Appendix 2

Michael T. Murphy, Lucas J. Redmond, Amy C. Dolan, Nathan W. Cooper, Karen Shepherdson, Christopher M. Chutter, and Sarah Cancellieri. Weather and climate change drive annual variation of reproduction by an aerial insectivore.

The long-term increase in global temperature since the beginning of the Industrial Revolution was interrupted mid-20th century, but began to increase again starting in the mid-1970s (Broecker 2017). We thus obtained temperature data (National Oceanic and Atmospheric Administration; http://www.yourweatherservice.com/) for the egg-laying months of the breeding season (May, June and July) for the 40-year period beginning in 1974 to evaluate whether climate change, as measured by temperature, was apparent at our central New York and southeastern Oregon study sites. Data came from weather stations in Cooperstown, New York (42.702 N, -74.977 W), and Burns, Oregon (43.585 N, -119.061 W), the weather stations with long-term records nearest our sites (30 and 75 km distant, respectively). We analyzed these data as a continuous 40-year record, but also separated into pre-study, study, and post-study periods to contextualize our field studies that occurred between 1989 and 2000 (New York) and 2002 to 2011 (Oregon). We examined mean month temperature (average of daily low and high temperatures) and average monthly daily high temperature

Mean monthly temperature in central New York increased from 1974 through 2013 in May (r = 0.480, P = 0.002), June (r = 0.729, P < 0.001), and July (r = 0.589, P < 0.001), but average maximum temperature did not (strongest relationship was May, r = 0.192, P = 0.235). We thus focused further analyses on mean temperature. Comparison of temperature records for the years preceding (1974 to 1988), during (1989 to 2000) and following (2001 to 2013) our research indicated that mean temperature trends in May trended upward after our study (r =

0.551, $P = 0.099$) but did not increase with time either before ($r = 0.136$, $P = 0.628$) or during ($r = 0.344$, $P = 0.274$; Figure A2.1A). On the other hand, June and July data indicated that our study took place during a period of rapidly climbing temperatures. Mean June temperature did not change with year during either the periods before ($r = -0.018$, $P = 0.948$) or after our study ($r = 0.246$, $P = 0.492$), but rose significantly between 1989 and 2000 ($r = 0.663$, $P = 0.019$; Figure A2.1B). Similarly, mean July temperature did not change with year in the years preceding our study ($r = -0.002$, $P = 0.993$), increased in July during our study ($r = 0.616$, $P = 0.033$) and tended to increase over the next 13 years as well ($r = 0.535$, $P = 0.060$; Figure A2.1C).

In Oregon, mean monthly temperature for May ($r = -0.056$, $P = 0.732$) and June ($r = -0.196$, $P = 0.227$) did not change over time, while the weak tendency for an increase in mean July temperature was not significant ($r = 0.243$, $P = 0.130$). Mean monthly maximum temperature showed a weak nonsignificant increase in May ($r = 0.254$, $P = 0.114$), no change in June ($r = 0.105$, $P = 0.518$), but a significant rise in July ($r = 0.604$, $P < 0.001$). Given the stronger signal produced by maximum temperature, we limited further analyses to this variable. Mean maximum temperature tended to increase in the years preceding our study (1974 to 2001) in May ($r = 0.333$, $P = 0.083$) and July ($r = 0.333$, $P = 0.083$), but not in June ($r = 0.093$, $P = 0.639$; Figure A2.2). Omitting one apparent outlier in July raised substantially the fit of maximum temperature to year ($r = 0.455$, $P = 0.017$). Although temperatures were high at the start of our study, 2002 marked the beginning of a 10-year downward trend in mean maximum temperature that was not significant in May ($r = -0.397$, $P = 0.256$), but was significant in June ($r = -0.706$, $P = 0.022$) and July ($r = -0.721$, $P = 0.019$; Figure A2.2). Despite the general cooling trend, mean maximum July temperature was higher between 2002 and 2011 than between 1974 and 2001 (Figure A2.2C; $t = 3.99$, df = 38, $P < 0.001$). The cooling trend in southeastern Oregon appeared to be temporary as mean maximum temperatures in May, June, and especially July of 2012 and 2013 returned to high values consistent with long-term warming of climate (Figure A2.2).

