Methods to Study and Control Diseases in Wild Populations

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Outline

- Surveillance
- Investigation of Pathogen Natural History
- Interventions
- Modeling

Surveillance

- Definition of surveillance
  The ongoing systematic collection and analysis of data and the provision of information which leads to action being taken to prevent and control a disease, usually one of an infectious nature.

- Requires diagnostic tools & case definitions

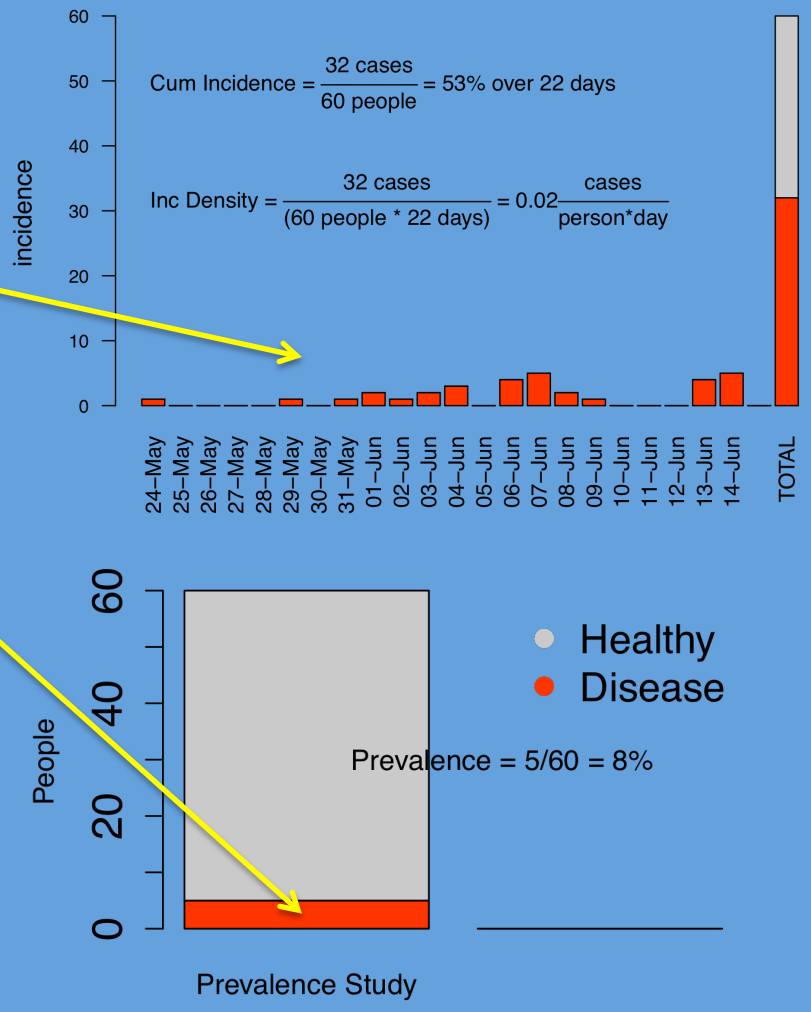
- Active vs passive

- Role of surveillance: What use is it?

- What kind of data can you collect on wildlife & plant diseases?

Recall: Epidemiological Jargon

- Incidence: # of new infections per unit time
- Prevalence: % of population infected at particular time
- Seroprevalence: % of population carrying antibodies indicative of past exposure



Surveillance: Incidence

- # of new events * host^{-1} * time^{-1}
- Events can be infection, onset of symptoms, death
- For what diseases is this measureable?
- You must be able to show that it is a new infection!

  acute infections (rabies virus, anthrax, *others?*)

- How do you know it is infected?

