LEVERAGING CITIZEN SCIENCE IN MAPPING & MODELLING OF INVASIVE SPECIES IN NORTHERN KENYA RANGELANDS'

SERVIR Eastern & Southern AFRICA

USAID FROM THE AMERICAN PEOPLE

NASA

RCMRD

OVERVIEW OF THE STUDY

1. INTRODUCTION
2. MATERIALS AND METHODS
3. RESULTS & DISCUSSION
4. CONCLUSION & RECOMMENDATIONS

WHICH INVASIVE SPECIES?

SERVIR Eastern & Southern AFRICA

INTRODUCTION: PROBLEM STATEMENT

- Invasion of alien plant species into African savannas poses great threat to the native biodiversity and changes ecosystem functioning.

- Kenya has had several invasions of alien species that have had negative impacts on biodiversity, agriculture and human development. For instance, prickly pear (*Opuntia* spp) out-competes native plants.

- The Northern Kenya Rangelands in the recent decades has experienced increased infestation by various invasive plant species shrinking forage space available for both livestock and wildlife.

- Identifying areas of invasion hotspots is extremely useful in prioritizing and planning the conservation and management actions over landscapes.

RESEARCH OBJECTIVES : MAIN & SPECIFIC OBJECTIVES

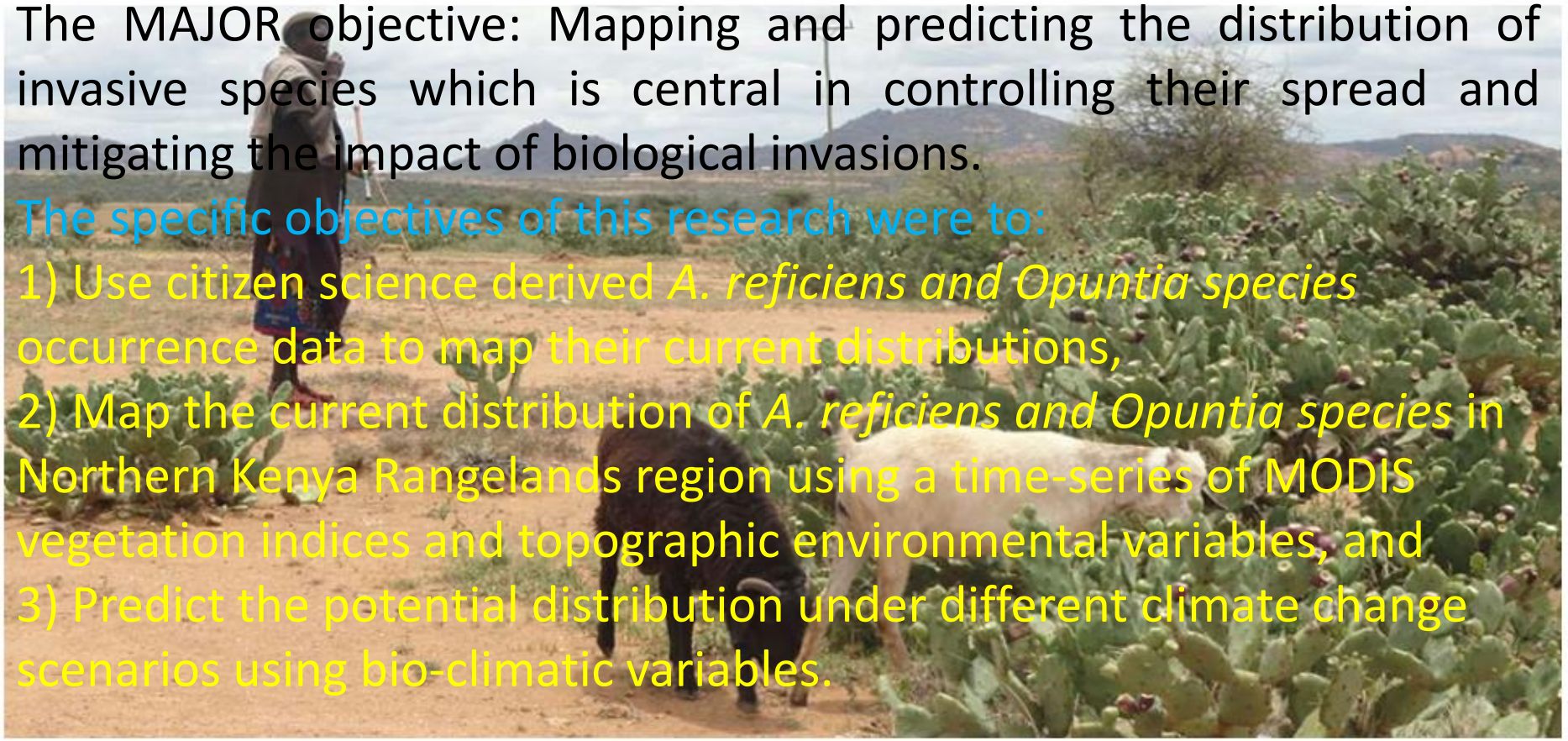
The MAJOR objective: Mapping and predicting the distribution of invasive species which is central in controlling their spread and mitigating the impact of biological invasions.

