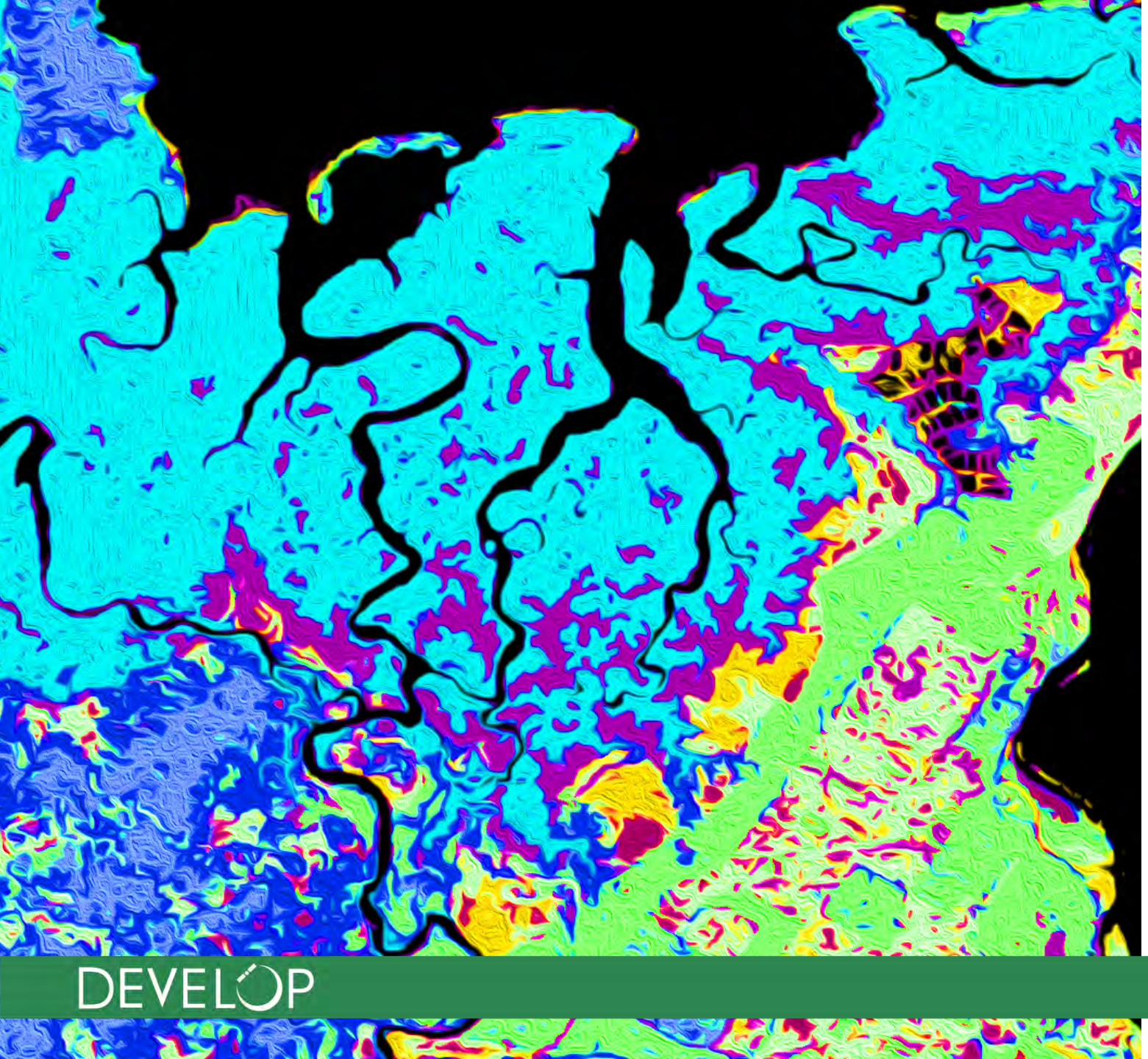


National Aeronautics and Space Administration

TALAMANCA-OSA ECOLOGICAL FORECASTING II

Assessing Habitat Suitability and Human-Jaguar Conflict Areas to Identify Potential Jaguar Corridors Connecting La Amistad and Corcovado National Parks in Costa Rica

Samuel Furey

Olivia Landry

Samantha Trust

Iris Fynn

DEVELOP

Background

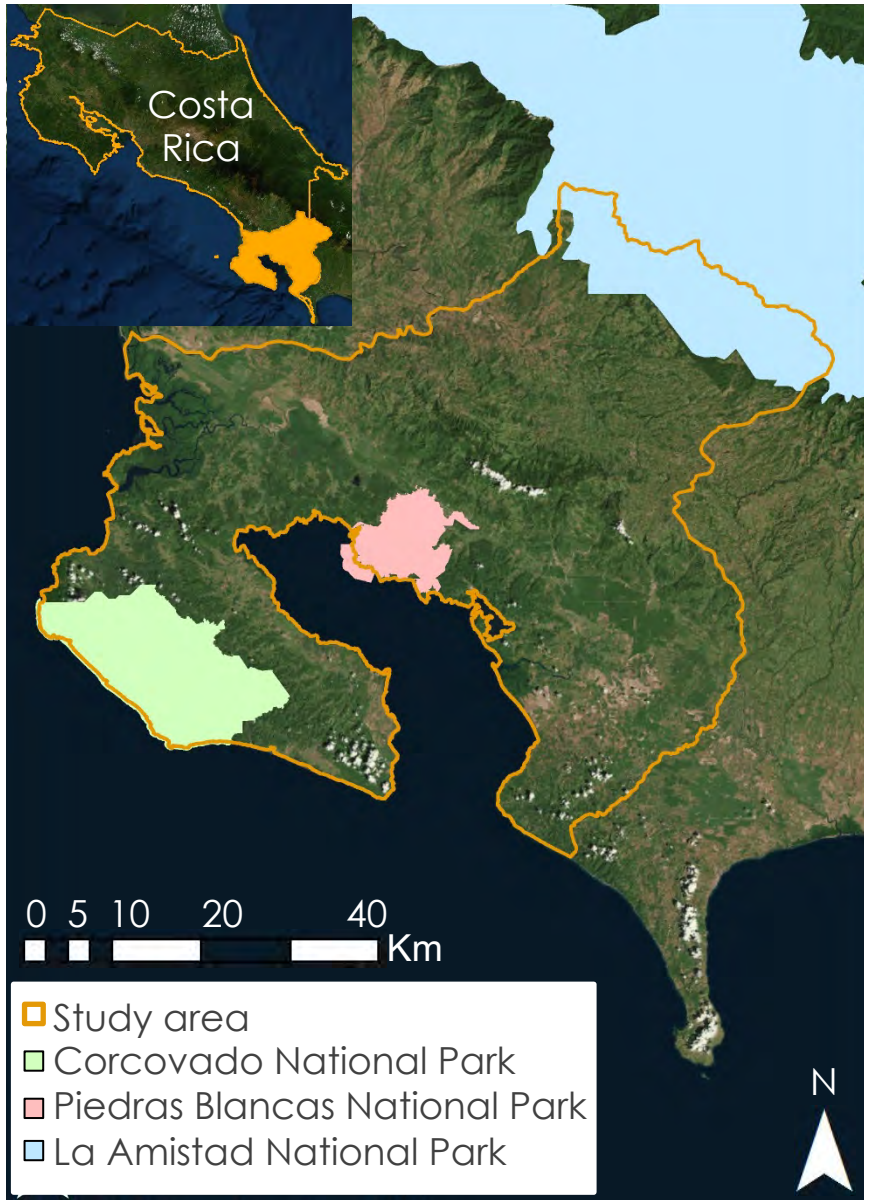
- Jaguars listed as **Near Threatened** on the International Union for Conservation of Nature (IUCN) Red List
- **Endangered** throughout Costa Rica
- Two isolated populations:
  - **Talamanca Mountains**
  - **Osa Peninsula**
- **Corridor** connects national parks and links habitat fragments

Study Area

- Study area encompasses **5382 km²** including the **Talamanca Mountains** and the **Osa Peninsula**

