The Future of Ursus Maritimus: Are Alaskan Polar Bears Threatened by Permafrost-Born Viruses?

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Background: As climate change continues to melt ancient arctic ice, new diseases are likely to be released from the permafrost. These have potential to further endanger an already declining population of polar bears (r = -0.06).

Objective: To explore how novel viruses with differing virality and death rate could impact polar bears, and understand what type of virus would undermine conservation efforts.

Methods:

A deterministic, stage-based model was built in Vensim to simulate population growth of Alaskan polar bears under different viral conditions. Projection matrix values were collected from the COMADRE database.

1. Created a model without viral interference
2. Appended an SIR model to adult groups
3. Ran 10,000 Monte-Carlo simulations with varying virality and death rates
4. Linearized population projection data for each simulation run, and fit regression line to estimate average growth rate

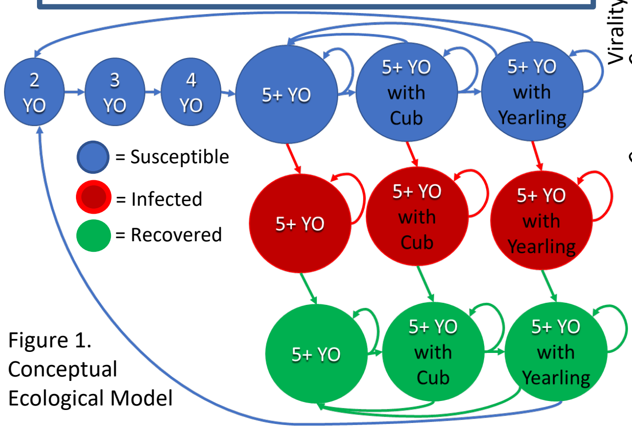

Figure 1. Conceptual Ecological Model

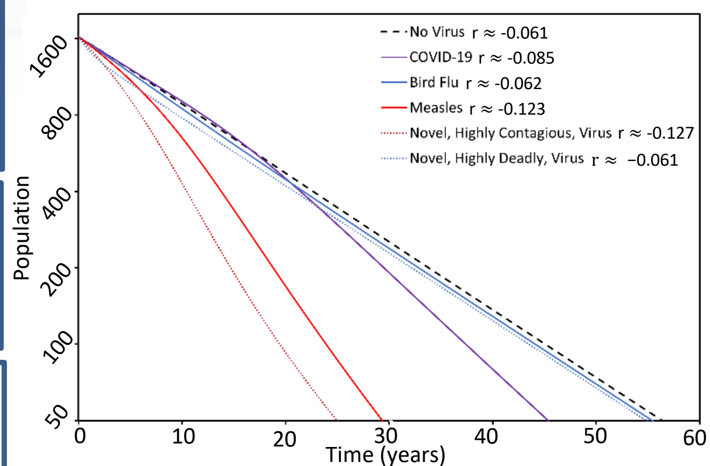

Figure 2. Log-scale plot of Alaskan polar bear population over time under different viral conditions (effective extinction of 50 bears).

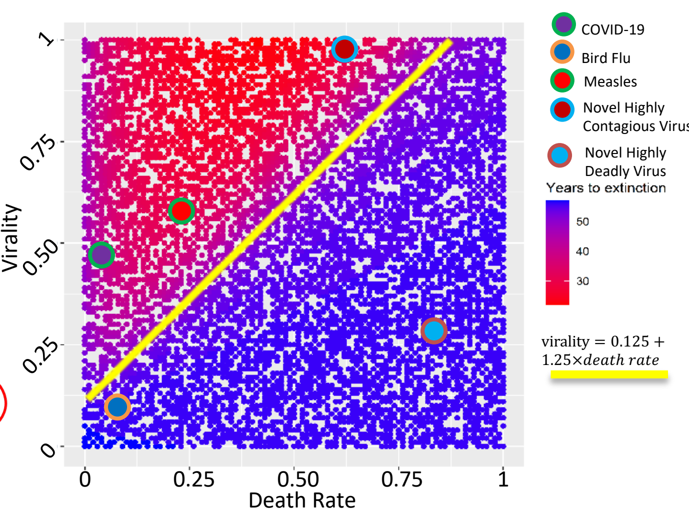

Figure 3. Phase plot of time to extinction as affected by virality and death rate. The phase transition is bound by the line: $virality = 1.25 \times death\ rate + 0.125$

Results:

- Average growth rate (r) varies from -0.06 to -0.15 (from slopes of regression lines)
- Most common viruses are projected to have minimal effects on time to extinction.
- The most dangerous viruses have a higher virality rate from 0.25 and above coupled with a lower death rate than 0.8 (Fig. 3).
- The most dangerous viruses can increase the rate of population decline and shorten the time to extinction from 57 to 25 years or below.
- Based on the elasticity matrix, the classes most likely to drive population dynamics are susceptible adults.

Conclusion:

Our study reveals the evolutionary constraints of viruses in the studied population (Fig 3.) More contagious but less deadly viruses are most likely to accelerate population decline, and result in faster extinction. Highly deadly viruses often kill hosts fast, and therefore are less widespread. Many non-deadly viruses (analogous the common cold) may be widespread, but do not accelerate extinction.

Ultimately, if the virality rate of a virus is greater than $1.25 \times death\ rate + 0.125$ than the virus should be considered a serious threat to polar bear conservation efforts.

References:

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