DRAFT Cougar Hunting Framework

Analytical Approach

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Outline

- Goals
- Frameworks
- Data sources
- Population model
- Cougar density
- Cougar habitat
- Next steps

Goals

- Review the research/science we have for cougar along with the draft issue statements, strategies and objectives developed for the new GMP.
  - Stable cougar population
  - Maintaining cougar social structure
- Describe the ecosystem effects of human related mortality to bear and cougar (i.e., recreational take and lethal removal associated with conflict).
- Develop a draft hunting framework that utilizes the best available science to maximize the likelihood of meeting management objectives while minimizing management risk.
- Develop measurable ways of assessing if the agency is meeting those objectives, and if not, to outline adaptive action(s) that can be taken to help meet those objectives.

Washington's framework

Total take = intrinsic growth rate **x** density **x** habitat

Population dynamics

Population size

Leslie Matrix Model

Contents lists available at SciVerse ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Effects of male trophy hunting on female carnivore population growth and persistence

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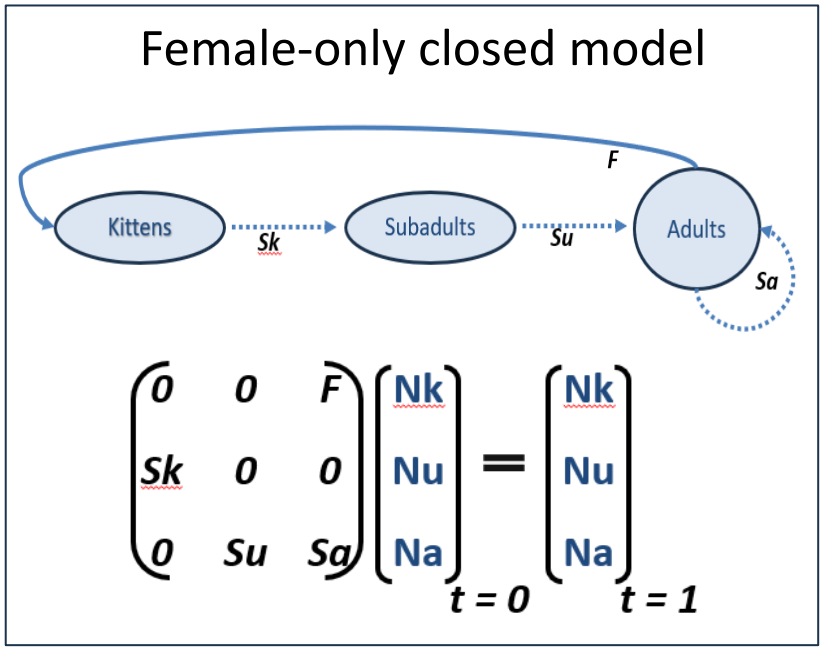
ARTICLE INFO

Article history:
Received 17 May 2013
Received in revised form 3 July 2013
Accepted 8 July 2013

Keywords:
Hunting
Cougars
Population growth
Compensatory mortality
Additive mortality

ABSTRACT

Carnivore populations are often managed based on the density dependent, compensatory mortality model, which suggests that trophy hunting of males causes an increase in female reproductive success, survival, and population growth. Our previous research on grizzly bears (*Ursus acrtos*) and cougars (*Puma concolor*) showed that increased mortality of males resulted in no net reduction in males due to increased immigration. Female reproduction and survival did not increase with male mortality. That research suggested that female demographics are additive to male mortality and might even be depensatory (inversely compensatory), whereby increased male immigration and infanticide may be associated with decreased female reproductive success, survival, and population growth. In this paper we test the compensatory, additive, and depensatory hypotheses by censoring female hunting deaths and plausible kitten infanticides from two independent cougar populations. The previously observed lack of compensatory demographics allowed us to censor deaths in this manner. The lightly hunted population (male hunting



Wielgus, R.B., D.E. Morrison, H.S. Cooley, B. Maletzke. 2013. Effects of male trophy hunting on female carnivore population growth and persistence. Biological Conservation 167:69-75.

Beausoleil, R. A., G. M. Koehler, B. T. Maletzke, B. N., Kertson, R. B. Wielgus. 2013. Research to regulation: cougar social behavior as a guide for management. Wildlife Society Bulletin 37:680-688.

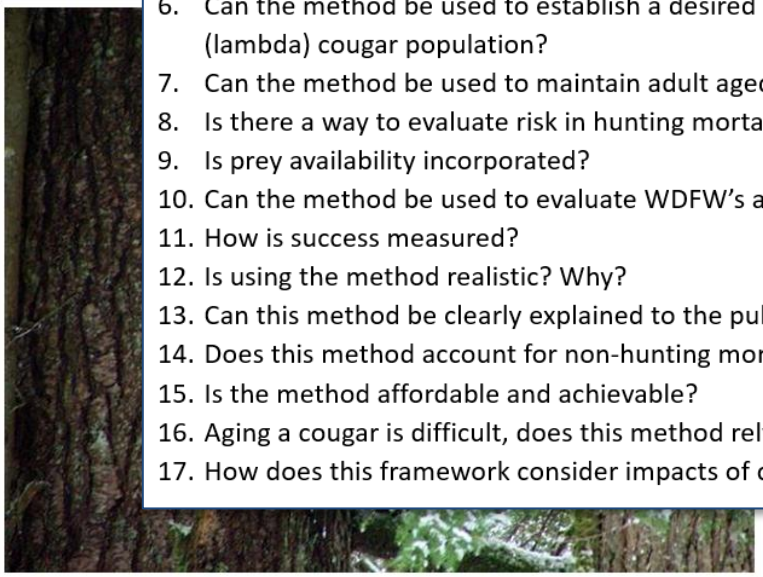
Review Other Agency Frameworks

Integrated Population Model and Resource Selection Function

Montana Fish, Wildlife, and Parks. 2019. Montana mountain lion monitoring and management strategy. 140pp. Helena, MT, USA.

