RATIONALE FOR OUR CONCLUSIONS ABOUT URBAN BLACK-TAILED DEER IMMUNOCONTRACEPTION IN OAK BAY AND ESQUIMALT, BC.

Briefing Note by Jason T Fisher, Ad. Associate Professor, University of Victoria
with contributions from Dr. Adam Hering (D.V.M., Ph.D.) and Dr. Andrew Barnas (Ph.D.)
and edited by Alina Fisher (MPAC).
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Bottom Line

In our joint Final Reports about the effects of immunocontraception (IC) in Oak Bay and Esquimalt, we concluded that IC likely contributed to reduction in the proportion of fawns in the population, and population density, in both regions. Below is a synopsis of our rationale.

Our conclusions that immunocontraception reduced deer reproduction and population density in Oak Bay and Esquimalt are supported by multiple independent lines of evidence:

- Pregnancy testing (Oak Bay) showed substantially lower pregnancy rates in IC treated deer
- Large and sustained declines in fawn recruitment following IC treatment
- Population density declines following initial growth periods after IC
- Timing of declines is not the same in the two municipalities, as in disease; instead declines follow IC in each case
- No evidence of mass die-offs from disease
- Continued immigration into treated areas (Oak Bay), evidence against region-wide disease

These findings:

- Are consistent across two independent municipalities
- Are based on cutting-edge wildlife population modelling methods
- Align with known biological effects of immunocontraception

Alternative explanations such as disease principally driving observed population and fawn declines are not supported by available evidence. Therefore, there is high confidence that observed population and fawn declines reflect real biological effects of immunocontraception.

I. Did the proportion of fawns drop after IC in Oak Bay?

1. We performed pregnancy testing on a subset of animals in Oak Bay in 2020 when we checked collars and deployed new control collars (when our GPS collars fell off). At that time 4/11 IC treated does were pregnant (36% pregnancy rate) while 18/19 control does were pregnant (95% pregnancy rate). The sample size is small and there is no comparable confirmation in Esquimalt but it is clear the contraception was working.
2. In the pre-treatment year (2018), the average proportion of fawns surviving to autumn was 0.46 (Figure 1A). In the post-treatment years, this average fawn proportion dropped to a low of 0.19. Taking 0.46 minus 0.19 equals a 0.27 drop in fawn proportions: 0.27 / 0.46 = *58% reduction in the relative proportion of fawns*. This drop in the proportion of detected fawns in autumn is very strong evidence for a drop in fawning rates (Figure 1A).
3. There was a drop in proportion of fawns from 2018 to 2019 that cannot be attributed to IC. This could be an artefact of natural variation in the data (which are presented in Figure 1B): the data are quite variable, meaning that average proportions can fluctuate quite a bit.
4. Alternatively, this 2019 drop could also be a real biological signal, meaning that fawns were driven down by from 0.46 to 0.27 (0.19, or a 41% drop) by something else.
5. An alternative explanation is that fawning was not affected by IC; instead, fawns were indeed born but then died before the autumn, via disease. Fawn mortality is naturally high but alone did not drive observed patterns: we know pregnancy was reduced, and no mass die-off of fawns was reported (Section VI).
6. In Figure 2, modeled does and autumn-fawn counts were predicted to be dropping slightly when we started the study (compare 2018 to 2019). However, the population density *increased* 2018 to 2019; there was no sign of any population decreases in this period.

FIGURE 1: Average proportion of adults to fawns in Oak Bay BC (A), and a plot showing variability in the distribution of detections (B).

