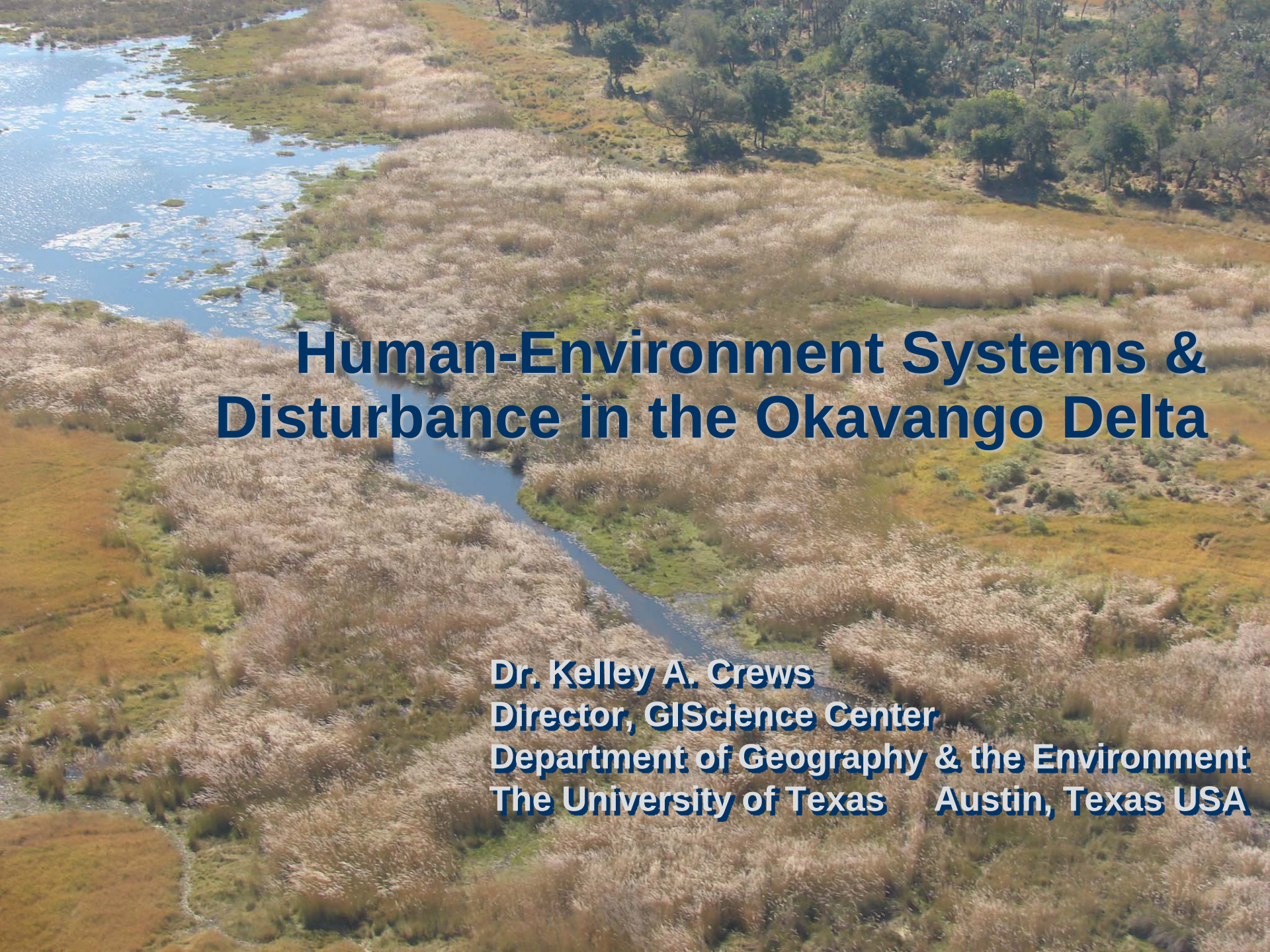

Human-Environment Systems & Disturbance in the Okavango Delta

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Director, GIScience Center
Department of Geography & the Environment
The University of Texas Austin, Texas USA

Context & Caveats

- Geography as **ground**ed **inter**disciplinarity
- Relatively new project underscores multi-scale heterogeneity
- Human-environment interactions
  - LULCC, disturbance ecology
  - Livelihood systems & vulnerability
  - Forecasting HIV/AIDS landscapes
- Comparative framework and benefits of geographically diverse network(s)

“Disturbance”

- Deviation from the norm
- Influence ecosystem structure and function through competition and resource availability
- Influence livelihoods through changing the context of adaptation
- Key [ecological] structuring process at mid-scales… positive influence

