Development and Evaluation of Sampling Designs for Chronic Wasting Disease Surveillance Programs

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Goals and Objectives:

- Develop a set of alternative sampling designs for detection and estimation of prevalence and spatial pattern of CWD in a given area.
- Evaluate the statistical operating characteristics (bias, precision) and cost-efficiency of the designs under alternative sets of assumptions about the spatial epidemiology and ecology of the disease and its host.
- Develop products that are adaptable for use by natural resource agencies with a variety of surveillance objectives.

Progress:

The primary goal of this project was to evaluate the properties of CWD detection and prevalence estimates generated from a range of statistical and convenience sample designs. We developed simulation methods that can be applied to different landscape settings and under alternative hypotheses about CWD prevalence and spatial distribution. We simulated deer density and disease in an Iowa landscape and compared estimators from statistical designs with known properties to estimators from convenience sampling approaches whose properties are unknown. We considered 2 convenience sampling approaches: road-kill sampling, and hunter-harvest sampling. These approaches were compared to an SRS design and a probability sample design that could be used with a sharp-shooting sampling strategy.

Under a spatially random disease model, the probability of detecting at least 1 diseased deer in a single annual sample and the mean number of annual samples required to detect at least 1 diseased deer were approximately the same for SRS and the 2-stage cluster sample for sharp-shooters. If 120 animals were sampled under these designs, there was at least an 84% chance of observing an infected animal in the first year, and it would take on average at least 1.20 annual samples to detect at least one infected animal. Results for these parameters were nearly identical for a clustered disease model.

Under the random disease distribution model, road kill estimates were roughly the same as the probability sample designs. Under the hot spot and spark model, the waiting time distribution for the road-kill sample had a very low detection probability (9%) and a long waiting time (> 11 years).

The hunter-shot convenience samples had a lower detection probability (80%) and longer waiting time (1.26 years to detect a disease-positive animal) than the probability sample designs and the road kill design. The detection probability was less (76%) and the waiting time longer (1.32 annual samples) for hunter-shot samples than for samples under clustered disease model.

The prevalence estimates were unbiased under either disease distribution model for both probability designs when the proper estimator was used. The mean of prevalence estimates for the road-kill design depended on the disease model. Under the random disease model, the true prevalence was greatly over estimated by the road-kill design. In contrast, under the clustered model, the true prevalence was grossly underestimated for the road-kill design. Compared to the true 1.5% prevalence rate, the mean of the prevalence estimates was 0.1%. For hunter-based samples, the mean of the prevalence estimate is slightly negatively-biased for both the random and the clustered disease distribution models.

Conclusions and Recommendations:

Convenience samples used to collect observational data for disease surveillance are often implicitly assumed to be representative of a population. However, sampling biases invariably occur and the inability to quantify the probability of obtaining a sample unit in a convenience sample makes it impossible to develop a statistically valid estimate of surveillance parameters. Simulation models can be used to gain knowledge about disease epidemiology, and the biases in convenience samples and to evaluate alternative sampling approaches.