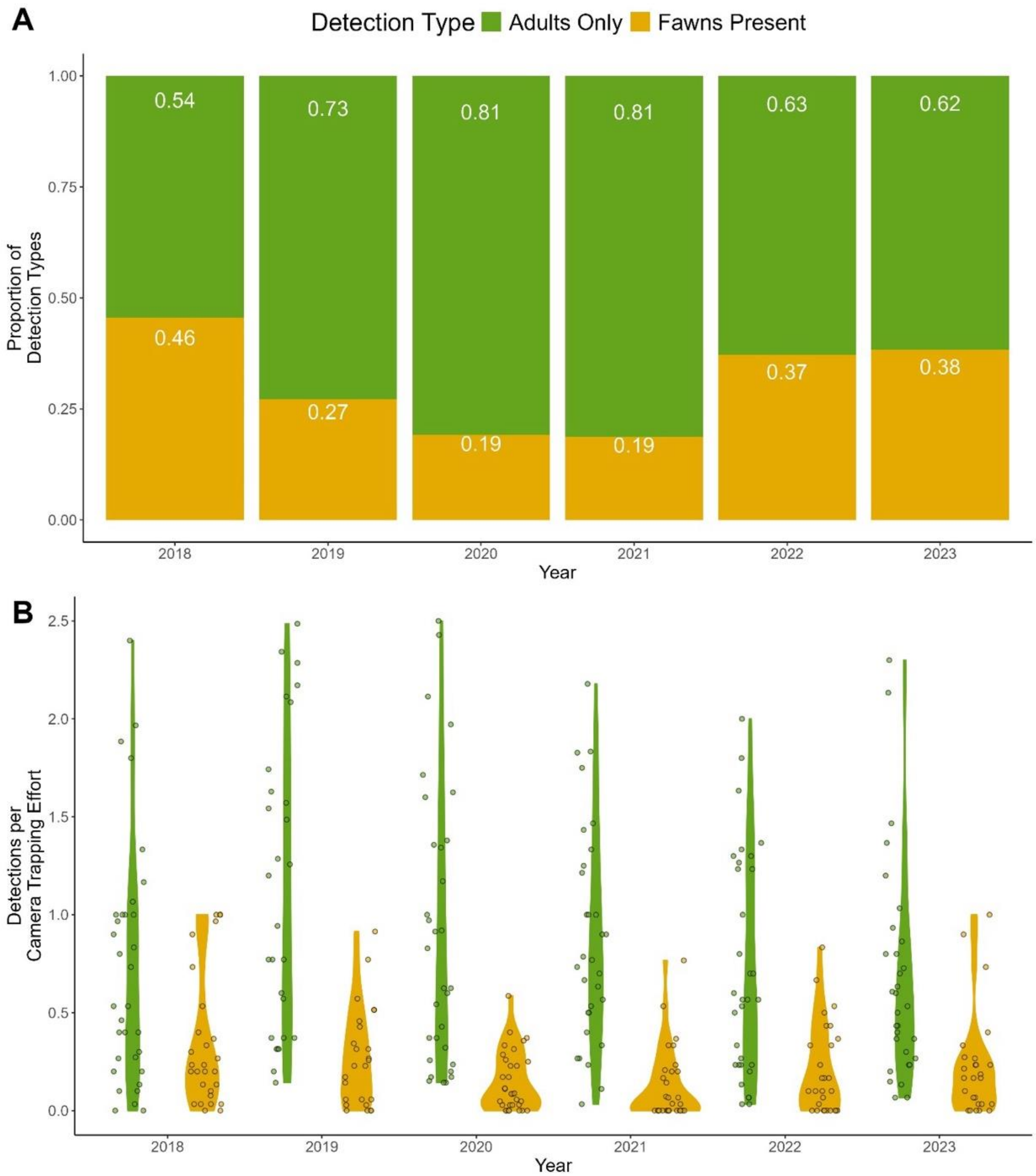
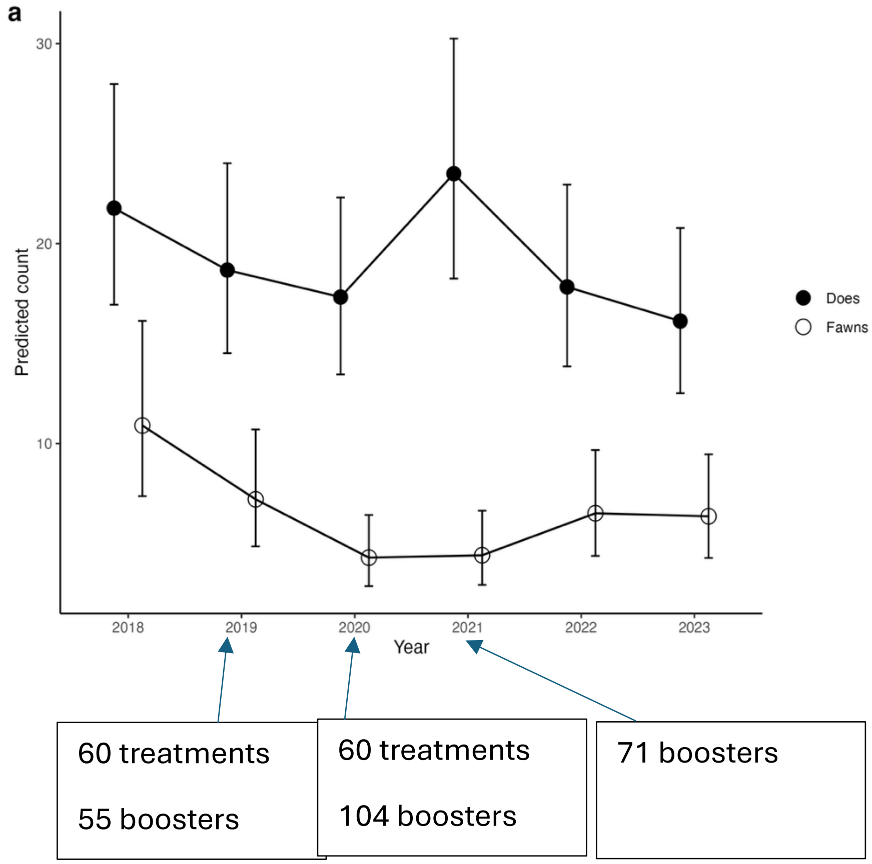


