POPULATION-LEVEL ECOLOGICAL RISK ASSESSMENT

MANAGING ECOLOGICAL RISKS USING POPULATION LEVEL RISK ASSESSMENT - A PROPOSED APPROACH TO CHARACTERIZE ELEVATED HQ VALUES

Presented to Remediation Technologies Symposium
Banff Alberta| October 16th 2025

Presentation Outline

Objective:

- Provide an example approach to manage ecological risks for a heavily contaminated site

Project/Problem Description

- Describe nature of impacts and identification of wildlife receptors of concern

Methodology

- Describe ecological exposure model and risks without population-level risks incorporated
- Describe toxicological information required for assessment of population-level risks
- Describe the population-level model

Results

- Putting it all together

Summary and Additional Considerations

Objectives

General topics to cover:

- Provide an ecological risk assessment approach to address ecological risks when predicted HQ values >>> 1.0
- Provide a quantitative estimate of the magnitude and likelihood of adverse effects to wildlife receptors
- Determine if there is potential for unacceptable population-level risks defined as contamination levels that would limit successful reproduction and population growth (i.e., viability)
- Added benefit is demonstration of how risks assessment can aid with risk management of large area sites and/or heavily impacted sites

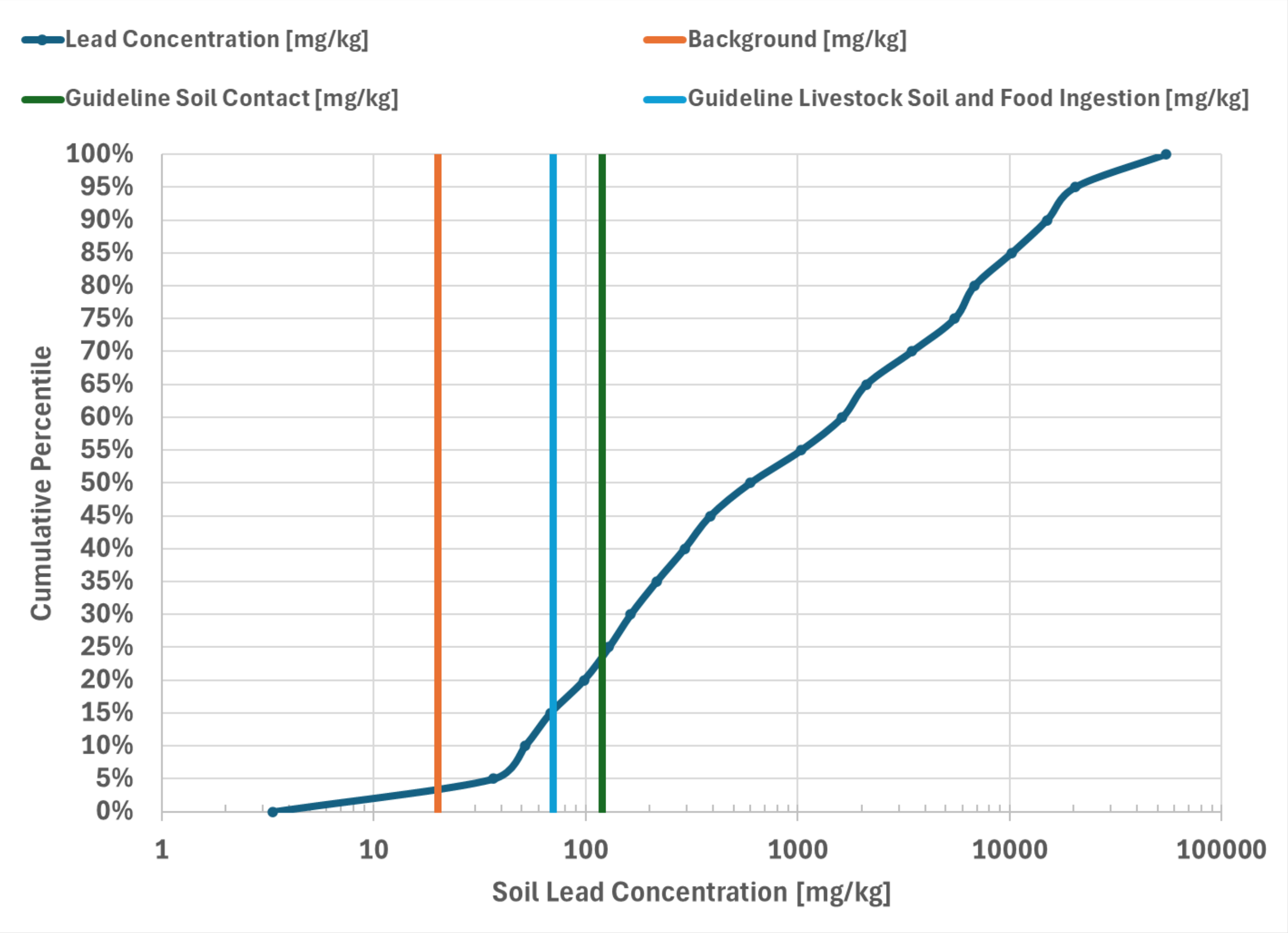
EXAMPLE: Bunker Hill Superfund Site, Coeur d'Alene, Idaho.
Photo courtesy BEIPC

Project Description

Particulars:

- Historical mining site heavily impacted with elevated **lead** concentrations in soil
- Across an impacted area of 2,000,000 m^2 or 2 km^2
- Site located in a remote region with limited access
- Detailed ecological risk assessment projected elevated risks (HQ values > 10) to the following wildlife receptors:
  - Agelaius phoeniceus (Red-winged Blackbird)
  - Canachites canadensis (Spruce Grouse)

Figure highlights exceedances of background and environmental guideline for soil across the site