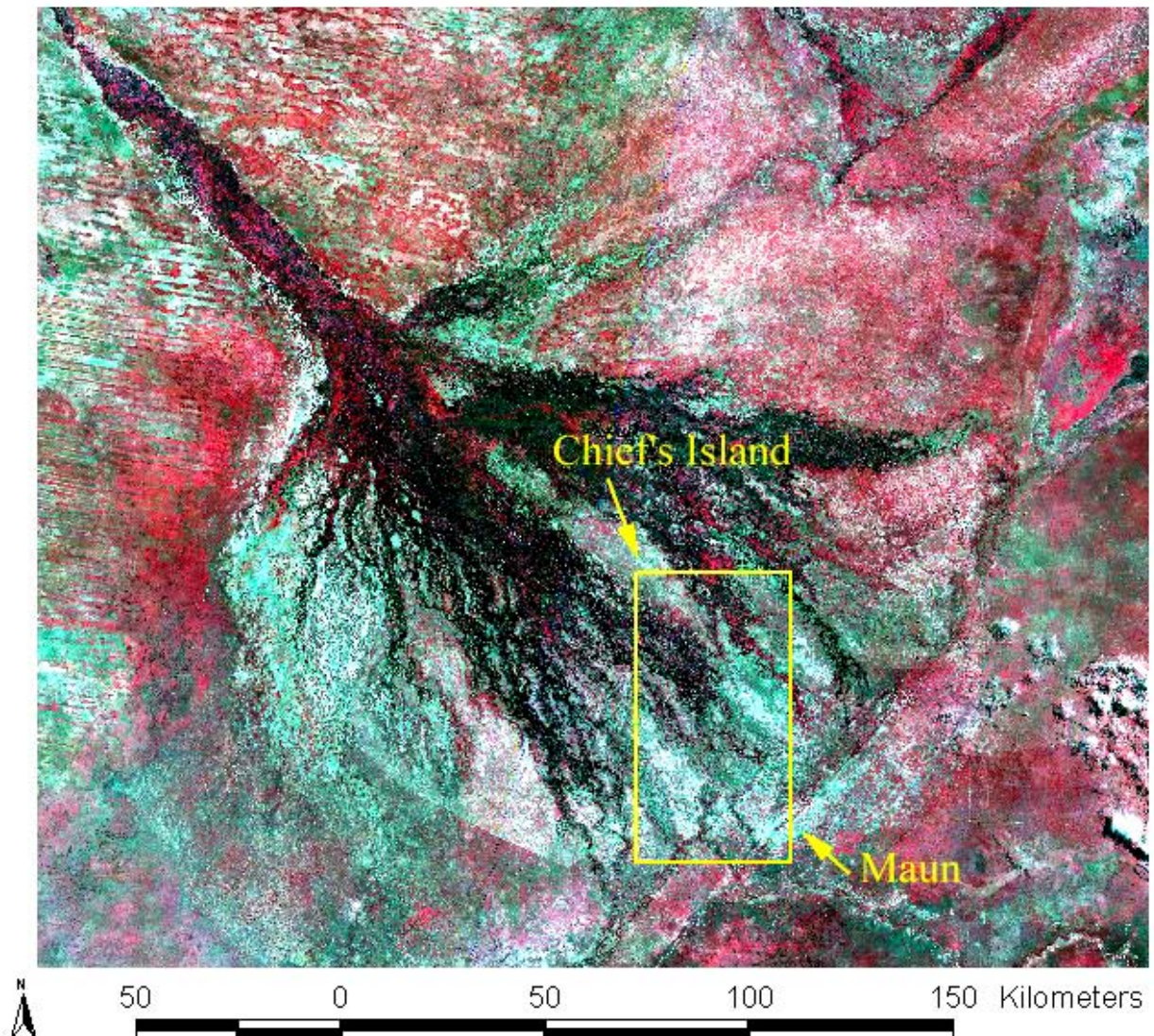
Okavango Delta, Botswana

Internationally recognized as Ramsar Wetland of Importance *(Botswana became contracting partner in 1997)*

Delta plays ecological, hydrological, biological role in region

Wetland extent is 8,000 – 15,000 km2

Seasonal landscape and cloud conditions



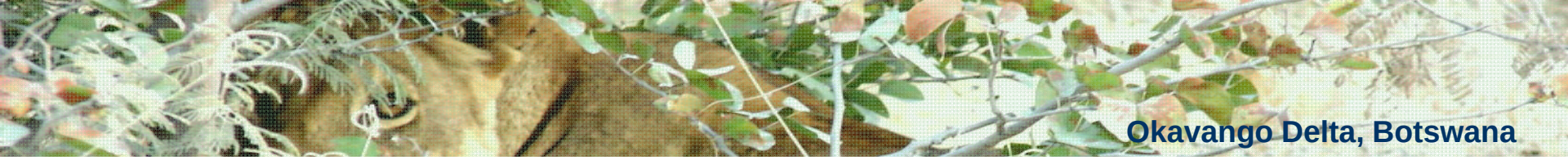
Characterization of flooding & fire

- Convenience of existing collaborative datasets
- Ecological time series
  - Permanent signals (trend, cycle, structured residual)
  - Transitory signals (disturbance)
- Relation to livelihood systems, management plans, and climatic cycles

Seasonally Inundated Floodplains

Photo from Aquarap 2000 survey

(advancing flood front)
Photo by Susan Ringrose



Remotely Sensed Imagery

- Multi-temporal, multi-spectral database
  - Landsat 5 Thematic Mapper (**70** scenes, 1989 – 2000) *
  - Landsat 7 Enhanced TM+ (**17** scenes, 1999 – 2003) **
  - EO-1 Advanced Land Imager (**26** scenes, 2001 – 2003) ***
  - 1.5 years of data geo-rectification and pre-processing to establish database
  - 30 m spatial resolution, ~2 - 3 month temporal resolution
- Ancillary data
  - GIS layers and shapefiles ****
  - MODIS products (daily acquisitions, 1 km spatial, 2001 - today)
  - IKONOS (2 scenes, 2000, 4/1 m spatial) **
  - SRTM Digital Elevation Model

Data Provided by:

* Techniche Universitaet Muenchen

** NASA Safari 2000 Mission

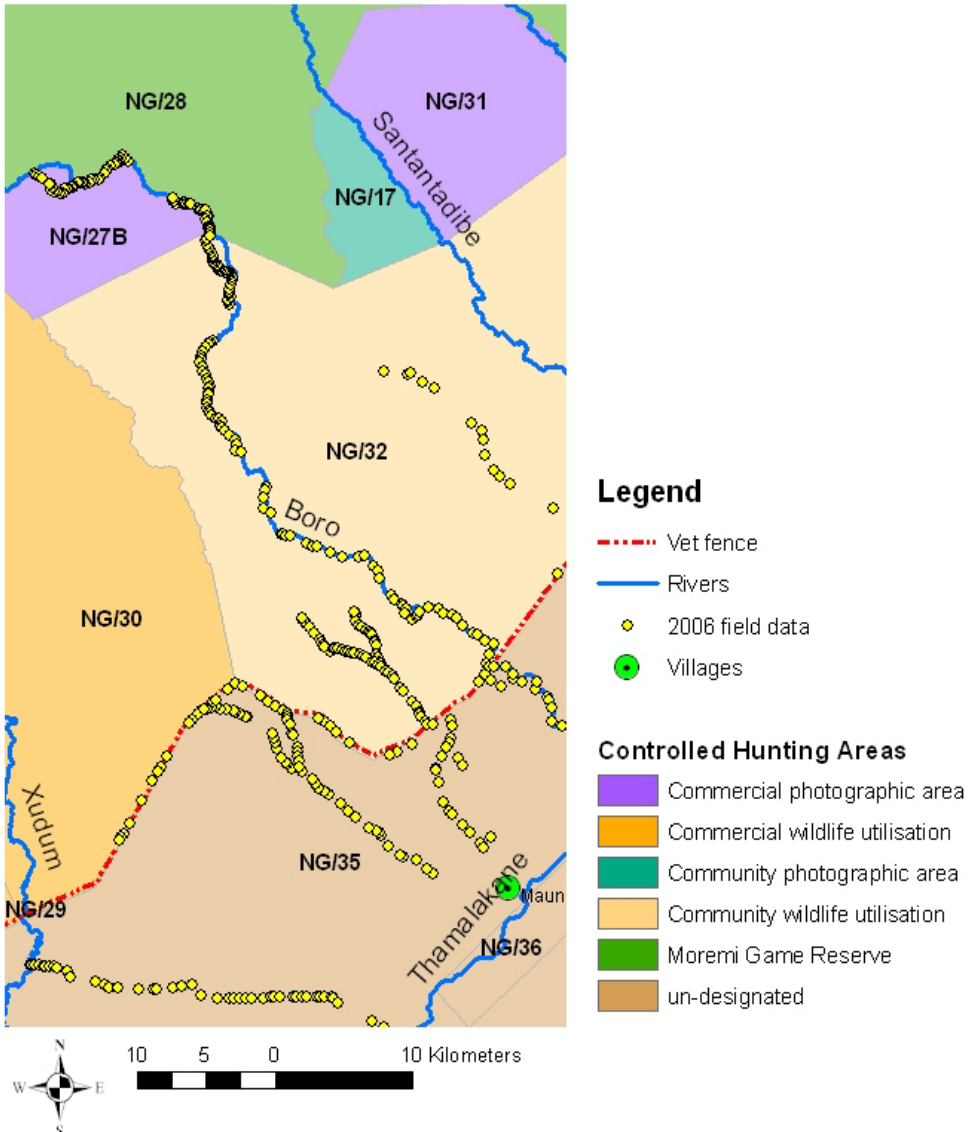
*** NASA EO-1 Scientific Calibration/Validation Mission