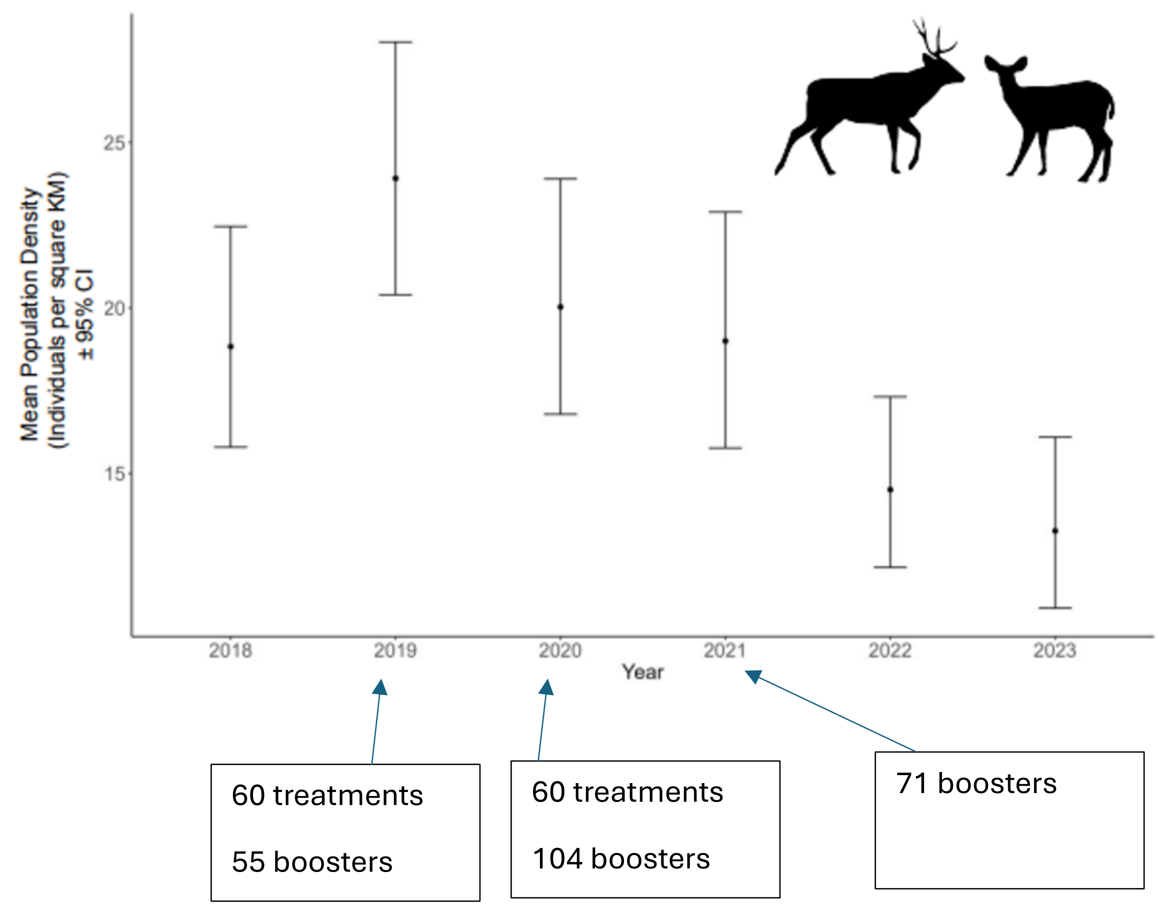
Figure 2: Modelled relative abundance of does and fawns by year, from temporal generalized linear models. Oak Bay BC.



