Food and Agriculture Organization of the United Nations

PPR Episystems Update

A Management Tool to Guide PPR Eradication

Jeffrey C. Mariner

Veterinary Epidemiologist

Episystems: A Management Tool to Guide Eradication

A virus episystem is a set of interconnected host population capable of maintaining circulation and transmission of the virus indefinitely

The role of specific populations in the episystem determines when, where and how actions should be taken to achieve eradication

Management and monitoring should be based on the episystem and the strategy to interrupt virus circulation in the episystem.

Core populations

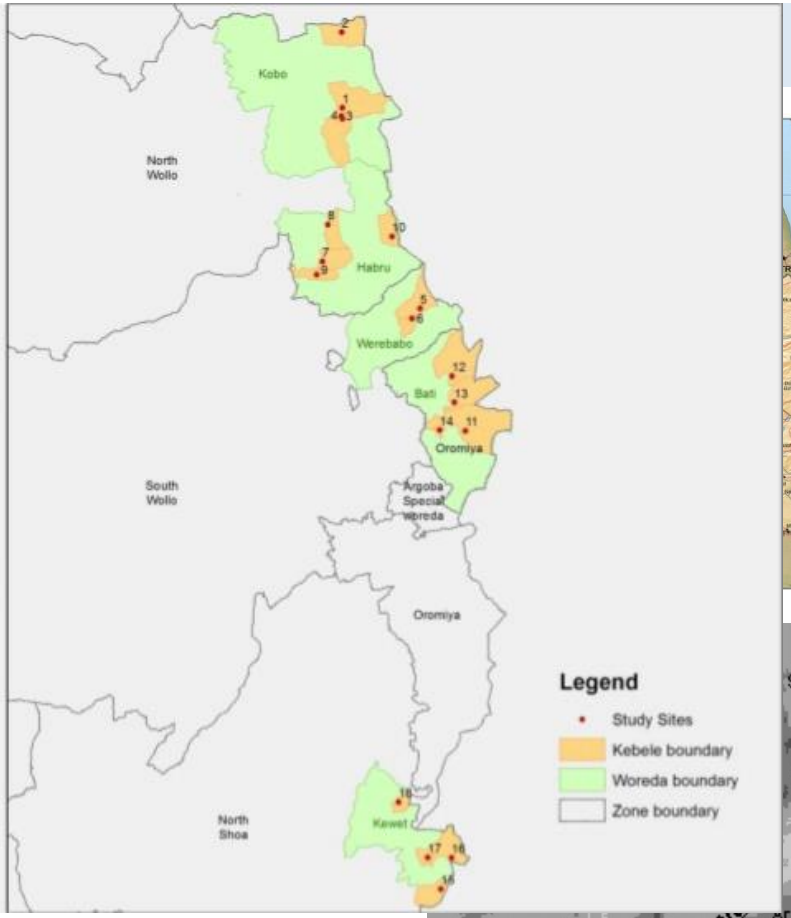
- The core of an episystem is the population components capable of sustaining PPR virus transmission over prolonged periods – *the reservoir*
  - For PPR - Domestic small ruminants
  - Often remote or marginalized communities
  - Surveillance and disease reporting databases often misleading
    - Northern Kenya

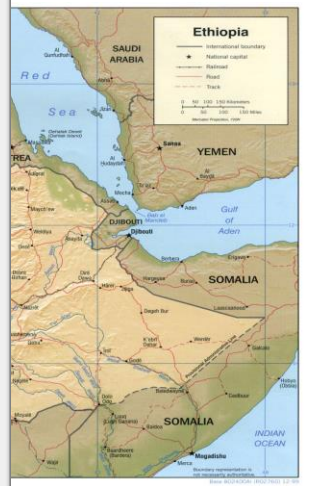
Incidental Infections - Periph populations

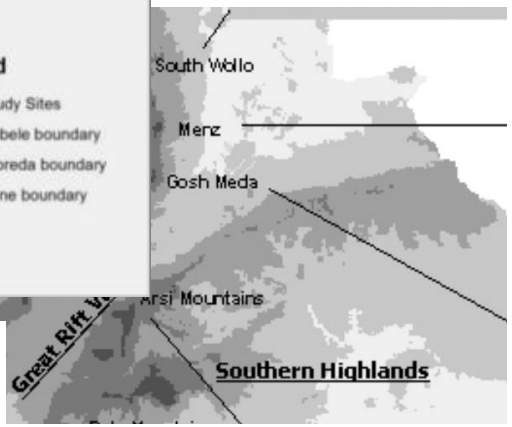
- Outbreaks spillover fro system
- Lower density/contact
- Periodic re-introductio
- Not all susceptible spec transmit PPR to the ext role in enabling virus m
  - Cattle
  - Wildlife
  - Camels

These are dead contribute to v

No	Zone	District	PA	PAs2007
1	North Wello	Kobo	Dibi (011)	Weyiru Dikalo
2	North Wello	Kobo	Addis kegn(05)	Mesno
3	North Wello	Kobo	Addis Alem (07)	Afaf
4	North Wello	Kobo	Afafe (022)	Afaf
5	South Wello	Werebabo	Arebati	Arabiti
6	South Wello	Werebabo	China	Chali
7	North Wello	Habru	Tis Keye	Were Lalo
8	North Wello	Habru	Jarota	Kule
9	North Wello	Habru	Mehal Amba	Mehal Amba
10	North Wello	Habru	Dire Roka	Kilewa
11	Oromia Special zone	Bati	Chekorti	Fara
12	Oromia Special zone	Bati	Felana	Weyo Filana
13	Oromia Special zone	Bati	Chachatu	Cha Chatu
14	Oromia Special zone	Bati	Sukai	Salmene
15	North Shoa	Kewet	Kureberet	Kure beret
16	North Shoa	Kewet	Sefiberet	Sefiberetina
17	North Shoa	Kewet	Medina	Madina
18	North Shoa	Kewet	Yelen	Yelen







› BMC Vet Res. 2019 Mar 8;15(1):84. doi: 10.1186/s12917-019-1828-6.

Molecular detection and phylogenetic analysis of Peste des petits ruminants virus circulating in small ruminants in eastern Amhara region, Ethiopia

Biruk Alemu [1], Getachew Gari [2], Geneviève Libeau [3], Olivier Kwiatek [3], Menbere Kidane [4], Rediet Belayneh [4], Bewuket Siraw [5], Barbara Wieland [6], Wondwoson Asfaw [7], Reta D Abdi [8 9]

Agree on simple terminology

The reservoir in the system is those populations that are required to maintain transmission of the virus

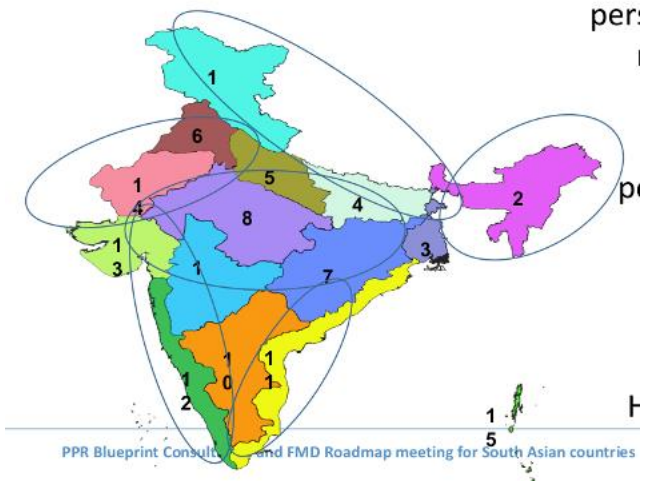
- Reservoir populations
- Core

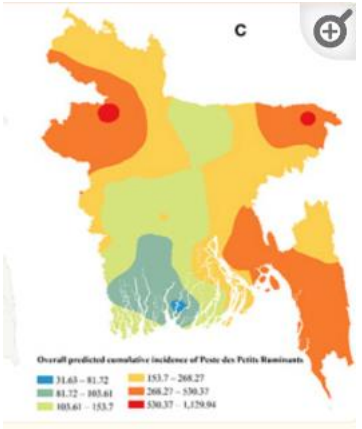
Other populations in the system that may become periodically infected but cannot maintain infection

- Peripheral
- Incidental

Issue of Scale

- Local episystems – Uganda and Bangladesh – stable clusters
- Regional episystems – China-Mongolia – interactions over distance
- Supra regional?