Statistical Population Recons

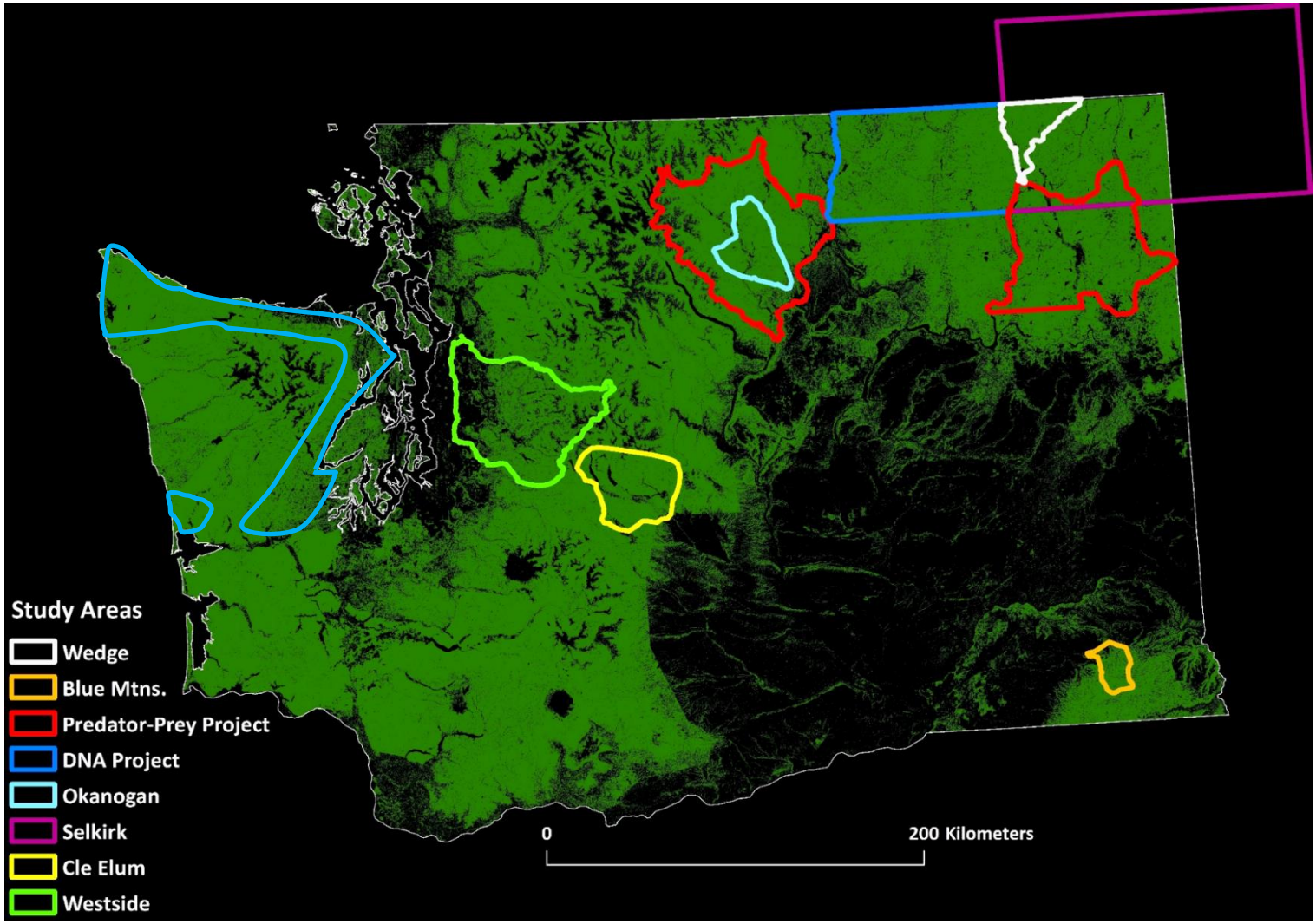
Howard, A.L, M. J. Clement, F. R. Peck
statistical population reconstruction.



Review Questions

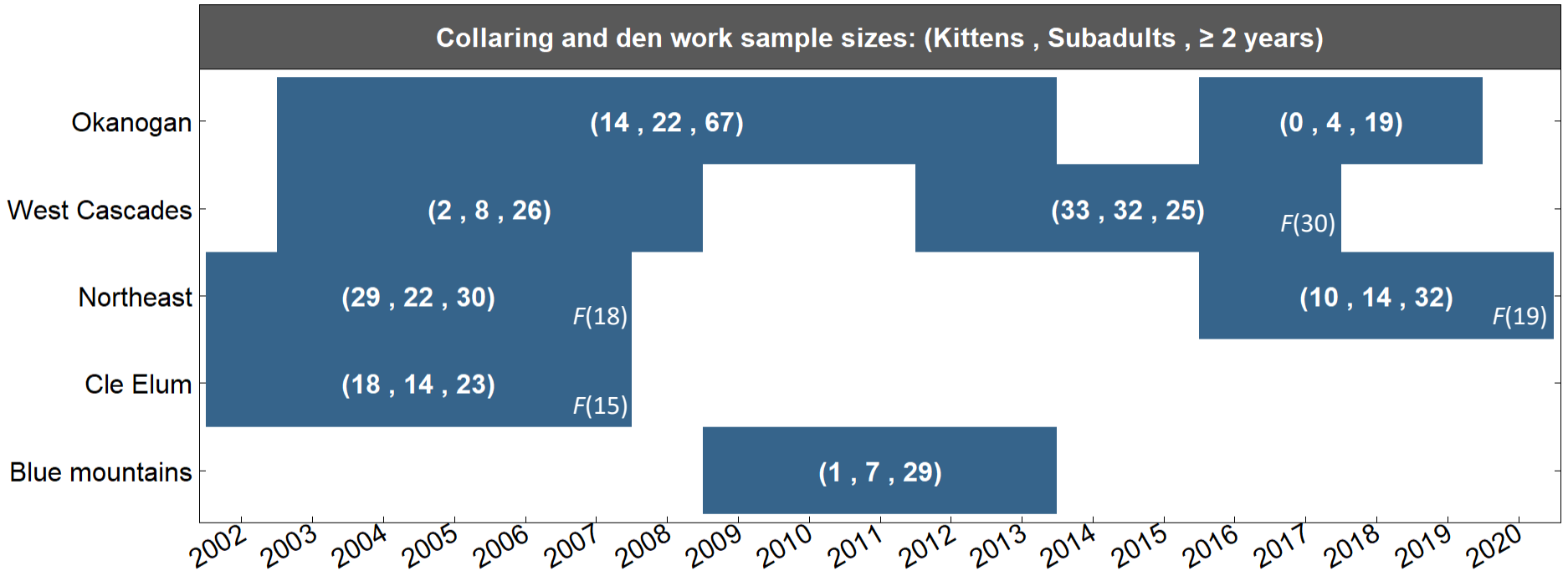
1. Strengths of method
2. Weaknesses of method
3. Is the method published in a peer-reviewed journal?
4. Do we have the WA data to do this?
5. Are there issues with scale? Is the method scalable?
6. Can the method be used to establish a desired hunting mortality level to achieve a stable (lambda) cougar population?
7. Can the method be used to maintain adult aged cougars in the population? (territoriality)
8. Is there a way to evaluate risk in hunting mortality level decisions?
9. Is prey availability incorporated?
10. Can the method be used to evaluate WDFW's ability to meet GMP objectives?
11. How is success measured?
12. Is using the method realistic? Why?
13. Can this method be clearly explained to the public and be understandable?
14. Does this method account for non-hunting mortality?
15. Is the method affordable and achievable?
16. Aging a cougar is difficult, does this method rely on field-aging hunted cougars?
17. How does this framework consider impacts of cougar hunting on ecological function?