II. Did population density drop after IC in Oak Bay?

1. At the onset of the study in the pre-treatment year, we estimated black-tailed deer density at 18.8 / km^2.
2. We observed marked increase in population density from 2018-2019, to 23.9 deer / km^2, a 27% increase.
3. Adult deer population density dropped from 23.9 deer / km^2 in 2019 to 13.3 deer / km^2 in 2023, *a 44% reduction in population size from the high point* (Figure 3).
4. Conclusion: There is a clear signal of a drop in population density, as well as the proportion of fawns, coincident in the years following the onset of IC treatment: changes manifesting after the first year and became especially prominent in the 3rd and 4th year post-treatment.

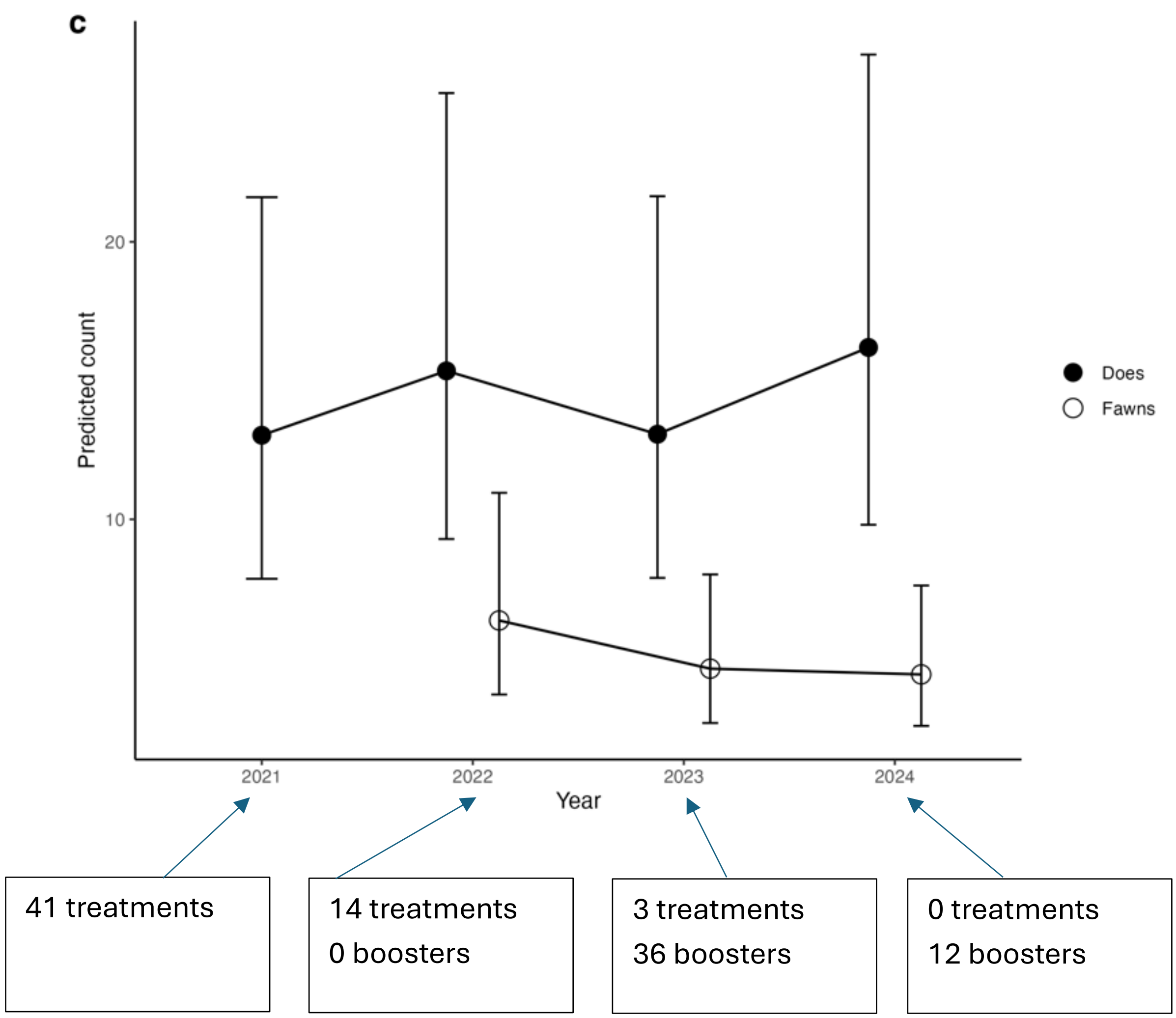
Figure 3: Deer population density estimated via Spatial mark-resight models. Oak Bay BC.



