**ASF Project**

**Objectives**

* Forecast results of control strategies
  + Probability that disease escapes managed/modeled area
  + Time until elimination
  + Cost
* Control strategies that will be examined
  + Hunting
  + Trapping
  + Toxicant
  + Vaccination
  + Carcass removal
  + Combinations of the above will be examined
  + Intensity (level of effort) of the above will be varied
  + These will be varied spatially, temporally, and demographically
  + ~ 10 scenarios will be modeled

**Timeline**

* Working prototype of model by end of 2016
* Maybe Shiny in 2017?
* Final deadline August 2018

**Roles**

* NWRC will build the model framework and the function that creates the initial population
* Other functions, starting with mortality, will be written collaboratively with Christiane
* Deliverables will include two publications (Christiane is lead author)
* One paper on the model itself; one paper on strategy evaluation
* NWRC will be more involved in first paper (Aaron 2nd author, Jordan and Chris depending on involvement)

**Model Construction Notes**

*Basics*

* Individual based, stochastic simulation model
* Daily time step
* Written in R initially, conversion to C++ as needed for speed via Rcpp package
* Possibly build web app via Shiny package
* Initial length of 365 days post burn-in

*Spatial Structure*

* Hexagonal cells
  + Side length = 3.849 km
  + Minimum diameter = 6.667 km
  + Area = 38.490 km^2
* Center cell surrounded by four rings with total of 61 cells

*Social Structure*

* Three types of sounders
  + Females and piglets
  + Males
  + Single males
* Four age categories for females
  + < 10 months
  + 10 – 12 months
  + 12 – 18 months
  + > 18 months
* Three age categories for males
  + < 10 months
  + 10 – 18 months
  + > 18 months

*Mortality (natural)*

* Mortality probabilities will not be density-dependent
* Mortality probabilities will vary by age category, but not by season or sex
* Abundance will be censored at carrying capacity (k)
* k = 230 pigs per cell (6 pigs per km^2)
* Mortality probabilities will be set via an iterative process using a working model
  + Too high and the abundance will not approach k
  + Too low and growth will be unrealistically fast when abundance < k
* Females with age > 96 months will be censored from the population
* Males with age > 72 months will be censored from the population

*Reproduction*

* Litters can only be produced from March 1 – May 31
* For females with age < 24 months, Prob(0, 1, 2 litters) = (0.5, 0.5, 0)
* For females with age > 24 months, Prob(0, 1, 2 litters) = (0.1, 0.8, 0.1)
* On March 1st, each fertile female in the population will be assigned a number of litters and a day on which to have those litters. When that day comes, the litter will be produced and those piglets get added to the population
* Piglets are assigned a mother id number; all pigs assigned a unique id number of their own
* For females with age < 24 months, Prob(1:8 piglets) = (0.25, 0.4, 0.2, 0.1, 0.05, 0, 0, 0)
* For females with age > 24 months, Prob(1:8 piglets) = (0.01, 0.02, 0.05, 0.05, 0.1, 0.2, 0.3, 0.27)
* Prob(female piglet) = 0.5

*Dispersal*

* Males with age > 10 months disperse from their group with other males from their litter.
* If males disperse from their original group with other males, the resulting small group separates when age > 18 months.
* Females selected for dispersal if group size is more than 25. Youngest females with age > 10 months selected first. Disperse with most recent litter that is < 10 months old.
* Dispersal occurs to own cell or adjacent cells with equal probabilities.

*Disease Transmission*

* Disease will be introduced in the center cell to one pig.
* Disease will be introduced in:
  + Breeding season (November 1 – January 31)
  + Outside of breeding season
  + These will be chosen per scenario and assigned a day for introduction randomly
* Allow the demographic structure to normalize before introducing disease.
* Time in exposed state: Prob(3, 4, 5 days) = (0.1, 0.7, 0.2).
* Time in infected state: Prob(4:9 days) = (0.05, 0.15, 0.4, 0.2, 0.1, 0.1).
* Individual survive and become immune with probability of 0.05.
* Prob(exposure) = f(I in adjacent cells, I in own cell, I in sounder, carcasses in own cell).
* Look to previous literature for functional form and transmission parameter.
* When counting I, weight I in own cell sounder by 1, then other categories of I by [0, 1].
* There is an additional disease state (dead and infected) to capture the effect that infected. carcasses have on the probability of living individuals becoming exposed.
* Carcasses will remain infective for random triangular (16, 21, 30) days between May 1 – October 1 and for random triangular (35, 56, 70) days Oct 2 – April 30.

*Emigration*

* The above function varies across the different categories of sounders and season.
* Movement in a single day is only possible to adjacent cells.
* Need to decide how pigs move into the modeled area from unmodeled areas.

*Initial Population*

* Initial distribution across age categories
  + Female <10 months: 0.27
  + Female 10 – 12 months: 0
  + Female 12 – 18 months: 0
  + Female >18 months: 0.25
  + Male <10 months: 0.27
  + Male 10 – 18 months: 0
  + Male >18 months: 0.21
* Initial distribution of ages within age categories
  + Female <10 months: runif (7:10 months)
  + Female 10 – 12 months: NA
  + Female 12 – 18 months: NA
  + Female >18 months: triangular (19, 19, 96 months)
  + Male <10 months: runif (7:10 months)
  + Male 10 – 18 months: NA
  + Male >18 months: triangular (19, 19, 72 months)
* When drawing initial ages, if we draw an age > 18, assign it to a single pig
* When drawing initial ages, if we draw an age < 18, assign it to three pigs
* Initial sounder size for females is 3 adults, 15 piglets
* Female sounders are created until the supply of piglets is exhausted
* Allocate remaining adult females to sounders of size runif(4:10)
* Adult males assigned to unique sounders
* Use an initial iteration for burn-in by taking repeated snapshots of untouched population after a certain point

*Management*

* Management may begin
  + Immediately
  + After a certain period of time has passed
  + After a certain number of pigs acquire the infection
* Strategies
  + Hunting primarily adult males
  + Hunting that also includes taking juveniles and females
  + Trapping
  + Toxicant
  + Vaccination
  + Combinations
* Recreational hunting during burn-in that takes primarily adult males
  + Need baseline hunting take
* Need functions that relate effort to costs and percentage of the population removed or vaccinated
  + Different functions for different strategies
* Need a standard definition of effort for each strategy and the cost per unit of effort for each

*Unmodeled Population*

* Assume there is a large unmodeled/untracked surrounding population
* Assume a carrying capacity of this unmodeled population
* Immigration into outside ring from unmodeled area depends on relative density of outside ring and unmodeled area
* When animals move into outside ring from unmodeled area, density in unmodeled area temporarily falls
* Make some assumption about the speed that density recovers in the unmodeled area
  + Could base this assumption of model results starting from small initial population and fitting logistic growth function
* Movement in takes place at the sounder level – randomly draw a sounder type to create when immigration is called for
* Dispersal from the unmodeled population must also be allowed
* Create an indicator for
  + Movement of an infectious individual into the unmodeled population
  + Probabilistic disease transmission to the unmodeled population
    - Transmission probabilities from each of the outside cells should be calculated separately
    - Once calculated, each of these probabilities is assessed against the fraction of the unmodeled population that lies adjacent to the outer cell. 3/30 of the unmodeled population lies adjacent to each outside cell.