Mark Elbroch, PhD., https://panthera.org/mark-elbroch-phd
Google Scholar: https://scholar.google.com/citations?user=Z-uQriQAAAAJ&hl=en
Research Gate: https://www.researchgate.net/profile/L-Mark-Elbroch

Vermont Department of Fish and Wildlife
Wildlife Action Plan - Revision 2015
Species Conservation Report

Common Name: **Eastern Mountain Lion**
Scientific Name: **Puma concolor couguar**
Species Group: **Mammal**

Conservation Assessment

Final Assessment: Medium Priority

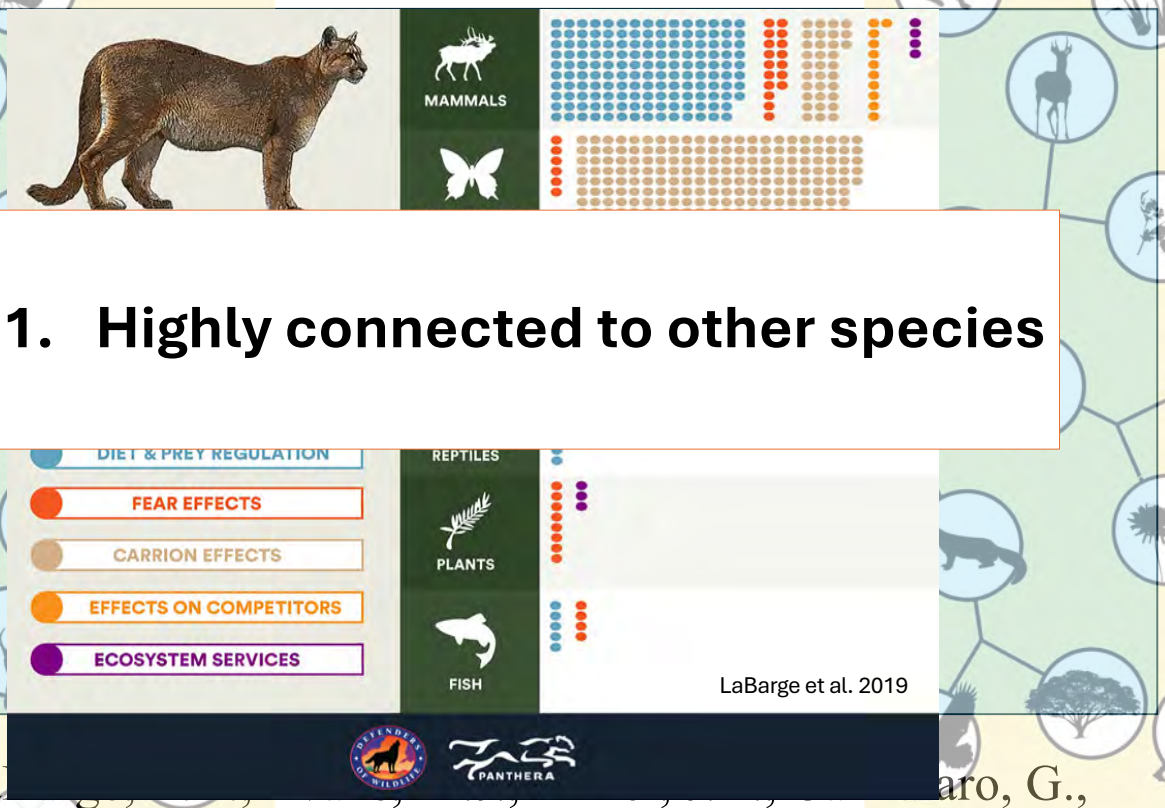
Global Rank: G5 **Global Trend:**
State Rank: SH **State Trend:** N/A
Extirpated in VT? yes **Regional SGCN?** No

Species Strategies

Strategy Type	Strategy Priority	Strategy Description	Performance Measure
Policy & Regulations	High	Pending federal delisting, maintain and enforce state protections of entire puma Genus.	
Research	Medium	Identify areas within state that could support viable Mountain Lion populations (Glick 2014) and develop a state recovery plan.	
Awareness Raising and Communications	High	Determine public attitudes towards Mountain Lion recovery efforts in VT (e.g. McGovern and Kretser 2014); Provide interpretive and public education material about Mountain Lions.	

Mark Elbroch, PhD., https://panthera.org/mark-elbroch-phd
Google Scholar: https://scholar.google.com/citations?user=Z-uQriQAAAAJ&hl=en
Research Gate: https://www.researchgate.net/profile/L-Mark-Elbroch


Play



1. **Highly connected to other species**

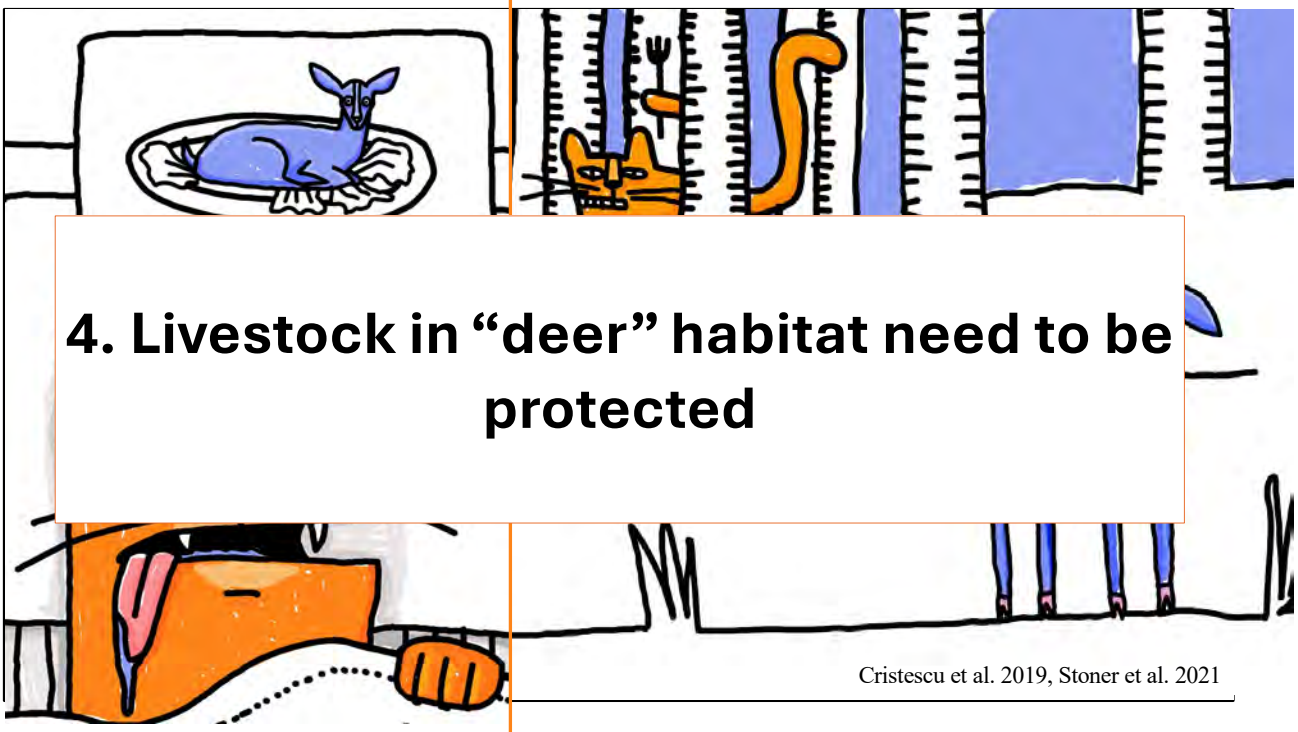
La[illegible]aro, G., Hunt, C. and Elbroch, L.M., 2022. Pumas Puma concolor as ecological brokers: a review of their biotic relationships. *Mammal Review*, *52*(3), pp.360-376.

LaBarge, L.R., Evans, M.J., Miller, J.R., Cannataro, G., Hunt, C. and Elbroch, L.M., 2022. Pumas Puma concolor as ecological brokers: a review of their biotic relationships. *Mammal Review*, *52*(3), pp.360-376.
Karandikar, H., Serota, M.W., Sherman, W.C., Green, J.R., Verta, G., Kremen, C. and Middleton, A.D., 2022. Dietary patterns of a versatile large carnivore, the puma (Puma concolor). *Ecology and evolution*, *12*(6), p.e9002.


3. They are curious, but ruled by caution
Jeff Hogan / Hogan Films

Cristescu, B; Bose, S; Elbroch, LM; Allen, ML; Wittmer, HU; . 2019. Habitat selection when killing primary versus alternative prey species supports prey specialization in an apex predator. Journal of Zoology 309, 259-268.

Stoner, D.C., Ditmer, M.A., Mitchell, D.L., Young, J.K. and Wolfe, M.L., 2021. Conflict, coexistence, or both? Cougar habitat selection, prey composition, and mortality in a multiple-use landscape. California Fish and Wildlife 107(3):147-172.



4. Livestock in “deer” habitat need to be protected

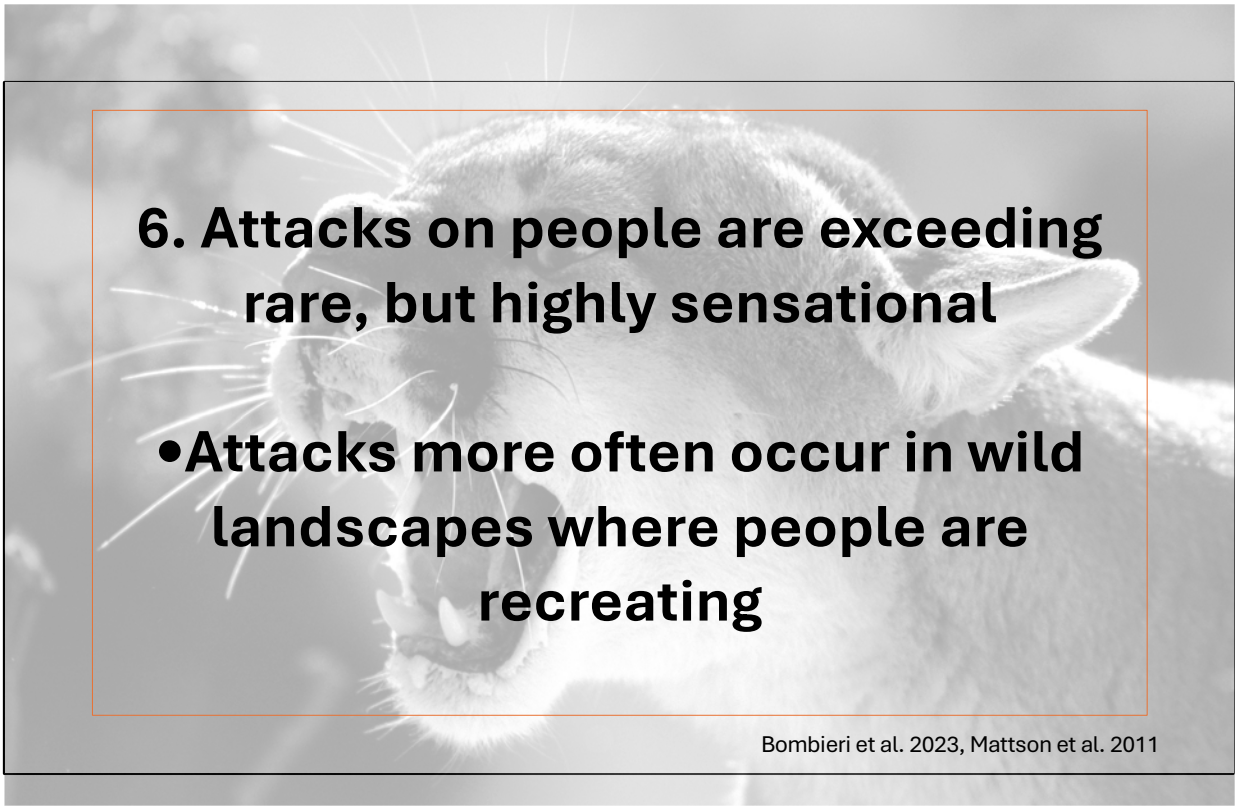
Cristescu et al. 2019, Stoner et al. 2021

Cristescu, B; Bose, S; Elbroch, LM; Allen, ML; Wittmer, HU; . 2019. Habitat selection when killing primary versus alternative prey species supports prey specialization in an apex predator. Journal of Zoology 309, 259-268.