III. Did the proportion of fawns drop after IC in Esquimalt?

1. Fawning rates for 2018 were not included in our final report. COVID delayed the project launch and our cameras were deployed October through November. In the later part of this season, early-born fawns are growing fast and can be mistaken as yearlings. We did not have confidence in those numbers, so did not include them in the report.
2. We continued new treatments and boostering in the following years (Figure 4); thus, we can compare "light treatment" in 2022 to "heavy treatment" in 2023 and 2024.
3. Modelled autumn-fawn counts dropped from 2022 levels (1 year after treatment) through 2023 and 2024, following additional treatments and boosters (Figure 4).
4. Predicted autumn-fawn counts *decreased disproportionately to doe counts*: a drop in reproductive output beyond the drop in overall population size.

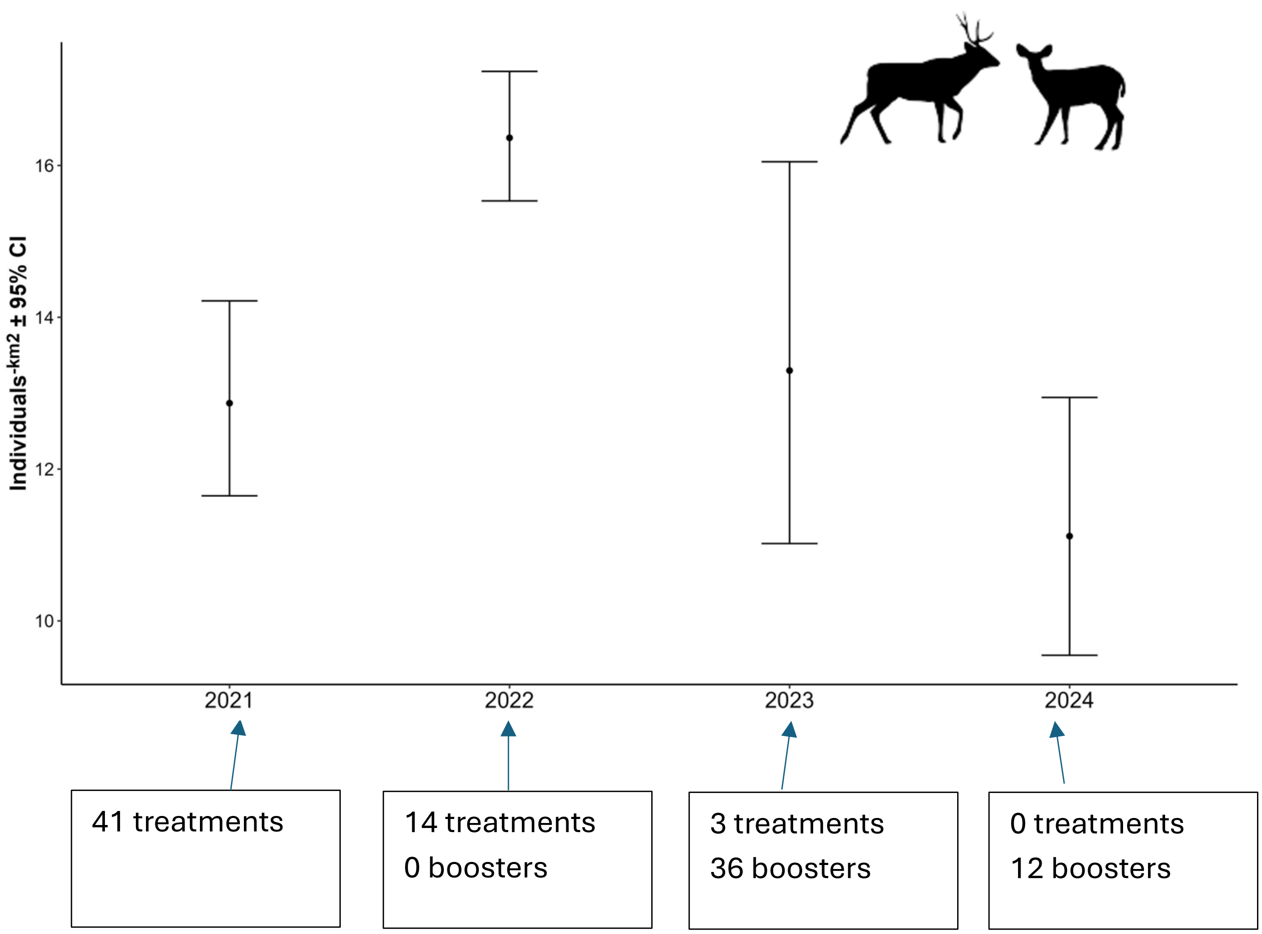
Figure 4: Modelled relative abundance of does and fawns by year, from temporal generalized linear models. Esquimalt BC.



IV. Did population density drop after IC in Esquimalt?

1. Adult identification and density modelling was unimpeded by the late 2021 start, as adults do not change appearance.
2. Modeled doe counts, and especially population density, were *increasing* in 2022, after treating 41 does, suggesting a population growth phase (Figure 4).
3. Population density increased from 12.7 deer / km^2 to 16.4 deer per km^2 after the first year when we treated 40 does (Figure 5). This represents a natural population increase of 29% – interestingly, almost the same as we observed in Oak Bay on the onset of study (27% increase).