  - La Amistad International Peace Park
  - Piedras Blancas National Park
  - Corcovado National Park

- **Study Period:** January 1987 to June 2019, Forecasting to 2030



Partners

Arizona Center for Nature Conservation – Phoenix Zoo

Dr. Jan Schipper	Field Conservation Research Director
Annie Johnson	Research Assistants
Chelsey Tellez	
Kyli Denton	
Kinley Ragan	

Credit: Arizona Center for Nature Conservation

Osa Conservation

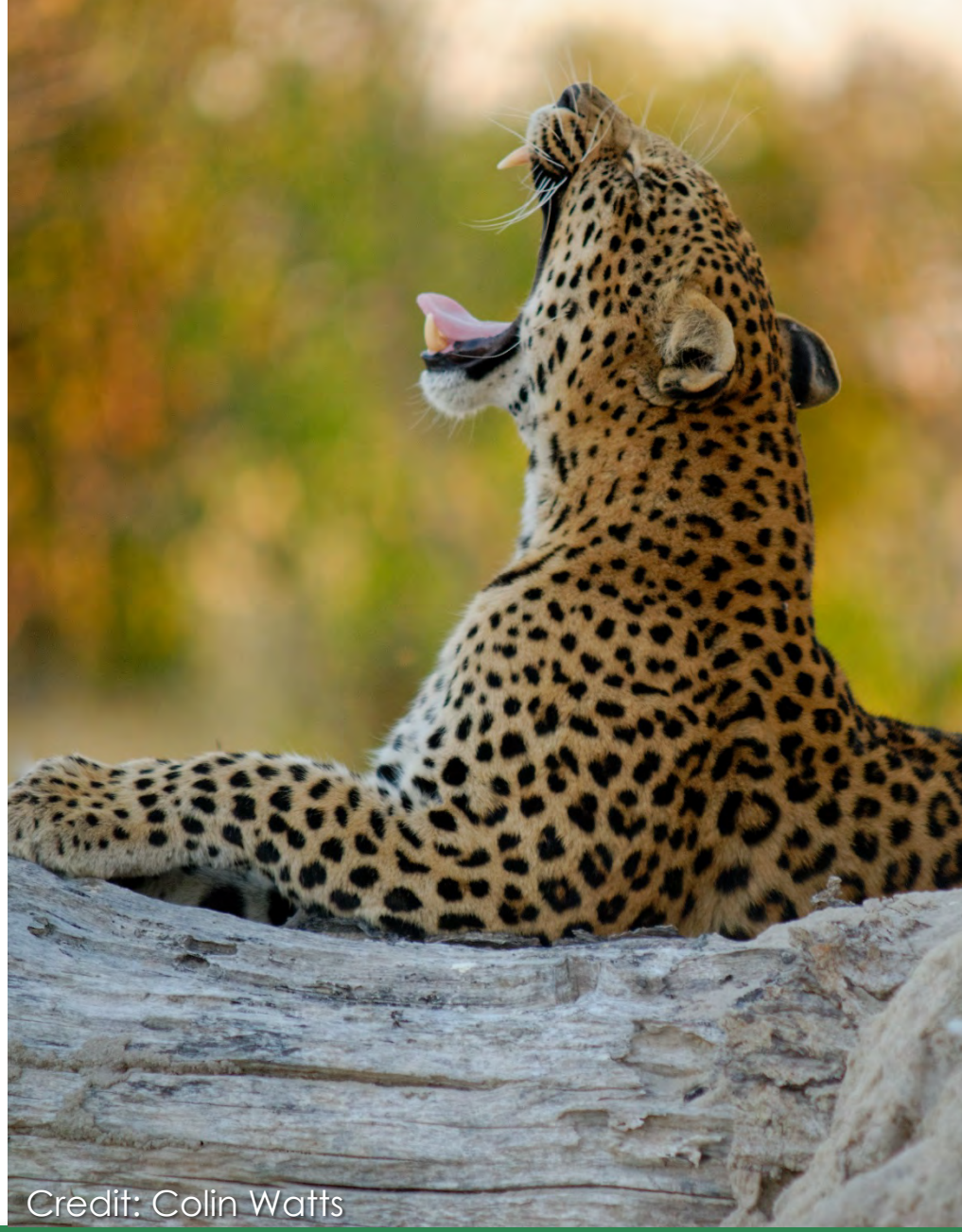
Hilary Brumberg	Healthy Rivers Program Coordinator

Credit: Osa Conservation

Credit: Isabelle Juskova

Community Concerns

- **Jaguar Habitats & Population:** Crops like pineapple and African oil palm plantations act as barriers to movement. Only an estimated 12 jaguars remain in Corcovado National Park.
- **Human–Jaguar Conflicts:** Decreased habitat size drives jaguars closer to humans, increasing the likelihood of human-jaguar conflict and retaliatory hunting.
- **Ecosystem Health:** Since jaguars are an apex predator and keystone species, the reduced number of individuals causes a negative trophic cascade.



Credit: Colin Watts

Objectives


Credit: Adolfo Felix

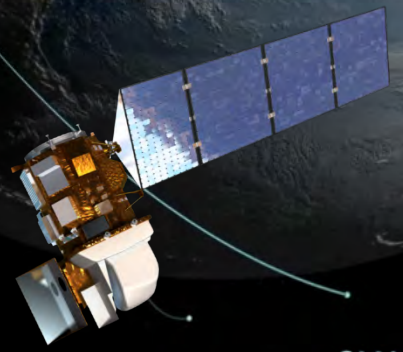
- **Conduct** historical land use and land cover analyses (**1987** and **1997**)
- **Forecast** land use and land cover classifications to year **2030**
- **Create** a human-jaguar conflict risk map based on environmental and human use factors
- **Model** corridors to aid jaguar movement between Costa Rica's La Amistad International Peace Park and Corcovado National Park

NASA Satellites and Sensors

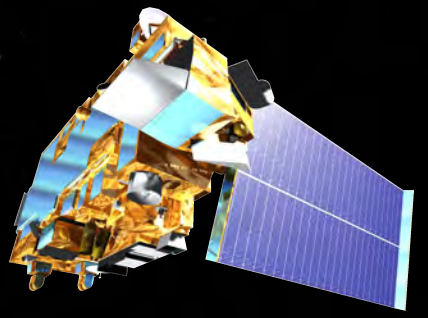
Terra
Suomi-NPP
OCO-2
Aqua
GPM
GRACE
GRACE
Cloudsat
CALIPSO
Aura
Landsat-7
CYGNSS-1
CYGNSS-4
CYGNSS-2
Jason-2
SMAP
ISS

Landsat 5 Thematic Mapper (TM)