Stoner, D.C., Ditmer, M.A., Mitchell, D.L., Young, J.K. and Wolfe, M.L., 2021. Conflict, coexistence, or both? Cougar habitat selection, prey composition, and mortality in a multiple-use landscape. California Fish and Wildlife 107(3):147-172.

5. US conflict with people occurs in backyards

Dellinger, J.A., Macon, D.K., Clifford, D.L. and Torres, S.G., 2021. Temporal trends and drivers of mountain lion depredation in California, USA. *Human-Wildlife Interactions*, *15*(1), pp.162-177.
Peebles, K.A., Wielgus, R.B., Maletzke, B.T. and Swanson, M.E., 2013. Effects of remedial sport hunting on cougar complaints and livestock depredations. *PLoS one*, *8*(11), p.e79713.

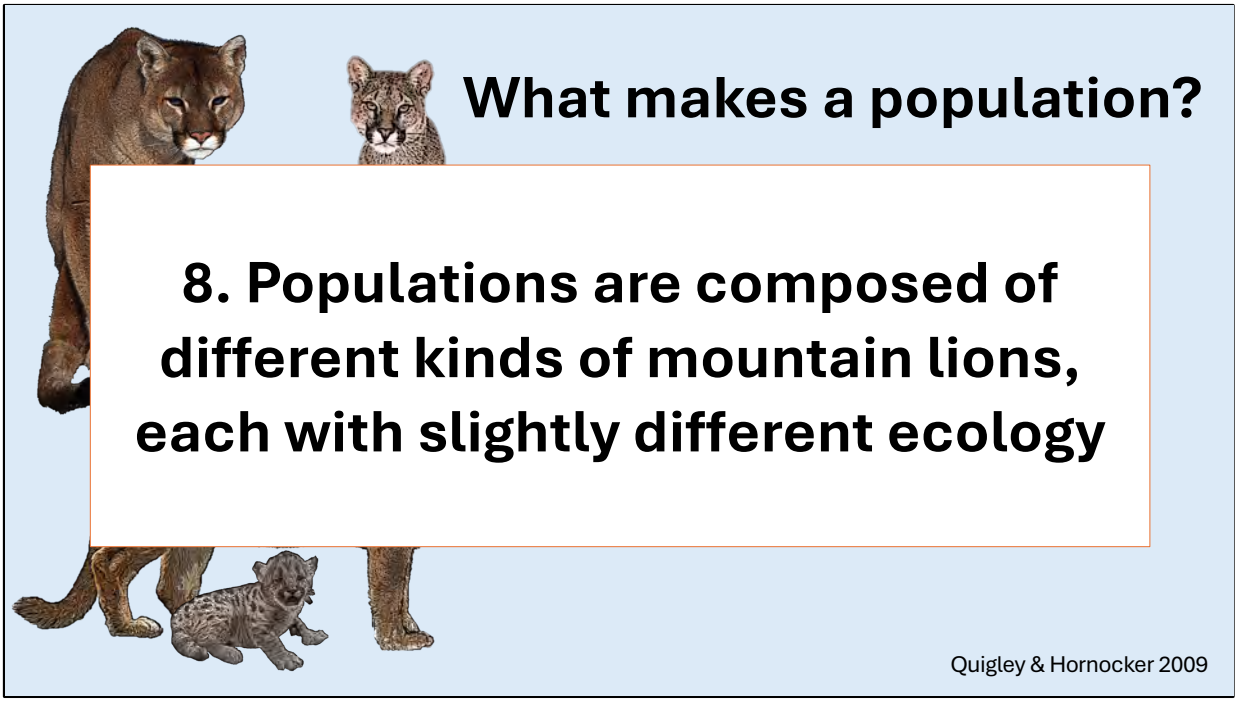


Mattson, D., Logan, K. and Sweanor, L., 2011. Factors governing risk of cougar attacks on humans. *Human-Wildlife Interactions*, *5*(1), pp.135-158.

Bombieri, G., Penteriani, V., Almasieh, K., Ambarlı, H., Ashrafzadeh, M.R., Das, C.S., Dharaiya, N., Hoogesteijn, R., Hoogesteijn, A., Ikanda, D. and Jędrzejewski, W., 2023. A worldwide perspective on large carnivore attacks on humans. *PLoS biology*, *21*(1), p.e3001946.

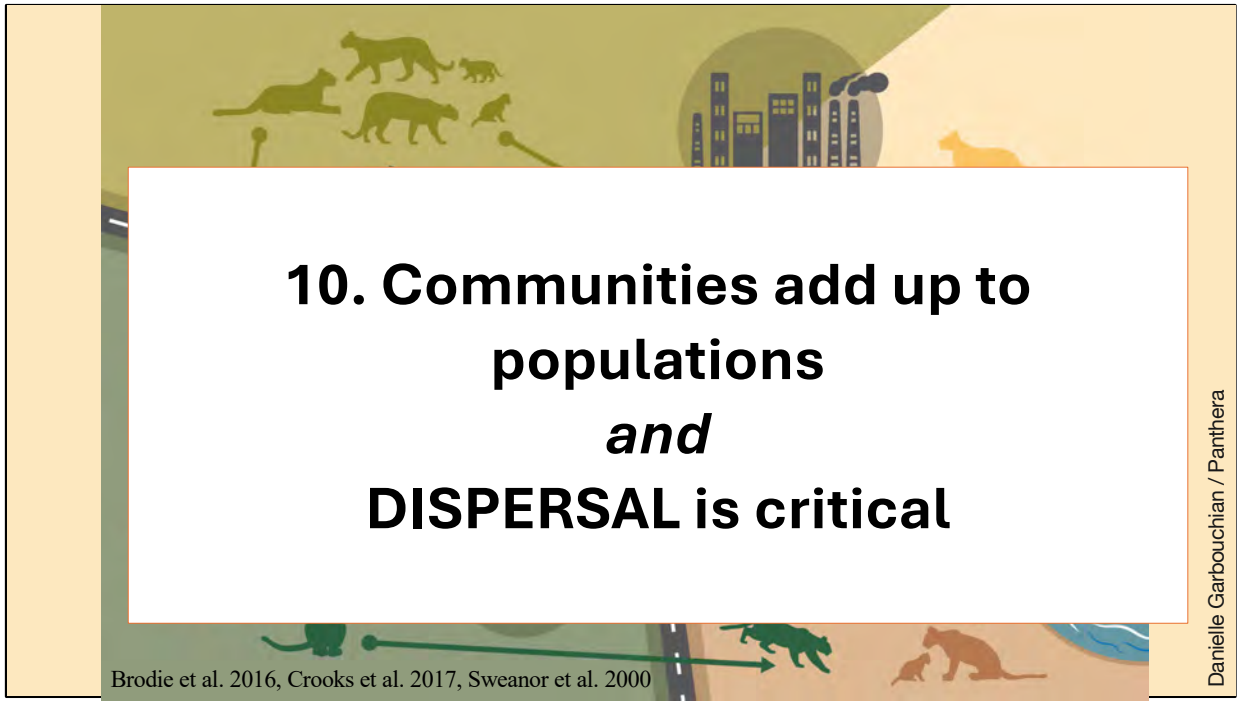
Compare **(1 fatality due to mountain lion every 4 yrs over last 130 yrs…vs. 440 people/yr in deer collisions, roughly 50 people/yr from dogs, 20 people/yr for lightning)**

and ecological associations. American Naturalist 127:744–771.

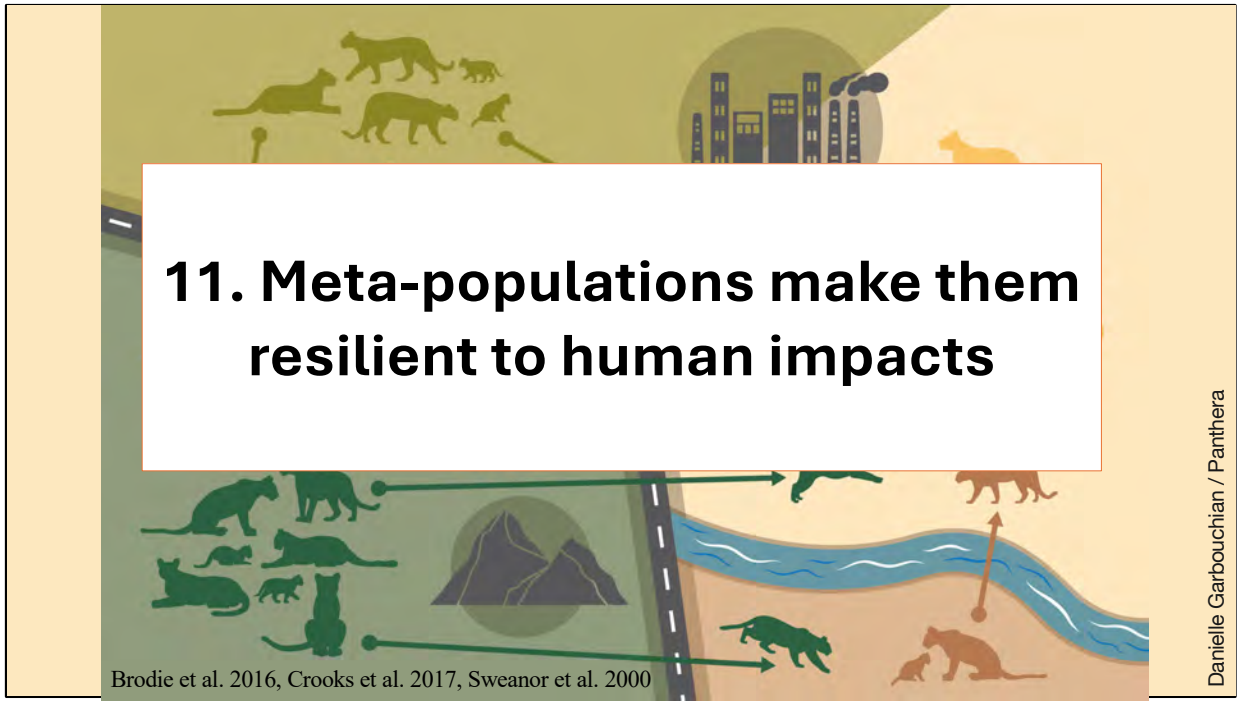


Quigley, H. & Hornocker, M. (2009). Cougar population dynamics. In Cougar: ecology and conservation: 59–75. M. Hornocker & S. Negri (Eds). Chicago: University of Chicago Press.

