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Faculty Summit **2017**



AI for Earth: AI for Protecting Wildlife, Forests, Fish

MILIND TAMBE

Founding Co-director, Center for Artificial Intelligence in Society (CAIS)

University of Southern California

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Co-Founder, Avata Intelligence

USC Center for Artificial Intelligence in Society (CAIS.USC.EDU)



USC Center for
Artificial Intelligence in Society



Mission Statement: Advancing AI research driven by...



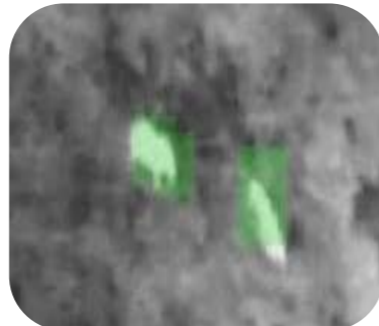
Grand Challenges of Social Work

- Ensure healthy development for all youth
- Close the health gap
- Stop family violence
- Advance long and productive lives
- End homelessness
- Achieve equal opportunity and justice



Overview of CAIS Project Areas

AI for Earth



- Machine learning/planning: Predicting poaching spots, patrols
- Real-world: Uganda, South Asia...

Overview of CAIS Project Areas

AI for Public Safety and Security



- Game theory: security resource optimization
- Real-world: US Coast Guard, US Federal Air Marshals Service...

Overview of CAIS Project Areas

AI for Low Resource Communities



- Social networks: Spread HIV information, influence maximization
- Real-world pilot tests: Big improvements

Partnerships

- Wildlife Conservation



- Public Safety and Security



- Low Resource Communities



What Might We Lose?

Murchison Falls National Park, Uganda



Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Image IBCAO

Google earth

Protecting Wildlife in Uganda



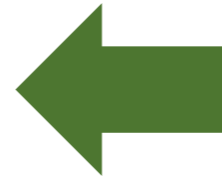
PAWS: Protection Assistant for Wildlife Security



Fang

Massive forests (1000 sq miles) to protect, limited security resources:

- Generate “intelligently” randomized patrols
- Learn adversary models



Patrol boat in Bangladesh
at Global Tiger Conference, 2014



Patrol with Rangers, Indonesia
Trip with WWF, 2015

AI for Public Safety and Security



Jain



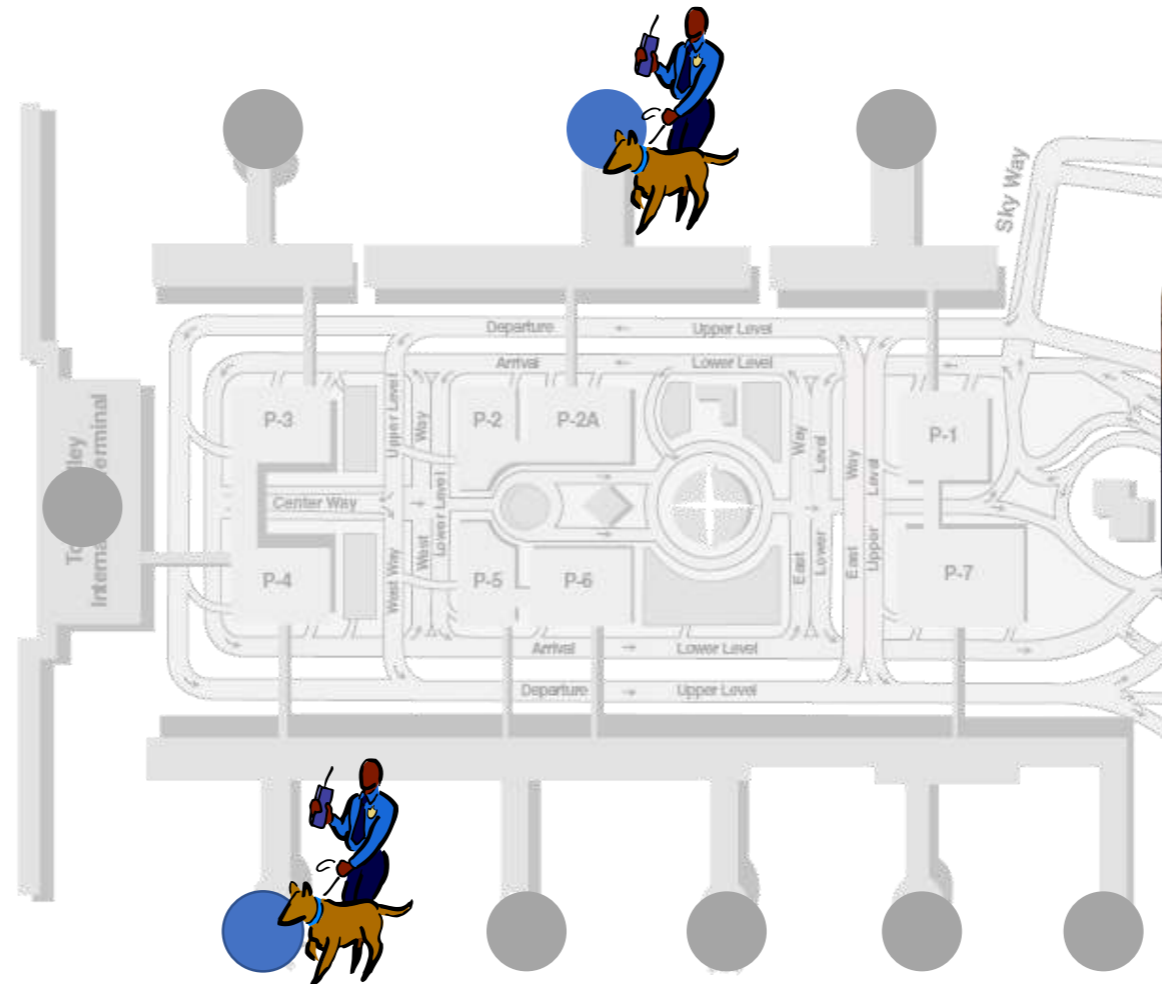
Pita

ARMOR: Assigning Limited Security Resources [2007]

Airports



2007



Canine patrol at LAX (ARMOR)

AI-based DECISION AIDS TO ASSIST IN SECURITY

Game Theory

Airports



2007

Player A

Player B



Paper

Rock

Scissors

Paper

0, 0

1, -1

-1, 1

Rock

-1, 1

0, 0

1, -1

Scissors

1, -1

-1, 1

0, 0

	Paper	Rock	Scissors
Paper	0, 0	1, -1	-1, 1
Rock	-1, 1	0, 0	1, -1
Scissors	1, -1	-1, 1	0, 0

Model: Stackelberg Security Games



Kiekintveld

Set of targets, payoffs based on targets covered or not...

Stackelberg: Defender commits to *randomized* strategy, adversary responds

Challenges faced: Massive scale games; difficult for a human planner



Defender



Adversary

	Terminal #1	Terminal #2
Terminal #1	4, -3	-1, 1
Terminal #2	-5, 5	2, -1

AI-based DECISION AIDS TO ASSIST IN SECURITY



Security Game Deployments



Fang

Security Games

Airports



2007

Air Marshals



2009

Ports



2011

PROTECT: Ferry Protection Deployed



Global Applications of Security using Game Theory

MILIND TAMBE'S ARMOR AND ITS MANY ITERATIONS ARE USED AROUND THE WORLD TO PROTECT AGAINST TERRORISM, POACHERS, ILLEGAL FISHING AND OTHER THREATS.

DEPLOYED

Ports — PROTECT
PROTECT intelligently randomizes U.S. Coast Guard patrols to optimize scarce resources to secure crowded piers, bridges and ferry terminals. PROTECT is employed at:
Part of New York and New Jersey
Part of Seattle
Part of Houston
Part of Los Angeles-Long Beach

Staten Island Ferry — PROTECT
PROTECT provides protection to the Staten Island Ferry, which carries up to 4,000 passengers at peak times.

Los Angeles International Airport — ARMOR
ARMOR intelligently randomizes schedules of checkpoints along the five roads that lead into the airport.

U.S. Air Traffic — IWS
As part of its multipronged strategy to prevent attacks, the Transportation Security Administration (TSA) has since 2009 deployed Milind Tamba's IWS system, which intelligently randomizes federal air marshals' flight schedules to make their air patrols unpredictable to would-be malefactors.

SUCCESS

Gulf of Mexico — ARMOR-FISH
ARMOR-FISH schedules patrols to thwart the shark and poacher.

Los Angeles — ARMOR
The Los Angeles Metro Authority (LA Metro) has TRUSTED to its schedules to deter crime and terrorism on LA Metro. (2011-2013)

Department later ran preliminary experiments to ascertain effectiveness in deploying scarce police personnel to deter crime and terrorism on LA Metro. (2011-2013)

Wimbo, began testing PAWS in forests in northeastern Malaysia, to evaluate its ability to generate effective patrols in the challenging, hilly terrain. (2014)



FUTURE TEST SITES

Singapore — STREETS
Singaporean traffic authorities could employ STREETS to intelligently randomize police patrols to catch reckless drivers, a big problem in this island nation.