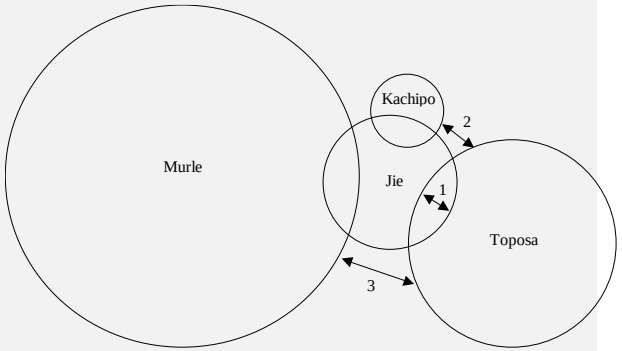


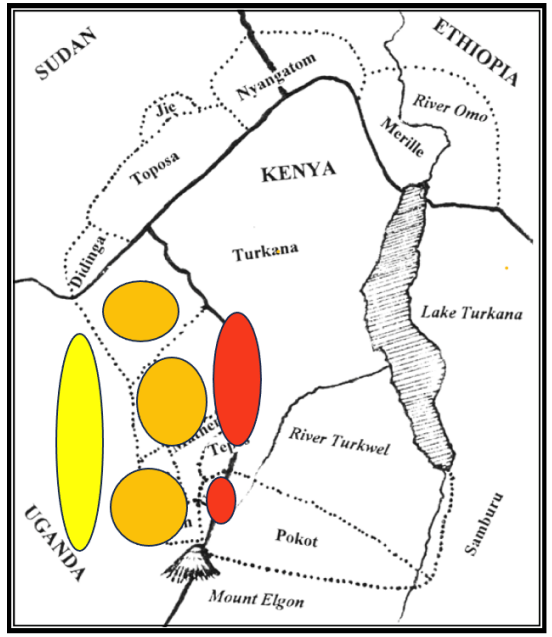
The Structure of Episystems

An episystem:

- May consist of one large population but more commonly consists of several interlinked sub-populations
- Small ruminant holdings of an ethnic community often share common herding and contact patterns and can be considered a population
- Movement and transhumance over a geographical area is often a feature that must be considered
- Can include value chains or marketing chains
- Can be a network of populations at different locations and not necessarily in a contiguous zone

Episystems typically transcend international borders and often involves more than one regional economic community



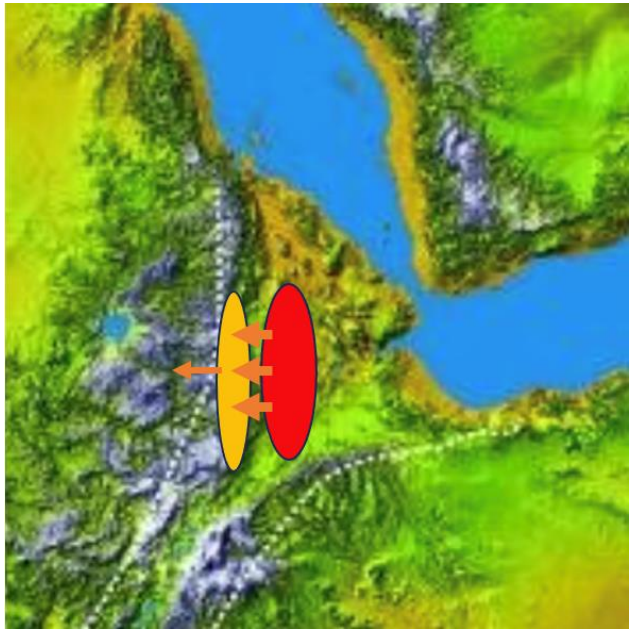


Episystems vs. Risk-Based Approaches

- The episystem approach is based on an understanding of the epidemiological patterns of disease transmission:
  - Direct evidence of disease transmission
    - Descriptions of patterns
    - Case and outbreak detection and investigation
    - Cluster analysis
  - Triangulated with risk factors
- Risk-based approaches utilize risk data as surrogates for direct evidence
  - A more probabilistic approach
  - Inferred patterns from circumstantial evidence
- **Risk-based vaccination is not episystems targeted vaccination**

Drivers of Episystems

- *Viral* attributes such as host range, receptor affinity, transmission rates, etc.
  - Viral attributes also evolve in the face of selective pressure.
- *Host*
  - individual and population
- *Environment*
  - Climate
  - Landscape
- Society, culture, political economy, production systems all shape ecosystems and episystems.
  - host population structure, mobility and the environment



Interrelated and Dynamic

Episystem description and assessment

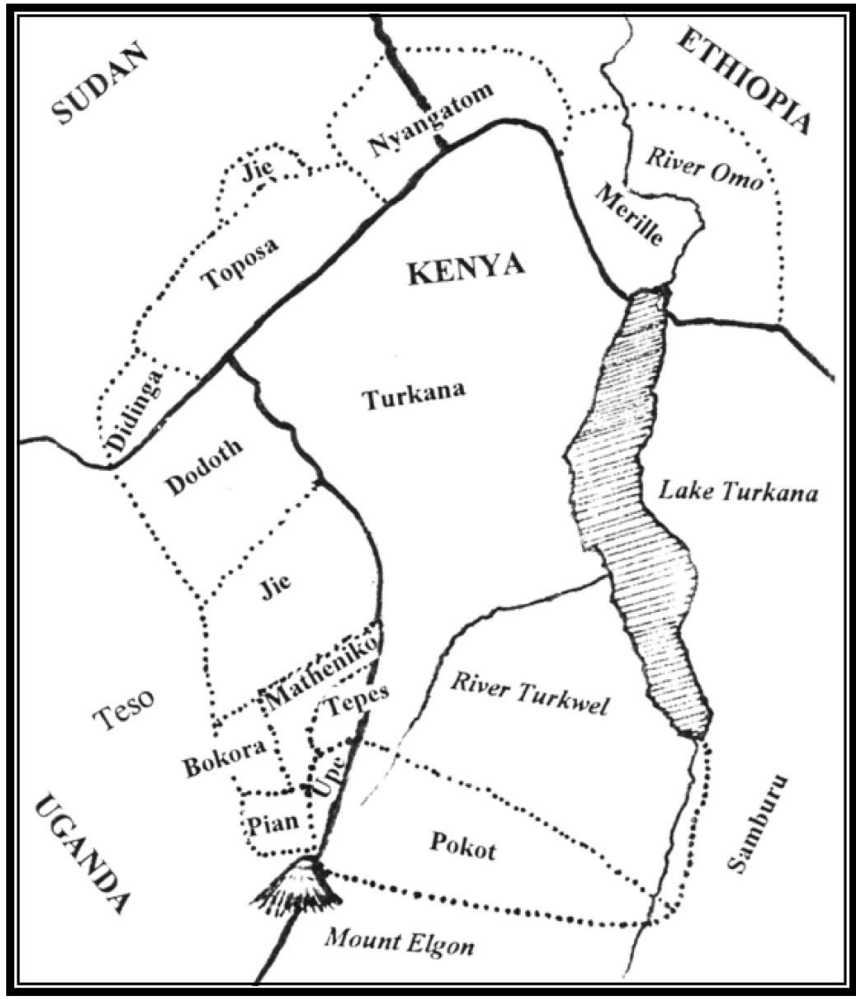
- The heart of assessing national PPR epidemiology (Stage 1)
- Conventional and participatory epidemiological characterization of:
  - Populations, contact patterns, outbreak patterns
- Analysis of the genetic sequence and clustering (molecular epidemiology) of strains detected in an episystem are:
  - The best epidemiological tool to delineate systems
  - Easily achievable if appropriately planned
  - Internationally available servicess for testing and analysis

