Evaluating Produce Consumption by Native Americans for Risk Assessments:

A Research Report Supporting the 2016 EPA Document on Biota Modeling for Superfund Risk Assessment

Grace Maley – Middlebury College
Virtual Student Federal Service Intern for the EPA
May 2020

Acknowledgements

This project was supported in part by an appointment to the U.S. Environmental Protection Agency (EPA), administered by the U.S. Department of State as part of the Virtual Student Federal Service program. This project was under the supervision of Stuart Walker and Michele Burgess of EPA's Office of Superfund Remediation and Technology Innovation and Jon Richards of EPA's Region 4 Superfund and Emergency Management Division. A special thanks to them, along with Karessa Manning of Oak Ridge National Laboratory, for all of their guidance and support throughout this project. In addition, thanks to those who reviewed this report and provided valuable feedback.

INTRODUCTION

In 2016, the Environmental Protection Agency (EPA) and Oak Ridge National Laboratory (ORNL) created a hierarchal selection process of biota modeling in the Preliminary Remediation Goal (PRG) and Dose Compliance Concentration (DCC) Calculators. This report, "Biota Modeling in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators for Use in EPA Superfund Risk Assessment: Explanation of Intake Rate Derivation, Transfer Factor Compilation, and Mass Loading Factor Sources," significantly improves 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. The key updated elements of the process are intake rates, transfer factors, and mass loading factors.

The Manning et al. (2016) document specifies 24 produce items. This report aims to supplement that 2016 report by incorporating more produce items that have been found in Native American diets. These new produce items are based on various food consumption surveys and reports (later listed). While these sources do not represent all Native Americans , these additions aim to create more comprehensive and inclusive risk assessment models.

MASS LOADING FACTOR SOURCE COMPILATION AND METHODS

Plant-specific mass loading factors (MLF) are an important factor of the PRG and DCC calculators. Manning et al. (2016) presents the plant-specific soil mass loading factors (MLF) of 24 produce items. These values are based on three sources: Hinton (1992), EA (2009), and Pinder and Mcleod (1989). As needed, Manning et al. converts these values into g soil/g fresh plant when the MLF source provided a dry weight MLF or units that were not presented in grams.

This report follows the same methodology, with supplemental sources as needed for produce types that can't be found within the above sources. Hinton's document and the EA "Updated Background to the CLEA Model", SC050021/SR3, provide MLFs. Table 6.3 of the EA document provides the majority of MLFs for this report. Conversion factors for dry plant to fresh plant are provided by Table G-1 in the EPA soil screening guidance (SSG). If the specific produce is not included in the SSG, then the average conversion factor for the produce type from Table 7.1 of the EA (2009) document is used. IAEA (2010), IAEA (2014), Yarkwan (2015), Okon et al. (2017) and Stuckel & Low (1996) provide moisture content conversion factors for mushroom, lichen, plantains, pawpaw, and maple syrup respectively.

TRANSFER FACTOR SOURCE COMILATION AND METHODS

Transfer factors (TF) are used in the PRG and DCC calculators to model radionuclide transfer to produce before human consumption. Soil to plant TFs are called BVs. BVs are used to determine the quantity of a radionuclide that is transferred to a plant.

Table B-1 in Appendix B outlines the BV sources and hierarchy for each of the new produce types. The BV source hierarchy is as follows:

1. IAEA
2. EA
3. NCRP-123
4. RADSSL
5. RESRAD
6. Baes paper

Many of the BVs listed in the hierarchy are already represented within the existing DCC and PRG calculator framework. Table B-1 classifies the new produce types within the existing groups. However, several groups were not present, including cattail shoots, sage, tree nuts, sunflower seeds, chia seeds, and wild mushrooms. These groups were categorized using IAEA TRS-472 produce groups.

The IAEA BV data provides more specification for produce types as it breaks down plants into parts. It also divides BVs into climate zone (temperate, tropical, and subtropical) and soil types (all (default), sand, loam, clay, organic, coral sand, and other). After IAEA values, this document uses the same hierarchy of sources as the Manning et al. (2016) document, where the breakdown explanations can be found in greater detail.