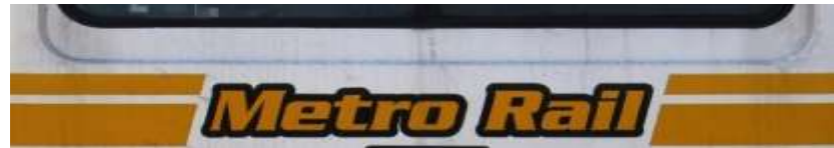
Madagascar — PAWS
Milind Tamba, working with Meredith Gore, an associate professor of conservation social sciences at Michigan State University, and a Malagasy civil society group called Alliance

Vashary Gasy (AVG), hopes to eventually employ PAWS in Madagascar to randomize patrol schedules for rangers, police and national park officials to reduce environmental crimes, especially illegal logging.

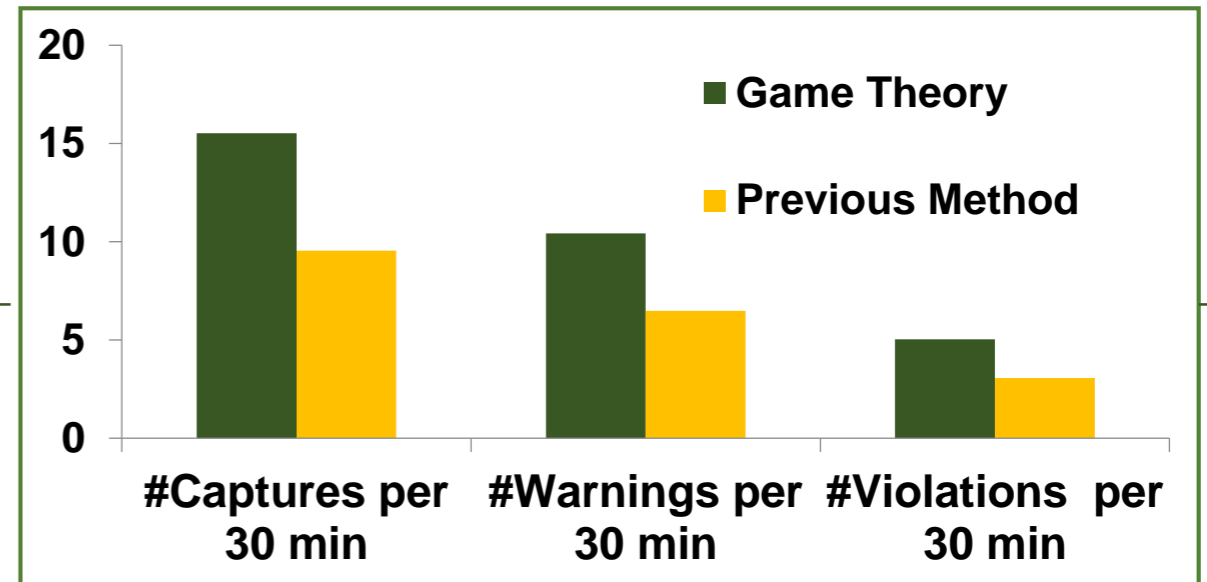


SOME RESULTS OF GAME THEORY for SECURITY

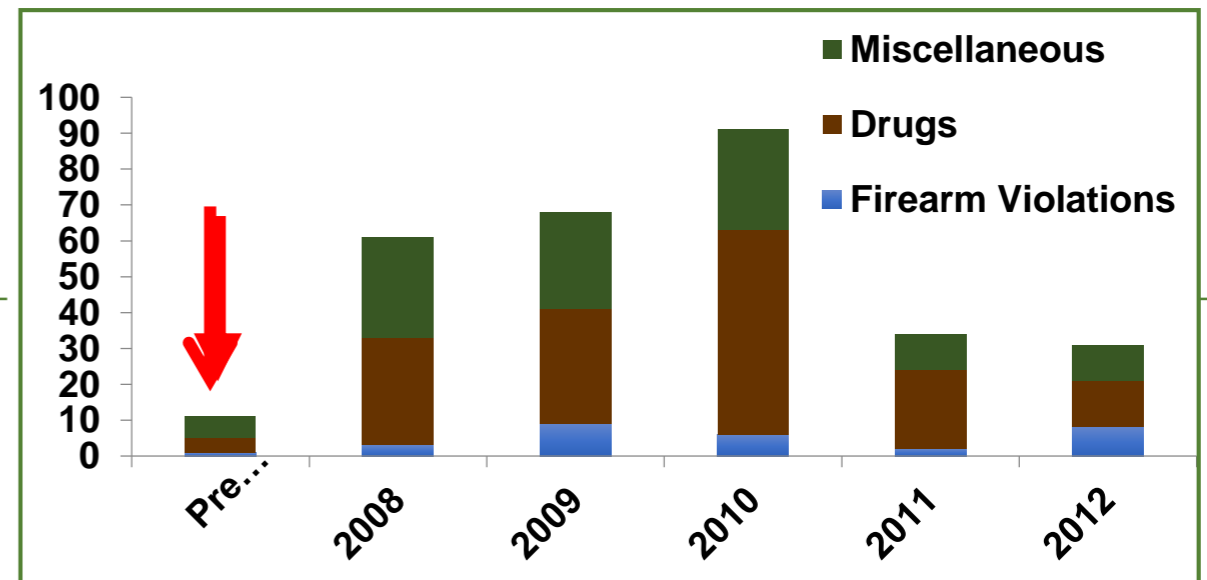
Ticketless Travelers Caught



- Game theory vs Previous Method



Arrests at LAX checkpoints

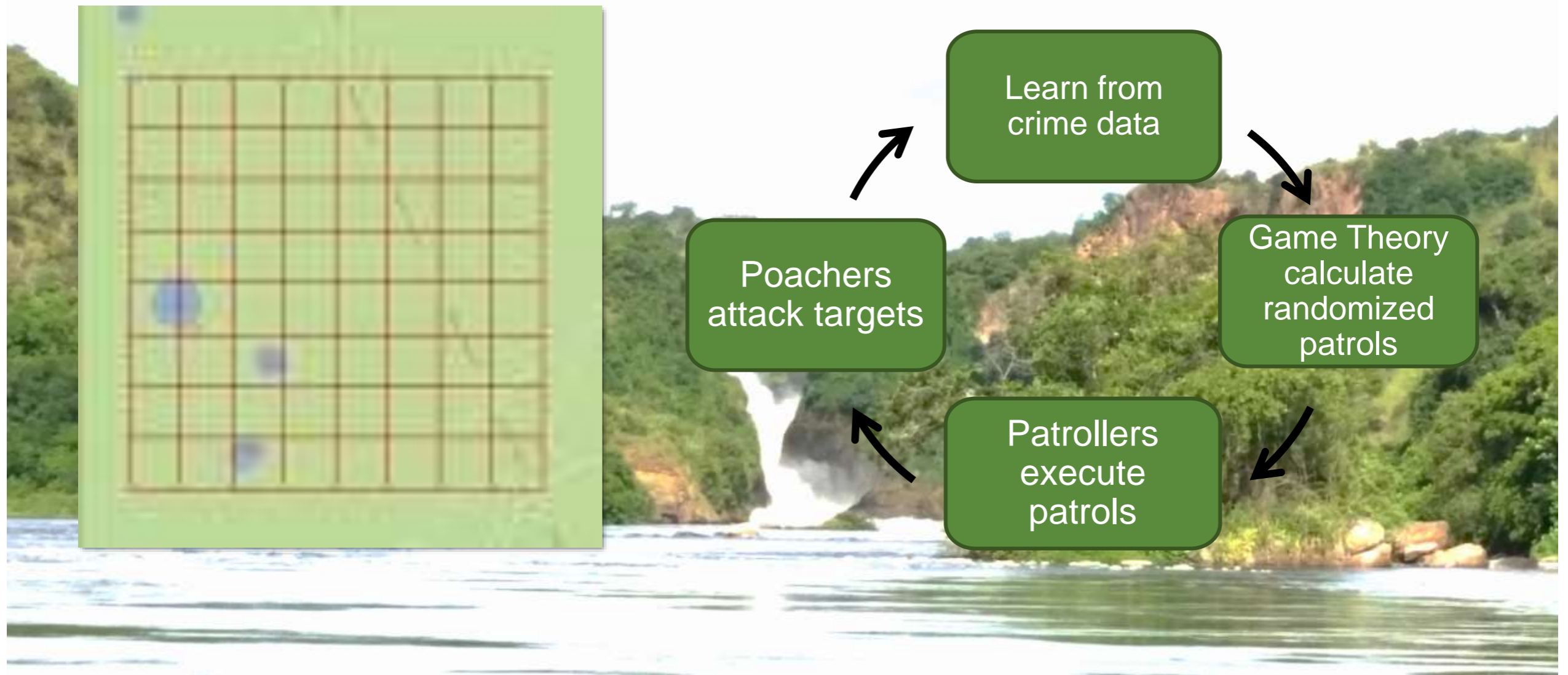


PAWS: Applying AI for protecting wildlife



Fang

Game Theory + Poacher Behavior Prediction



PAWS Patrols in the Field



Fang

Early Trials in Uganda and Malaysia

Important Lesson: Geography!