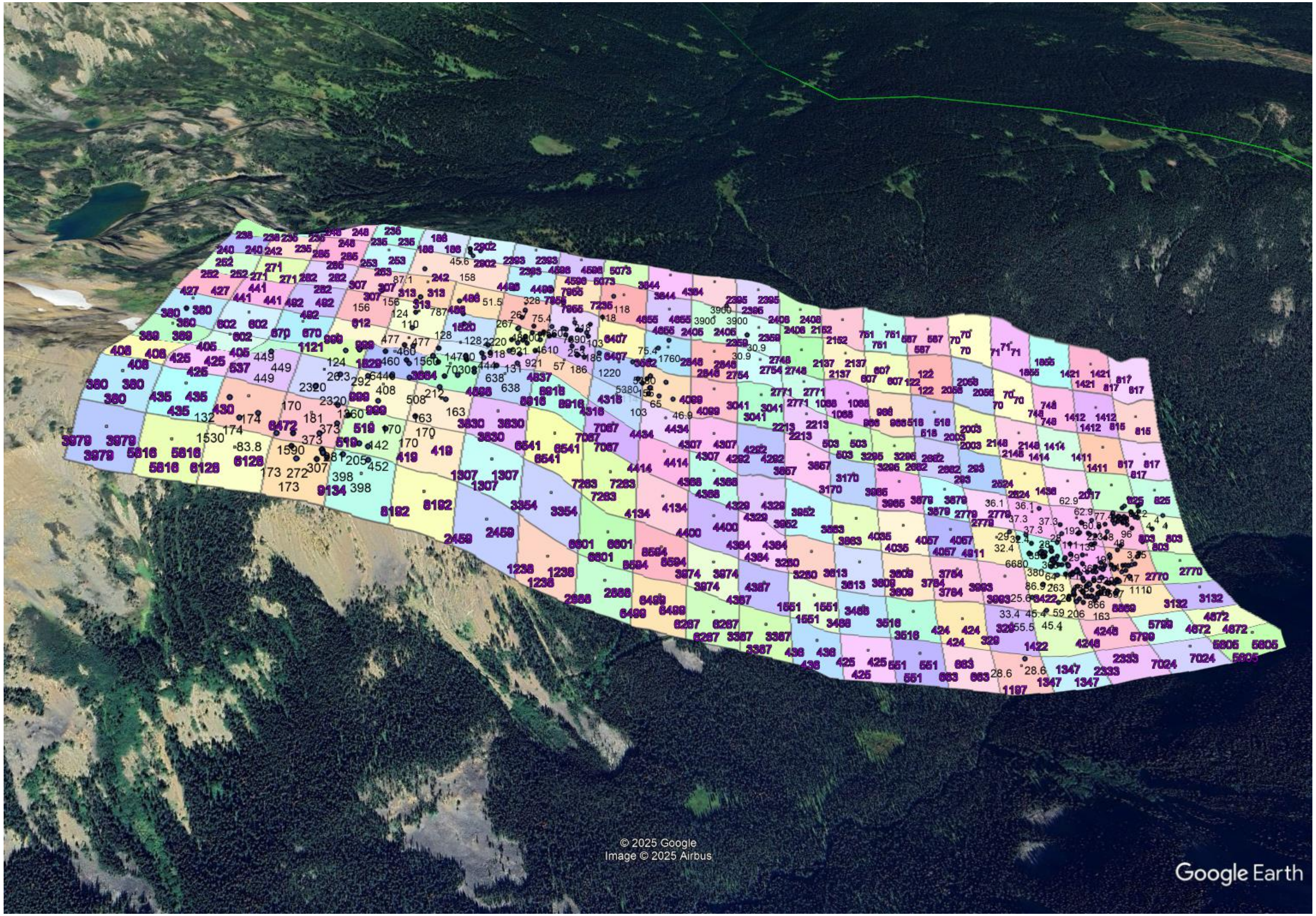
Methodology – Spatial Analysis

The Setup:

- Site characterized with over 350 soil samples and 70% of the samples were collected within the top 30cm depth (i.e., surface soil)
- Divided site into a grid of equal sized polygons roughly equivalent to home range of target wildlife receptors (i.e., 100m x 100m = 10,000 m^2 or 1 hectare)
- Used GIS kriging software to interpolate surface soil concentrations across entire study area in a grid
- Applicable to small home range receptors such as grouse and blackbird

Methodology

Kriging output in Google Earth



Methodology

Kriging output in Excel – Hypothetical Example

Predicted Lead Concentrations in Soil for each 100m x 100m Area / Polygon (i.e., 1 Hectare) [mg/kg]																					
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	238	235	248	235	186	2902	2383	4598	3644	4384	2395	2406	2152	751	587	70	71	1855	1421	817	20
20	240	242	285	253	242	242	4498	7955	4655	2405	2359	2748	2137	607	122	2058	70	748	1412	815	20
20	252	271	282	307	313	488	6736	13966	3582	2648	2754	2771	1088	966	518	2003	2148	1414	1411	817	20
20	427	441	482	812	1420	1520	5101	2216	4369	4099	3041	2213	503	3295	2662	293	2524	1436	2017	825	20
20	380	602	670	999	1818	4289	7050	4837	4434	4307	4292	3857	3170	3985	3879	2779	2490	3058	4676	803	20
20	389	405	596	1121	1829	3664	4896	8916	4414	4366	4329	3952	3863	4035	4057	4911	8282	1004	3022	2770	20
20	408	425	537	541	999	2131	3830	6541	4134	4400	4364	3280	3613	3809	3794	3993	3422	6956	8869	3132	20
20	380	435	430	6472	518	419	1307	3354	8594	3974	4387	1551	3488	3516	424	329	1422	4246	5799	4672	20
20	3979	5816	6126	9240	9134	8192	2459	1236	6499	6267	3367	436	425	551	663	1197	1347	2333	7024	5605	20
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

Background soil concentration

Methodology – Predict Wildlife Exposures [mg/day]

Wildlife exposure pathways included:

- Direct exposure to soil (i.e., incidental ingestion)
- Dietary consumption of a portion of the following:
  - Arthropods
  - Worms
  - Browse

Used models to predict dietary concentrations based on soil

- Can be literature based or site-specific model for uptake factors
- Used literature:
  - Terrestrial invertebrate (i.e., arthropods) based on Beyer and Sample 2017
  - Terrestrial invertebrate (i.e., earthworms) based on Sample et al 1998
  - Browse concentrations (i.e., grasses and leaves) based on BJC 1998

Methodology – Predicted Dietary Concentrations

Predicted Lead Concetrations in Browse [mg/kg-DW]

1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
1.3	5.4	5.4	5.5	5.4	4.7	22.0	19.7	28.5	25.0	27.7	19.8	19.8	18.6	10.3	9.0	2.7	2.7	17.1	14.7	10.8	1.3
1.3	5.4	5.5	6.0	5.6	5.5	5.5	28.1	38.7	28.7	19.8	19.6	21.3	18.5	9.1	3.7	18.1	2.7	10.3	14.7	10.8	1.3
1.3	5.6	5.8	5.9	6.2	6.3	8.1	35.3	53.1	24.8	20.9	21.4	21.4	12.7	11.9	8.4	17.9	18.6	14.7	14.7	10.8	1.3
1.3	7.5	7.6	8.0	10.8	14.7	15.3	30.2	18.9	27.7	26.7	22.6	18.9	8.2	23.6	21.0	6.1	20.3	14.8	17.9	10.9	1.3
1.3	7.0	9.1	9.7	12.1	16.9	27.4	36.2	29.3	27.9	27.5	27.4	25.8	23.1	26.3	25.9	21.5	20.2	22.7	28.7	10.7	1.3
1.3	7.1	7.3	9.1	12.9	17.0	25.1	29.5	41.3	27.8	27.7	27.5	26.2	25.8	26.5	26.5	29.5	39.6	12.1	22.5	21.4	1.3
1.3	7.3	7.5	8.5	8.6	12.1	18.5	25.7	34.7	26.8	27.8	27.7	23.6	24.9	25.6	25.6	26.3	24.1	35.9	41.2	23.0	1.3
1.3	7.0	7.6	7.5	34.5	8.4	7.4	14.1	23.9	40.4	26.2	27.7	15.5	24.4	24.5	7.5	6.5	14.7	27.2	32.4	28.7	1.3
1.3	26.3	32.5	33.5	42.1	41.9	39.4	20.0	13.6	34.6	33.9	23.9	7.6	7.5	8.7	9.6	13.4	14.3	19.5	36.1	31.8	1.3
1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3

