**Supplemental Information 2**

#-----------------------------specify the model----------------------------------------

cat(file="Nmixure.txt","

model {

#-------------------priors and constraints

for (t in 1:nyears){

alpha0[t] ~ dunif(0,1)

omega[t] ~ dgamma(0.25,0.25)

}

beta0 ~ dnorm(0, 0.1)

for (k in 1:10) { #k covariates for ecological model

beta[k] ~ dnorm(0, 0.1)

}

for (k in 1:1) {

alpha[k] ~ dnorm (0, 0.1)

}

for (t in 1:nyears){ #randon survey effect

tau.p[t] <- pow(sd.p[t], -2)

sd.p[t] ~ dunif(0,3)

}

tau.lam <- pow(sd.lam, -2)

sd.lam ~ dunif(0, 2)

#-------------------likelihood

for (i in 1:nsites){

for(t in 1:nyears){

z[i,t] ~ dbern(omega[t])

N[i,t] ~ dpois(lambda[i,t]\*z[i,t])

eps.lam[i,t] ~ dnorm(0, tau.lam)

log(lambda[i,t]) <- beta0 + beta[1]\*area[i]

+ beta[2]\*gradient[i]

+ beta[3]\*tempdiff[i,t] + beta[4]\*DO[i,t]

+ beta[5]\*tribdis[i,t] + beta[6]\*dep[i,t]

+ beta[7]\*vel[i,t] + beta[8]\*conduct[i,t]

+ beta[9]\*tvar[i,t] + beta[10]\*ggd[i,t]

+ eps.lam[i,t]

for (j in 1:nsurveys){

C[i,j,t] ~ dbin(p[i,j,t], N[i,t])

eps.p[i,j,t] ~ dnorm(0, tau.p[t])

logit(p[i,j,t]) <- alpha0[t] + alpha[1]\*bright[i,j,t]

+ eps.p[i,j,t]

#-------------------posterior predictive check

C.sim[i,j,t] ~ dbin(p[i,j,t], N[i,t])

e.count[i,j,t] <- N[i,t] \* p[i,j,t]

#-------------------chi-2 discrepancy tests

chi2.actual[i,j,t] <- pow((C[i,j,t]-e.count[i,j,t]),2)/(e.count[i,j,t]+e)

chi2.sim[i,j,t] <- pow((C.sim[i,j,t]-e.count[i,j,t]),2)/(e.count[i,j,t]+e)

}

}

}

#-------------------fit statistics

fit.actual <- sum(chi2.actual[,,])

fit.sim <- sum(chi2.sim[,,])

bpv <- step(fit.sim-fit.actual)

c.hat <- fit.actual/fit.sim

#-------------------derived quantities

for (i in 1:nsites){

for (t in 1:nyears){

totalN[i,t] <- sum(N[i,t])

}

}

}

")