  diagnostics: laboratory & symptoms

Surveillance: Prevalence

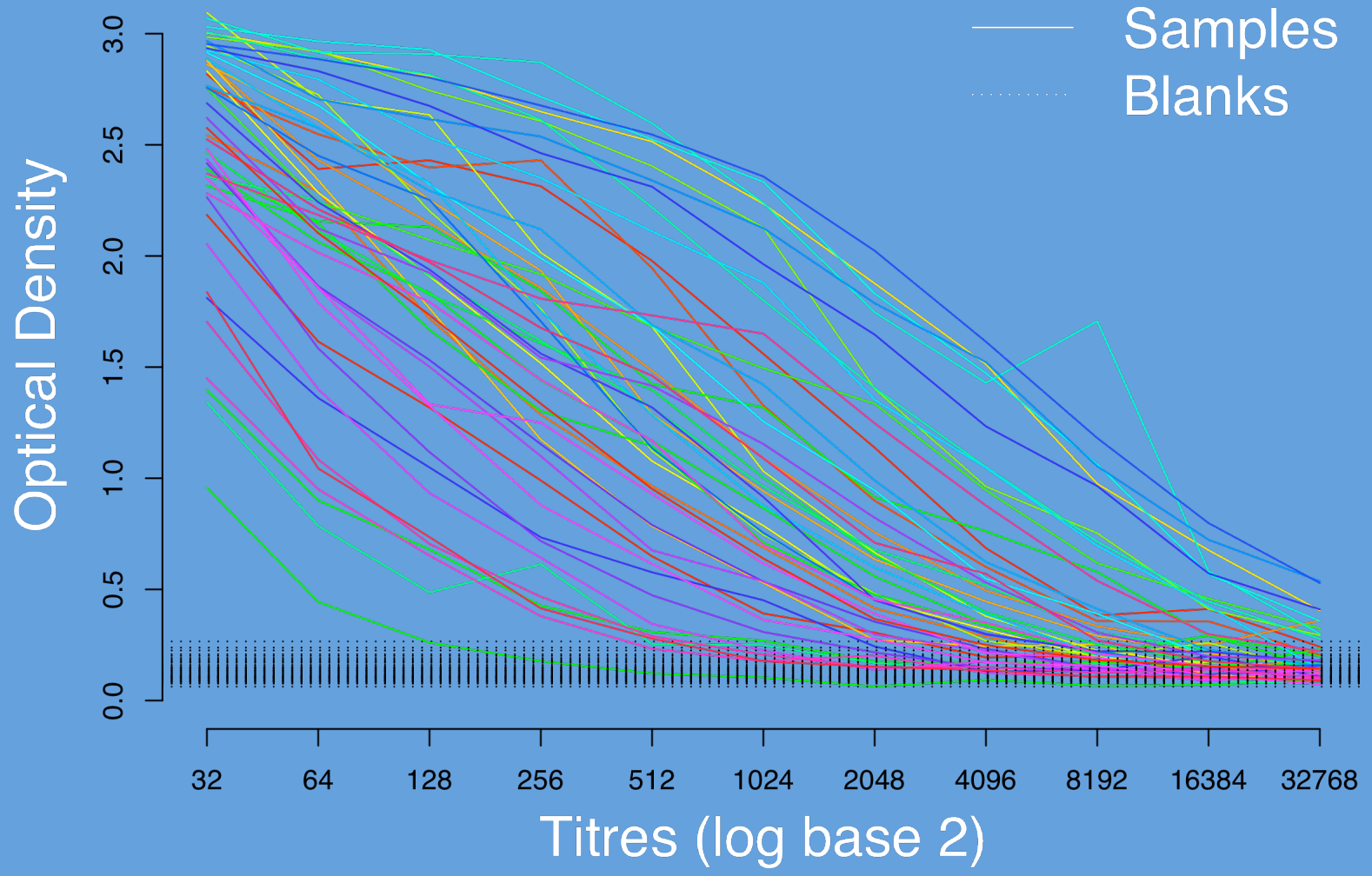
- # proportion of hosts with a specified outcome
- Outcomes: Symptoms, Harboring a pathogen, Seropositivity
- For what diseases is this measureable?
- Prevalence ≈ Incidence * Duration
- So for diseases of short duration, prevalence may be undetectable.

Surveillance: Mortality

- Definition of surveillance
- Active vs passive
- Role of surveillance

- What kind of data can you collect on wildlife & plant diseases?
  - Incidence?
  - Prevalence?
  - Seroprevalence?
  - Mortality?
  - Pathogen Density?

Surveillance: Seroprevalence



Investigation of Pathogen Natural History

- What is causing the disease?
- How is it transmitted?
- Where, when, and in which animals/plants is it most problematic?
- Why do we see these population level patterns?

What is causing the disease?

- Identification of the causal agent…Not easy!
- Veterinarians, Pathologists, Microbiologists
- Just because a pathogen is present does not mean it causes the disease!
- Koch's Postulates

Koch's Postulates

(1) The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy animals.*

(2) The microorganism must be isolated from a diseased organism and grown in pure culture.

(3) The cultured microorganism should cause disease when introduced into a healthy organism.

(4) The microorganism must be reisolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

How is it transmitted?

- Directly?
- STD?
- Water-borne?
- Vector-borne?
- Vertically?

Where/When is it transmitted?

- Temporal Patterns
  - Seasonality
  - Recruitment & recurrent epidemics: Rabies
- Spatial Patterns
  - Geographic patterns
  - Density gradients
  - Species Overlap & inter-species transmission

Which individuals are affected?

- Demography
  - Sex
  - Age
  - Diet
  - Behavior
- Population level patterns
  - Immunity from history of infection

Prevention & Interventions

- Treatment
- Vaccination
- Culling
- Vector Control
- Direct Pathogen Control
- Reserve Design

What are dynamic models for?

- Rigorously stating hypotheses
- Linking across scales
  - We measure disease parameters at the level of individuals
  - We are interested in results at the level of populations
  - Models are essential for linking these scales because they explicitly account for dependence of individuals (inherent in infection processes)
- Exploring the un-explorable
  - When ethical, logistical, or resource limitations prevent experimental or observational studies

Statistical Models

- Account for bias and random error to find correlations that may imply causality.
- Often the first step to assessing relationships.
- Assume independence of individuals (at some scale).

Dynamic Models

- Systems Approach: Explicitly model multiple mechanisms to understand their interactions.
- Links observed relationships at different scales.
- Explicitly focuses on dependence of individuals

By developing dynamic models in a probabilistic framework we can account for dependence, random error, and bias while linking patterns at multiple scales.

The SIR model & some extensions

- The basic SIR model
- Mass action vs frequency dependent transmission
- Adding an exposed class
- Realistic waiting time distributions
- Difference equations vs differential equations
- Heterogeneity
- Age structure

Title: Disease Ecology Methods
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URL: http://www.cnr.berkeley.edu/getzlab/people/steve_bellan.html
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