Examples of PPR Episystems

Karamoja

Karamojong cluster

- Areas of Uganda, Kenya, South Sudan and Ethiopia
- Herds of Turkana, Karamojong, Jie, Dodoth, Toposa, Nyangatom and Pokot
- Defined homestead areas with complex transhumance and livestock exchange patterns



Epidemiological Mapping

Focus group of key informants

- on the ground

Interactive list epidemiological factors

Groups map factors

- Like layers in a GIS

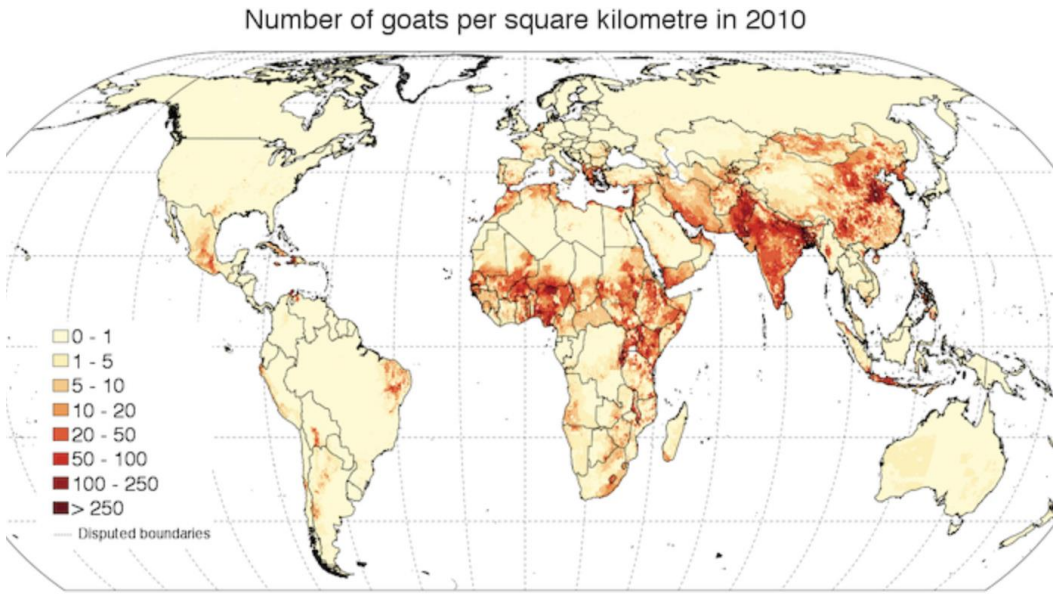
Exam the patterns and areas of intensity of factors

Assessing a PPR Episystem

Episystem Map Layers

- Populations and their interactions
  - Livestock and wildlife
  - Density and intensity of interactions
  - Critical community size
- Movement pathways and seasonal congregations
- Past epidemiological patterns
- Vaccination levels and gaps
- Insecurity
- Linkages to other systems