Elbroch, L Mark; Levy, Michael; Lubell, Mark; Quigley, Howard; Caragiulo, Anthony; . 2017. Adaptive social strategies in a solitary carnivore. *Science Advances* 3, e1701218.



See references for next slide.



Crooks KR, Burdett CL, Theobald DM, King SRB, Di Marco M, Rondinini C, Boitani L. Quantification of habitat fragmentation reveals extinction risk in terrestrial mammals. Proc Natl Acad Sci U S A. 2017 Jul 18;114(29):7635-7640.

Brodie JF, Paxton M, Nagulendran K, Balamurugan G, Clements GR, Reynolds G, Jain A, Hon J. Connecting science, policy, and implementation for landscape-scale habitat connectivity. Conserv Biol. 2016 Oct;30(5):950-61.

Sweanor, L.L., Logan, K.A. and Hornocker, M.G., 2000. Cougar dispersal patterns, metapopulation dynamics, and conservation. *Conservation Biology*, *14*(3), pp.798-808.

12. They are currently absent in approaching 2/3 of historic range in US and Canada


Exploring Cougar Recovery in the East
NORTHEAST WILDERNESS TRUST
PANTHERA
TOMPKINS CONSERVATION
1885
Michigan Technological University
THE OHIO STATE UNIVERSITY
Sebastian Kennerknecht / Panthera

1. Is their habitat in the East?
2. Are their large contiguous blocks?
3. When will they recolonize on their own?

Is there habitat in the East?

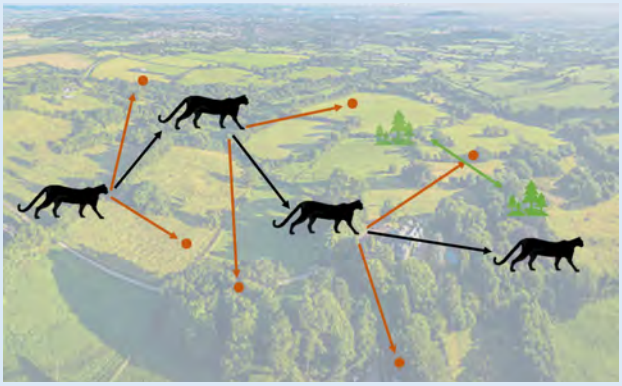
Resource Selection Functions

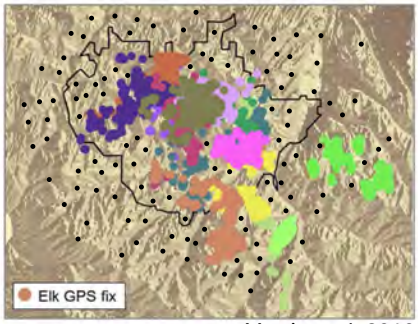
- Predicting where you might find animals
- Extrapolation from small to larger scales

**(Diversity of sampling and size of data set)

Newer Step Selection Functions

2.5 million locations from 374 individual mountain lions





Morris et al. 2016

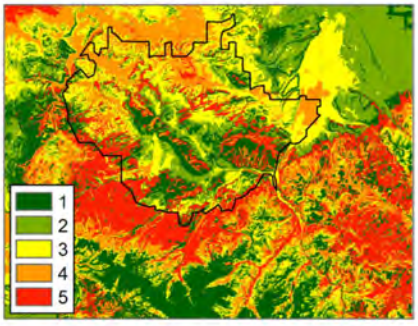
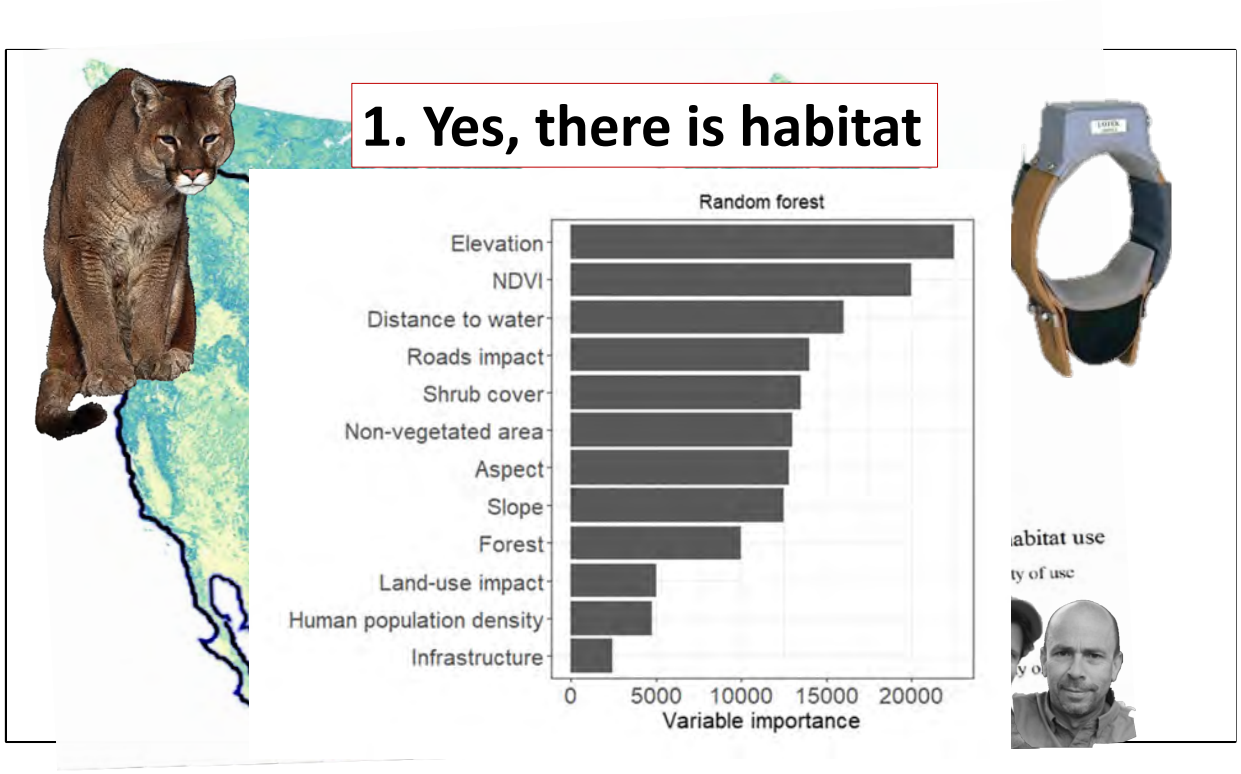
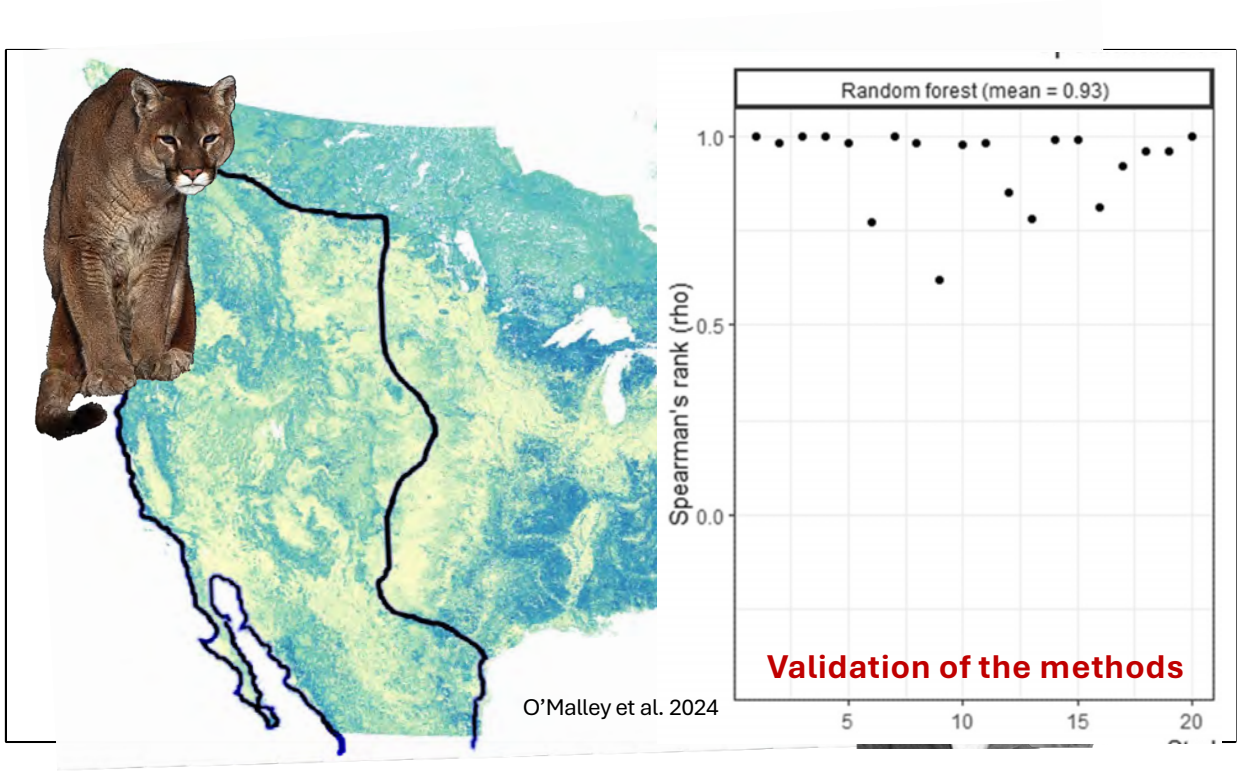


Table 1 Candidate landscape and human impact variables and hypothesized effects on mountain lion resource selection. A positive sign indicates a greater probability of selection associated with that variable while negative sign indicates a lesser probability of selection associated with that variable