Cougar Research in WA (1998-2024)



Intrinsic growth rate

Assembled 8 data sets:18 years across 5 areas in WA

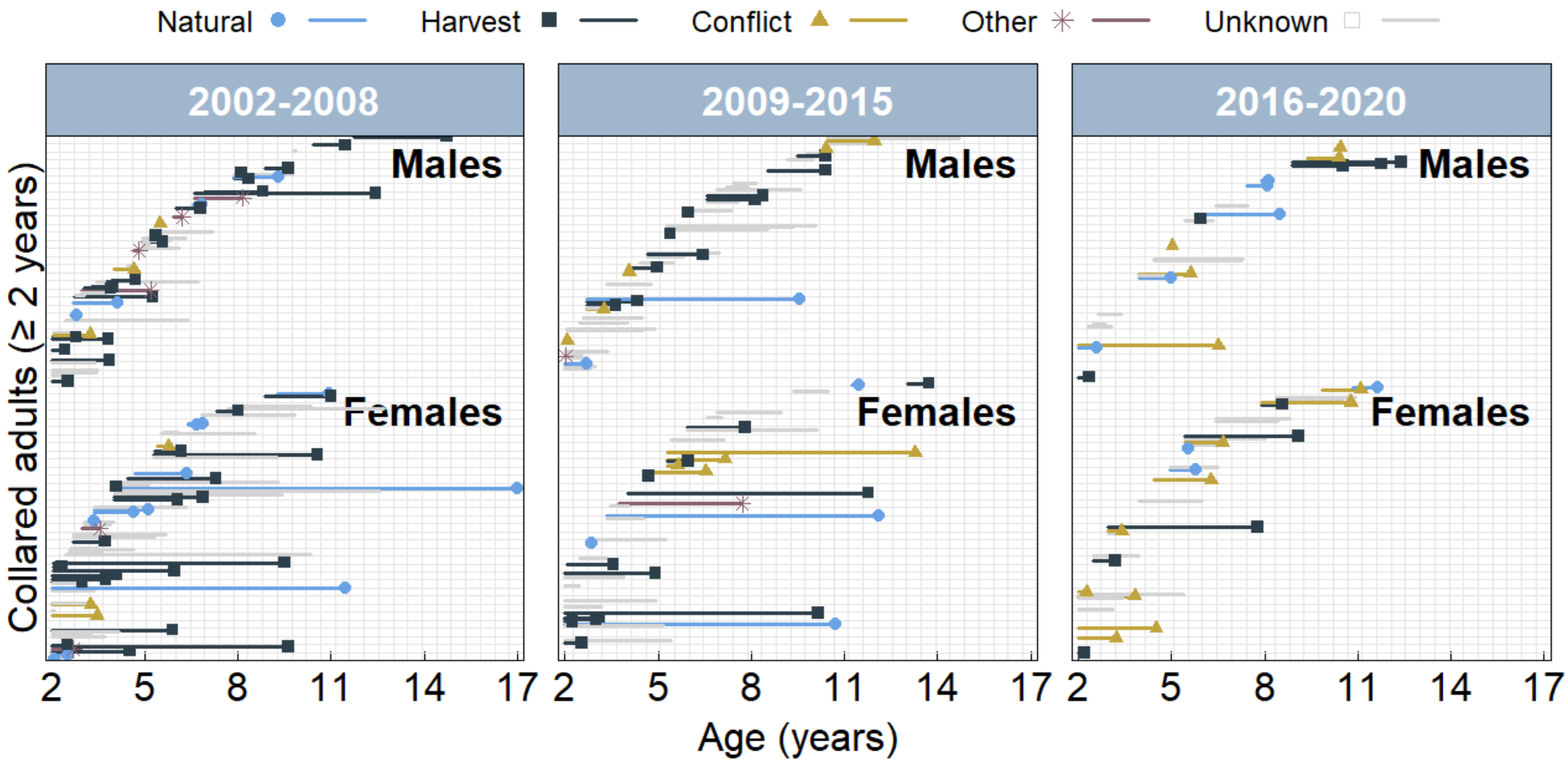


Assembled 8 datasets spanning 18 years across 5 areas in WA

		Female	Male		
Total	362	182	179		
Adults	247	130	117	Low	High
Age at capture		4.03 ± 2.34	4.89 ± 2.68	Wedge	Ok. (ppp)
				3.19 ± 1.78	5.32 ± 2.52
Age at known mortality		6.41 ± 3.43	6.55 ± 3.14	Wedge	BM
				4.48 ± 1.86	7.82 ± 4.29