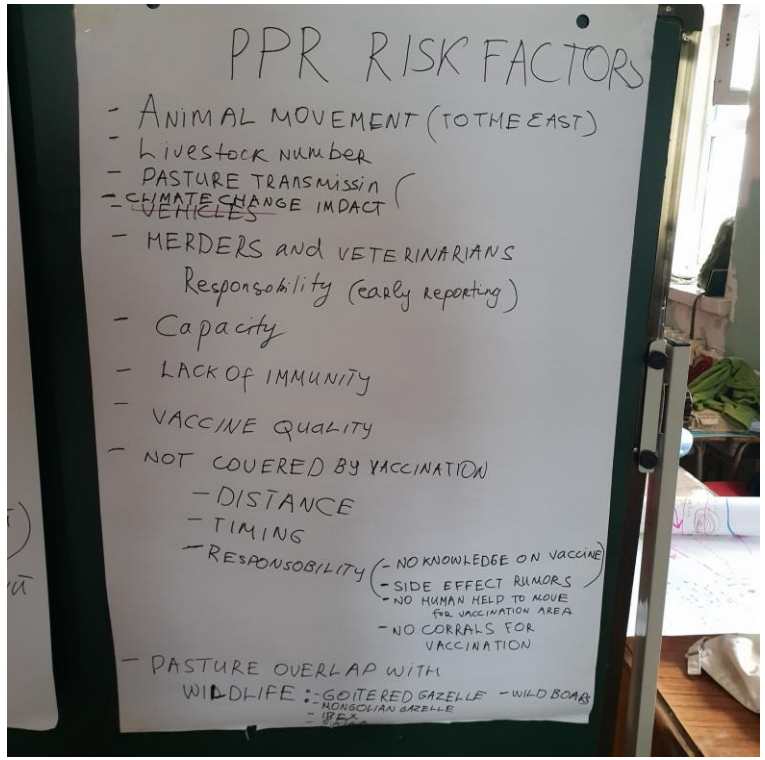
Goat Density in 2010

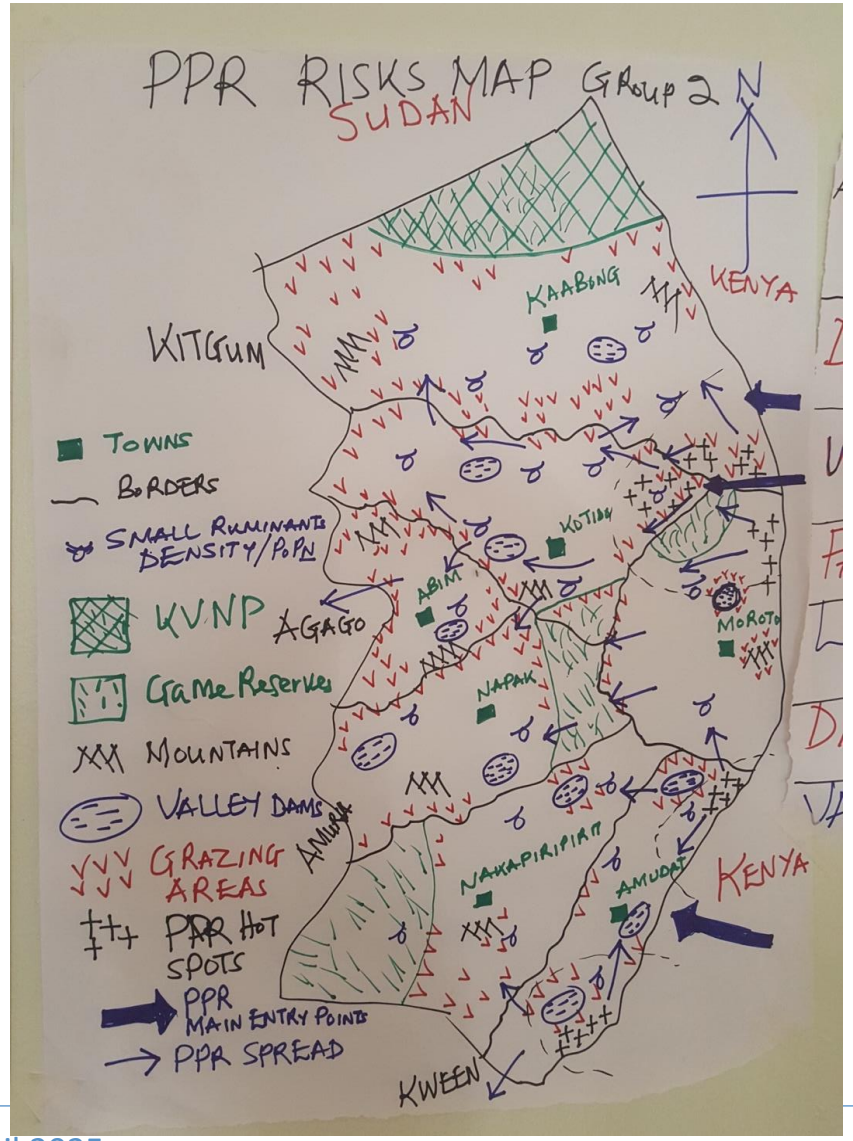


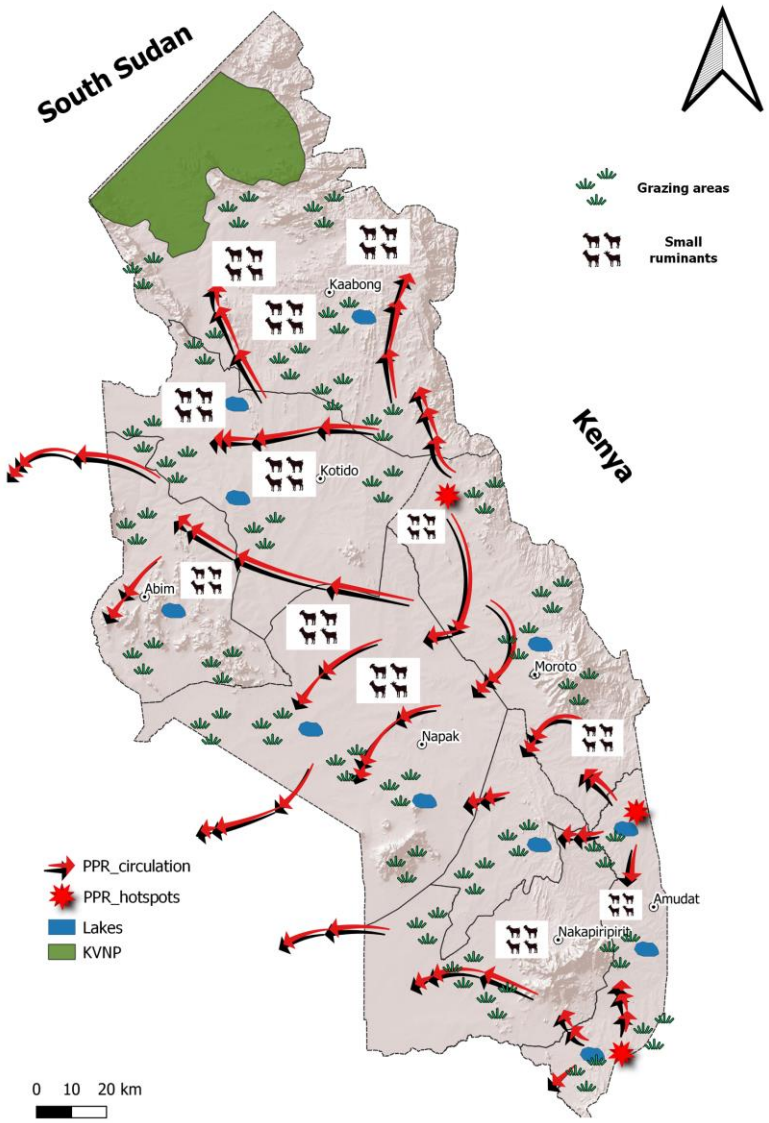
FAO 2010

Assessing a PPR Episystem

Examples of Episystems





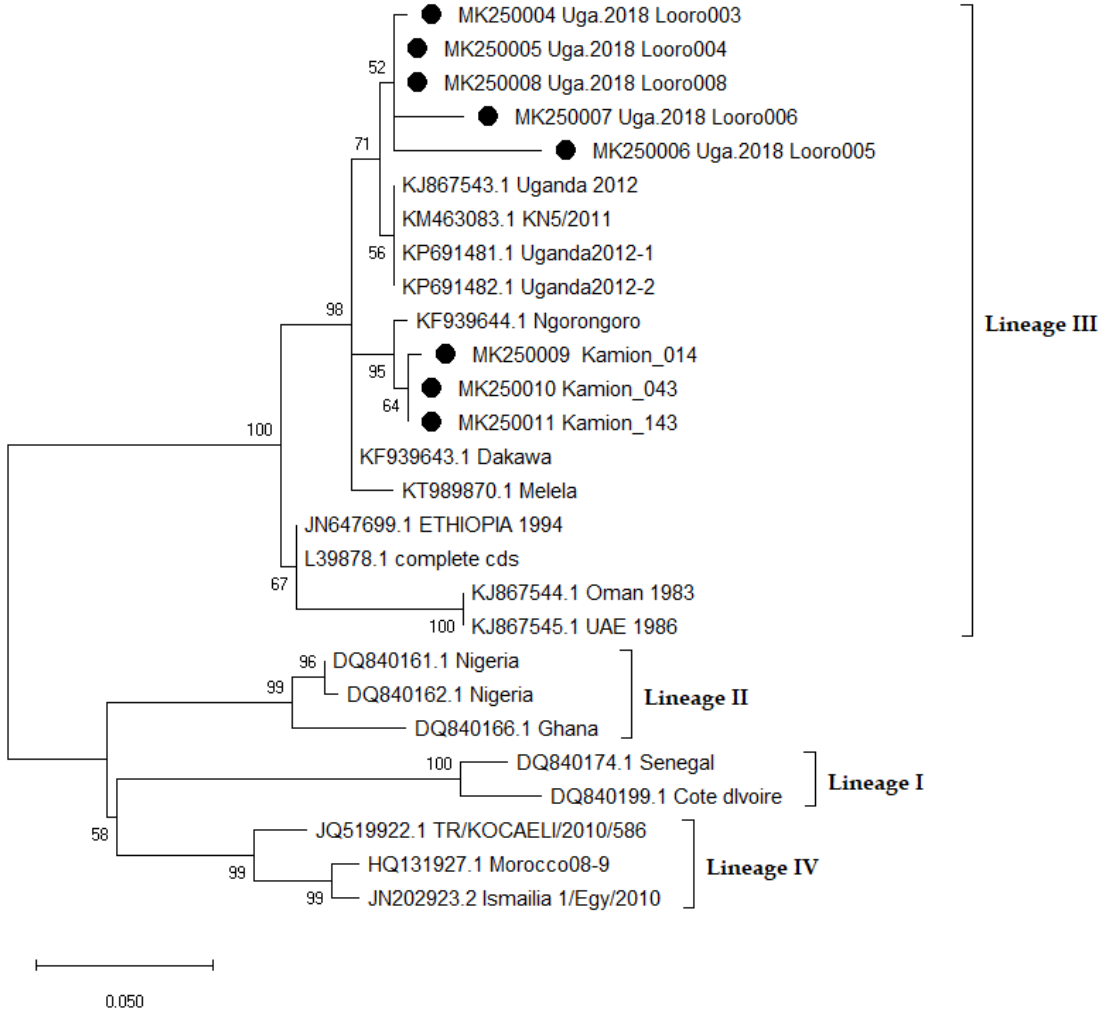


Examples of PPR Episystems

Molecular epidemiology to define drivers of the system

Partial N gene sequences

- Looro and Kamion clusters
- Separated by ~125 kms
- Clusters more closely related to other areas of East Africa than each other
- Two separate systems?