**** HOORC

Field Work

Observed vegetation patterns on landscape

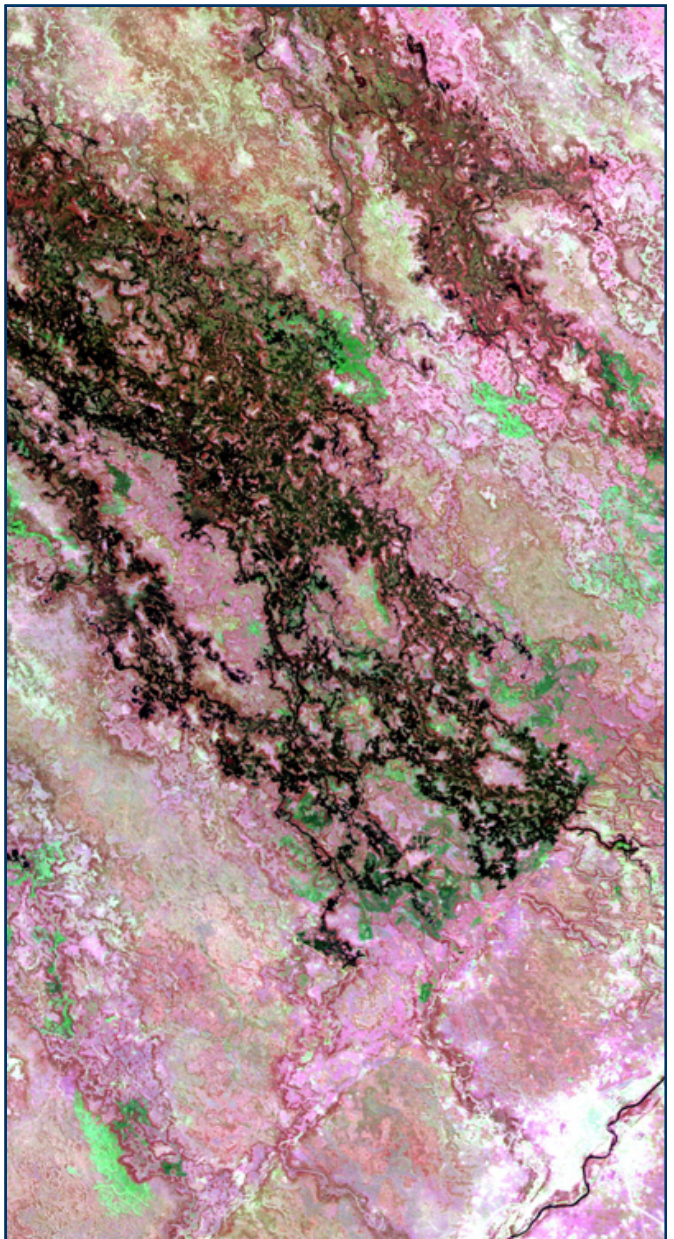
Assessment of trends in data with corresponding vegetation