The new transfer factor values that are not included in the DCC and PRG calculators can be found here. The BVs of new produce items that already fit into existing food categories in the calculators are not relisted in this spreadsheet.

INGESTION RATES

Ingestion rates are based on data from reports by the following:

1. Environment International Ltd. for the Confederated Tribes of the Colville Reservation (2012)
2. Harper and Ranco in conjunction with five federally recognized Tribal Nations in Maine for the EPA (2009)
3. New York State Energy and Development Administration (NYSERDA) (2015)
4. CB&I Federal Services LLC for the EPA (2017).
5. Harper (2008) for the Quapaw Tribe in Oklahoma
6. Harper (2006) for the Elem Pomo tribe at Clear Lake, CA
7. Integral Consulting Inc. (2007) for International Paper at a St. Regis Paper company site
8. Garvin et al. (2015) of Tribal Environmental Management Services LLC for the Six Treaty Tribes of Oklahoma

Ingestion rates from each report are provided by Appendix C. The formatting and data differ for each table due to the varying information provide by each source. Again, the ingestion rates are not representative of all Native Americans but will provide greater insight into potential risks associated with produce consumption absent more tribal or site-specific data.

In the Harper and Ranco (2009) report, ingestion rates are broken down into ‘Inland-Anadromous”, “Inland Non-Anadromous”, and “Coastal”. However, the ingestion rates of produce are the same for all three. As a result, only one table is used here that represents each of the three areas in the original source.

In the NYSERDA (2015) report, Table C-3 presents the average of 6 different areas within the nation. The original data was in lbs/week. To make it more consistent with other data, it is converted to grams per day.

REFERENCES

ANL. (2001). *User's Manual for RESRAD Version 6.0.* ANL/EAD-4. Argonne National Laboratory, Argonne, IL.

Baes III, C.F., Sharp, R.D., Sjoreen, A.L., and Shor, R.W. (1984). *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture*. Oak Ridge, TN: Oak Ridge National Laboratory. ORNL-5786.

CB&I Federal Services LLC. (2017). *Carson River Mercury Site Operable Unit 2 Human Health Risk Assessment Report*. US EPA.

E.A. (2009). *Updated Technical Background to the CLEA Model*. Bristol, U.K.: Environment Agency. SC050021/SR3.

Environment International Ltd. (2012). *Food Questionnaire Data Report: Upper Columbia River Resources Survey*. Confederated Tribes of the Colville Reservation.

Garvin, E.M., S.G. Garvin, and C.F. Bridge. (2015). *Analysis of Heavy Metals (Pb, Zn, Cd) in Culturally Significant Plants within the Grand Lake Watershed of northeastern Oklahoma*. Miami, OK: Tribal Environmental Management Services LLC.

Harper, B. (2006). *Elem Pomo Tribe Human Health Risk Assessment Exposure Scenario*. Oregon State University.

Harper, B. (2008). *Quapaw Traditional Lifeways Scenario*. AESE, Inc.

Harper, B. & Ranco, D. (2009). *Wabanaki Traditional Cultural Lifeways Exposure Scenario*. US EPA.

Hinton, T. G. (1992). Contamination of plants by resuspension: a review, with critique of measurement methods. *Sci. Total Environ*, *121*, 171-193.

IAEA. (2009). *Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments*. Vienna, Austria: International Atomic Energy Agency.

IAEA. (2010). *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments*. Vienna, Austria: International Atomic Energy Agency. Technical Report Series 472.

IAEA. (2014). *Handbook of Parameter Values for the Prediction of Radionuclide Transfer to Wildlife.* Vienna, Austria: International Atomic Energy Agency. Technical Report Series 479.

Integral Consulting Inc. (2007). *Human Health and Ecological Risk Assessment: St. Regis Paper Company Site Cross Lake, MN.* Broomfield, CO. International Paper.

Ixtaina, V.Y., Nolasco, S.M, Tomas, M.C. (2008). Physical properties of chia (*salvia hispanica* L.) seeds. *Industrial crops and products, 28,* 286-193.

