

## Veterinary Fences in the KAZA TFCA: Assessment of Livestock Disease Risks of Potential Removal of Specific Fence Sections, with an Emphasis on the Botswana-Namibia Border

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KAZA AHSWG Meeting

Livingstone, Zambia

11 June 2024

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# Outline

- Review of objectives
- Risk assessment method
- Risk mitigation strategies
- Select disease/fence pathways
- Report results & recommendations
- Meeting recommendations

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## Objective

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- Phase 1 focused on veterinary fences affecting key wildlife dispersal areas in KAZA
  - Sections recommended as high priority for removal based on wildlife impacts
- The objective of the second phase is **to assess the change in livestock disease risk from the current situation vs. a hypothetical scenario where specific fence sections identified in Phase 1 are removed**

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## Risk Scenarios

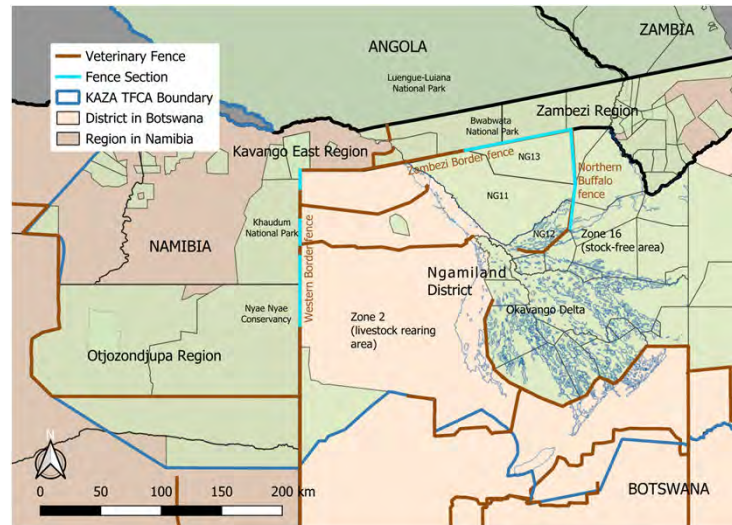
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- Status quo risk, with fences as is
- Potential risk if fence section(s) were removed
- Potential risk if fence section(s) were removed and risk mitigation measures in place

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## Fence Sections

- Zambezi Border fence (east of the Okavango River)
- Northern Buffalo fence
- Western Border fence (3 sections)



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## Risk Pathways

- Zambezi & Western Border fences – risk to Botswana
  - SAT-type FMD from cattle
  - SAT-type FMD from buffalo
  - SAT-type FMD from poaching
  - Serotype O FMD
  - CBPP
  - PPR

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## Risk Pathways

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- Zambezi & Western Border fences – risk to Namibia
  - SAT-type FMD from cattle
  - SAT-type FMD from buffalo
  - SAT-type FMD from poaching

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## Risk Pathways

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- Northern Buffalo fence – risk to zone 2
  - SAT-type FMD from buffalo
  - SAT-type FMD from poaching

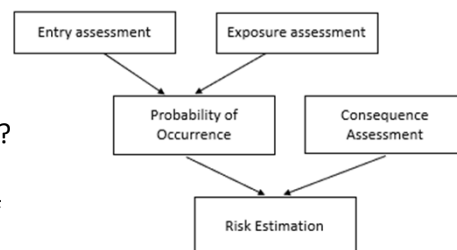
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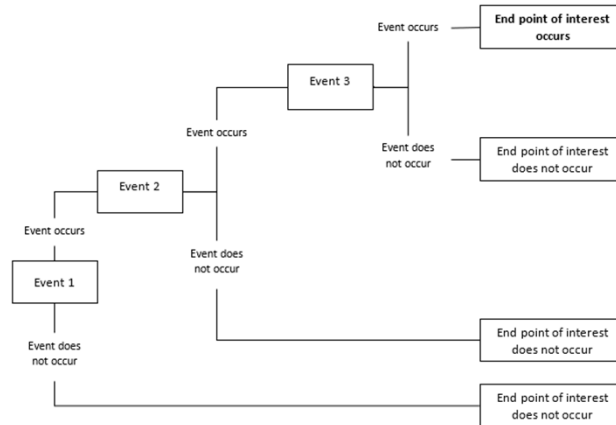
## OIE/WOAH Approach

- Import risk analysis
  - Entry/release assessment
    - How likely is a pathogen to enter a zone/country?
  - Exposure assessment
    - How likely are animals to become exposed?
  - Consequence assessment
    - What is the magnitude of consequences of an outbreak?
  - Risk estimation
    - What is the overall risk from the above assessments?



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## Scenario Tree



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## Risk Categories and Combinations

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- Qualitative approach
- OIE (WOAH) Handbook on Import Risk Analysis does not have standardized risk categories or combination matrices
- Events are conditional (each depends on previous step)
  - Multiply probabilities sequentially to calculate risk for pathway

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# Risk Categories

Adapted from Rinchen et al. 2020

Risk Category	Definition
<b>Negligible</b>	Likelihood of an event occurring is so rare that it does not merit consideration
<b>Very low</b>	Likelihood of an event occurring is rare but can occur
<b>Low</b>	Likelihood of an event occurring is occasional
<b>Moderate</b>	Likelihood of an event occurring is regular
<b>High</b>	Likelihood of an event occurring is very often

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## Baseline Combination Matrix for Risk

- Published in 1998 from proceedings of OIE meeting; since adapted into numerous other matrices, but **there is no one standard risk matrix**

Probability of dissemination	Economic impact and health impact			
	Negligible	Low	Moderate	High
Negligible	N	L	L	M
Low	L	L	M	M
Moderate	L	M	M	H
High	M	M	H	H

N = Negligible  
L = Low  
M = Moderate  
H = High

- Combination table rules judged too severe – overestimate risk (Dufour & Moutou 2007)

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## How are Qualitative Probabilities Multiplied?

- Probabilities are between 0 and 1
- When multiplying probabilities, the product cannot be higher than the lower probability
  - Example: Negligible risk x High risk
  - Assume Negligible = 0.001 and High = 1 for this example
  - $0.001 \times 1 = 0.001$
- Gale et al. 2010, Roche et al. 2015, Babayani & Thololwane 2022

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## Risk Matrix for Combining Probabilities

Probability of occurrence = entry x exposure

Exposure Probability	Negligible	Entry Probability			
		Very Low	Low	Moderate	High
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Very low	Negligible	Very low	Very low	Very low	Very low
Low	Negligible	Very low	Low	Low	Low
Moderate	Negligible	Very low	Low	Moderate	Moderate
High	Negligible	Very low	Low	Moderate	High

Adapted from Rinchen et al. 2020

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## Combining Occurrence and Consequences

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- For DVS, the **magnitude** of consequences for an outbreak is important
- Consequence assessment methods not well defined
- How to combine a probability [of occurrence] and a magnitude [of consequences]?
- Requires a different matrix

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## Approach for Consequence Assessment

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- Dufour et al. 2011
  - Consequences could decrease or increase weighting of risk
  - If consequences are minor, the estimated risk should be lower
  - If consequences are grave, the estimated risk should be higher, even for low probabilities of occurrence
- Example from maritime industry:
  - If a maintenance job on a ship has very low risk of an accident occurring, but the consequence could result in a human fatality → overall risk is higher

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# Modified Risk Matrix (Dufour et al. 2011)

		Probability of occurrence										
		0	1	2	3	4	5	6	7	8	9	
Consequences	0	N	N	N	N	N	N	N	N	N	N	N
	1-3	NN	N	NN	NN	NN	NN	NN	NN	NN	NN	NN
		M	N	NN	NN	NN	NN	NN	NN	NN	M	EL
		EL	N	NN	NN	NN	NN	NN	NN	NN	M	EL
	4-6	VL	N	NN	NN	NN	M	M	EL	EL	VL	VL
		L	N	NN	M	M	EL	EL	VL	VL	L	L
		NVH	N	M	EL	EL	VL	VL	L	L	NVH	NVH
	7-9	QH	N	L	L	L	NVH	NVH	NVH	QH	QH	QH
		H	N	NVH	NVH	NVH	QH	QH	QH	H	H	H
		VH	N	QH	QH	QH	H	H	H	VH	VH	VH

N = Null  
 NN = Nearly null  
 M = Minute  
 EL = Extremely low  
 VL = Very low  
 L = Low  
 NVH = Not very high  
 QH = Quite high  
 H = High  
 VH = Very high

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## Combining Probability of Occurrence and Magnitude of Consequences

Adapted from Dufour et al. 2011

		Probability of Occurrence			
Consequences	Negligible	Very Low	Low	Moderate	High
Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Very low	Negligible	Negligible	Negligible	Very low	Very low
Low	Negligible	Very low	Very low	Very low	Low
Moderate	Low	Low	Low	Moderate	Moderate
High	Moderate	Moderate	Moderate	Moderate	High

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# Uncertainty Definitions

Adapted from Fournié et al. 2014

Uncertainty Category	Definition
Low	There are solid and complete data available; strong evidence is provided in multiple references; authors report similar conclusions. Several experts have multiple experiences of the event, and there is a high level of agreement between experts.
Moderate	There are some but not complete data available; evidence is provided in a small number of references; author report conclusions that vary from one another. Experts have limited experience of the event and/or there is a moderate level of agreement between experts.
High	There are scarce or no data available; evidence is not provided in references but rather in unpublished reports or based on observations, or personal communication; authors report conclusions that vary considerably between them. Very few experts have experience of the event and/or there is a very low level of agreement between experts.

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## Approach for Uncertainty

- Conservative approach: worst (highest) uncertainty is retained for the overall outcome
  - Crotta et al. 2016, Rinchen et al. 2020


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# Risk Mitigation



**The Herding 4 Health (H4H) Programme,**

- partnership NGOs Wild Entrust and CLAWS (Communities Living Amongst Wildlife Sustainably), Conservation International (CI) and the MoA,
- raise awareness of Commodity Based Trade (CBT) and the H4H protocols
- Piloting of mobile quarantine in the Okavango
- Botswana will actively promote H4H and CBT protocols especially the mobile quarantine concept to be universally accepted.

Presented by Botswana DVS at KAZA AHSWG meeting in 2023

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# Risk Mitigation

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## H4H model

- Strategic active herding and kraaling by skilled herders implementing planned grazing through collective action at village level
- Maintain continuous control and knowledge of livestock movements
- Use low-stress handling techniques
- Kraaled at night in a predator-proof boma

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# Risk Mitigation

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## H4H model

- Avoid contact with wildlife, particularly buffalo, impala, and predators
- Avoid contact with cattle outside herd
- Cattle branded and appropriately identified for traceability
- Maintain records for cattle
  - Dipping and vaccinations

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# Risk Mitigation

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## H4H risk mitigation

- Control of animal movements
  - Cattle are attended and not straying
  - Avoid disease transmission from other cattle
  - Avoid disease transmission from buffalo

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# Risk Mitigation

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## H4H risk mitigation

- Improved animal health
  - Animals observed on a daily basis
  - Herders trained in basic animal health care (recognizing signs of disease)
    - **In the face of reduced extension officers, training individuals with frequent contact with livestock to recognize disease is crucial** (Babayani and Thololwane 2022)
  - More rapid reporting of illnesses

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# Risk Mitigation

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## H4H risk mitigation

- Improved animal health
  - Cattle are acclimated to regular low-stress handling
  - Easier to round up and present for dipping, vaccination, surveillance
  - Vaccination compliance is part of H4H model
  - Better vaccination coverage – higher herd immunity

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# Risk Mitigation

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## H4H risk mitigation

- Improved animal health
  - Better body condition and nutritional status
  - Planned grazing and kraaling reduces distances to find adequate food and water
  - Typical conditions: cattle move within a radius ~10 km/day to access water and grazing around a kraal
  - Under H4H: goal is <5 km/day total walking distance (or 2.5 km radius)
  - Graze away from villages using mobile kraals during wet season when food and water abundant, then minimize energy expended by grazing close to village during dry season

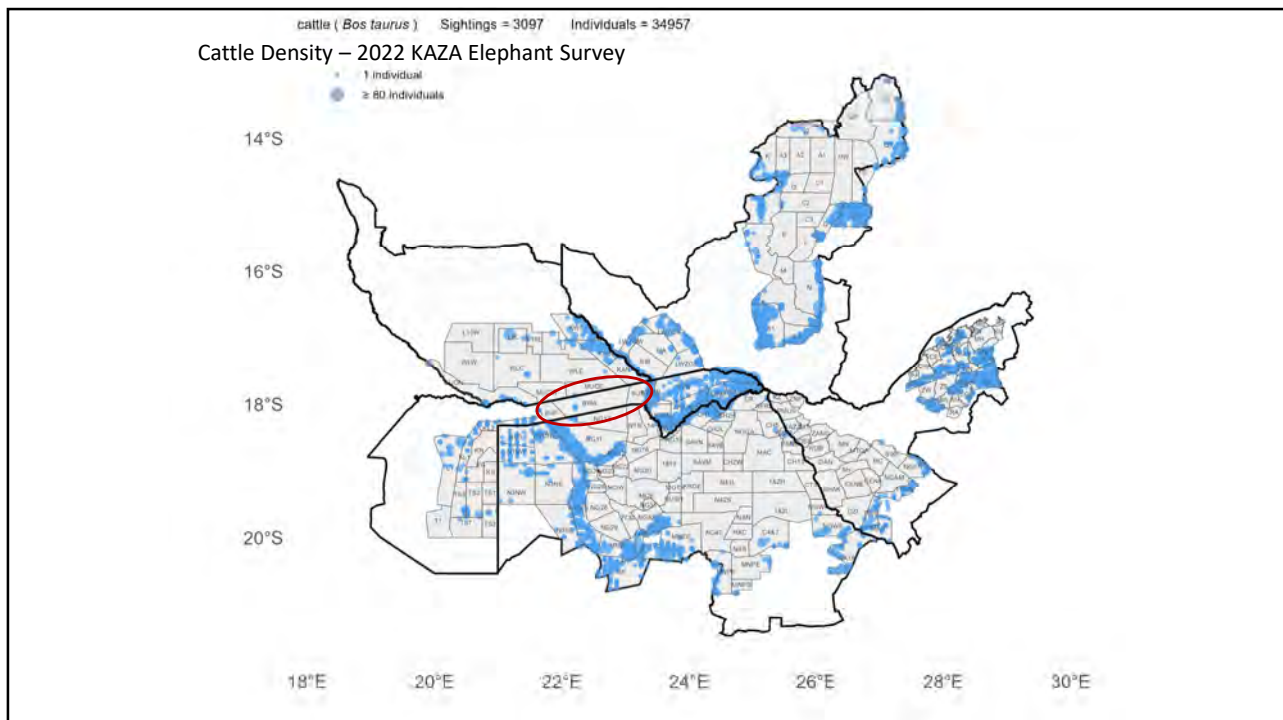
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# Risk Mitigation

## Removal of cattle from Bwabwata National Park

- Cabinet decision to remove cattle has not been enforced
- Cattle currently concentrated around Omega settlement but potential for eastward spread
- Removal of cattle makes FMD/CBPP risk from Namibia side near Zambezi fence negligible

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## Risk Mitigation

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- Vaccination

- Vaccination is a cornerstone of managing FMD and CBPP
- Vaccination coverage varies
- High vaccination coverage in highest risk areas is essential
- Field strain/vaccine matching is essential to provide protection
  - BVI capacity necessary
- Post-vaccination monitoring is essential to ensure protection
  - BNVL capacity necessary – reagent shortages have delayed PVM
  - No BW samples tested from 2020 or 2021 (COVID)
  - NA samples collected 2017, sent to BVI 2018, results not received until 2019

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## Risk Mitigation

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- Surveillance

- Monitoring high-risk areas
- Surveillance has not been carried out according to protocols, often due to lack of resources
  - 2021: FMD surveillance samples tested 15 months after collection, 31 NSP positive, evidence of follow-up for only 23 samples (2023 EU Audit - BW)
  - 2022: 11,002 FMD surveillance samples planned, only 6,901 received and 4,230 tested (2023 EU Audit – BW)
  - 2022: PPR surveillance not done in June FMD campaign in Ngamiland due to lack of supplies (FMD Campaign Report)

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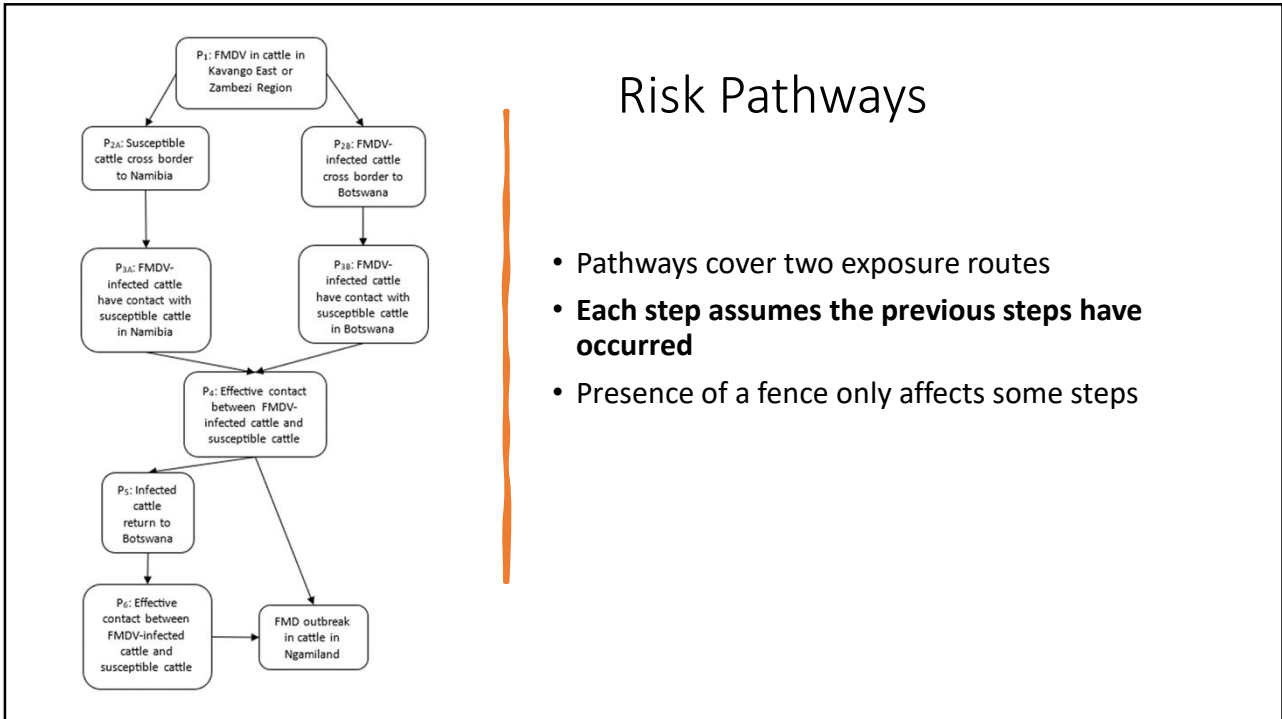
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## Outline for Risk Pathways

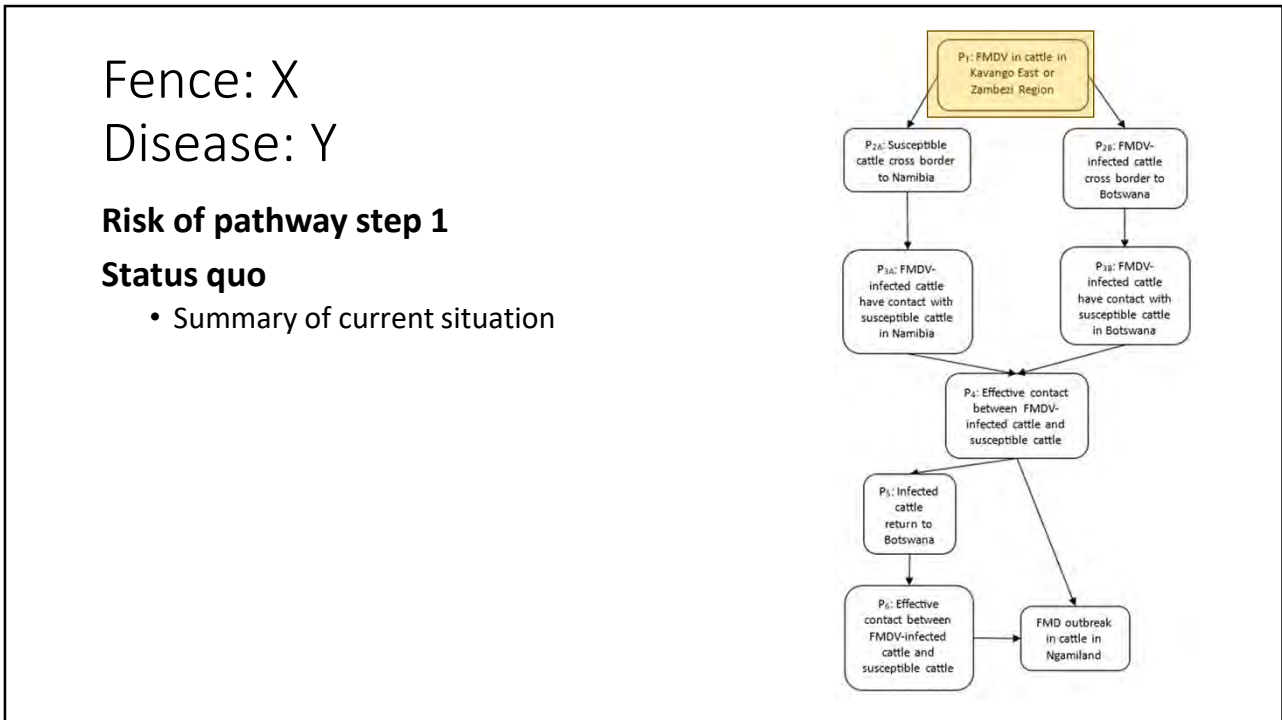
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- Hazard identification
- Fence status
- Step-by-step review of current risk, hypothetical risk under removal alone and hypothetical risk under removal with risk mitigation
- Consequence assessment
- Risk estimation

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Fence: X  
Disease: Y

### Risk of pathway step 1

#### Status quo

Current risk is **very low** with **moderate** uncertainty

#### Removal

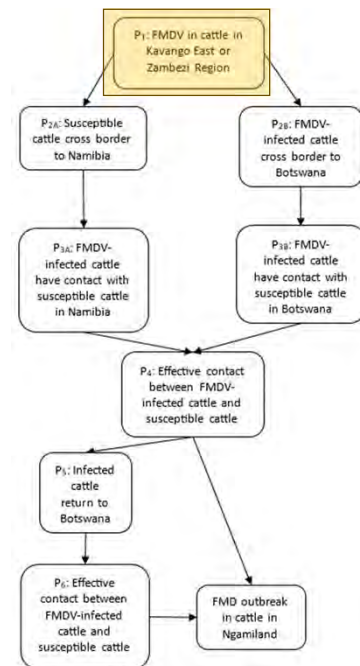
- Summary of effects of removal on risk for this step