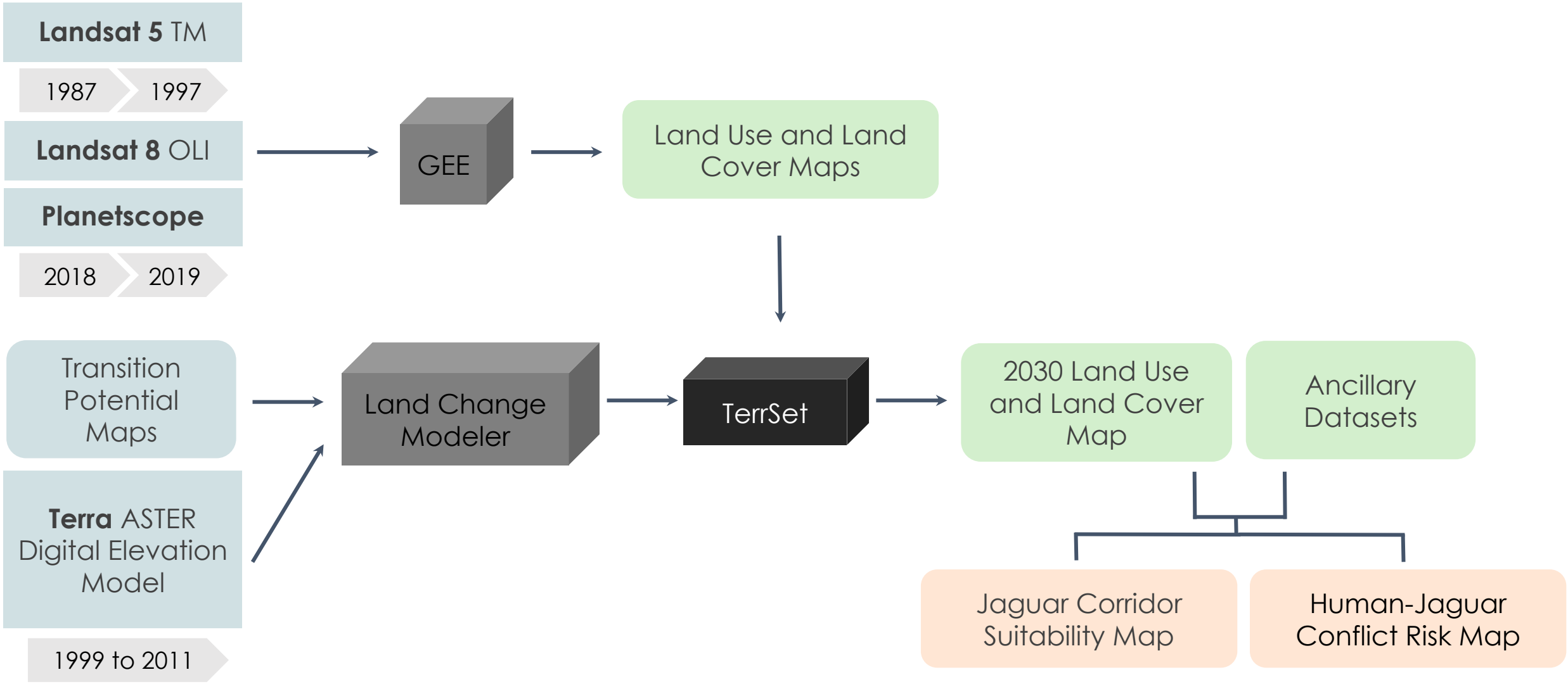
Landsat 8 Operational Land Imager (OLI)



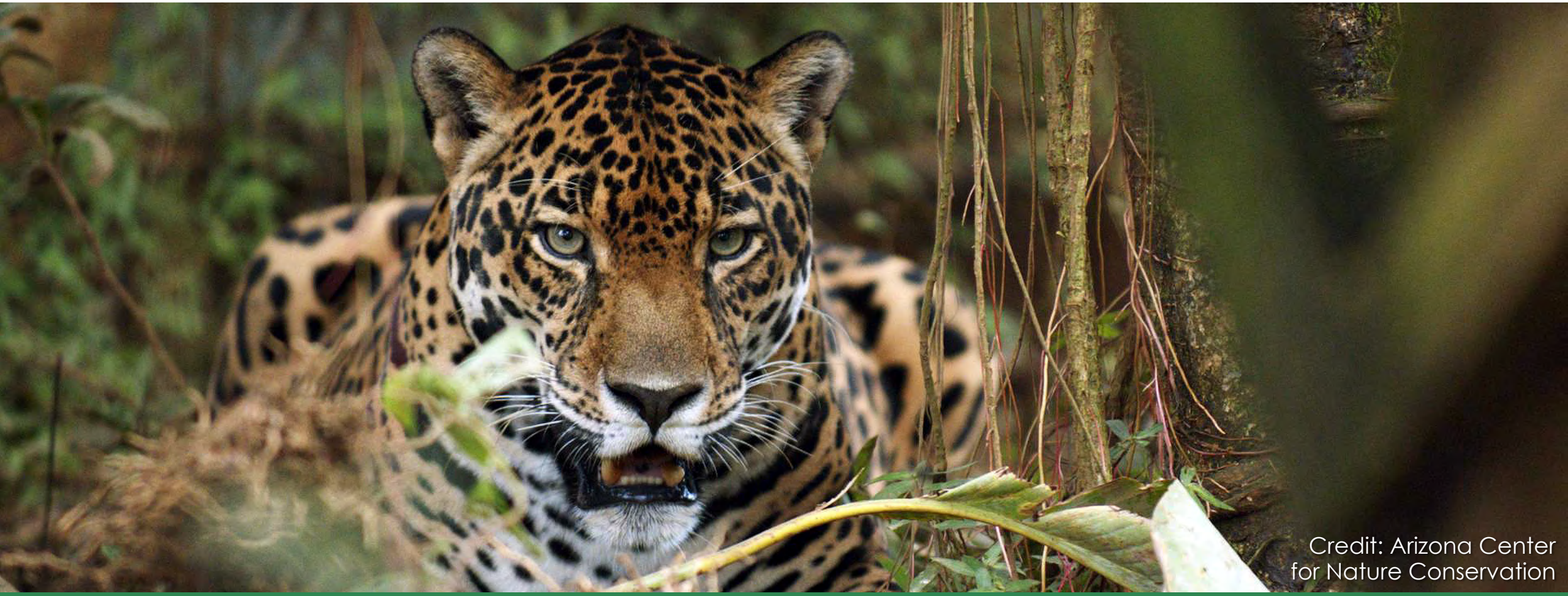
Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)



