Using NAADSM to model wildlife-livestock disease transmission in a rangeland system: challenges and insights

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Background:

Efforts to predict the potential spread of foot-and-mouth disease (FMD) in the U.S. livestock industry have focused primarily on confined livestock operations. Rangeland livestock systems have received little attention, despite having unique characteristics that would make FMD more difficult to detect and control. Rangeland cattle are often unsupervised for long periods during the summer grazing season. If FMD were to emerge in a rangeland system, it might go undetected for much longer than in a confined operation. Rangeland livestock also interact frequently with highly mobile wild ungulates. An infected wild ungulate could transmit FMD to many livestock herds in the course of its daily movements, and would be difficult to locate and destroy due to the vast and remote landscape.

Objectives & Methods:

The ability of existing epidemiological models (many of which were developed for confined livestock systems) to accommodate a rangeland livestock system's unique features has gone largely untested. This study's objectives are to:

1. determine which features of a rangeland livestock system can be accommodated in the epidemiological modeling software "NAADSM";
2. explore, through sensitivity analysis, the relative importance of the following parameters in a rangeland livestock system: probability of FMD transmission between species, distance traveled per day by wild ungulates, and livestock-wildlife contact rate.

Results & Discussion:

1. Some features of the rangeland livestock system are inconsistent with assumptions that underlie NAADSM and other models of its kind. The most critical inconsistency is the assumed behavior of "indirect" contacts. In the confined livestock systems for which NAADSM was developed, indirect contacts such as a milk-truck can spread FMD between herds. In the rangeland system, wild ungulates are instead the indirect contacts. Indirect contacts in NAADSM are assumed to respond to a quarantined or destroyed livestock herd by ceasing all traffic to that farm, and altering their routes among remaining farms. Wild ungulates, however, are unlikely to respond to a quarantined or destroyed herd/farm/grazing allotment in that manner. Assumptions in many models about indirect contacts are sufficiently inconsistent with wild ungulate behavior to preclude meaningful simulation of disease-control activities. Code modification will be necessary to more accurately represent wildlife as an indirect contact.
2. Sensitivity analysis reveals that an FMD outbreak's severity, as predicted

by NAADSM, is more sensitive to distance traveled per day by wild ungulates, and the associated wildlife-livestock contact rate, than to the probability of disease transmission.

Conclusions:

NAADSM represents one of many epidemiological models that researchers might attempt to apply to rangeland livestock systems. Insights gained from this study will 1) help researchers gauge other models' potential performance *ex ante*, 2) inform the development of models that better accommodate rangeland livestock systems, and 3) suggest priorities for additional data collection.