Covariate	Data source (resolution)	Hypothesized effect on resource selection	Published support of hypothesized effect
Biotic/landscape (bottom-up)			
Distance to water	JRC Global Surface Water (30 m)	-	Dellinger et al. 2020
Normalized difference vegetation index	Landsat 8 (30 m)	+	Logan and Sweanor 2001, Walters 2001
Gross primary productivity	Landsat 8 (30 m)	+	Logan and Sweanor 2001, Walters 2001
Precipitation	PERSIANN-CDR	+	Logan and Sweanor 2001, Walters 2001
Slope	U.S. Geological Survey (30 m)	+	Zeller et al. 2017
Forest cover	MOD44Bv006 (250 m)	+	Robinson et al. 2015, Dellinger et al. 2020
Shrub cover	MOD44Bv006 (250 m)	+	Robinson et al. 2015, Dellinger et al. 2020
Non-vegetation	MOD44Bv006 (250 m)	-	Zeller et al. 2017, Dellinger et al. 2020
Elevation	U.S. Geological Survey (30 m)	+	Robinson et al. 2015, Dellinger et al. 2020
Aspect	U.S. Geological Survey (30 m)	South preferred	Robinson et al. 2015
Human impact/competition (top-down)			
Roads impact	Wildlife Conservation Society	-	Zeller et al. 2017, Dellinger et al. 2020
Land-use impact	Wildlife Conservation Society (100 m)	-	Robinson et al. 2015, Zeller et al. 2017
Infrastructure impact	Wildlife Conservation Society (100 m)	-	Robinson et al. 2015, Zeller et al. 2017
Population density	U.S. Census Bureau (100 m)	_	Dellinger et al. 2020

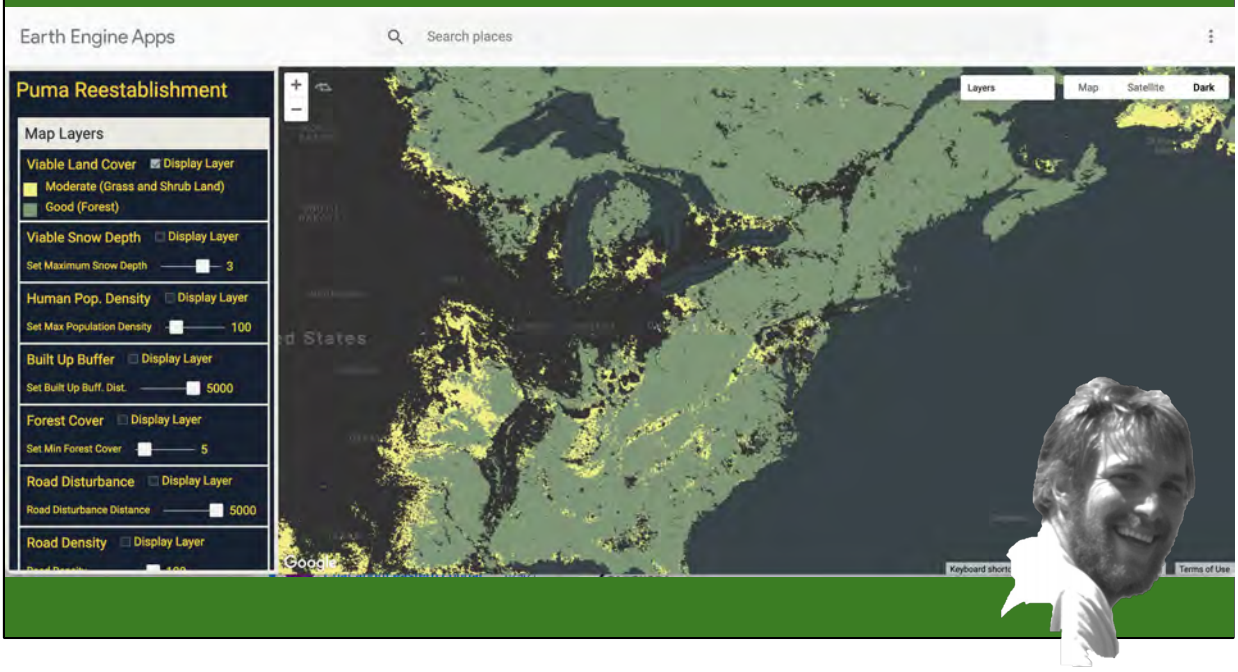


O'Malley, W.C., Elbroch, L.M., Zeller, K.A., Beie
Beale, M.M., Beausoleil, R.A., Kertson, B., Kno
Kunkel, K., Maletzke, B.T. and Martins, Q., 20
Machine learning allows for large-scale habitat prediction of a wide-ranging carnivore across diverse ecoregions. *Landscape Ecology*, *39*(5), pp.1-16.



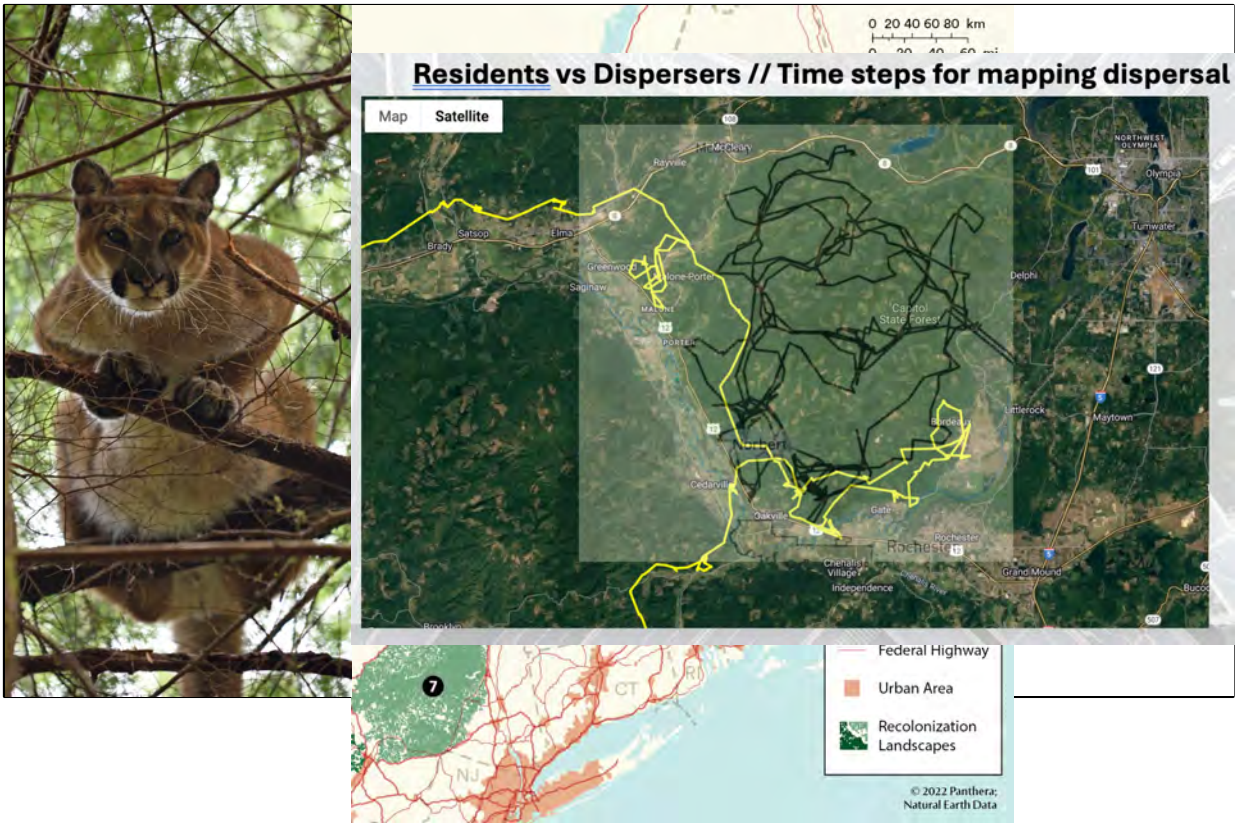
O'Malley, W.C., Elbroch, L.M., Zeller, K.A., Beie
Beale, M.M., Beausoleil, R.A., Kertson, B., Kno
Kunkel, K., Maletzke, B.T. and Martins, Q., 20
Machine learning allows for large-scale habitat prediction of a wide-ranging carnivore across diverse ecoregions. *Landscape Ecology*, *39*(5), pp.1-16.

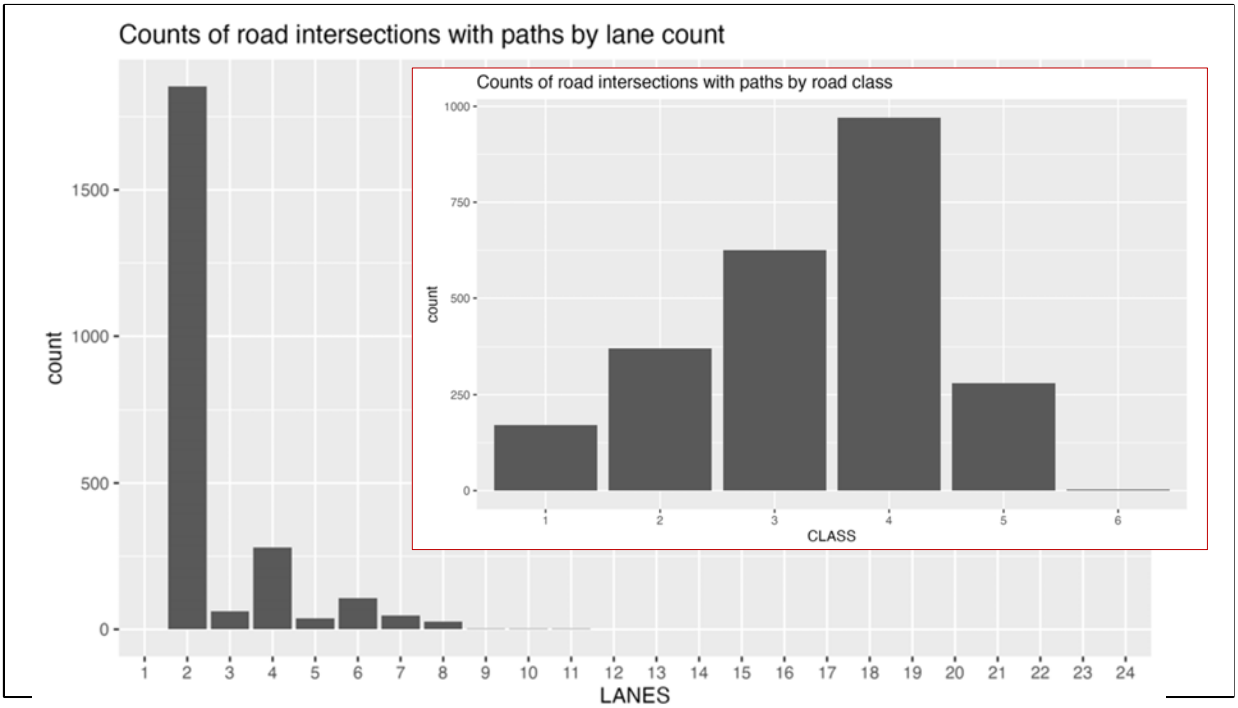
Question #2. Are there large contiguous blocks of suitable habitat?