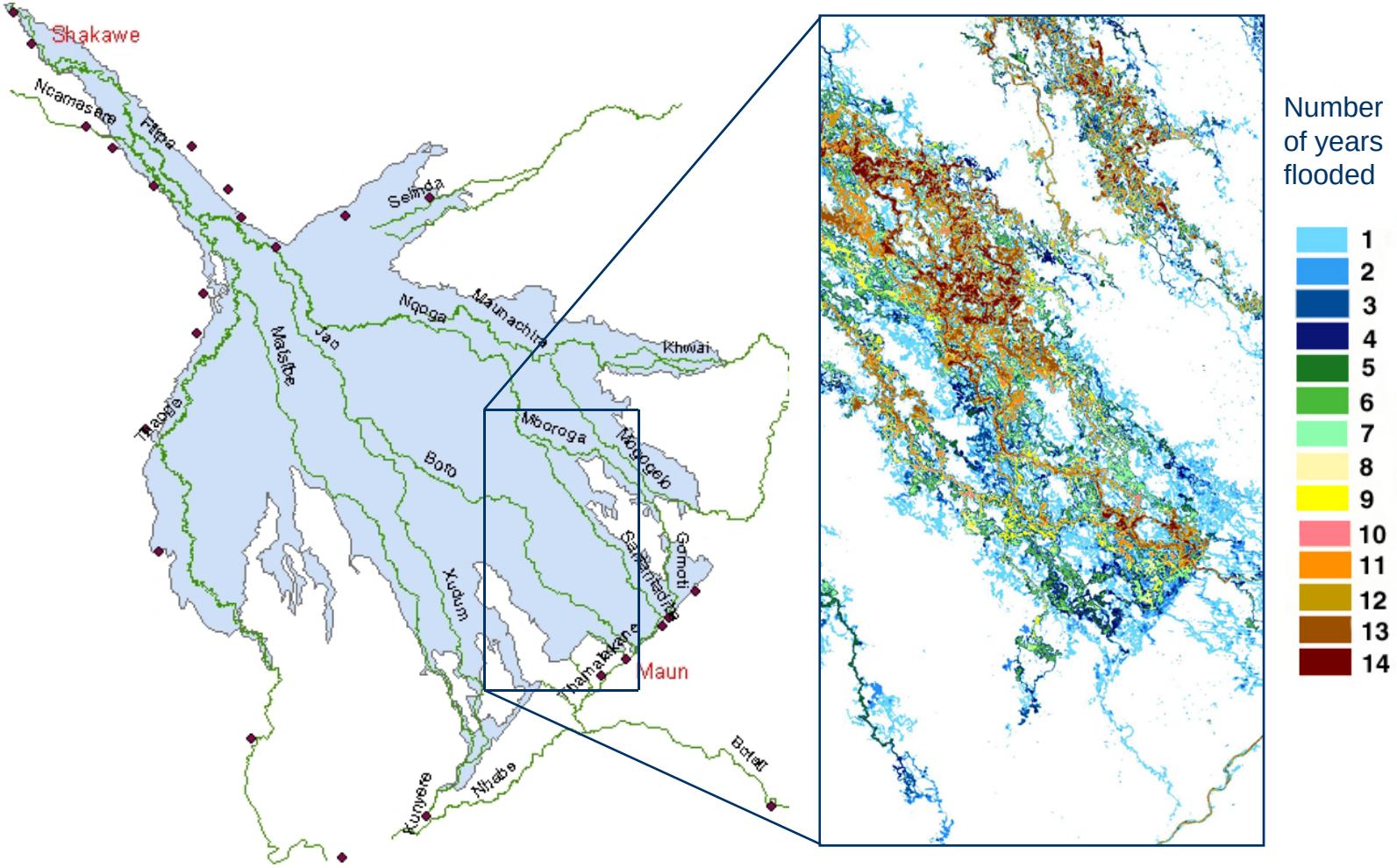
Extract Flood/Fire

Flood and Fire distribution extracted using unsupervised classification

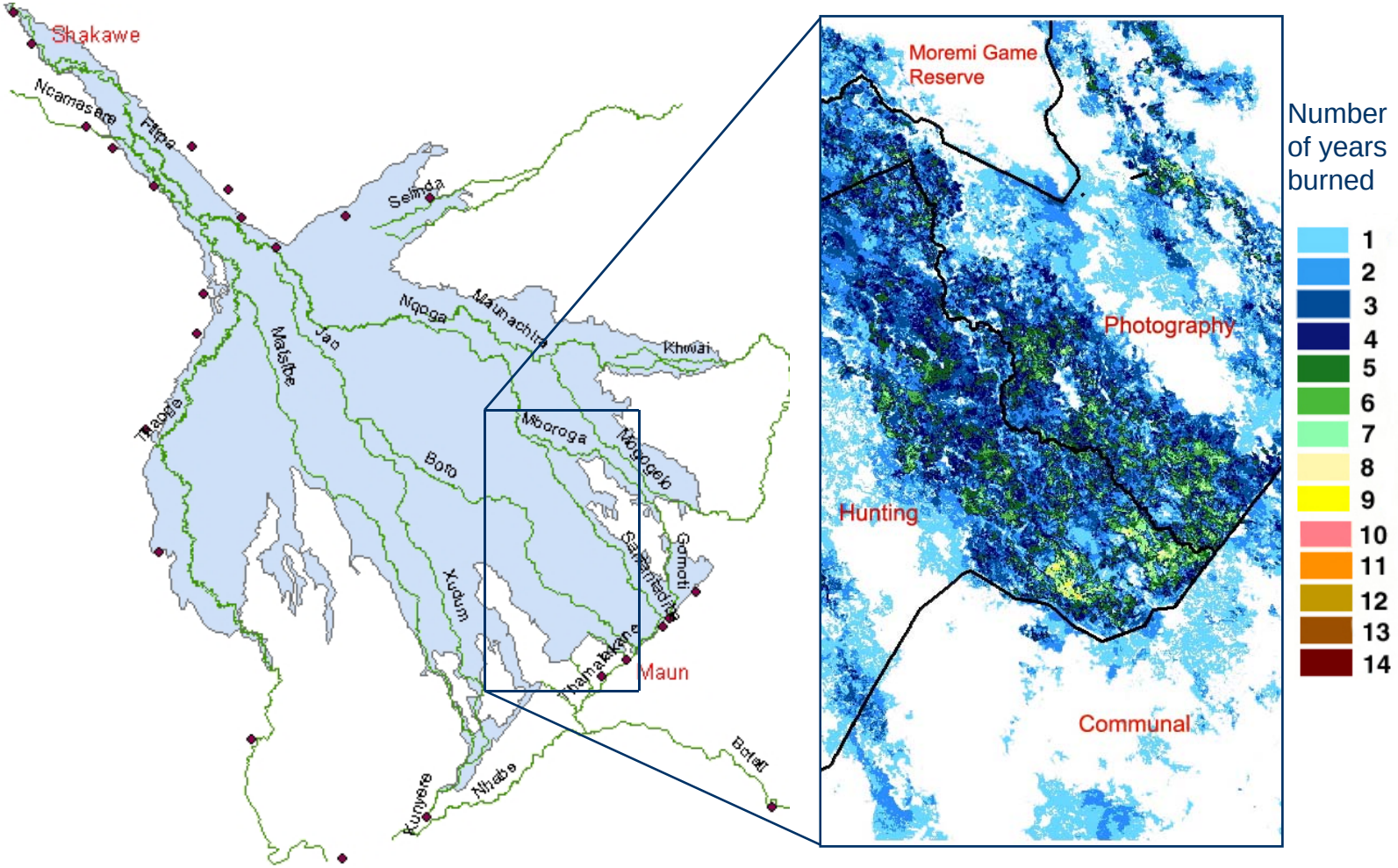
1991 June 24 subset of study area.
Bands 4, 7, 2 shown

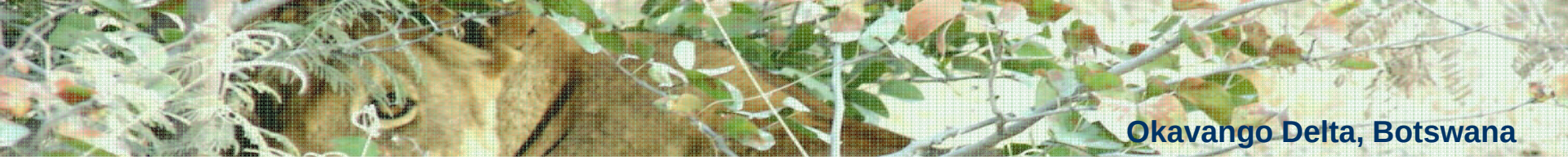


14-year Flooding History (1989 – 2002)

