Ecography

ECOG-01514
Taylor, D. H., Ballinger, M. J., Medeiros, A. S. and Kotov, A. A. 2015. Climate-associated tundra thaw pond formation and range expansion of boreal zooplankton predators. – Ecography doi: 10.1111/ecog.01514

Supplementary material

Appendix 1

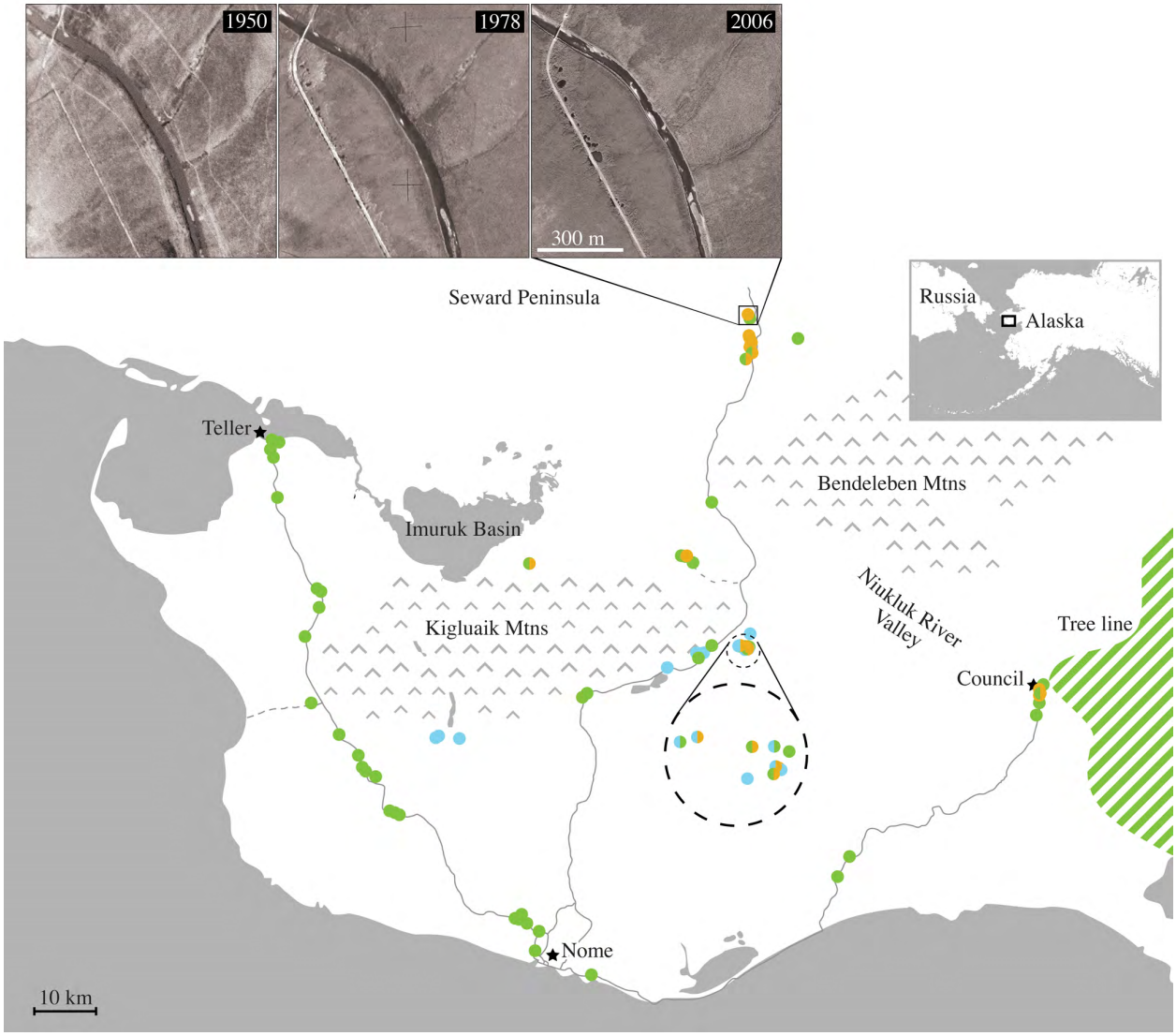
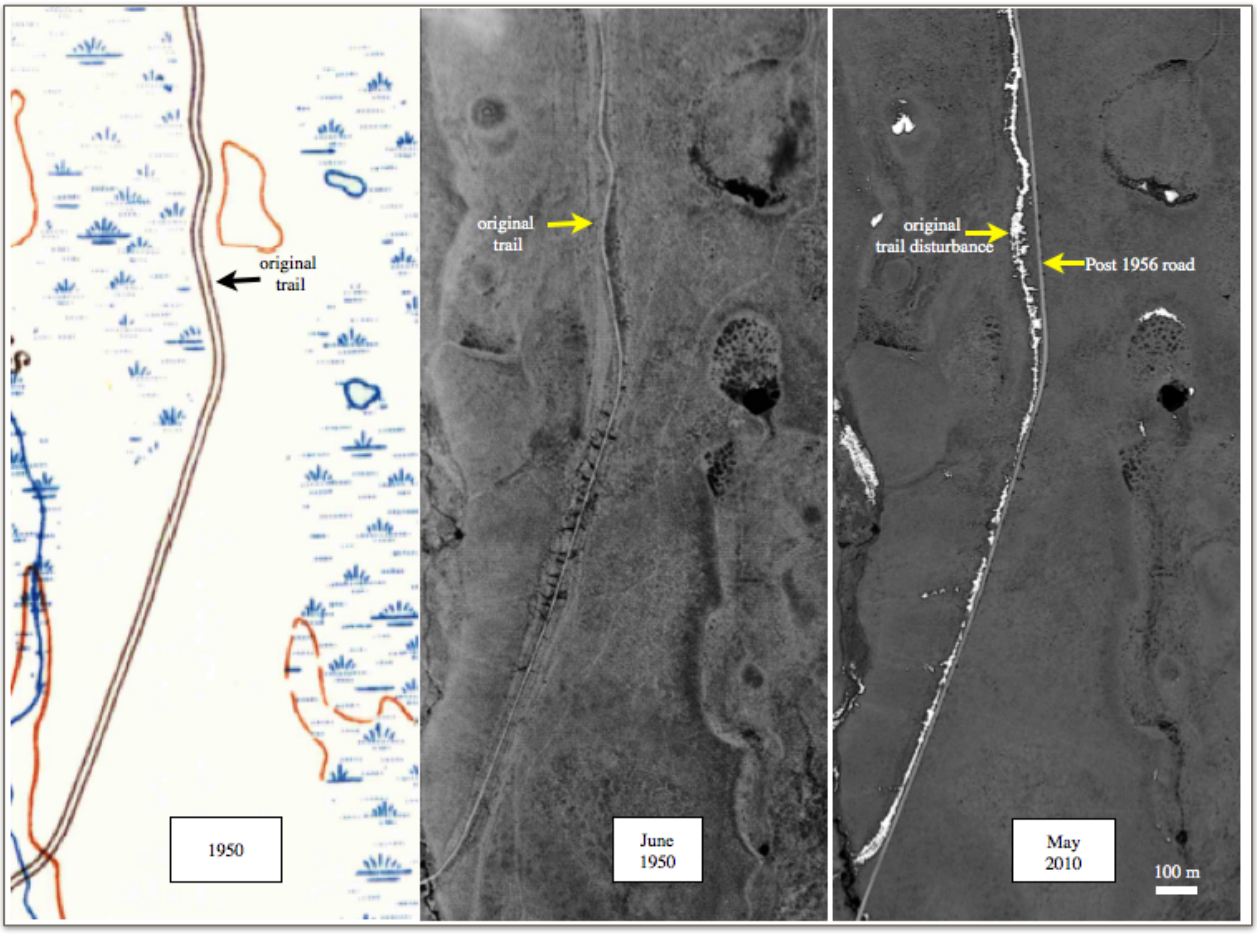