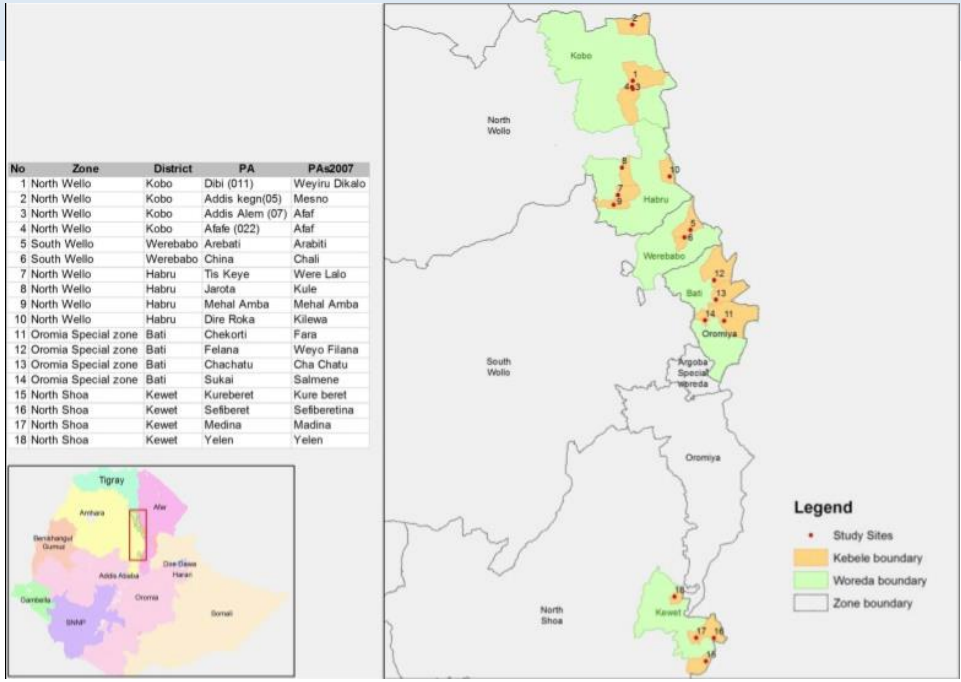
Participatory Assessments – Hypothesis and validation

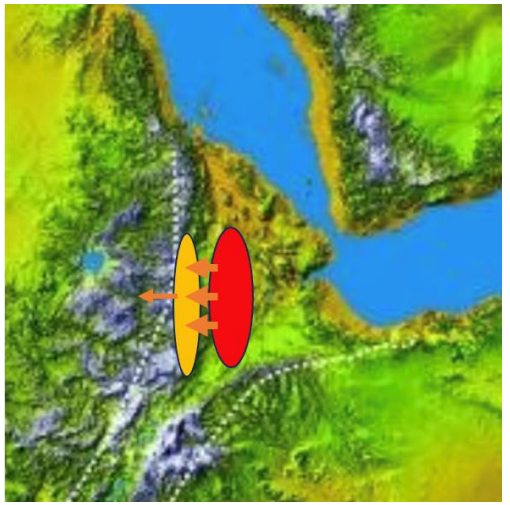
- The outcome of the initial assessment is working hypothetical scenario and map of the reservoir and and incidentally affected populations.
- This hypothesis is validated through participatory field assessments of the component populations.
- The participatory assessments will gather local knowledge (livestock owner and professional) on the patterns of PES events.
  - Some communities have specific names for PPR.
- Ideally, the field assessments will lead to the detection of cases and additional virological and molecular data that confirm or refute the initial hypothesis.
- Usually the outcome is a refinement of the working hypothesis.

Holistic analysis

- Strengths of Alemu et al
  - Targeting of study location
  - Case finding in the field
  - Genetic analysis
- Challenges Alemu et al highlight
  - Fragmentation of analysis
  - National borders and now state borders
  - Incomplete understanding of episystem
    - Core reservoir not identified
  - Leading to - Ineffective recommendations

No	Zone	District	PA	PAs2007
1	North Wello	Kobo	Dibi (011)	Weyiru Dikalo
2	North Wello	Kobo	Addis kegn(05)	Mesno
3	North Wello	Kobo	Addis Alem (07)	Afaf
4	North Wello	Kobo	Afafe (022)	Afaf
5	South Wello	Werebabo	Arebati	Arabiti
6	South Wello	Werebabo	China	Chali
7	North Wello	Habru	Tis Keye	Were Lalo
8	North Wello	Habru	Jarota	Kule
9	North Wello	Habru	Mehal Amba	Mehal Amba
10	North Wello	Habru	Dire Roka	Kilewa
11	Oromia Special zone	Bati	Chekorti	Fara
12	Oromia Special zone	Bati	Felana	Weyo Filana
13	Oromia Special zone	Bati	Chachatu	Cha Chatu
14	Oromia Special zone	Bati	Sukai	Salmene
15	North Shoa	Kewet	Kureberet	Kure beret
16	North Shoa	Kewet	Sefiberet	Sefiberetina
17	North Shoa	Kewet	Medina	Madina
18	North Shoa	Kewet	Yelen	Yelen