The specific objectives of this research were to:

1) Use citizen science derived *A. reficiens and Opuntia species* occurrence data to map their current distributions,

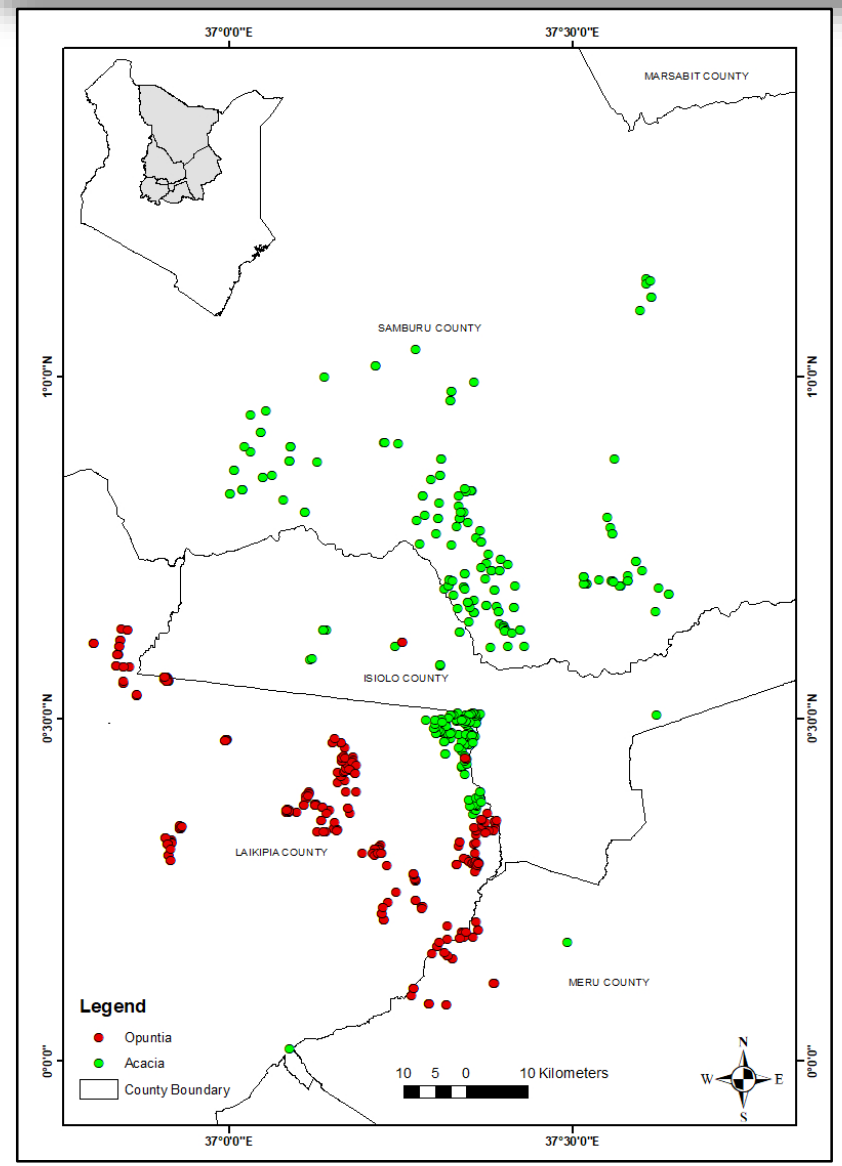
2) Map the current distribution of *A. reficiens and Opuntia species* in Northern Kenya Rangelands region using a time-series of MODIS vegetation indices and topographic environmental variables, and

3) Predict the potential distribution under different climate change scenarios using bio-climatic variables.



Animals feed on opuntia at Makurian. PHOTO | SARAH OOKO

MATERIALS AND METHODS : STUDY AREA



- The larger Laikipia-Samburu ecosystem is peculiar in Kenya, Consisting of different habitats and land use practices (Wittemyer et al. 2010).
- Laikipia is predominantly large-scale ranches with resident wildlife species.
- Samburu is a lower-elevation pastoralist grazing region composed of forested ranges (Omondi et al. 2002).
- The region is in a transition area for the three major vegetation types; semi-desert grassland, shrubland, and *Acacia*. The vegetation is mainly grassland, woodland, bushland and dry forest with scattered declining riparian forest.

MATERIALS AND METHODS : MODELING DATA & SOURCE

- Global Climate Data (WorldClim) (www.worldclim.com) ,
- NDVI & EVI - Land Processes Distributed Active Archive Center (LPDAAC),
- GIS Ancillary Data - World Resources Institute ,
- SOIL TYPES - Soil and Terrain Database for Kenya (KENSOTOR) ,
- Altitude - Shuttle Radar Topography Mission (SRTM – 30m) ,
- Population Density (Government of Kenya)
- Occurrence Data (Citizen Science data)

Acacia reficiens

MATERIALS AND METHODS: CITIZEN SCIENCE DATA

NEWS

Pastoralists go digital in rooting out plants harmful to livestock

FRIDAY, MAY 4, 2018 12:30

Wilfred ole Mejooli (right) takes photos of the invasive opuntia cactus with a fellow community member. PHOTO | SARAH

Involves training and engaging citizen scientists in data collection

- *Saves time*
- *Cuts down project costs*
- *Empower the local communities*

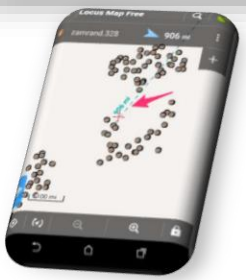
… connecting space to village …

USAID FROM THE AMERICAN PEOPLE

NASA

RCMRD

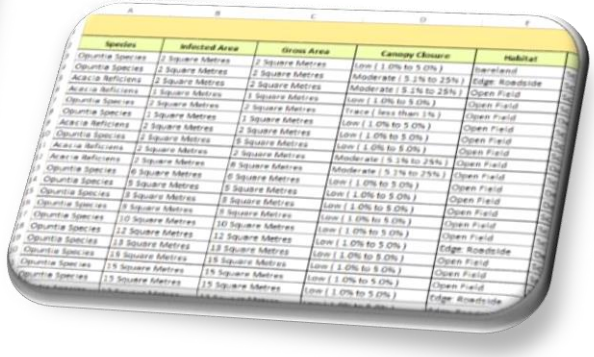
DATA COLLECTION PROTOCOL & TOOLS DEVELOPMENT



Random points loaded to locus map

18m radius circular plot

Invasive Species Mapper



Digital database

... connecting space to village ...