Risk remains **very low** with **moderate** uncertainty

#### Removal with risk mitigation

- Summary of effects of risk mitigation on risk for this step

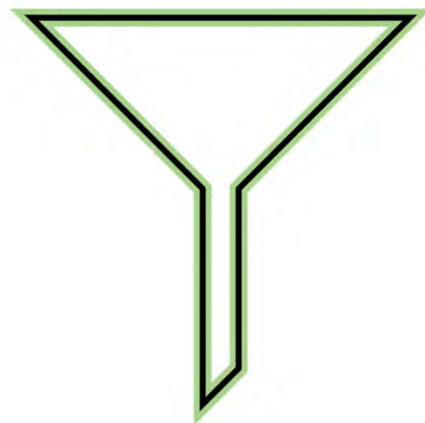
Risk remains **very low** with **moderate** uncertainty



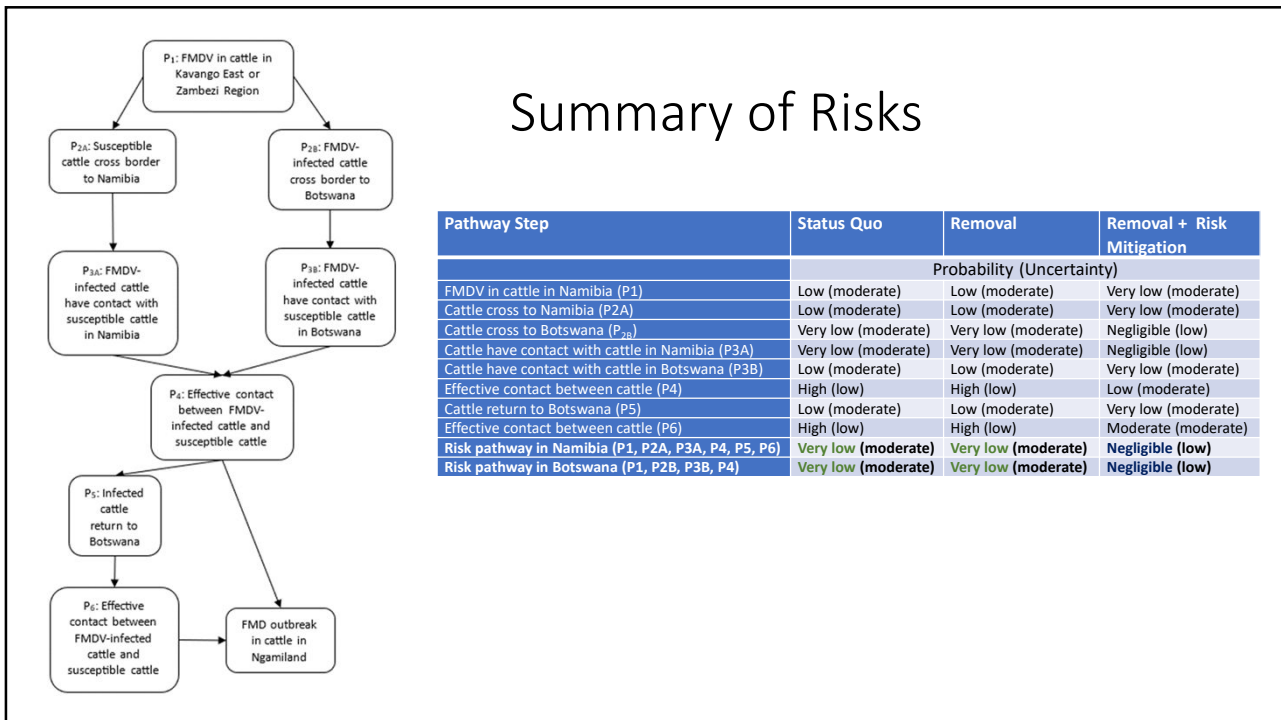
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## Risk Bottlenecks

- For some steps, the risk is very low or negligible
- Based on the matrix, the risk for the entire disease occurrence pathway then becomes very low or negligible
- These “risk bottlenecks” are denoted with a green funnel



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## Disease Y at Fence X

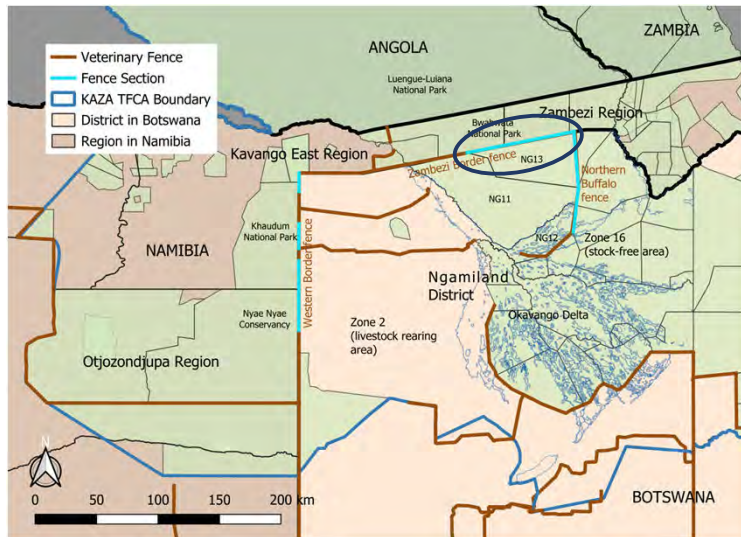
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	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

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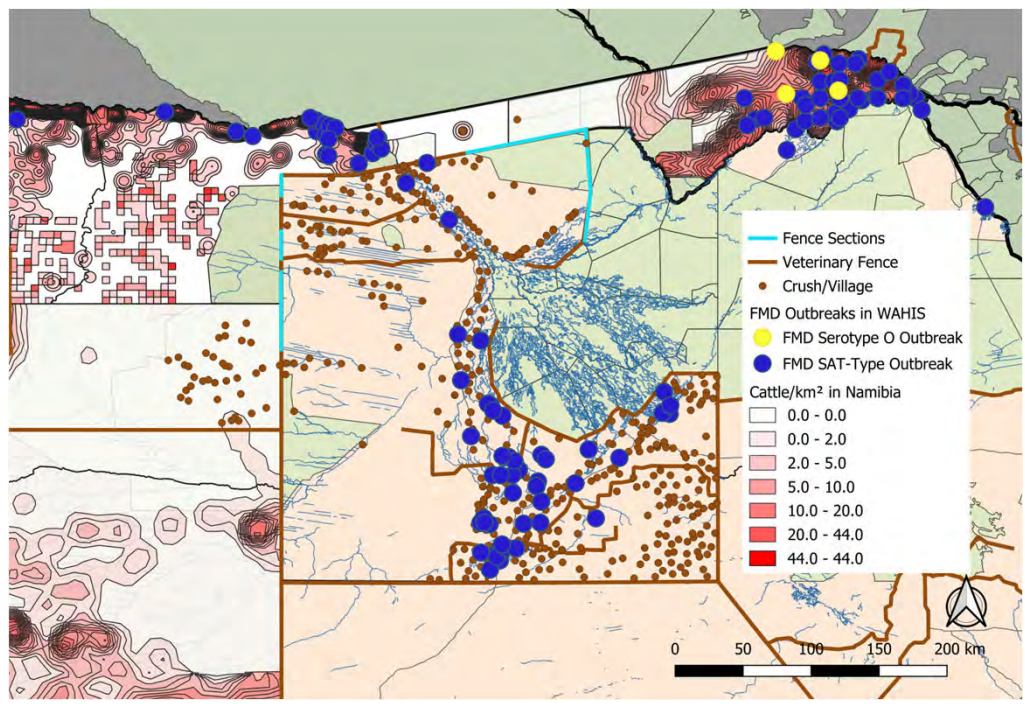
# Risk Pathway 1

Serotype O FMD from cattle at Zambezi Border fence



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# FMD Outbreak History (WAHIS, 2007 – present)



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## Eastern Zambezi Border Fence Status

- East of Okavango River – Zambezi Border fence conditions poor
- Condition rated 1/5, no maintenance being performed (DVS monthly reports, NAMBOT patrol reports)

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### E. Zambezi Border Fence Nov. 2022



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## E. Zambezi Border Fence Nov. 2022



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## Fence: Zambezi Border Disease: Serotype O FMD

- Hazard identification
  - Serotype O of the *Aphthovirus* genus in family Picornaviridae causing FMD in cattle in zone 2



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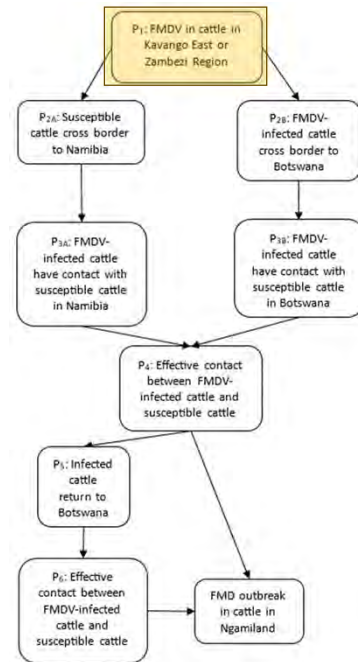


# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of FMDV in cattle in Namibia

### Status quo

- Serotype O outbreak in Namibia, 2021
- Achieved >90% emergency vaccination coverage
- Vaccination against type O (and SATs), 3x/yr
- Illegal movement of cattle from Zambia still a threat



# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of FMDV in cattle in Namibia

### Status quo

Current risk is **low** with **moderate** uncertainty

### Removal

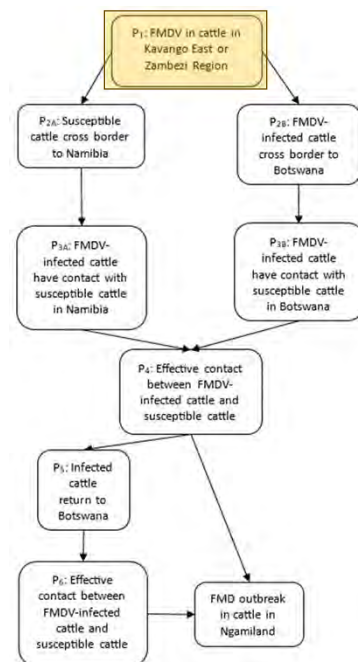
Does not affect risk of serotype O in Kavango East/Zambezi

Risk remains **low** with **moderate** uncertainty

### Removal with risk mitigation

Removal of cattle from Bwabwata – no cattle expected on the other side of the fence; maintain high vaccination coverage in Namibia

Risk decreases to **very low** with **moderate** uncertainty

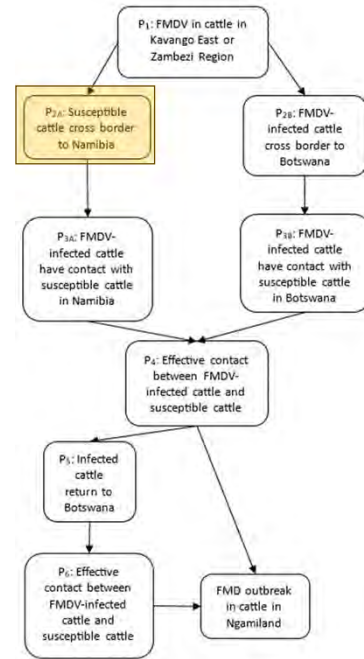


# Fence: Zambezi Border Disease: Serotype O FMD

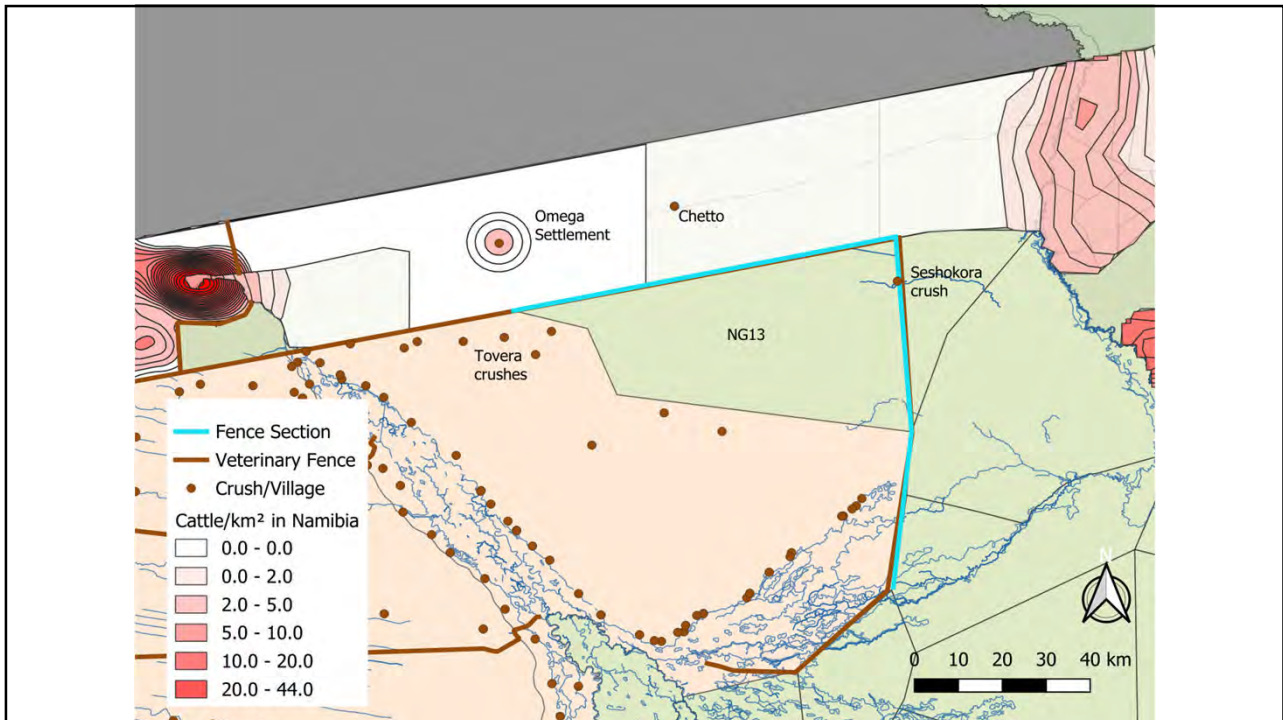
## Risk of cattle crossing to Namibia

### Status quo

- Fence in poor condition, many sections down
- Few cattle posts near Zambezi fence
  - Isolated cattle at Seshokora crush
  - Tovera crushes near western border of NG13
- Free-ranging cattle move up to 30 km/day in search of water and grazing (nomadic pastoralist systems), 5-15 km/day in settled pastoralist systems (van Raay and de Leeuw 1974)
- Cattle spoor observed up to ~10 km from Tovera IV during ground survey (Atkinson et al. 2022)
- 2022: 11 cattle from Seshokora crush found in Zambia, believed to have been stolen

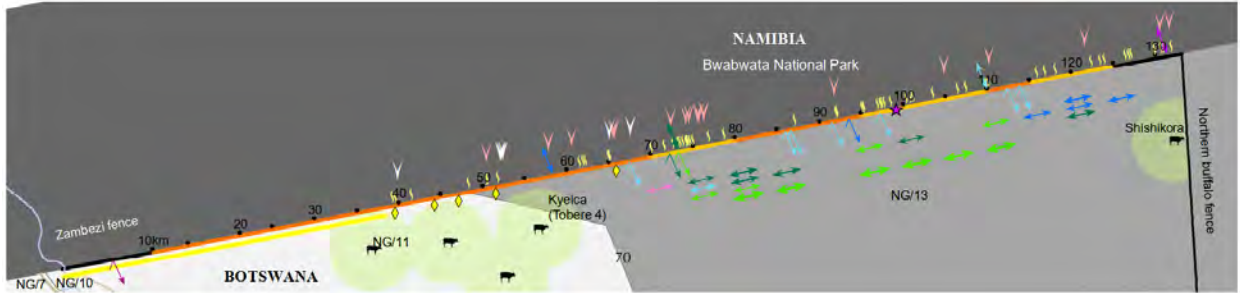


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# 2020 Ground Survey

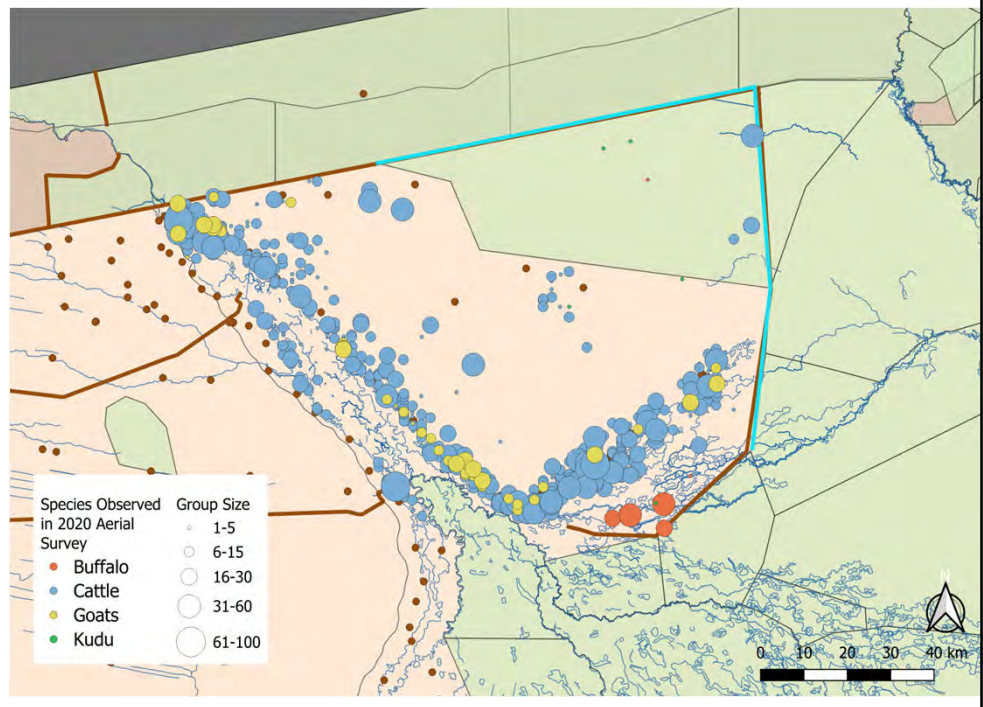


- Active cattlepost
  - Cow spoor detection (outside of continuous livestock areas)
  - Continuous livestock presence alongside fence (spoor not recorded here)
  - Indicative livestock range (5km radius)
- Gaps enabling wildlife crossings**
- Gap (fence flat or <50cm above ground), regular crossing trail at time of survey.
  - Gap (fence flat or <1m above ground), with or without spoor, potential for use as a regular crossing trail at other times.
  - Major fence damage (damaged wires + poles + droppers) also potentially enabling crossings. Under-representation of damaged sites as does not include sites where less than 3 structural components are damaged.

Atkinson et al. 2022

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# Select Livestock and Wildlife Species Observed in 2020 Aerial Survey (data courtesy of Ecoexist)



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# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of cattle crossing to Namibia

### Status quo

Current risk is **low** with **moderate** uncertainty

### Removal

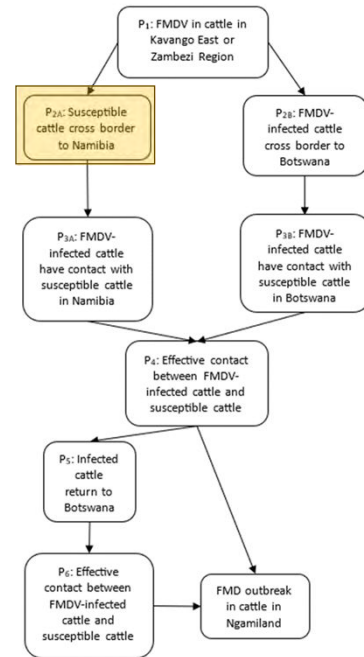
Unlikely to significantly change risk of cattle coming across border; few cattle nearby, no evidence of continuous cattle presence in this section and fence already in poor condition

Risk remains **low** with **moderate** uncertainty

### Removal with risk mitigation

Active herding under H4H would control cattle movements, avoid crossing border

Risk decreases to **very low** with **moderate** uncertainty

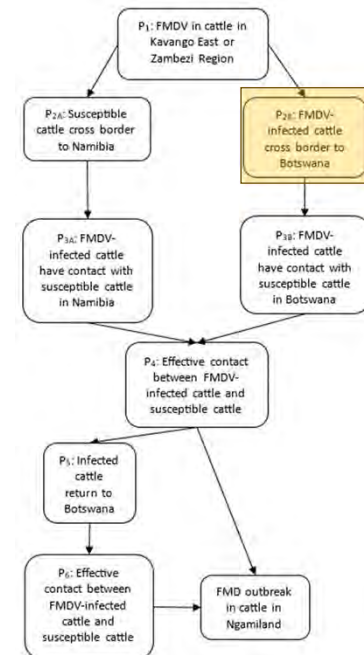


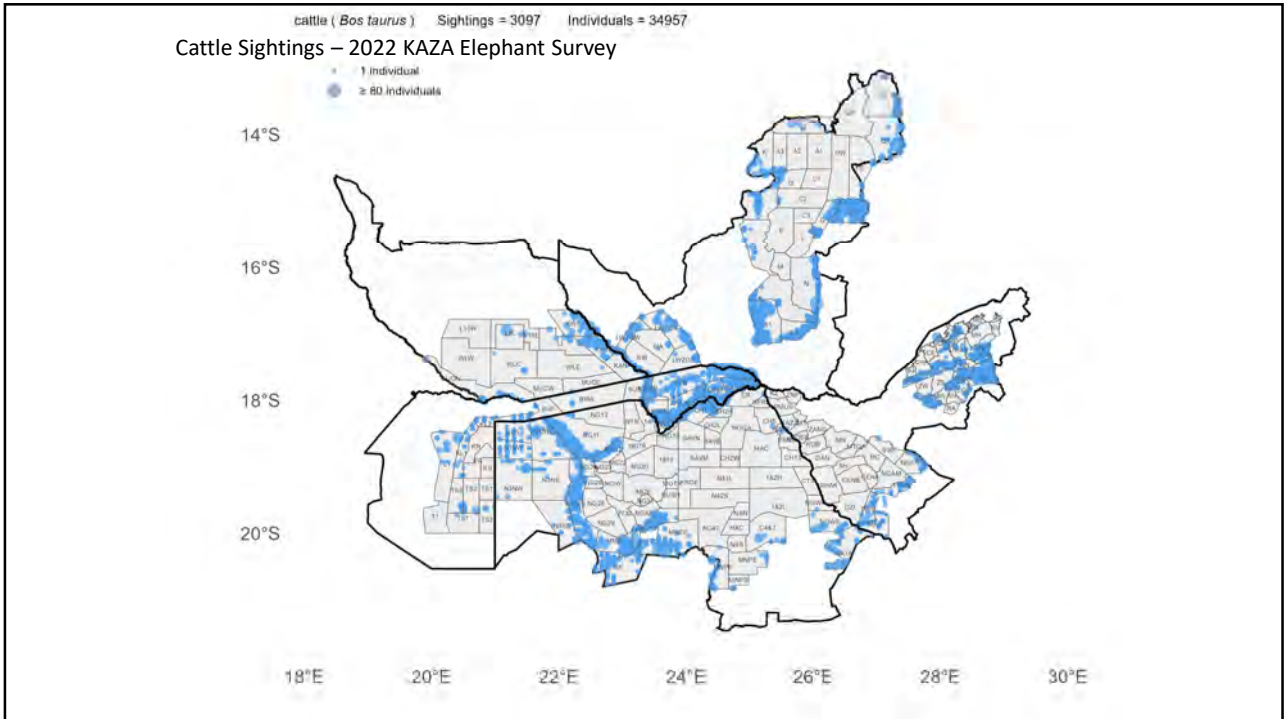
# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of cattle crossing to Botswana