4. Following more treatments and boosters, in 2023 the population fell to 13.3 deer / km^2 and then fell again in 2024 to 11.1 deer per km^2. *This represents a 31% reduction from the highest population density* (Figure 5).
5. We conclude there is a clear signal of a drop in population density coincident with the onset of IC treatment manifesting after the second year, and especially the 3rd year.

Figure 5: Deer population density estimated via Spatial mark-resight models. Esquimalt BC.



V. What does the ratio of marked to unmarked animals tell us?

1. Oak Bay is a completely open system with a very large deer population in neighbouring Saanich, as well as deer in Victoria. We expected and observed a high degree of cross-border movement.
2. Esquimalt is a peninsula with low movement potential except for the isthmus with Songhees Reserve and View Royal, or at the Vic West border (which is highly developed with likely low deer density).
3. We expected the open Oak Bay system, but not the closed Esquimalt system, to experience an influx of unmarked deer after the population dropped and new territories became available. This is what we observed (Figure 6).
4. The proportion of marked OB deer increased as we captured and treated more animals, then decreased as OB animals died **and new unmarked animals entered the system**. This means Saanich / Victoria had surplus deer that emigrated into Oak Bay.
    a. The decrease in marked animals would also be due to tag loss, but our collars were quite robust and where we were able to check, loss was minimal.
5. If disease (Section VI) were running through the CRD, Saanich would be hit as well, with concomitant population crashes. In that event we would not expect surplus animals to emigrate into newly available territories in Oak Bay – instead we would expect surviving animals to stay resident.