USAID FROM THE AMERICAN PEOPLE

NASA

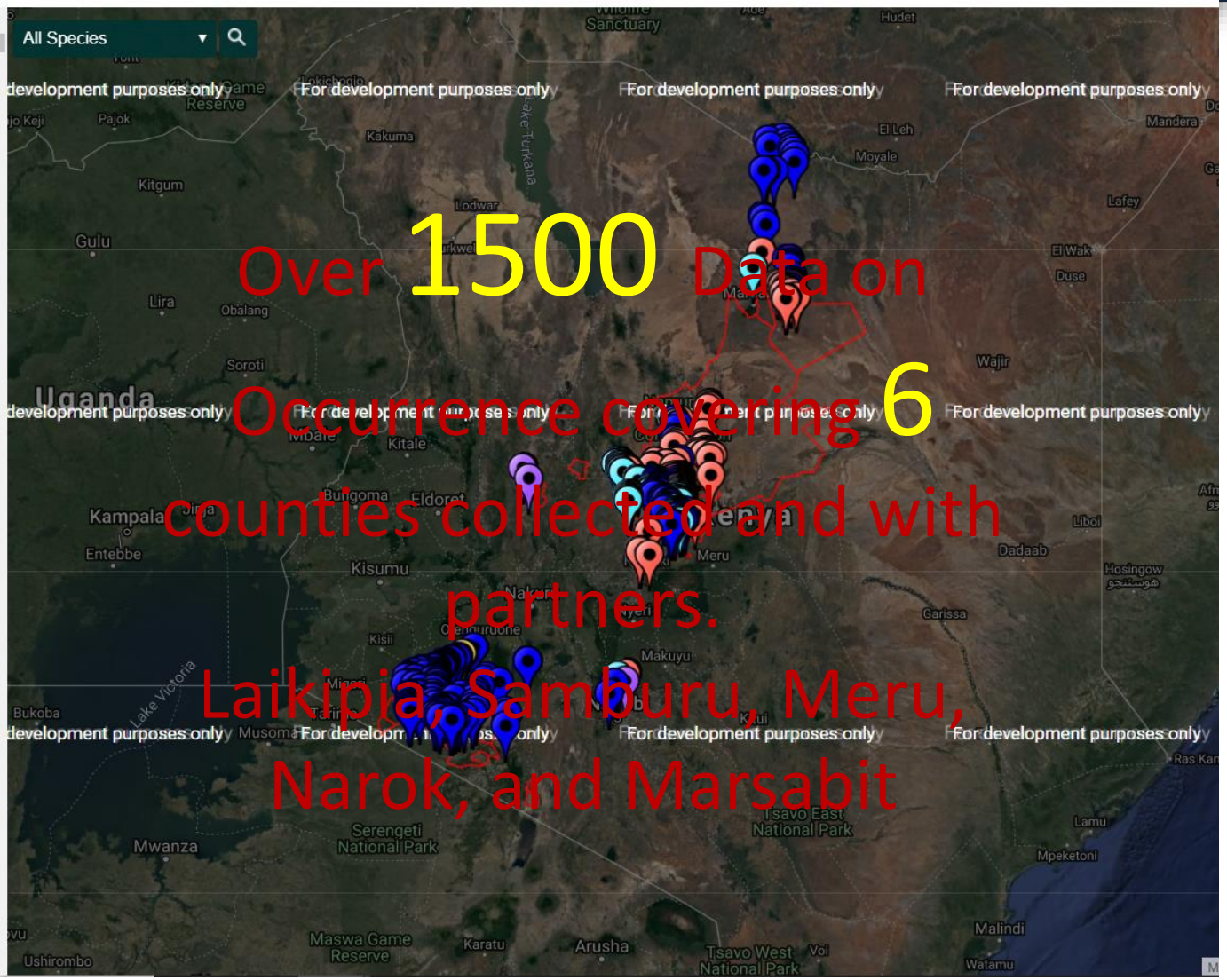
RCMRD

SERVIR Eastern & Southern AFRICA

INVASIVE SPECIES MAPPING VISUALIZATION TOOL

INVASIVE SPECIES DATA

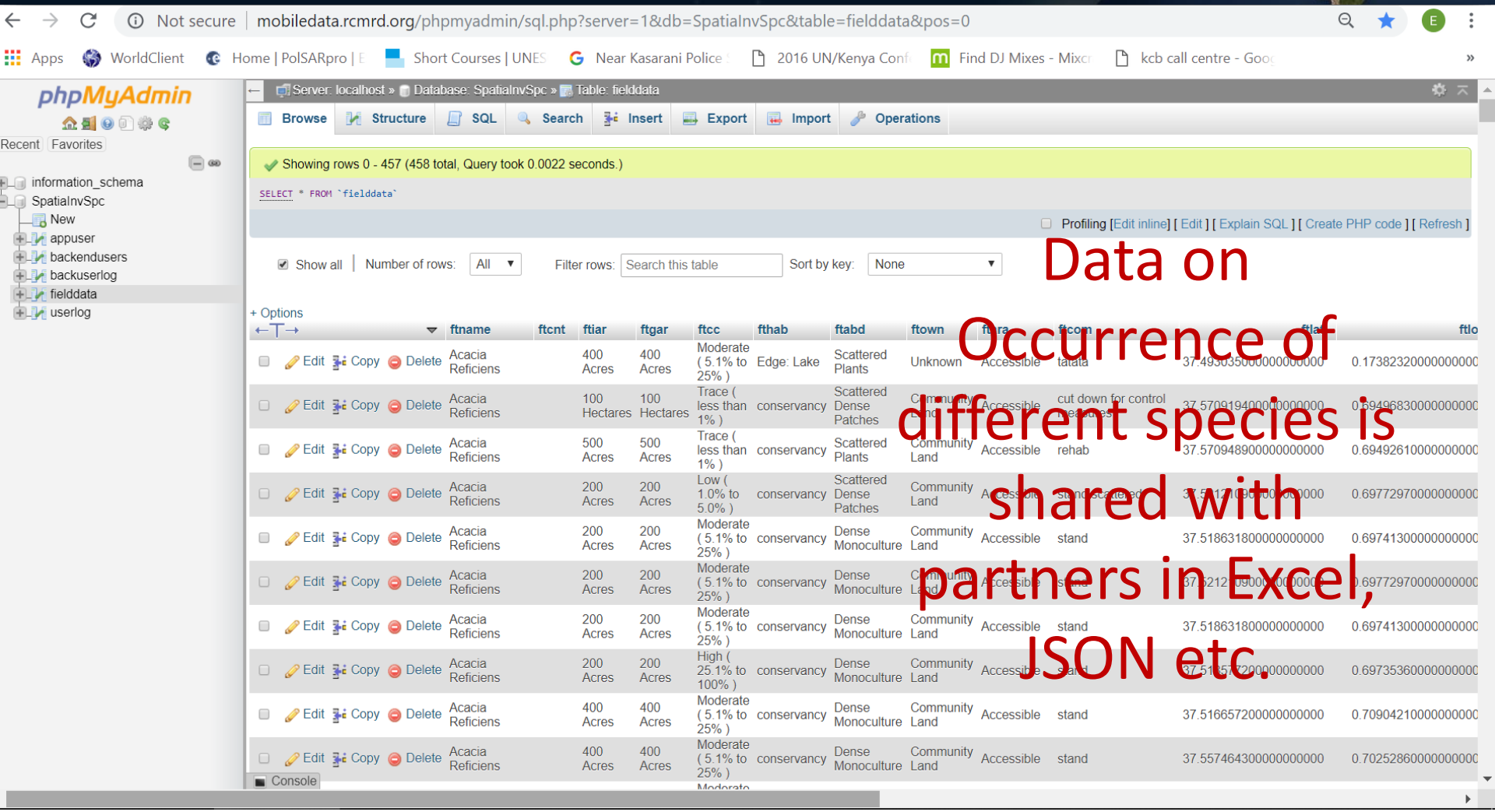
SPECIES	AGENT	LOCATE
Opuntia Species	kiloku	>>>
Opuntia Stricta	kiloku	>>>
Lake Kibale	ecosmart	>>>
Hema lake	ecosmart	>>>
Murders Lake	ecosmart	>>>
Sacha wetland	ecosmart	>>>
Akagera river	ecosmart	>>>
wetland	ecosmart	>>>
wetland with sugarcane	ecosmart	>>>
	ecosmart	>>>
wetland Rweru	ecosmart	>>>
Every wetland	ecosmart	>>>
	ecosmart	>>>
wetlands Nyabalongo	ecosmart	>>>
wetlands Nyabilongo	ecosmart	>>>
wetland	ecosmart	>>>
wetlands	ecosmart	>>>
wetlands	ecosmart	>>>
croped wetland	ecosmart	>>>



http://mobiledata.rcmrd.org/invspec/ *... connecting space to village ...*

USAID FROM THE AMERICAN PEOPLE NASA RCMRD

INVASIVE SPECIES OCCURRENCE ONLINE DATABASE



	ftname	ftcnt	ftiar	ftgar	ftcc	fthab	ftabd	ftown	ftpa	ftcom	ftla	ftlo
Edit Copy Delete	Acacia Reficiens		400 Acres	400 Acres	Moderate (5.1% to 25%)	Edge: Lake	Scattered Plants	Unknown	Accessible	tatata	37.49303500000000000	0.17382320000000000
Edit Copy Delete	Acacia Reficiens		100 Hectares	100 Hectares	Trace (less than 1%)	conservancy	Scattered Dense Patches	Community Land	Accessible	cut down for control measures	37.57091940000000000	0.69496830000000000
Edit Copy Delete	Acacia Reficiens		500 Acres	500 Acres	Trace (less than 1%)	conservancy	Scattered Plants	Community Land	Accessible	rehab	37.57094890000000000	0.69492610000000000