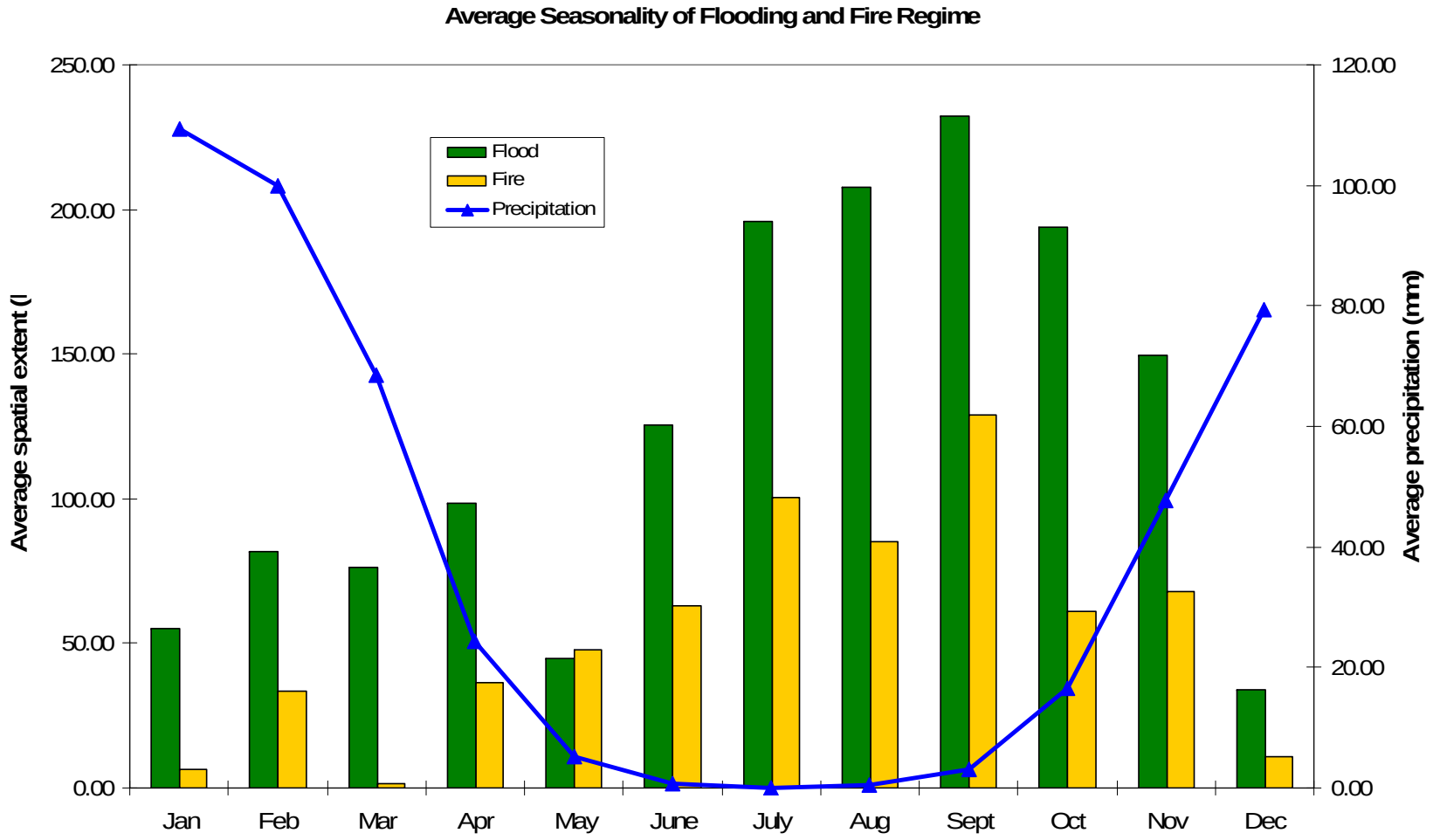


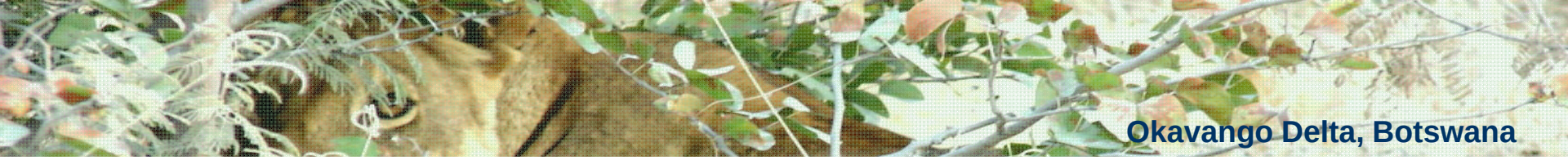
14-year Burning History (1989 – 2002)





Seasonality of Regimes





Processing Steps

Radiometric/Atmospheric Correction

Compared both TOA and apparent surface reflectance

Compute Enhanced Vegetation Index (EVI)

EVI is used as a surrogate for vegetation vigor

Cluster EVI time-series

ISODATA: resulting in 35 temporal clusters

Build 35 Trajectories

Compute statistics under cluster mask to build 35 trajectories

Harmonic Regression on trajectories

Harmonic regression on EVI trajectories to examine components of permanent signal

