**Additional file 4: Appendix S2.** The code for developing a generalized additive model (GAM) of sub-model A in R. Abbreviations in the code are as follows: data.csv in line 1, dataset which include response variable and explanation variables; RpPA in line 3, presence and absence data of territories of the rock ptarmigan; AfR in line 3, area fraction of alpine fellfield communities; SgR in line 3, area fraction of snowbed grassland communities; DistR in line 3, distance from the ridge; PpR in line 3, area fraction of *Pinus pumila* communities; STUDY\_TIME in line 3, the number of surveys.

d<- read.table("data.csv", sep=",", header=TRUE)

library(mgcv)

gamRp <- gam(d$RpPA~s(AfR)+s(SgR)+s(DistR, PpR), family=binomial, data=d, maxit=1000, offset=d$STUDY\_TIME)