Methodology



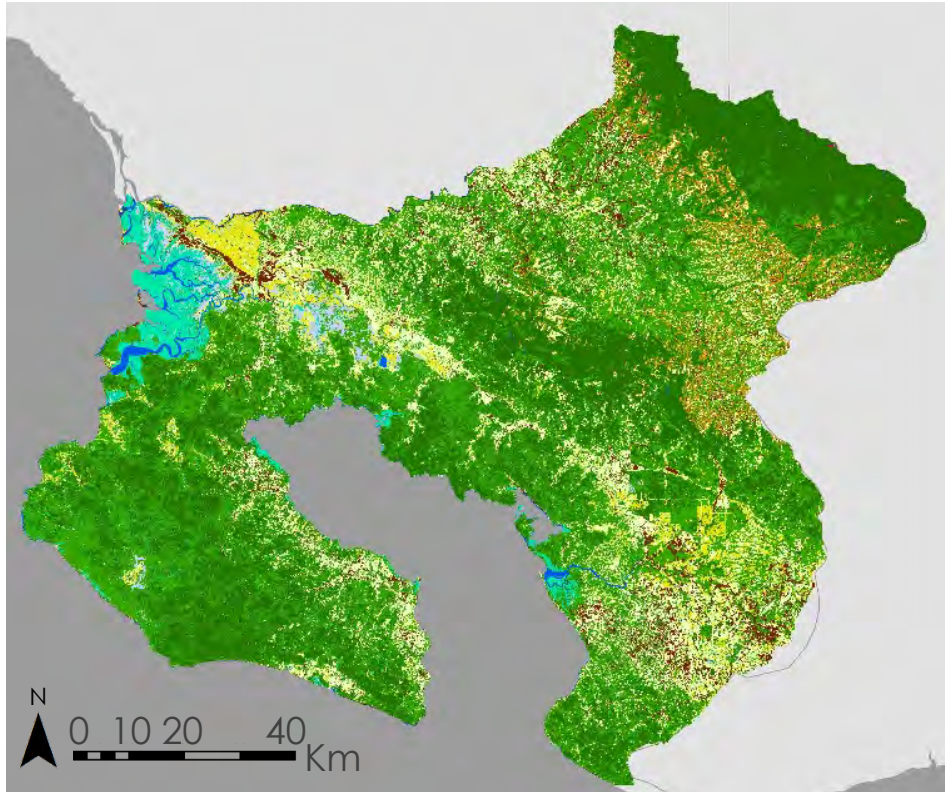
Results



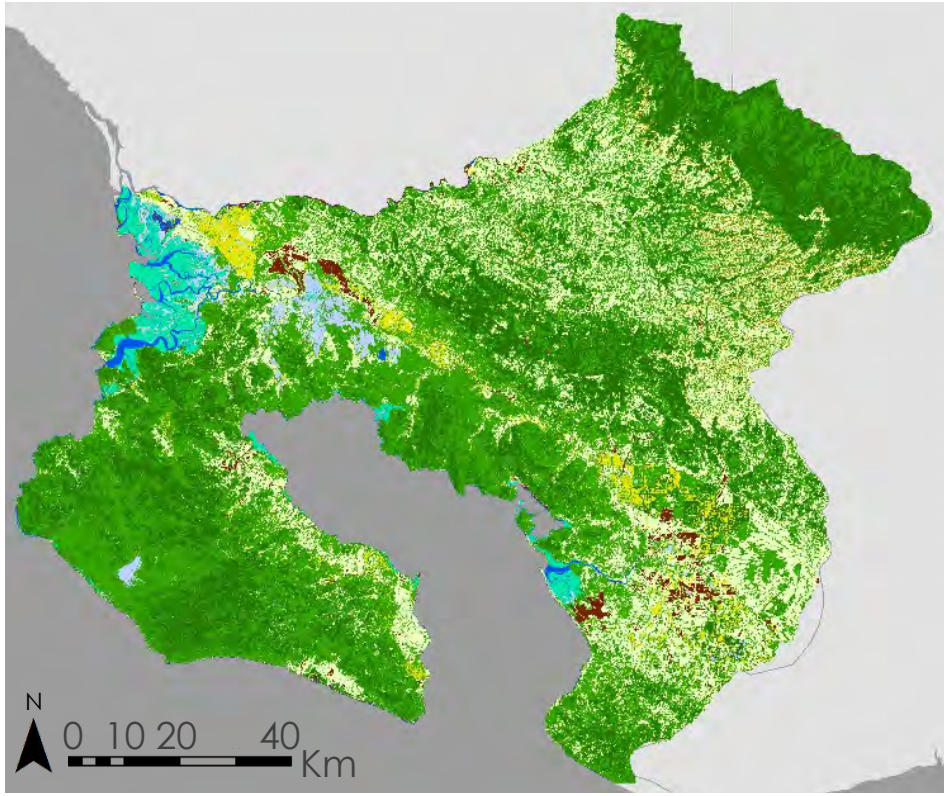
Credit: Arizona Center for Nature Conservation

Historical Land Use and Land Cover

- Coffee
- Exposed Soil/Urban
- Grassland/Pasture
- Mangrove
- Wetland
- Palm Plantation
- Páramos
- Primary Forest
- Secondary Forest
- Water