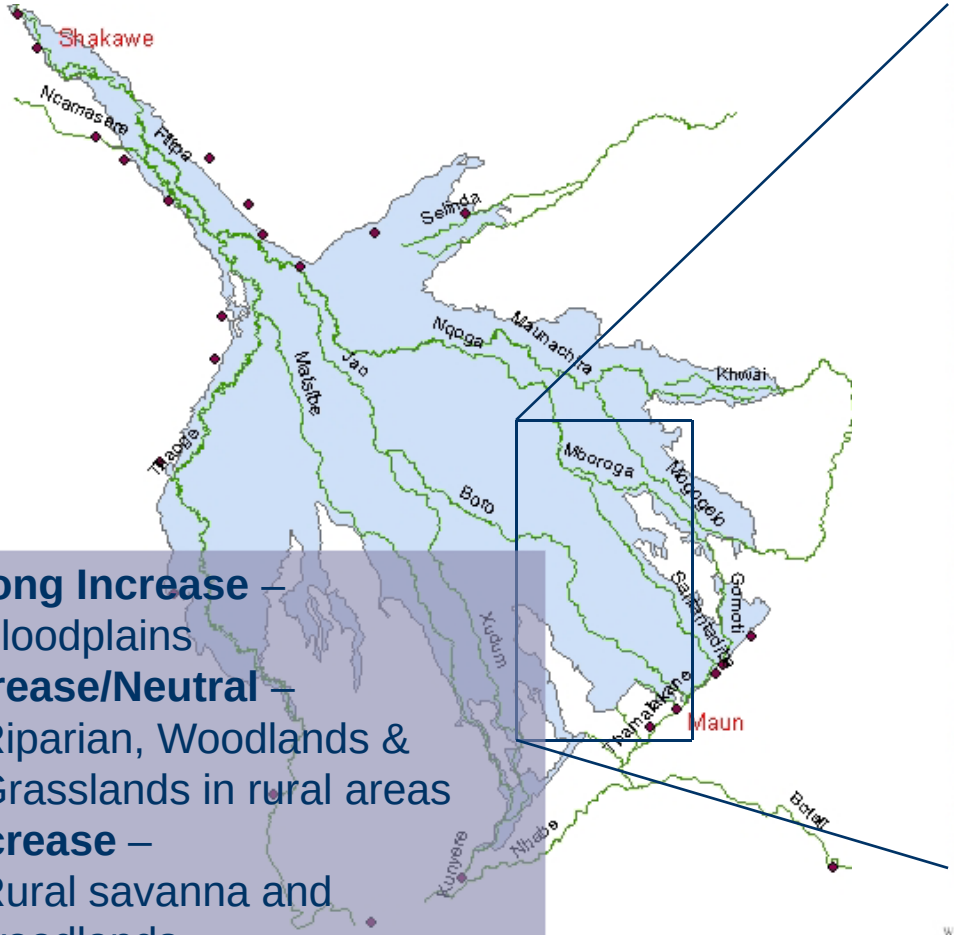
Wavelets to identify periodicities in residuals

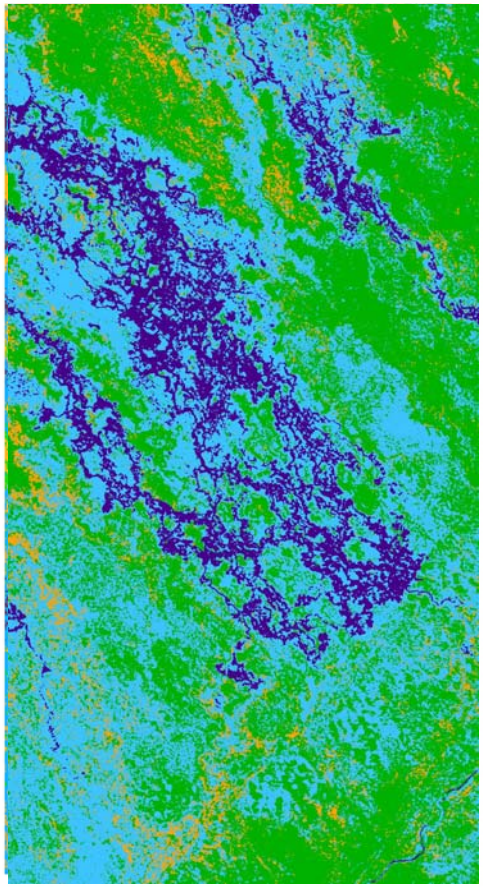
Wavelet decomposition identifies other periodicities in vegetation response

Updated Harmonic regression

2nd Harmonic regression using identified periodicities to compute overall goodness of fit

14-year Vegetation Trends





Case 2
Trend, semi-annual, annual, quasi-decadal cycles

EVI Change from 1989 - 2002

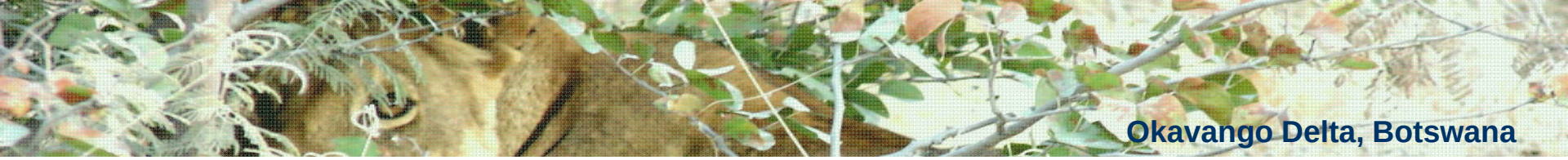
Strong Increase

Increase

No Increase

Decrease

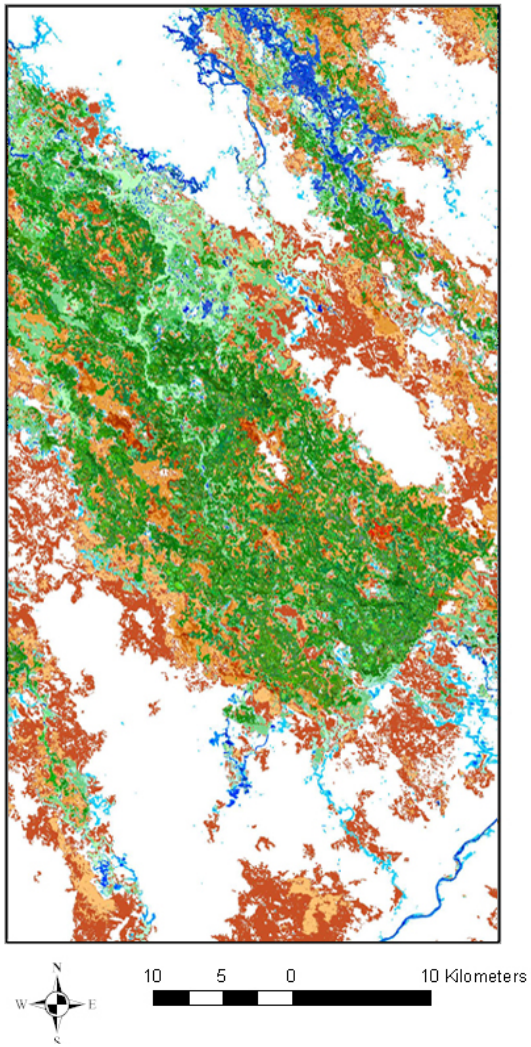
Strong Increase –
Floodplains
Increase/Neutral –
Riparian, Woodlands & Grasslands in rural areas
Decrease –
Rural savanna and woodlands