Adult cougar history and mortality

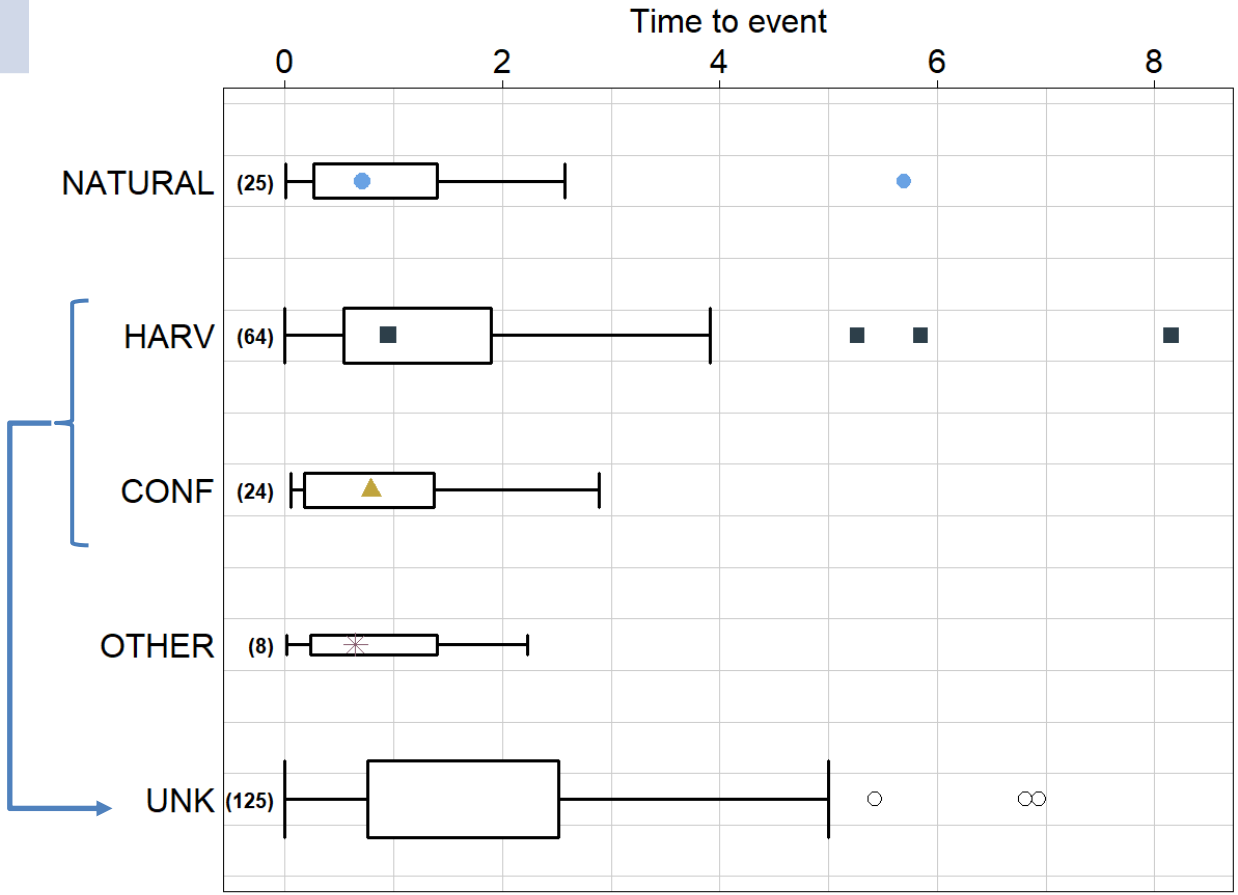
By periods when studies occurred



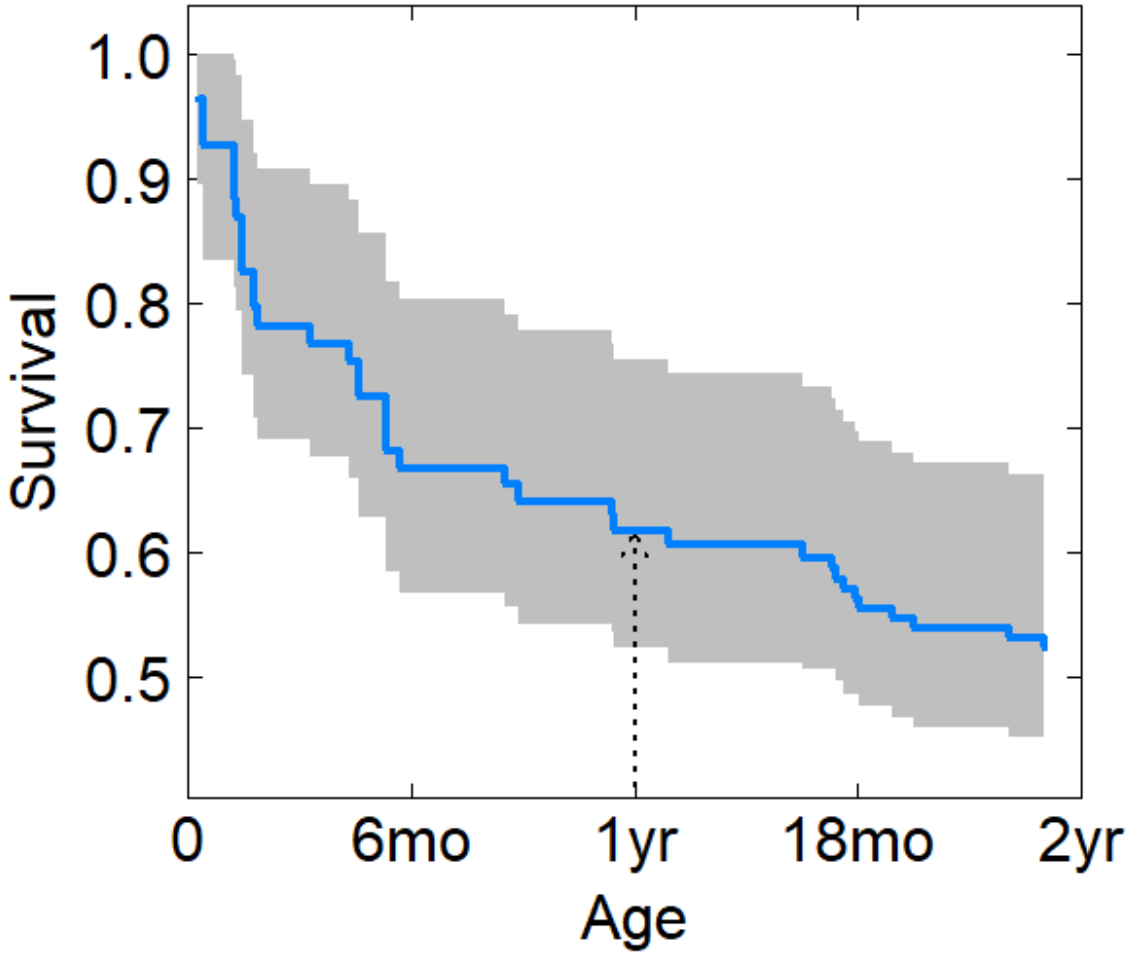
Adult cougar survival

models	parameters	interactions
Proportional, Exponential. Log-, Weibull	Sex , Source , Age , Year	Random effects

Right-censored for natural intrinsic growth rate

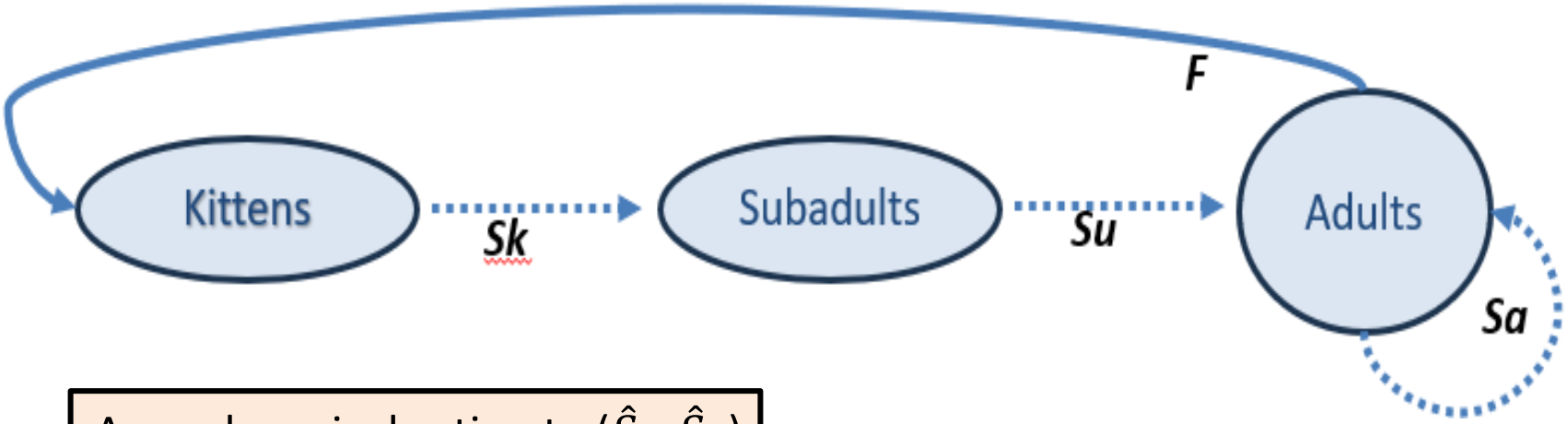


Kitten and subadult survival



10k parametric bootstrapped (95% CI)

For fecundity ($\hat{F}$) in a birth flow system $0.95(1.18 \pm 0.25, n = 82)$
kittens/surviving female/year: 1.12 (0.68 - 1.57)

