PCN

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Getting started with PCN

The mathematical model used in this software is described here: https://www.sciencedirect.com/science/article/abs/pii/S0022519321001235?dgcid=author

David A. Ewing, Vivian Blok, Helen Kettle. "A process-based, stage-structured model of potato cyst nematode population dynamics: Effects of temperature and resistance", Journal of Theoretical Biology,Volume 522, 2021.

This vignette shows some examples of how this package can be used.

1. Run model at constant soil temperature

```
fixTemp=14
deltaT=0

numYears=1 #number of years to simulate
simStartDay=90 #day of the year the simulation starts e.g. 1st April
initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts

out=PCNmodel(numYears=numYears,
    simStartDay=simStartDay,
    initialEggsPerGram=initialEggsPerGram,
    soil.density = soil.density,
    temperature.pars=list(
        temperatureSpline=NULL,
        fixTemp = fixTemp,
        deltaT = deltaT
    )
          )


plotPCN(out$solution,out$parms,ylim=c(0,350),main=paste('fixed temp of',fixTemp,'+',deltaT))

cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))

text(250,150,paste('Final number of cysts is',cysts.final),cex=1.2)
```

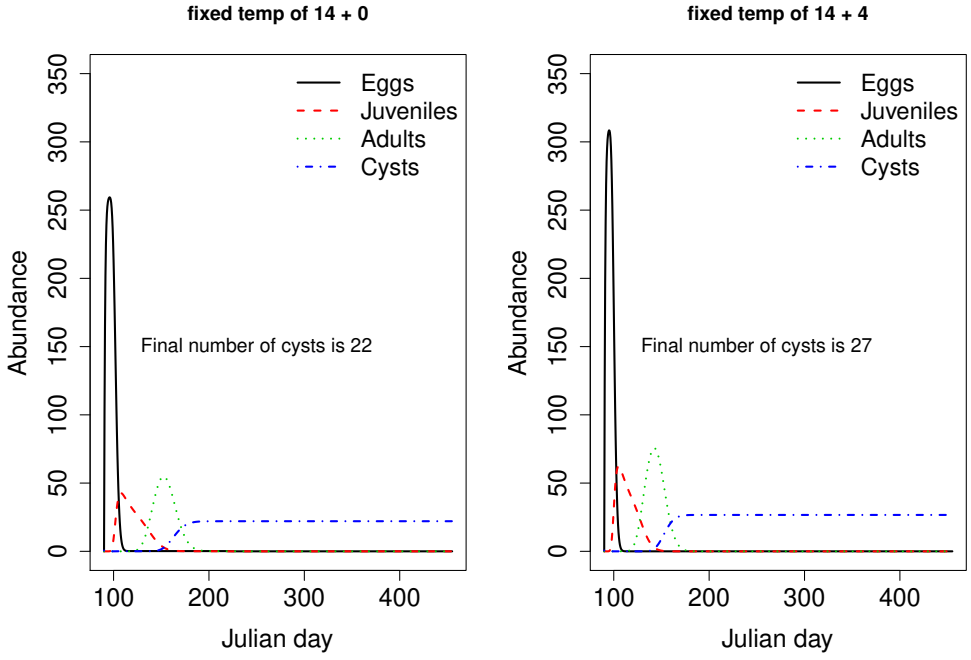

Figure 1: Run model at constant temperature

2. Run model with sinusoidal soil temperature

```
deltaT=0

### Model settings
numYears=1 #number of years to simulate
simStartDay=90 #day of the year the simulation starts e.g. 1st April
initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts (derivs, initialCinditions.R)

dev.new(height=7,width=10)
par(mfrow=c(1,2))

out=PCNmodel(numYears=numYears,
    simStartDay=simStartDay,
    initialEggsPerGram=initialEggsPerGram,
    soil.density = soil.density,
    temperature.pars=list(
        temperatureSpline=NULL,
        fixTemp = 13,
        deltaT = deltaT
    )
            )


out1=out

plotPCN(out$solution,out$parms,ylim=c(0,250),main=paste('fixed temp'))
```

```
cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))