Vial, 2010

Tounkara et al, 2019

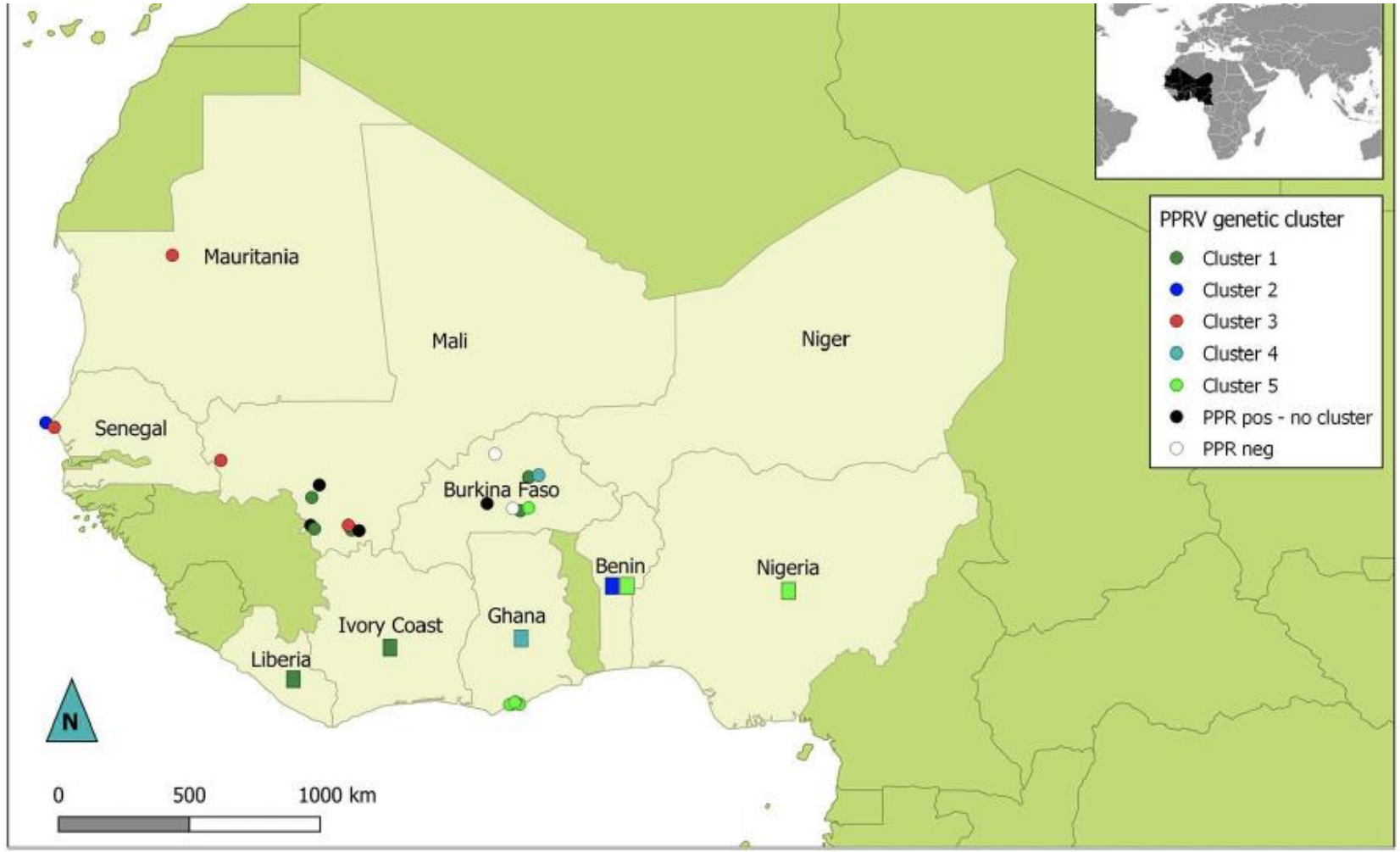


FIGURE 2 | Map of West Africa showing sampling location according to their PPRV lineage II genetic cluster. Dots represent location of samples obtained for this study. Rectangles indicate countries of origin for publically available sequence data used in this study and belonging to genetic clusters of interest in this study. Dots and rectangles are colored according to the genetic cluster (C1 to C5) they were placed in by phylogenetic analysis (see **Figure 1**). Black dots represent PPRV

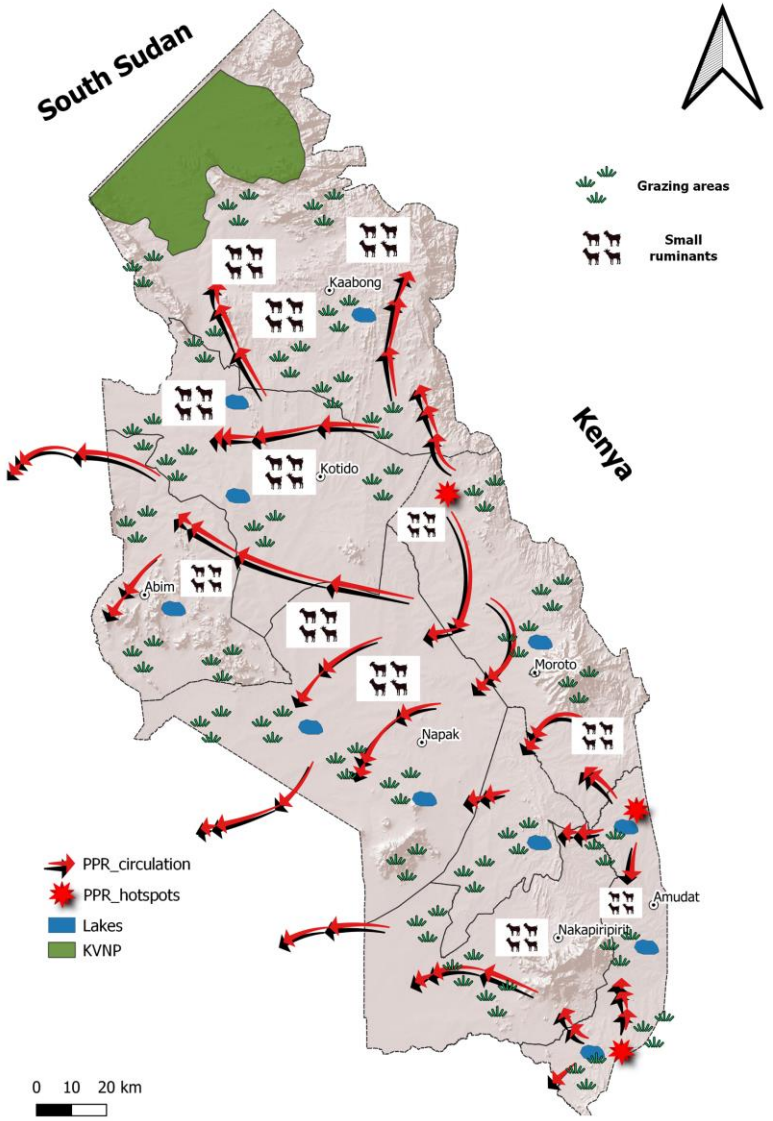
Planning strategies

Which are the core populations?

Which are the peripheral populations?

Where do you focus vaccination to stop the cycle?