Edit Copy Delete	Acacia Reficiens		200 Acres	200 Acres	Low (1.0% to 5.0%)	conservancy	Scattered Dense Patches	Community Land	Accessible	stand scattered	37.51812090000000000	0.69772970000000000
Edit Copy Delete	Acacia Reficiens		200 Acres	200 Acres	Moderate (5.1% to 25%)	conservancy	Dense Monoculture	Community Land	Accessible	stand	37.51863180000000000	0.69741300000000000
Edit Copy Delete	Acacia Reficiens		200 Acres	200 Acres	Moderate (5.1% to 25%)	conservancy	Dense Monoculture	Community Land	Accessible	stand	37.52121090000000000	0.69772970000000000
Edit Copy Delete	Acacia Reficiens		200 Acres	200 Acres	Moderate (5.1% to 25%)	conservancy	Dense Monoculture	Community Land	Accessible	stand	37.51863180000000000	0.69741300000000000
Edit Copy Delete	Acacia Reficiens		200 Acres	200 Acres	High (25.1% to 100%)	conservancy	Dense Monoculture	Community Land	Accessible	stand	37.51657200000000000	0.69735360000000000
Edit Copy Delete	Acacia Reficiens		400 Acres	400 Acres	Moderate (5.1% to 25%)	conservancy	Dense Monoculture	Community Land	Accessible	stand	37.51665720000000000	0.70904210000000000
Edit Copy Delete	Acacia Reficiens		400 Acres	400 Acres	Moderate (5.1% to 25%)	conservancy	Dense Monoculture	Community Land	Accessible	stand	37.55746430000000000	0.70252860000000000

Data on Occurrence of different species is shared with partners in Excel, JSON etc.

http://mobiledata.rcmrd.org/phpmyadmin/tbl_export.php?db=SpatialnvSpc&table=fielddata&single_table=true

... connecting space to village ...