Manning, K. L., Dolislager F.G., Bellamy M.B. (2016). *Biota Modeling in EPA's Preliminary Remediation Goal and Dose Compliance Concentration Calculators for Use in EPA Superfund Risk Assessment: Explanation of Intake Rate Derivation, Transfer Factor Compilation, and Mass Loading Factor Sources.* Oak Ridge, TN: Oak Ridge National Laboratory

Nanba, K., Tarjan, S. Takase, T., Varga, B. (2016). Goal Oriented Sampling Strategies for Radionuclide Monitoring. *International Nuclear Safety Journal*, 5(2), 26-64.

National Council on Radiation Protection and Measurements (NCRP). (1996). *Report No. 123 Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground Vol. I and II.*

Okon, W.I., A.I. Ogri, G.O. Igile, and I.J. Atangwho. (2017). Nutritional quality of raw and processed unripe Carica papaya fruit pulp and its contribution to dietary diversity and food security in some peasant communities in Nigeria. *International Journal of Biological and Chemical Sciences*, 11(3), 1000-1011.

Pinder, J.E.; McLeod, K.W. 1989. Mass Loading of Soil Particles on Plant Surfaces. *Health Physics Journal*, *57*(6), 935-942.

Stuckel, J.G. & Low, N.H. (1996). The chemical composition of 80 pure maple syrup samples produced in North America. *Food Research International, 29,* 373-379.

U.S. EPA. (1996). *Soil Screening Guidance: Appendix G*. EPA540/R-96/018. Washington, D.C.: Office of Solid Waste and Emergency Response.

U.S. EPA. (2000). EPA Radionuclide Soil Screening Level (SSL). *Directive 9355.4-16A. Soil Screening Guidance for Radionuclides: User's Guide.* Office of Solid Waste and Emergency Response (OSWER), Washington, D.C

Yarkwan, B. and R.H. Uvir. (2015). Effects of Drying Methods on the Nutritional Composition of Unripe Plantain Flour. *Food Science and Quality Management*, 41.

APPENDIX A – MASS LOADING FACTORS

Table 1. Mass Loading Factors

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
Bulbs and roots									
Root Vegetables[1]	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
Indian carrot	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.097	EA (2009)	9.70E-05	g dry soil / g fresh plant
Leek	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.097	EA (2009)	9.70E-05	g dry soil / g fresh plant
Wild Potato Vine	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.21	EA (2009)	2.10E-04	g dry soil / g fresh plant
Wild Onion	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.080	EA (2009)	8.00E-05	g dry soil / g fresh plant
Fruits									
Oregon grape	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.166	EA (2009)	1.66E-04	g dry soil / g fresh plant
Plantain	1.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.4023	Yarkwan (2015)	4.03E-01	g dry soil / g fresh plant

[1] Includes Balsamaroot, Bitterroot, Burdock, Camas, Cattail, Chicory, Dandelion, Green dragon, Huss huss, Jack in the Pulpit, Wild carrot, Lomatium, Spring beauty, Valerian, Wild potato vine, Spicebush, Mayapple, Solomon's seal, Curly dock, Black Willow, Greenbrier, Violet, and Wild grape

Pawpaw	2.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.7393	Okon et al. (2017)	1.48E+00	g dry soil / g fresh plant
Mayapple	3.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.058	EA (2009)	1.74E-01	g dry soil / g fresh plant
Chokecherries	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.15	EA (2009)	1.50E-04	g dry soil / g fresh plant
Other vegetables (above ground)									
Beans (pinto, kidney, white)	45	mg dry soil /g dry plant	Hinton (1992)	0.045	g dry soil / g dry plant	0.111	SSG	5.00E-03	g dry soil / g fresh plant
Buckbrush	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.079	EA (2009)	7.90E-05	g dry soil / g fresh plant
Cattail shoot	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.079	EA (2009)	7.90E-05	g dry soil / g fresh plant
Peas	45	mg dry soil /g dry plant	Hinton (1992)	0.045	g dry soil / g dry plant	0.257	SSG	1.16E-02	g dry soil / g fresh plant
Squash (winter, Navajo)	175	mg dry soil /g dry plant	Hinton (1992)	0.175	g dry soil / g dry plant	0.082	SSG	1.44E-02	g dry soil / g fresh plant
River Birch	-0.999	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.079	EA (2009)	-7.89E-02	g dry soil / g fresh plant
Wild rose	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.079	EA (2009)	7.90E-05	g dry soil / g fresh plant
Greens, tea									