### Status quo

- Cattle in Omega settlement in Bwabwata National Park ~15 km from fence
- Heavy predator density and lack of water in dry season
- Infected cattle in maximal shedding stage less likely to walk long distances





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## Fence: Zambezi Border Disease: Serotype O FMD

**Risk of cattle crossing to Botswana**

**Status quo**

Current risk is **very low** with **moderate** uncertainty

**Removal**

Unlikely to significantly change risk of cattle coming across border; few cattle nearby

Risk remains **very low** with **moderate** uncertainty

**Removal with risk mitigation**

Removal of cattle from Bwabwata limits risk to stray animals

Risk decreases to **negligible** with **low** uncertainty

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graph TD
    P1["P1: FMDV in cattle in Kavango East or Zambezi Region"]
    P2a["P2a: Susceptible cattle cross border to Namibia"]
    P2b["P2b: FMDV-infected cattle cross border to Botswana"]
    P3a["P3a: FMDV-infected cattle have contact with susceptible cattle in Namibia"]
    P3b["P3b: FMDV-infected cattle have contact with susceptible cattle in Botswana"]
    P4["P4: Effective contact between FMDV-infected cattle and susceptible cattle"]
    P5["P5: Infected cattle return to Botswana"]
    P6["P6: Effective contact between FMDV-infected cattle and susceptible cattle"]
    Outbreak["FMD outbreak in cattle in Ngamiland"]

    P1 --> P2a
    P1 --> P2b
    P2a --> P3a
    P2b --> P3b
    P3a --> P4
    P3b --> P4
    P4 --> P5
    P4 --> P6
    P5 --> P6
    P6 --> Outbreak
    