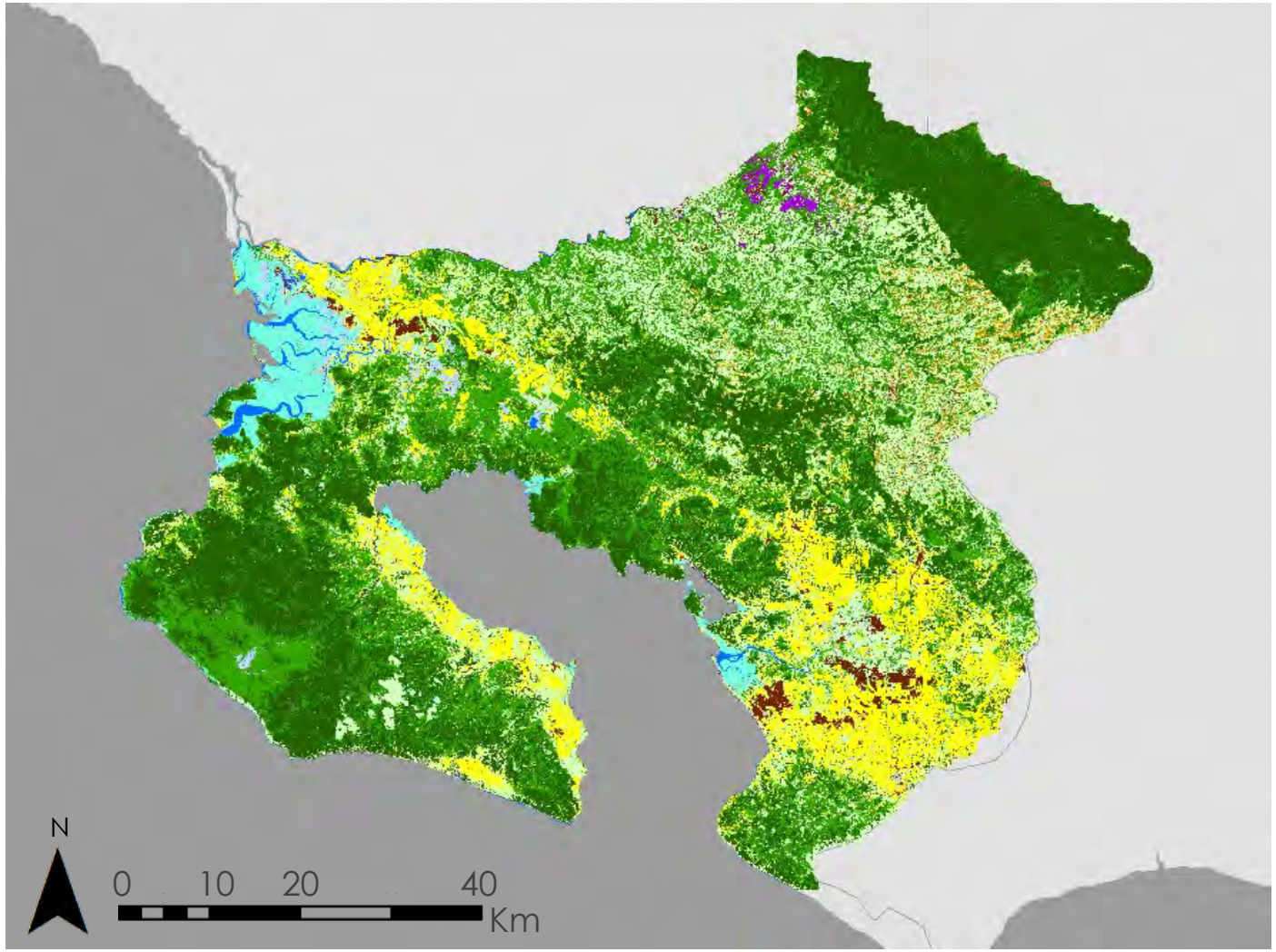
Land Use & Land Cover 1987



Land Use & Land Cover 1997

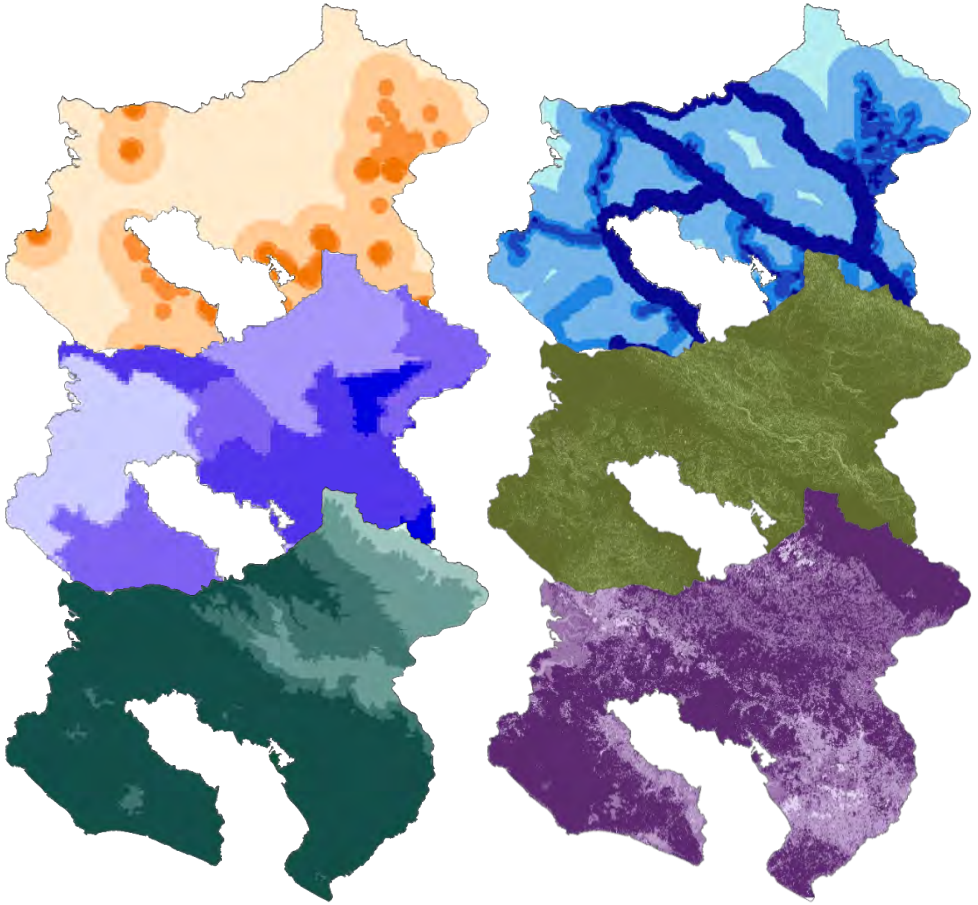
Projected 2030 Land Use and Land Cover

- Coffee
- Exposed Soil/Urban
- Grassland/Pasture
- Mangrove
- Wetland
- Palm Plantation
- Páramos
- Pineapple
- Primary Forest
- Secondary Forest
- Water