Literature Cited

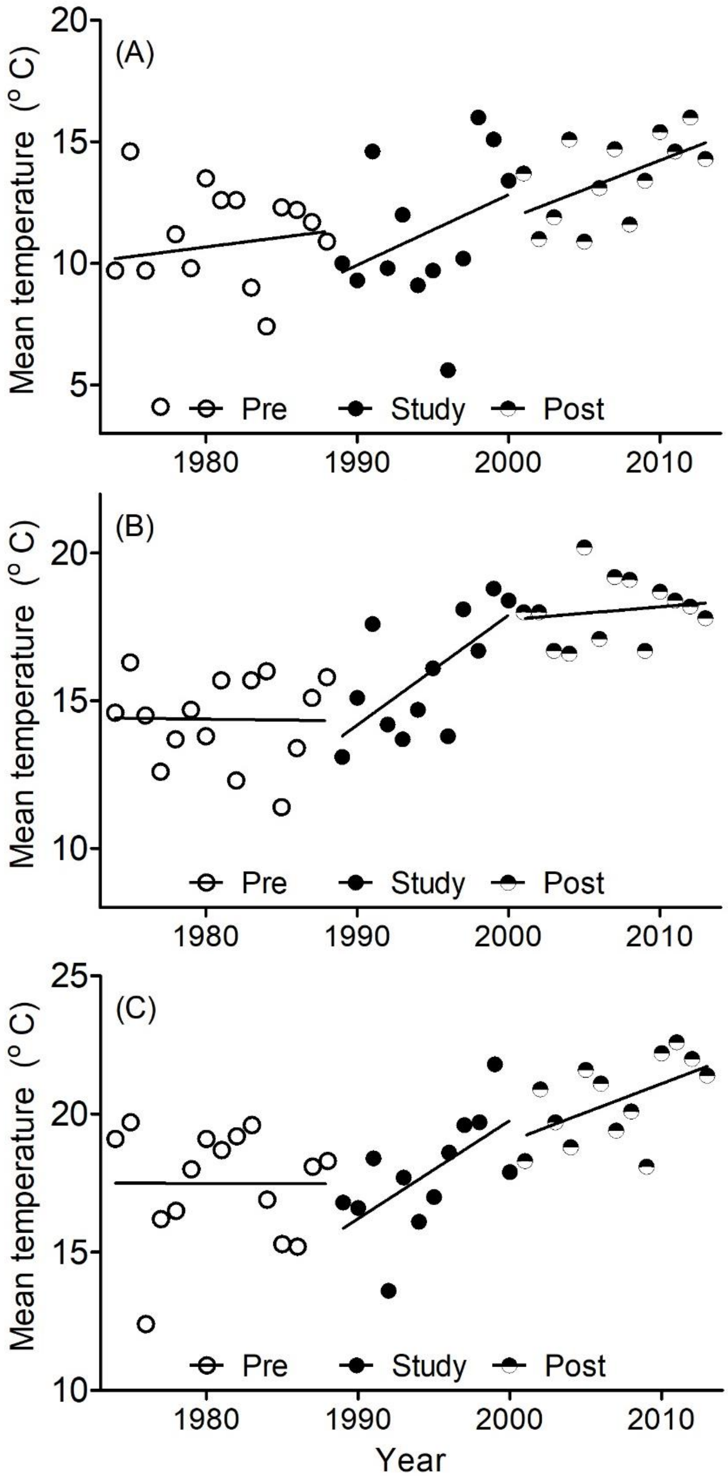
Broecker, W. 2017. When climate change predictions are right for the wrong reasons. Climate Change 142:1-6.

Figure legends

Figure A2.1. Mean monthly temperature for May (A), June (B), and July (C) from 1974 through 2013 in central New York. Data are presented and analyzed separately for the years before (open circles), during (filled circles), and after our study (half-filled circles).