Trends based on Flooding/Fire

14-year Spatial Association of Flooding and Fire

Browns → Fire Only
Blues → Flood Only
Greens → Both Flooding and Fire

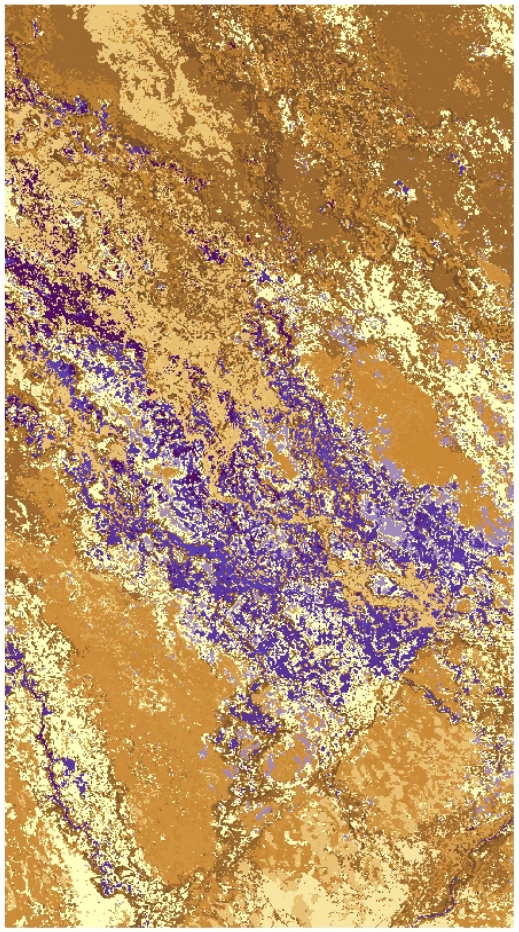


Identified all pixels with similar disturbance history (e.g. burn 1, flood 4)

Stratified pixels by land management (e.g. hunting vs. photography concessions or Moremi vs. communal)

Results: Higher R^2 tend to be associated with lower burning, more flooding, and not in the communal areas.

Overall Regression R^2



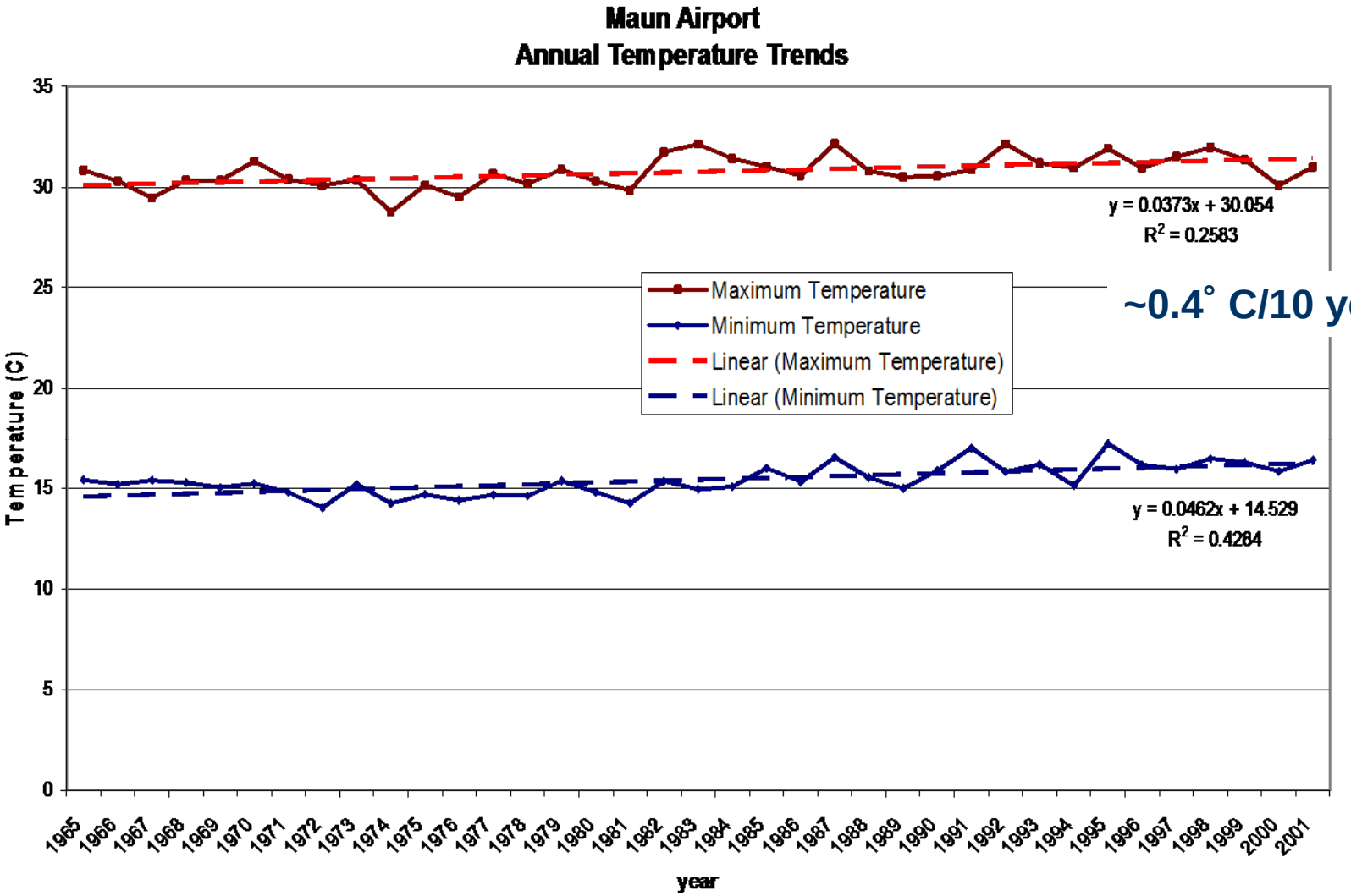
Variability in vegetation response appears to be largely cyclical

Applying semi-annual, annual, and quasi-decadal cycles

Riparian vegetation had best R^2 (0.88)