Predicted Lead Concetrations in Earthworms [mg/kg-DW]

9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
9.0	66.6	65.9	68.8	65.9	54.6	500.9	427.2	726.1	601.9	698.7	429.0	430.6	393.5	168.3	137.9	24.8	25.1	349.0	281.5	180.1	9.0
9.0	67.0	67.5	77.0	69.9	67.5	67.5	713.4	1130.2	733.4	430.4	423.8	479.3	391.3	141.7	38.8	379.6	24.8	167.7	280.1	179.7	9.0
9.0	69.7	73.9	76.3	81.7	83.0	118.8	988.2	1779.9	593.6	465.2	480.1	482.5	226.9	206.2	124.7	371.3	392.9	280.4	279.9	180.1	9.0
9.0	106.7	109.5	117.6	179.2	281.3	297.2	789.6	402.9	696.8	661.8	520.1	402.5	121.8	554.9	467.2	78.7	447.5	283.9	373.4	181.5	9.0
9.0	97.1	140.8	153.4	211.8	343.4	686.5	1025.2	756.4	705.2	688.8	686.9	630.1	537.9	646.9	633.0	483.7	442.6	522.5	736.1	177.6	9.0
9.0	98.9	102.2	139.6	232.5	345.1	604.6	763.9	1239.1	702.6	696.4	691.7	642.6	630.9	653.5	656.4	765.8	1167.5	212.7	517.5	482.4	9.0
9.0	102.8	106.3	128.4	129.1	211.8	390.4	626.6	965.0	666.4	700.8	696.2	552.9	597.8	623.8	621.8	648.0	572.1	1014.2	1233.8	532.7	9.0
9.0	97.1	108.3	107.3	956.8	124.7	105.1	263.1	562.9	1202.9	645.5	699.1	302.1	581.0	584.8	106.1	86.4	281.7	680.9	875.7	735.6	9.0
9.0	646.2	877.8	915.3	1275.3	1263.5	1157.3	438.2	251.5	960.0	932.3	564.7	108.5	106.3	131.0	152.2	245.1	269.6	420.0	1022.2	852.0	9.0
9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

Arthropod concentrations not presented but about 10x lower than earthworms

Methodology – Predicted Exposures and Risks

Exposure and Risk for Grouse:

- Site exposure ranged from 0.27 to 10 mg/kg-BW/day
- Background exposure 0.12 mg/kg-BW/day
- Figure presents HQ values based on avian TRV of 1.63 mg/kg/day (ECCC 2021; US EPA 2005)

Browse	Arthropods	Worms
90%	5%	5%

Predicted Wildlife Hazard Quotient [Unitless]

0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
0.07	0.37	0.37	0.38	0.37	0.32	2.04	1.78	2.81	2.39	2.72	1.78	1.79	1.65	0.80	0.68	0.17	0.17	1.49	1.24	0.85	0.07
0.07	0.37	0.38	0.42	0.39	0.38	0.38	2.77	4.15	2.84	1.79	1.76	1.96	1.65	0.70	0.24	1.60	0.17	0.80	1.24	0.85	0.07
0.07	0.39	0.40	0.42	0.44	0.45	0.60	3.69	6.21	2.36	1.91	1.96	1.97	1.03	0.95	0.62	1.57	1.65	1.24	1.24	0.85	0.07
0.07	0.55	0.56	0.59	0.85	1.24	1.30	3.03	1.69	2.71	2.60	2.11	1.69	0.61	2.23	1.92	0.43	1.85	1.25	1.58	0.86	0.07
0.07	0.51	0.69	0.74	0.98	1.47	2.68	3.81	2.92	2.74	2.69	2.68	2.49	2.17	2.54	2.50	1.98	1.83	2.11	2.85	0.84	0.07
0.07	0.52	0.53	0.69	1.06	1.48	2.40	2.94	4.50	2.73	2.71	2.70	2.53	2.49	2.57	2.58	2.95	4.27	0.98	2.10	1.97	0.07
0.07	0.53	0.55	0.64	0.64	0.98	1.64	2.47	3.61	2.61	2.73	2.71	2.22	2.38	2.46	2.46	2.55	2.29	3.77	4.48	2.15	0.07
0.07	0.51	0.56	0.55	3.58	0.62	0.54	1.17	2.25	4.38	2.54	2.72	1.32	2.32	2.33	0.55	0.46	1.24	2.66	3.32	2.85	0.07
0.07	2.54	3.32	3.45	4.62	4.58	4.24	1.82	1.13	3.59	3.50	2.26	0.56	0.55	0.65	0.74	1.10	1.20	1.75	3.80	3.24	0.07
0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

HQ>1.0

Methodology – Predicted Exposures and Risks

Exposure and Risk for Blackbird:

- Site exposure ranged from 1.1 to 58 mg/kg-BW/day
- Background exposure 0.45 mg/kg-BW/day
- Figure presents HQ values based on avian TRV of 1.63 mg/kg/day (ECCC 2021; US EPA 2005)

Browse	Arthropods	Worms
70%	15%	15%

Predicted Wildlife Hazard Quotient [Unitless]																					
0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
0.27	1.64	1.62	1.69	1.62	1.37	10.66	9.18	15.13	12.68	14.59	9.21	9.25	8.50	3.85	3.20	0.67	0.68	7.59	6.21	4.10	0.27
0.27	1.65	1.66	1.87	1.71	1.66	1.66	14.88	23.03	15.28	9.24	9.11	10.23	8.45	3.28	1.01	8.21	0.67	3.83	6.18	4.09	0.27
0.27	1.71	1.80	1.86	1.98	2.01	2.79	20.27	35.51	12.51	9.94	10.24	10.29	5.08	4.64	2.92	8.05	8.48	6.19	6.18	4.10	0.27
0.27	2.53	2.59	2.76	4.08	6.21	6.53	16.38	8.69	14.56	13.86	11.04	8.68	2.85	11.74	9.98	1.91	9.59	6.26	8.09	4.13	0.27
0.27	2.32	3.26	3.53	4.76	7.48	14.35	20.99	15.73	14.72	14.40	14.36	13.24	11.40	13.57	13.29	10.31	9.49	11.09	15.33	4.04	0.27
0.27	2.36	2.43	3.24	5.19	7.51	12.73	15.88	25.14	14.67	14.55	14.45	13.48	13.25	13.70	13.76	15.92	23.75	4.78	10.99	10.29	0.27
0.27	2.44	2.52	2.99	3.01	4.76	8.43	13.17	19.82	13.95	14.63	14.54	11.70	12.59	13.11	13.07	13.59	12.08	20.78	25.03	11.30	0.27
0.27	2.32	2.56	2.54	19.66	2.92	2.49	5.83	11.90	24.44	13.54	14.60	6.63	12.26	12.33	2.51	2.08	6.21	14.24	18.07	15.32	0.27
0.27	13.55	18.11	18.85	25.84	25.61	23.55	9.40	5.59	19.72	19.18	11.93	2.56	2.52	3.05	3.50	5.46	5.96	9.03	20.93	17.61	0.27
0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27