```

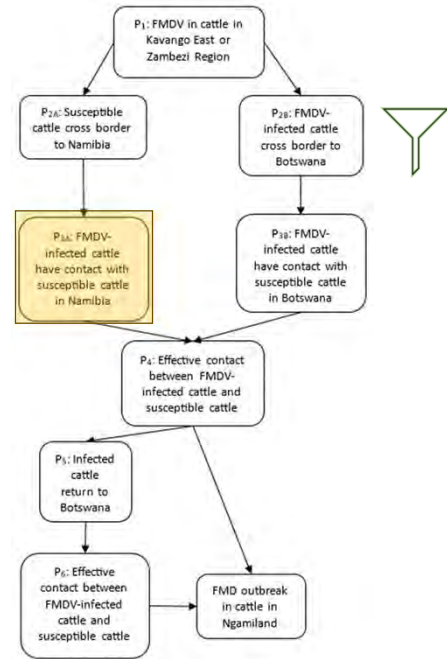
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# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of contact between susceptible and infected cattle in Namibia

### Status quo

- Cattle need to travel well into Bwabwata to make contact with other cattle near Omega
- Cattle contact networks in pastoral systems not well-studied (VanderWaal et al. 2017)
- Kenya: more contacts during dry season, higher contact rates at waterholes and bomas (VanderWaal et al. 2017)



# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of contact between susceptible and infected cattle in Namibia

### Status quo

Current risk is **very low** with **moderate** uncertainty

### Removal

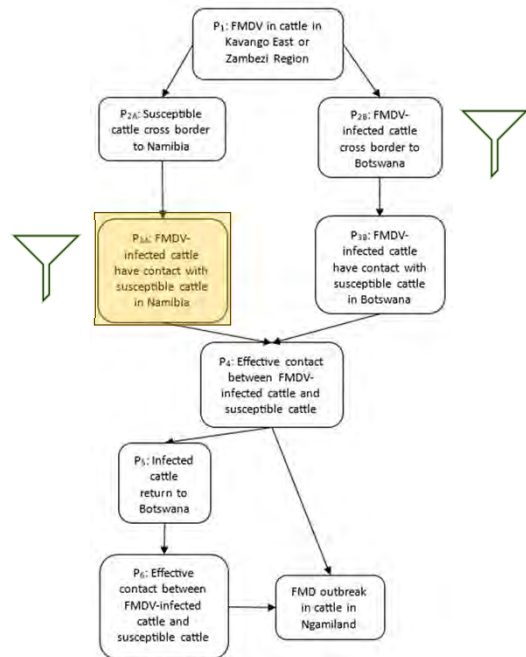
Would not change risk of contact after border has been crossed

Risk remains **very low** with **moderate** uncertainty

### Removal with risk mitigation

Removal of cattle from Bwabwata National Park would eliminate risk of contact with resident cattle

Risk decreases to **negligible** with **low** uncertainty

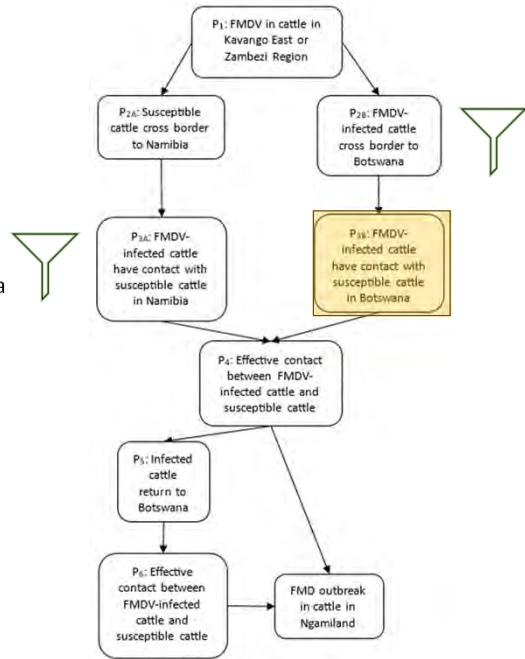


# Fence: Zambezi Border Disease: Serotype O FMD

**Risk of contact between susceptible and infected cattle in Botswana**

**Status quo**

- Contact near Tovera crushes most likely given cattle near Omega



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# Fence: Zambezi Border Disease: Serotype O FMD

**Risk of contact between susceptible and infected cattle in Botswana**

**Status quo**

Current risk is **low** with **moderate** uncertainty

**Removal**

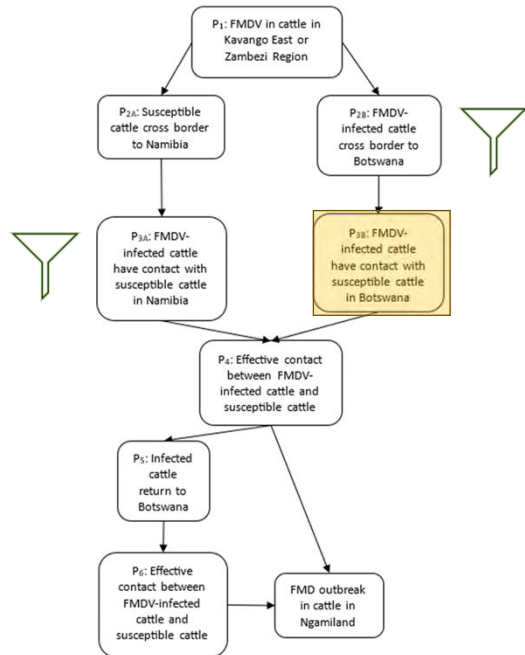
Would not change risk of contact after border has been crossed

Risk remains **low** with **moderate** uncertainty

**Removal with risk mitigation**

Active herding under H4H would limit contact with any stray cattle

Risk decreases to **very low** with **moderate** uncertainty



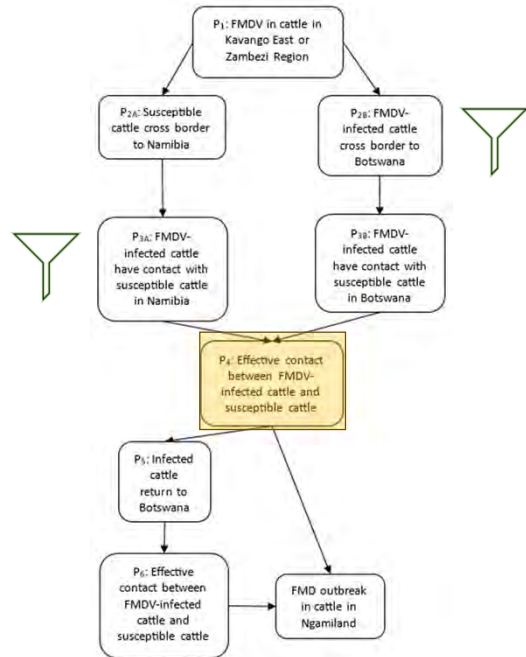
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# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of effective contact between cattle

### Status quo

- Cattle in Ngamiland not vaccinated against serotype O



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# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of effective contact between cattle

### Status quo

Current risk is **high** with **low** uncertainty

### Removal

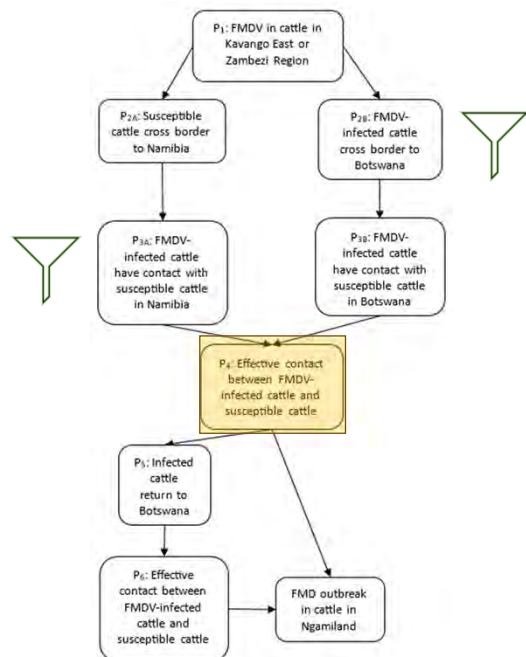
Would not affect risk of effective contact

Risk remains **high** with **low** uncertainty

### Removal with risk mitigation

Target high-risk crushes for FMD serotype O vaccination; active herding under H4H lowers risk of effective contact

Risk decreases to **low** with **moderate** uncertainty



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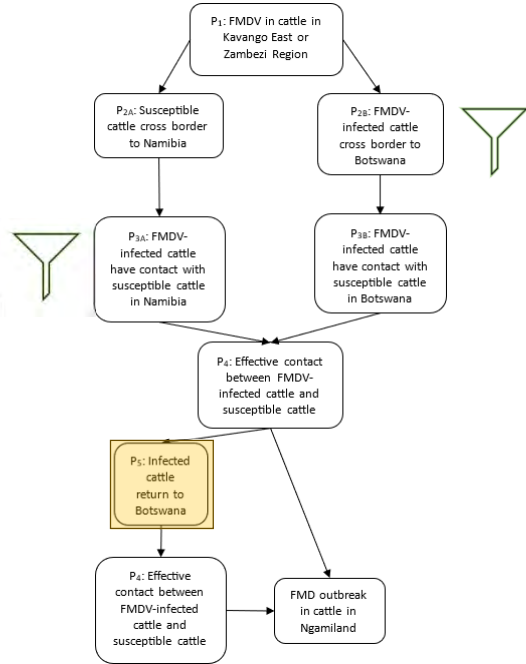


# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of cattle returning to Botswana

### Status quo

- Cattle would need to return quickly before clinical signs developed
- If discovered, cattle would be destroyed rather than repatriated
- High density of predators



# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of cattle returning to Botswana

### Status quo

Current risk is **low** with **moderate** uncertainty

### Removal

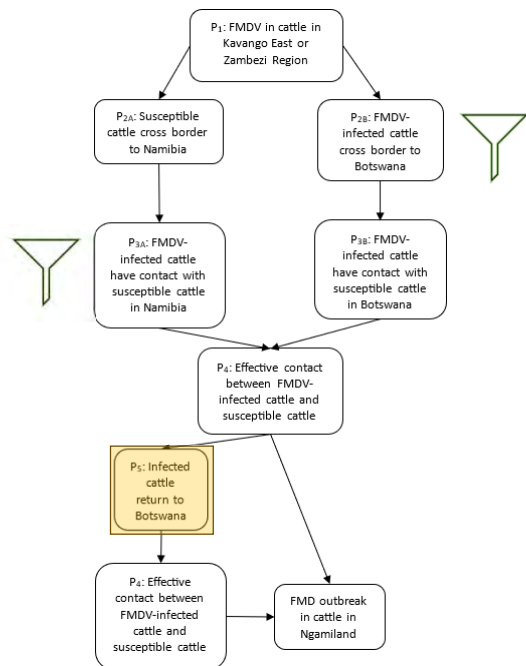
Border easier to cross but cattle still need to navigate through Bwabwata

Risk remains **low** with **moderate** uncertainty

### Removal with risk mitigation

Cattle under H4H should not be herded back to Botswana

Risk decreases to **very low** with **moderate** uncertainty

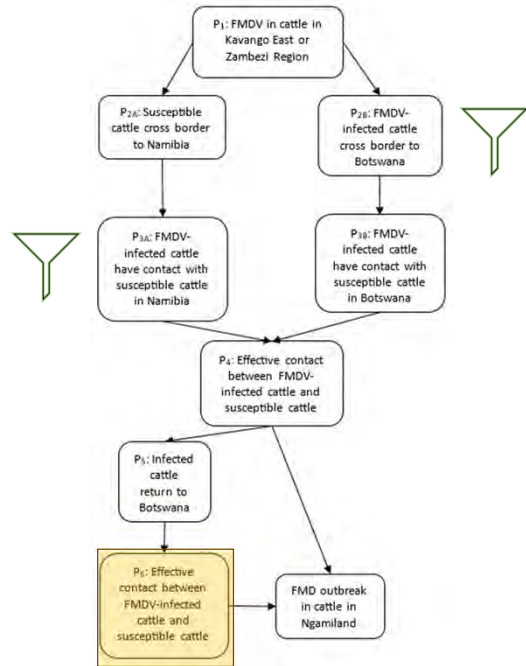


# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of effective contact between cattle in Botswana

### Status quo

- Cattle in Ngamiland not vaccinated against serotype O



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# Fence: Zambezi Border Disease: Serotype O FMD

## Risk of effective contact between cattle in Botswana

### Status quo

Current risk is **high** with **low** uncertainty

### Removal

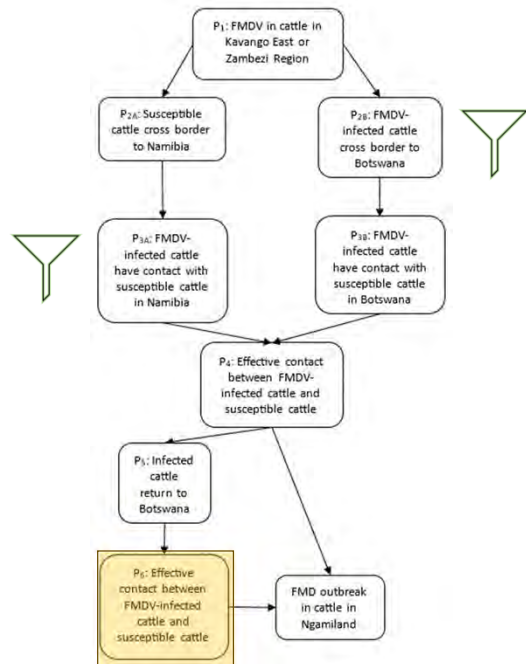
Would not affect effective contact in Botswana

Risk remains **high** with **low** uncertainty

### Removal with risk mitigation

Target high-risk crushes for FMD serotype O vaccination; improved animal health and higher vaccination coverage under H4H

Risk decreases to **moderate** with **moderate** uncertainty



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Fence:  
Zambezi  
Border

Disease:  
Serotype O  
FMD

- Consequence assessment
  - Cattle never exposed to or vaccinated against a strain typically have severe clinical signs (Kitching 2002)
  - High proportion of cattle showed clinical signs simultaneously in Namibia outbreak (Banda et al. 2022)
  - Very high morbidity and high production costs (up to 25% loss in milk production, 20% in weight gain) (Mokopasetso 2021 at AHSWG)

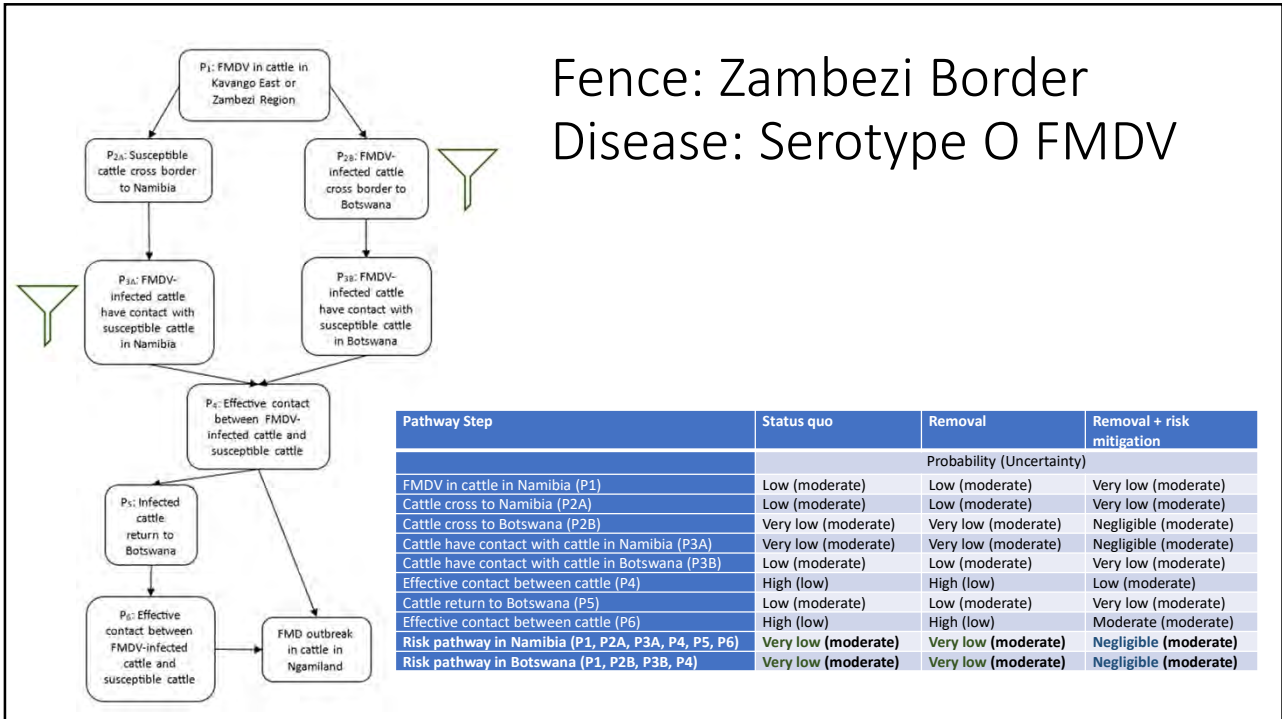
69

Fence:  
Zambezi  
Border

Disease:  
Serotype O  
FMD

- Consequence assessment
  - Control costs – testing, personnel time, vaccination, surveillance
  - Vaccination costs may be higher if vaccinating against SAT-types and serotype O
    - Namibia spent N\$6,000,000 on vaccine against serotype O alone during first round of vaccination in 2021 outbreak
- Magnitude of consequences: **high** with low uncertainty

70



71

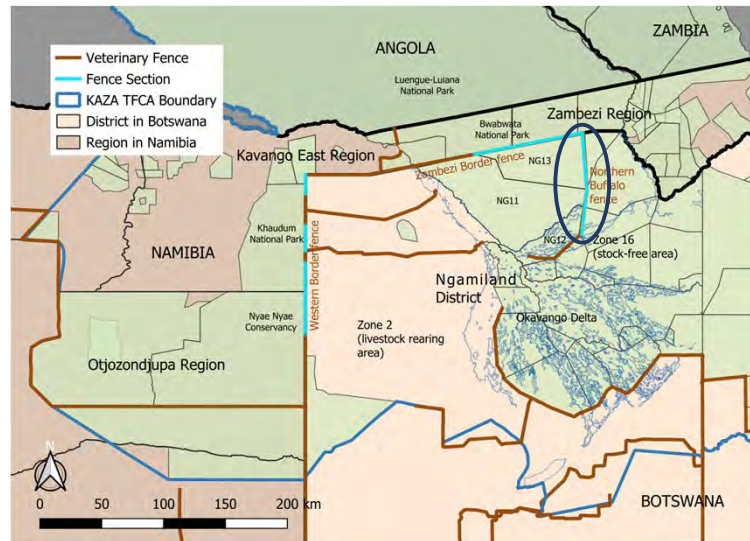
## FMDV Serotype O at the Zambezi Border fence east of the Okavango River

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	negligible
Magnitude of Consequences	high	high	high
Overall Risk Estimate	moderate	moderate	moderate

72

# Risk Pathway 2

SAT-type FMD from buffalo at Northern Buffalo fence



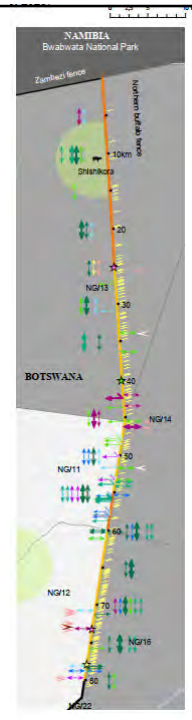
73

# Northern Buffalo Fence Status

- Fence in good condition near BDF camp, deteriorates further south

### Gaps enabling wildlife crossings

- Gap (fence flat or <50cm above ground), regular crossing trail at time of survey.
- Gap (fence flat or <1m above ground), with or without spoor, potential for use as a regular crossing trail at other times.
- Major fence damage (damaged wires + poles + droppers) also potentially enabling crossings. Under-representation of damaged sites as does not include sites where less than 3 structural components are damaged.



