New Hampshire
Wildlife Coalition

April 17,2023

Mr. Scott Mason, Executive Director
New Hampshire Fish and Game Commissioners
NH Fish & Game Department
11 Hazen Dr.
Concord, NH 03301

RE: Comments 2023-2024 Biennial Rulemaking

Dear Director Mason and Commissioners:

In accordance with the announcement governing comments on biennial rulemaking I submit the following comments.

These comments are in three parts:

1) A review of the role of predators in New Hampshire's ecosystems and the need for biennial rules changes.
2) Our proposal for biennial rules changes.
3) "Beyond Harvest and Catch per Unit Effort"- Recommendations for additional lines of evidence to support New Hampshire furbearer management decision-making.

Respectfully submitted,

WS Bosworth
Weldon Bosworth, Ph.D.
for NH Wildlife Coalition

The Role of Predators in New Hampshire's Ecosystems

Predators play a crucial role in New Hampshire ecosystems and are an integral part in the dynamic balance and functioning of ecosystems. Their presence or absence can have significant effects on the overall health and stability of these ecosystems. Some of the ecosystem functions predators provide:

1) Regulation of prey populations: Predators help to control the populations of their prey species. By hunting and consuming herbivores, such as deer or rodents, predators help to prevent overgrazing or overpopulation of these prey species which helps to maintain a healthy balance between predators, prey, and the vegetation upon which their prey feed. <u>Healthy forests need healthy predator populations</u>.

2) Biodiversity conservation: Predators play a critical role in maintaining biodiversity in New Hampshire ecosystems. They help to regulate the populations of various prey species, preventing any one species from dominating and outcompeting others. This promotes a diverse array of plant and animal species, which contributes to the overall health and resilience of the ecosystem.

3) Trophic cascade effects: Healthy predator populations can have cascading effects throughout the food web. This is known as trophic cascades. When predators are present in an ecosystem, their activities regulate the population sizes of their prey, which in turn can influence the populations of other species at lower trophic levels. For example, if the population of coyotes and bobcats, both apex predators in New Hampshire, declines, this can lead to an increase in the population of deer, their prey. This can then result in increased browsing pressure on vegetation, which can have cascading effects on plant communities, insects, and other animals that depend on those plants.

4) Control of zoonotic diseases: By preying on rodents, they can limit the spread of zoonotic diseases such as Lyme disease which can be transmitted from rodents to humans. By selectively targeting the sick or weak members of a prey population they can remove animals that are more likely to be disease carriers. This is especially critical in New Hampshire where Lyme disease and other tick borne diseases are on the rise.

5) Strengthening genetic "health" of prey populations: By preying on the sick, weak and old members of a prey populations predators help strengthen the populations gene pool.

6) Ecosystem resilience: Predators help to maintain the resilience of ecosystems by regulating the populations of prey species. This helps ecosystems withstand disturbances such as climate change, disease outbreaks, or habitat loss.

7) Behavior modification: The presence of predators can also influence the behavior of prey species. Prey species may alter their feeding, mating, or movement behaviors in response to the possibility of predation. This can have indirect effects on ecosystem dynamics, such as influencing the distribution and abundance of certain plant species, which in turn can affect other species in the ecosystem.

In conclusion, healthy predator populations predators are essential components of New Hampshire ecosystems. Wildlife management efforts should prioritize maintaining healthy predator populations. Unfortunately, in New Hampshire, predators always seem to “bat last”, i.e., less time and effort is spent on monitoring and understanding predator populations than on “game” populations. This is counterintuitive since the health of “game” populations is, to a large extent, dependent on a healthy population of predators.

The sustainability of New Hampshire’s game species populations, white-tailed deer, bear, turkey, etc. is testimony to focused management of these species. Their harvest is relatively constant year to year. In addition, New Hampshire’s moose population, because it is significantly impacted by winter ticks, is closely monitored and decisions made annually to ensure a reasonably healthy population. These are examples of successful wildlife population management.

In contrast, the significant decline over the last 30 years in the harvest of all furbearer species except coyotes is testimony to ineffective management (See Figure 1 and Table 1 below)[1]. Particularly disturbing is the significant decline in the harvest of all predators in the last 20 years (See the following four graphs depicting the “Trends in Predator Furbearer Harvest Last 20 Years”, below).

For three of the predator species, fisher, red fox and gray fox, catch per unit effort (CPUE) metrics also show a decline (See graphs on “Trends in CPUE of Fisher, Red Fox and Gray Fox” below). In these graphs, unlike those presented at the biennial hearing, a frame of reference for the decline has been included. In one graph for each species the annual average CPUE for the years 1990-2004 compared to the annual average CPUE for the years 2005-2022, and for the second graph for each species, a linear regression line depicting the rate of decline in CPUE over the period 1990-2022. Thes following table compares the decline for each species using both methods.

Species	Decline comparing annual average CPUE for the period 1990-2004 to the period 2005 -2022	Decline based upon interpolation of regression line
Fisher	52%	70%
Red Fox	34%	50%
Gray Fox	40%	68%

While the magnitude of change may be somewhat different depending upon the method, both methods, using an objective frame of reference, conclude there is a significant change. The concurrence of these two lines of evidence should be a “wake up call” to implement some management action. It should be noted that the threshold of change in harvest for other species, e.g., white-tailed deer and bear, that warrants management action is 12.5%.

This leads us to our recommendations for changes in biennial rules.

[1] All data for these graphs and tables is NHFG data (See Table 2 and Table 3)

Our Proposal for Changes in Wildlife Rules

We propose the following rules changes for the 2023-2024 biennium:

1) Closing the trapping and hunting season for fisher statewide.
2) Limiting the bag limit of red fox and gray fox to three per season, that limit to apply to both trapping and hunting with firearms, crossbow or bow and arrow.
3) Shortening the season for taking red fox and gray fox by firearms, crossbow or bow and arrow to four months, December 1 through March 31.
4) Closing the season from April 1 to August 31 for taking coyotes by firearms, cross bow or bow and arrow.
5) Requiring permits or tags and registration for the taking of red fox, gray fox or coyote by firearms, cross bow or bow and arrow.

These proposals are made in recognition of the value of New Hampshire's predatory furbearers to New Hampshire's ecosystems and the fact that the current rules are based upon only a partial understanding of the abundance of these predatory species gained through trappers reports. Until a database can be established for annual harvest of these predator species that includes those shot through their long seven-month open season, it is impossible to evaluate with any confidence the impact of current seasons and bag limits on these populations.

For these reasons, a cautionary approach is recommended. The precautionary principle is a guiding principle in environmental and wildlife management that advocates for making management decisions that favor the well-being of the wildlife populations when conclusive scientific evidence of impact is not available. In this case, the uncertainty of how many of these predators are shot each year suggests that until such data are available rules governing the harvest of predators should be conservative.

Beyond Harvest and Catch per Unit Effort

New Hampshire Fish and Game is indeed fortunate to have a consistent database on harvest and CPUE dating at least back to 1990, and for harvest of several species dating back to 1922. However, my experience over the last 6 years is that rather than relying on this database to make decisions, rationale is offered during biennial rulemaking to disregard these data and rely instead upon subjective and anecdotal information. As an example, although the fisher CPUE in the southern tier showed over a 50% decline during the most recent biennial rulemaking presentation, reasons were given why one, essentially, should disregard this evidence. Instead, the discussion was diverted to other studies that were being conducted or planned to be conducted that would, somehow, show different results. I believe decision making that places more weight of evidence on unsupported opinions and anecdotal evidence than on 30 years of data collected using a consistent protocol is far from "sound science".