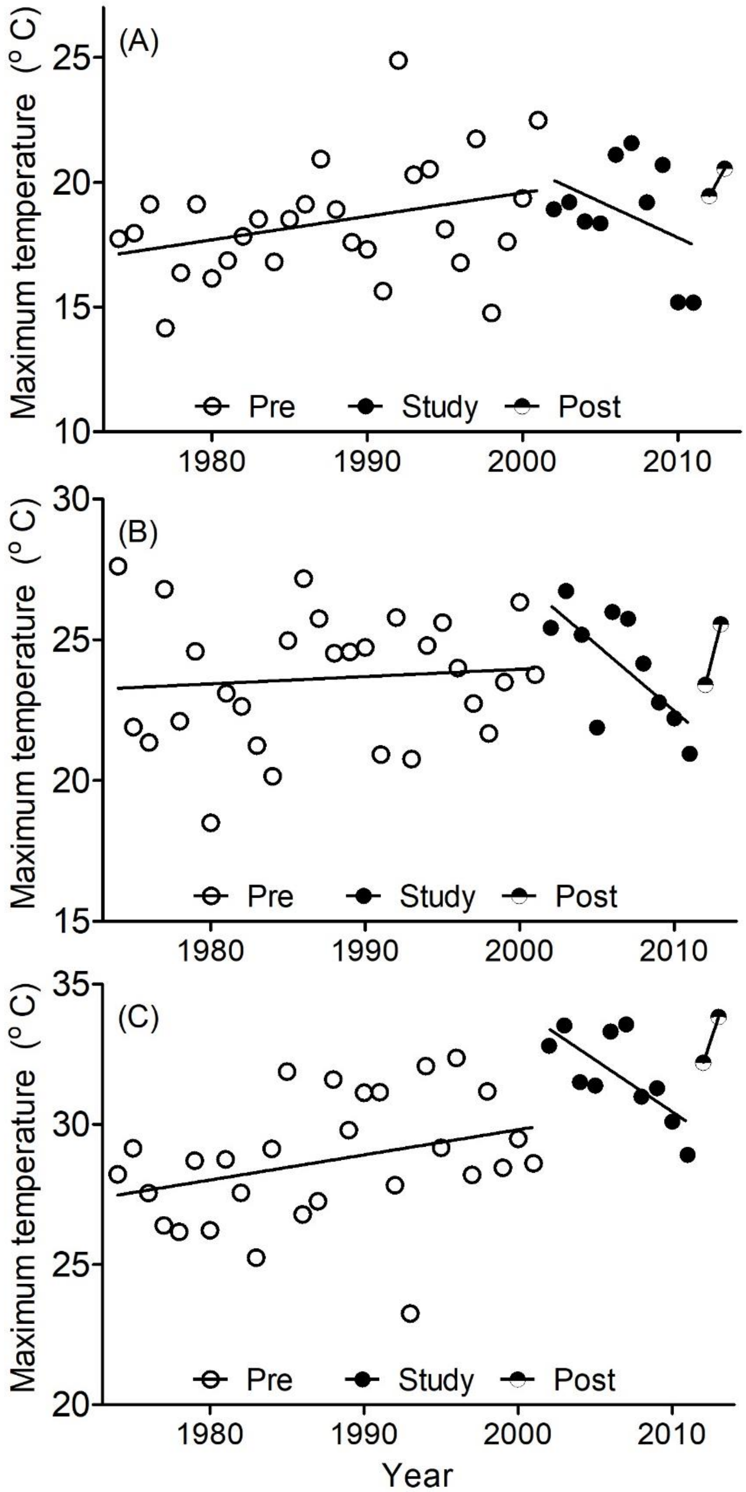
Figure A2.2. Mean monthly temperature for May (A), June (B), and July (C) from 1974 through 2013 in southeastern Oregon. Data are presented and analyzed separately for the years before (open circles), during (filled circles), and after our study (half-filled circles).

Figure A2.1.



(A)
(B)
(C)
Mean temperature (° C)
Pre
Study
Post
1980
1990
2000
2010
Year

Figure A2.2.



(A)
Maximum temperature (° C)
25
20
15
10
Pre
Study
Post
1980
1990
2000
2010
(B)
Maximum temperature (° C)
30
25
20
15
Pre
Study
Post
1980
1990
2000
2010
(C)
Maximum temperature (° C)
35
30
25
20
Pre
Study
Post
1980
1990
2000
2010
Year