text(250,150,paste('Final number of cysts is',cysts.final),cex=1.2)
print(paste('final number of cysts is',cysts.final))

#increase deltaT
out=PCNmodel(numYears=numYears,
    simStartDay=simStartDay,
    initialEggsPerGram=initialEggsPerGram,
    soil.density = soil.density,
    temperature.pars=list(
        temperatureSpline=NULL,
        fixTemp = NA,
        deltaT = deltaT
    )
            )


out2=out
plotPCN(out2$solution,out2$parms,ylim=c(0,250),main=paste('sinusoidal temp'))

cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))
text(250,150,paste('Final number of cysts is',cysts.final),cex=1.2)
```

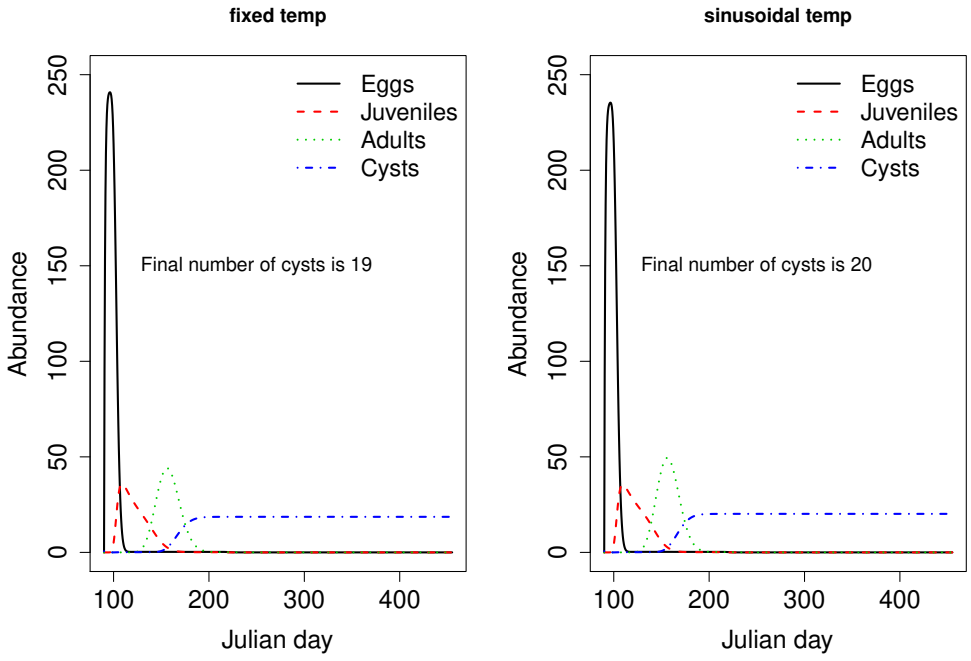

Figure 2: Run model with sinusoidal temperature

3. Run model with splined temperature data

Here we simulate some temperature measurements, run them through **smooth.spline()** and then input to **PCNmodel()**

```
numYears=1 #number of years to simulate
simStartDay=50 #day of the year the simulation starts e.g. 1st April
initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts (derivs, initialCinditions.R)

#make up some temperature data
time.data=seq(0,numYears*365+10)
temp.data=NA*time.data
for (i in 1:length(time.data)){
    temp.data[i]= 15 + 3*sin(2*pi*(time.data[i]%%365-100)/365) + rnorm(1,0,5)
}
#fit spline
temp.spline=smooth.spline(temp.data)

dev.new(width=10,height=6)
par(mfrow=c(1,2))

plot(time.data,temp.data,type='l',xlab='Julian days',ylab='soil temperature (oC)')
lines(temp.spline$x,temp.spline$y,col='red',lwd=2)
legend('bottom',legend=c('data','spline'),col=c('black','red'),lty=1)

out=PCNmodel(numYears=numYears,
    simStartDay=simStartDay,
    initialEggsPerGram=initialEggsPerGram,
    soil.density = soil.density,
    temperature.pars=list(
        temperatureSpline=temp.spline,
        fixTemp = NA,
        deltaT = 0 # apply this temperature change over the baseline.
    )
            )

plotPCN(out$solution,out$parms)
cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))
text(250,150,paste('Final number of cysts is',cysts.final),cex=1.2)
```