As an example, I've heard many times that one explanation for the decline in furbearer's harvest is 'fewer trappers with lower success" and that changes in habitat are responsible. However, no data has ever been offered to objectively substantiate these claims. <u>Actually the number of trappers has actually increased over the last 30 years and if changes in habitat are responsible, why would that variable not be operative for populations of game species which seem to be doing just fine?</u>

I do believe, however, that collecting additional data on predatory furbearers using other lines of evidence to supplement the trapping data will certainly increase confidence in decision-making. The presentation on furbearers at this year's biennial rulemaking hearings included a discussion on "secondary indices to supplement the CPUE data for coyote, red fox, gray fox and coyote" whose results, it was implied, would be very useful in supplementing both harvest and CPUE data. These included:

1) Spring Turkey Survey
2) Fall Archery Hunter Survey
3) A UNH monitoring study using camera traps.

I have reviewed the results of the two survey efforts and believe that they will provide useful data provided they continue to be conducted annually and with consistent protocols. The information for the first three years shows little variability, however, and it will take several more years and careful comparison to the trapping data to see whether these surveys are sensitive to changes. Essentially, until this line of evidence is validated by showing changes that the harvest and CPUE metrics also document, the survey data are of very limited use.[2] Until then, these survey results cannot be used as a secondary index and no weight should be placed upon their results.

The UNH monitoring study is an ambitious effort and, as I mentioned last year when it was introduced, if continued for several years and in several different habitats, can provide useful information. One of New Hampshire Wildlife Coalition's scientists attended a recent public presentation on this monitoring study and provided a critical review of the study. That review is appended as Appendix 1 and summarized here:

> *In summary, the results the study could be used to provide annual estimates of the statewide or WMU densities and abundance of managed furbearers and be useful in describing inter-annual trends if the design is repeated consistently over sufficient generation times (years) for the mammal species of interest. However, it is very clear to me that the results of this study will not provide reliable estimates of population abundance or density (i.e., the number of each mammal species of interest present in each WMU or statewide during each period monitored) as stated in the study objectives (Objective 1) without additional work to address the inherent assumptions of the statistical model and methods.*
>
> *The most obvious assumption made and not tested is that the population of each wildlife species of interest detected (sampled) by the cameras in this study is "closed" with respect to immigration and emigration into and out of the study area. Simply put, the sampling design, NEST model, and its variance estimator only provides accurate population abundance or density estimates if there is no movement by the target species into or out of the study area (e.g., camera cluster or WMU) during the sampling interval.*
>
> *… at best, this camera trap design provides unadjusted estimates of detections per unit area that could be biased high by multiple detections (counts) of the same individual. Furthermore, the investigators indicated that the camera clusters were not truly random, because they avoided*

[2] This means that results from these surveys is consistent with the results of the trapping data in terms of magnitude and timing of relative changes.

> *placing cameras on game trails, footpaths, and in wetlands. Game trails exist because they are frequently traveled by one or more furbearers and footpaths are commonly traveled by many of these furbearer species. Therefore, by eliminating a randomly selected camera location if it viewed a game trail or footpath and moving that location elsewhere, a true random allocation of camera sites was not sampled, with the result being an underestimate of the number of detections. Likewise, the perimeter of wetlands is often traveled by these furbearers, again biasing the number of detections downward by not allowing a game camera to be placed there if the random point fell there. By violating the randomness assumption of camera placement there is no way of knowing if the number of camera detections per unit area from this study is biased high, low, or not at all.*

These are but a few of the shortcomings of this study which will need to be addressed in future years of conducting the study. Until these shortcomings are addressed, the results of this monitoring survey cannot be used as a supplemental line of evidence with which to evaluate relative changes in the populations of any of the targeted species.

You should also be aware that <u>before</u> an index of abundance, such as would result from the camera trap study, can be used to make quantitative assessments of population trends, it must first be calibrated, ideally, against an absolute measure of abundance. Since absolute measures of abundance are generally not practical for furbearers, an alternative option is to calibrate two indices of abundance against one another, for example the trapping results and the camera trap results. A strong concordance between the two indices indicates that they can be considered reliable reflections of actual abundance, particularly if the association is maintained in a variety of habitats.

Based upon my experience with tweaking and working the nits out of experimental methods such as the camera trap study, I would estimate it would be at least five years before there would be sufficient time-series data to make it a useful line of evidence. In addition, it would have to be continued at a relatively high cost to NHFG.

Other programs which could be implemented which have the potential to provide data that would be useful in supplementing the trapping data at less cost are:

1) Monitoring roadkill, and
2) Requiring mandatory tags (or permits) and reporting of all furbearing predators shot with firearms, crossbow or bow and arrow.

<u>Roadkill Monitoring</u>

Although there are some roadkill data collected by NHFG, there does not appear to be any consistent protocol for collecting these data and the data are limited to only a few species. Although I've heard it mentioned that these data are evidence or corroboration of "trends", there is no way unless the data are collected following the same protocols from year to year and place to place that this conclusion would stand up to scientific scrutiny.

I have commented before on how collecting roadkill data could be used as a line of evidence to supplement the trapping data. Once a roadkill monitoring program is set up it could be continued at very little cost to the Department and, in my opinion, would have a greater probability of providing useful data in a shorter time than the turkey and bowhunter surveys.

Requiring mandatory tags (or permits) and reporting of all furbearing predators shot with firearms, crossbow or bow and arrow.

This was the subject of my petition in September 2021 and I direct your attention to that petition for how such a program would work. Having mandatory reporting of furbearers taken by trap and not those taken by firearms, crossbow or bow and arrow provides only an incomplete basis for estimating changes in these predator populations over time. Allowing unlimited take of furbearers (except for fisher which have a bag limit of two) by firearms, crossbow or bow and arrow without knowing whether that furbearer population can sustainably tolerate that harvest is analogous to withdrawing funds from a savings account without knowing how much is in the account.

Requiring mandatory tags and reporting would cost far less to set up than the UNH study and provide much more useful information in a shorter time. Once setup, it can be continued at little cost and after a few years provide data comparable to the trapping data.

Trends in the Harvest of New Hampshire's Furbearers
(Data upon which these graphs are based are NHFG's trapping data, see tables which follow)

Figure 1.