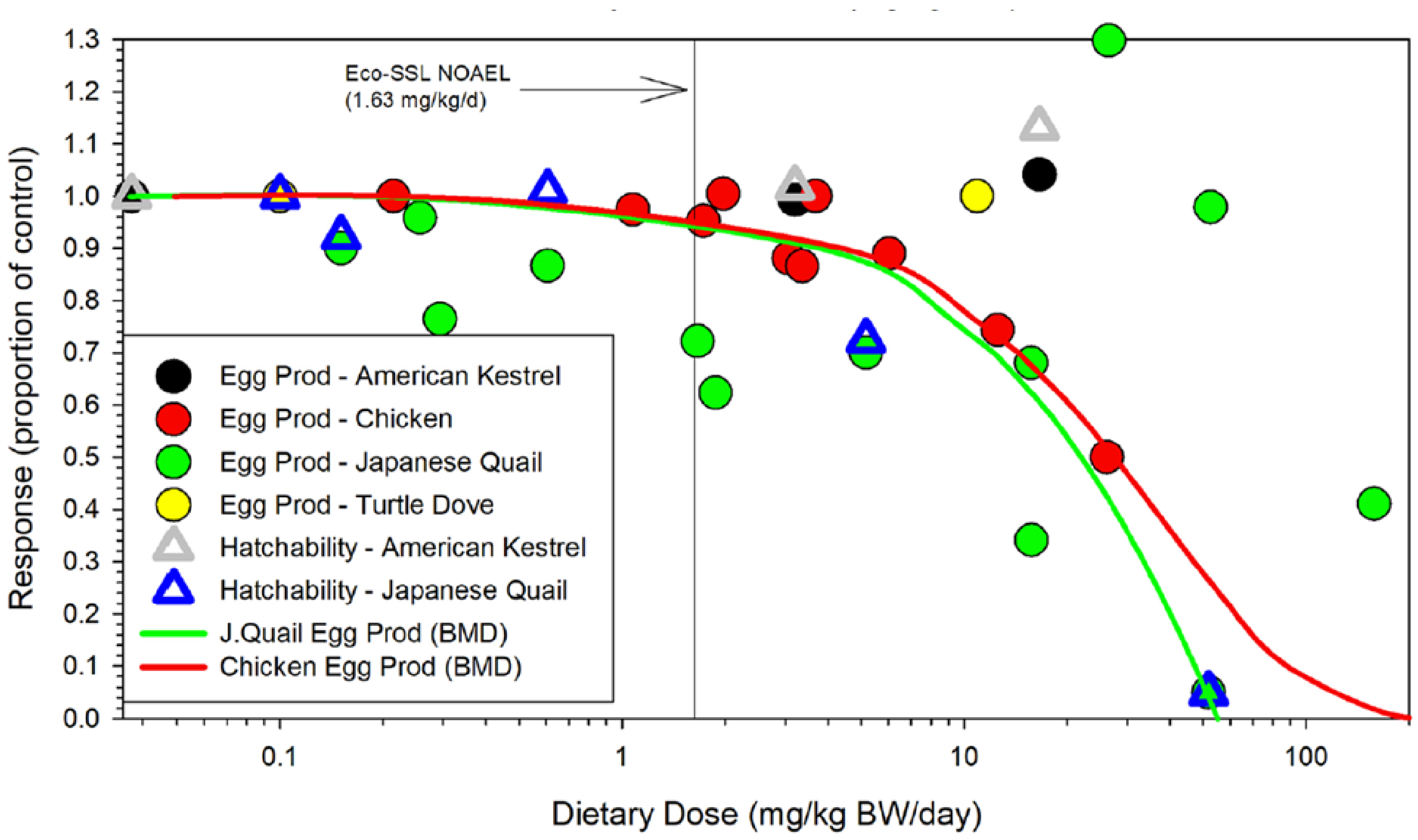
HQ>1.0

HQ>10

Methodology – Toxicological Dose Response Model

Key Aspects:

- Dose response model available that predicts severity of adverse effects with increasing dose (Sample et al 2019)
- Model predicts level of reduced egg production with increasing exposure to lead
- For example:
  - When exposure is 100 mg/kg/day model predicts egg production to be 10% of control



Methodology – Toxicological Dose Response Model

Typically select reproductive endpoint (CCME 2020) such as egg production

- Sample et al (2019) provided dose- response analysis of egg production in birds
- Japanese quail and chicken data were used in the re-construction of the dose-response model
- Sample et al (2019) concluded that:
  - Effective Dose at 10% reduction (ED10) for chicken was 4.4 mg/kg/d and
  - ED20 was 9.8 mg/kg/d
- Dose response equation calculated as follows:

$$R = a \times \left(c - (c-1) \times e^{-(b \times dose)^{d}}\right)$$

Where

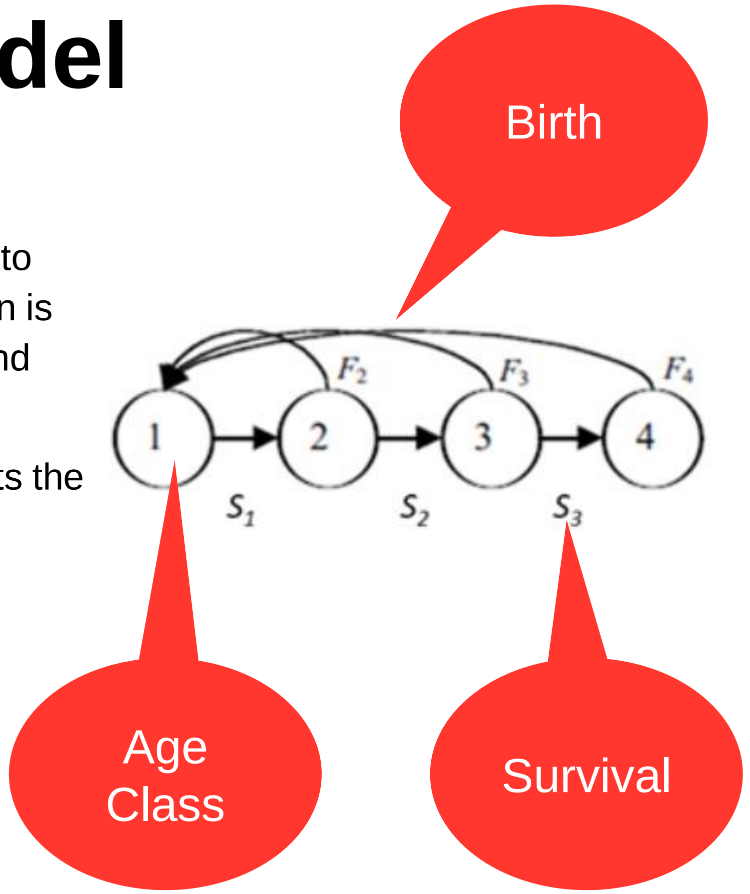
- R = Egg production response
- a = 0.985
- b = 0.0255
- c = 4.14E-08
- d = 1.03
- Dose = Predicted exposure in mg/kg/day

Methodology – Population-level Model

The Leslie Matrix (Leslie 1945):