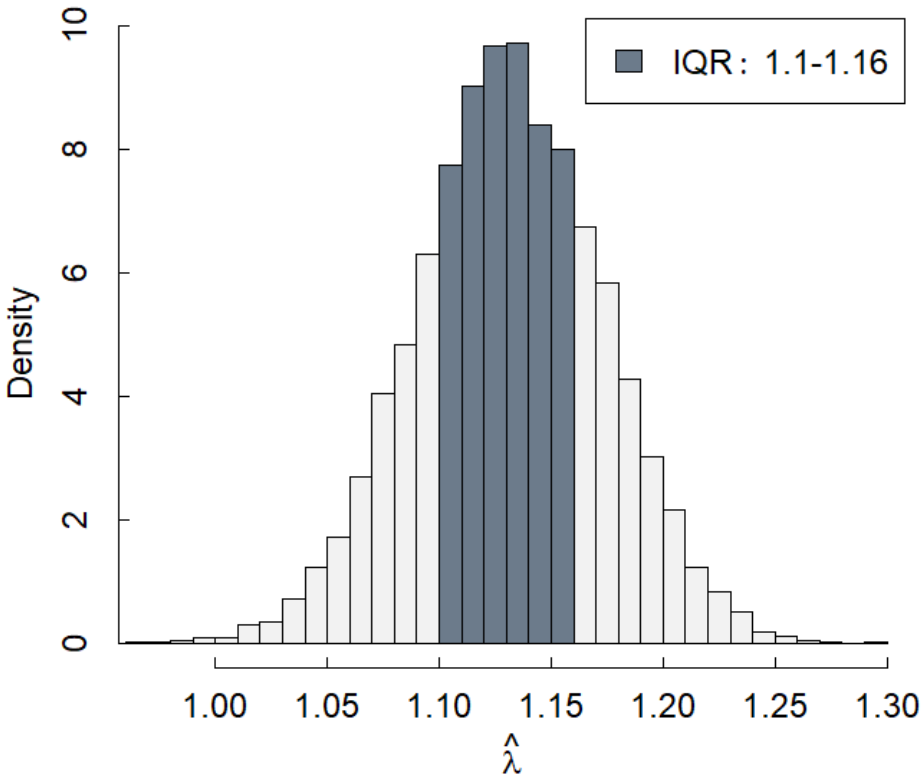


Annual survival estimate ($\hat{S}_k, \hat{S}_u$)
Kittens 62% (53% - 75%)
Subadults 85% (77% - 94%)

Annual adult survival estimate ($\hat{S}_a$)
Females 91% (85% - 94%)
Males 89% (82% - 93%)

Intrinsic growth rate $\hat{\lambda} = 1.13$

$$\underbrace{\begin{pmatrix} 0 & 0 & F \\ Sk & 0 & 0 \\ 0 & Su & Sa \end{pmatrix}}_{\lambda} \begin{pmatrix} Nk \\ Nu \\ Na \end{pmatrix}_{t=0} = \begin{pmatrix} Nk \\ Nu \\ Na \end{pmatrix}_{t=1}$$



Take 13% (10%-16%) from

$N_{t+1} \rightarrow N_t \rightarrow 1.13N_t \rightarrow \cdots$

Estimating cougar density

Note on Density & Standardization

- Standardization in reporting density estimates was lacking
  - Total? ≥12 months old? ≥18 months? Adults only?

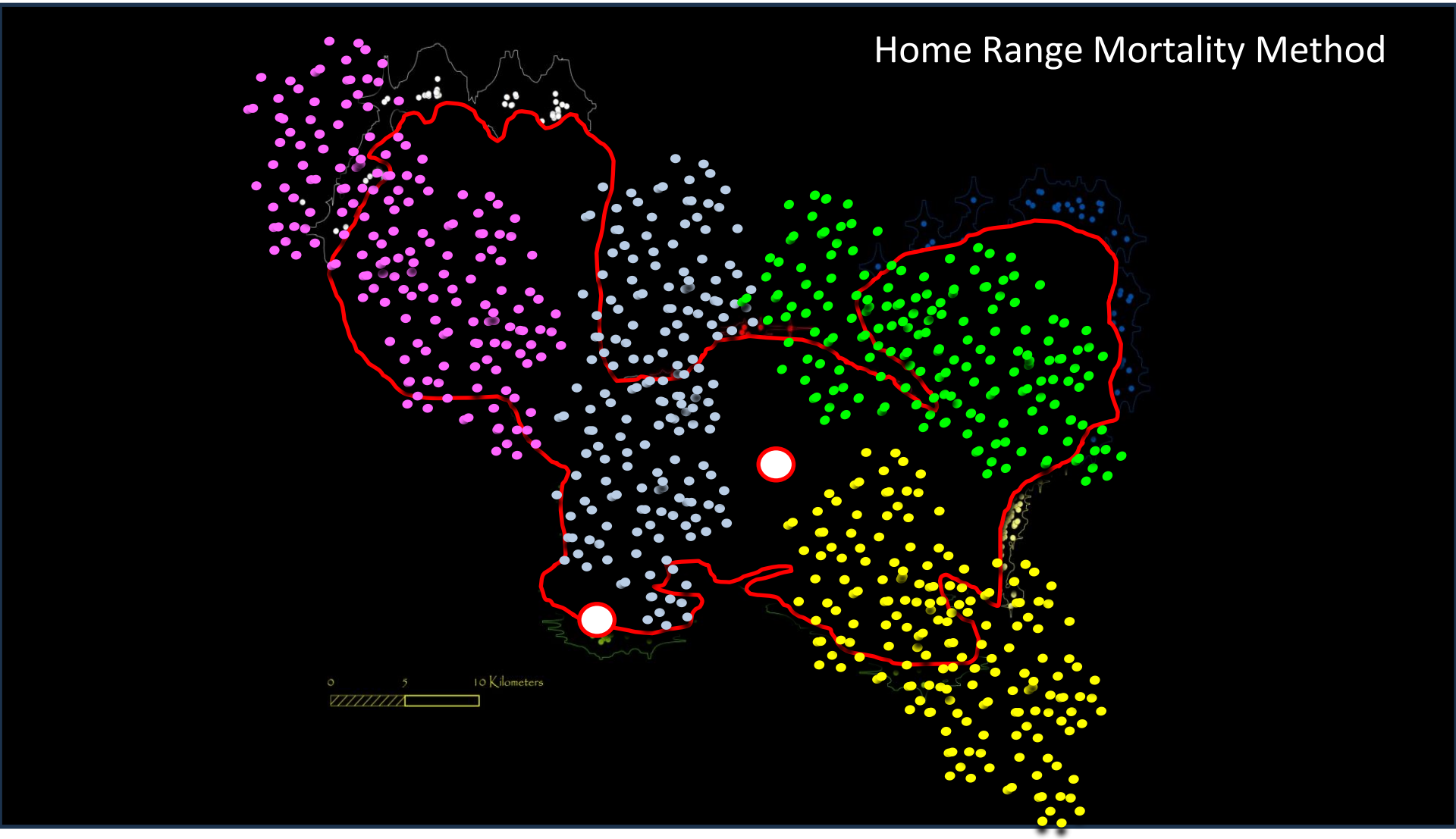
- When was the estimate derived?
  - Winter-only seasonal estimate (smaller area of use)
  - Estimate derived annually across multiple seasons?

- What technique was used?
  - Track counts, scent stations, camera stations, scat collection, tissue collection via biopsy darts, capture-recapture, spatial vs non-spatial model-generated estimates, GPS collar-derived methods?