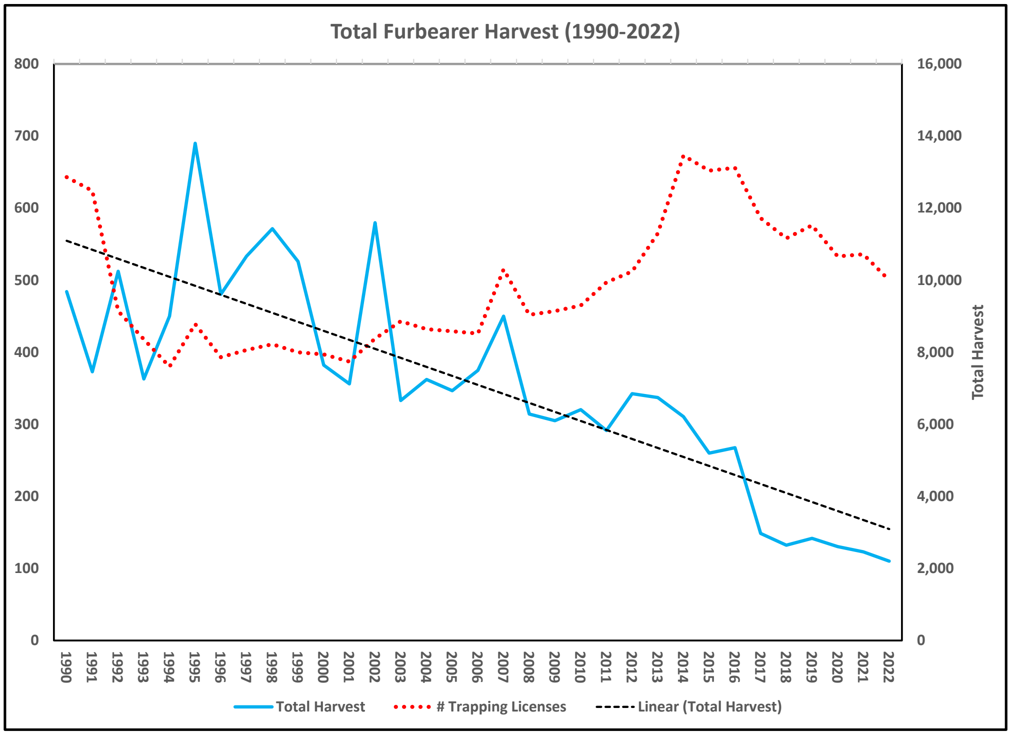
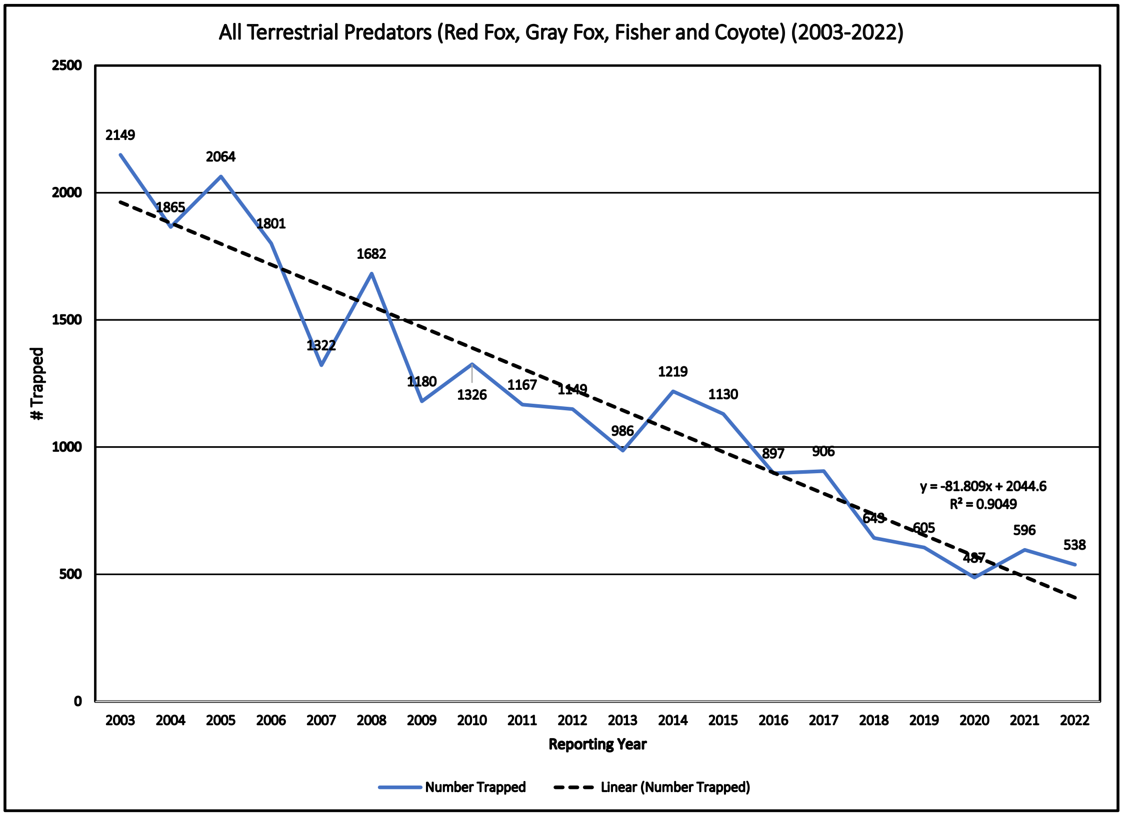


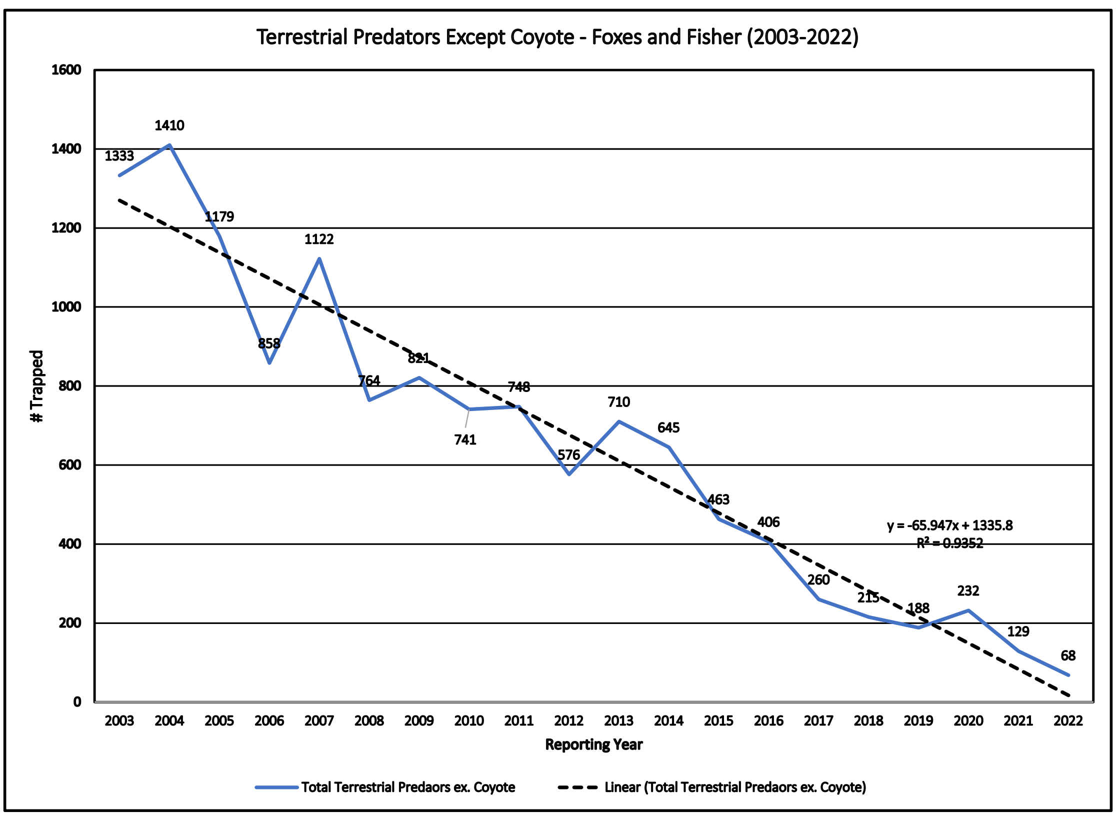
Table 1.

