**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. Species not listed are assumed to have susceptibility of 0.
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.
6. minProbID – The minimum probability of infected converting to diseased. At moderate pressurehead, the probability of disease development can be greater than 0. In the examples below, minProbID is set to 0.10.
7. maxProbDI – The maximum probability of diseased converting to infected. At moderate pressurehead, the probability of disease symptoms disappearing can be high, but might be less than 1. In the examples below, maxProbDI is set to 0.85.

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, (minProbID – 1)/phWet \* ph + 1, IF(ph > phDry, IF(ph > phMax, 1, m1 \* ph + b1),minProbID))

m1 = (1-minProbID)/(phMax - phDry), b1 = minProbID – (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) = MIN(maxProbDI,IF(ph < phWet, 0, IF(ph > phDry, 0, IF(ph <= (phDry – phWet)/2, m2 \* ph + b2, m3 \* ph + b3))))

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).