Atkinson et al. 2022

74

Nov. 2022



75

Nov. 2022



76

## Fence: N. Buffalo

### Disease: SAT-type FMD (buffalo)

- Hazard identification
  - SAT-1, SAT-2, and SAT-3 serotypes of the *Aphthovirus* genus in family Picornaviridae causing FMD in cattle in zone 2

77

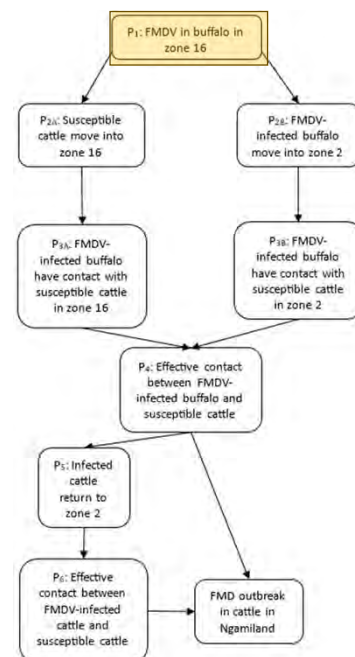
## Fence: N. Buffalo

### Disease: SAT-type FMD (buffalo)

#### Risk of FMDV excretion in buffalo in zone 16

##### Status quo

- Buffalo lose maternal immunity at 3-6 months of age, natural infection occurs soon after antibodies wane (Thomson et al. 1992)
- Viraemia stage short; up to 7 days post-infection (Gainaru et al. 1986, Maree et al. 2016)
- Within 14 days of infection, FMDV cannot be recovered from tissues, secretions, excretions other than pharyngeal mucosa (Jori et al. 2009)
- Previous risk assessment: fraction of the year with at least one contagious buffalo calf is 0.07 (Sutmoller et al. 2000)



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## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

### Risk of FMDV excretion in buffalo in zone 16

#### Status quo

Current risk is **low** with **moderate** uncertainty

#### Removal

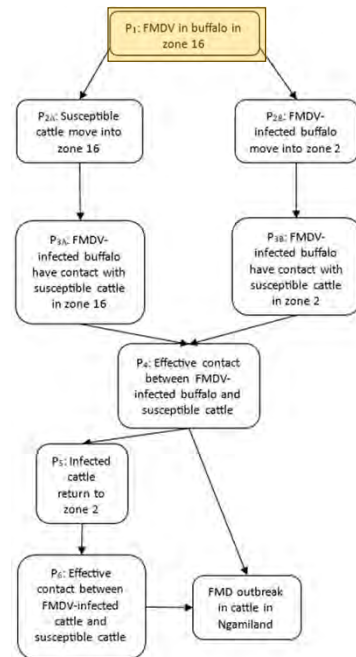
Will not impact FMDV excretion in buffalo

Risk remains **low** with **moderate** uncertainty

#### Removal with risk mitigation

No practical interventions

Risk remains **low** with **moderate** uncertainty

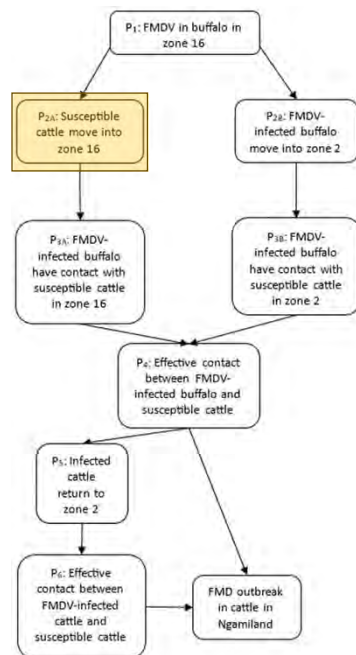


## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

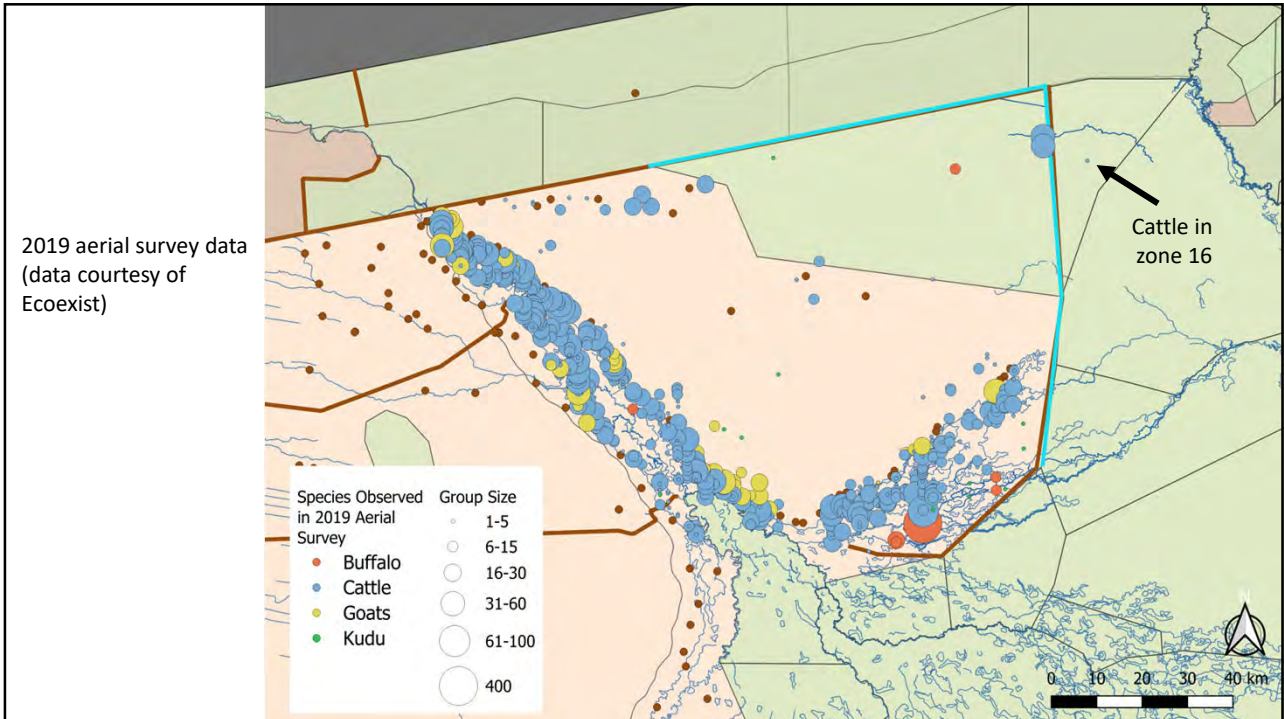
### Risk of cattle moving into zone 16

#### Status quo

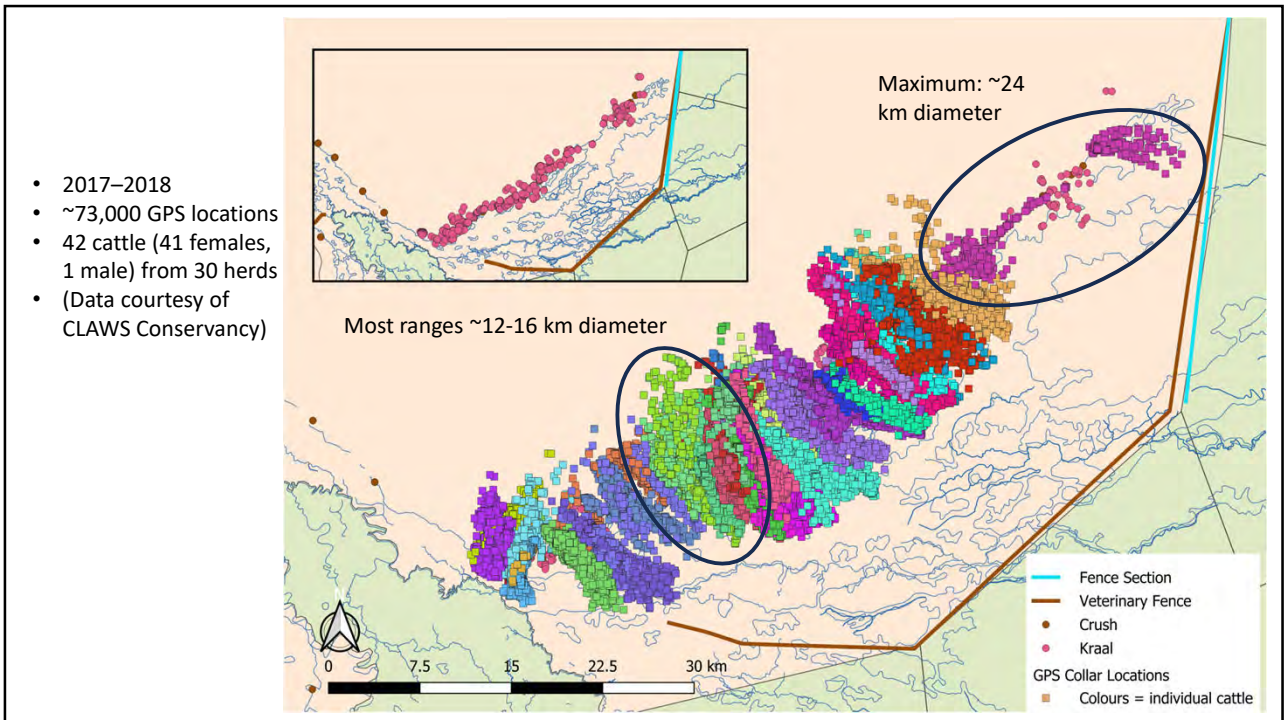
- Cattle most concentrated near southern end of fence (not proposed for removal)
- Poor condition of the fence – cattle could cross
- Major breaks observed near Seshokora during June 2021 NAMBOT patrol
- People cut the fence to allow cattle to graze in zone 16 (June 2022 NW District monthly report); cattle observed in zone 16 on 2019 aerial survey
- Cattle in northern delta prefer areas close to human settlements, experience significant predation by lions >4 km from settlements (Weise et al. 2019)







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## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

### Risk of cattle moving into zone 16

#### Status quo

Current risk is **low** with **moderate** uncertainty

#### Removal

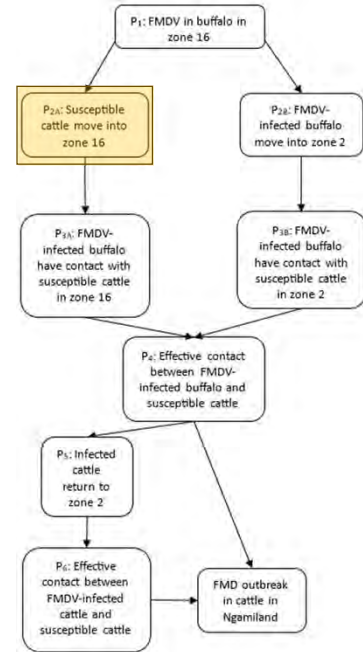
Cattle near Seshokora might move into zone 16; cattle in northern delta less likely to move into zone 16

Risk increases to **moderate** with **moderate** uncertainty

#### Removal with risk mitigation

Cattle movements controlled under H4H

Risk decreases to **very low** with **moderate** uncertainty



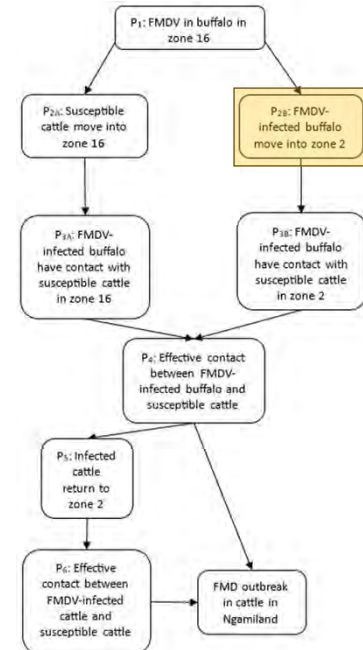
83

## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

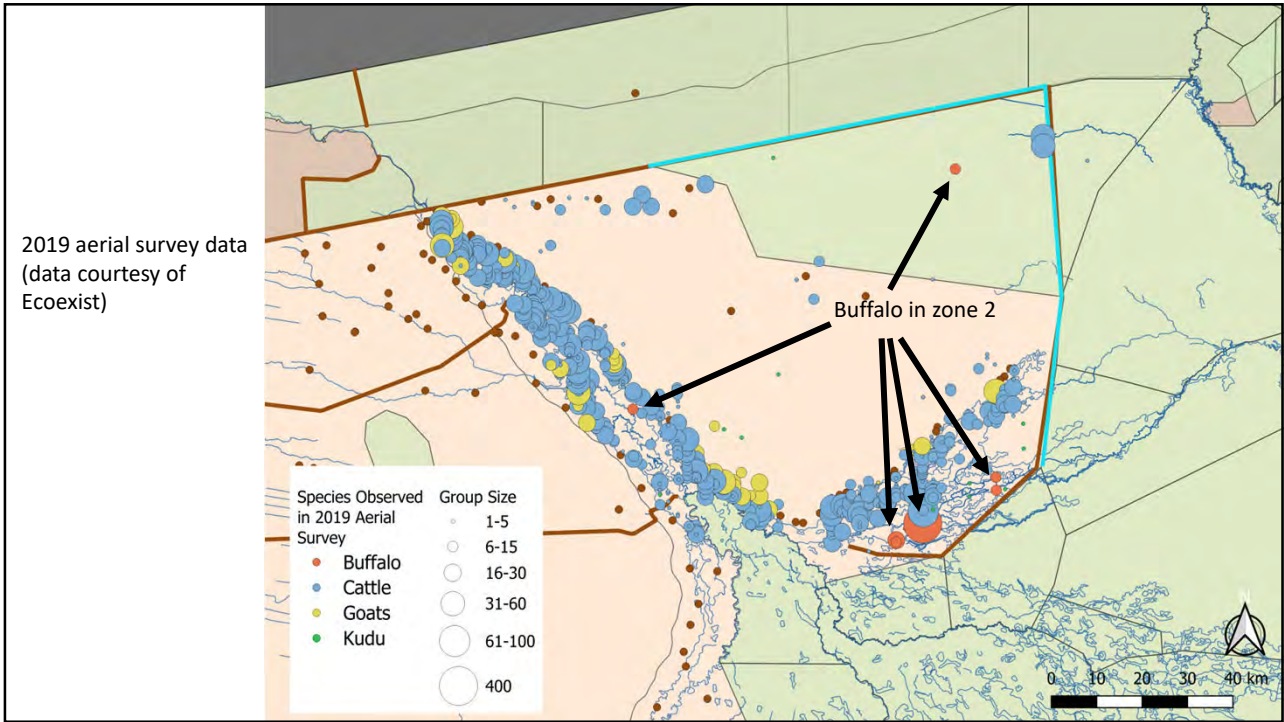
### Risk of buffalo moving into zone 2

#### Status quo

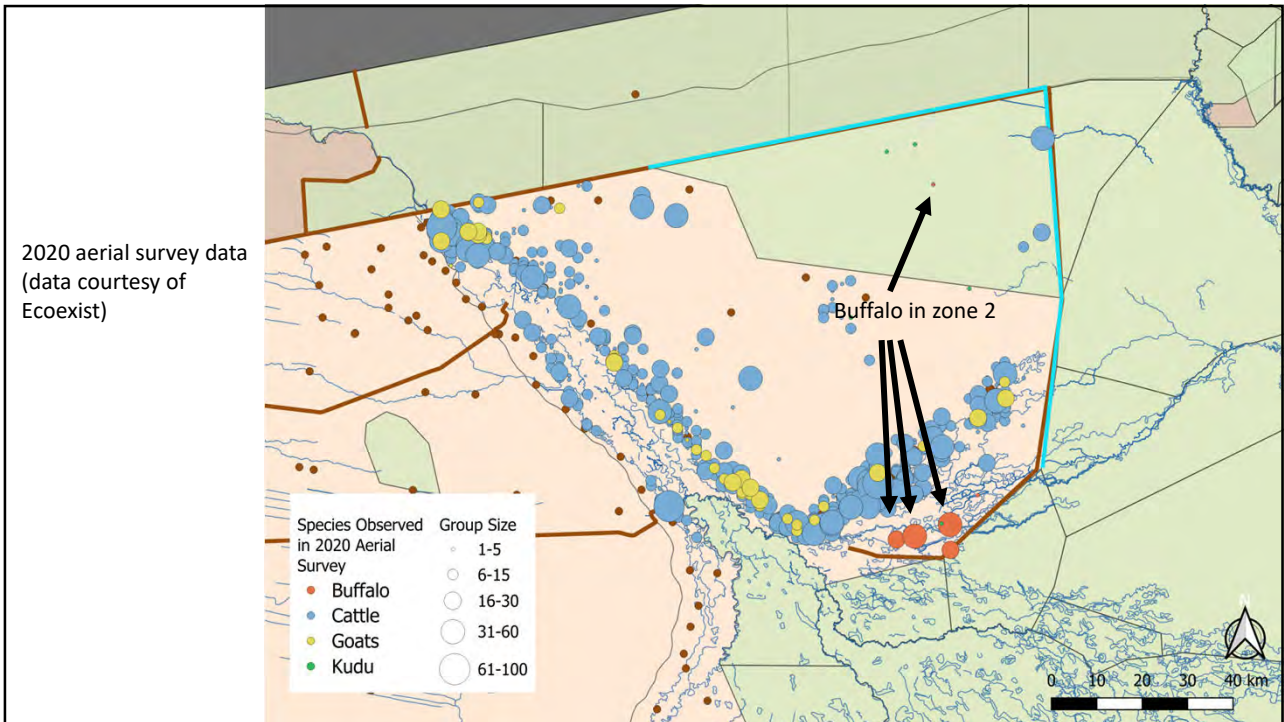
- Buffalo observed in zone 2 on 2019 and 2020 aerial surveys
- 20% (3/15) attempted buffalo crossings successful during 2020 fence surveys
- 3 buffalo incursion reports in northern delta in 2023
  - Many farmers no longer report due to poor response



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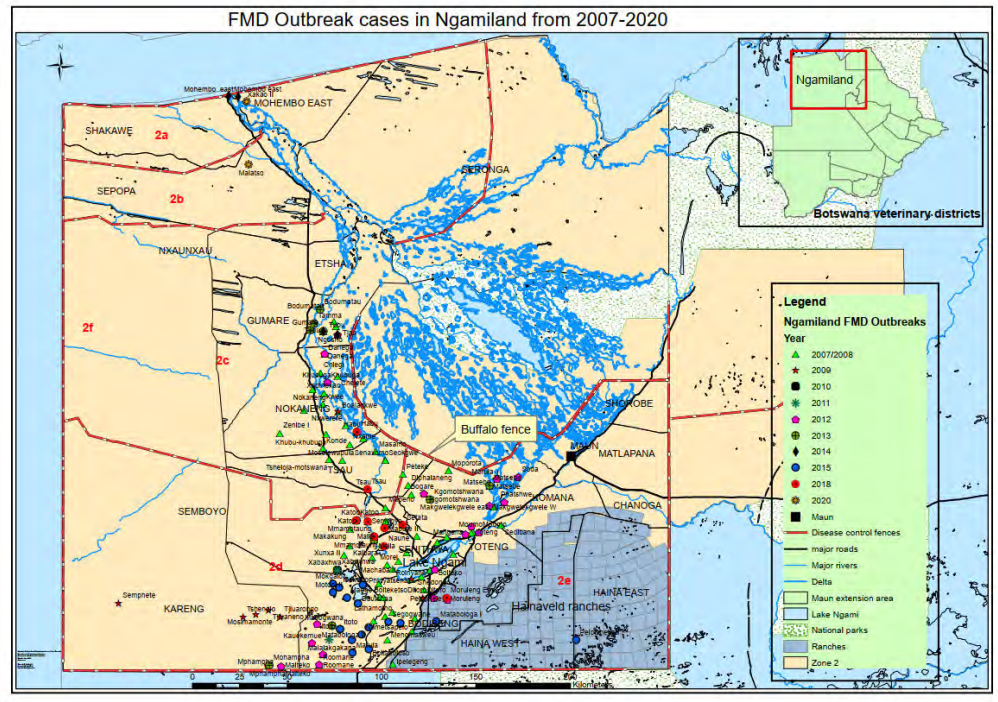


85



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# Botswana DVS FMD Outbreak Map (2007 – 2020)



87

## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

### Risk of buffalo moving into zone 2

#### Status quo

Current risk is **moderate** with **low** uncertainty

#### Removal

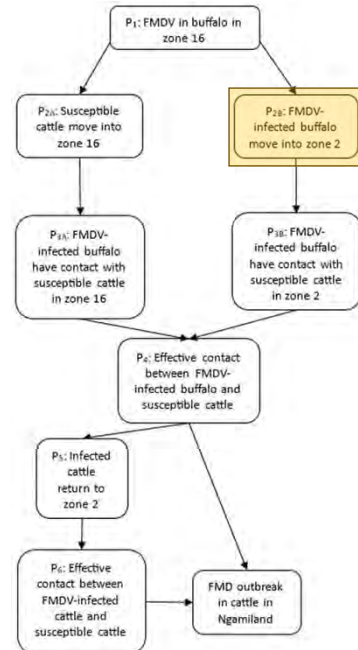
Buffalo spoor recorded during surveys, likely to cross without fence present

Risk increases to **high** with **low** uncertainty

#### Removal with risk mitigation

Restoration of connectivity is the goal – animal crossings are expected

Risk remains **high** with **low** uncertainty



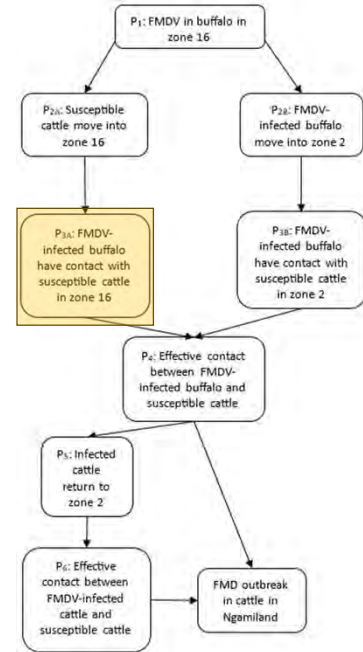
88

# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

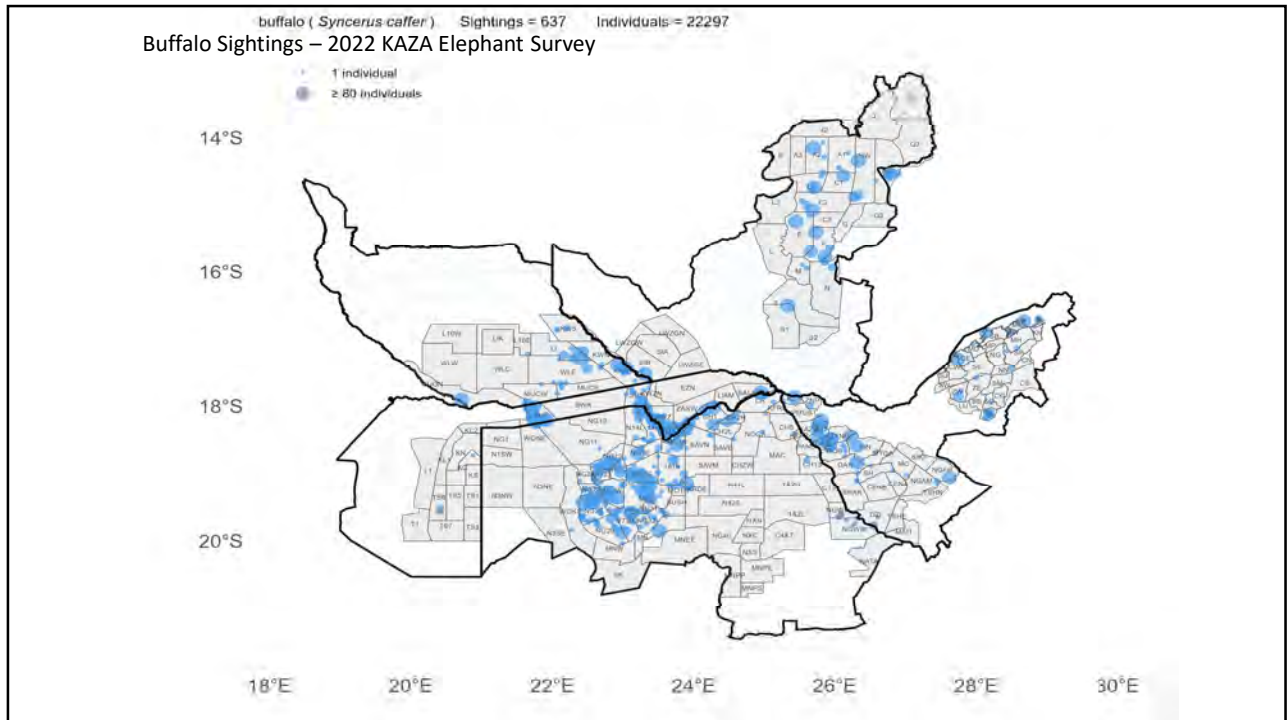
## Risk of buffalo-cattle contact in zone 16

### Status quo

- Buffalo more concentrated near Kwando River (2022 KAZA Elephant Survey) in dry season
- Contact rates among cattle and buffalo uncommon (Miguel et al. 2013)
  - Study using GPS collars in Zimbabwe
  - Contact = cattle within 300m of buffalo location <15 days after location recorded
  - Cattle herded to grazing then left; kraaled at night
  - 39/70 cattle/season combinations: NO contacts with buffalo recorded
  - $1.1 \times 10^{-4} - 6.6 \times 10^{-8}$  contacts relative to number of cattle-buffalo location pairs



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## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

### Risk of buffalo-cattle contact in zone 16

#### Status quo

Current risk is **moderate** with **moderate** uncertainty

#### Removal

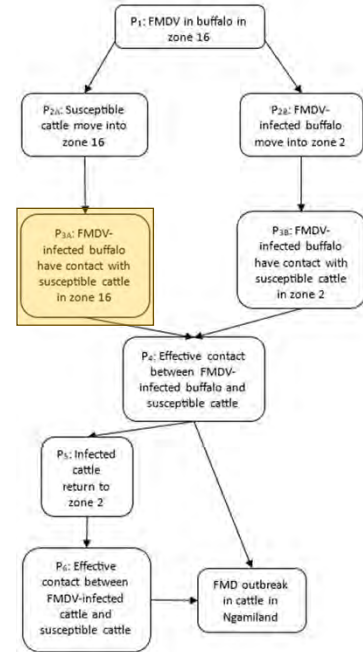
Cattle from Seshokora crush most likely to enter zone 16 and potentially have contact with buffalo

Risk remains **moderate** with **moderate** uncertainty

#### Removal with risk mitigation

Active herding under H4H limits straying and contact with buffalo; some already in place in Eretsha

Risk decreases to **very low** with **moderate** uncertainty



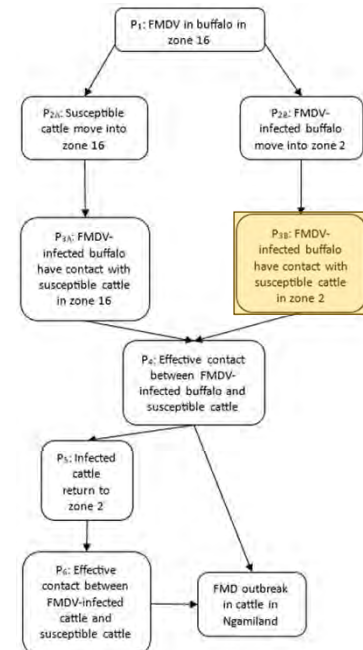
91

## Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

### Risk of buffalo-cattle contact in zone 2

#### Status quo

- As described previously, but fewer buffalo present in zone 2 than in zone 16



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# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Risk of buffalo-cattle contact in zone 2

### Status quo

Current risk is **low** with **moderate** uncertainty

### Removal

Contact at Seshokora may be more likely

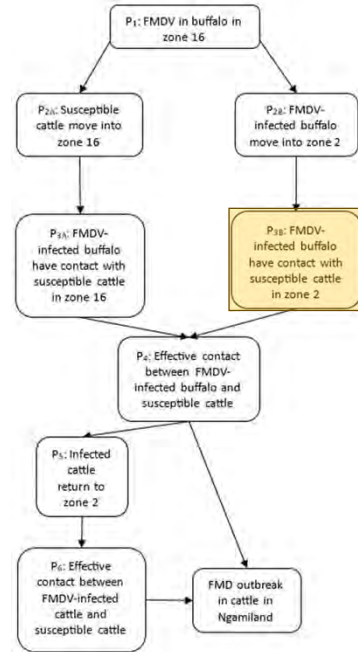
Risk remains **low** with **moderate** uncertainty

\*risk considered moderate based on discussion at validation meeting

### Removal with risk mitigation

Active herding under H4H limits contact with buffalo; some already in place in Eretsha

Risk decreases to **very low** with **moderate** uncertainty

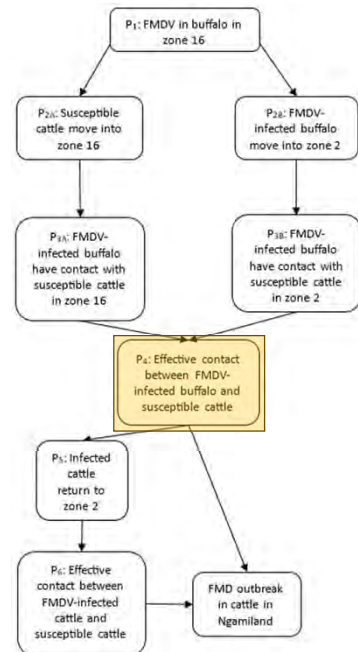


# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Effective contact between buffalo and cattle

### Status quo

- Natural transmission from buffalo does occur
  - HOW is still unclear
- Cattle co-housed with acutely infected buffalo often failed to become infected (Gainaru et al. 1986)
- Cattle herded with infected buffalo for 2.5 years failed to become infected (Hedger 1976)
- Cattle did not become infected after sharing drinking troughs and hay racks with infected buffalo for 15 mo (Bengis et al. 1986)

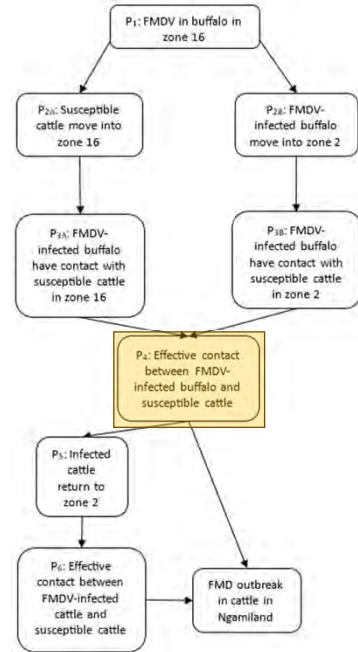


# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Effective contact between buffalo and cattle

### Status quo

- FMD outbreaks do not occur continuously in areas where buffalo and cattle are in contact (e.g., Chobe District)
- Kenya: 8,500 cattle and 1,200 buffalo share water and grazing in Ol Pejeta Conservancy; study found no evidence of buffalo-cattle FMDV transmission, few clinical outbreaks compared to cattle in surrounding communities (Omondi et al. 2020)



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# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Effective contact between buffalo and cattle

### Status quo

Current risk is **very low** with **moderate** uncertainty

### Removal

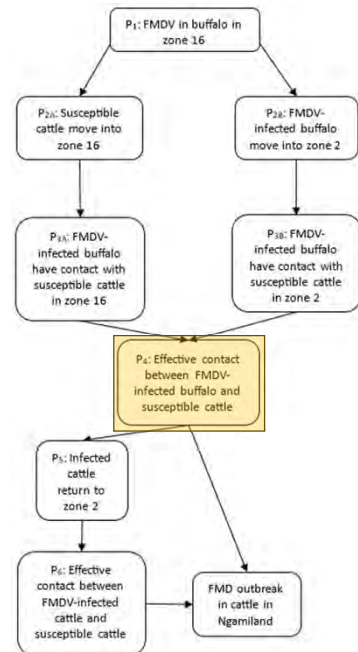
Will not affect effective buffalo-cattle contact

Risk remains **very low** with **moderate** uncertainty

### Removal with risk mitigation

Under H4H, active herding would reduce contact with buffalo and cattle likely to be in better physical condition, immune status, and vaccinated

Risk remains **very low** with **moderate** uncertainty



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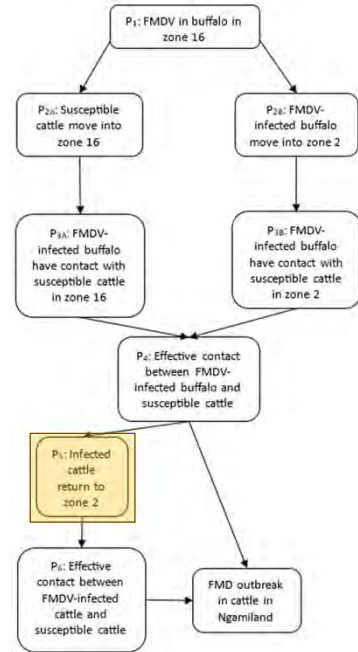


# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Risk of cattle returning to zone 2

### Status quo

- Cattle not likely to be reported in this remote area
- Probability of cattle returning from the delta (along Southern Buffalo fence) estimated as high (Babayani and Thololwane 2022)



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# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Risk of cattle returning to zone 2

### Status quo

Current risk is **high** with **low** uncertainty

### Removal

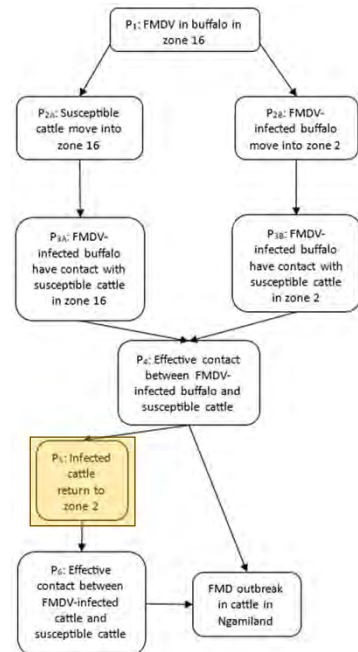
Fence removal would make it easier for cattle to return to zone 2

Risk remains **high** with **low** uncertainty

### Removal with risk mitigation

Cattle under H4H should not be herded back to zone 2

Risk decreases to **low** with **moderate** uncertainty



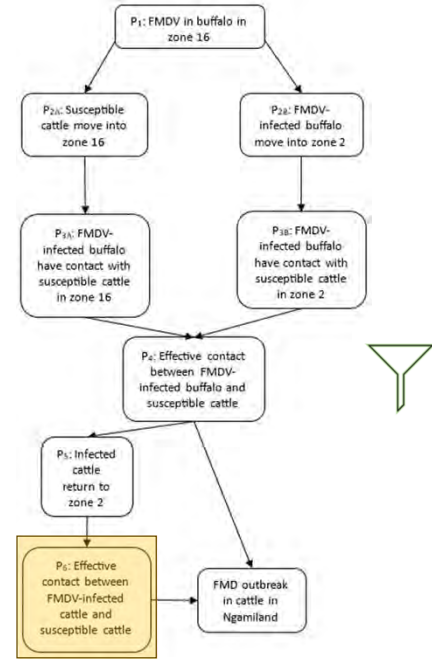
98

# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Risk of effective contact between cattle in zone 2

### Status quo

- Variable vaccination coverage offers uncertain protection
- Strain characterization data from Ngamiland suggest outbreak strains related, likely independently circulating in cattle



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# Fence: N. Buffalo Disease: SAT-type FMD (buffalo)

## Risk of effective contact between cattle in zone 2

### Status quo

Current risk is **high** with **low** uncertainty

### Removal

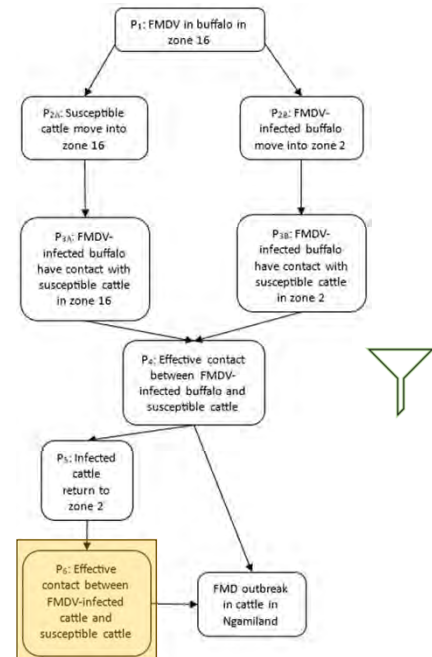
Removal would not affect effective contact in zone 2

Risk remains **high** with **low** uncertainty

### Removal with risk mitigation

Improved condition and higher vaccination coverage under H4H would raise immunity and prevent contact with other herds

Risk decreases to **moderate** with **moderate** uncertainty



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Fence:  
Northern  
Buffalo

Disease:  
SAT-type  
FMD  
(buffalo)

- Consequence assessment
  - Cattle morbidity and mortality from SAT-type FMD usually low (Kitching 2002)
  - Animals with partial natural or vaccinal immunity may have mild clinical signs that are missed, especially if free-roaming and not closely observed (Kitching 2002)
  - Low milk yield, poor draught performance (Kitching 2002); milk output drops by as much as 33% (Office of the Auditor General 2018)
- Magnitude of consequences: **moderate** with low uncertainty

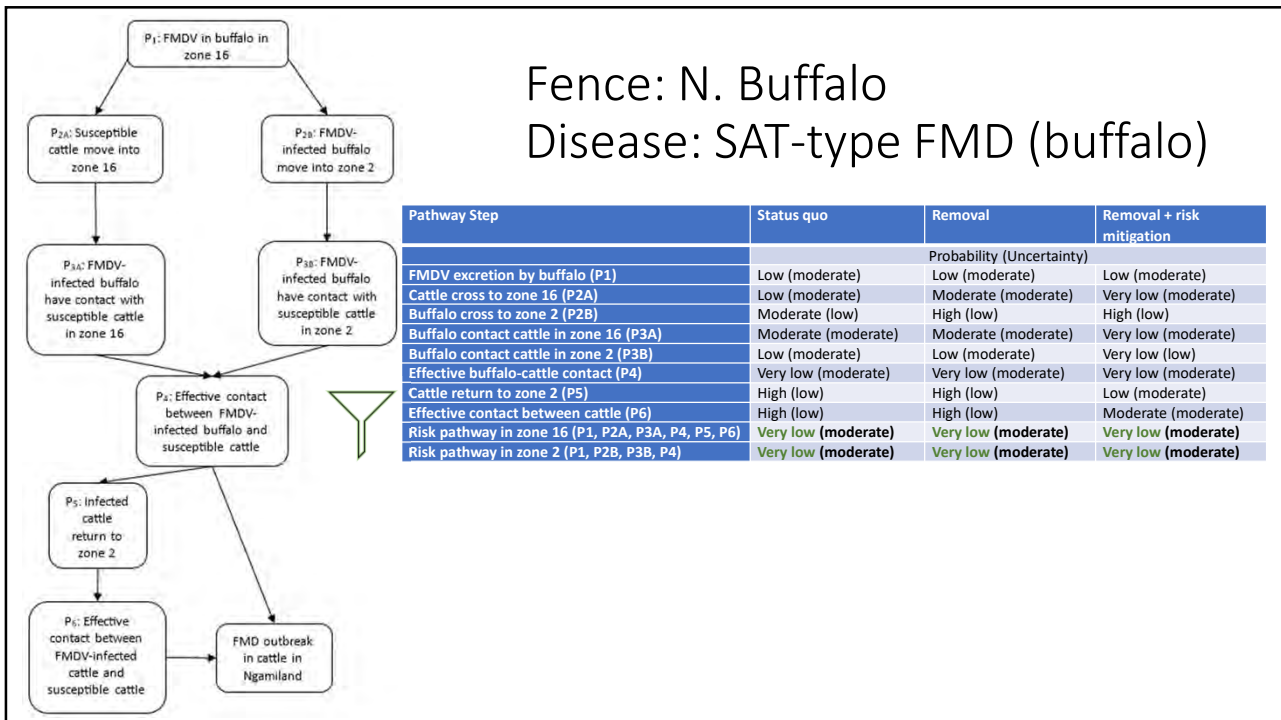
101

Fence:  
Northern  
Buffalo

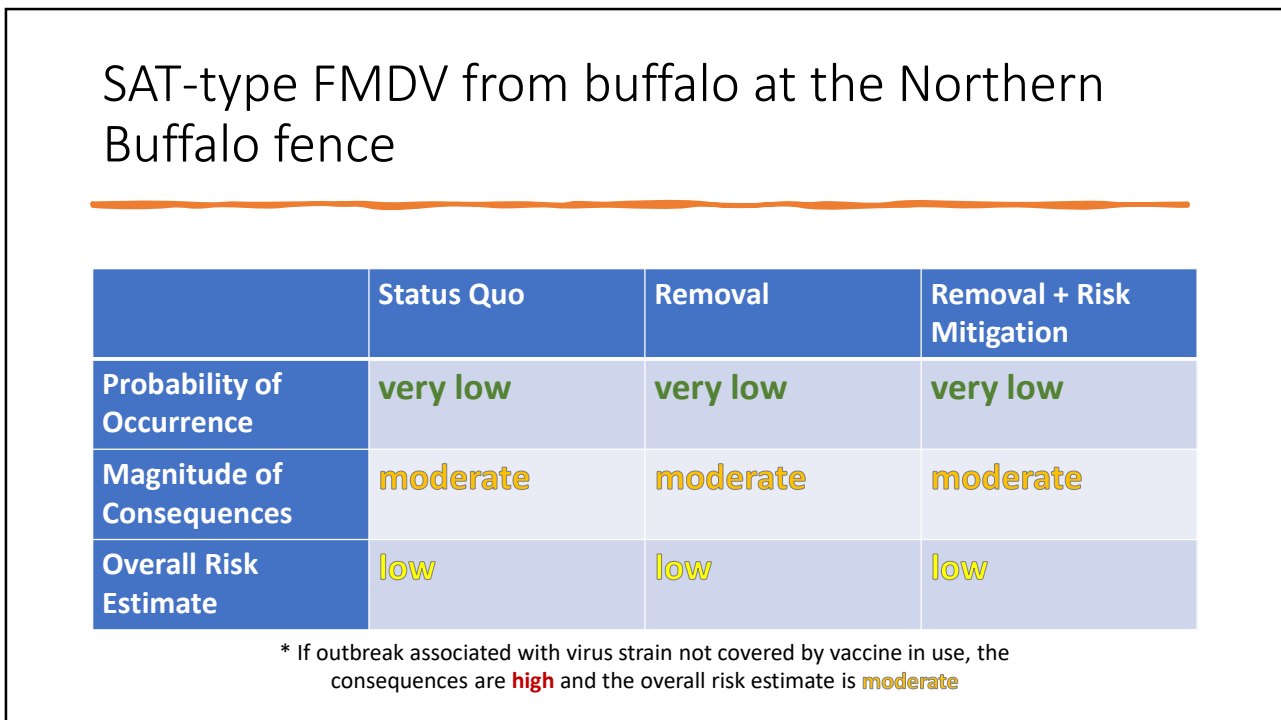
Disease:  
SAT-type  
FMD  
(buffalo)

- Consequence assessment
  - Control costs – testing, personnel time, vaccination, surveillance
  - 2020 FMD outbreak – savingram with P8,800,000 budgeted for FMD control
    - P300,000 for fencing
    - P600,000 for machines
    - P4,000,000 for travel
    - P1,500,000 for salary and wages of temporary staff
    - P2,400,000 for allowances for permanent staff
  - Movement restrictions can affect market access
- Magnitude of consequences: **moderate** with low uncertainty

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## Take-Home Messages

The veterinary fence sections of interest are semi-permeable under the status quo




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## Take-Home Messages

The risks for disease outbreaks remained the same under proposed removal




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## Take-Home Messages

Removing fences impacts risks at some - but not all - steps in the risk pathway




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## Take-Home Messages

Removing fences can affect the risk of a pathogen entering a country or zone  
Risk mitigation measures can reduce risk of entry and exposure



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Take-Home Messages

Intentional illegal movement of livestock across international borders remains a risk

This slide features a large orange semi-circle on the left side. The text "Take-Home Messages" is written in white inside this semi-circle. To the right of the semi-circle, the text "Intentional illegal movement of livestock across international borders remains a risk" is displayed in black. In the bottom right corner, there is a decorative graphic consisting of several short, curved yellow lines.

111

Take-Home Messages

Fences have limited impact on the risk of poaching

This slide features a large orange semi-circle on the left side. The text "Take-Home Messages" is written in white inside this semi-circle. To the right of the semi-circle, the text "Fences have limited impact on the risk of poaching" is displayed in black. In the bottom right corner, there is a decorative graphic consisting of several short, curved yellow lines.