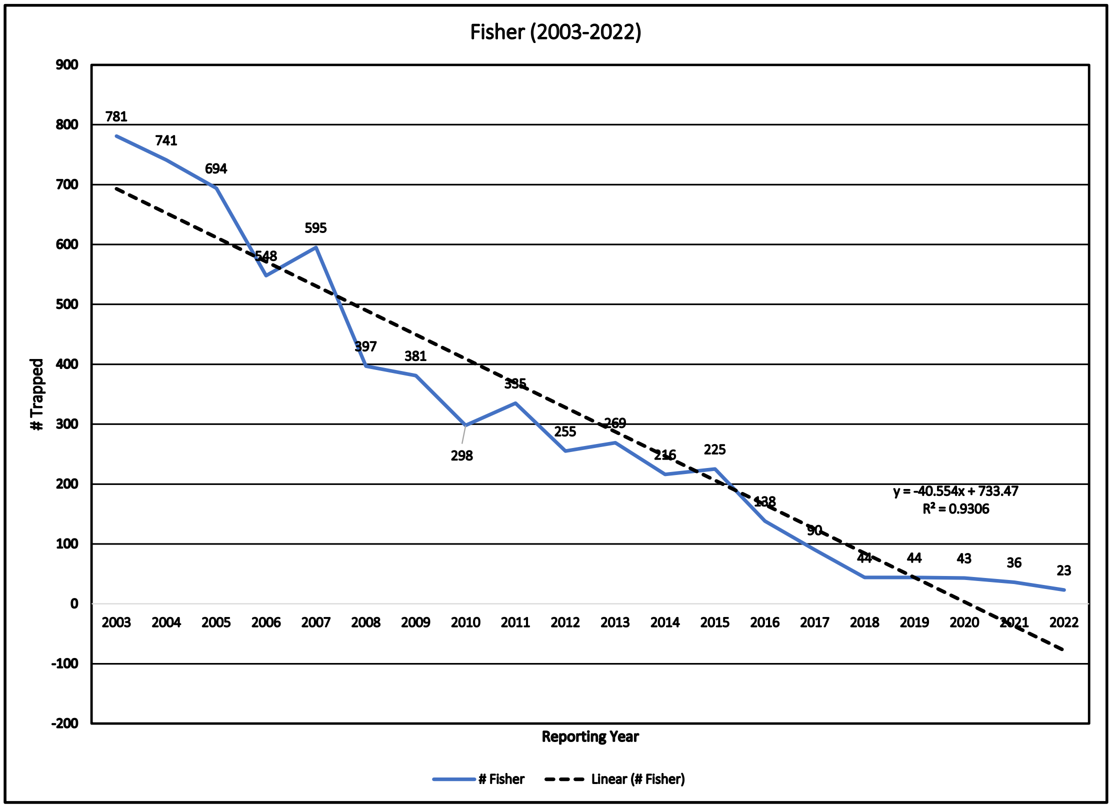
Species	Annual Average Harvest 15-year period 1990-2004	Annual Average Harvest last three years 2000-2022	Percent Decline
Beaver	3514	1198	66%
Muskrat	2856	363	87%
Otter	334	104	69%
Mink	434	47	89%
Raccoon	696	183	74%
Coyote	351	349	1%
Fisher	682	34	95%
Gray Fox	109	18	83%
Red Fox	353	89	75%
# Trapping Licenses	443	*539	+32%

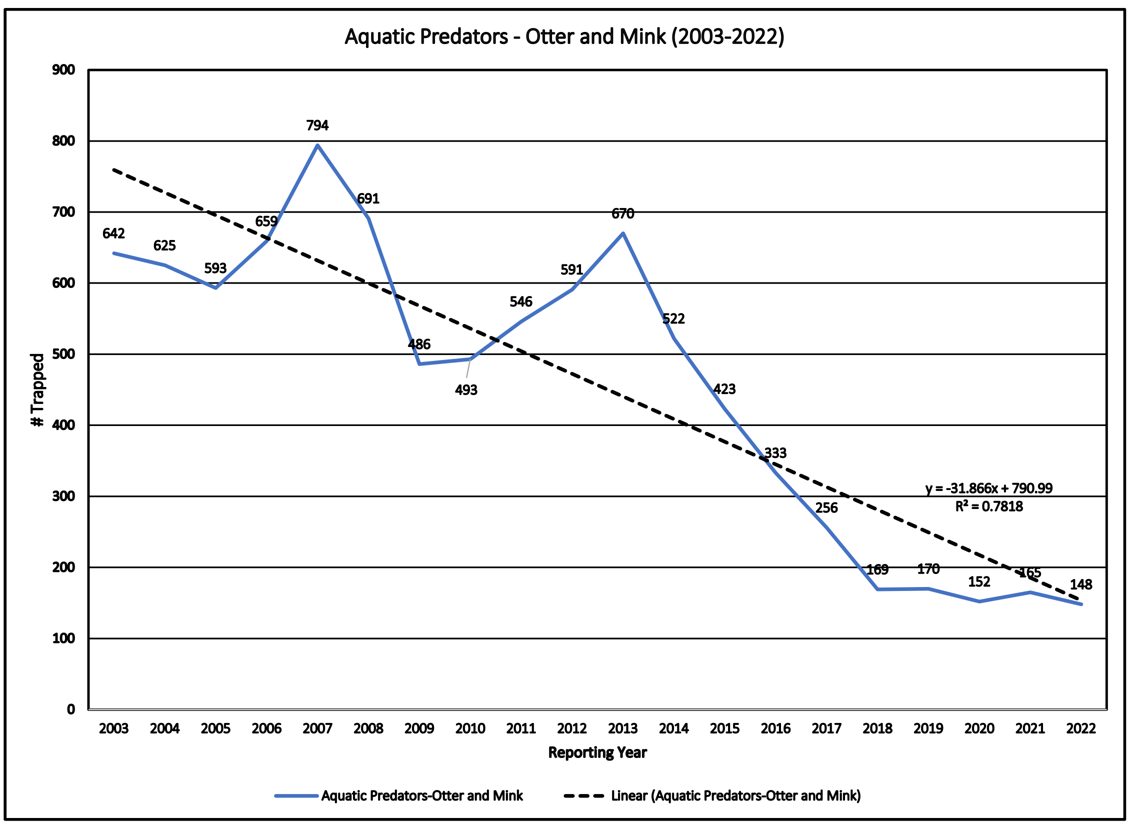
One species (Fisher) >90% decline
Three Species (Muskrat, Mink and Gray Fox) > 80% decline
Two Species (Racoon and Red Fox) > 70% decline
A total of 6 of 9 species >70% decline
* 2022 estimated at 550

