# Supplemental doc 2 - Davidson_et_al_WinBUGS code

# Cormack Jolly Seber model, robust design

# BEGIN MODEL
model {

# SET PRIORS

# survival terms
phi0 ~ dunif(0.01,0.99)   # mean survival rate
logit.phi <- log(phi0/(1-phi0)) # transform to logit scale...
precipEff ~ dunif(-3,3) # beta term for effect of precip on survival
predEff ~ dunif(-3,-0.1) # beta term for "predation" effect (random effect)

# capture probability terms
p0 ~ dunif(0.01,0.99)  # probability of capture per secondary trapping occasion
logit.p <- log(p0/(1-p0)) # transform to logit scale

# temporary emigration terms
gamma.prime ~ dunif(0.01,0.99) # probability of staying off site, pollack's robsut design- temp immigration terms
gamma.dprime ~ dunif(0.01,0.99) # probability of leaving sampled area, pollack's robsut design - temp immigration terms

# model "good year" vs "bad year"
pbadyr ~ dunif(0.05,0.95)

for(t in 1:ns){
  badyr[t] ~ dbern(pbadyr)
}

# SET OVERALL PROCESS MODEL
# SURVIVAL MODEL

for(i in 1:nan){
    for(t in 1:(ns-1)){
        mu.phi[i,t] <- logit.phi + predEff*badyr[t] + precipEff*precip[t] #+ juvEff*isJuv[i,t] # simple function for survival rate + maleEff*isMale[i]
        phi[i,t] <- 1/(1+exp(-1*mu.phi[i,t]))
    }
}

########## Latent variable: onsite status (temporary emigration and immigration)

for(i in 1:nan){
    onsite[i,first[i]] ~ dbern(1) # at first capture, animal is on site

    for(t in (first[i]+1):ns){
        muonsite[i,t] <- (onsite[i,(t-1)] * (1-gamma.dprime)) + ((1-onsite[i,(t-1)]) * (1-gamma.prime)) # probability of each individual being on site, all subsequent periods
        onsite[i,t] ~ dbern(muonsite[i,t]) # latent variable: is it still in the sampling area?? # onsite status of each individual
    }
}

########## Latent variable: living or dead

for(i in 1:nan){
    alive[i,first[i]] ~ dbern(1) # at first capture, the animal is alive

    for(t in (first[i]+1):ns){
        mualive[i,t] <- alive[i,(t-1)] * pow(phi[i,t-1],interval[t-1]) # probability of each ind being alive, all subsequent periods
        alive[i,t] ~ dbern(mualive[i,t]) # latent variable- is it still alive?
    }
}

# OBSERVATION MODEL (actual data likelihood)

for(i in 1:nan) {
    for(t in (first[i]+1):ns) {
        for(j in 1:nss[t]){  
            mu.p[i,t,j]  <- logit.p #+ indeff[i] # logit probability of capture for this individual [[add term for # of grids deployed]]
            p[i,t,j]     <- 1/(1+exp(-1*mu.p[i,t,j])) # convert back to probability scale
            muy[i,t,j]   <- alive[i,t]*onsite[i,t]*p[i,t,j] # if it's alive and onsite, then it's seen with prob. p.
            y[i,t,j]    ~ dbern(muy[i,t,j]) # DATA NODE likelihood of observed data...
        }
    }
}
CALCULATE ABUNDANCE USING HORVITZ-THOMPSON ESTIMATOR....

    # note: only applies to sampled areas (grids)
    # account for # grids deployed
    # note: should be per hectare.

for(t in 1:ns){  # first "remind ourselves" of the mean cap prob per suboccasion
    for(j in 1:nss[t]){  
        mu.p2[t,j] <- logit.p
        p2[t,j] <- 1/(1+exp(-1*mu.p2[t,j]))  # back to prob. scale
    }
}

for(t in 2:ns){
    pncap[t,1] <- 1-p2[t,1]  # pncap refers to the probability of not capturing for entire 3-day interval
    for(j in 2:nss[t]){  
        pncap[t,j] <- pncap[t,j-1]*(1-p2[t,j])
    }
    pcap[t] <- 1-pncap[t,nss[t]]  # pcap refers to the prob of being capture for entire 3-day period
    N[t] <- nan2[t] / pcap[t]  # estimate of total abundance within sampled region...
    Nperha[t] <- N[t]/3  # convert to abundance per ha (assuming 3 grids were always deployed...)