4. Using sinusoidal temperature, look at effect of planting potatoes a month earlier

```
numYears=1 #number of years to simulate
simStartDay=90 #day of the year the simulation starts e.g. 1st April

initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts (derivs, initialCinditions.R)


dev.new(width=13,height=6)
par(mfrow=c(1,3))

for (plantingDOY in c(60,90,120)){

    out=PCNmodel(numYears=numYears,
```

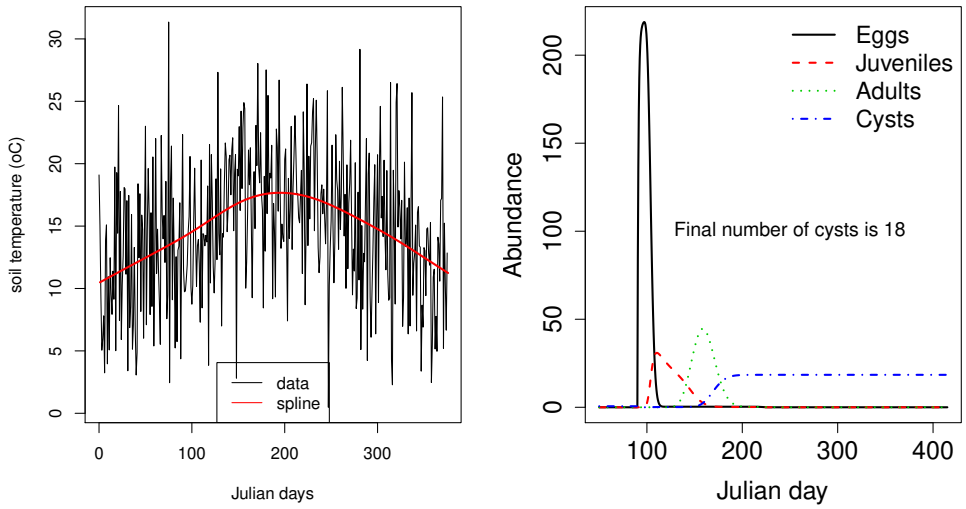

Figure 3: Run model with splined temperature data

```
        simStartDay=simStartDay,
        initialEggsPerGram=initialEggsPerGram,
        soil.density = soil.density,
        plantingDOY=plantingDOY, # potatoes planted on this day of the year
        harvestingDOY=plantingDOY+216, # potatoes harvested on this day of the year
        temperature.pars=list(
            temperatureSpline=NULL,
            fixTemp = NA,
            deltaT = 0
        )
                )


    plotPCN(out$solution,out$parms,ylim=c(0,250),main=paste('Planting day of year is',plantingDOY))

    cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))

    text(250,150,paste('Final number of cysts is',cysts.final),cex=1.5)


}
```

5. Change number of potato plants

```
numYears=1 #number of years to simulate
simStartDay=50 #day of the year the simulation starts e.g. 1st April

initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts (derivs, initialCinditions.R)
```