Trends in Predator Furbearer Harvest Last 20 Years

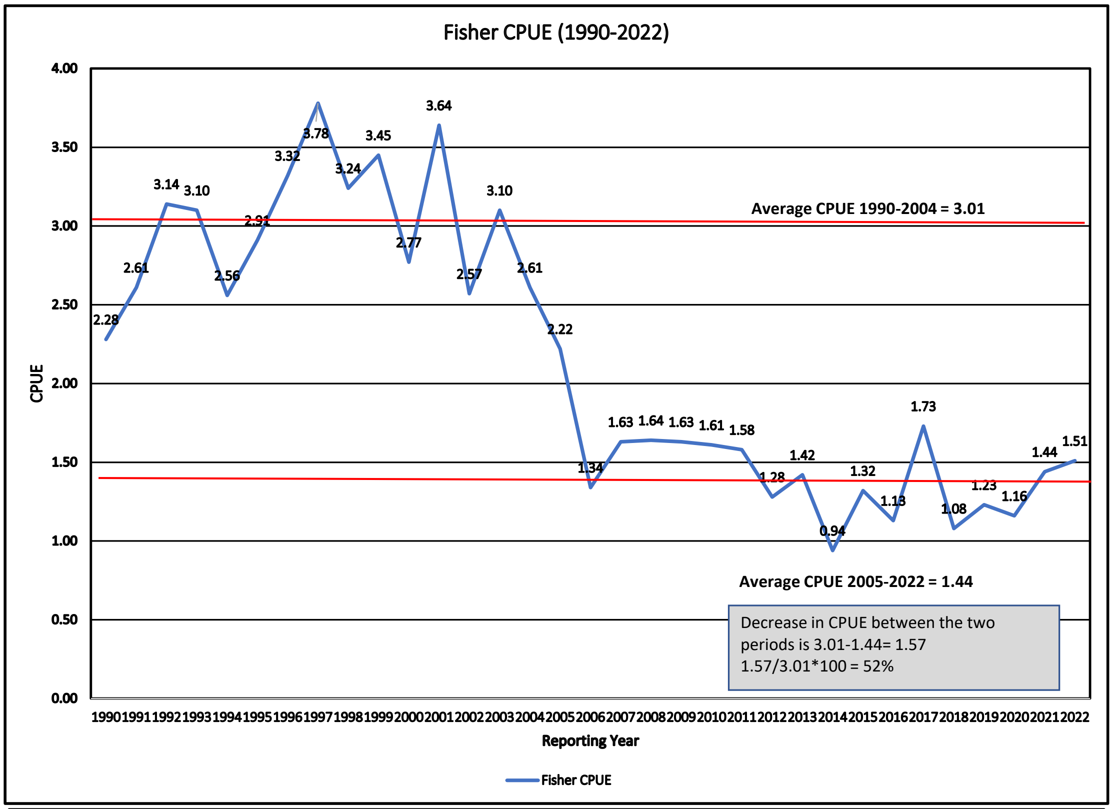


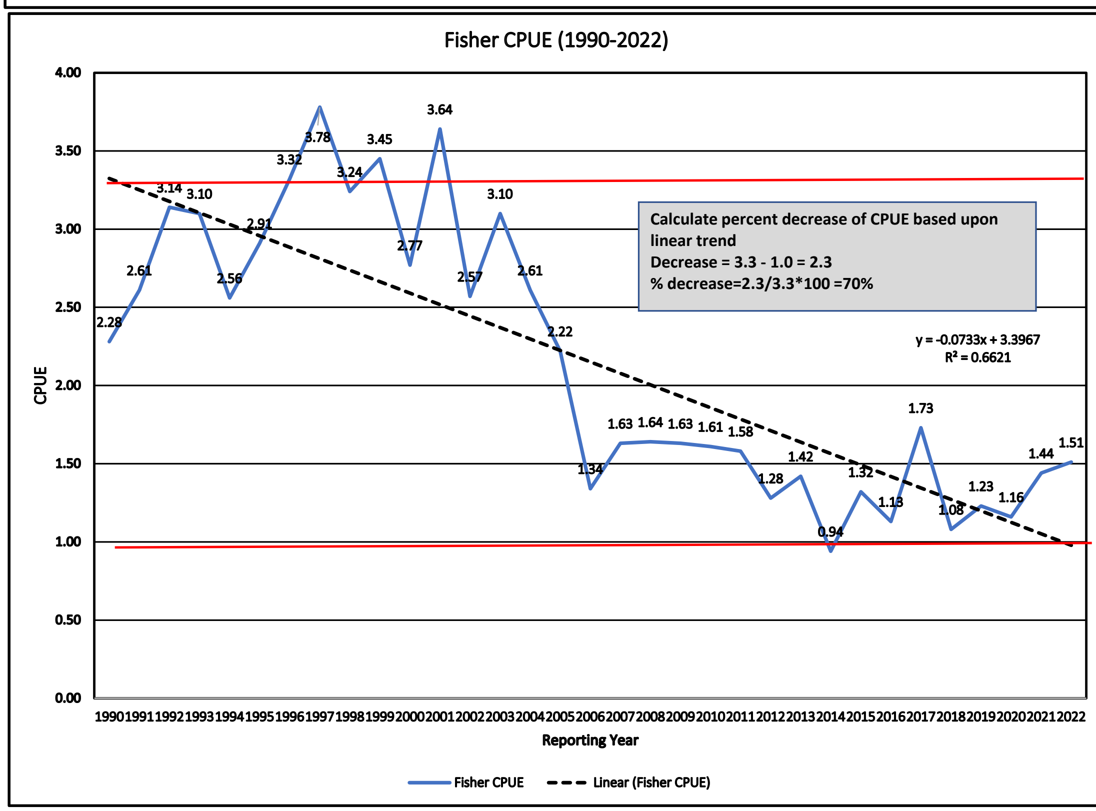



Fisher (2003-2022)
Trapped
Reporting Year
y = -40.554x + 733.47
R² = 0.9306
# Fisher
Linear (# Fisher)

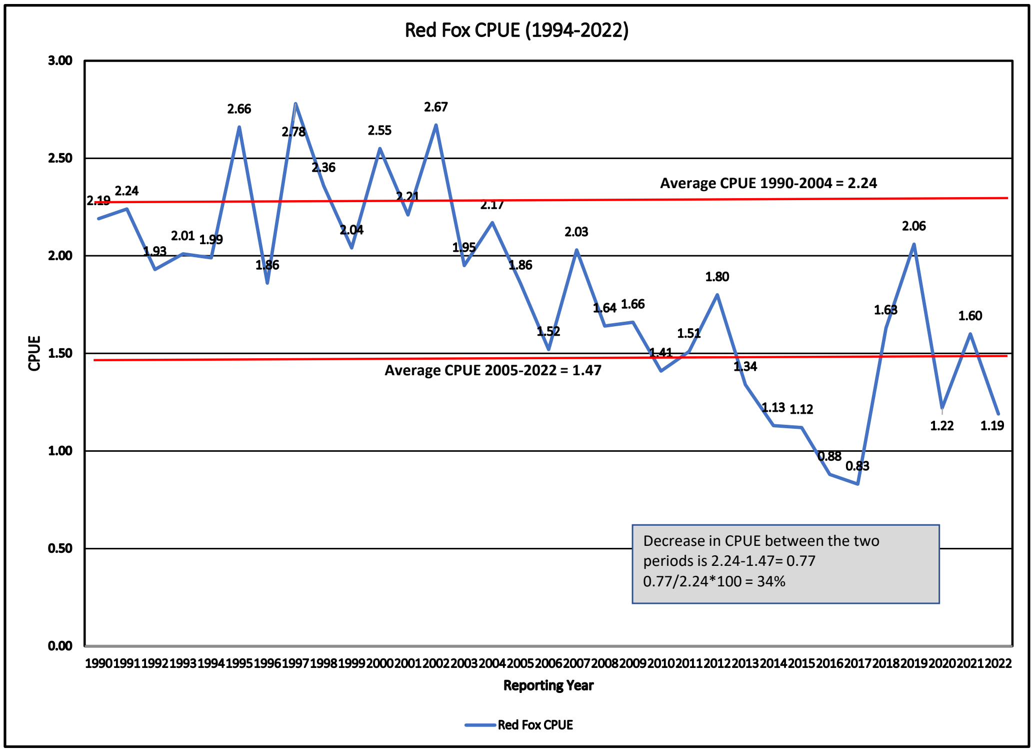

Aquatic Predators - Otter and Mink (2003-2022)
Trapped
Reporting Year
y = -31.866x + 790.99
R² = 0.7818
Aquatic Predators-Otter and Mink
Linear (Aquatic Predators-Otter and Mink)

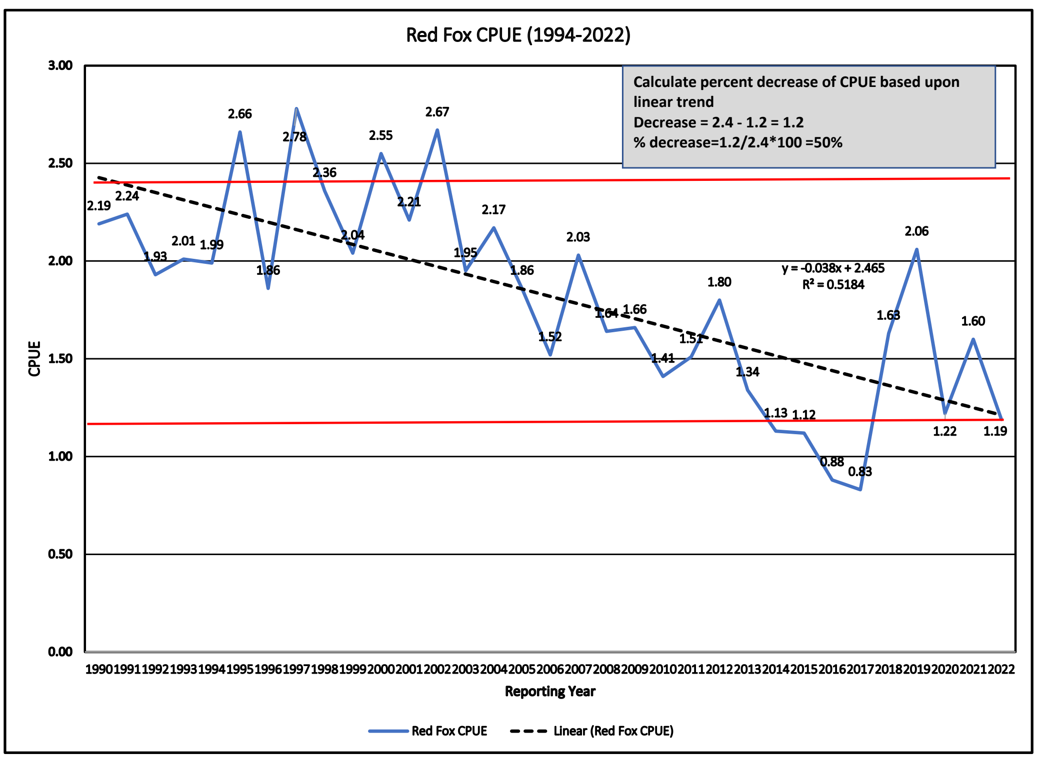
Trends in CPUE of Fisher, Red Fox and Gray Fox
(Changes in Fisher CPUE estimated by two methods)