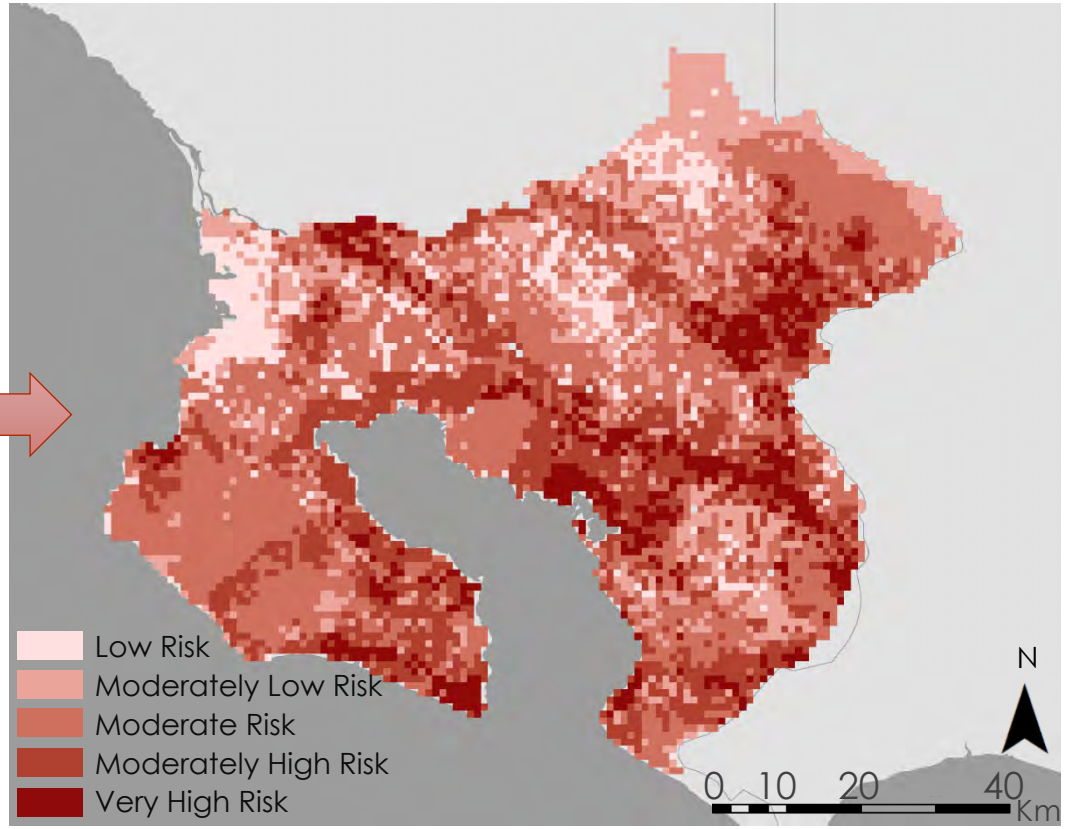


Projected Land Use & Land Cover 2030

Projected 2030 Human-Jaguar Risk Assessment

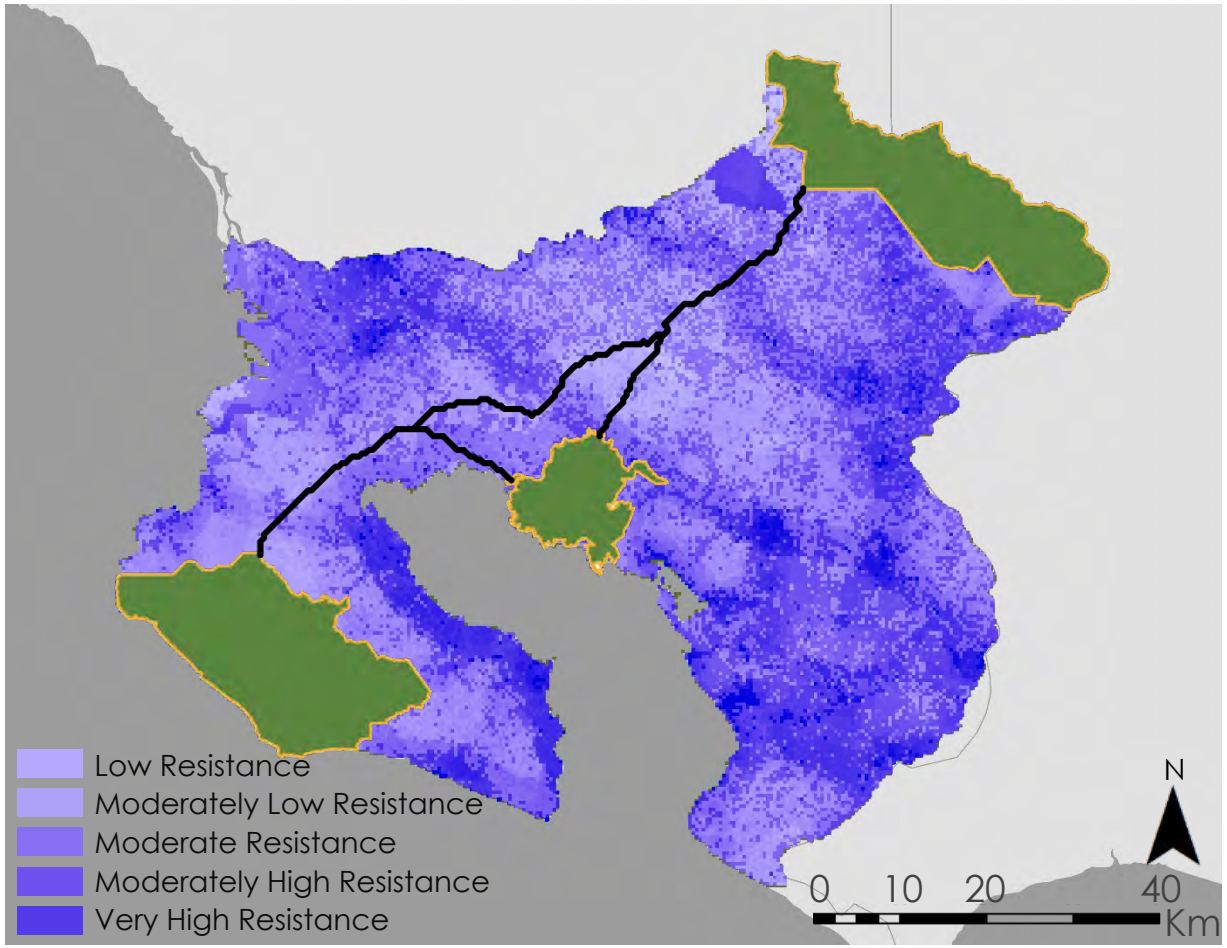


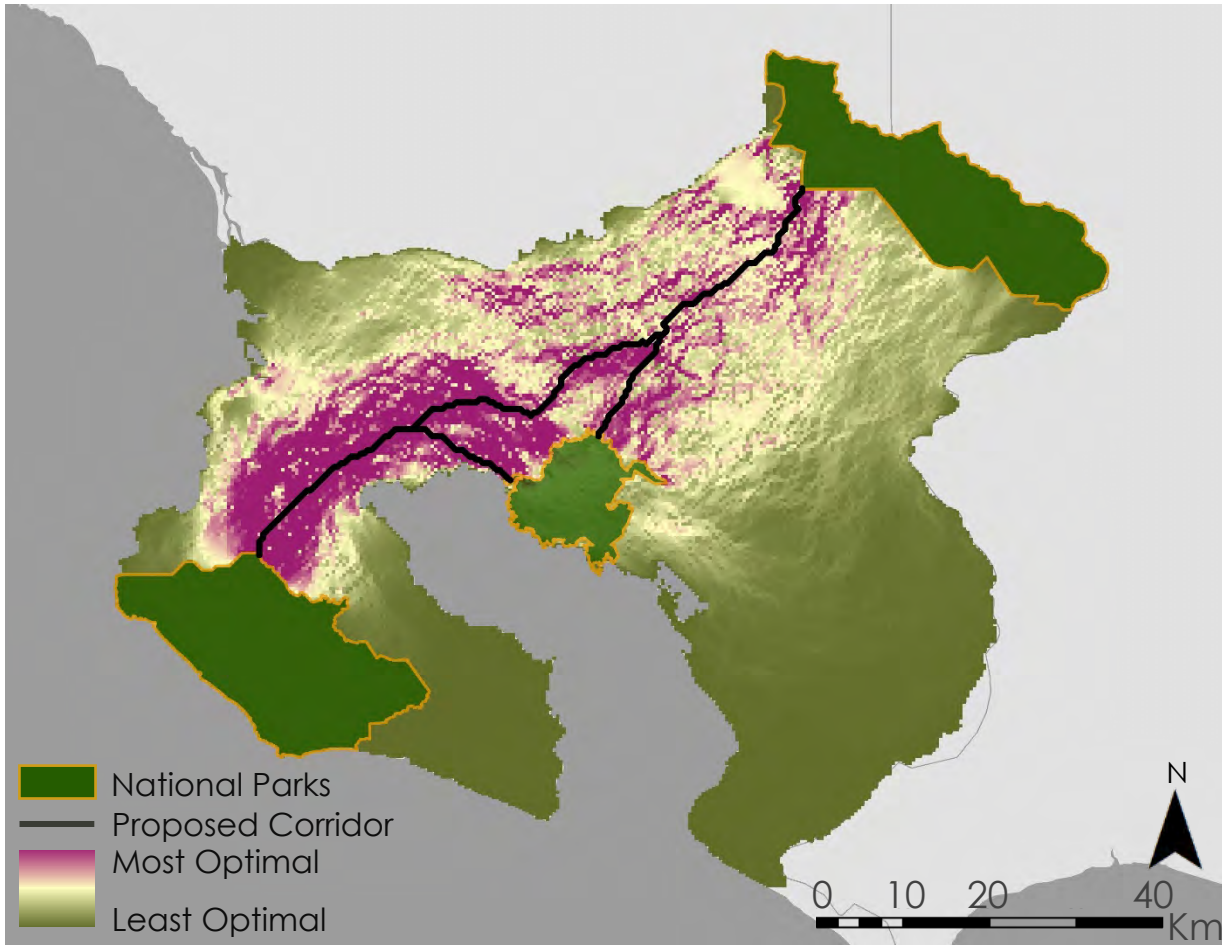
Reclassified Risk Value Rasters



Human-Jaguar Conflict Risk Assessment

Corridor Connecting La Amistad and Corcovado National Parks





Errors and Uncertainties

- When using **TerrSet Land Change Modeler** the future changes used during forecasting are assumed to change at the **same rate** as change in the historical data provided
- Legend **categories must be identical** in both land cover dates in order to **project accurately**
- **Pineapple was not forecasted** to 2030 as it was non-existent in our study area in 1987

Conclusions

- Between 2019 and 2030
- **Palm plantation** will **increase** by **3.7%,** with a slight increase around the Pan-American Highway and a **significant** increase in the northern Osa region.
- **Secondary forest** will **decrease** by **4.3%** as it is replaced with palm plantations in the northern Osa, **encroaching on Corcovado**
- There is a projected **higher** human-jaguar conflict **risk** around the **Pan-American Highway** and in **populated areas**, specifically in Playa Pan Dulce, Pavones, Puerto Jiménez, Golfito, Paso Canoas and San Vito.
- Corridors modeled in Linkage Mapper **showed two potential corridors** through the **Buenos Aires Canton** area

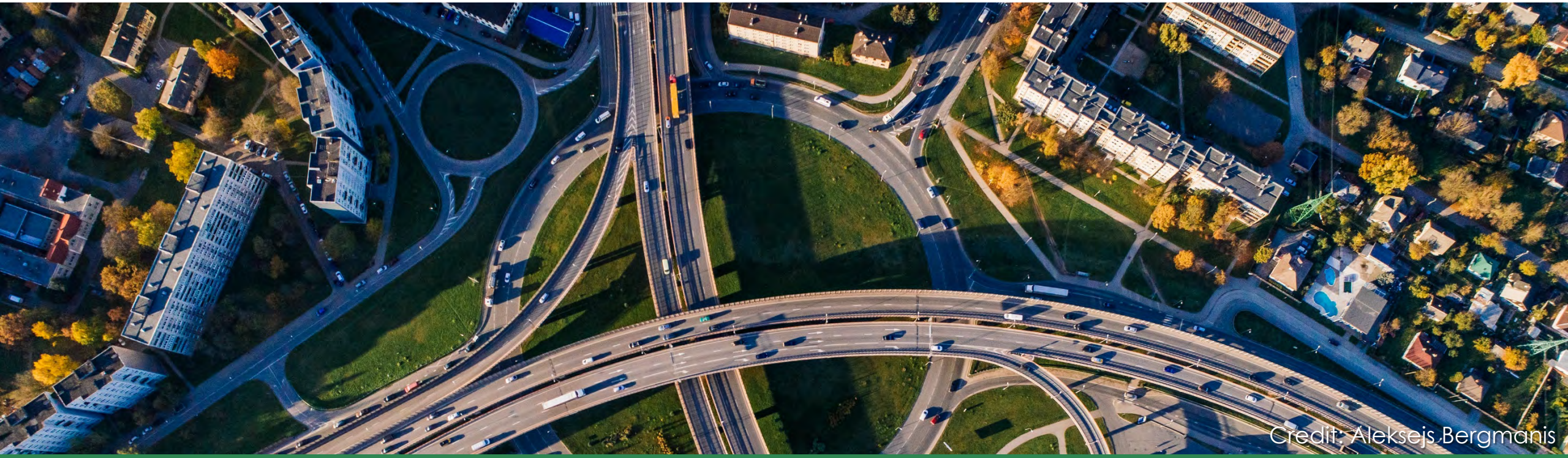
Credit: Arizona Center for Nature Conservation

Future Work

- Forecast using historical data in addition to more recent land use and land cover data
- Later work should incorporate the use of Fragstats metrics in identifying patterns and relationships between the land cover types.
- Model potential jaguar corridors and risk assessments using jaguar prey availability data

Applications to Planning

- Will help **facilitate** the decision-making process for future environmental planning in Costa Rica
- Will **inform** planners about the implications of non-sustainable agricultural and planning practices on wildlife



Acknowledgements

Science Advisors – University of Georgia

- **Dr. Marguerite Madden**, Director – Center for Geospatial Research
- **Dr. Steve Padgett-Vazquez,** University of Georgia

Contributors

- Osa Peninsula Water Resources II Team
- Talamanca-Osa Ecological Forecasting I Team