112



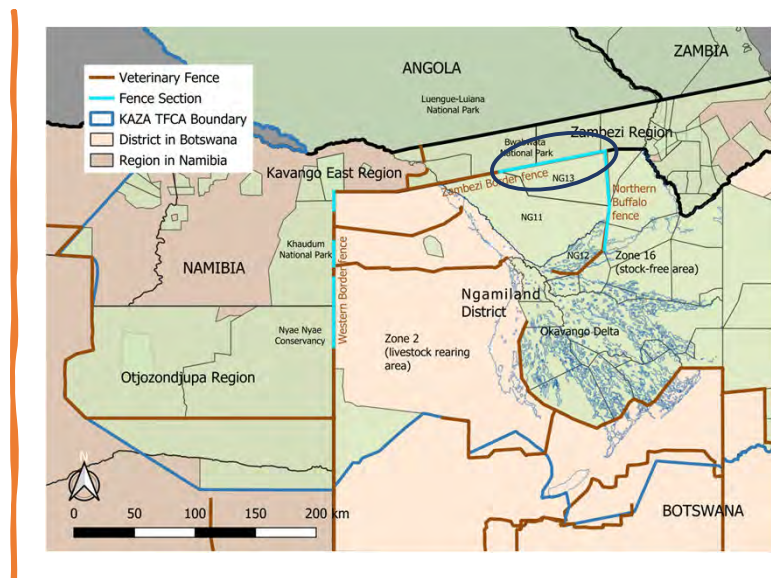
# Take-Home Messages

Very low probability of FMD viraemia in adult buffalo and negligible risk of effective contact between poachers and cattle are risk bottlenecks in poaching pathways



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# Zambezi Border Fence



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## Risks to Botswana at Zambezi Border Fence – SAT-type FMD from cattle

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Botswana at Zambezi Border Fence – SAT-type FMD from buffalo

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Botswana at Zambezi Border Fence – SAT-type FMD from poaching

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	negligible	negligible	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Botswana at Zambezi Border Fence – FMD Serotype O

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	negligible
Magnitude of Consequences	high	high	high
Overall Risk Estimate	moderate	moderate	moderate

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## Risks to Namibia at Zambezi Border Fence – SAT-type FMD from cattle/buffalo

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Namibia at Zambezi Border Fence – SAT-type FMD from poaching

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	negligible	negligible	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Botswana at Zambezi Border Fence - CBPP

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	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	negligible
Magnitude of Consequences	high	high	high
Overall Risk Estimate	moderate	moderate	moderate

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## Risks to Botswana at Zambezi Border Fence – PPR

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	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

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## Summary of results from Zambezi Fence

- **Negligible** risk of FMD from cattle if cattle are removed from Bwabwata National Park
  - The direct consequences for serotype O are higher than those for SAT-type FMD, hence higher risk estimate

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## Summary of results from Zambezi Fence

- Risk from buffalo or poaching does not change measurably
  - Buffalo pathways have a risk bottleneck at **very low** effective contact between buffalo and cattle
  - Poaching pathways have a risk bottleneck at **very low** risk of viraemia in adult buffalo and **negligible** risk of effective contact between a poacher and cattle

124

## Summary of results from Zambezi Fence

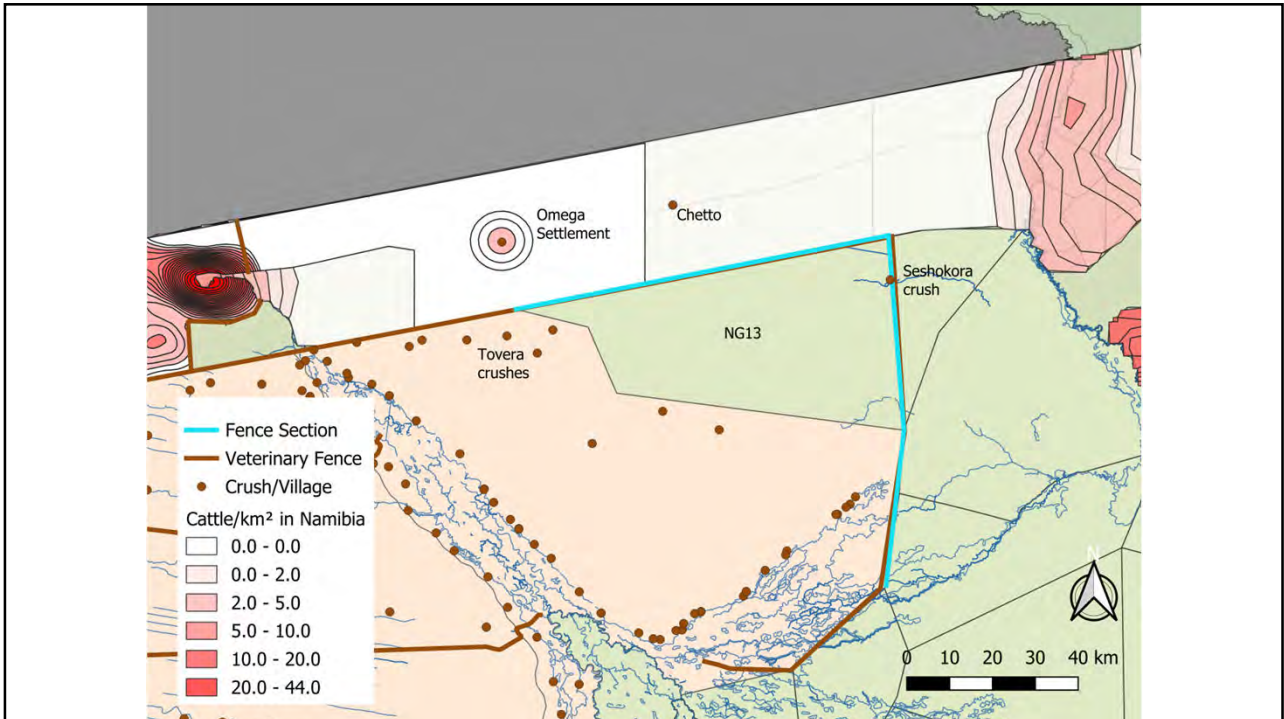
- Risk of CBPP or PPR occurring is **very low**
- Highest risk areas on Namibia-Angola border are not near this fence

125

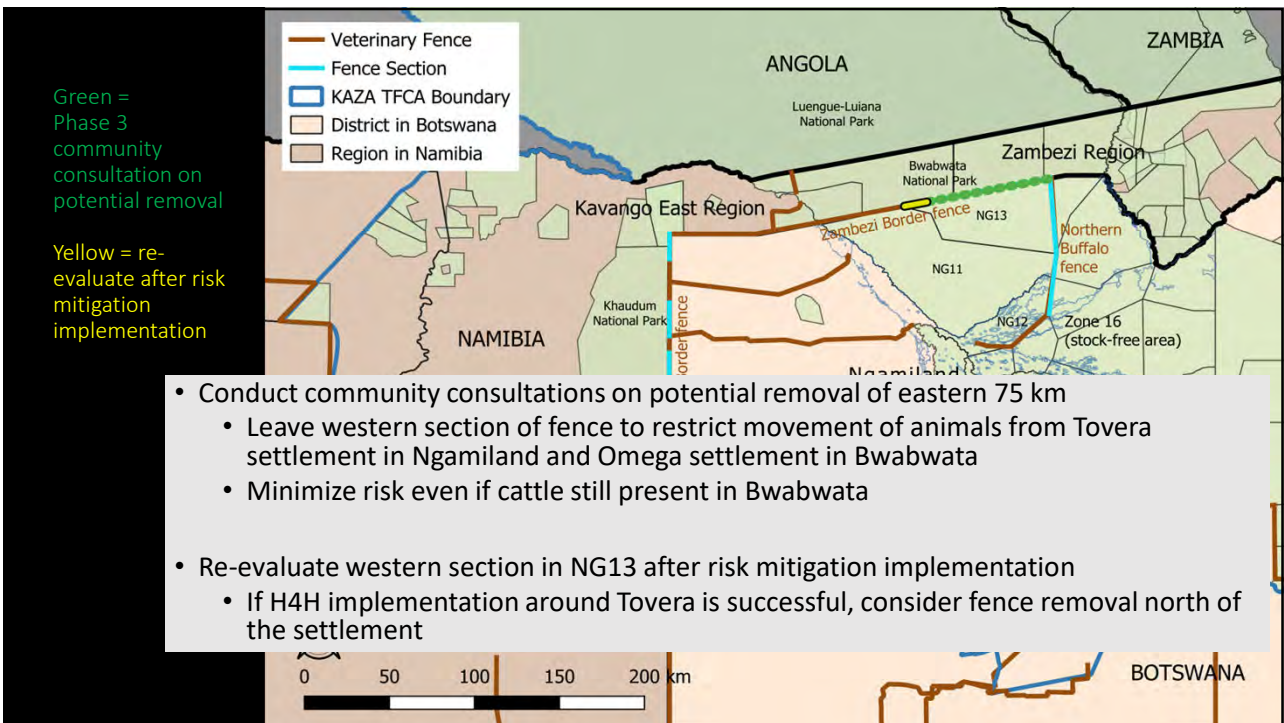
## Recommendations – Zambezi Border fence

- The probability of occurrence for SAT-type FMD and PPR outbreaks was **very low** or **negligible**, overall risk estimated as **low**
- The probability of occurrence for CBPP and FMD serotype O outbreaks was **very low**, overall risk estimated as **moderate** based on higher consequences
- **The risks are the same for both the status quo and removal scenarios; not starting from zero risk**

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## Recommendations

- Community consultations are critical
  - Perspectives on fences and removal
  - H4H implementation must be driven by “bottom-up” demand (communities), not “top-down” command (compulsory by DVS)
- Communities should be empowered to become partners with DVS in disease control
  - Example of community task forces in Zambia assisting with CBPP control
  - Use indigenous knowledge and on-the-ground eyes and ears (H4H herders) to supplement DVS extension officers

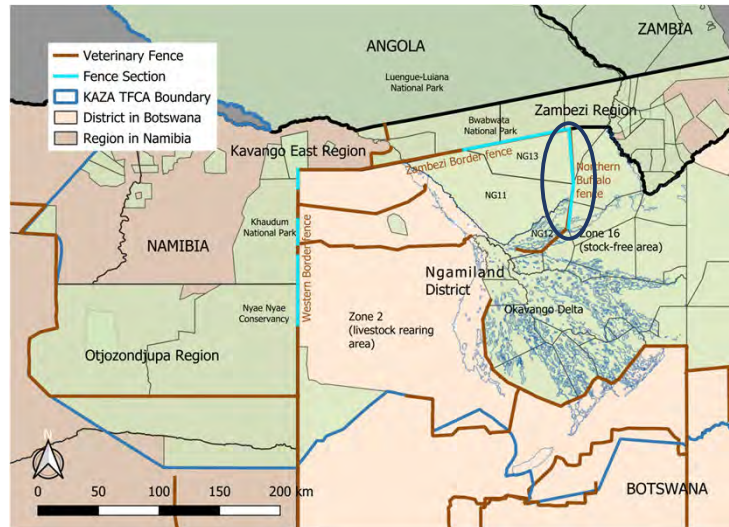
129

## Recommendations

- Employing risk mitigation strategies such as vaccination depends on Botswana and Namibia DVS having capacity and funding to carry out their mandate
- Current funding levels are insufficient to implement disease control as intended
- A business case must be developed for improving DVS funding

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# Northern Buffalo Fence



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## Risks at Northern Buffalo Fence – SAT-type FMD – buffalo

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks at Northern Buffalo Fence – SAT-type FMD – poaching

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	negligible	negligible	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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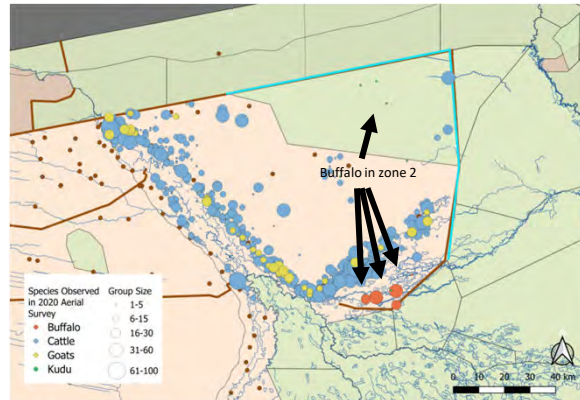
## Summary of results from Northern Buffalo Fence

- Lower overall risk profile
  - Few cattleposts nearby
  - Cattle only occur on one side of the fence
  - Same country
- Risk from buffalo or poaching does not change measurably
  - Buffalo pathways have a risk bottleneck at **very low** effective contact between buffalo and cattle
  - Poaching pathways have a risk bottleneck at **very low** risk of viraemia in adult buffalo and **negligible** risk of contact between a poacher and cattle

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## Summary of results from Northern Buffalo Fence

- Evidence from aerial and ground surveys supports some presence of buffalo in subzone 2a
  - The cattleposts near the Northern Buffalo fence have not experienced FMD outbreaks

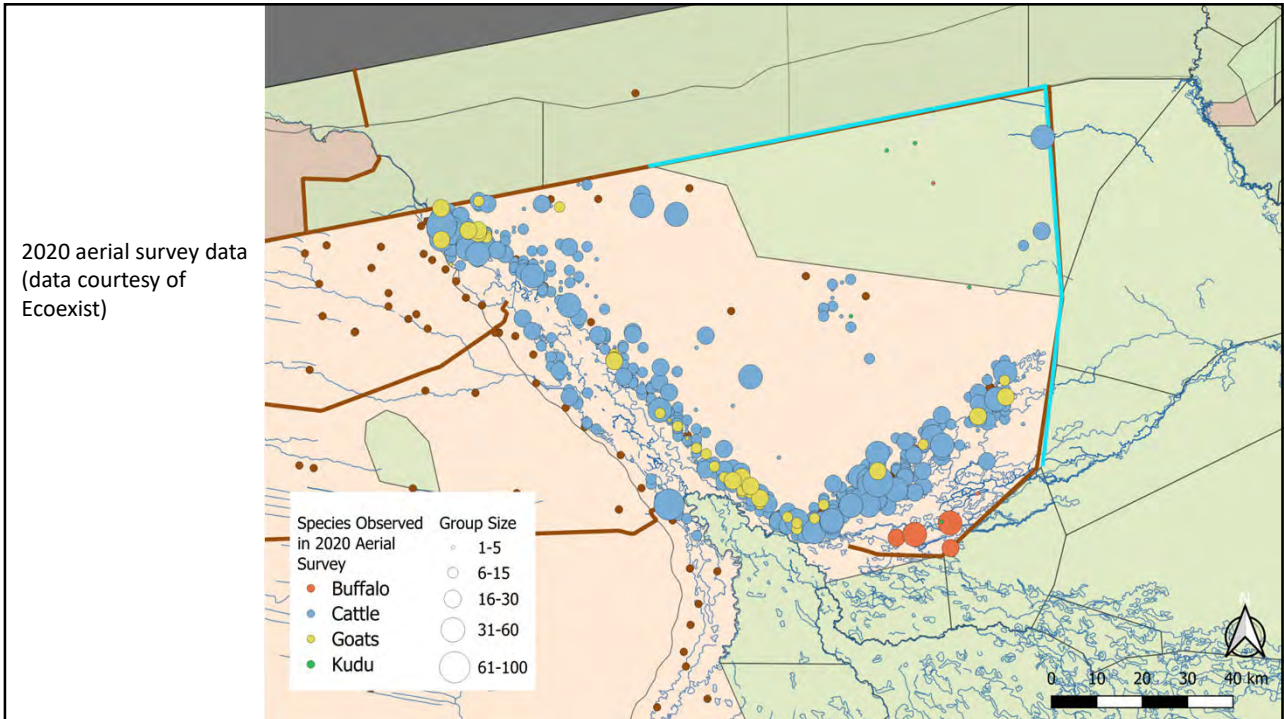


135

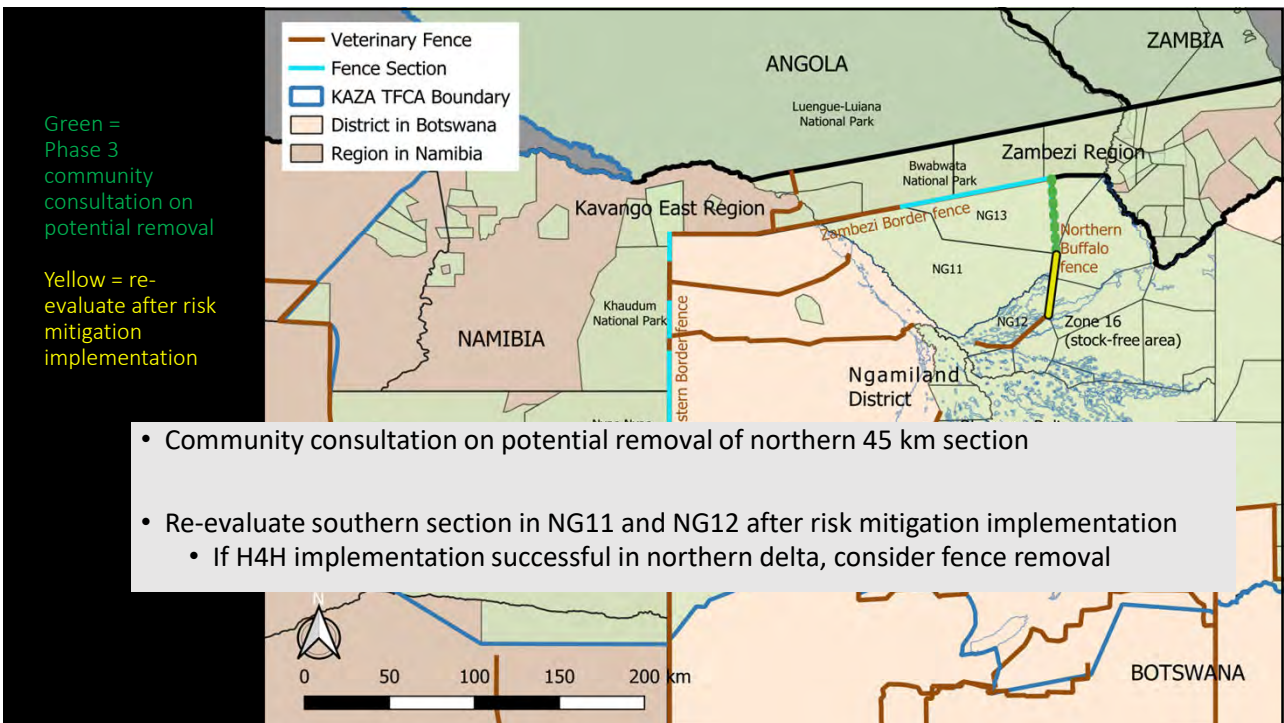
## Recommendations – Northern Buffalo fence

- The probability of occurrence for SAT-type FMD outbreaks was **very low** or **negligible**, overall risk estimated as **low**
- The risks are the same for both the status quo and removal scenarios; not starting from zero risk**

136

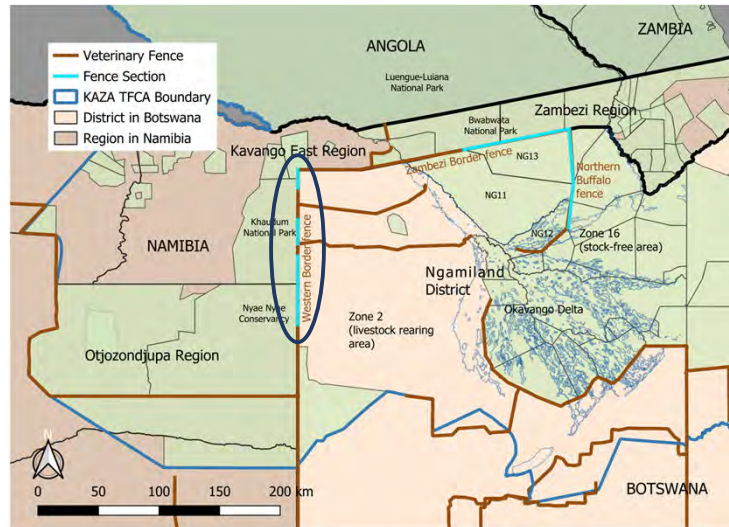


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# Western Border Fence



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## Risks to Botswana at Western Border Fence – SAT-type FMD from cattle

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Botswana at Western Border Fence – SAT-type FMD from buffalo/poaching