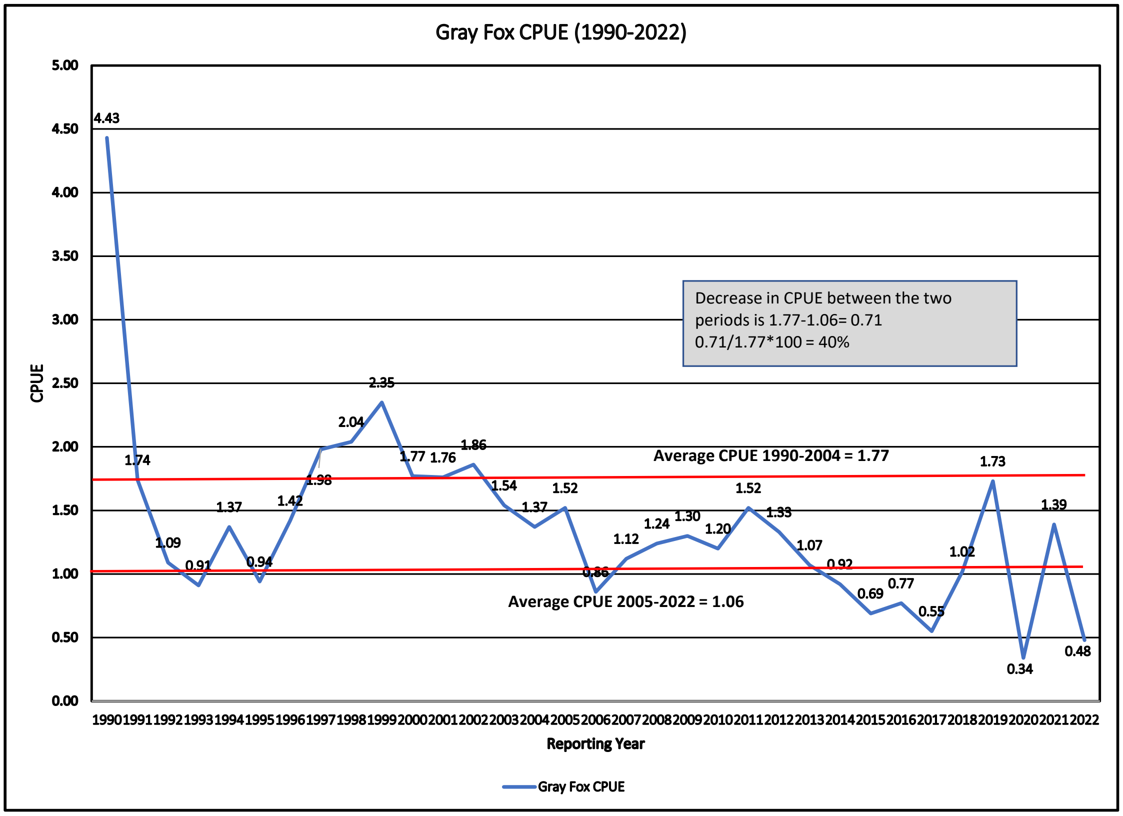




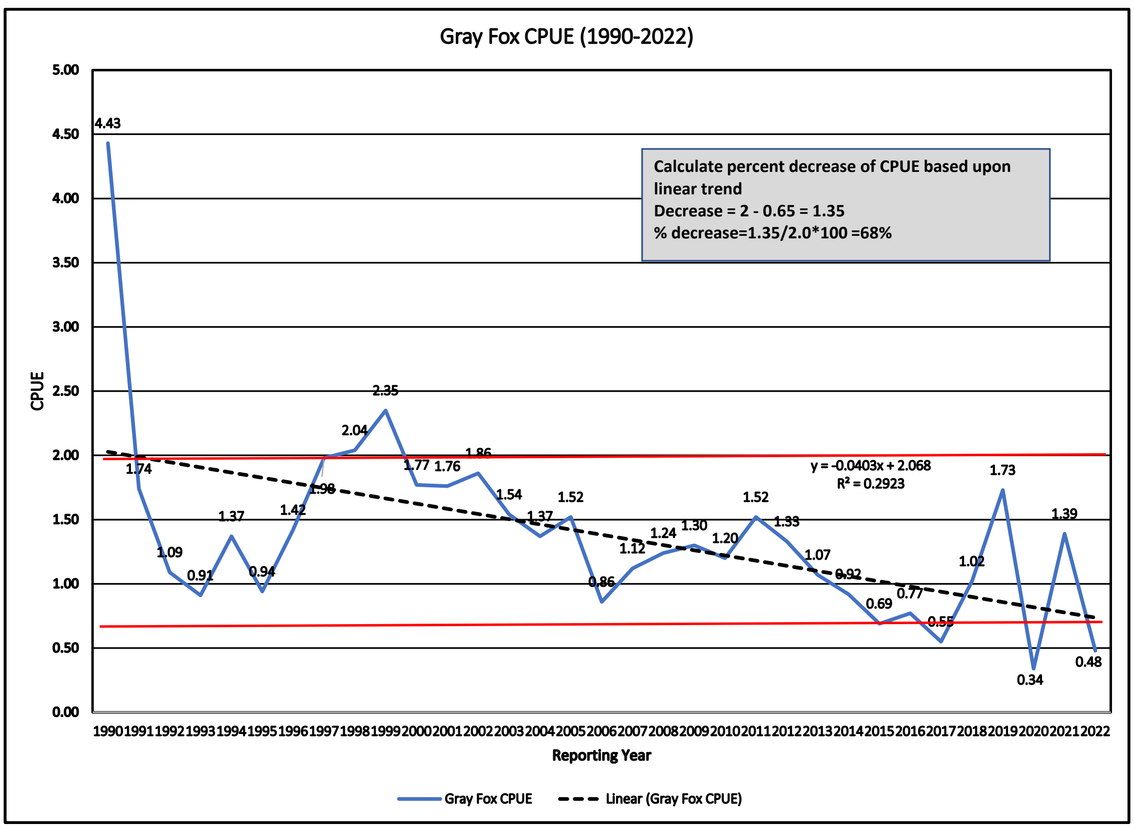
(Changes in Red Fox CPUE estimated by two methods)







Gray Fox CPUE (1990-2022)
Decrease in CPUE between the two periods is 1.77-1.06= 0.71
0.71/1.77*100 = 40%
Average CPUE 1990-2004 = 1.77
Average CPUE 2005-2022 = 1.06
CPUE
Reporting Year
Gray Fox CPUE



Gray Fox CPUE (1990-2022)
Calculate percent decrease of CPUE based upon linear trend
Decrease = 2 - 0.65 = 1.35
% decrease=1.35/2.0*100 =68%
y = -0.0403x + 2.068
R² = 0.2923
CPUE
Reporting Year
Gray Fox CPUE
Linear (Gray Fox CPUE)