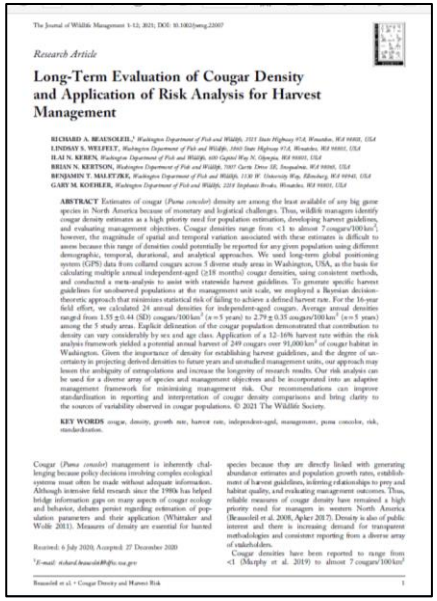
- From 91 cougar estimates published in the literature
  - 71% needed correction for bias
  - When standardized to independent-aged density, the range-wide density mean = 1.6 - 2.02 (95% interval < 3.6) cougars/100km^2

Murphy, S.M., R.A. Beausoleil, H. Stewart, and J.J. Cox. 2022. Review of puma density estimates reveals sources of bias and variation, and the need for standardization. Global ecology and conservation 354 (e02109)

2021 Density Calculations



2021 Density Calculations (24 annual densities - mean = 2.2)



Research Article

Long-Term Evaluation of Cougar Density and Application of Risk Analysis for Harvest Management

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ABSTRACT Estimates of cougar (*Puma concolor*) density are among the least available of any big game species in North America because of monetary and logistical challenges. Thus, wildlife managers identify cougar density estimates as a high priority need for population estimation, developing harvest guidelines, and evaluating management objectives. Cougar densities range from <1 to almost 7 cougars/100 km^2; however, the magnitude of spatial and temporal variation associated with these estimates is difficult to assess because this range of densities could potentially be reported for any given population using different demographic, temporal, durational, and analytical approaches. We used long-term global positioning system (GPS) data from collared cougars across 5 diverse study areas in Washington, USA, as the basis for calculating multiple annual independent-aged (≥18 months) cougar densities, using consistent methods, and conducted a meta-analysis to assist with statewide harvest guidelines. To generate specific harvest guidelines for unobserved populations at the management unit scale, we employed a Bayesian decision-theoretic approach that minimizes statistical risk of failing to achieve a defined harvest rate. For the 16-year field effort, we calculated 24 annual densities for independent-aged cougars. Average annual densities ranged from 1.55 ± 0.44 (SD) cougars/100 km^2 (n = 5 years) to 2.79 ± 0.35 cougars/100 km^2 (n = 5 years) among the 5 study areas. Explicit delineation of the cougar population demonstrated that contribution to density can vary considerably by sex and age class. Application of a 12–16% harvest rate within the risk analysis framework yielded a potential annual harvest of 249 cougars over 91,000 km^2 of cougar habitat in Washington. Given the importance of density for establishing harvest guidelines, and the degree of uncertainty in projecting derived densities to future years and unstudied management units, our approach may lessen the ambiguity of extrapolations and increase the longevity of research results. Our risk analysis can be used for a diverse array of species and management objectives and be incorporated into an adaptive management framework for minimizing management risk. Our recommendations can improve standardization in reporting and interpretation of cougar density comparisons and bring clarity to the sources of variability observed in cougar populations. © 2021 The Wildlife Society.

KEY WORDS cougar, density, growth rate, harvest rate, independent-aged, management, *puma concolor*, risk, standardization.

Cougar (*Puma concolor*) management is inherently challenging because policy decisions involving complex ecological systems must often be made without adequate information. Although intensive field research since the 1980s has helped bridge information gaps on many aspects of cougar ecology and behavior, debates persist regarding estimation of population parameters and their application (Whittaker and Wolfe 2003). Measures of density are essential for hunted species because they are directly linked with generating abundance estimates and population growth rates, establishment of harvest guidelines, inferring relationships to prey and habitat quality, and evaluating management outcomes. Thus, reliable measures of cougar density have remained a high priority need for managers in western North America (Beausoleil et al. 2008, Apker 2017). Density is also of public interest and there is increasing demand for transparent methodologies and consistent reporting from a diverse array of stakeholders.

Cougar densities have been reported to range from <1 (Murphy et al. 2019) to almost 7 cougars/100 km^2

Received: 6 July 2020; Accepted: 27 December 2020

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Study Area	Year	Annual Independent-Aged Density/100km^2	Average Independent-Aged Density/100km^2 (SD)
Okanogan	2008	2.10	1.55 (0.44)
	2009	1.90	
	2010	1.41	
	2011	1.30	
	2012	1.02	
Columbia	2009	2.99	2.79 (0.35)
	2010	3.07	
	2011	3.06	
	2012	2.48	
	2013	2.35	
King	2013	2.26	2.34 (0.08)
	2014	2.40	
	2015	2.31	
	2016	2.44	

Study Area	Year	Annual Independent-Aged Density/100km^2	Average Independent-Aged Density/100km^2
Kittitas	2002	3.11	2.37 (0.56)
	2003	2.49	
	2004	2.58	
	2005	1.69	
	2006	1.97	
Stevens	2002	1.93	1.96 (0.20)
	2003	1.98	
	2004	2.28	
	2005	1.88	
	2006	1.72	

Beausoleil, R.A., L.S. Welfelt, I.N. Keren, B.N. Kertson, B.T. Maletzke, and G.M. Koehler. 2021. Long-term evaluation of cougar density and application of risk analysis for harvest management. Journal of Wildlife Management 85:462–473

Density Calculations not Used
(+14 - for a total of 38 densities)

Biopsy Project - 9 years (2003-2011)

- Ferry County – no handling of cougars required (DNA)
- Mark–recapture SECR model - mean density (≥ 12 months) of 2.2 cougars/100 km^2

Beausoleil, R.A., J.D. Clark, and B.T. Maletzke. 2016. A long-term evaluation of biopsy darts and DNA to estimate cougar density: an agency citizen science collaboration. Wildlife Society Bulletin 40:583–592