Leafy Greens[2]	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.08	EA (2009)	8.00E-05	g dry soil / g fresh plant
Herbaceous Flowering Plants[3]	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.08	EA (2009)	8.00E-05	g dry soil / g fresh plant
Wild Lettuce	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.04	EA (2009)	4.00E-05	g dry soil / g fresh plant
Lichen	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.36	IAEA (2014)	3.60E-04	g dry soil / g fresh plant
Buckbrush	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.079	EA (2009)	7.90E-05	g dry soil / g fresh plant
Wild Mint	1.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.113	EA (2009)	1.13E-01	g dry soil / g fresh plant
Sage	24	mg dry soil /g dry plant	Hinton (1992)	0.024	g dry soil / g dry plant	0.113	EA (2009)	2.71E-03	g dry soil / g fresh plant
Seeds, Nuts, Grain									
Tree Nuts	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.967	SSG	9.67E-04	g dry soil / g fresh plant
Acorns	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	1.967	SSG	1.97E-03	g dry soil / g fresh plant
Dried sunflower seeds	3	mg dry soil /g dry plant	Hinton (1992)	0.003	g dry soil / g dry plant	N/A	None	3.00E-03	g dry soil / g dry plant

[2] Includes watercress, fiddleheads, duckweed, and bracken fern

[3] Includes Wood-sorrel, Mullein, Pokeweed, Violet, Buttercup, Jewelweed, Peppergrass

Wild Rice	250	mg dry soil /g dry plant	Hinton (1992)	0.25	g dry soil / g dry plant	N/A	N/A	2.50E-01	g dry soil / g fresh plant
Chia seeds	0.001	g dry soil / g dry plant	EA (2009)	None	g dry soil / g dry plant	0.007	Ixtaina (2008)	7.00E-06	g dry soil / g fresh plant
Other									
Wild mushrooms	250	mg dry soil /g dry plant	Hinton (1992)	0.25	g dry soil / g dry plant	0.1	IAEA (2010)	2.50E-02	g dry soil / g fresh plant

APPENDIX B – TRANSFER FACTOR SOURCE COMPILATION

Table B-1. Transfer Factor Hierarchy

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									
Root Vegetables[4]	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.
Wild Potato-Vine	Tuber	IAEA TRS 472	30-Am, Ba, Cd, Ce,Cm, Co, Cr, Cs, Fe, I,La, Mn, Na, Nb, Np,P, Pb, Pm, Po, Pu, Ra,Ru, Sr, Tc, Te, Th, U,Y, Zn, Zr	Root Vegetable	EA	19-Ag, Au, Br, Ca, Cl,Er, Eu, Ga, In, Lu, Mo,Ni, Rb, S, Sb, Se, Sm,Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Arrowhead	Tuber	IAEA TRS 472	30-Am, Ba, Cd, Ce,Cm, Co, Cr, Cs, Fe, I,La, Mn, Na, Nb, Np,P, Pb, Pm, Po, Pu, Ra,Ru, Sr, Tc, Te, Th, U,Y, Zn, Zr	Root Vegetable	EA	19-Ag, Au, Br, Ca, Cl,Er, Eu, Ga, In, Lu, Mo,Ni, Rb, S, Sb, Se, Sm,Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

[4] Includes Balsamaroot, Bitterroot, Burdock, Camas, Cattail, Chicory, Dandelion, Green dragon, Huss huss, Jack in the Pulpit, Indian Carrot, Wild carrot, Leek, Lomatium, Spring beauty, Valerian, Wild potato vine, Spicebush, Mayapple, Solomon's seal, Curly dock, Black Willow, Greenbrier, Violet, and Wild grape