Figure 6: Modeled counts of marked to unmarked deer in Oak Bay BC.

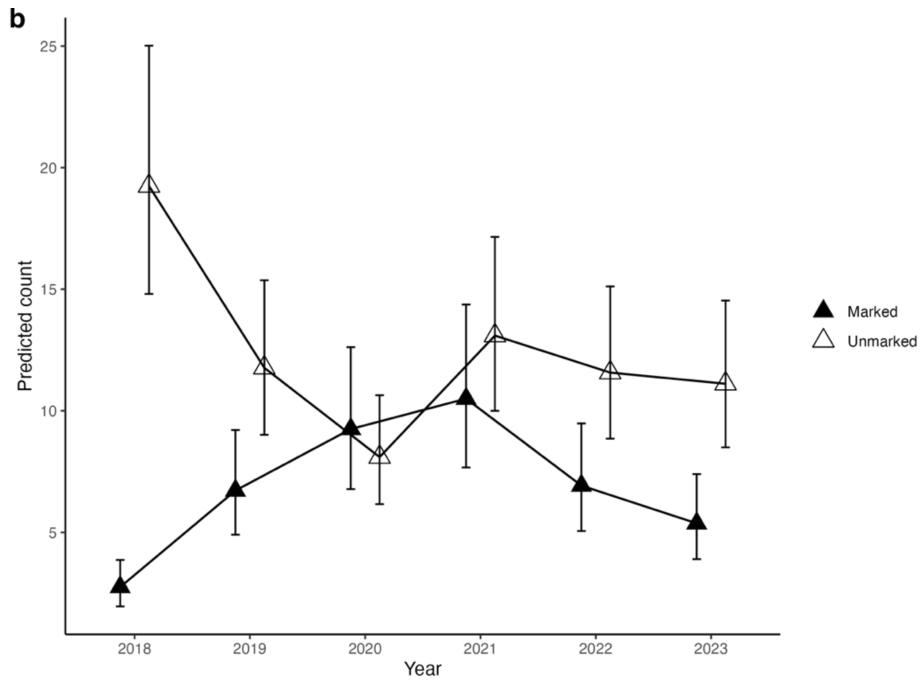
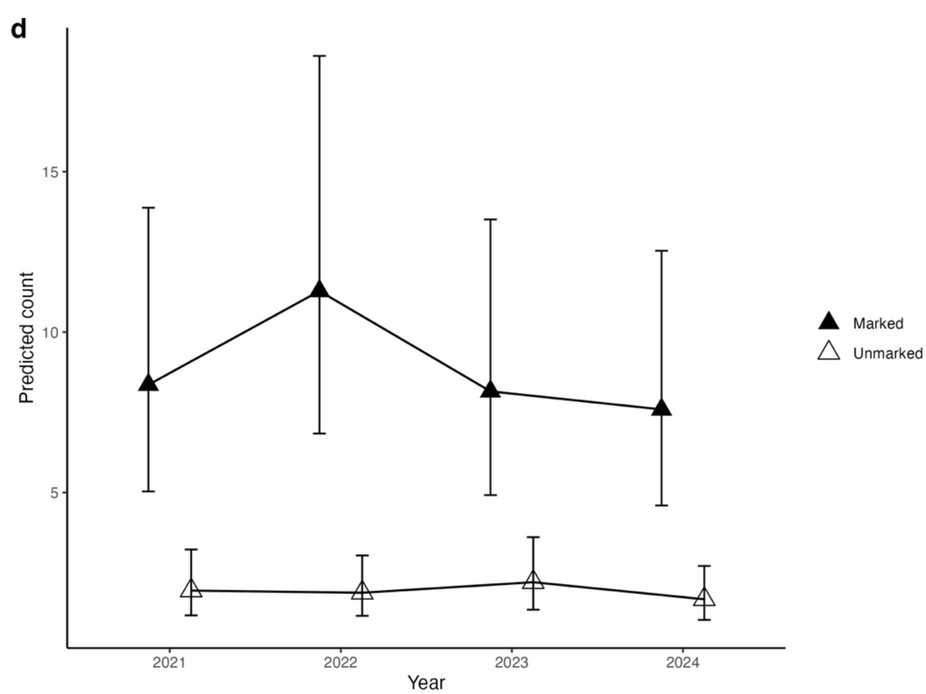


Figure 7: Modeled counts of marked to unmarked deer in Esquimalt BC.