- Is a discrete, age-structured model of population growth that is very popular in population ecology. The Leslie matrix (also called the Leslie model) is one of the most well-known ways to describe the growth of populations (and their projected age distribution), in which a population is closed to migration (i.e., immigration and emigration) growing in an unlimited environment, and where only one sex, usually the female, is considered.
- Used in ecology to model the changes in a population of organisms over a period and projects the growth of populations that have age structure
- Leslie Matrix predicts the following regarding the population (rate of increase-λ):
  - Growth (stable age distribution)
  - No growth
  - Decline (unsuccessful population)

Requires survival and fertility (birth) rate for each age class/group (Caswell 2001; Gotelli 2001)



Methodology – Population-level Model

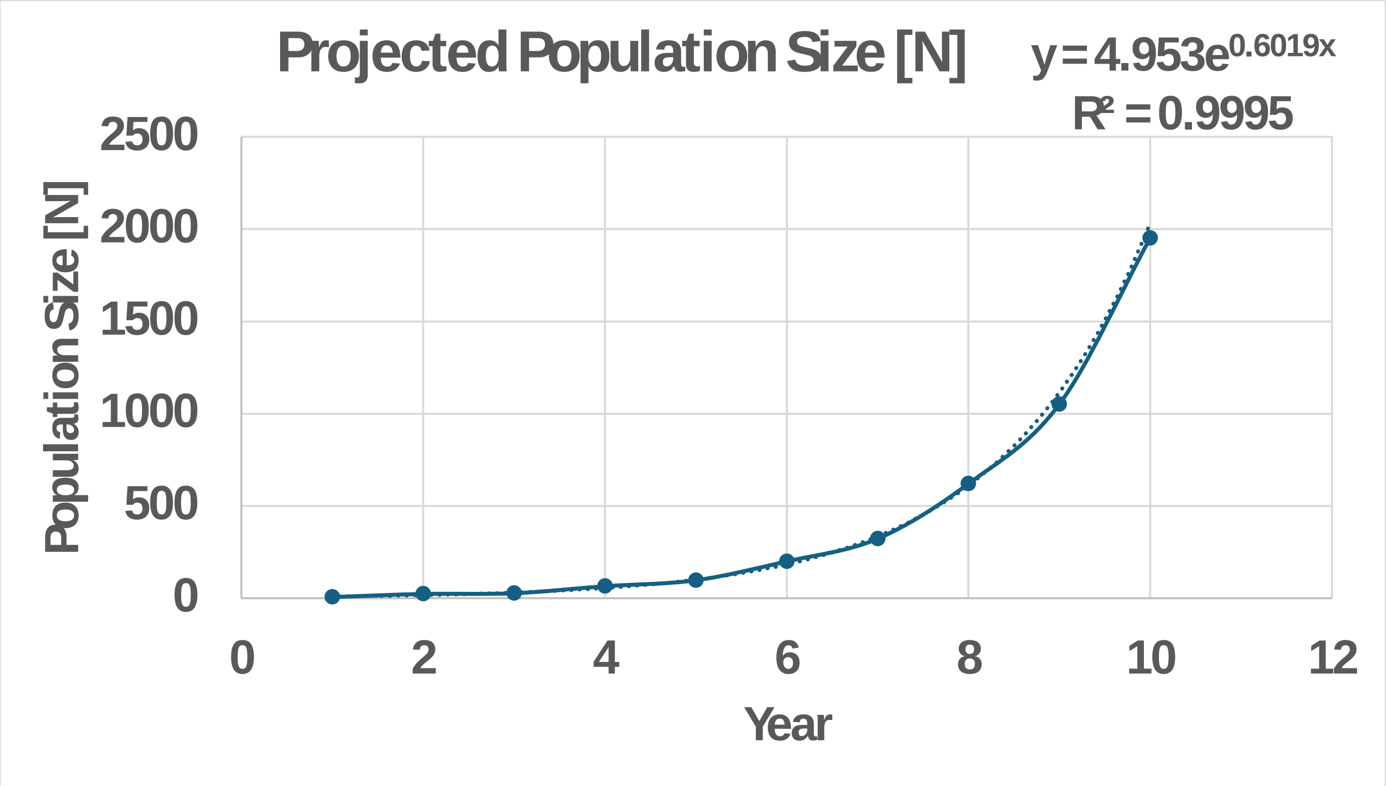
Literature search determined the vital statistics for the Grouse

How do we use this information?

- Use matrix model to determine how reduced egg production levels could impact the reproductive success of the wildlife population.

Vital Statistics (Clutch Size and Survival Rate)					
0	3.00	3.00	4.00	4.00	7.00
0.64	0	0	0	0	0
0	0.64	0	0	0	0
0	0	0.64	0	0	0
0	0	0	0.79	0	0
0	0	0	0	0.79	0