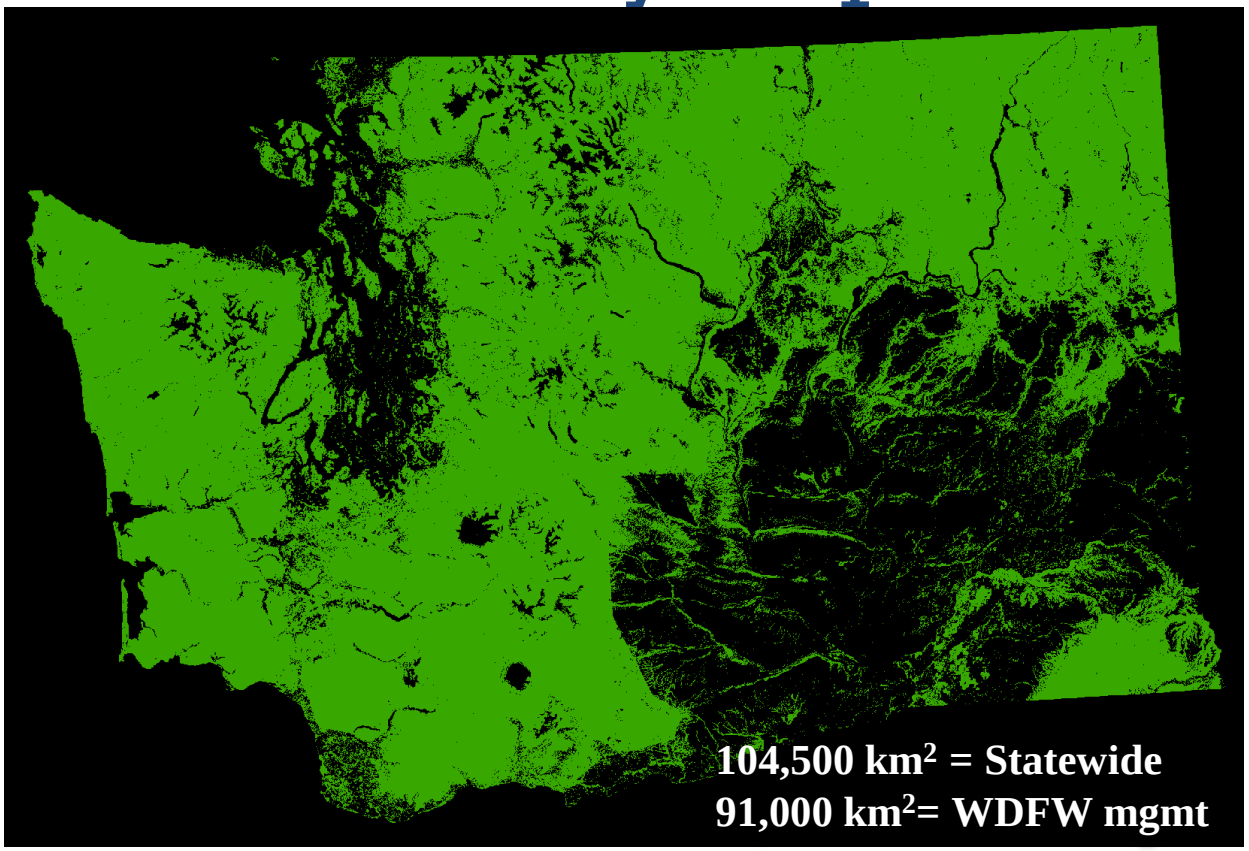
Multi-State Project - 5 years (1998-2003)

- Conducted in WA, BC, & ID
- Total density estimate (included all age classes)
- Minimum relative densities declined from 1.47 cougars/100 km^2 to 0.85 cougars/100 km^2.

Lambert, C.S., R.B. Wielgus, H.S. Robinson, D.T. Katnik, H.S. Cruickshank, R. Clark, and J. Almack. Cougar population dynamics and viability in the Pacific Northwest. Journal of Wildlife Management 70(1).

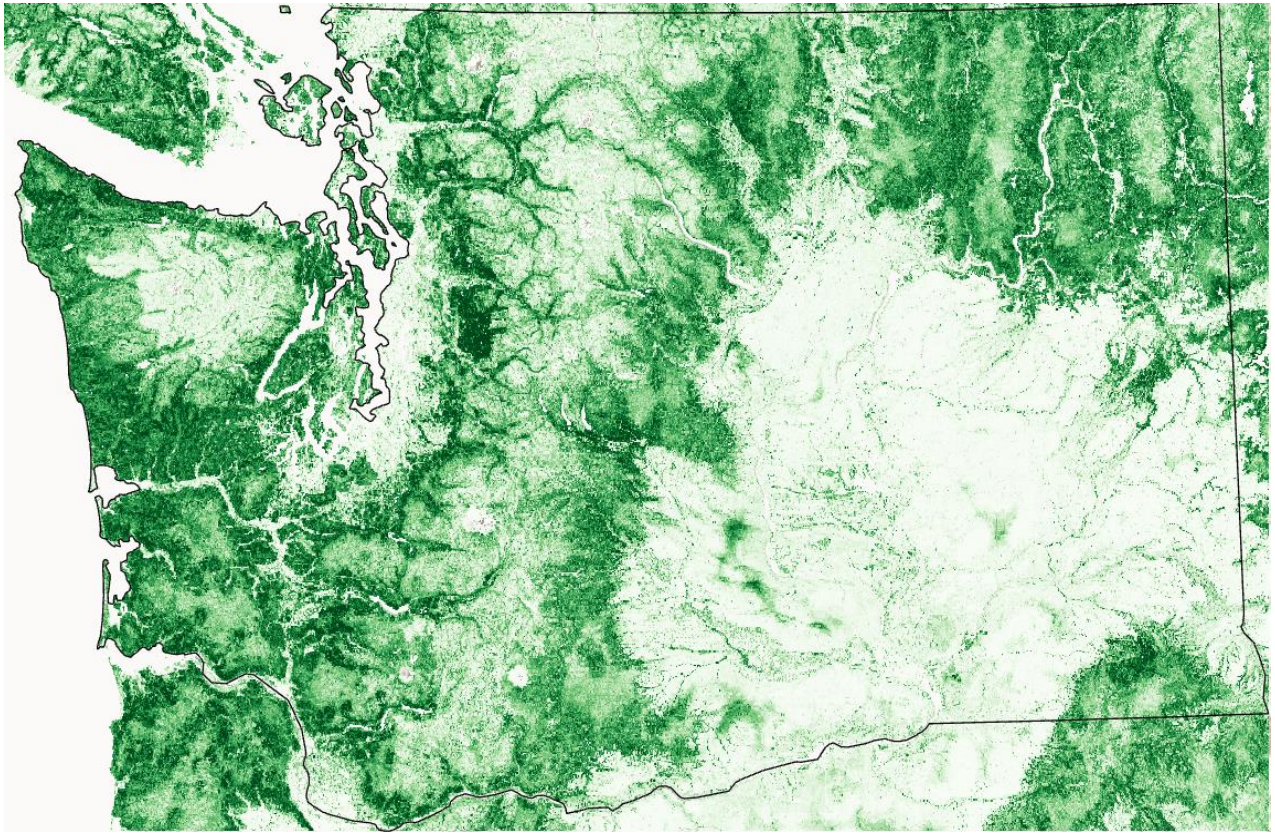
Quantifying Cougar Habitat

Quantifying Cougar Habitat Binary Map



- Basemap was LandFire
- Used cougar GPS collar locations used to ID habitat (binary)
- District Bio input