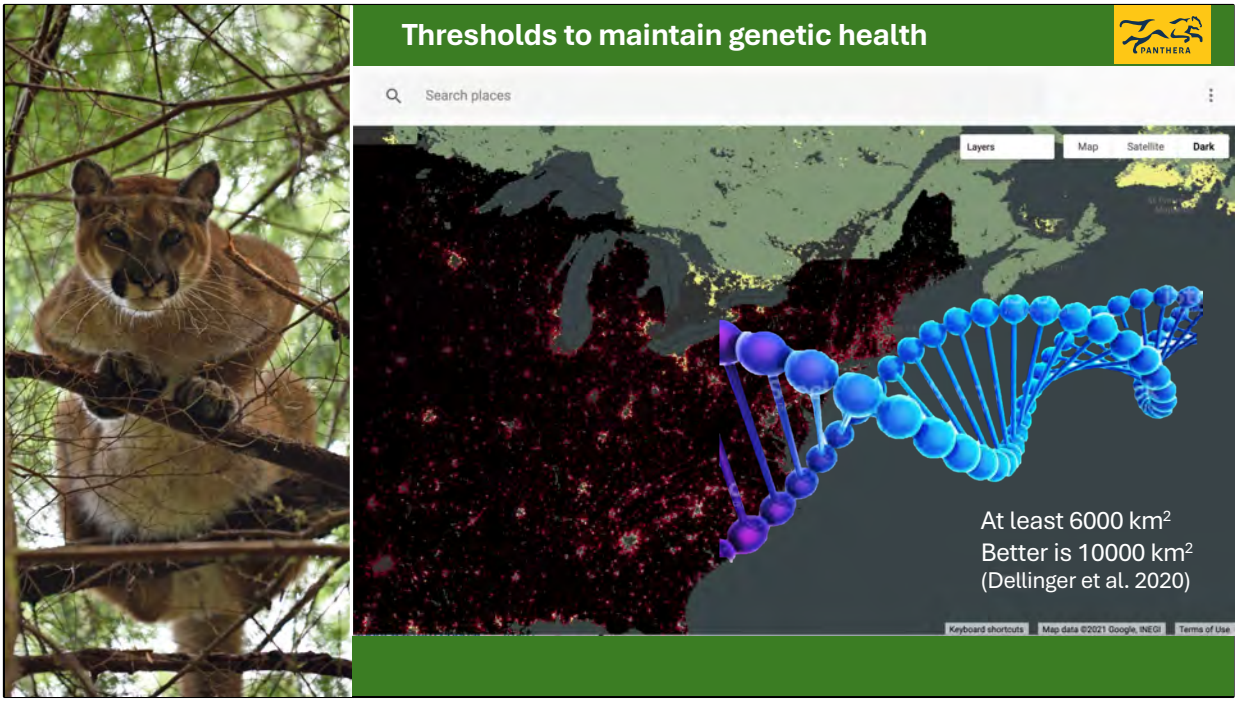


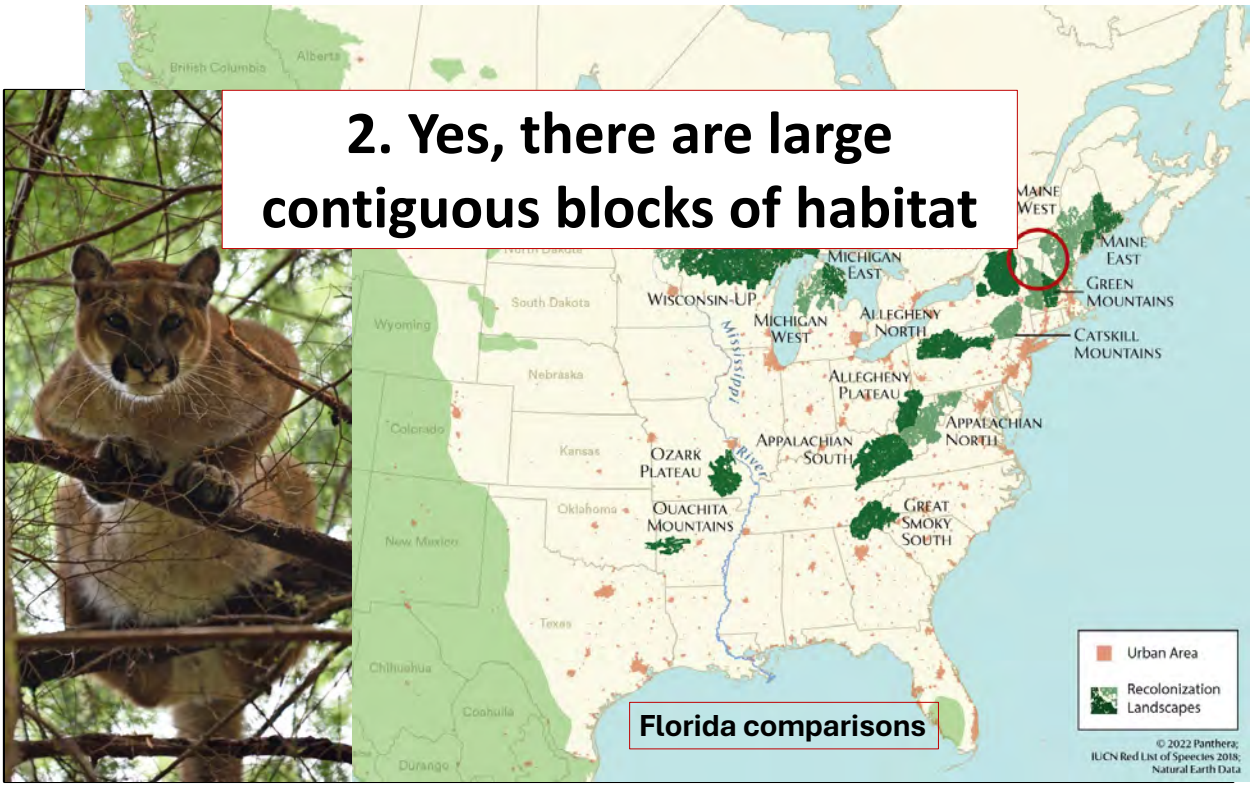
Ecological assumption	Habitat Variable	Threshold Description	Data Source	Spatial Resolution
Pumas avoid open habitats in North America (LaRue and Nielsen 2008; Burdett et al. 2010; Gray et al. 2016)	Land cover	Exclude agriculture, high elevation rock and grasslands.	Friedl & Sulla-Manashe (2018)	500 m
Pumas require strutured habitat for hunting and survival (Gray et al., 2016).	Forest cover	Pumas excluded from cells with <53% forest cover	Hansen et al. (2013)	30 m
Pumas follow prey, and deer and elk avoid deep snow (Laundré & Hernández, 2003; Poole & Mowat, 2005)	Maximum snow depth	Pumas (and puma prey) excluded when average winter snow depth ≥50cm	SNODAS	1 km
Pumas excluded from areas with high housing density (Burdett et al., 2010)	Housing density	Pumas excluded when housing density ≥0.68 units/ha	ICLUS	90 m
Pumas excluded from habitat adjacent people (Wilmers et al., 2013; Yovovich et al., 2021)	Human development proximity	Pumas excluded from habitat ≤600m from human structures	Yang et al (2018)	30 m
People excluded from habitat immediateoly adjacent large highways (Knopff et al., 2014)	Highway proximity	Pumas excluded from habitat within 170m of interstate highways and major arterials.	TIGER US Census Roads	NA
Pumas and livestock may have conflict that leads to lower puma survival; puma survival is higher in habitat with low livestock density (Guerisoli et al. 2021)	Livestock density	Pumas excluded from habitat with ≥14.5 animals/km²	Robinson et al. (2014)	10 km

This is not about car strikes—this is about the likeliness of a home range crossing such roads (which is unlikely, so it could divide populations.


Residents vs Dispersers // Time steps for mapping dispersal
Map
Satellite
Federal Highway
Urban Area
Recolonization Landscapes
© 2022 Panthera; Natural Earth Data

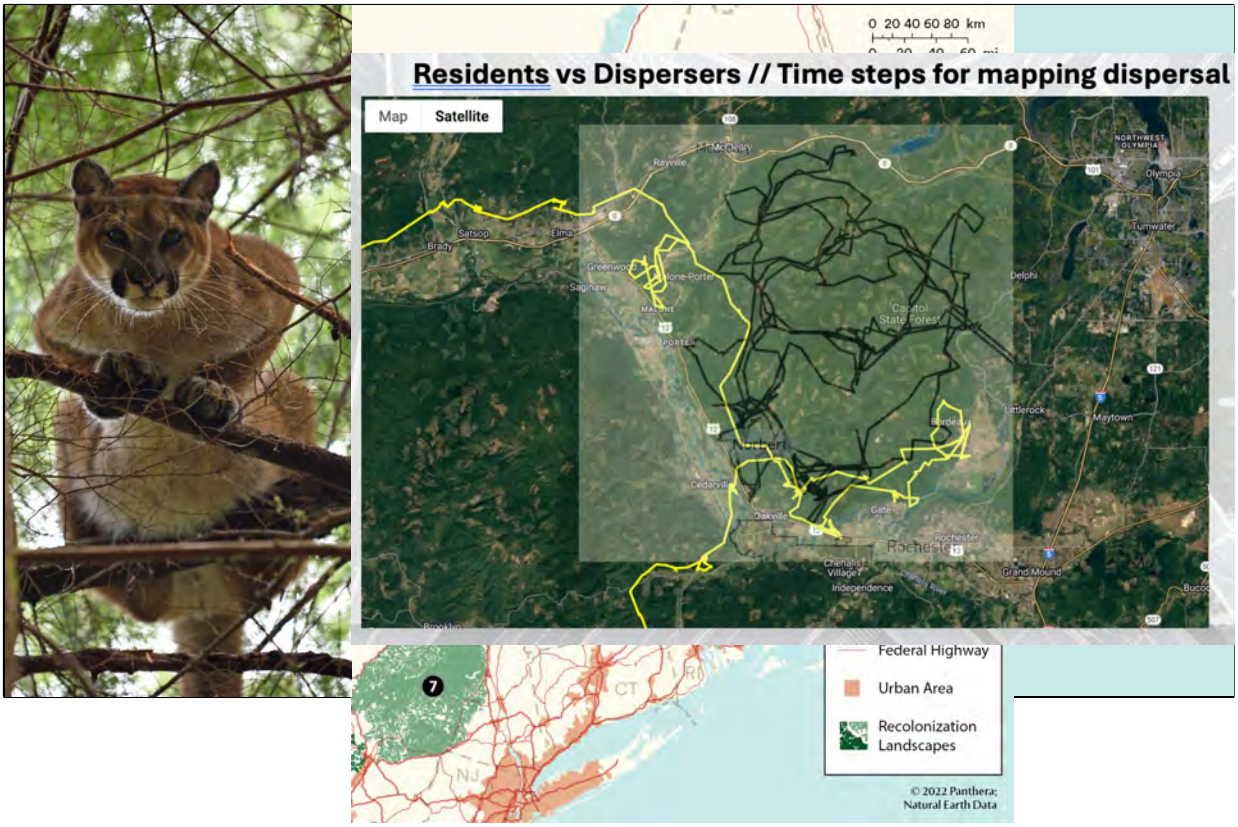

Counts of road intersections with paths by lane count
count
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
LANES
Counts of road intersections with paths by road class
count
1000
750
500
250
0
1 2 3 4 5 6
CLASS


Thresholds to maintain genetic health
PANTHERA
Search places
Layers
Map
Satellite
Dark
At least 6000 km²
Better is 10000 km²
(Dellinger et al. 2020)
Keyboard shortcuts
Map data ©2021 Google, INEGI
Terms of Use



Yovovich, Veronica; Robinson, Nathaniel; Robinson, Hugh; Manfredo, Michael J; Perry, Shelby; Bruskotter, Jeremy T; Vucetich, John A; Solórzano, Luis Aníbal; Roe, Lydia A; Lesure, Alison; . 2023. Determining puma habitat suitability in the Eastern USA. *Biodiversity and Conservation* 32, 921-941.