VI. Could population fluctuations have been caused by factors other than IC, such as disease?

1. Several factors contribute to fawning rates, and to fawn and adult mortality. Environmental fluctuations, such as drought or heavy rain, temperature, and disease can all play a role.
2. Adenovirus Hemorrhagic Disease (AHD) is a contagious, often fatal viral disease affecting deer. It causes rapid death from internal hemorrhaging, respiratory distress, and diarrhea. AHD has been observed in southern Vancouver Island deer.
3. It could be that disease (or environment, etc.) induced abortions leading to lower fawning rates and we fully cannot discount some contribution.
4. To the best of our knowledge, no deer from this study sent for AHD testing came back positive. However, we do not know the level of testing conducted by the province.
5. Nonetheless, *for AHD and not IC* to have created the observed patterns, the following conditions would have to be met:
    a. AHD would have to hit Oak Bay in 2020, coinciding with the years after first IC treatment.
    b. AHD would have to hit Esquimalt in 2023, *3 years after Oak Bay*, *and again coinciding with the years after first IC treatment*.
    c. AHD disproportionately affects fawns. A mass die-off of fawns would have to be latent (hidden): no pulse of dead fawns was reported by the public, or by public works, from either very heavily populated region. In the several 100s of hours of searching the towns for deer, we found very few dead fawns.
    d. Adult deaths incurred by AHD would also have to be largely latent: public works reported no marked increase in carcass collection in either municipality during the study.
    e. AHD pressure on Oak Bay fawns *would have to alleviate in 2022 and 2023, coincident with years after we stopped treatment*. Esquimalt data end before this same pattern could be assessed.
6. These conditions suggest to us a series of coincidences too unlikely to be credited. It would be an extraordinary misfortune that the fawning rates bottomed out naturally just in time for our IC treatment in Oak Bay, and then *again* in Esquimalt.
7. In wildlife ecology we go by weight of evidence (Table 1) and likelihoods. We deem this double-coincidence, without evidence of die-offs from a heavily populated areas, unlikely.
8. We conclude that IC is influencing fawning and the population, with disease or other external influences such as temperature extremes, drought, auto collisions influence only contributory.

Table 1: Weight-of-evidence summary table.

Evidence type	Finding	Interpretation
Pregnancy testing	Lower pregnancy in treated deer	IC reduced reproduction
Fawn recruitment	Large decline after treatment	Reduced recruitment
Population density	Sustained declines	Population reduction
Immigration patterns	Continued influx of untreated deer into Oak Bay	No regional disease collapse
Independent municipalities	Same pattern in both locations	Replicable effect

VII. Evaluation of alternative explanations raised by external critics

Some external parties have suggested that observed population changes could reflect disease, environmental variability, or modelling artefacts rather than immunocontraception.

These alternatives are unlikely for the following reasons:

Claim: Disease principally caused population decline

Not supported because:

- No increase in carcass recovery was reported
- No observed mortality pulse in heavily monitored populations
- Immigration into treated areas continued, indicating no regional population collapse
- Timing of declines differed between municipalities, inconsistent with regional disease outbreak

Claim: Population decline reflects natural fluctuations

Not supported because:

- Population density increased initially before IC, declining following treatment

- Declines persisted across multiple years
- Declines alleviated after cessation of treatment
- Declines occurred independently in two municipalities following treatment

Claim: Modelling methods are unreliable

Incorrect because:

- Spatial mark-resight modelling is the new gold-standard method for density estimation in wildlife ecology
- Independent population models converged on the same conclusions
- Methods are peer-reviewed first by representatives of the University of Victoria Faculty of Graduate Studies, and second by independent scientists through the publication process
- Similar modelling approaches are used in government wildlife management globally

Final Conclusion

Multiple independent lines of evidence consistently indicate that immunocontraception reduced reproduction and contributed to population decline in Oak Bay and Esquimalt.

Based on the available evidence, immunocontraception is the most plausible and scientifically supported explanation for the observed demographic changes.