The 20:80 rule: 20% of the population accounts for 80% of the transmission

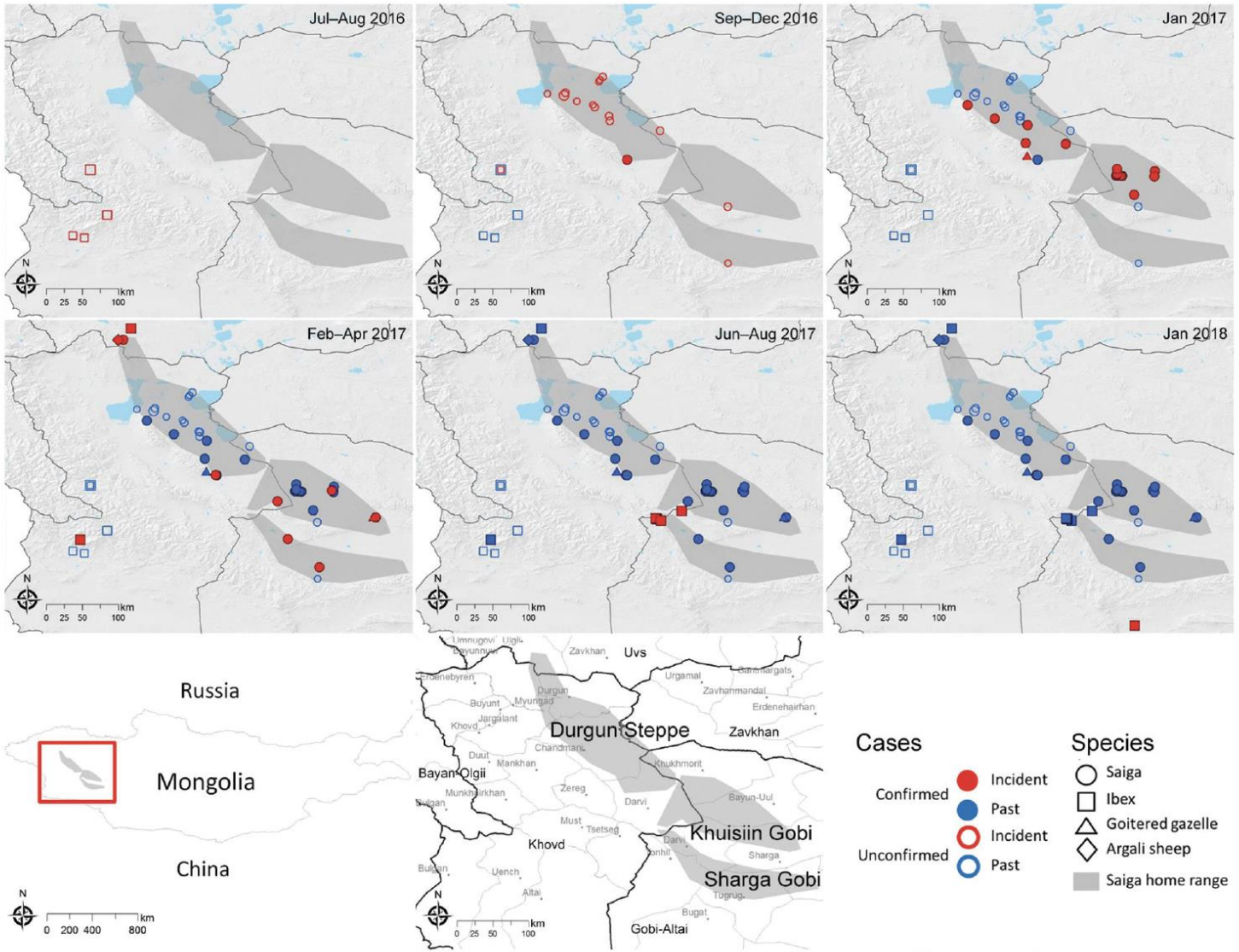


Second Introduction of PPR to China - 2014

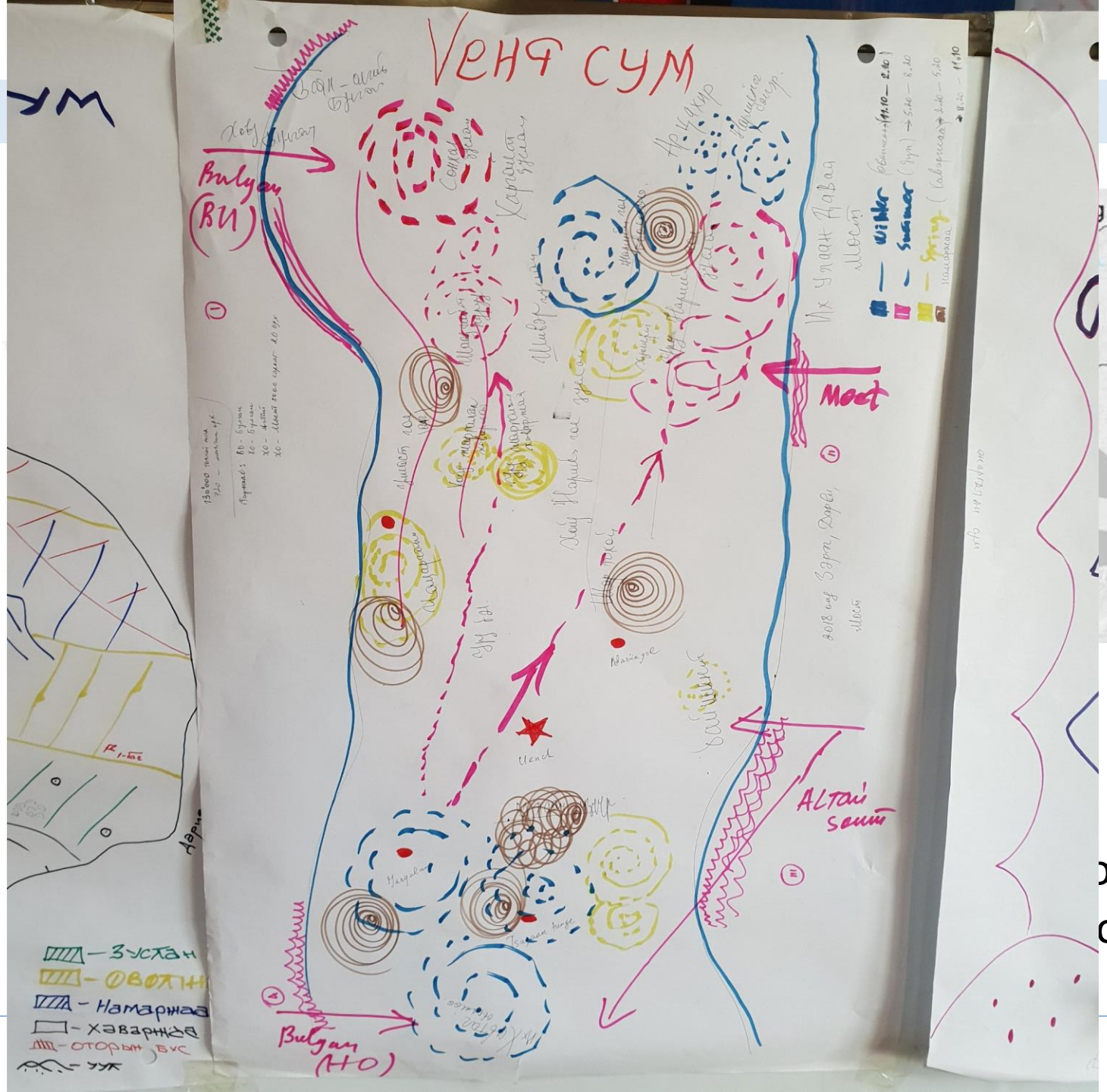
Was the source Central Asia?

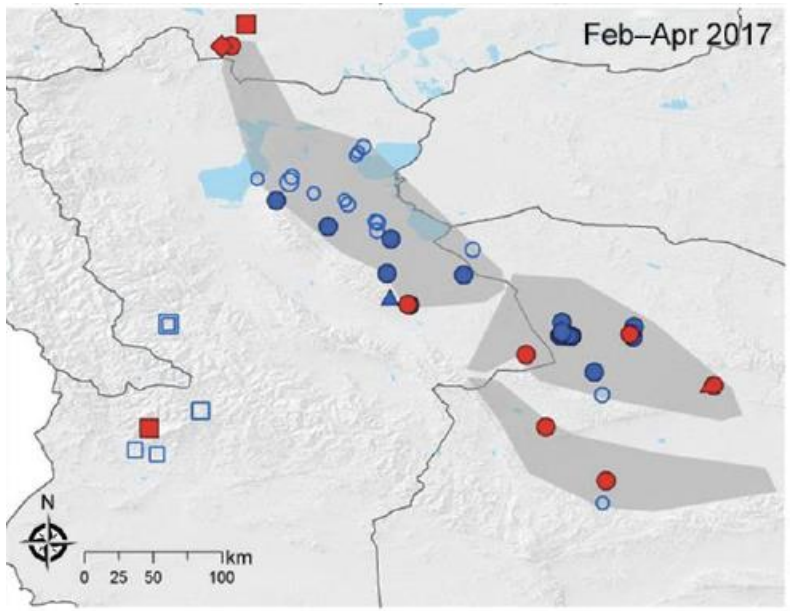
Evolution – What factors affected the distribution of outbreaks?