(green)	Clutch Size
(orange)	Juvenile Survival
(blue)	Survival

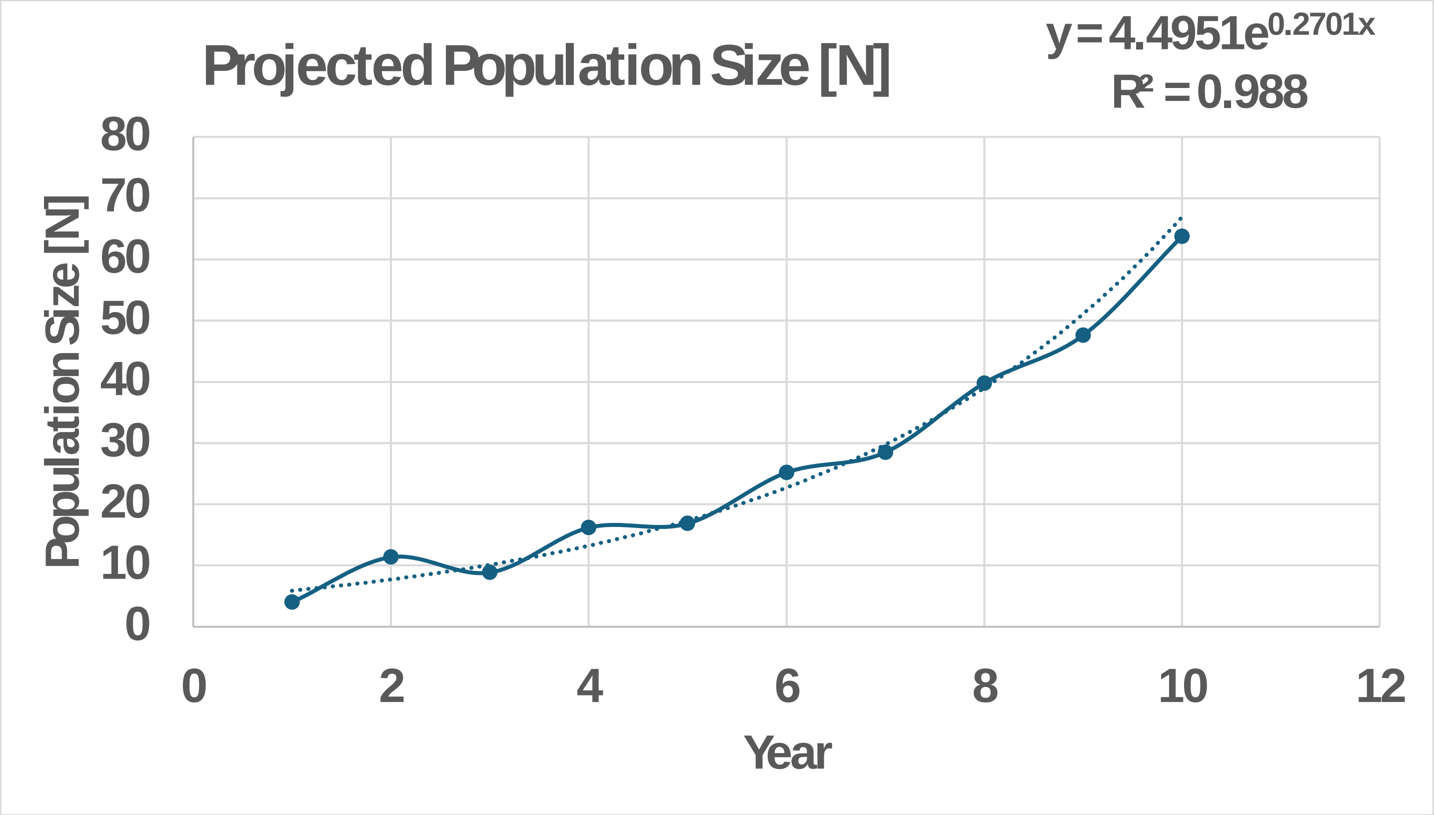


Methodology – Population-level Model

Literature search determined the vital statistics for the Blackbird

Vital Statistics (Clutch Size and Survival Rate)					
0	2.43	2.43	3.00	3.50	3.70
0.4	0	0	0	0	0
0	0.41	0	0	0	0
0	0	0.6	0	0	0
0	0	0	0.6	0	0
0	0	0	0	0.8	0

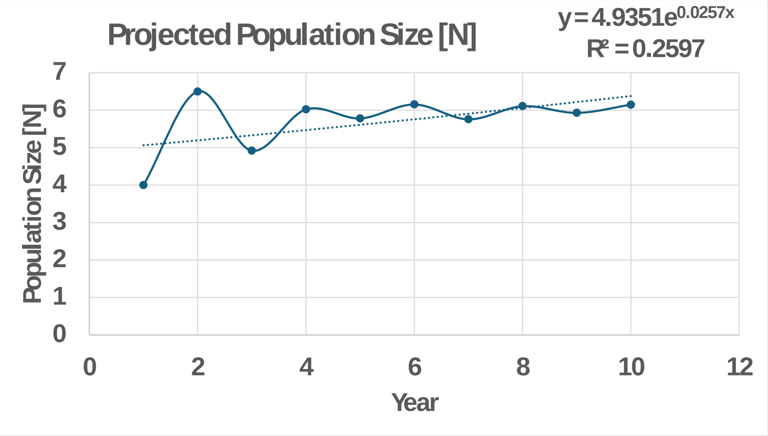
(green)	Clutch Size
(orange)	Juvenile Survival
(blue)	Survival



Methodology – Population-level Model

Assumed egg production 50% from normal - Blackbird

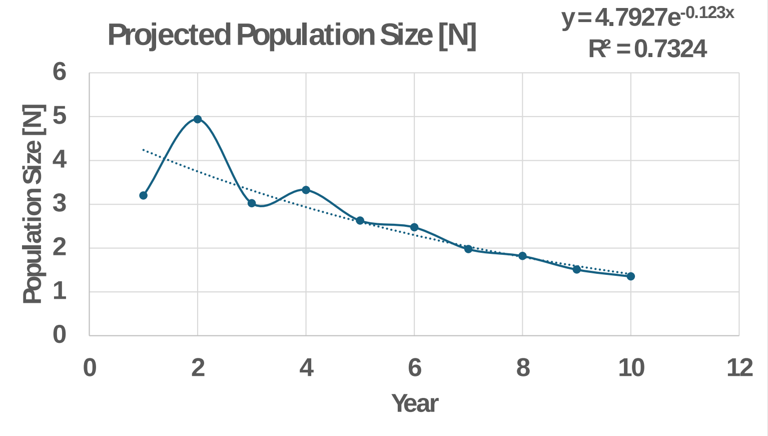
Modified Vital Statistics (Clutch Size and Survival Rate)					
0	1.22	1.22	1.50	1.75	1.85
0.4	0	0	0	0	0
0	0.41	0	0	0	0
0	0	0.6	0	0	0
0	0	0	0.6	0	0
0	0	0	0	0.8	0



Assumed egg production 50% and survival 80% from normal

Modified Vital Statistics (Clutch Size and Survival Rate)					
0	1.22	1.22	1.50	1.75	1.85
0.32	0	0	0	0	0
0	0.328	0	0	0	0
0	0	0.48	0	0	0
0	0	0	0.48	0	0
0	0	0	0	0.64	0

(green)	Clutch Size
(orange)	Juvenile Survival
(blue)	Survival



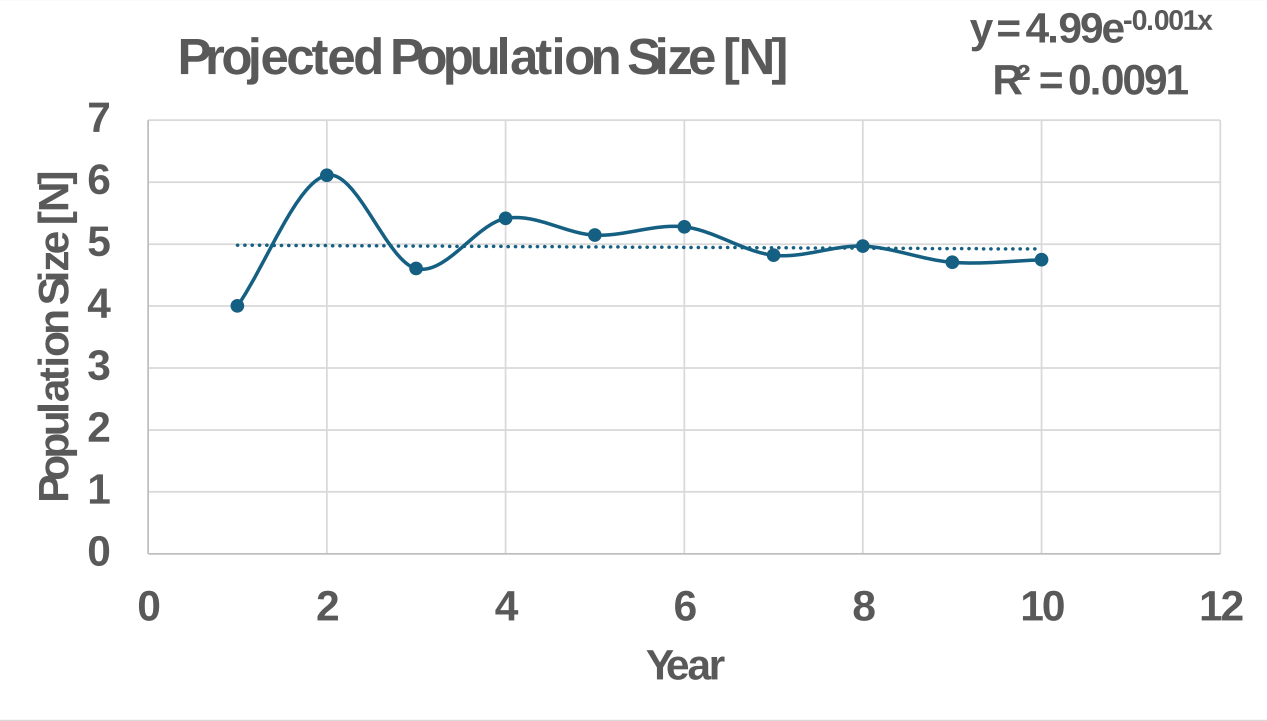
Methodology – Population-level Model

Used Leslie matrix to determine critical egg production for blackbird (i.e., zero growth)