Table 2. CPUE 1990-2022 (NH Fish and Game Data)

Season (Reporting Year)	Beaver	Muskrat	Otter	Mink	Raccoon	Coyote	Fisher	Gray Fox	Red Fox
1990	5.90	7.96	3.39	1.16	18.04	1.15	2.28	4.43	2.19
1991	7.33	10.80	2.39	1.58	17.58	1.36	2.61	1.74	2.24
1992	6.51	7.34	2.08	1.21	24.94	1.64	3.14	1.09	1.93
1993	9.74	7.69	2.06	1.32	19.21	1.76	3.10	0.91	2.01
1994	6.58	6.92	1.43	1.01	20.91	1.81	2.56	1.37	1.99
1995	7.91	6.90	2.02	1.76	14.40	1.18	2.91	0.94	2.66
1996	7.66	6.73	2.21	1.75	26.50	1.83	3.32	1.42	1.86
1997	8.51	10.20	2.29	1.77	24.50	3.00	3.78	1.98	2.78
1998	7.04	7.90	1.19	2.40	30.60	2.32	3.24	2.04	2.36
1999	9.28	11.20	2.81	4.20	8.22	2.01	3.45	2.35	2.04
2000	9.87	10.10	2.28	2.72	3.62	1.34	2.77	1.77	2.55
2001	8.85	7.97	1.60	1.68	3.87	2.47	3.64	1.76	2.21
2002	9.99	8.97	2.12	2.25	3.97	2.86	2.57	1.86	2.67
2003	8.55	8.91	2.15	1.85	3.16	2.26	3.10	1.54	1.95
2004	8.82	10.60	2.33	1.73	3.38	1.68	2.61	1.37	2.17
2005	8.97	10.60	1.76	2.19	2.57	1.85	2.22	1.52	1.86
2006	6.38	7.76	1.58	2.07	2.46	1.77	1.34	0.86	1.52
2007	7.31	5.41	1.58	1.30	1.78	2.77	1.63	1.12	2.03
2008	8.82	7.28	2.11	2.64	3.17	2.30	1.64	1.24	1.64
2009	7.52	5.87	1.63	2.08	2.67	2.30	1.63	1.30	1.66
2010	7.62	6.24	2.48	2.07	3.57	2.00	1.61	1.20	1.41
2011	8.82	5.73	1.97	2.08	3.18	1.92	1.58	1.52	1.51
2012	6.86	5.64	1.55	1.99	3.07	2.40	1.28	1.33	1.80
2013	5.29	4.85	1.26	1.43	2.49	1.46	1.42	1.07	1.34
2014	5.96	5.07	1.55	1.09	2.72	1.21	0.94	0.92	1.13
2015	5.52	4.70	1.96	1.91	2.20	1.21	1.32	0.69	1.12
2016	4.71	5.31	1.46	1.47	3.41	1.06	1.13	0.77	0.88
2017	7.23	5.70	2.77	1.57	1.62	1.41	1.73	0.55	0.83
2018	6.92	6.53	1.65	1.75	3.68	1.52	1.08	1.02	1.63
2019	8.27	6.75	3.15	2.05	2.95	2.17	1.23	1.73	2.06
2020	6.14	5.64	2.11	1.34	1.68	1.19	1.16	0.34	1.22
2021	5.73	11.17	2.80	2.05	2.81	1.77	1.44	1.39	1.60
2022	7.45	6.48	2.29	1.53	2.71	2.03	1.51	0.48	1.19

Table 3. Harvest 1990-2022 (NH Fish and Game Data)

Season (Reporting Year)[1]	Beaver	Muskrat	Otter	Mink	Raccoon	Coyote	Fisher	Gray Fox	Red Fox
1990	3098	3764	329	465	890	169	406	58	504
1991	2589	2381	261	358	796	155	440	63	415
1992	3372	3886	316	537	965	227	442	76	426
1993	2059	2525	285	381	854	260	426	86	381
1994	3612	2273	405	441	994	298	525	76	378
1995	5901	4389	504	513	888	342	722	97	444
1996	4048	2731	317	386	902	380	426	75	343
1997	4752	2976	451	587	519	345	642	129	264
1998	3980	3980	344	429	684	398	1187	104	324
1999	3784	3517	288	453	923	318	923	120	195
2000	3412	1714	291	416	374	279	885	89	181
2001	2879	2169	244	262	244	358	683	75	208
2002	4313	3577	386	616	555	556	1001	183	409
2003	2280	1458	275	367	415	532	781	188	364
2004	2626	1495	321	304	433	654	741	215	454
2005	2366	2118	279	314	55	622	694	104	381
2006	3057	2109	367	292	350	464	548	71	239
2007	3377	2651	345	449	495	560	595	190	337
2008	2270	1587	214	477	557	416	397	134	233
2009	2756	1170	209	277	362	505	381	154	286
2010	2603	1736	240	253	409	426	298	189	254
2011	2337	1272	214	332	524	401	335	187	226
2012	3229	1698	344	247	347	410	255	114	207
2013	2484	1800	285	385	571	509	269	150	291
2014	2324	1658	241	281	577	485	216	172	257
2015	2044	1383	166	257	454	434	225	76	162
2016	2244	1432	163	170	434	500	138	101	167
2017	1202	547	146	110	321	383	90	55	115
2018	1140	500	82	87	230	390	44	56	115
2019	1371	557	95	75	249	299	44	26	118
2020	1318	363	119	33	177	364	43	30	159
2021	1165	402	97	68	190	409	36	15	78
2022	1167	335	106	42	206	277	23	13	32

Appendix 1

MEMORANDUM

DATE: 27 March 2023

TO: Weldon Bosworth, Ph.D.
New Hampshire Wildlife Coalition

FROM: Mark Mattson, Ph.D.

RE: UNH Presentation: Monitoring Mammals Across the Granite State

I attended a recent presentation titled "Monitoring Mammals Across the Granite State" by Dr. Remington Moll, Assistant Professor of Wildlife Ecology and Management of the University of New Hampshire (UNH) and his Ph.D. Graduate Student, Andrew Butler. This presentation was sponsored by the NH Audubon Society Seacoast Chapter coincident with their March monthly meeting held at the Seacoast Science Center in Rye, NH on 8 March 2023 beginning at 07:30 PM. There were about 20 people in attendance, including the presenters, and the presentation lasted for about 45 minutes. The purpose of this Memorandum is to provide my observations and comments about the content of this presentation as you requested.

The stated objectives of this underlying and ongoing research; forming the basis for this presentation, were:

Objective 1. To determine the efficacy of an emerging non-invasive technique to estimate furbearer abundance and wildlife-habitat relationships using camera trap data.

Objective 2. To compare population estimates from camera traps with those from track station surveys.

Objective 3. To determine the effect of lure on wildlife detection rate.

The presentation was clear, well prepared and presented, and likely targeted towards a lay audience, although perhaps also prepared for a wildlife management or scientific audience, because several slides presenting statistical formulation or statistical methods were skipped over and not discussed. The mammal species targeted by this research were: Moose, and some furbearer species as classified by the New Hampshire Fish and Game (NHFG), including bobcat, eastern coyote, fisher, martin, mink, and raccoon. Deer and bear were not specifically discussed.

The presenters first described their objectives, then discussed their sampling designs and methods. Their approach was to spatially partition the NH land area into 13 geographic units or strata, with each of these 13 strata defined as a single Wildlife Management Unit (WMU) as specified by NHFG. Each WMU is delimited primarily by road boundaries, thus facilitating NHFG's regulation of harvest seasons and take limits for hunted or trapped mammals in different parts of the state. However, because these units are spatially defined by man-made structures (roads), and not natural features like habitat type, the researchers also recognized four broad geographic zones within NH, generally corresponding to habitat features such as human development and forestry practices. These four habitat zones were described as southern tier, middle urbanized state, White Mountains, and northern forest harvest area. The investigators also indicated that part of their current or future research would be to explore the use of satellite imagery from Google maps, which is apparently updated weekly and has spatial resolution of 10 ft by 10 ft, to further partition the 13 WMUs into more specific habitat types that may be more germane to the mammal species studied.