Figure A1. Map of the study region on the Seward Peninsula in northwestern Alaska showing the distribution of three detected species of the phantom midge *Chaoborus*. Green shading near Council indicates the boreal-tundra transition. Blue circles indicate ponds where we detected tundra-adapted predators (*Chaoborus trivittatus*); Orange circles indicate ponds where we detected the boreal predator after 2011 (*Chaoborus americanus*); and green circles indicate ponds where we detected the boreal *Chaoborus* cf. *flavicans*. For ponds with multiple sample dates the most recent results are shown. The gravel road system is shown as gray lines. Sampling occurred during 2000-2014 in late summer. The square inset shows historical imagery near the Kougarok Bridge. Pond formation and expansion is apparent over time in the image. These ponds were occupied by boreal *Chaoborus* (largely *C. americanus*) in recent collections. The circular inset shows an off road region magnified for clarity that contains several ponds with mixed species composition for the genus *Chaoborus*. Note that *C.*

americanus is absent from much of the road system and that a possible lowland dispersal corridor (orange arrow) from the tree line at Council exists in the valleys between the Kigluaik and Bendeleben mountains.


original
trail
1950
original
trail
June
1950
original
trail disturbance
Post 1956 road
May
2010
100 m

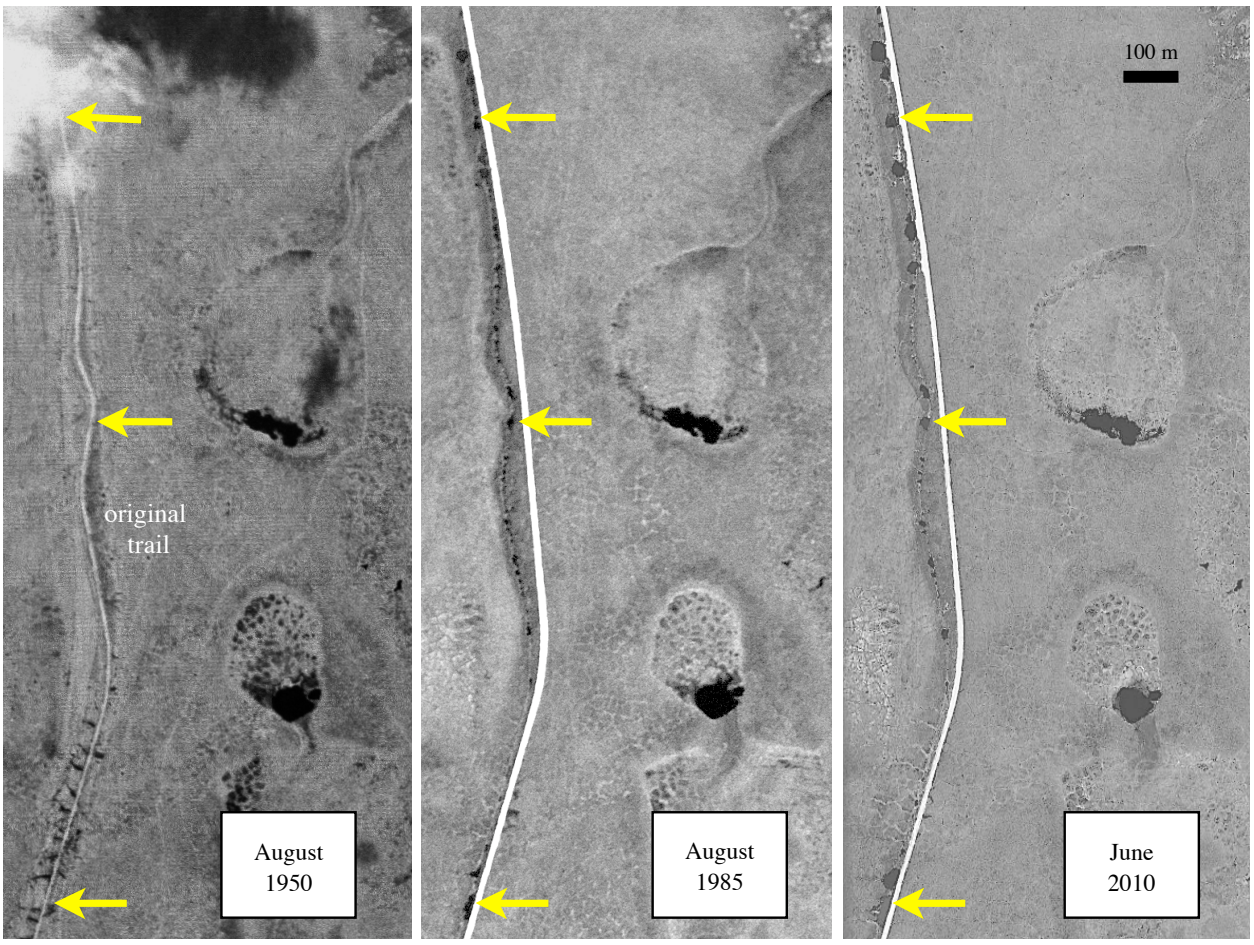

original
trail
August
1950
August
1985
100 m
June
2010

Figure A2. Historical imagery of a section of the Kougarok Road north of Nome Alaska showing the site of recently formed ponds and their expansion. Top row: The images reveal that a depression formed in the permafrost by the former trail has formed a network of ponds. Bottom row: While the two older ponds on the right side of the images are of similar sizes between 1950 and 2010, the new ponds appear to be getting larger in surface area in recent decades (e.g., yellow arrows). Thus, the expansion appears consistent with recent permafrost melting and basin expansion and not with annual variation in evaporation or precipitation. The older ponds on the right contained *Heterocope* and *Daphnia tenebrosa* while the sampled recent ponds contained *Chaoborus americanus*/*C. flavicans and Daphnia pulex*.

