mammals	$0.235Wt^{0.822}$(g)	$0.099Wt^{0.90}$(kg)
Rodents	$0.621Wt^{0.564}$(g)	Not identified
Herbivores	$0.577Wt^{0.727}$(g)	Not identified
Birds		
All Birds	$0.648Wt^{0.651}$(g)	$0.059Wt^{0.67}$(kg)
Passerines	$0.398Wt^{0.850}$(g)	Not identified
Non-Passerines	$0.301Wt^{0.751}$(g)	Not identified
Sea Birds	$0.485Wt^{0.704}$(g)	Not identified

- Key components for TFs in the original document are animal intake rates of food, water, and soil
- These values are less consistent for wild animals, but the EPA Wildlife Exposure Factors Handbook provides guidelines for various animal groups
- Wt is the body weight (wet) of the animal in grams (g) or (kg)
- Food intake rates are in grams of dry matter per day.
- Fish species proved to be particularly difficult to find due to high variability

Animal intake Rates(Appendix C)

Food, Water, Soil

According to Wildlife Exposure Handbook, soil intake rates are highly variable and difficult to measure for species in the wild.

This figure presents an equation that can be used to calculate the soil ingestion rates for an organism given the specific environment and circumstances.

$$ADD_{pot} = \left(\sum_{k=1}^{m} (C_k \times FS \times IR_{total}(\text{dry weight}) \times FR_k)\right)/BW \qquad [4\text{-}23]$$

ADD_{pot}	=	Potential average daily dose (e.g., in mg/kg-day).
C_k	=	Average contaminant concentration in soils in the k^{th} foraging area (e.g., in mg/kg dry weight).
FS	=	Fraction of soil in diet (as percentage of diet on a dry-weight basis divided by 100; unitless).
IR_{total}	=	Food ingestion rate on a dry-weight basis (e.g., in kg/day). Nagy's (1987) equations for estimating FI rates on a dry-weight basis (presented in Section 3.1) can be used to estimate a value for this factor. If the equations for estimating FI rates on a wet-weight basis presented in Section 4.2 are used, conversion to ingestion rates on a dry-weight basis would be necessary.
FR_k	=	Fraction of total food intake from the k^{th} foraging area (unitless).
BW	=	Body weight (e.g., in kg).
m	=	Total number of foraging areas.

Source: EPA (1993)

Questions?

Poll Questions

1. What is your affiliation?
   - Do you represent a tribal government, EPA, state government, consultant, or other group? Please describe
2. Are you aware of a risk assessment that assessed food consumption by a tribe that was not included in Grace's presentation.
   - If yes, is it publicly available?
   - If yes, please provide information on it (e.g., name of site/tribe) how to obtain (e.g., website, contact name and phone number)
3. Are you aware of a study that assessed food consumption by a tribe that was not included in Grace's presentation.
   - If yes, is it publicly available?
   - If yes, please provide information on it (e.g., name of study/tribe) how to obtain (e.g., website, contact name and phone number)