USAID FROM THE AMERICAN PEOPLE

NASA

RCMRD

METHODS : MAXENT MODELLING - MULTI-COLLINEARITY

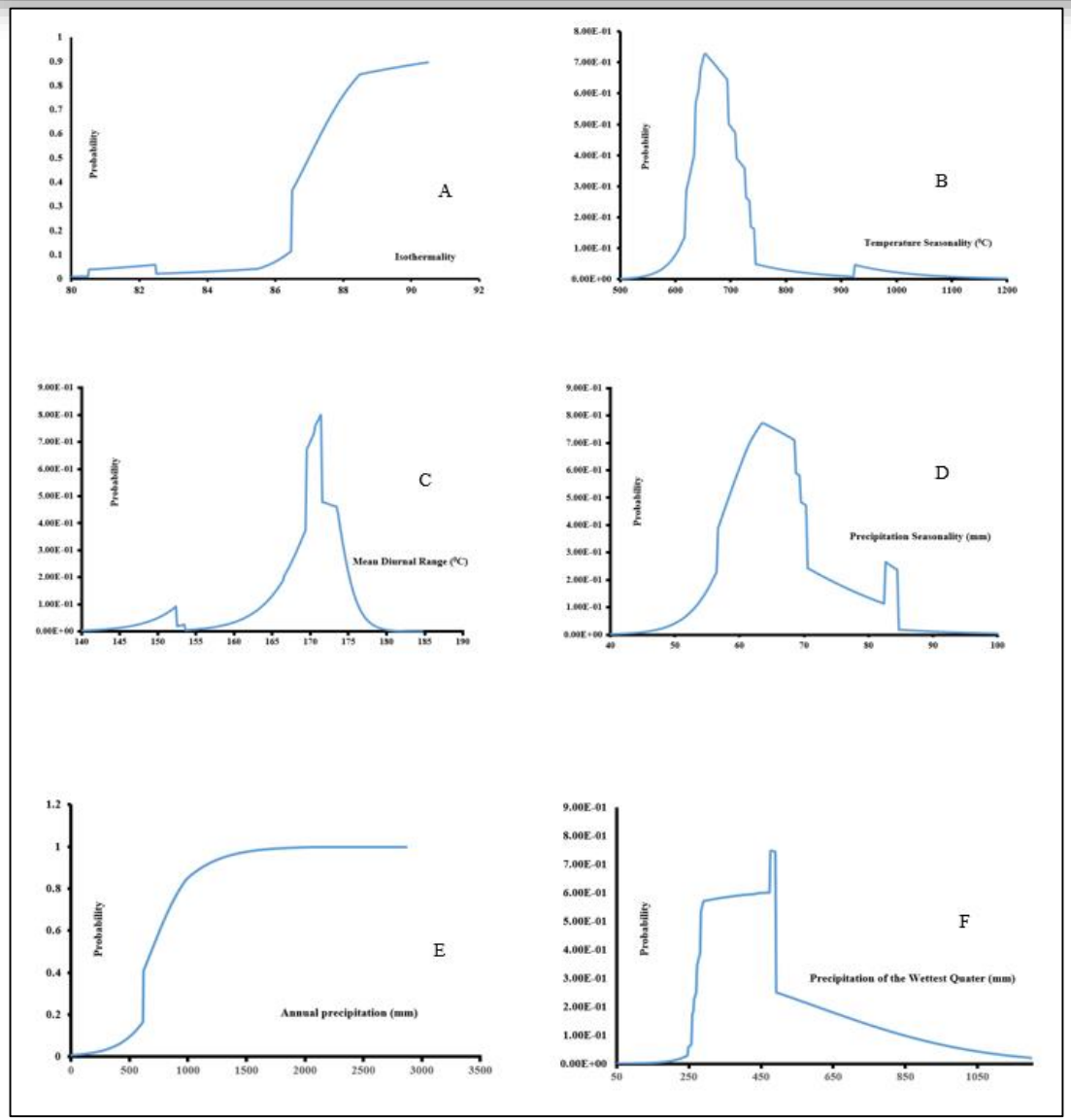
MaxEnt - Multi- collinearity and Variance Inflation Factor Tests

- Correlated variables → spatial bias → over-representation of the response variable
- Correlation > 5 or Correlation < -5 → VIF test
- Variance Inflation Factor (VIF) > 5 → not included
- The variables of less importance were removed systematically, leaving variables of percent importance resulting in an AUC > 0.8.
- A total of 362 *A. reficiens* and 338 *Opuntia* species geo-tagged presence observations were randomly
- The mean of 25 replicates was used in identifying suitable habitats.
- We evaluated the model performance using the average test AUC, mean testing omission rate metrics and mean regularized training gain.