Wild Onion	Non-Leafy Vegetable	IAEA TRS 472	26-Ag, Am, Cm, Co,Cr, Cs, Fe, I, La, Mn,Na, Nb, Np, P, Pb, Pu,Ra, Ru, Sb, Sr, Te,Th, U, Y, Zn, Zr	Root Vegetable	EA	22-Au, Ba, Br, Ca, Ce,Cl, Er, Eu, Ga, In, Lu,Mo, Ni, Pm, Po, Rb, S,Se, Sm, Tc, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Fruits									
Chokecherries	Shrub	IAEA TRS 472	4-Cs, Sr, Pu, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Oregon grape	Shrub	IAEA TRS 472	4-Cs, Sr, Pu, Sr	Fruit	EA	15- Au, Ca, Cm, Er, Ga, I, In, Nb, Np, P, Pm, S, Tc, Tl, Y	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Mayapple	Herbaceous	IAEA TRS 472	4-Am, Cs, Pu, Sr	Fruit	EA	20-Au, Ca, Cm, Er, Ga,I, In, Mn, Mo, Nb, Np,P, Pm, Ru, S, Sb, Tl, V,Y, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Co, H, Ra, Rn, Tc, Th, and U.
Pawpaw	Woody Tree	IAEA TRS 472	4-Am, Cs, Pu, Sr	Fruit	EA	39-Ag, Au, Ba, Br, Ca,Ce, Cl, Co, Cr, Er, Eu,Fe, Ga, I, In, La, Lu,Mo, Na, Nb, Np, P,Pm, Po, Ra, Rb, Ru, S,Sb, Se, Sm, Tc, Th, Tl,U, V, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Plantain	Woody Tree	IAEA TRS 472	4-Am, Cs, Pu, Sr	Fruit	EA	39-Ag, Au, Ba, Br, Ca,Ce, Cl, Co, Cr, Er, Eu,Fe, Ga, I, In, La, Lu,Mo, Na, Nb, Np, P,Pm, Po, Ra, Rb, Ru, S,Sb, Se, Sm, Tc, Th, Tl,U, V, Y, Zn, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Other vegetables (above ground)									
Beans (pinto, kidney, white)	Legume Seed	IAEA TRS 472	24-Am, Cd, Ce, Cl, Cm, Co, Cs, Fe, I, La, Mn, Np, Pb, Pm, Po, Pu, Ra, Ru, Sb, Sr, Tc, Th, U, Zn	Green Vegetable	EA	24-Ag, Au, Ba, Br, Ca, Cr, Er, Eu, Ga, In, Lu, Mo, Na, Nb, Ni, P, Rb, S, Se, Sm, Tl, V, Y, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Buckbrush	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Cattail shoot	Grass Stem	IAEA TRS 472	17-Am, Ba, Ce, Cs, Co, K, La, Mn, Ni, Np, Pb, Pu, Ra, Sr, Th, U, Zn	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Peas	Legume Seed	IAEA TRS 472	24-Am, Cd, Ce, Cl, Cm, Co, Cs, Fe, I, La, Mn, Np, Pb, Pm, Po, Pu, Ra, Ru, Sb, Sr, Tc, Th, U, Zn	Green Vegetable	EA	24-Ag, Au, Ba, Br, Ca, Cr, Er, Eu, Ga, In, Lu, Mo, Na, Nb, Ni, P, Rb, S, Se, Sm, Tl, V, Y, Zr	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Squash (winter, Navajo)	Non-Leafy Vegetable	IAEA TRS 472	26-Ag, Am, Cm, Co, Cr, Cs, Fe, I, La, Mn, Na, Nb, Np, P, Pb, Pu, Ra, Ru, Sb, Sr, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	22- Au, Ba, Br, Ca, Ce, Cl, Er, Eu, Ga, In, Lu, Mo, Ni, Pm, Po, Rb, S, Se, Sm, Tc, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
River Birch	Woody Tree	IAEA TRS 472	4-Am, Cs, Pu, Sr	Green Vegetable	EA	22- Au, Ba, Br, Ca, Ce, Cl, Er, Eu, Ga, In, Lu, Mo, Ni, Pm, Po, Rb, S, Se, Sm, Tc, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Wild rose	Shrub	IAEA TRS 472	2-Cs, Sr	Green Vegetable	EA	22- Au, Ba, Br, Ca, Ce, Cl, Er, Eu, Ga, In, Lu, Mo, Ni, Pm, Po, Rb, S, Se, Sm, Tc, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Greens, tea									
Watercress	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD,Baes paper	Any elements not previously listed, including H and Rn.