Not suitable to use FL as a comparison for 2 reasons: 1) they lack large contiguous habitat as determined by these methods, and 2) their small founder population was not genetically healthy to begin with


Residents vs Dispersers // Time steps for mapping dispersal
Map
Satellite
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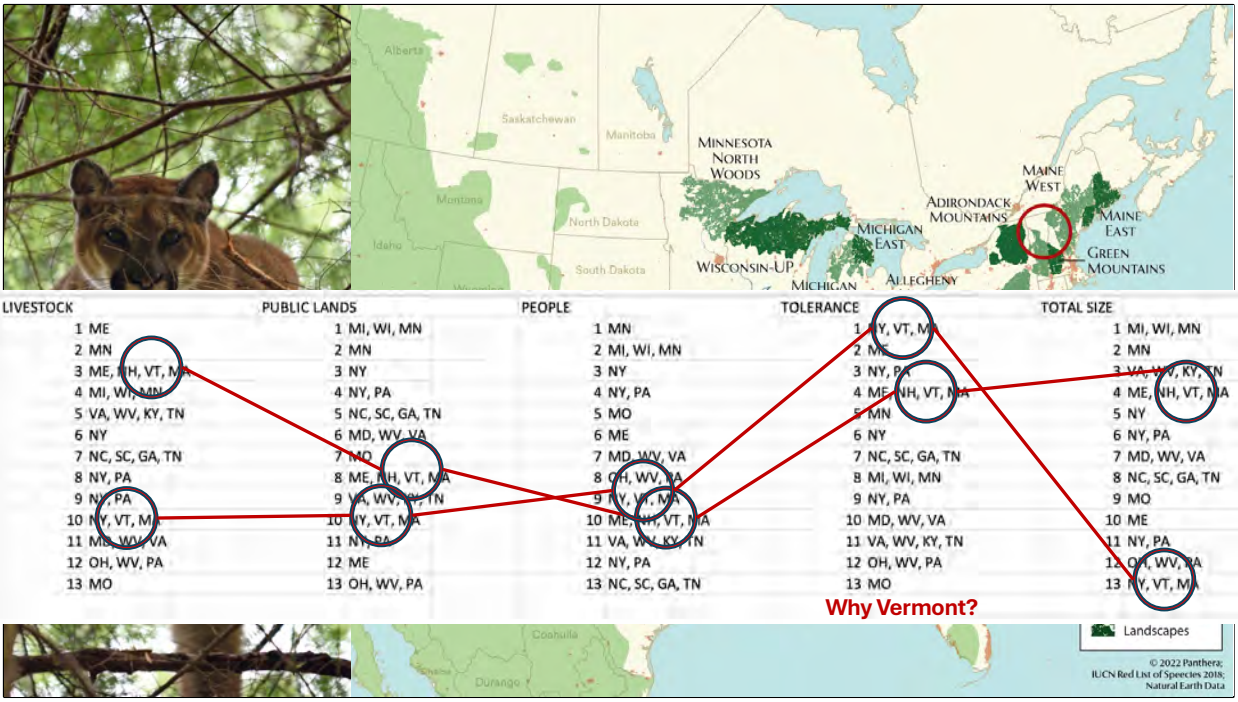
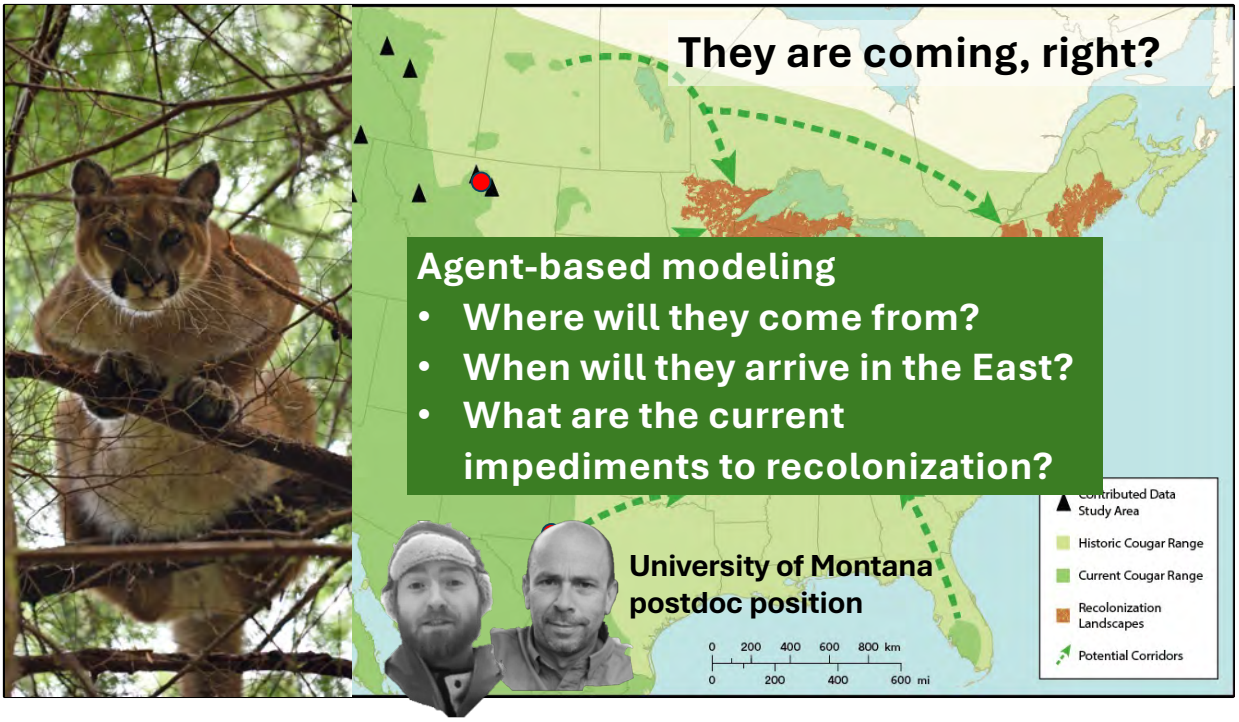
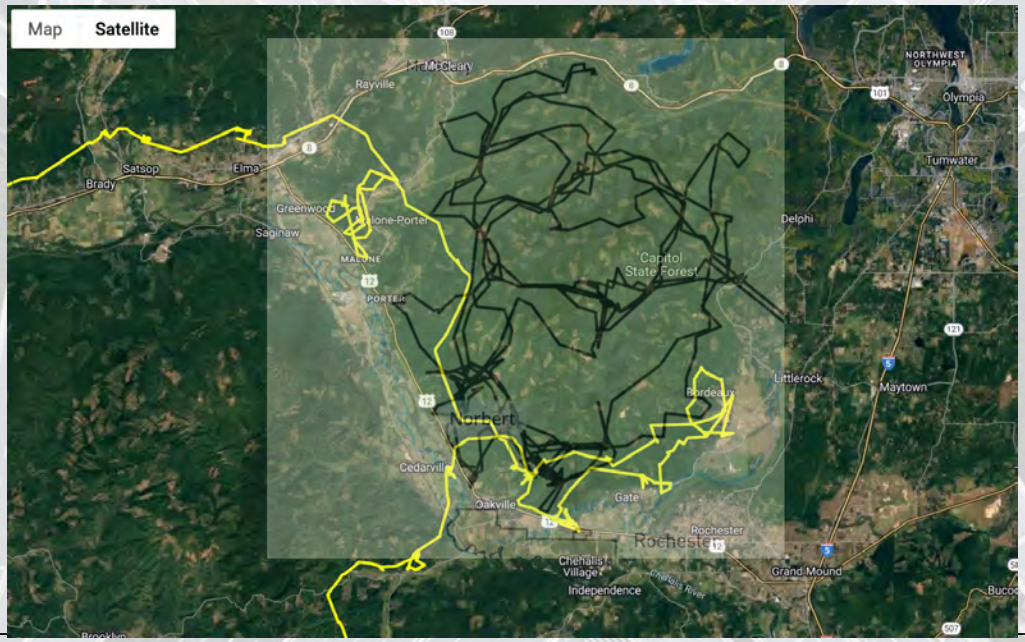
© 2022 Panthera; Natural Earth Data


Alberta
Saskatchewan
Manitoba
Montana
North Dakota
Idaho
South Dakota
MINNESOTA NORTH WOODS
MICHIGAN EAST
WISCONSIN-UP
MICHIGAN
ALLEGHENY
ADIRONDACK MOUNTAINS
MAINE WEST
MAINE EAST
GREEN MOUNTAINS
LIVESTOCK
1 ME
2 MN
3 ME, NH, VT, MA
4 MI, WI, MN
5 VA, WV, KY, TN
6 NY
7 NC, SC, GA, TN
8 NY, PA
9 NY, PA
10 NY, VT, MA
11 ME, WV, VA
12 OH, WV, PA
13 MO
PUBLIC LANDS
1 MI, WI, MN
2 MN
3 NY
4 NY, PA
5 NC, SC, GA, TN
6 MD, WV, VA
7 MO
8 ME, NH, VT, MA
9 VA, WV, KY, TN
10 NY, VT, MA
11 NY, PA
12 ME
13 OH, WV, PA
PEOPLE
1 MN
2 MI, WI, MN
3 NY
4 NY, PA
5 MO
6 ME
7 MD, WV, VA
8 OH, WV, PA
9 NY, VT, MA
10 ME, NH, VT, MA
11 VA, WV, KY, TN
12 NY, PA
13 NC, SC, GA, TN
TOLERANCE
1 NY, VT, MA
2 ME
3 NY, PA
4 ME, NH, VT, MA
5 MN
6 NY
7 NC, SC, GA, TN
8 MI, WI, MN
9 NY, PA
10 MD, WV, VA
11 VA, WV, KY, TN
12 OH, WV, PA
13 MO
TOTAL SIZE
1 MI, WI, MN
2 MN
3 VA, WV, KY, TN
4 ME, NH, VT, MA
5 NY
6 NY, PA
7 MD, WV, VA
8 NC, SC, GA, TN
9 MO
10 ME
11 NY, PA
12 OH, WV, PA
13 NY, VT, MA
Why Vermont?
Coahuila
Durango
Landscapes
© 2022 Panthera;
IUCN Red List of Species 2018;
Natural Earth Data


They are coming, right?
Agent-based modeling
• Where will they come from?
• When will they arrive in the East?
• What are the current impediments to recolonization?
University of Montana postdoc position
0 200 400 600 800 km
0 200 400 600 mi
Study Area
Historic Cougar Range
Current Cougar Range
Recolonization Landscapes
Potential Corridors

Residents vs Dispersers // Time steps for mapping dispersal



For example, residents won't generally cross a highway with 5000-7000 cars/day, but dispersers will...