MATERIALS AND METHODS : % CONTRIBUTION/PERMUTATION IMPORTANCE

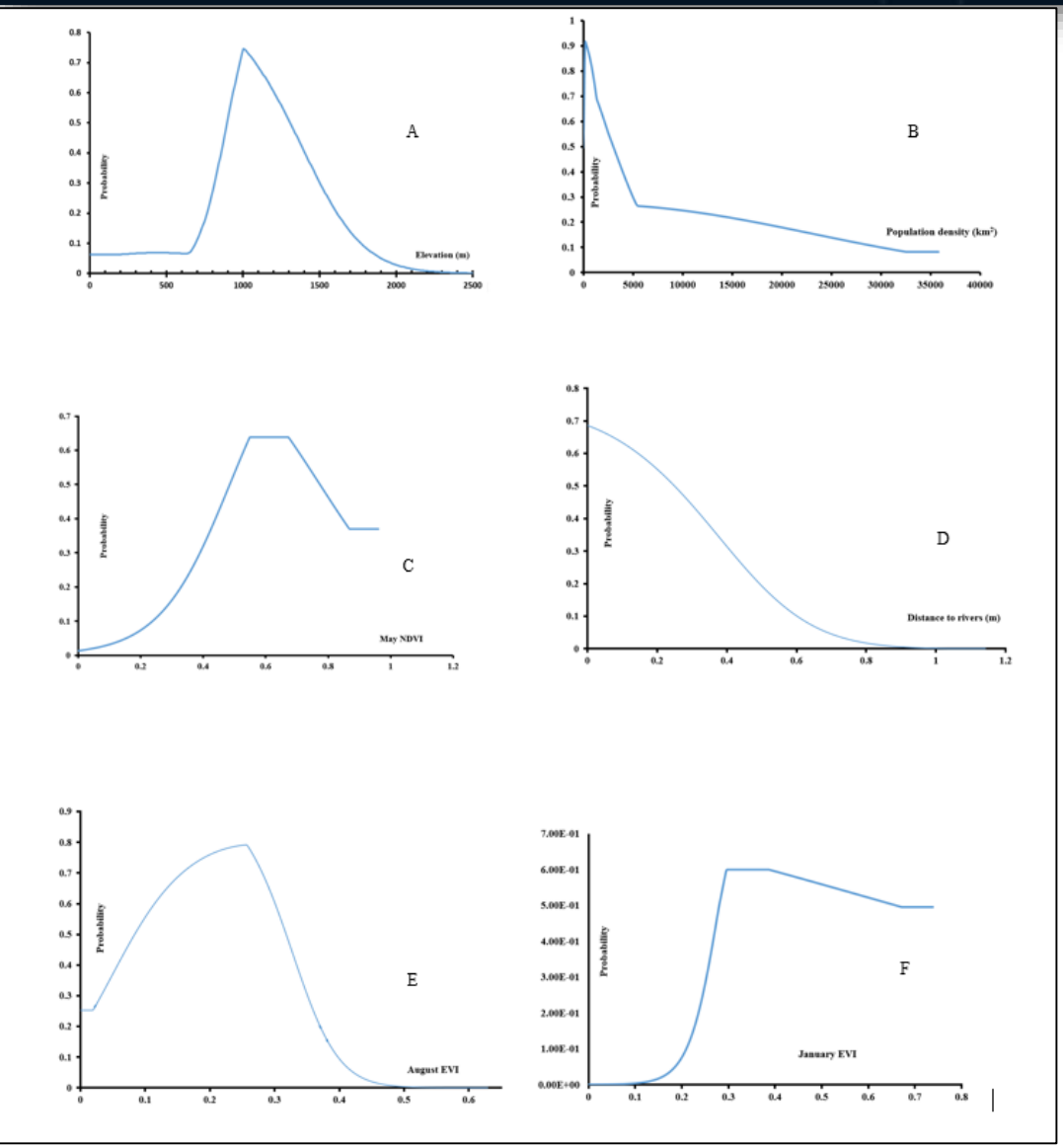
Acacia reficiens			*Opuntia species*		
Variable	*% contribution*	*Permutation importance*	*Variable*	*% contribution*	*Permutation importance*
Altitude	*48*	*60*	*Altitude*	*53*	*70*
Population density	*29*	*19*	*August EVI*	*19*	*8*
May NDVI	*11*	*9*	*January EVI*	*9*	*8*
Distance to rivers	*7*	*2*	*August NDVI*	*8*	*5*
August NDVI	*6*	*1*	*Population density*	*7*	*3*
Soil drainage	*3*	*4*	*May NDVI*	*4*	*5*
August EVI	*2*	*2*	*Soil drainage*	*0*	*1*
January EVI	*1*	*5*			
Climatic predictors					
Isothermality	*45*	*1*	*Isothermality*	*32*	*10*
Temperature Seasonality	*19*	*45*	*Precipitation Seasonality*	*22*	*48*
Mean Diurnal Range	*19*	*6*	*Annual Precipitation*	*14*	*29*
Precipitation of the Wettest Month	*7*	*4*	*Precipitation of the Wettest Quarter*	*10*	*5*
			Precipitation of Coldest Quarter	*8*	*1*

RESULTS: THE INPUT VARIABLES RESPONSE CURVES



Isothermality [A], Temperature seasonality (^{0}C) [B], Mean Diurnal Range (^{0}C) [C], Precipitation Seasonality (mm) [D] Annual precipitation (mm) [E],] and Precipitation of the Wettest Quarter (mm) [F].