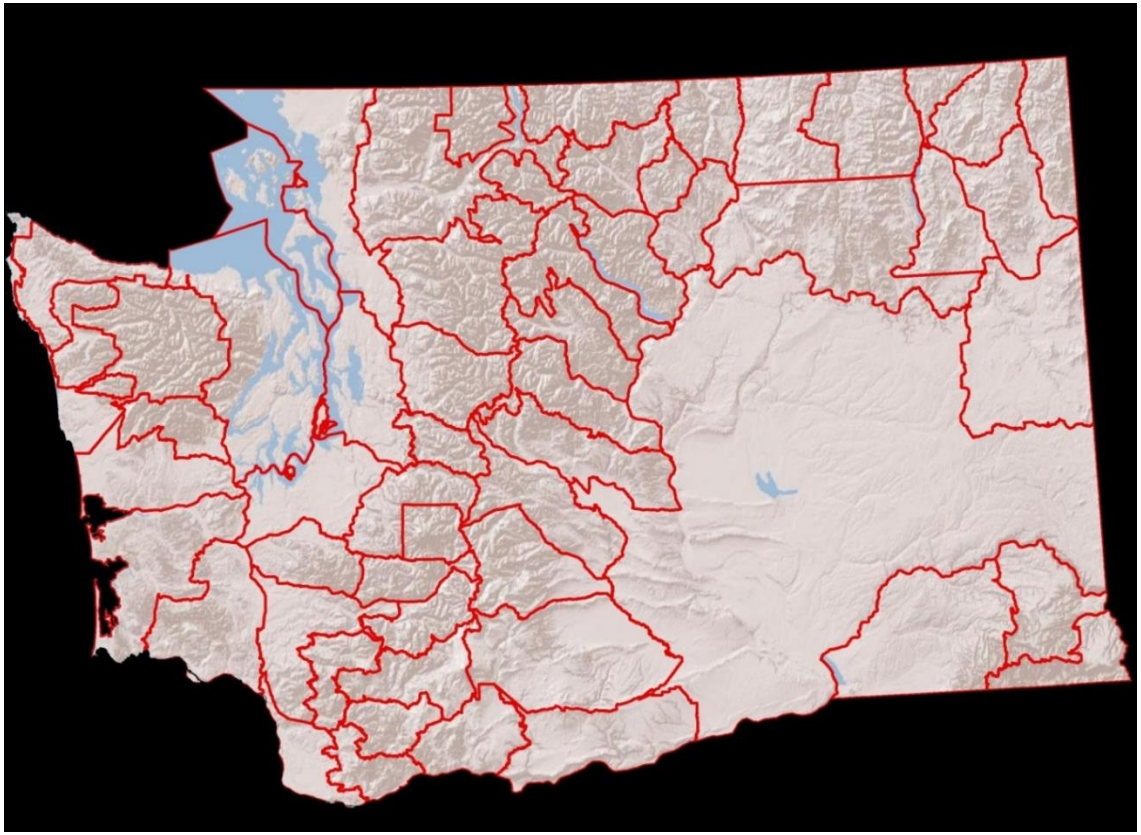
Quantifying Cougar Habitat
2024 RSF Map



- Generated using 20 research projects throughout the west
- Resource selection function (RSF) quantifies a gradient of habitat selection
- With our density estimates, could be used to model density variations statewide

Cougar population management units

PMUs & Harvest Guidelines

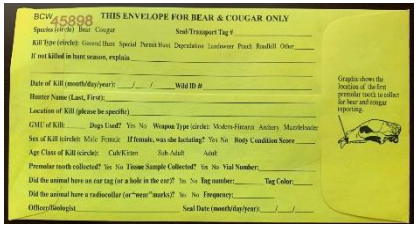


- **Currently implemented at the PMU scale**
- **PMUs have relevance to the scale of research projects**
- **To meet mgmt objectives**
  - **total human mortality = intrinsic growth rate x density x habitat**

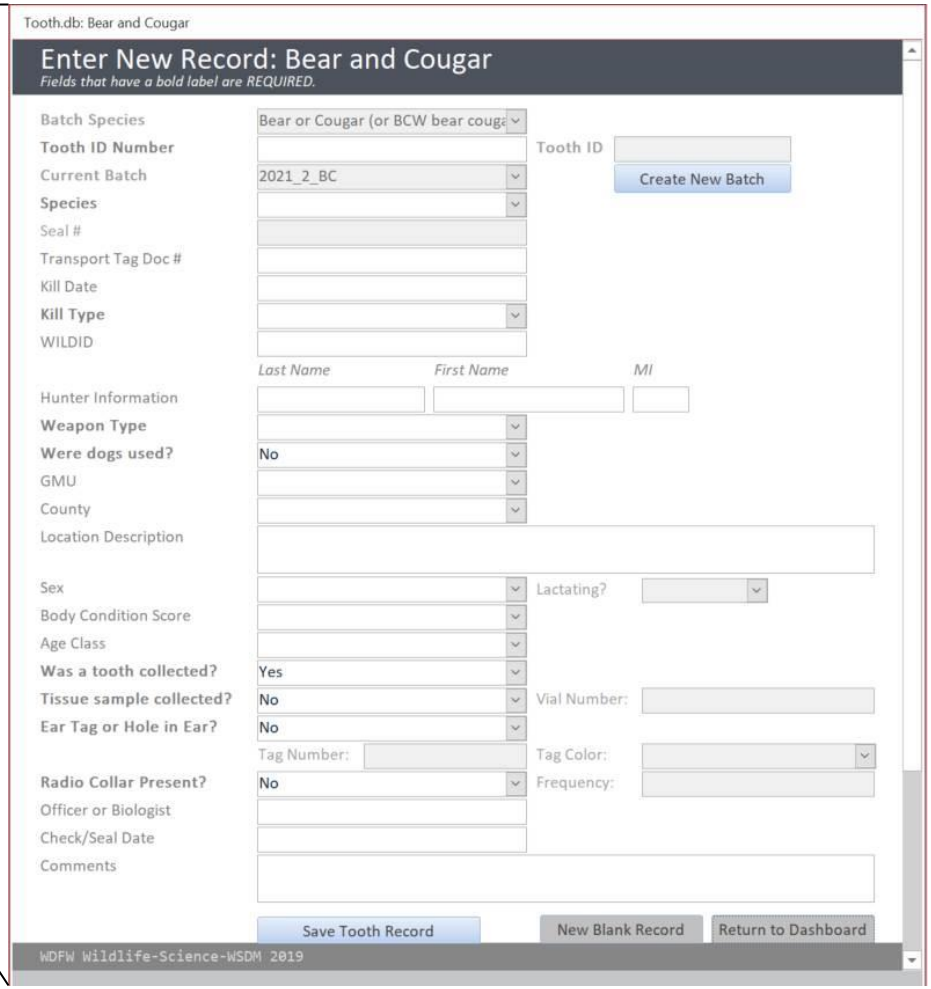
Document mortalities & Adaptive management
WDFW mechanism

ArcGIS Survey123

24- Hour Hotline & Website



Sample collection



Next steps

Science Tasks by end of March

- ☑ Estimate intrinsic growth rate
- ☑ Estimate cougar density
- ☑ Quantify cougar habitat (pending decision)
- ☑ Review by external scientists (partially completed)
- ☑ Describe the ecosystem effects of human related mortality to bear and cougar (ongoing, end of March completion)
- ☑ Estimate total take with upper/lower bounds (e.g., guidelines) that meets objectives
- ❑ Scale determination
- ❑ Analysis on past total take levels in specific areas (e.g., northeastern WA)

Future

- Coordination for incorporating data from other research entities
- Consider revising PMUs (biologist input, genetics, connectivity, etc.)
- Consider methods for monitoring

QUESTIONS?