- Line you shall not pass
- Equal to 46% of normal egg production
- Any lower would be potentially detrimental to population

Modified Vital Statistics (Clutch Size and Survival Rate)					
0	1.12	1.12	1.38	1.61	1.70
0.4	0	0	0	0	0
0	0.41	0	0	0	0
0	0	0.6	0	0	0
0	0	0	0.6	0	0
0	0	0	0	0.8	0

(green)	Clutch Size
(orange)	Juvenile Survival
(blue)	Survival



Results - Blackbird

Predicted Wildlife Hazard Quotient [Unitless]

0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
0.27	1.64	1.62	1.69	1.62	1.37	10.66	9.18	15.13	12.68	14.59	9.21	9.25	8.50	3.85	3.20	0.67	0.68	7.59	6.21	4.10	0.27
0.27	1.65	1.66	1.87	1.71	1.66	1.66	14.88	23.03	15.28	9.24	9.11	10.23	8.45	3.28	1.01	8.21	0.67	3.83	6.18	4.09	0.27
0.27	1.71	1.80	1.86	1.98	2.01	2.79	20.27	35.51	12.51	9.94	10.24	10.29	5.08	4.64	2.92	8.05	8.48	6.19	6.18	4.10	0.27
0.27	2.53	2.59	2.76	4.08	6.21	6.53	16.38	8.69	14.56	13.86	11.04	8.68	2.85	11.74	9.98	1.91	9.59	6.26	8.09	4.13	0.27
0.27	2.32	3.26	3.53	4.76	7.48	14.35	20.99	15.73	14.72	14.40	14.36	13.24	11.40	13.57	13.29	10.31	9.49	11.09	15.33	4.04	0.27
0.27	2.36	2.43	3.24	5.19	7.51	12.73	15.88	25.14	14.67	14.55	14.45	13.48	13.25	13.70	13.76	15.92	23.75	4.78	10.99	10.29	0.27
0.27	2.44	2.52	2.99	3.01	4.76	8.43	13.17	19.82	13.95	14.63	14.54	11.70	12.59	13.11	13.07	13.59	12.08	20.78	25.03	11.30	0.27
0.27	2.32	2.56	2.54	19.66	2.92	2.49	5.83	11.90	24.44	13.54	14.60	6.63	12.26	12.33	2.51	2.08	6.21	14.24	18.07	15.32	0.27
0.27	13.55	18.11	18.85	25.84	25.61	23.55	9.40	5.59	19.72	19.18	11.93	2.56	2.52	3.05	3.50	5.46	5.96	9.03	20.93	17.61	0.27
0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27

HQ>1.0

HQ>10

46%	Target Response

Predicted Egg Production Response [Unitless]

0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
0.97	0.92	0.92	0.92	0.92	0.93	0.62	0.66	0.52	0.57	0.53	0.66	0.66	0.68	0.84	0.86	0.96	0.96	0.71	0.76	0.83	0.97
0.97	0.92	0.92	0.91	0.92	0.92	0.92	0.52	0.37	0.51	0.66	0.67	0.64	0.69	0.86	0.94	0.69	0.96	0.84	0.76	0.83	0.97
0.97	0.92	0.91	0.91	0.91	0.90	0.87	0.41	0.22	0.58	0.64	0.64	0.63	0.79	0.81	0.87	0.70	0.69	0.76	0.76	0.83	0.97
0.97	0.88	0.88	0.88	0.83	0.76	0.74	0.49	0.68	0.53	0.54	0.61	0.68	0.87	0.60	0.64	0.91	0.65	0.75	0.70	0.83	0.97
0.97	0.89	0.86	0.85	0.80	0.72	0.53	0.40	0.50	0.52	0.53	0.53	0.56	0.60	0.55	0.56	0.63	0.66	0.61	0.51	0.83	0.97
0.97	0.89	0.89	0.86	0.79	0.71	0.57	0.50	0.34	0.53	0.53	0.53	0.55	0.56	0.55	0.55	0.50	0.36	0.80	0.62	0.63	0.97
0.97	0.89	0.88	0.87	0.87	0.80	0.69	0.56	0.42	0.54	0.53	0.53	0.60	0.57	0.56	0.56	0.55	0.59	0.40	0.34	0.61	0.97
0.97	0.89	0.88	0.88	0.42	0.87	0.89	0.77	0.59	0.35	0.55	0.53	0.74	0.58	0.58	0.88	0.90	0.75	0.54	0.45	0.51	0.97
0.97	0.55	0.45	0.44	0.33	0.33	0.36	0.66	0.78	0.42	0.43	0.59	0.88	0.88	0.86	0.85	0.78	0.76	0.67	0.40	0.46	0.97
0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97

Results - Grouse

- Exposure model and dose-response model used to convert dose into egg production responses for each polygon
- Critical level calculated to be 17%
- Lowest egg production response predicted to be 76% (0.76)
- No exceedances of calculated critical level, as such, population should be viable across the site

Predicted Egg Production Response [Unitless]																					
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
0.98	0.97	0.97	0.97	0.97	0.97	0.90	0.91	0.87	0.89	0.88	0.91	0.91	0.92	0.95	0.96	0.98	0.98	0.92	0.93	0.95	0.98
0.98	0.97	0.97	0.97	0.97	0.97	0.97	0.87	0.82	0.87	0.91	0.91	0.91	0.92	0.96	0.97	0.92	0.98	0.95	0.93	0.95	0.98
0.98	0.97	0.97	0.97	0.97	0.97	0.96	0.84	0.76	0.89	0.91	0.91	0.91	0.94	0.95	0.96	0.92	0.92	0.93	0.93	0.95	0.98
0.98	0.96	0.96	0.96	0.95	0.93	0.93	0.87	0.92	0.88	0.88	0.90	0.92	0.96	0.90	0.91	0.97	0.91	0.93	0.92	0.95	0.98
0.98	0.96	0.96	0.95	0.94	0.92	0.88	0.84	0.87	0.88	0.88	0.88	0.89	0.90	0.88	0.89	0.91	0.91	0.90	0.87	0.95	0.98
0.98	0.96	0.96	0.96	0.94	0.92	0.89	0.87	0.81	0.88	0.88	0.88	0.88	0.89	0.88	0.88	0.87	0.82	0.94	0.90	0.91	0.98
0.98	0.96	0.96	0.96	0.96	0.94	0.92	0.89	0.84	0.88	0.88	0.88	0.90	0.89	0.89	0.89	0.88	0.89	0.84	0.81	0.90	0.98
0.98	0.96	0.96	0.96	0.84	0.96	0.96	0.94	0.89	0.82	0.88	0.88	0.93	0.89	0.89	0.96	0.97	0.93	0.88	0.85	0.87	0.98
0.98	0.88	0.85	0.85	0.81	0.81	0.82	0.91	0.94	0.84	0.85	0.89	0.96	0.96	0.96	0.95	0.94	0.94	0.91	0.84	0.86	0.98
0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