RESULTS: THE INPUT VARIABLES RESPONSE CURVES

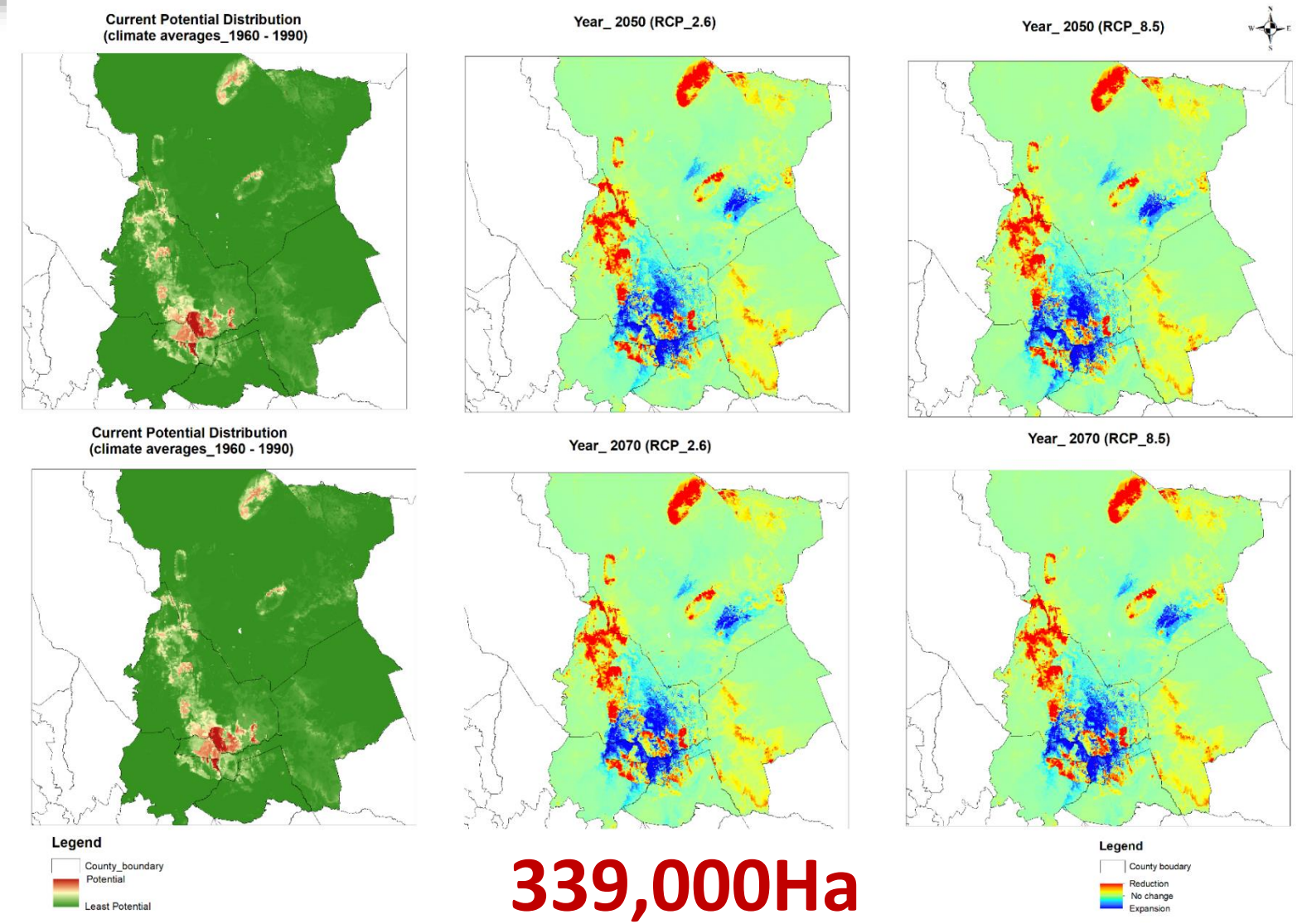


Elevation (m) [A], Population density (km^2) [B], May NDVI [C], Distance to rivers (km) [D], August EVI [D], and January EVI [D].

RESULTS: EVALUATION METRICS

- The models generated $p < 0.005$, hence performed better than random prediction.
- The high mean test AUC values (0.97 and 0.985 for *A. reficiens* and *Opuntia* species respectively)
- High discriminative ability to differentiate optimal conditions for invasive plant species from random pseudo-absence points.
- The models yielded moderate test gain values of 2.4 and 2.7, for *A. reficiens* and *Opuntia* species respectively .