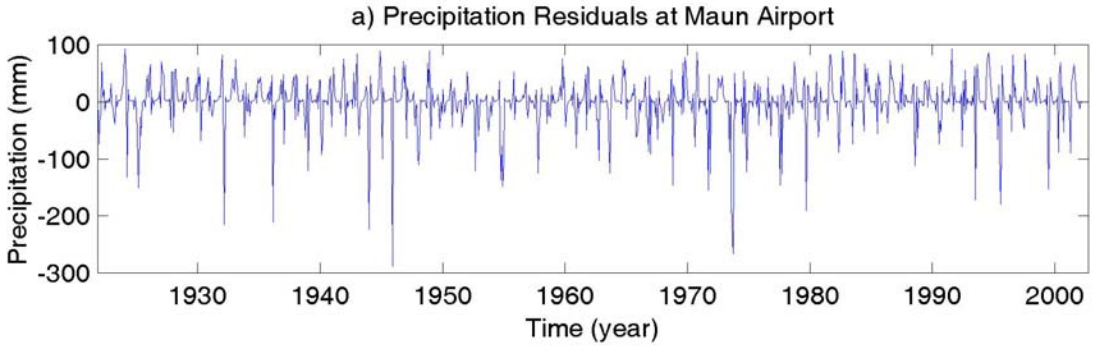
Seldom flooded areas had R^2 (0.63)

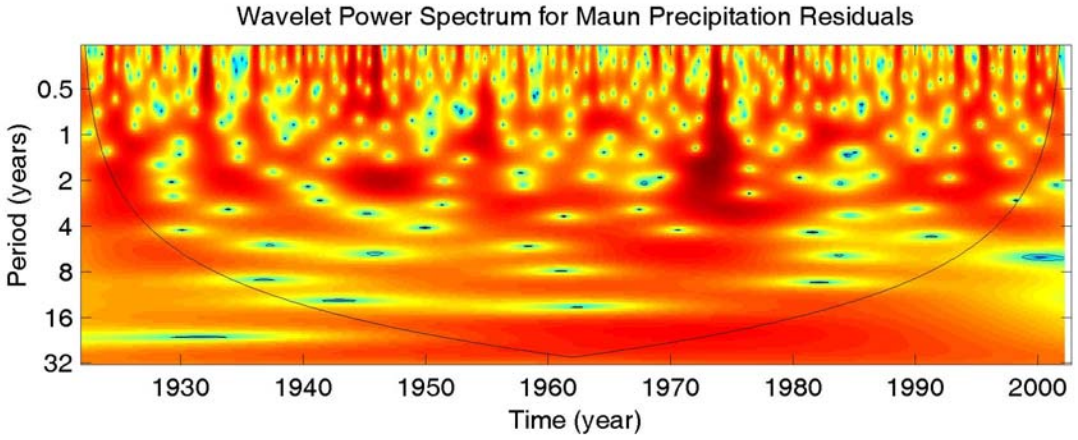
Temperature Trends at Maun Airport



~0.4˚ C/10 years

Climatic Signals





80-year precipitation record from Maun airport

Precipitation data from Botswana Meteorological Services

IMPORTANT:
Correlation is not causation

Lessons learned

- Jargon, dialogue, and buy-in (capacity building)
- Importance of local collaborators, regional heterogeneity
- Portability of approach- to whom do we build crosswalks?
- Time investment in building / cementing networks and “language training”
- Public administration and development studies communities

thank you

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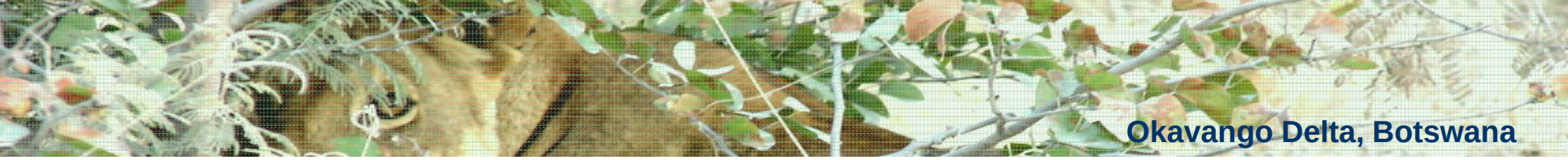
Data Provided by:
Techniche Universitaet Muenchen
NASA Safari 2000 Mission
NASA EO-1 Scientific Calibration/Validation Mission
Harry Oppenheimer Okavango Research Centre



Temporal Spacing of Imagery

Maun Airport Monthly Precipitation Totals (mm) *Source Botswana Meteorological Services*

Yellow boxes indicate coincident Landsat image

Year	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
88/89	12.9	14.5	46.0	215.5	180.0	44.3	96.3	0.0	0.0	0.0	0.0	7.6	617.1
89/90	17.4	5.5	41.5	87.1	110.0	33.3	17.3	0.0	0.0	0.0	0.0	0.0	312.1
90/91	28.5	13.3	78.4	177.6	134.0	123.0	0.0	0.0	0.0	0.0	0.0	5.8	560.6
91/92	6.7	40.7	55.1	50.1	7.4	87.9	5.0	0.0	0.0	0.0	0.0	1.4	254.3
92/93	14.3	23.9	155.0	66.5	122.0	15.4	47.4	0.0	0.0	0.7	0.0	8.2	453.4
93/94	0.0	44.0	15.2	275.0	50.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0	390.4
94/95	16.6	54.1	10.4	27.0	14.4	0.0	2.0	0.0	0.0	0.0	22.0	11.0	146.5
95/96	3.5	105.0	46.1	189.3	281.0	9.0	0.4	2.9	0.0	0.0	0.0	0.5	637.2
96/97	26.6	24.8	67.8	153.8	19.2	64.8	1.8	5.1	0.0	0.0	0.0	13.0	363.9
97/98	1.7	50.5	109.0	150.2	18.6	28.4	32.6	0.0	0.0	0.0	0.0	0.0	391.0
98/99	7.9	14.2	63.5	110.0	56.5	41.2	3.8	10.0	0.0	0.0	0.0	0.0	307.1
99/00	5.7	43.7	45.0	255.0	183.5	31.2	21.7	2.3	2.6	0.0	0.0	0.0	590.7
00/01	0.0	126.2	29.3	34.0	103.8	47.7	87.8	3.5	0.0	0.0	0.0	0.0	432.3
01/02	22.3	126.4	41.4	58.6	36.0	15.3	6.0	0.0	0.0	0.0	12.8	0.0	318.8
02/03	31.2	69.1	54.9	30.5	51.1	5.5	30.4						