GA – Athens Node Leadership

- **Shelby Ingram**, Acting Center Lead/Project Coordination Fellow

Project Partners

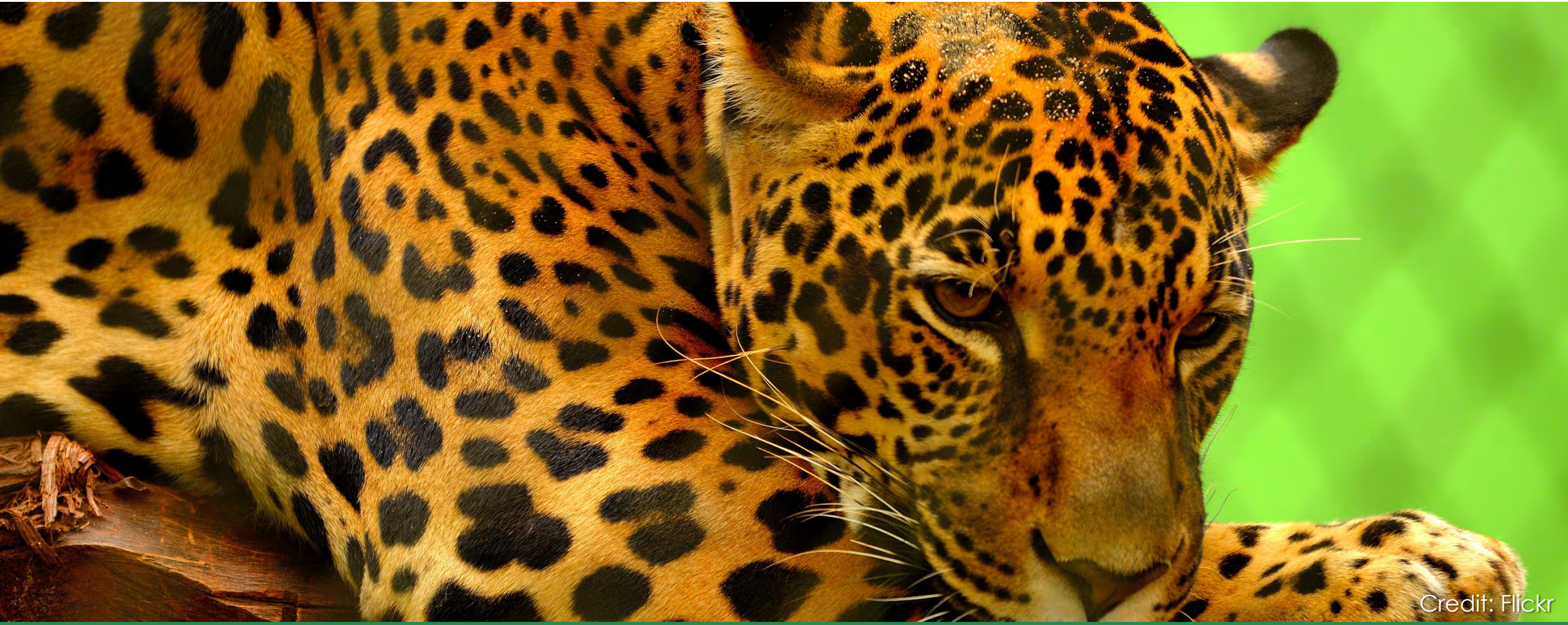
Arizona Center for Nature Conservation

- **Dr. Jan Schipper**, Field Conservation Research Director
- **Annie Johnson, Chelsey Tellez**, **Kyli Danton** and **Kinley Ragan**, Field Conservation Research Assistants

Osa Conservation

- **Hilary Brumberg**, Healthy Rivers Program Coordinator

Questions?



Appendices

- Appendix A
  - Surface reflectance bands and wavelengths used to calculate NDVI and EVI
- Appendix B
  - Equations used to calculate NDBI, NDMI, NDWI, TCB, TCG, TCW
- Appendix C
  - Partner and literature sources for elevation cut offs for land use and land cover classification
- Appendix D
  - Transition Potential Maps used for TerrSet
- Appendix E
  - Values and weights assigned for human-jaguar conflict risk map
- Appendix F
  - Values and weights assigned for resistance raster used as an input for Linkage Mapper
- Appendix G
  - Cantones (poltical districts) within Study Area

Appendix A

Table A1

Surface reflectance bands and wavelengths used to calculate NDVI and EVI

Surface Reflectance	Landsat 5 TM		Landsat 8 OLI	
	Band	Wavelength (μm)	Band	Wavelength (μm)
Blue	1	0.45 - 0.52	2	0.452 - 0.512
Red	3	0.63 - 0.69	4	0.636 - 0.673
NIR	4	0.77 - 0.90	5	0.851 - 0.879

Appendix B

Normalized Difference Built Index (NDBI)

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$

Normalized Difference Moisture Index (NDMI)

$$NDMI = \frac{NIR - SWIR}{NIR + SWIR}$$

Normalized Difference Water Index (NDWI)

$$NDWI = \frac{Green - NIR}{Green + NIR}$$

Tasseled Cap Brightness (TCB)

$$TCB = (0.2043 * BLUE) + (0.4158 * GREEN) + (0.5524 * RED) + (0.5741 * NIR) + (0.3124 * SWIR1) + (0.2303 * SWIR2)$$

Tasseled Cap Greenness (TCG)

$$TCG = (-0.1603 * BLUE) + (0.2819 * GREEN) + (-0.4934 * RED) + (0.7940 * NIR) + (-0.0002 * SWIR1) + (-0.1446 * SWIR2)$$

Tasseled Cap Wetness (TCW)

$$TCW = (0.0315 * BLUE) + (0.2021 * GREEN) + (0.3102 * RED) + (0.1594 * NIR) + (-0.6806 * SWIR1) + (-0.6109 * SWIR2)$$

Equations used to calculate NDBI, NDMI, NDWI, TCB, TCG, TCW

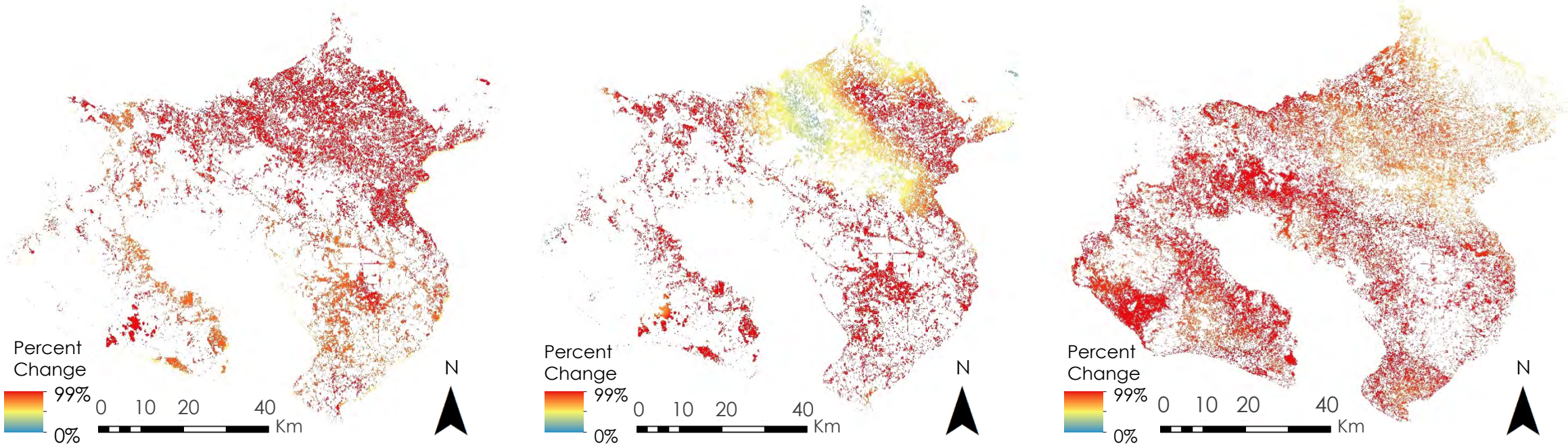
Appendix C

Table C1

Partner and literature sources for elevation cut offs for land use and land cover classification