A total of 302 wildlife cameras were deployed throughout the state to record target species detections, recorded by a short video clip on each camera. Within each WMU, clusters of eight to ten wildlife cameras were placed at random locations, with the number of clusters presumably selected in direct proportion to the area of each WMU. Therefore, the measurement parameter was the detection of one of the target species identified in a short video clip at each camera location. The cameras were deployed during an eight- or nine-week period in spring and early summer, considered to be the breeding and nursery season for the target species. This camera monitoring period was selected because the target species were assumed to not be moving into or out of the general area of the camera trap clusters, thus the sampled population was considered statistically "closed".

In addition to these camera traps, considered to be the primary sampling units, track station transects were established near the camera clusters to compare these traps to the camera results for detecting the target mammals. A track station was a three-foot diameter circle of cleared ground into which a layer of sandbox sand was spread and viewed frequently, and swept clean after viewing, to record the animal tracks for species identification, and between one and ten track stations were established for each transect. Having this second sampling method allowed the investigators to compare the number of sightings (detections) from the cameras to the species found leaving tracks in the sand circles.

Commercially purchased skunk scent was also placed, presumably randomly, at selected camera clusters and track stations to determine if adding a strong scent would increase the number of mammal detections. The investigators determined early in the study that the use of skunk scent as an attractant didn't work well and abandoned this method. It wasn't clear to me if the track stations worked or how these track station results compared to the camera trap results, but the rest of the presentation focused on the camera trap results.

Moose, black bear and deer were considered somewhat differently than the other target mammals and were not the primary focus of this presentation. Due to their large size, moose, bear and deer could perhaps also be detected (counted) by aerial surveys with drones, and the researchers expressed interested in future evaluation of drones that flew systematic transects over areas in the winter with no leaf cover to estimate moose or deer density, condition (twinning rates of moose), reproductive success and possibly population abundance as has been done in other states for censusing these large mammals.

Camera trap detections were entered into a database by teams of undergraduates examining the eight or nine weeks of camera monitoring. There was interest by the researchers in future work to use artificial intelligence to collapse the gaps between detections, thus reducing the time and tedium of processing the approximately 60,000 hours (302 cameras x 24 hours/day x ~8 weeks; my estimate) of recorded camera observations from the described study. Quality control verification of identification and detections was not mentioned.

The statistical model formula used to estimate density (#/KM^2) of each furbearer detected by the 302 wildlife camera traps deployed in the present study was referred to as a NEST model, as applied to this spatially stratified systematic cluster sampling design. Variance for the estimated density was calculated using the methods of Stevens and Olsen (2003) from the NEST model, but this variance estimator was not discussed in the presentation. The spatially stratified systematic sampling design using clusters of wildlife cameras is an important method that helps improve the precision of the density estimates among spatial strata by containing high variance among a restricted portion of the entire population sampled (Cochran 1977).

The NEST formula for estimating density from this camera trap study as presented used the number (N_C) of detections for a mammal species from each camera (C) and multiplied it by the duration the species is observed by the camera in seconds (Tc). This product (C*Tc) is then divided by the product of the measured or known area viewed by each camera in its detection zone (KM^2) and the total time (T) in seconds the camera recordings were reviewed. This formula produced the number of camera detections per unit area viewed, which could then be averaged among clusters and scaled up to the number of detections per unit area within each WMU (stratum). If multiplied by the area of each WMU, the resultant product would be the number of detections of each furbearer species per WMU.

Conceptually, the results from these statistical methods could be used to provide annual estimates of the statewide or WMU densities and abundance of managed furbearers and be useful in describing inter-annual trends if the design is repeated consistently over sufficient generation times (years) for the mammal species of interest. However, it is very clear to me that the results of this study will not provide reliable estimates of population abundance or density (i.e., the number of each mammal species of interest present in each WMU or statewide during each period monitored) as stated in the study objectives (Objective 1) without additional work to address the inherent assumptions of the statistical model and methods (Foster and Harmsen 2011).

The most obvious assumption made and not tested is that the population of each wildlife species of interest detected (sampled) by the cameras in this study is "closed" with respect to immigration and emigration into and out of the study area. Simply put, the sampling design, NEST model, and its variance estimator only provides accurate population abundance or density estimates if there is no movement by the target species into or out of the study area (e.g., camera cluster or WMU) during the sampling interval. When I asked the investigators about this fundamental assumption, they stated that they selected the nursery season time frame for monitoring because it was assumed each furbearer species of interest would remain nearby to their denning locations until their offspring were ready to disperse. But no testing of this closed population assumption was incorporated into the study as far as I can tell. Furthermore, I understand that mated pairs of furbearer species like the Eastern Coyote will remain nearby and defend home territory during the nursery season, thus satisfying the assumption of a closed population, but if either of the pair is lost during this assumed closed period, there may be immigration of unmated individuals from outside into the previously defended territory (Gese 2001), and thus represent an open population and violation of this closed assumption.

The investigators also stated that they relied on the random allocation of camera cluster placement within each WMU, and random scatter of cameras within each cluster, to ensure that the camera detections were representative of the local (WMU) population of each furbearer. However, a detection is not a count of each individual in that furbearer population unless each individual is uniquely identified, and not represented by a duplicate or multiple count of the same individual. Therefore, at best, this camera trap design provides unadjusted estimates of detections per unit area that could be biased high by multiple detections (counts) of the same individual. Furthermore, the investigators indicated that the camera clusters were not truly random, because they avoided placing cameras on game trails, footpaths, and in wetlands. Game trails exist because they are frequently traveled by one or more furbearers and footpaths are commonly traveled by many of these furbearer species. Therefore, by eliminating a randomly selected camera location if it viewed a game trail or footpath and moving that location elsewhere, a true random allocation of camera sites was not sampled, with the result being an underestimate of the number of detections. Likewise, the perimeter of wetlands is often traveled by these furbearers, again biasing the number of detections downward by not allowing a game camera to be placed there if the random point fell there. By violating the randomness assumption of camera placement, there is no way of knowing if the number of camera detections per unit area from this study is biased high, low, or not at all.

There are numerous "open" population statistical sampling designs that could have been used to estimate the absolute (not relative) species abundance of furbearers in NH (e.g., Seber 1982). Many of these open population estimators rely on mark/recapture techniques or DNA analysis of scat or hair samples to uniquely identify individuals, thus removing any potential for bias by multiple counting. These "open" population estimators often have built in tests of assumptions of immigration and emigration during the study period, thus allowing evaluation of the validity of the design and not requiring the "closed" population assumption for each wildlife species of interest.

The use of spatially explicit integrated population modeling techniques (Chandler and Clark 2014; Clawson et al. 2013; Skalski et al. 2012) to estimate furbearer actual abundance in NH WMUs could be particularly useful. For example, an integrated population model was used effectively for harvest management in neighboring Maine to estimate black bear distributions and their relationship to population abundance from 1997 through 2013, in combination with mark/recapture, radio tracking, and demographic data (Linden and Mckinney 2016). Spatially explicit integrated population models for each furbearer of interest are time and labor intensive, thus expensive, but their development and use in NH would provide scientifically valid abundance or density estimates for furbearer management (Murphy et al. 2022). At the very least, calibration of less intensive, and relative, indices of furbearer abundance that presently exist like the camera trap methods describe in this presentation, hunter observations, road kill counts (Mahard et al. 2016), or reported trapping harvest should be performed before the resulting data are used in harvest management decisions.

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