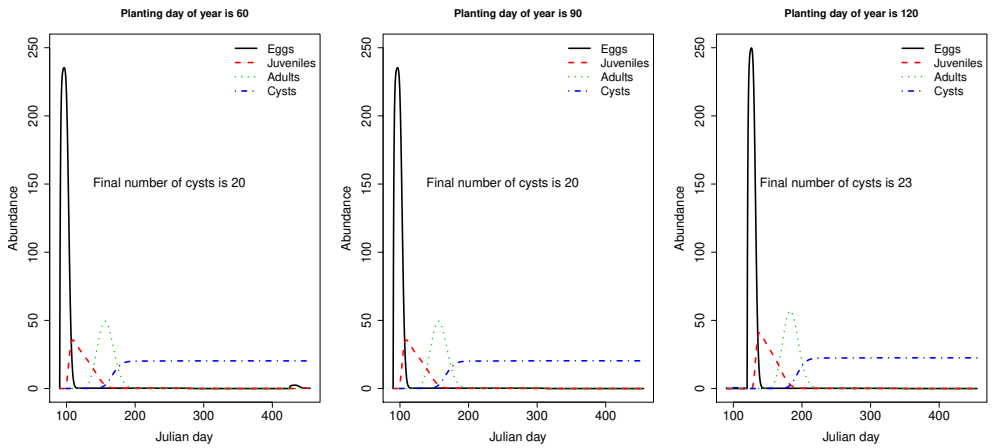

Figure 4: Change potato planting time

```
dev.new(width=13,height=6)
par(mfrow=c(1,3))

for (n in 1:3){

    out=PCNmodel(numYears=numYears,
        simStartDay=simStartDay,
        initialEggsPerGram=initialEggsPerGram,
        soil.density = soil.density,
        temperature.pars=list(
            temperatureSpline=NULL,
            fixTemp = NA,
            deltaT = 0
        ),
    plant.pars=list(
        resistanceFactor = 0, # resistance factor of potatoes
        N.plants = n, # Number of potato plants
        root.length = 500, # maximum length of plant roots (cm) in healthy plant
        roots.per.cm = 0.5 # root length density of potato plants
    )
                )


    plotPCN(out$solution,out$parms,ylim=c(0,800),main=paste(n,'potato plants'))

    cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))

    text(250,400,paste('Final number of cysts is',cysts.final),cex=1.5)

}
```

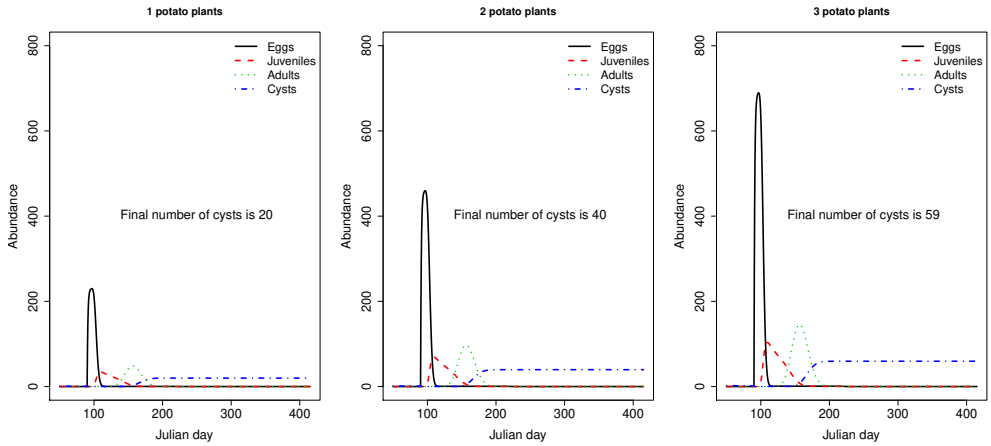

Figure 5: Change number of potato plants

6. Change potato plant resistance

```
numYears=1 #number of years to simulate
simStartDay=50 #day of the year the simulation starts e.g. 1st April
initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts (derivs, initialCinditions.R)


dev.new(width=13,height=6)
par(mfrow=c(1,3))

for (n in c(0,0.5,1)){

    out=PCNmodel(numYears=numYears,
        simStartDay=simStartDay,
        initialEggsPerGram=initialEggsPerGram,
        soil.density = soil.density,
        temperature.pars=list(
            temperatureSpline=NULL,
            fixTemp = NA,
            deltaT = 0
        ),
    plant.pars=list(
        resistanceFactor = n, # resistance factor of potatoes
        N.plants = 1, # Number of potato plants
        root.length = 500, # maximum length of plant roots (cm) in healthy plant
        roots.per.cm = 0.5 # root length density of potato plants
    )
                )


    plotPCN(out$solution,out$parms,ylim=c(0,250),main=paste('Resistance factor:',n))

    cysts.final=round(sum(out$solution[nrow(out$solution),c('C.pre','C','C.d')]))
```

```
    text(250,150,paste('Final number of cysts is',cysts.final),cex=1.5)


}
```