Milkweed	Herbs	IAEA TRS 472	8- Ag, Cs, I, K, Ra, Pb, Sr, Th, U	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Herbaceous Flowering Plants[5]	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Duckweed	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Wild lettuce	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

[5] Includes Wood-sorrel, Mullein, Pokeweed, Violet, Buttercup, Jewelweed, Peppergrass

Bracken Fern	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Buckbrush	Shrub	IAEA TRS 472	2-Cs, Sr	Green Vegetable	EA	22- Au, Ba, Br, Ca, Ce, Cl, Er, Eu, Ga, In, Lu, Mo, Ni, Pm, Po, Rb, S, Se, Sm, Tc, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Fiddleheads	Leafy Vegetable	IAEA TRS 472	35-Ag, Am, Ba, Ce, Cl, Sm, Co, Cr, Cs, Fe, I, K, La, Mn, Mo, Na, Nb, Np, P, Pb, Po, Pr, Pu, Ra, Rb, Ru, Sb, Sr, Tc, Te, Th, U, Y, Zn, Zr	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Lichen	Lichen	IAEA TRS 479	39-Ag, Al, Am, As, B, Ba, Be, Br, Cd, Ce, Co, Cr, Cs, Cu, Eu, Fe, Hf, La, Lu, Mn, Mo, Na, Ni, Pb, Po, Ra, Rb, Sb, Sc, Se, Sm, Sr, Ta, Th, Ti, U, V, Yb, Zn	None				NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Wild mint	Herbs	IAEA TRS 472	8- Ag, Cs, I, K, Ra, Pb, Sr, Th, U	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

Sage	Herbs	IAEA TRS 472	8- Ag, Cs, I, K, Ra, Pb, Sr, Th, U	Green Vegetable	EA	16-Au, Br, Ca, Cm, Er, Eu, Ga, In, Lu, Ni, Pm, S, Se, Tl, V	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Seeds, Nuts, Grain									
Tree Nuts	Other	IAEA TRS 472	8-Cs, Co, Sr, K, Pu, Pb, U, Zn	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Dried sunflower seeds	Other (Sunflower)	IAEA TRS 472	2-U, Ra	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Wild Rice	Rice	IAEA TRS 472	12- Co, Cs, I, Mn, Pb, Po, Ra, Sr, Tc, Th, U, Zn	None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including Am, H, Pu, and Rn.	None	None	None
Chia seeds	Other	IAEA TRS 472	8-Cs, Co, Sr, K, Pu, Pb, U, Zn	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.
Other									
Wild mushrooms	Mushroom	IAEA TRS 472	Cs, Sr, Pu	None			None	NCRP-123, RADSSL, RESRAD, Baes paper	Any elements not previously listed, including H and Rn.

APPENDIX C – RAW INGESTION RATES

Table C-1. Confederated Tribes of the Colville Reservation (2012)

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%

Table C-2. 5 Harper and Ranco (2009)

Food category	% of 2000 kcal	equivalent 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

Table C-3. NYSERDA (2015)

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

Table C-4. CB&I Federated Services LLC (2017)

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

Table C-5. Harper (2008)

Food Category	Ingestion Rate (g/d)
Corn	267
Legumes	92
Squash, other veg	133
Nuts, grains, seeds	24
Roots & bulbs	133
Fruits & berries	167
Greens & sweets	200

Table C-6. Harper (2006)

Food Group	Estimated Percent of Annual Diet	% x 2000 kcal = Dail Calories	Daily amount (g/d)
Acorns	30	600	120
Roots, tubers, rhizomes, corms	10	200	250
Bulbs	5	100	360
Seeds, pinole, atole	5	100	20
Fruits and berries	5	100	140
Greens, shoots	5	100	333
Teas, medicines, sweeteners	5	100	36

Table C-7. Integral Consulting (2007)

Food Category	Adult Consumption Rate (kg/day)	Child Consumption Rate (kg/day)
Wild Rice	0.41	1.4

Table C-8. Garvin et al. (2015)

Food Category	Child Serving Size (g)	Adult Serving Size (g)
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