RESULTS: MODELLING EXTENTS OF ACACIA – USING MAXENT



339,000Ha

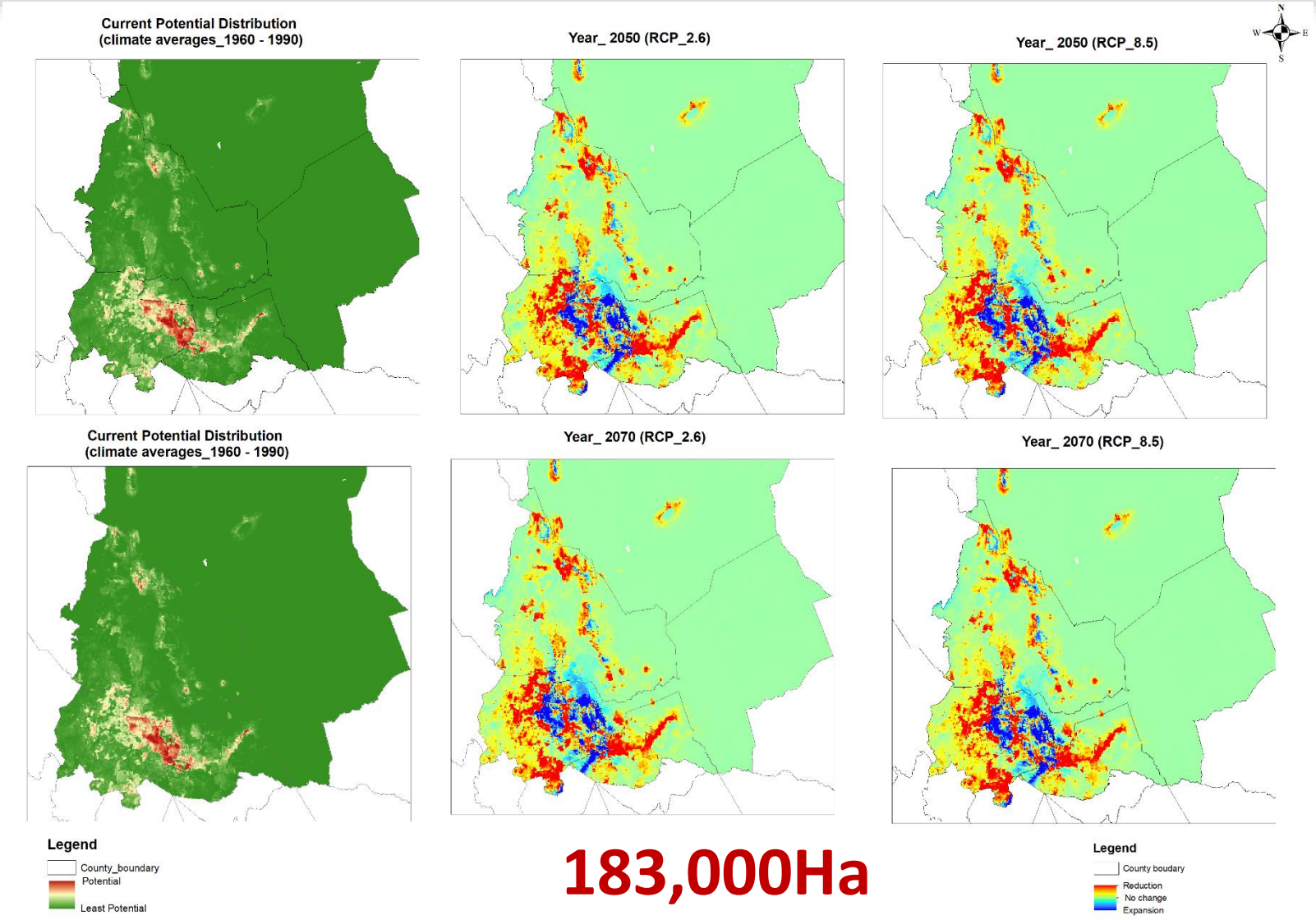
… connecting space to village …

USAID FROM THE AMERICAN PEOPLE

NASA

RCMRD

RESULTS: MODELLING EXTENTS OF OPUNTIA SPP – USING MAXENT



183,000Ha

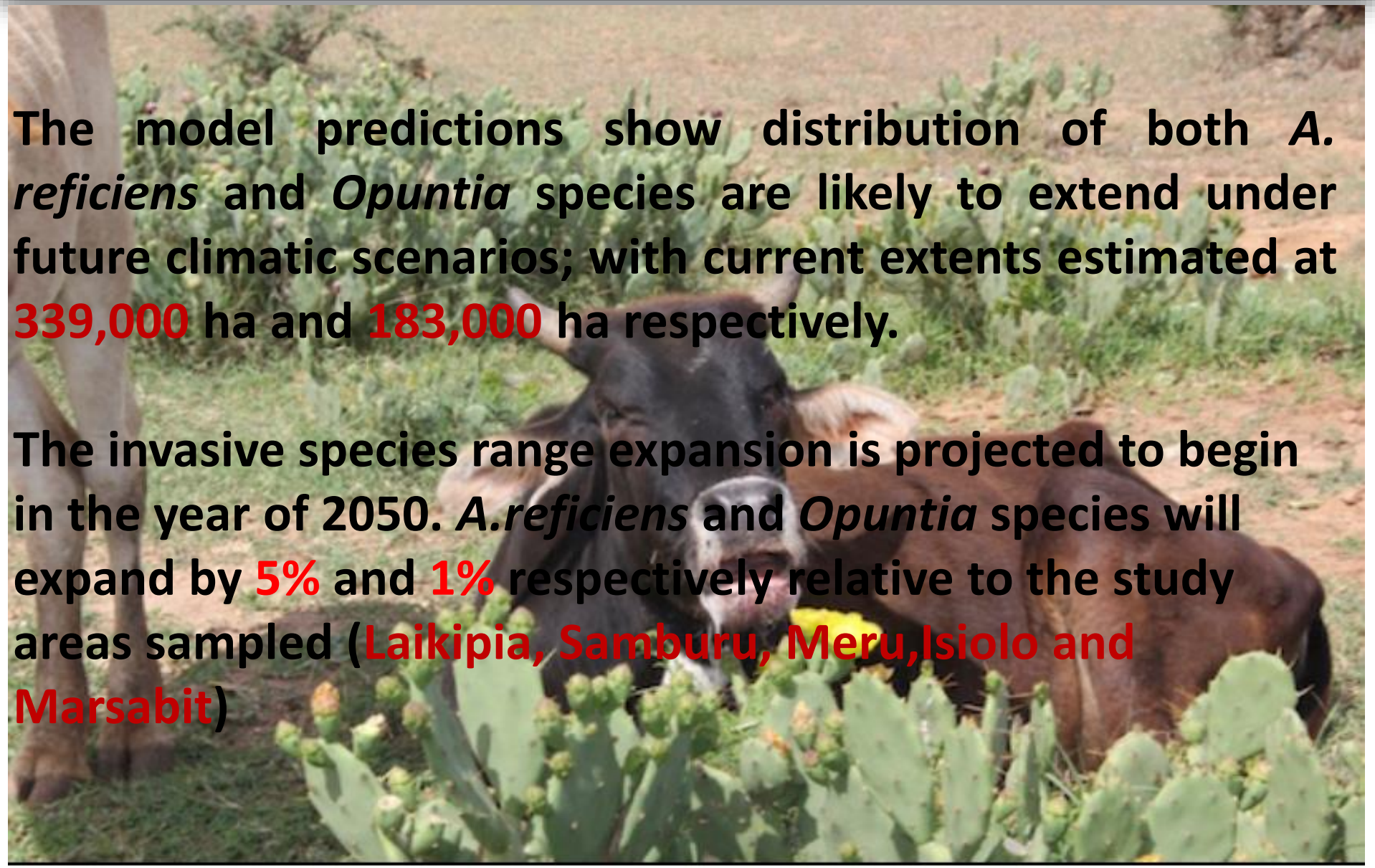
… connecting space to village …

USAID FROM THE AMERICAN PEOPLE

NASA

RCMRD

RESULTS: MODELLING EXTENTS OF ACACIA & OPUNTIA SPP – USING MAXENT



The model predictions show distribution of both *A. reficiens* and *Opuntia* species are likely to extend under future climatic scenarios; with current extents estimated at 339,000 ha and 183,000 ha respectively.

The invasive species range expansion is projected to begin in the year of 2050. *A.reficiens* and *Opuntia* species will expand by 5% and 1% respectively relative to the study areas sampled (Laikipia, Samburu, Meru,Isiolo and Marsabit)

CONCLUSION

- Our findings suggest that suitable habitats for *A. reficiens* and *Opuntia* species are throughout most parts of Laikipia Samburu regions.
- In this study, altitude, population density, distance to rivers, NDVI of May and August, EVI of January and August were important variables in identifying the current extends of the invasion.
- Minimal seasonal variations in temperature and rainfall were important predictors in projecting suitable areas of invasion in 2050 and 2070.
- The study revealed that topo-climatic variables combined with remotely-sensed data (vegetation indices) can be used with the invasive species occurrence data in a predictive model to quantify the current and potential extents of *A. reficiens* and *Opuntia* species.

RECOMMENDATIONS

- The method used is easy and transferable to areas with similar challenges of invasive species.
- Regional governments can use the modelled maps and the distribution data to help conservationists and decision makers in the formulation of policies to assist in managing and monitoring the ecosystems.

Thank You