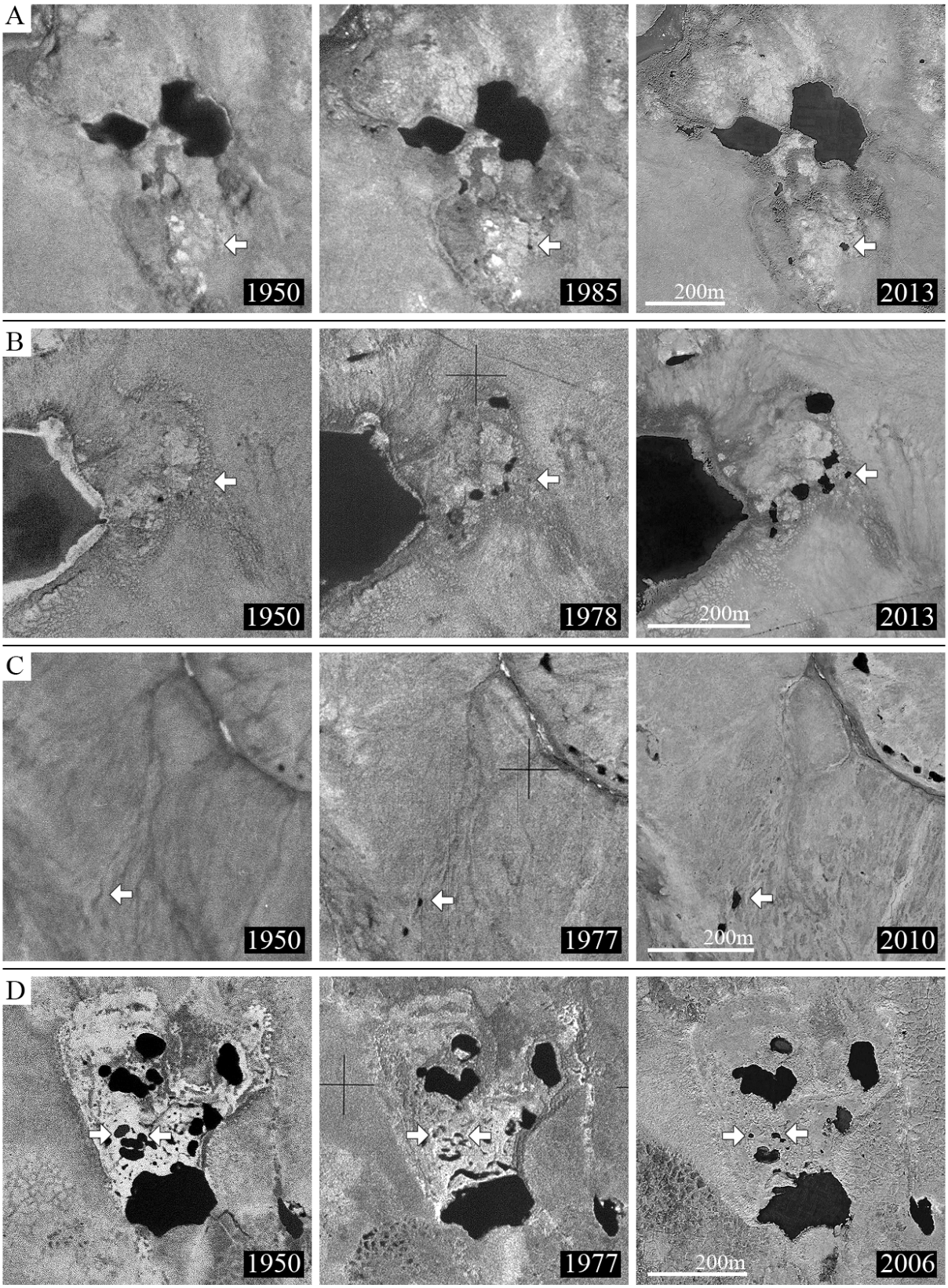


Figure A3. Historical images of recently formed tundra ponds in the central Seward Peninsula showing the formation and expansion of small ponds over time. Pond sites that are both distant from the road

disturbances and contained boreal species of the predator *Chaoborus* in recent samples are marked by white arrows. A-C: thaw pond formation where adjacent larger ponds appear to lack significant surface area changes. D: ponds formed by recent shrinkage and fractionation of a larger, older thermokarst pond. We hypothesize that these recently formed ponds located in intermontane lowlands comprise dispersal networks for aquatic boreal predators from the treeline to the tundra.