Class	Elevation Restrictions in Code	Elevation Range from Literature	Partner Source	Literature Source
Grassland/Pasture	Less than 2000 m	~1500 m	Dr. Jan Schipper	Holl & Quiros-Nietzen 1999
Paramos	Greater than 2000 m	3100 to 3300 m	Dr. Jan Schipper	Kappelle & Horn 2016
Coffee	Greater than 870 m	1000 to 1300 m	Dr. Jan Schipper	Avelino et al. 2005
Mangrove	Less than 500 m	less than 200 m	Jiménez, J. A. 2016	Jiménez, J. A. 2016
Melina/Teak on the Osa Peninsula	Less than 120 m	N/A	Hilary Brumberg	N/A
Wetland	Less than 500 m	less than 200 m	Jiménez, J. A. 2016	Jiménez, J. A. 2016

Appendix D



Transition from Grassland/Pasture to Exposed Soil/Urban

Transition from Grassland/Pasture to Palm Plantation

Transition from Secondary Forest to Grassland/Pasture

Figure D1. Transition Potential Maps used for TerrSet

Appendix E

Elevation (m)	Suitability Value (0-3, 3 being most suitable)
0-1000	3
1000-2000	2
2000-3000	1
>3000	1

Slope (degrees)	Suitability Value (0-3, 3 being most suitable)
0-15	3
15-30	2
30-45	1
>45	0

Pop. Count (persons/sq. km)	Risk Value (0-3, 3 having highest risk)
0	0
0-5	1
5-25	2
25-150	3

Land Cover Type	Suitability Value (1-5, 5 being most suitable for jaguars)
Pineapple	1
Palm Plantation	2
Mangrove	3
Water	2
Grassland/Pasture	3
Exposed Soil/Urban	1
Primary Forests	5
Secondary Forests	5
Wetland	4
Coffee	4
Paramos	1

Tables E1- E7. V*alues and weights assigned for human-jaguar conflict risk map*

Bivariate Key Values (based on distance and size of settlement)	Risk Value (1-5, 5 being highest risk of conflict with humans)
0	1
1	1
2	2
3	3
4	4
5	5
6	5

Bivariate Key Values (based on distance and size of road)	Risk Value (1-5, 5 being highest risk of conflict with humans)
0	1
1	1
2	2
3	3
4	4
5	5
6	5

Layer Name	Weight of Influence (%, must add to 100)
Slope	10
Elevation	10
LULC	30
Population	10
Cities	20
Roads	20

Appendix F

Elevation (m)	Resistance Value (1-10, 10 being highest resistance to movement of jaguars)
0-1000	0
1000-2000	2
2000-3000	6
>3000	10

Slope (degrees)	Resistance Value (1-10, 10 being highest resistance to movement of jaguars)
0-15	0
15-30	2
30-45	5
45-60	7
>60	10

Distance to River (km)	Resistance Value (1-10, 10 being highest resistance to movement of jaguars)
0-.5km	0
.5-1km	1
1-2km	2
2-4km	3
4-8km	4
8-16km	5
>32km	5

Land Cover Type	Resistance Value (1-10, 10 being highest resistance to movement of jaguars)
Pineapple	10
Palm Plantation	6
Mangrove	5
Water	9
Grassland/Pasture	5
Exposed Soil/Urban	10
Primary Forests	0
Secondary Forests	1
Wetland	3
Coffee	4
Paramos	10

Tables F1- F7. V*alues and weights assigned for resistance raster used as an input for Linkage Mapper*

Bivariate Key Values (based on distance and size of settlement)	Resistance Value (1-10, 10 being highest resistance to movement of jaguars)
0	0
1	2
2	4
3	6
4	8
5	10
6	10

Bivariate Key Values (based on distance and size road)	Resistance Value (1-10, 10 being highest resistance to movement of jaguars)
0	0
1	2
2	4
3	6
4	8
5	10
6	10

Layer Name	Weight of Influence (%, must add to 100)
Slope	5
Elevation	5
LULC	40
Distance to Rivers	10
Cities	20
Roads	20

Appendix G

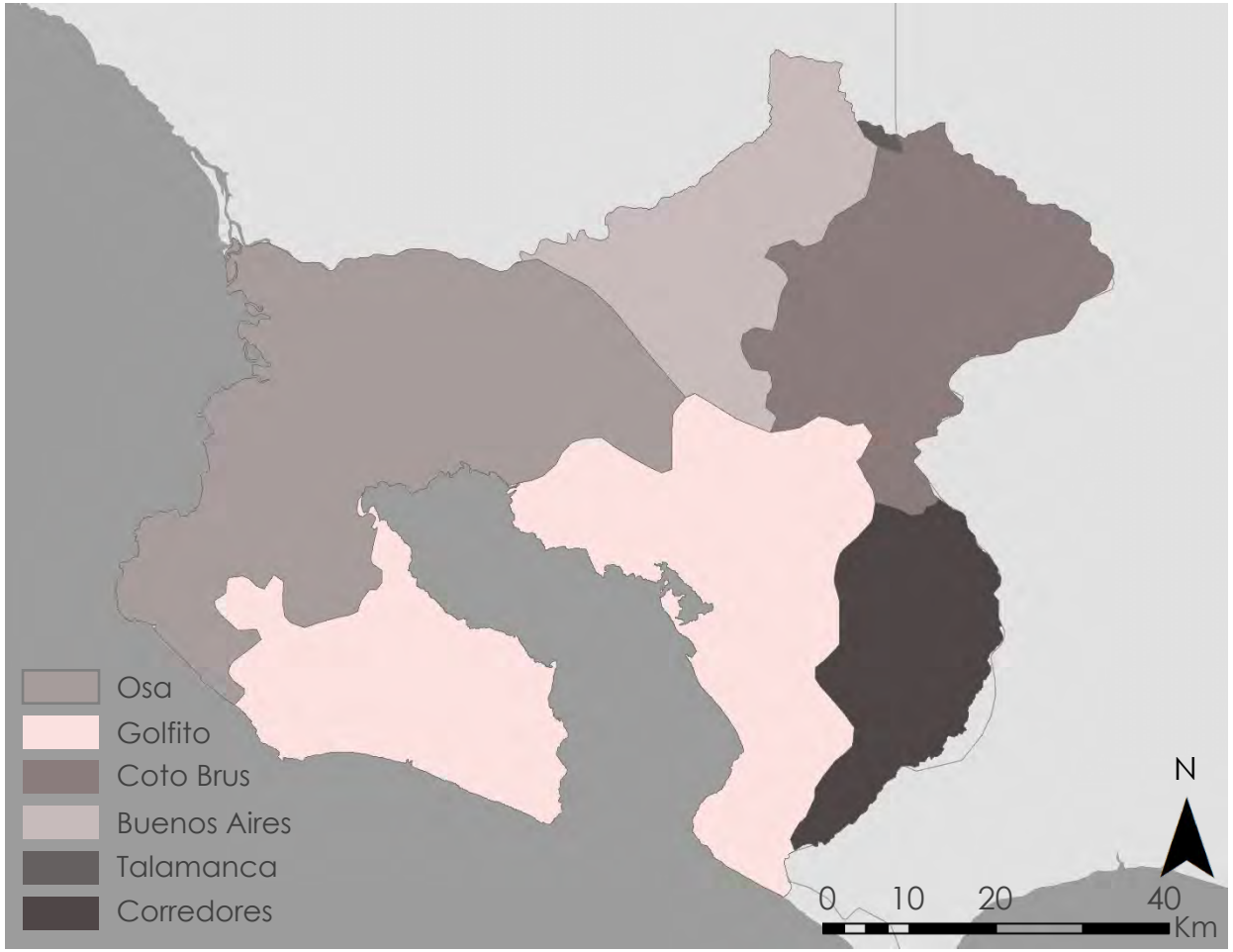


Figure G1. Cantones (political districts) of Study Area