**Root Rot Pseudocode**

Assumptions:

1. Pathogen can disperse everywhere
2. Each active cell has a mutually exclusive status of Susceptible (S), Infected non-symptomatic (I) or Diseased symptomatic (D)
3. Cells that are Infected (I) or Diseased (D) only revert to a status of Susceptible (S) when pathogen is absent (Presence == 0)
4. Cells that are Diseased (D) can revert to a status of Infected (I), and will always revert to I if all susceptible tree hosts are eliminated

Inputs:

1. Starting condition map – Optional map coded to represent initial cell status. If no map is provided, all active cells are assume to be Susceptible (S).

* 0 = Nonactive
* 1 = Susceptible (S)
* 2 = Infected (I)
* 3 = Diseased (D)

1. Species susceptibility table – For each tree species (i) an index of susceptibility to damage when disease occurs [Susceptibility(*i*)], ranging from 0.0 – 1.0, where 1.0 is completely susceptible and 0.0 is unsusceptible.
2. LethalTemp – The minimum temperature below which *P. cinnamomi* cannot survive. In the examples below, LethalTemp is set to -24. From McConnell and Balci (2014), this may be about -24 oC (*P. cinnamomi* unable to survive in USDA hardiness zone 6 or higher).
3. phWet – The pressurehead threshold below which the soil is considered wet. Under wet conditions it is possible for a site to progress from S to I and from I to D. In the examples below, phWet is set to 30. Pressurehead equals 0 when soil is saturated and increases as water is reduced. A pressurehead of approximately 33 equates to soil field capacity, and 150 equates to soil wilting point.
4. phDry – The pressurehead threshold above which the soil is considered dry. Under dry conditions it is possible for a site to progress from I to D. In the examples below, phDry is set to 150. Pressurehead equals 0 when soil is saturated and increases as water is reduced. A pressurehead of approximately 33 equates to soil field capacity, and 150 equates to soil wilting point.
5. phMax – The pressurehead threshold above which the soil is considered dry enough to be optimal for site progression from I to D. In the examples below, phMax is set to 250. Pressurehead equals 0 when soil is saturated and increases as water is reduced. A pressurehead of approximately 33 equates to soil field capacity, and 150 equates to soil wilting point.

Calculations at each timestep:

1. Evaluate each site for transitions between states
   1. Probability of each transition is a combination of presence (controlled by temperature [dTemp]) and conducive environment (controlled by soil water [dWater])
   2. Presence:
      1. dTemp = (AnnTmin - LethalTemp) / ABS(LethalTemp)
         1. AnnTmin is the average minimum monthly temperature across years in the timestep
         2. Constrain dTemp between 0 and 1
      2. Presence is a binary 0 or 1 value, which is 1 if a uniform random number is greater than dTemp, or 0 if <= dTemp.
      3. If Presence == 0, site transitions to Susceptible (S) regardless of current state
      4. If Presence == 1, other transitions are possible based on Conducive Environment
   3. Conducive environment:
      1. Each site has a probability of converting from its current state to another state, depending on how conducive the environment is. Conducive environment is a function of the wetness of soil and the presence of susceptible hosts.
      2. Site currently Susceptible (S) can transition to Infected (I) or Diseased (D)
         1. Probability of S converting to I [p(S:I)] decreases linearly from 1 when saturated (ph = 0) to 0 at phWet:

p(S:I) = IF(ph < phWet, -1/phWet \* ph + 1, 0)

phWet = 30

* + - 1. Probability of S converting to D [p(S:D)] is the product of the probabilities p(S:I) and p(I:D), i.e., it must make both transitions.
         1. p(S:D) = p(S:I) \* p(I:D)
    1. Site currently Infected (I) can transition to Diseased (D) or Susceptible (S)
       1. Probability of I converting to D [p(I:D)] is bimodal. Probability decreases from 1 when saturated (ph = 0) to 0 at phWet. Probability increases from 0 at phDry to 1 at phMax.:

p(I:D) = IF(ph < phWet, -1/phWet \* ph + 1, IF(ph > phDry, IF(ph > phMax, 1, m1 \* ph + b1),0))

m1 = 1/(phMax - phDry), b1 = -1\*phDry \* m1

* + - 1. Probability of I converting to S [p(I:S)] is binary depending on the presence of the pathogen.
         1. If Presence == 0, then p(I:S) = 1
         2. If Presence ==1, then p(I:S) = 0
    1. Site currently Diseased (D) can transition to Susceptible (S) or Infected (I)
       1. Probability of D converting to S [p(D:S)] is binary depending on the presence of the pathogen.
          1. If Presence == 0, then p(D:S) = 1
          2. If Presence ==1, then p(D:S) = 0
       2. D converts to I if no cohorts present with susceptibility > 0, or with probability [p(D:I)] when pressurehead is between phWet and phDry. Maximum probability occurs at the midpoint between phWet and phDry:
          1. If all Susceptibility(i) == 0, then p(D:I) = 1
          2. Else, p(D:I) = IF(ph < phWet, 0, IF(ph > phDry, 0, IF(ph <= (phDry – phWet)/2, m2 \* ph + b2, m3 \* ph + b3)))

phWet = 30

phDry = 150

m2 = 1/((phDry – phWet)/2 - phWet), b2 = -1\*phWet \* m2;   
m3 = 1/((phDry – phWet)/2 - phDry), b2 = -1\*phDry \* m3

1. After updating site status, for any site with status of Diseased (D), calculate damage:
   1. For each cohort on the site, damage is determined by the susceptibility of the species:
      1. Damage = Susceptibility(i)
      2. Damage is a proportional removal of cohort biomass representing the death of that proportion of individual trees.

Notes:

* Relative abundance or host biomass do not contribute to the calculations.
* All sites with a Diseased (D) status will experience the same impact per species, but the status of D is probabilistic.
* All cohorts of a species are impacted equally (no modification based on age or biomass).