Models within models…
Probability of surviving a road crossing

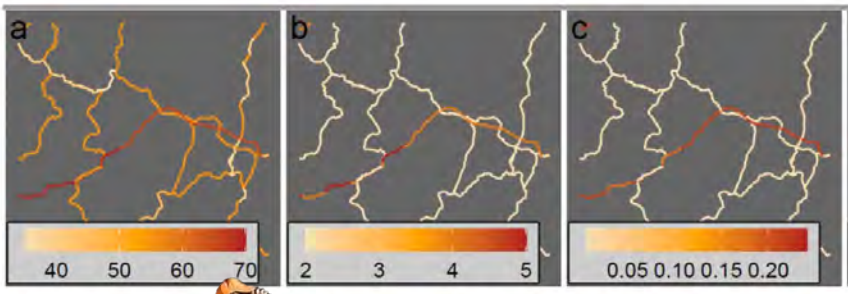
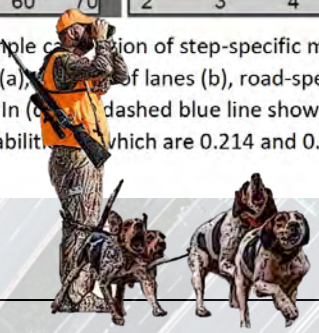


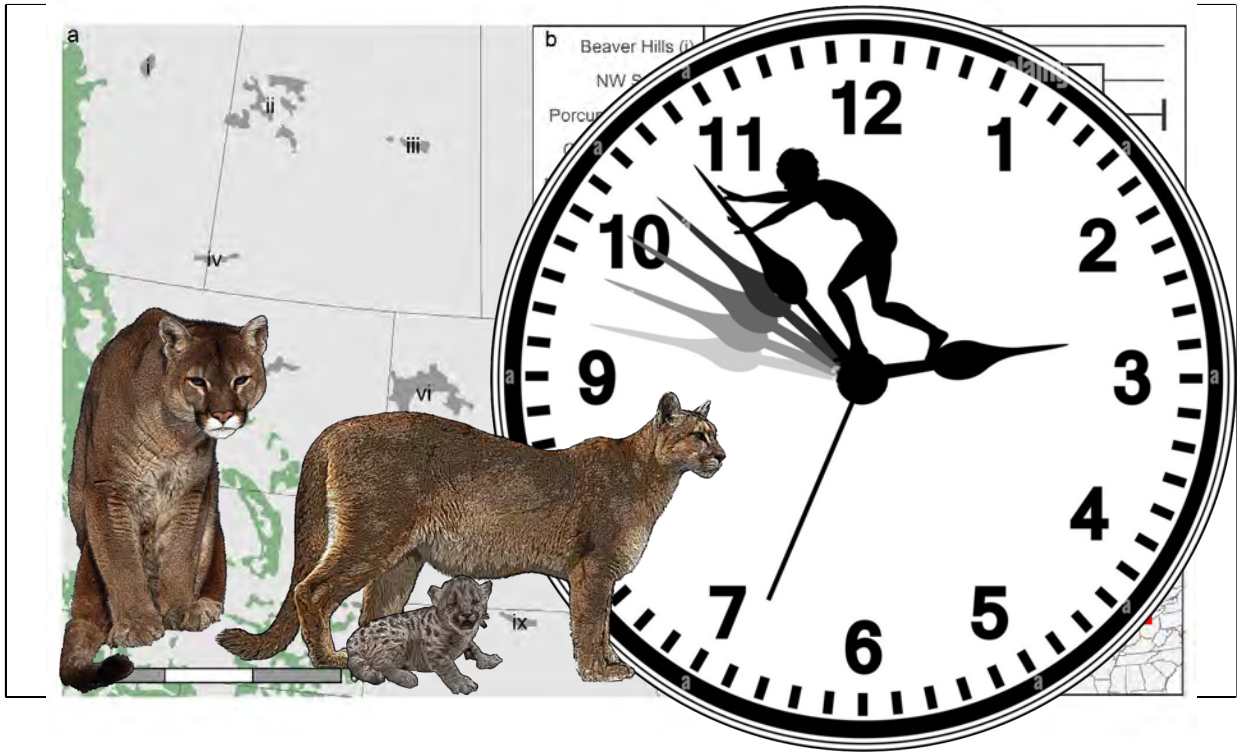
Figure S3. Example c… ion of step-specific mortality probabilities from crossing roads, showing speed limit in miles per hour (a), … f lanes (b), road-specific mortality probability (c), and cell-specific mortality probability (d). In (… dashed blue line shows a hypothetical next step crossing two roads, the individual mortality probabilit… which are 0.214 and 0.007, yielding a cumulative probability of 1-((1-0.214)*(1-0.007)) = 0.22.