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	negligible	negligible	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Namibia at Western Border Fence – SAT-type FMD from cattle/buffalo

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Namibia at Western Border Fence – SAT-type FMD from poaching

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	negligible	negligible	negligible
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

\* If outbreak associated with virus strain not covered by vaccine in use, the consequences are **high** and the overall risk estimate is **moderate**

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## Risks to Botswana at Western Border Fence – Serotype O FMD

	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	high	high	high
Overall Risk Estimate	moderate	moderate	moderate

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## Risks to Botswana at Western Border Fence - CBPP

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	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low / low	very low / low	very low
Magnitude of Consequences	high	high	high
Overall Risk Estimate	moderate	moderate	moderate

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## Risks to Botswana at Western Border Fence - PPR

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	Status Quo	Removal	Removal + Risk Mitigation
Probability of Occurrence	very low	very low	very low
Magnitude of Consequences	moderate	moderate	moderate
Overall Risk Estimate	low	low	low

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## Summary of results from Western Border Fence

- The risk of SAT-type and serotype O FMD from cattle in this area is **very low** in general
  - The **very low** likelihood of the virus in cattle here acts as a bottleneck in these pathways
  - Few SAT-type outbreaks historically in this area, none near fence
  - No history of FMD serotype O in this area

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## Summary of results from Western Border Fence

- Risk of SAT-type FMD from buffalo or poaching of buffalo from Namibia is **negligible**
  - Only buffalo near fence are FMD-free, which acts as a bottleneck in these pathways
- Risk of CBPP occurring is **low** or **very low** and fence not that close to recent outbreaks near Angola border
- Risk of PPR is **very low**; no evidence of presence in Namibia

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## Recommendations – Western Border fence

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- The probability of occurrence for SAT-type FMD from cattle in Namibia to Botswana was **very low**, overall risk estimated as **low**
- The risk of SAT-type FMD from buffalo and poaching in Namibia to Botswana was **negligible**, overall risk estimated as **low**
- The risk of occurrence for FMD serotype O outbreaks was **very low**, overall risk estimated as **moderate** based on higher consequences

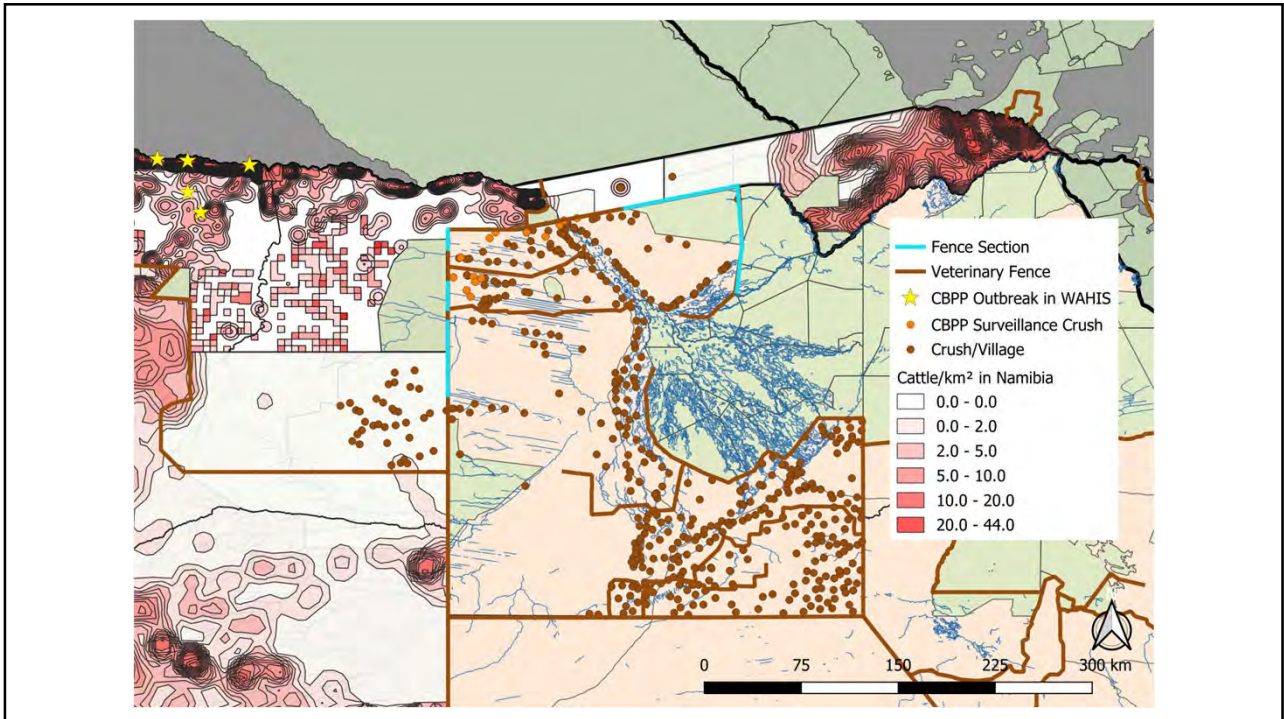
149

## Recommendations – Western Border fence

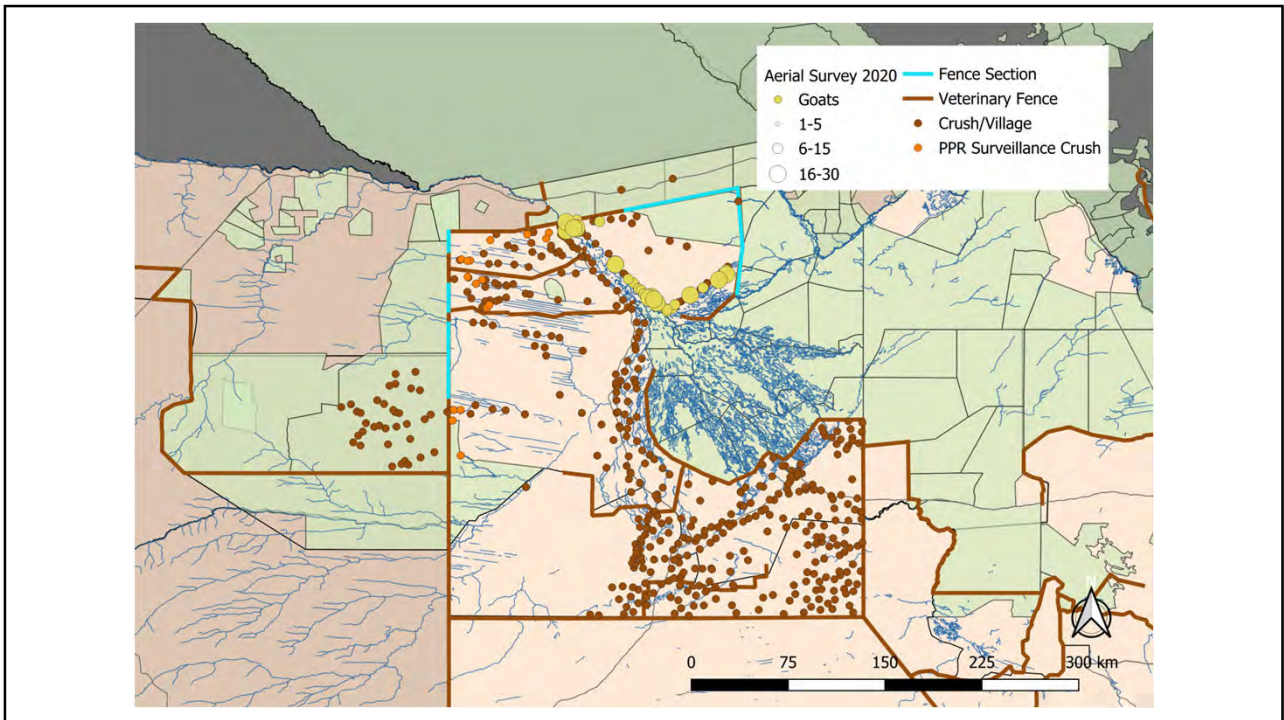
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- The risk of occurrence for CBPP **very low** or **low**, overall risk estimated as **moderate** based on higher consequences
- The risk of occurrence for PPR was **very low**, overall risk estimate is **low**
- **The risks are the same for both the status quo and removal scenarios; not starting from zero risk**

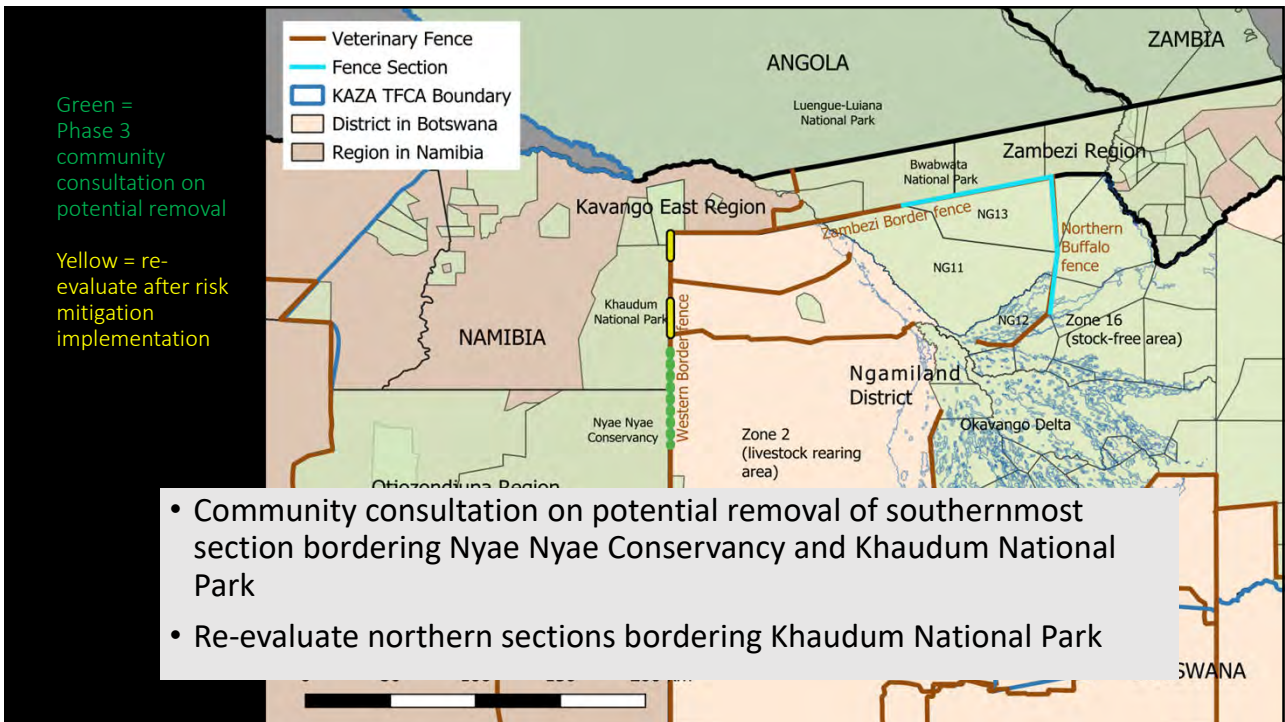
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# Outline

- Review of objectives
- Risk assessment method
- Risk mitigation strategies
- Select disease/fence pathways
- Report results & recommendations
- Meeting recommendations**

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## Special Considerations

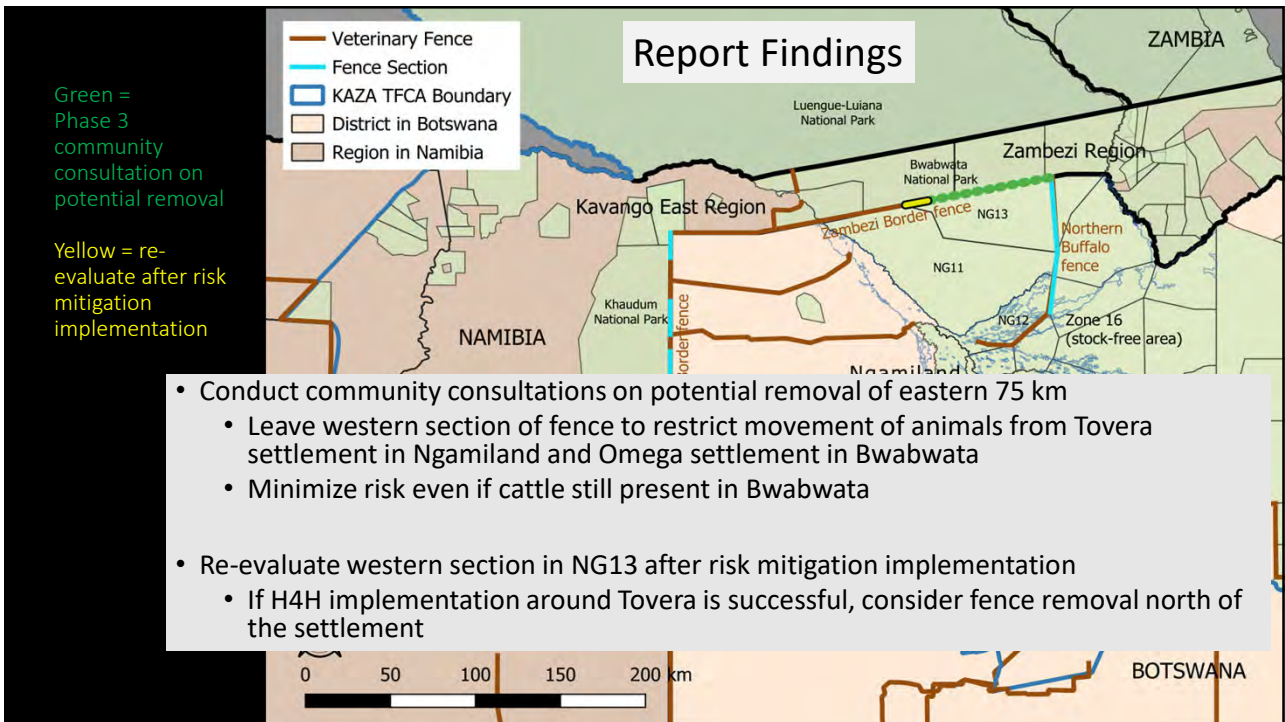
- Serotype O at Zambezi fence
  - Very low probability of occurrence but moderate overall risk
  - Risk to Chobe District should be considered (but not relevant to these fences)
- Fence patrols should be an explicit part of risk mitigation
  - BDF camp at Zambezi Border/Northern Buffalo fence junction provides confidence
- Limitation of the analysis: cattle mobility in the region
  - Seasonal movements by farmers
  - Potential for future livestock presence at currently undeveloped boreholes

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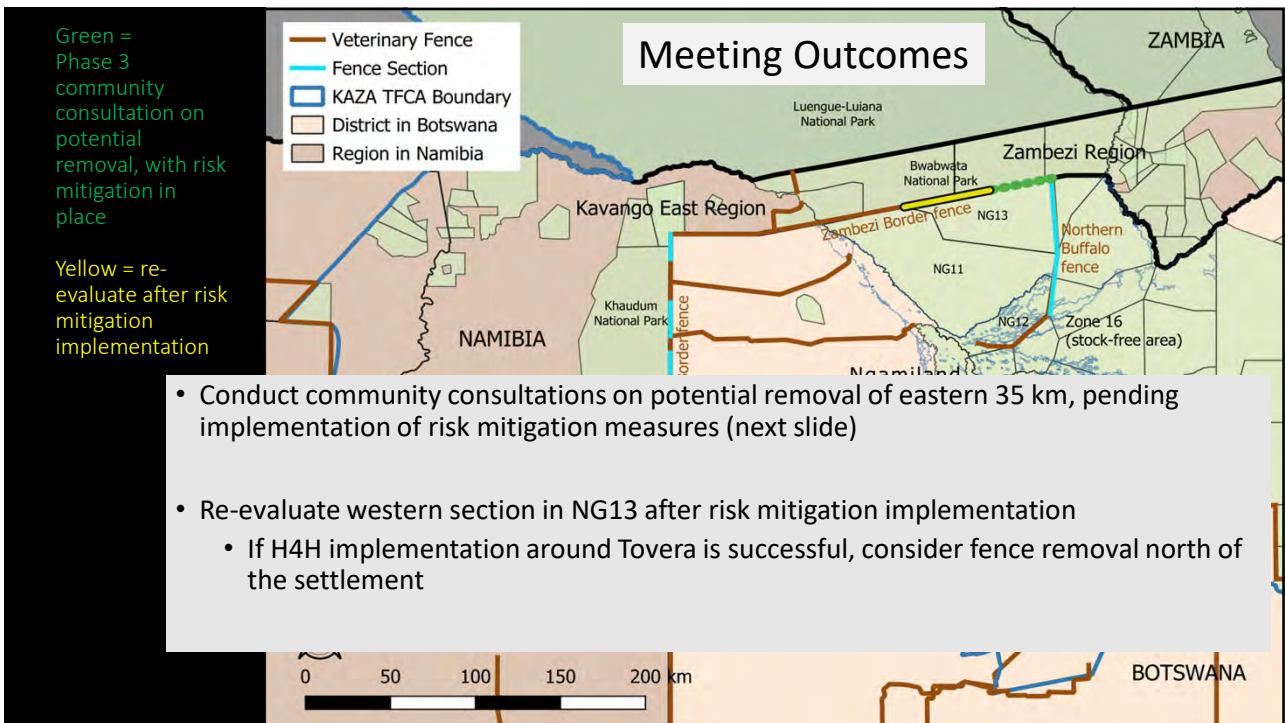
## Special Considerations

- How will wildlife move if fences are removed? Will they be at higher risk of poaching in areas not currently accessible?
  - E.g., if poaching pressure in Angola is high, elephants in the eastern panhandle might not disperse even if fences were removed
  - There is poaching pressure in northern Botswana; merits further consultation with KAZA Elephant Working Group
- Lingering worries from the severity of 1995 CBPP outbreak management consequences
  - Meat other than lung is still safe for trade
  - Live cattle trade suspended
- Cattle movement between BW and NA along the Western Border fence is higher than it appears from the records provided

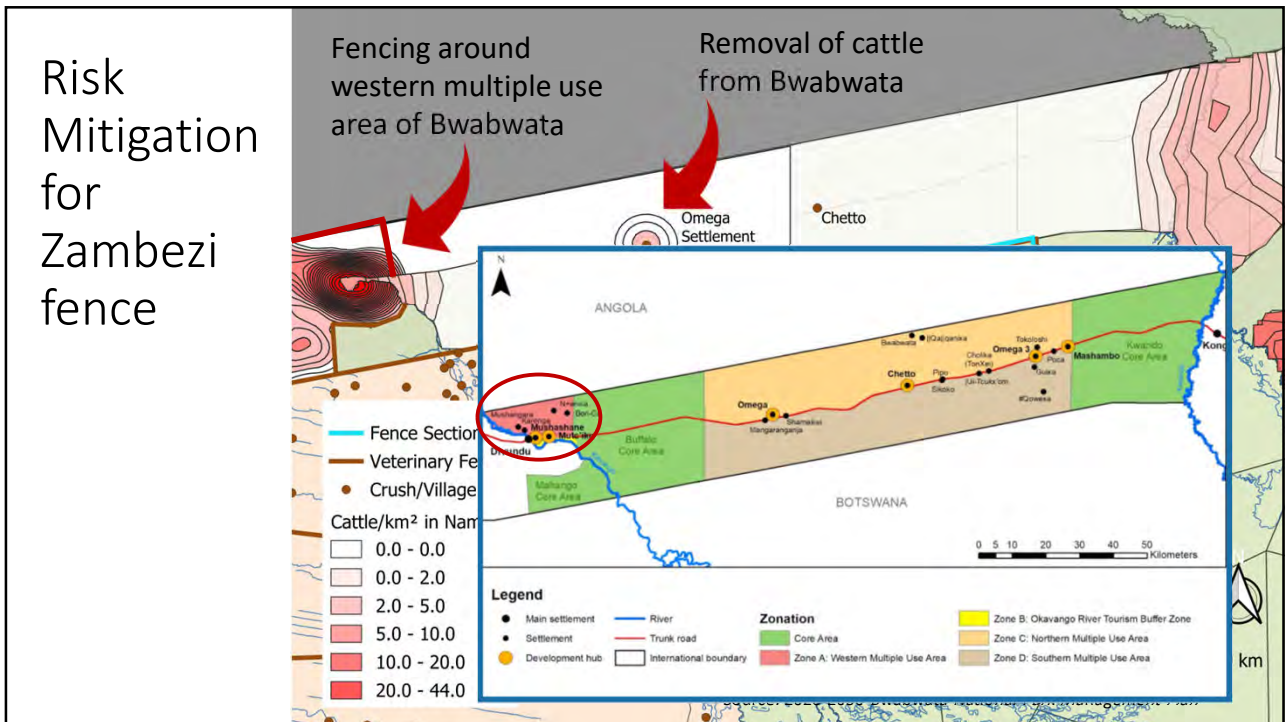
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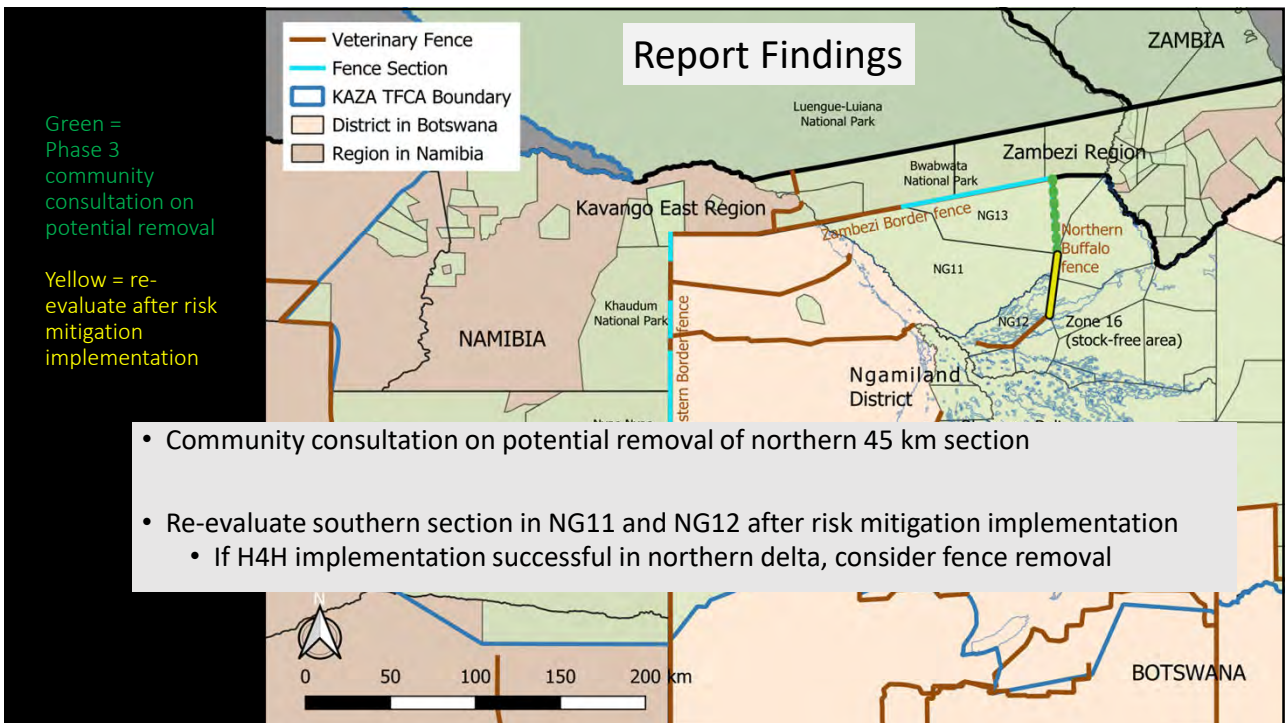
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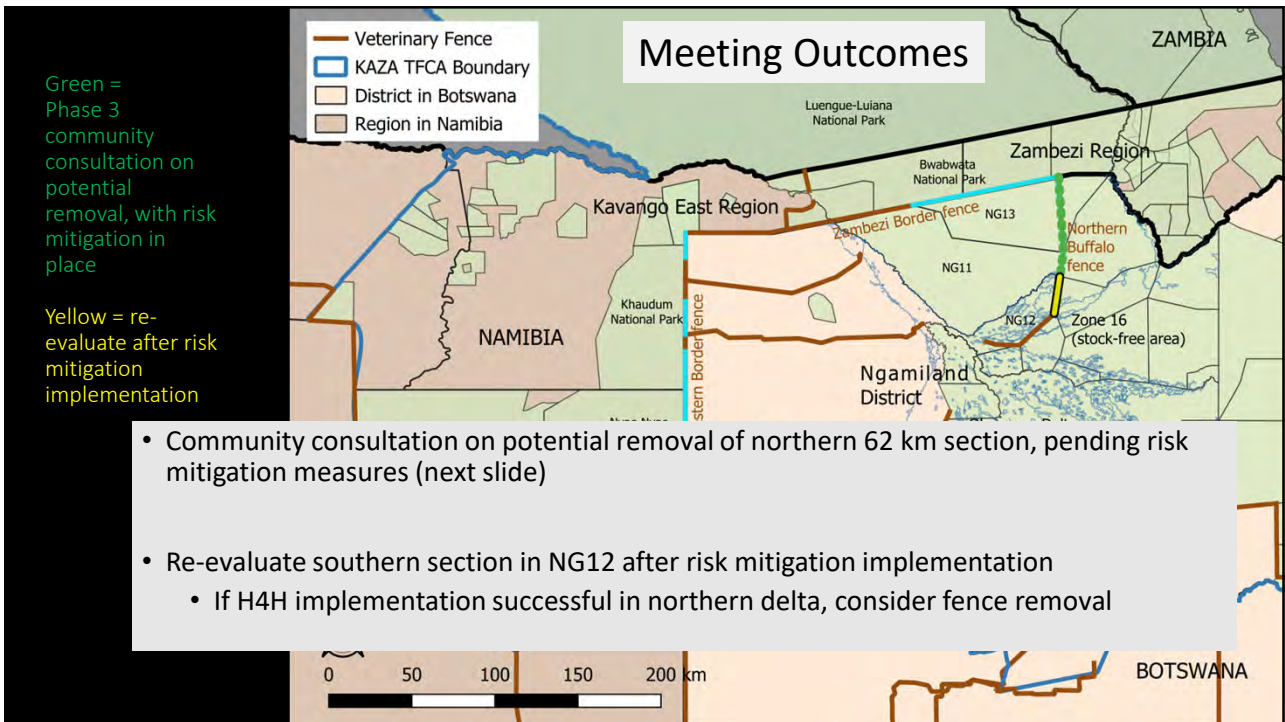


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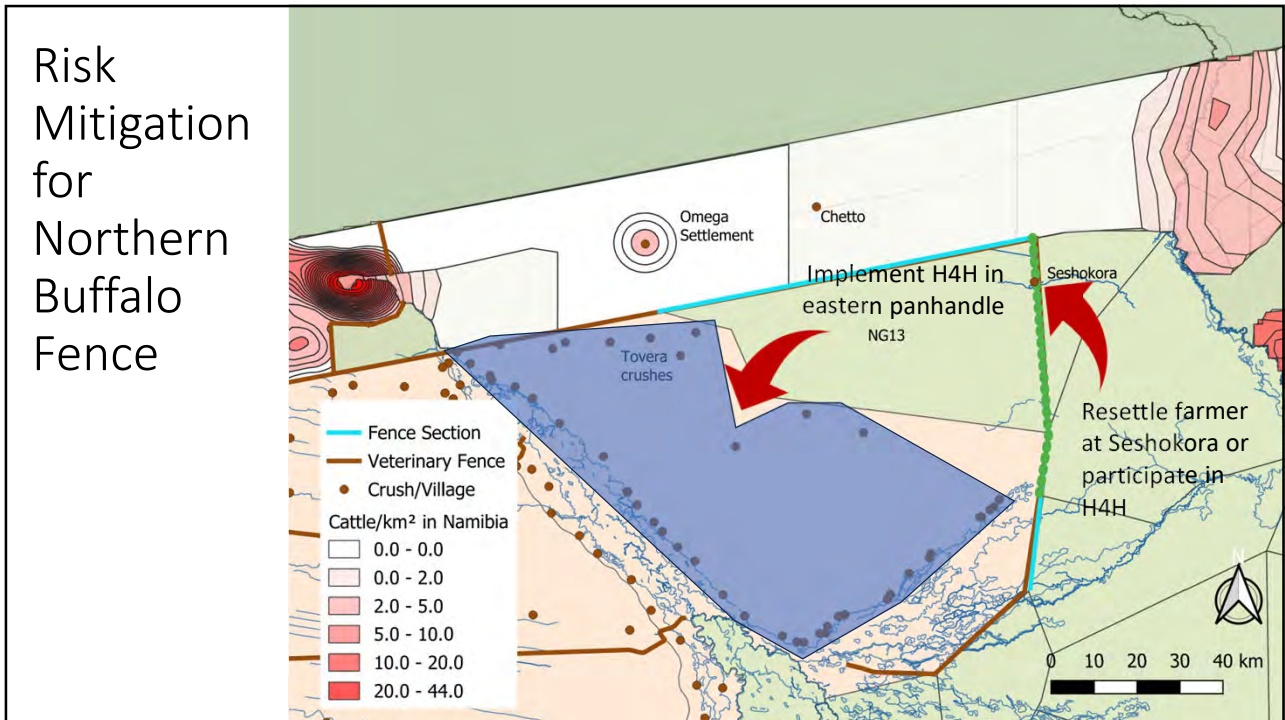


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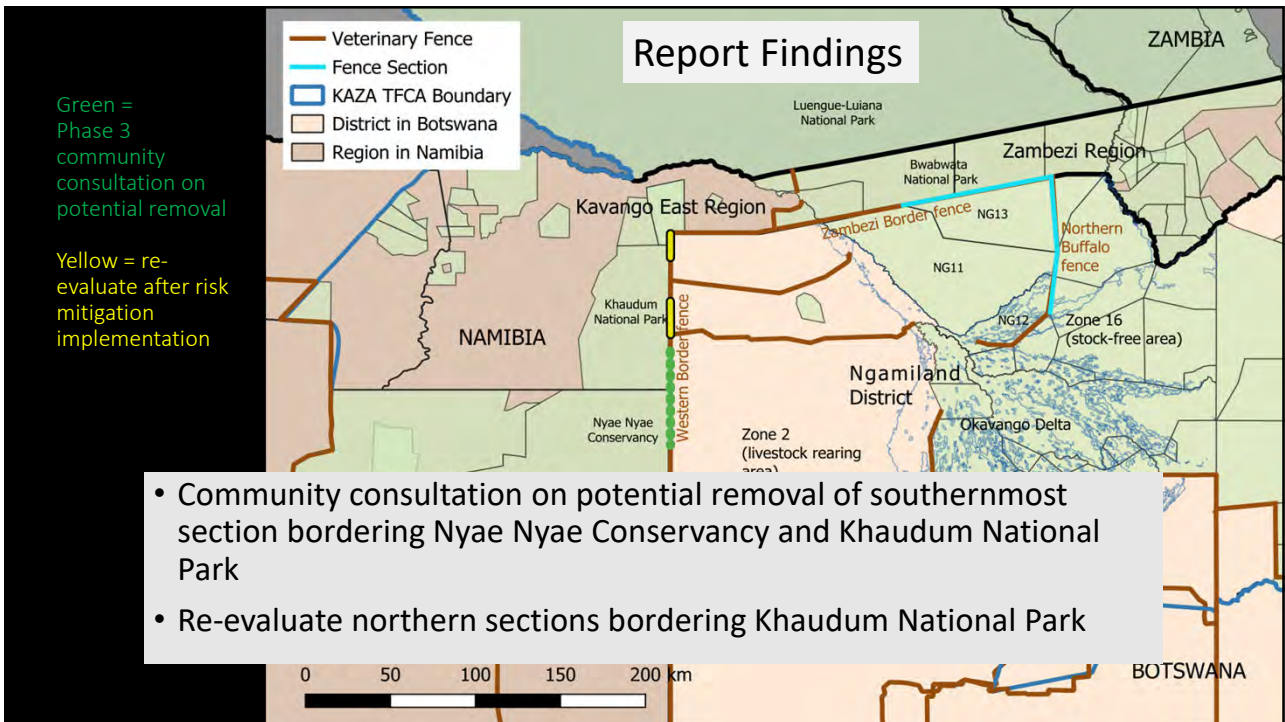




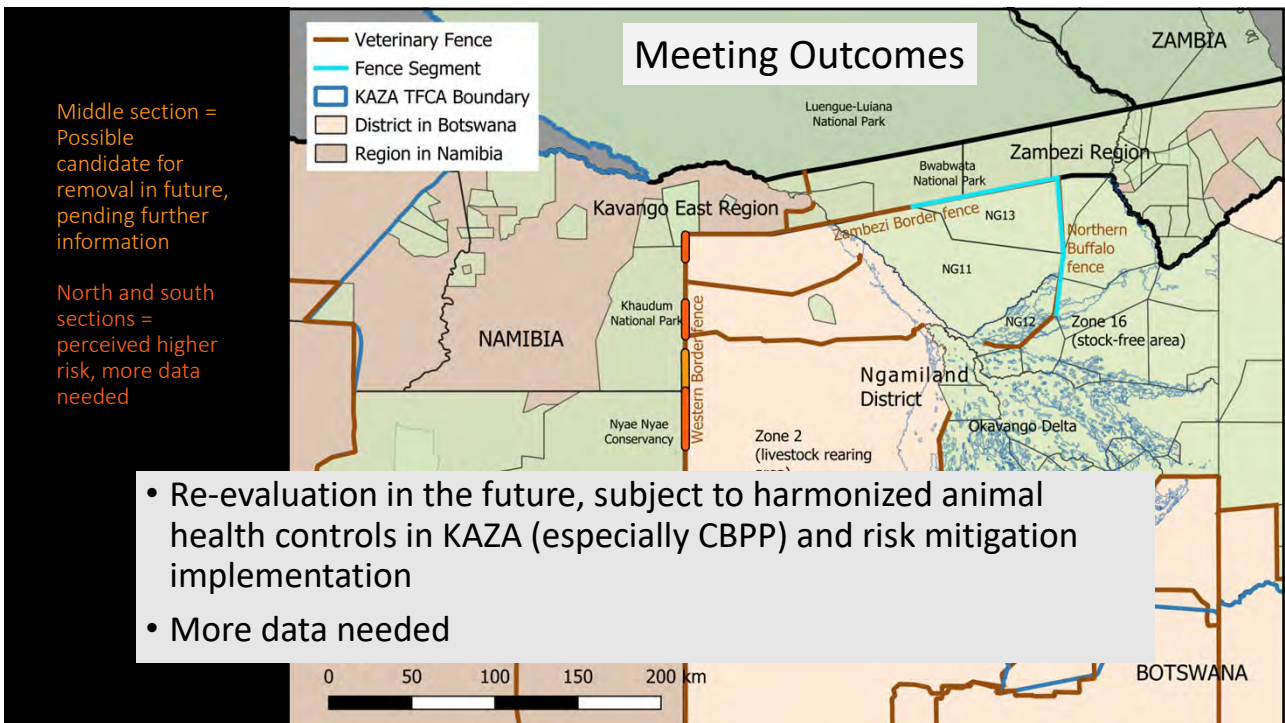
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## Meeting Outcomes

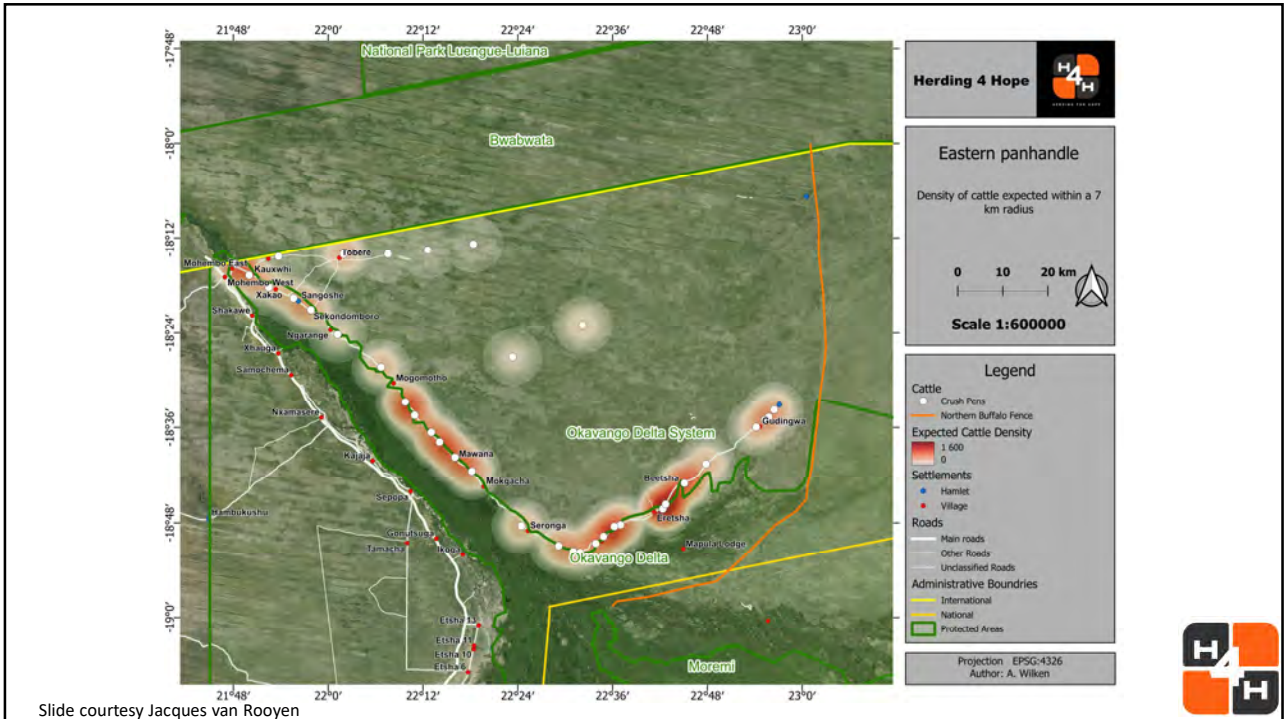
- Recommendations revised bilaterally
- Data gaps and technical corrections identified
- Important considerations for Phase 3 noted

165

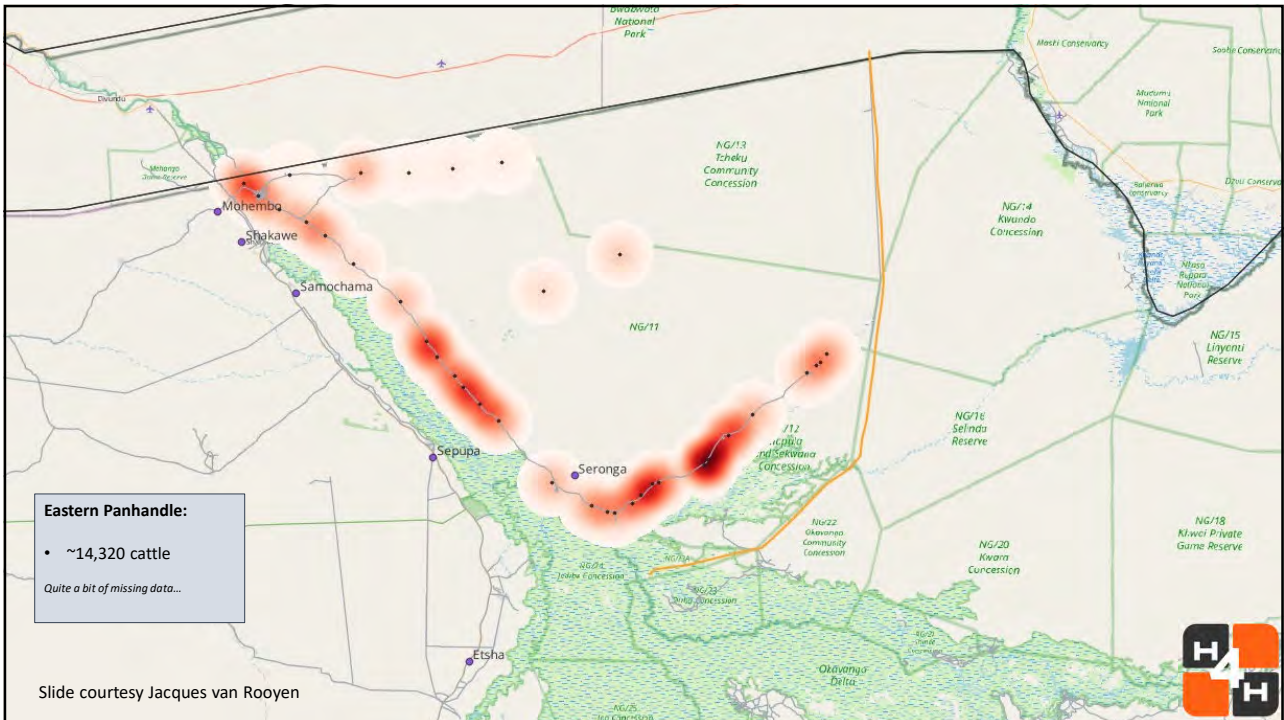
## H4H Implementation

What might H4H roll-out in the eastern panhandle look like?

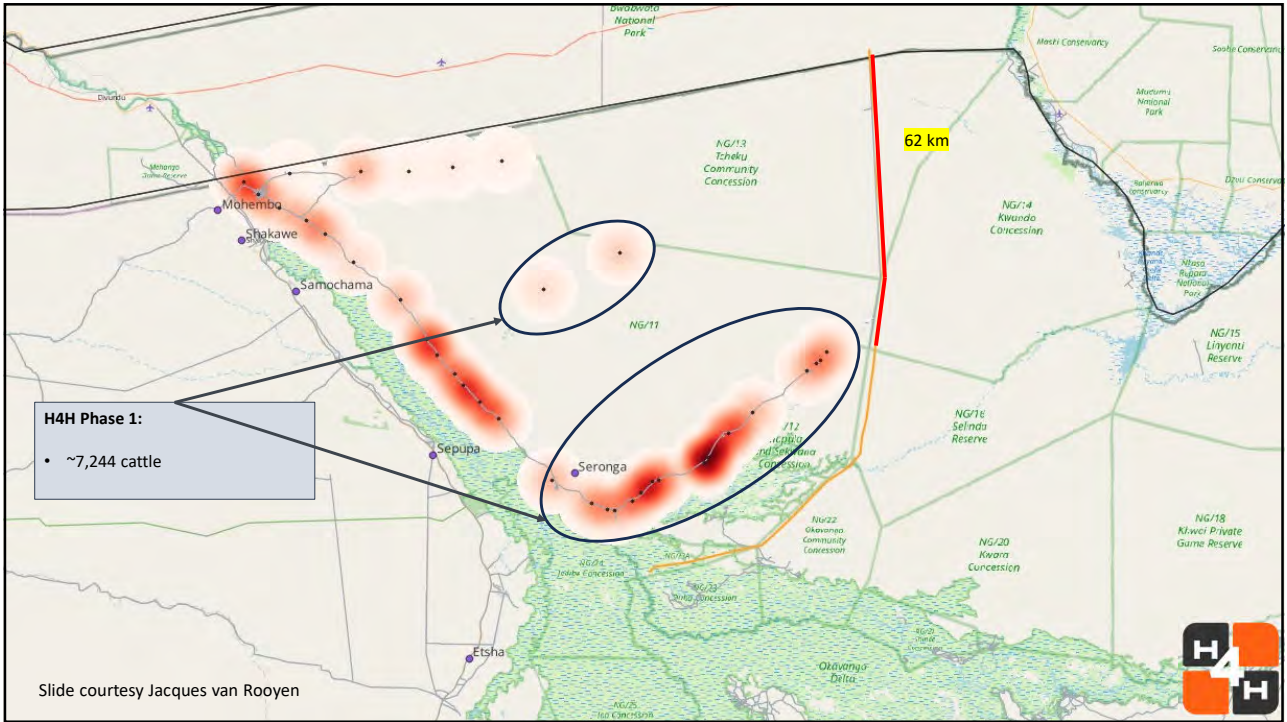
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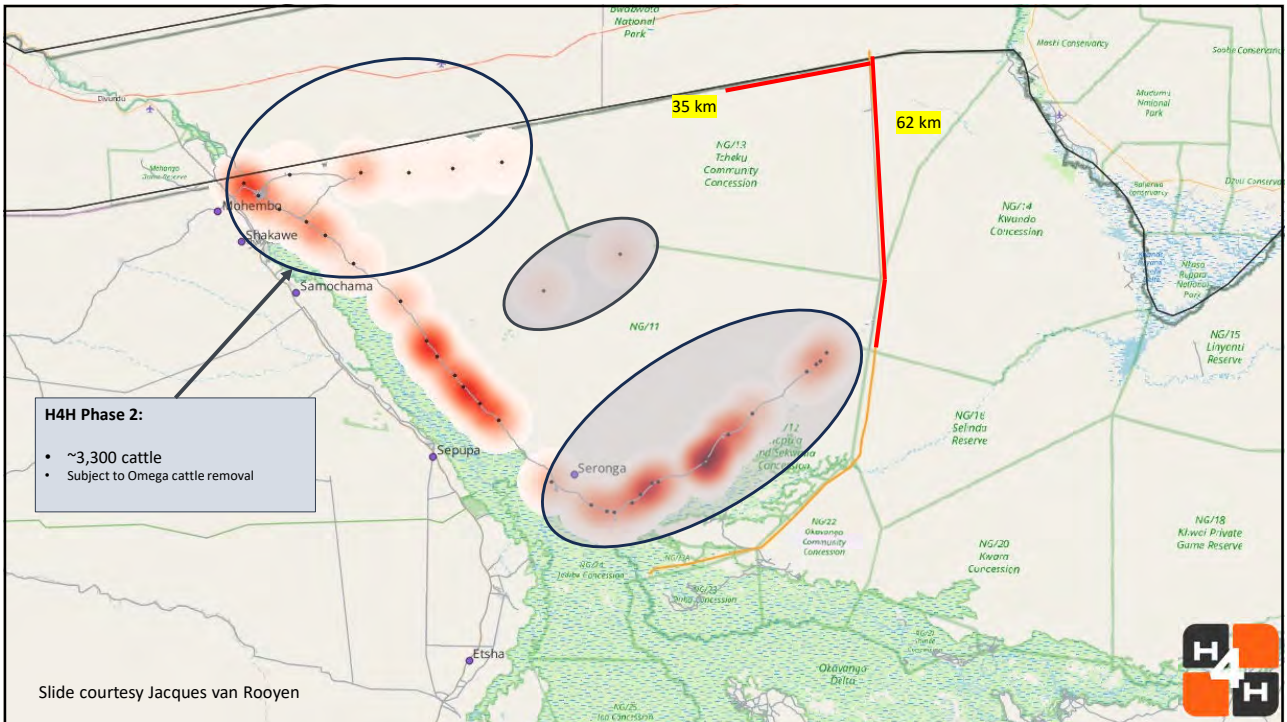
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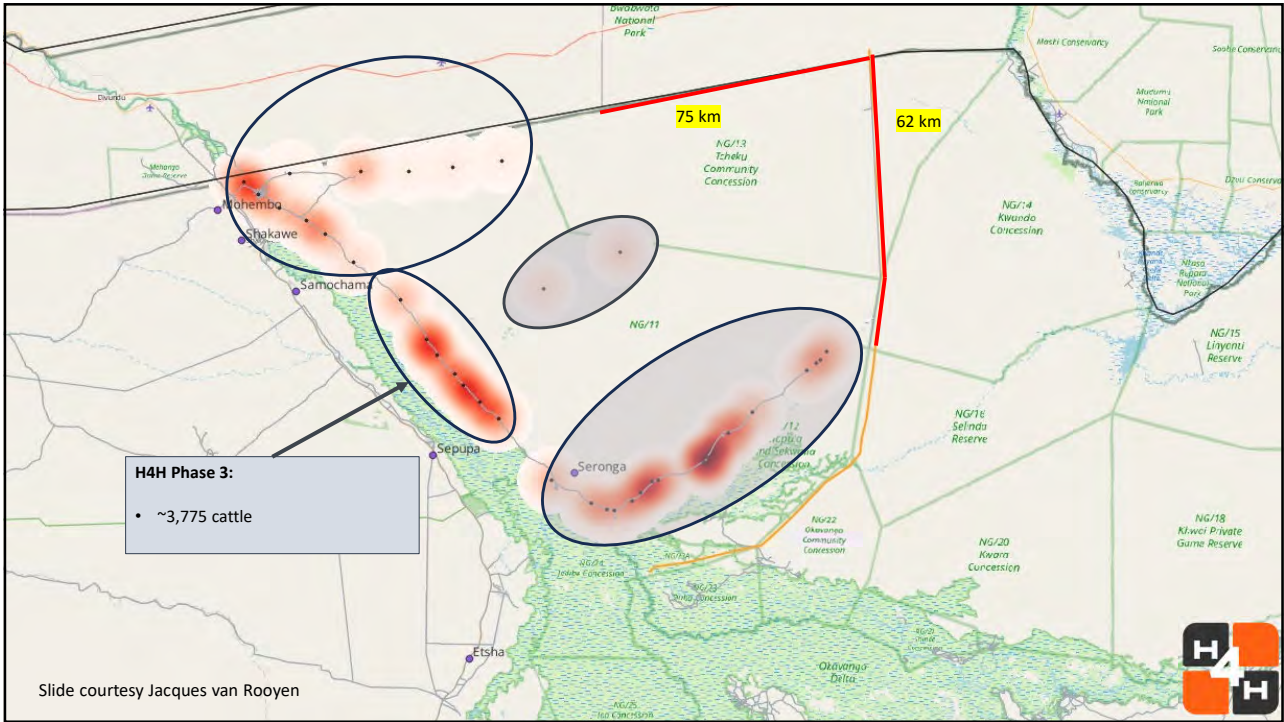
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