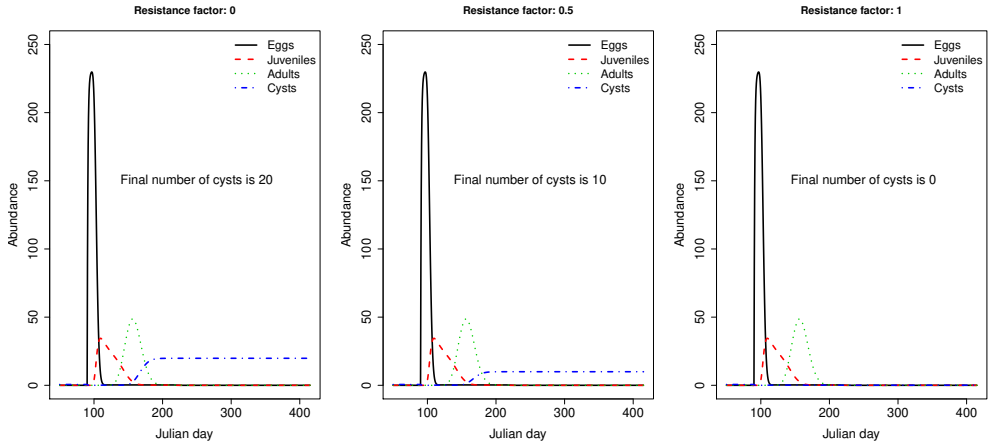

Figure 6: Change potato plant resistance to PCN

7. Run for multiple years on a 6 year rotation i.e. potatoes are planted in years 1, 7, 13. . . .etc

Temperature is constant

```
numYears=20 #number of years to simulate
simStartDay=90 #day of the year the simulation starts e.g. 1st April
initialEggsPerGram = 0.1 # Initial egg density
soil.density = 1.5 # Soil density - used to calculate initial cysts (derivs, initialCinditions.R)

out=PCNmodel(numYears=numYears,
    simStartDay=simStartDay,
    initialEggsPerGram=initialEggsPerGram,
    soil.density = soil.density,
    plantingYears=seq(1,numYears,by=6),
    temperature.pars=list(
        temperatureSpline=NULL,
        fixTemp = 14,
        deltaT = 0
    ),
    )


dev.new()
time=out$solution[,'time']
cysts=rowSums(out$solution[,c('C.pre','C','C.d')])
plot(time/365,cysts,type='l',cex.lab=1.4,xlab='Years',main='Planting every 6 years',col='blue',lwd=2)
```

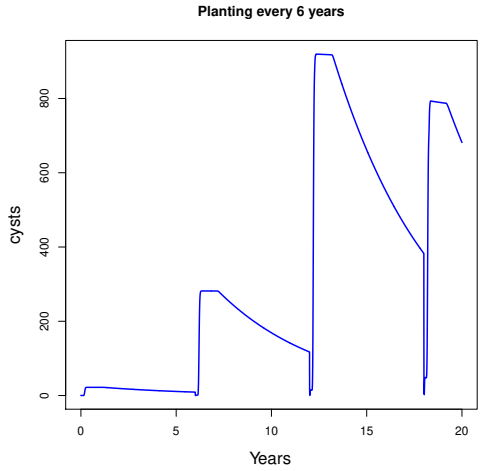

Figure 7: Constant temperature, potatoes planted on 6 yr rotation