Summary, Applications & Additional Considerations

Summary:

- Determines critical level of exposure and risk that is most likely associated with adverse / detrimental impacts to the wildlife population
- Helps with interpretation of risks when HQ values are elevated and can add more confidence in risk management decisions
- Provides an additional line of evidence (LOE) to risk characterization (CCME 2020)
- Provides risk management tool that helps with the following:
  - Helps with defining areas of greatest impact requiring further assessment or priority
  - Helps with designing wildlife monitoring programs to confirm risks
  - Helps with establishing direction of risk gradients for further study and/or monitoring programs
  - Helps with remedial options analysis

Additional Considerations:

- Exposure can include habitat quality to further refine risks in spatially explicit exposure models where wildlife have a larger home range and expected to spend a portion or most of their time foraging outside the study area (see Hope 2001, 2006; Wickwire et al. 2004; Wickwire et al. 2011)

Additional Considerations

Additional Considerations:

- **Wildlife behaviour** - Proposed population level assessment focuses on females; however, it may be useful to consider males as well. For example, male blackbirds will occupy a nesting area before the female, and it may be helpful to evaluate risks to males as well using a mortality benchmark.
- **Disease** – Besides natural population pressures (e.g., predators) there may be other anthropogenic (e.g., pesticides) or unforeseen external factors (e.g., disease) that may affect population viability.
- **Population models** – Depending on the receptor lifestyle habitats and sensitivities another model maybe more suitable.
- **Habitat quality** – There is an inverse relationship between Habitat Quality and Foraging Area, which are dynamic. As such, the home range for a receptor may increase for a breeding pair in areas with poor habitat quality.
- **CCME 2020** – Provides guidance on Beyond Point Estimates of Exposure

Disclaimers…

- No, I have not implemented this strategy successfully with a regulator in Canada but have used the outcomes to aid with prioritizing risk management options and to aid with wildlife monitoring programs.
- I am not a population/wildlife ecologist.

THANK YOU

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References

ECCC (Environment Canada and Climate Change). 2021. Federal Contaminated Sites Action Plan (FCSAP): Ecological Risk Assessment Guidance Module 7: Default wildlife toxicity reference values (TRVs) recommended for use at FCSAP sites; prepared by Environment and Climate Change Canada, April 1, 2021, 164 p.

USEPA (United States Environmental Protection Agency). 2005. Ecological Soil Screening Levels for Lead. Interim Final. OSWER Directive 9285.7-70. Washington (DC): Office of Solid Waste and Emergency Response. [accessed March 2015]. https://www.epa.gov/sites/production/files/2015-09/documents/eco-ssl_lead.pdf.

Beyer WN, Sample BE. 2017. An evaluation of inorganic toxicity reference values for use in assessing hazards to American robins (Turdus mi-gratorius). Integr Environ Assess Manag 13:352–359.

BJC (Bechtel Jacobs Company LLC). 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Prepared for the US Department of Energy, Office of Environmental Management. BMC/OR-133. September 1998.

References

Sample, B.E., Beyer, W.N., Wentsel, R. 2019. Revisiting the Avian Eco-SSL for Lead: Recommendations for Revision. Integrated Environmental Assessment and Management, 15(5):739-749.

Leslie, P. H. 1945. On the use of matrices in certain population mathematics. Biometrika 33: 183–212.

Caswell, H. 2001. Matrix Population models, Second Edition. Sinauer Associates, Inc. Sunderland, MA.

Gotelli, N. 2001. A Primer of Ecology, Third Edition. Sinauer Associates, Sunderland, MA.

CCME (Canadian Council of Ministers of the Environment). 2020. Ecological Risk Assessment Guidance Document. ISBN 978-1-77202-044-1 PDF

Sample BE, Beauchamp JJ, Efroymson RA, Suter II GW, Ashwood TL. 1998. Development and Validation of Bioaccumulation Models for Earthworms. Prepared for the US Department of Energy, Office of Environmental Management. ES/ER/TM-220. February 1998.

References

Wickwire WT, Menzie CA, Burmistrov D, Hope BK. 2004. Incorporating spatial data into ecological risk assessments: the spatially explicit exposure module (SEEM) for ARAMS. In: Kapustka LA, Galbraith H, Luxon M, Biddinger GR,editors. Landscape ecology and wildlife habitat evaluation: Critical information for ecological risk assessment, land-use management activities, and biodiversity enhancement practices. ASTM STP 1458. West Conshohocken (PA): ASTM International.

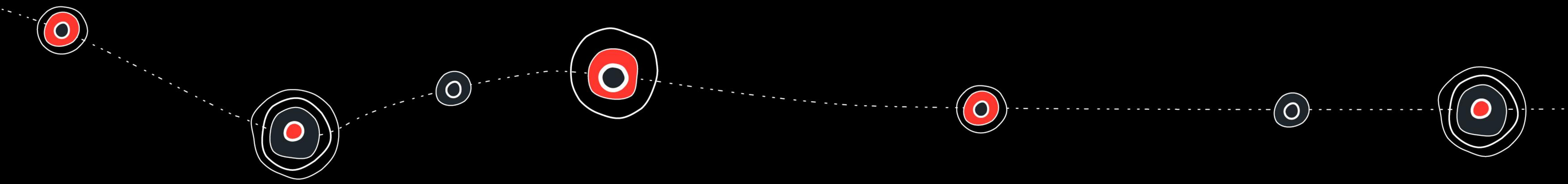
Hope BK. 2001. A spatially and bioenergetically explicit terrestrial ecological exposure model. Toxicol Ind Health. 2001 Jun;17(5-10):322-32.

Hope BK. 2006. An examination of ecological risk assessment and management practices. Environ Int. 2006 Dec;32(8):983-95.

Wickwire T, Johnson MS, Hope BK, Greenberg MS. 2011. Spatially explicit ecological exposure models: a rationale for and path toward their increased acceptance and use. Integr Environ Assess Manag. 2011 Apr;7(2):158-68.

TITLE

BBB



As an organization that transcends geographic and national boundaries, Local Contexts acknowledges that all of the lands and waters we occupy are Indigenous Homelands. We recognize the ongoing significance of these lands and waters for Indigenous Peoples in the past, present, and future.

As people who have influence over the built environment, we recognise our responsibility to ensure First Peoples culture and connections to Country are strong and continue into the future.

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