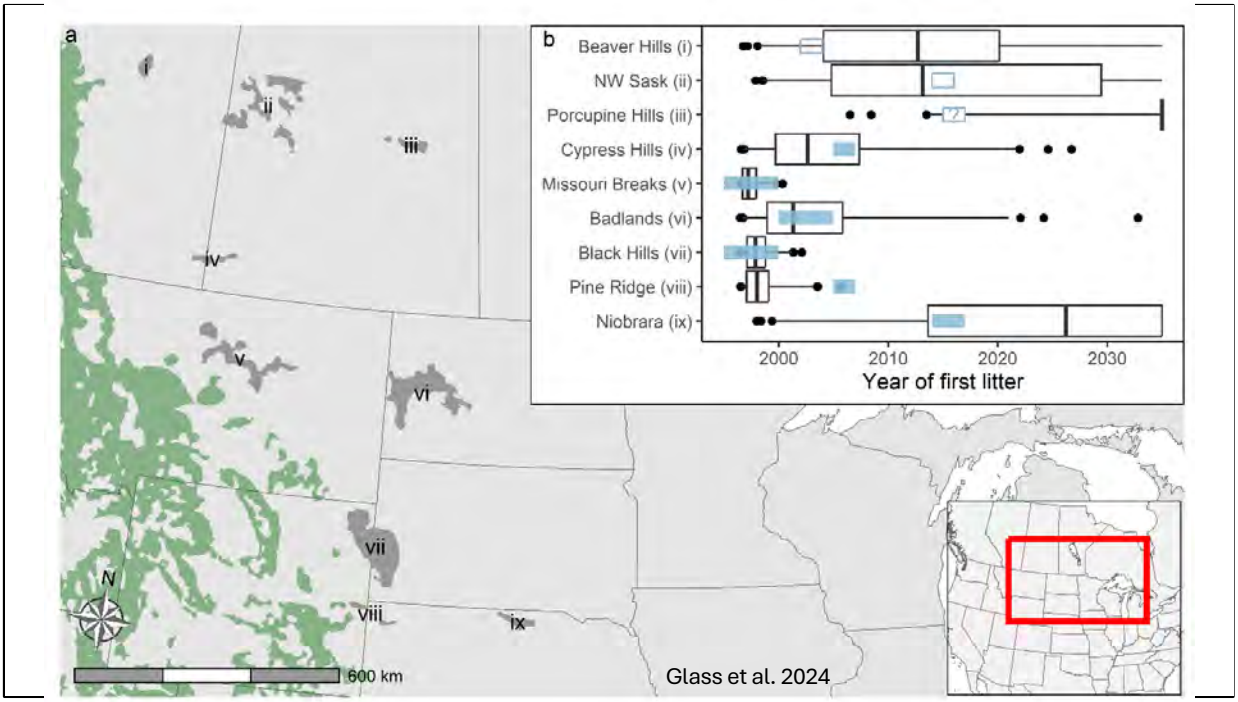
Causes of mortality

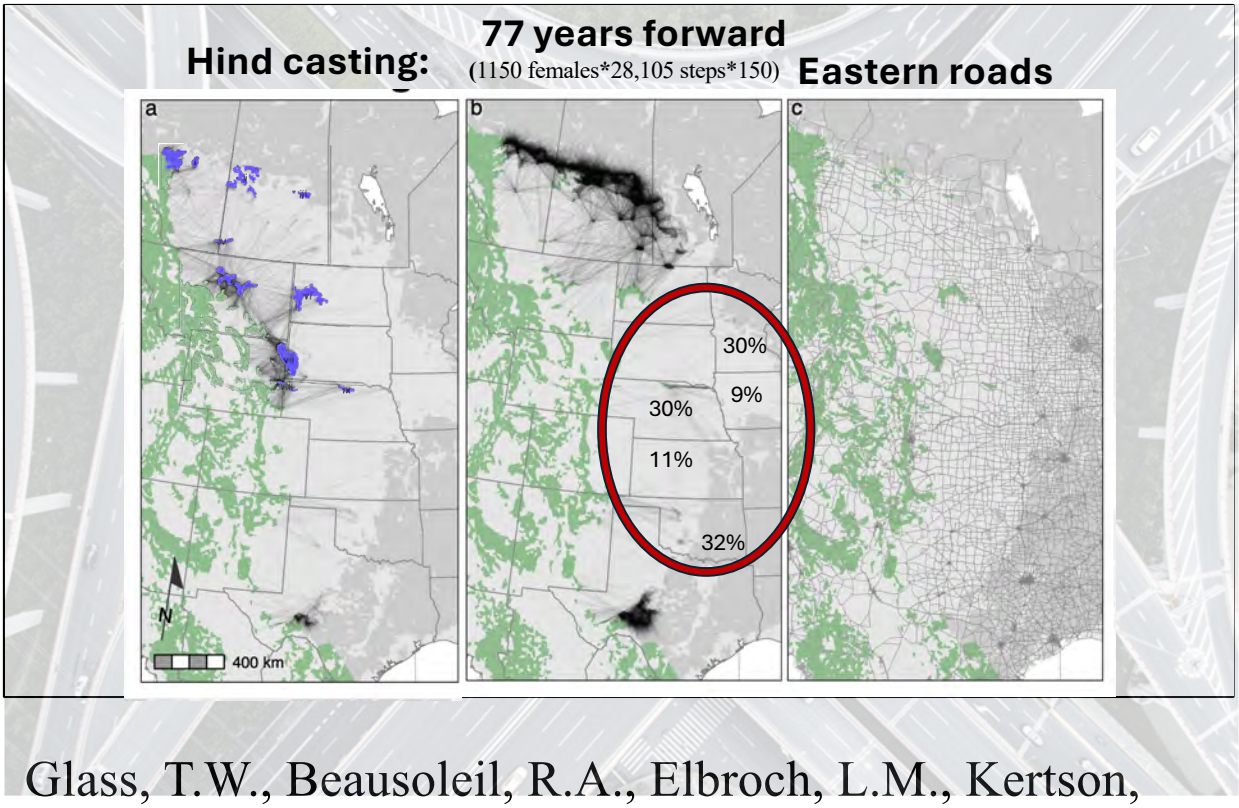
Anthropogenic

Natural




a
i
ii
iii
iv
vi
ix
b
Beaver Hills (i)
12
1
2
3
4
5
6
7
9
10
11

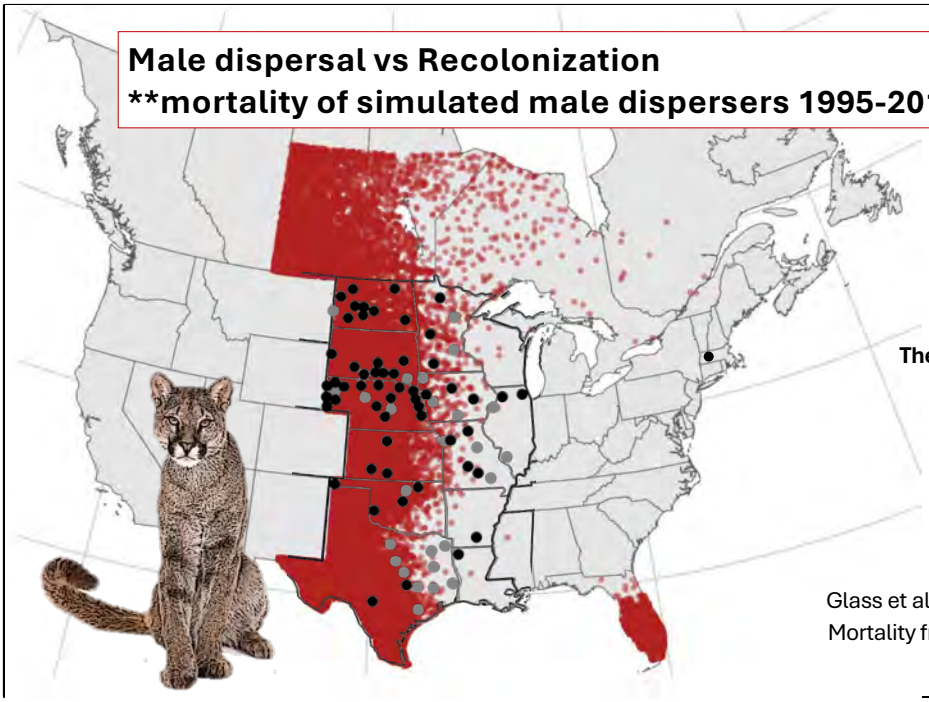

a
i
ii
iii
iv
v
vi
vii
viii
ix
N
600 km
b
Beaver Hills (i)
NW Sask (ii)
Porcupine Hills (iii)
Cypress Hills (iv)
Missouri Breaks (v)
Badlands (vi)
Black Hills (vii)
Pine Ridge (viii)
Niobrara (ix)
2000
2010
2020
2030
Year of first litter
Glass et al. 2024



Glass, T.W., Beausoleil, R.A., Elbroch, L.M., Kertson, B.N., Maletzke, B.T., Martins, Q., Matchett, M.R., Vickers, T.W., Wilmers, C.C., Wittmer, H.U. and Robinson, H., 2024. Limited cougar recolonization of eastern North America predicted by an individual-based model. *Biological Conservation*, *298*, p.110756.

-
-

Male dispersal vs Recolonization
****mortality of simulated male dispersers 1995-2015**



The "Connecticut Cat," 2011

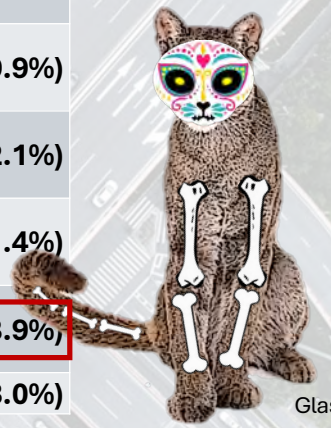
Glass et al. 2024
Mortality from: LaRue et al. 2019

Mortality of simulated male disperses 1995-2015.

The "Connecticut Cat," 2011

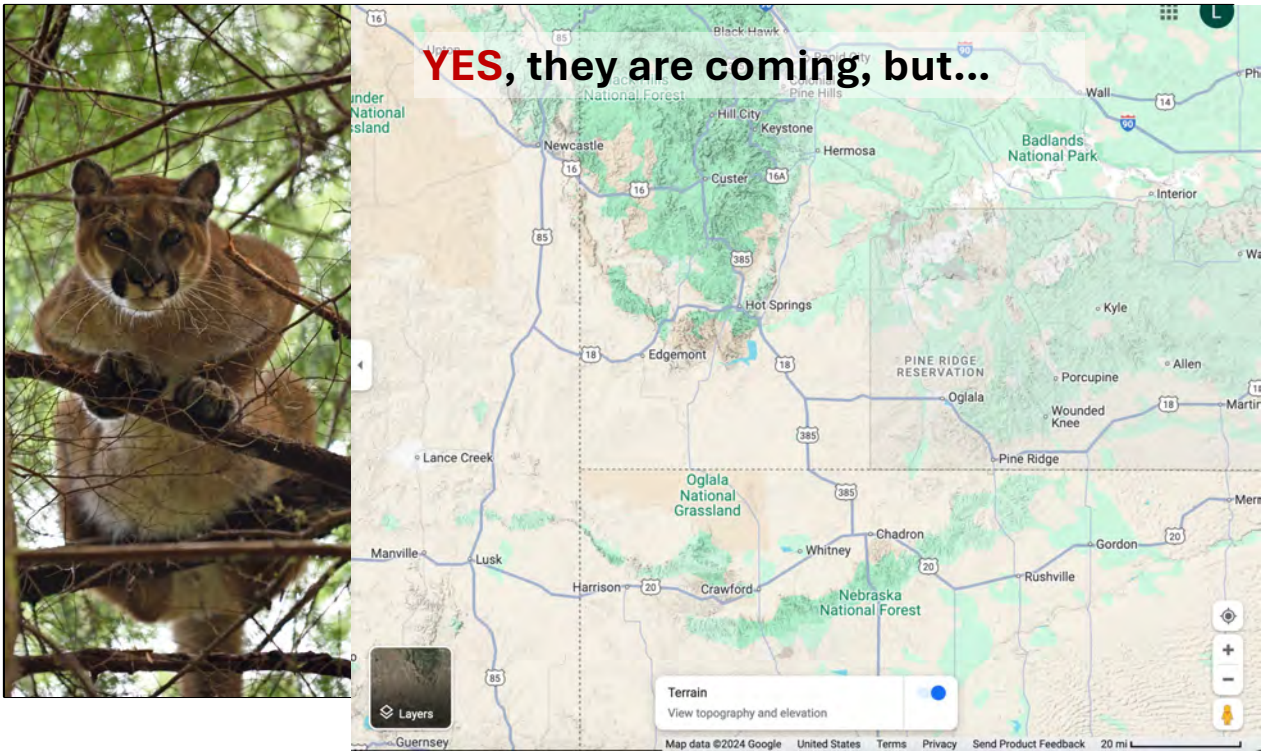
86.3% of Eastward-moving females will likely die.

Outcome	
Harvest	35.4% (35.1 – 35.5%)
Roadkill	29.7% (29.5 - 29.9%)
Non-harvest mortality	11.9% (11.8 – 12.1%)
Natural mortality	11.1% (11.0 - 11.4%)
Established and reproduced	8.8% (8.7 – 8.9%)
Established without mate	2.9% (2.8 – 3.0%)



Glass et al. 2024

Glass, T.W., Beausoleil, R.A., Elbroch, L.M., Kertson, B.N., Maletzke, B.T., Martins, Q., Matchett, M.R., Vickers, T.W., Wilmers, C.C., Wittmer, H.U. and Robinson, H., 2024. Limited cougar recolonization of eastern North America predicted by an individual-based model. *Biological Conservation*, *298*, p.110756.


YES, they are coming, but...
Black Hawk
Hill City
Keystone
Newcastle
Hermosa
Custer
Badlands National Park
Interior
Hot Springs
Kyle
Edgemont
PINE RIDGE RESERVATION
Porcupine
Allen
Oglala
Wounded Knee
Lance Creek
Pine Ridge
Oglala National Grassland
Chadron
Whitney
Gordon
Manville
Lusk
Harrison
Crawford
Rushville
Nebraska National Forest
Guernsey
Layers
Terrain
View topography and elevation
Map data ©2024 Google
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Vermont Department of Fish and Wildlife
Wildlife Action Plan - Revision 2015
Species Conservation Report

Common Name: **Eastern Mountain Lion**
Scientific Name: **Puma concolor couguar**
Species Group: **Mammal**

Conservation Assessment

Final Assessment: Medium Priority

Global Rank: G5 **Global Trend:**
State Rank: SH **State Trend:** N/A
Extirpated in VT? yes **Regional SGCN?** No

Species Strategies

Strategy Type	Strategy Priority	Strategy Description	Performance Measure
Policy & Regulations	High	Pending federal delisting, maintain and enforce state protections of entire puma Genus.	1
Research	Medium	Identify areas within state that could support viable Mountain Lion populations (Glick 2014) and develop a state recovery plan.	2 3
Awareness Raising and Communications	High	Determine public attitudes towards Mountain Lion recovery efforts in VT (e.g. McGovern and Kretser 2014); Provide interpretive and public education material about Mountain Lions.	4 5

What we're currently working on?

- Numerous social studies assessing tolerance for large carnivores and support for reintroduction. Our initial work was done to compare across states, and now we are refining our work with data collected at the county level.

(*Without doubt additional targeted surveys will need to be conducted in Vermont across various constituent groups as part of a local feasibility study.)

- Mapping habitat as a combination of human tolerance and habitat suitability
- Mapping probable human-caused mortality / survival across the region

(*Our habitat work will make mapping suitable habitat in VT, will be a much easier task.)

st and fastest way to produce the required materials for a feasibility study is to pay professional contractors to do the work. The inclusion of graduate students makes the process much much longer and much more expensive. In terms of time I'd suggest a complete feasibility study could be conducted in 18 months.


Thank you for listening
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