First PPR Introduction to Mongolia



Pruvot et al., 2020





Pruvot et al., 2020

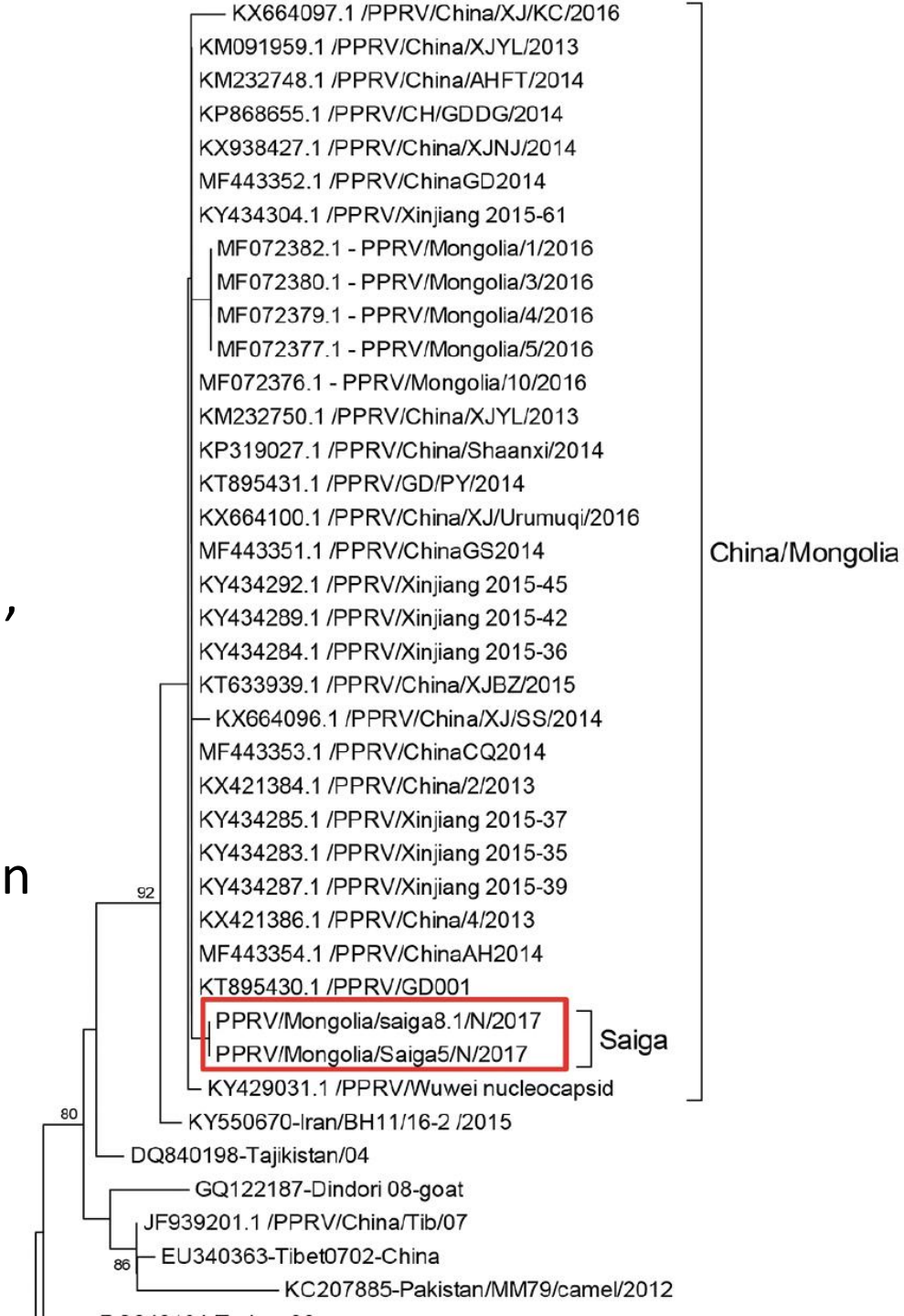
ower evolution

on and case evolution

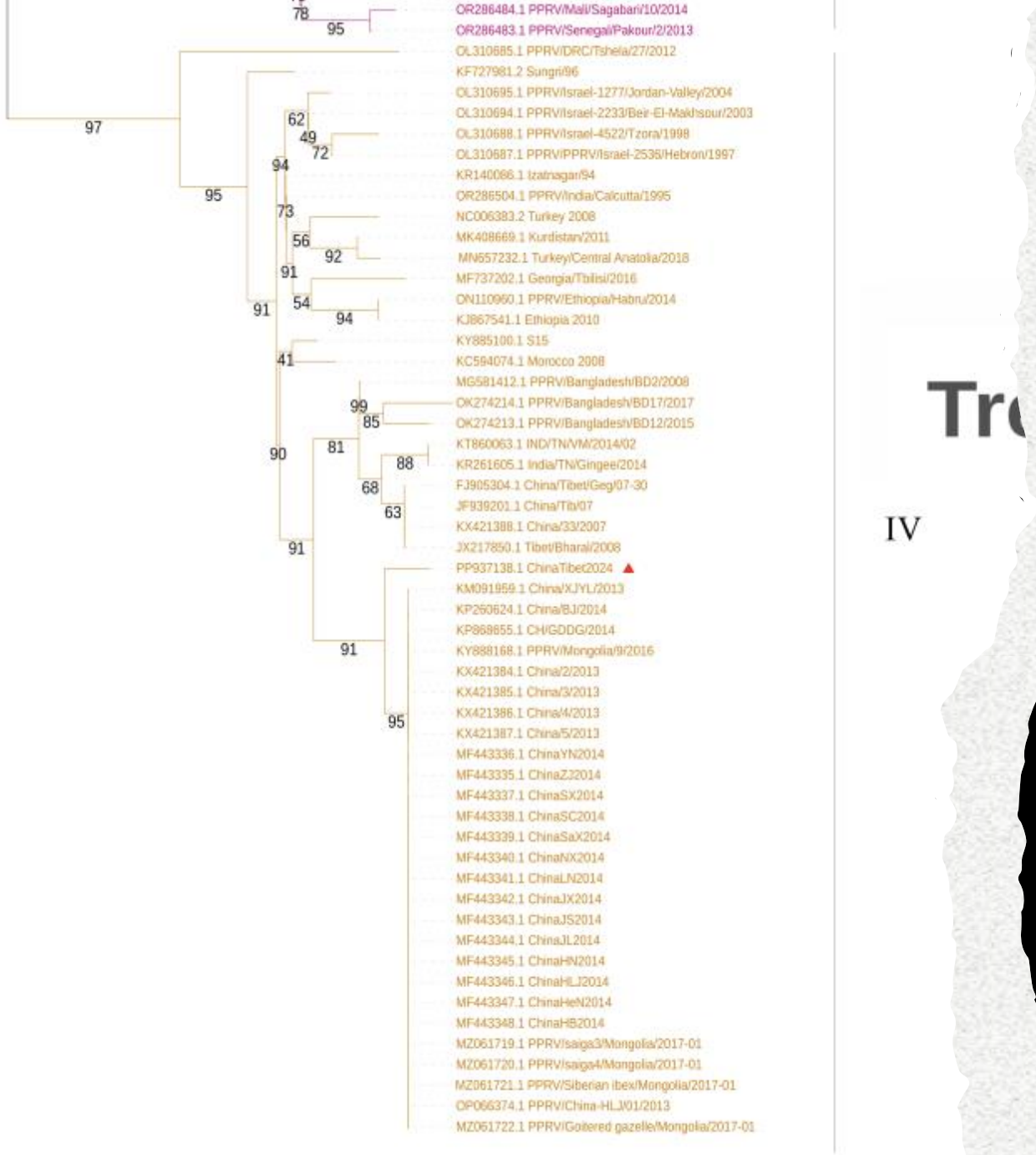
First PPR Introduction into Mongolia

- Isolates Cluster with China
- Most common ancestor analysis finds Mongolian livestock isolates predate Mongolian wildlife isolates (Benfield et al., 2021)
- Mongolia developed an NSP focused on control in the Western regions
- Mongolia outbreaks in subsequent years in Central and Eastern regions
- Re evaluate the episystem analysis

Pruvot et al., 2020




Russia
Mongolia
?
China
N
0 200 400 800
km



Jiao Xu et al., 2024

- Rutong County, Tibet
- Bharals and Argali
- Clusters closely with 2013-14 strains

The Role of Participatory Epidemiology and Molecular Epi

- Understand risk from the ground up
- Triangulation of information
  - Multiple methods and multiple sources
    - Timelines and maps of past outbreaks
  - Diverse types of information
  - Includes biological test data
  - Interactive epidemiological mapping
- Best bet scenario for the episystem
- Testing episystem hypotheses through molecular epi
  - Cluster analysis
  - Ancestor analysis and divergence timelines

Management based on episystems elimination

- Vaccination should be targeted to the interlinked reservoir communities
- Vaccination should be implemented simultaneously across all reservoir populations in the episystem
- Vaccination methods should be appropriate to the community
- Goal of 80% herd immunity within one vaccination campaign
- Suboptimal vaccination coverage can favor persistent endemism
- Non-reservoir, incidentally infected populations are best protected by eliminating the virus reservoir. Scattering of resources leads to failure.
- Surveillance to validate the episystem assessment, measure progress and detect changes in the episystems
- Management, monitoring and evaluation all based on the episystems present
- Performance indicators monitor on the actions based on the episystems assessments
- Episystems, action plans and monitoring plans updated annually


Thank you