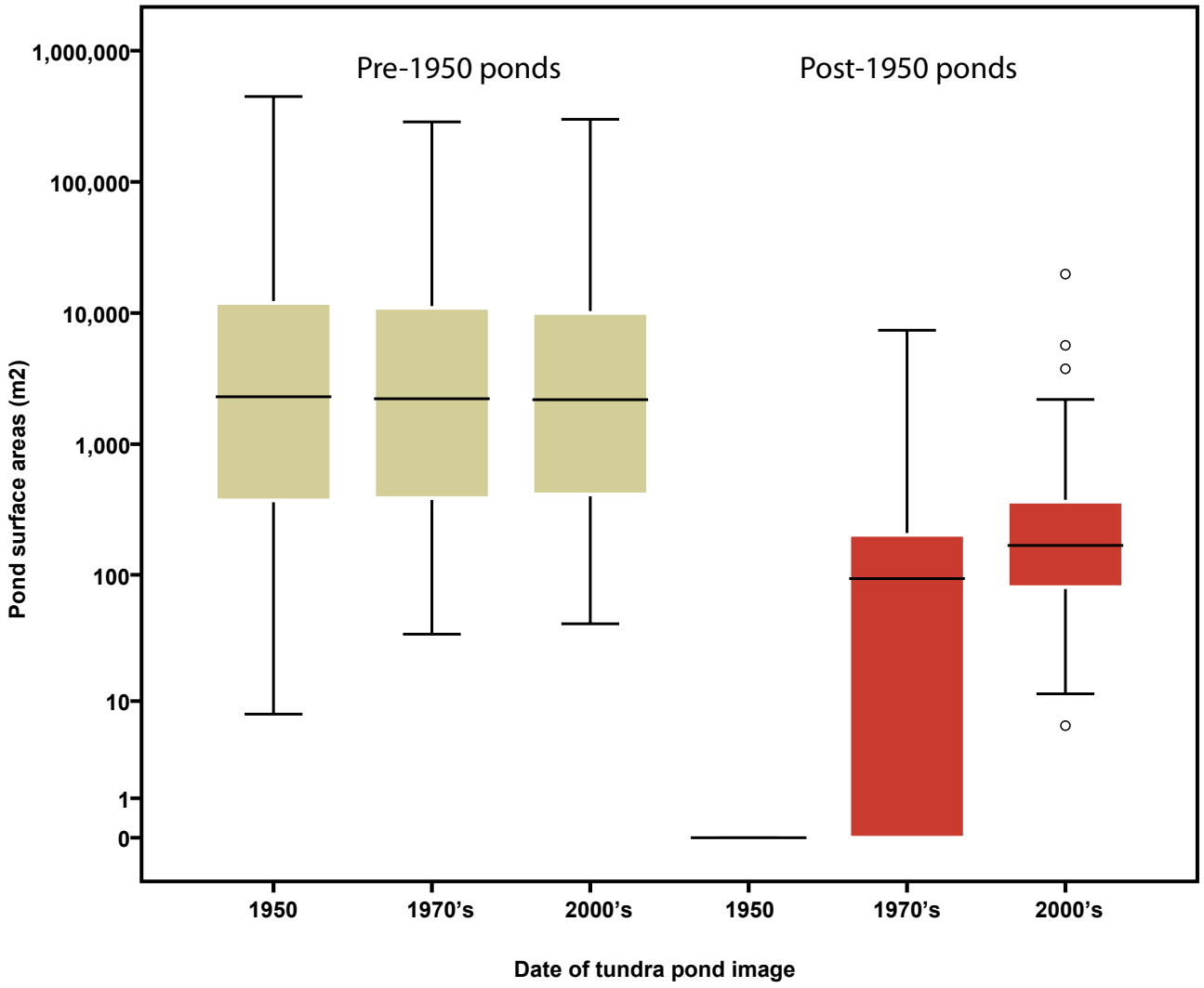


Figure A4. Boxplots of pond surface areas (log scale) at three time intervals based on aerial and satellite imagery. The left half of the graph is based on ponds that pre-date 1950 (n=127) while the right side of the graph is based on ponds that have formed since 1950 (n=145). Pond sizes before formation were scored as zero surface area for 1950 and the 1970's.