Uganda



Andrew Lemieux



Malaysia

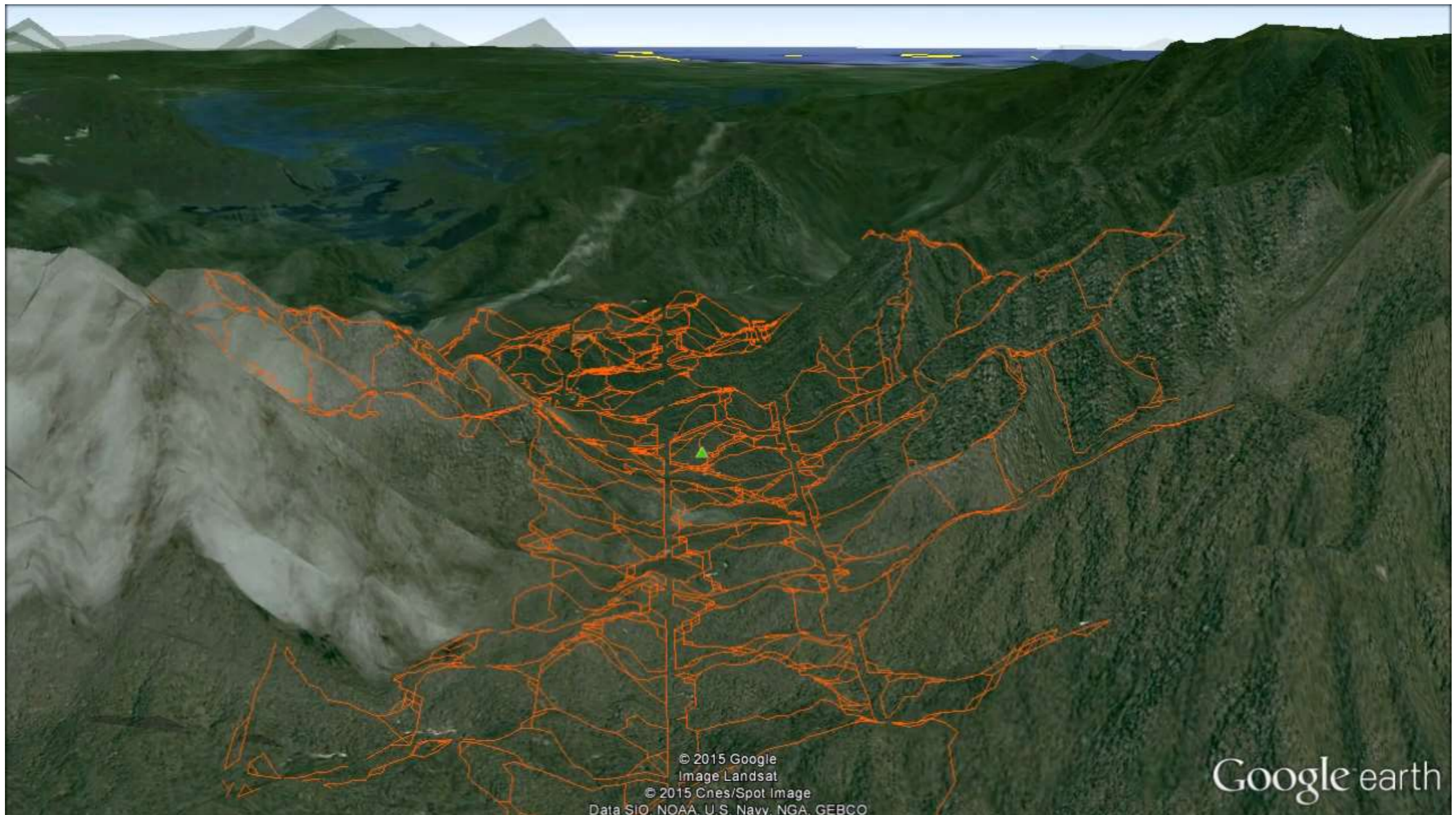


Panthera



PAWS: Protection Assistant for Wildlife Security [2016]

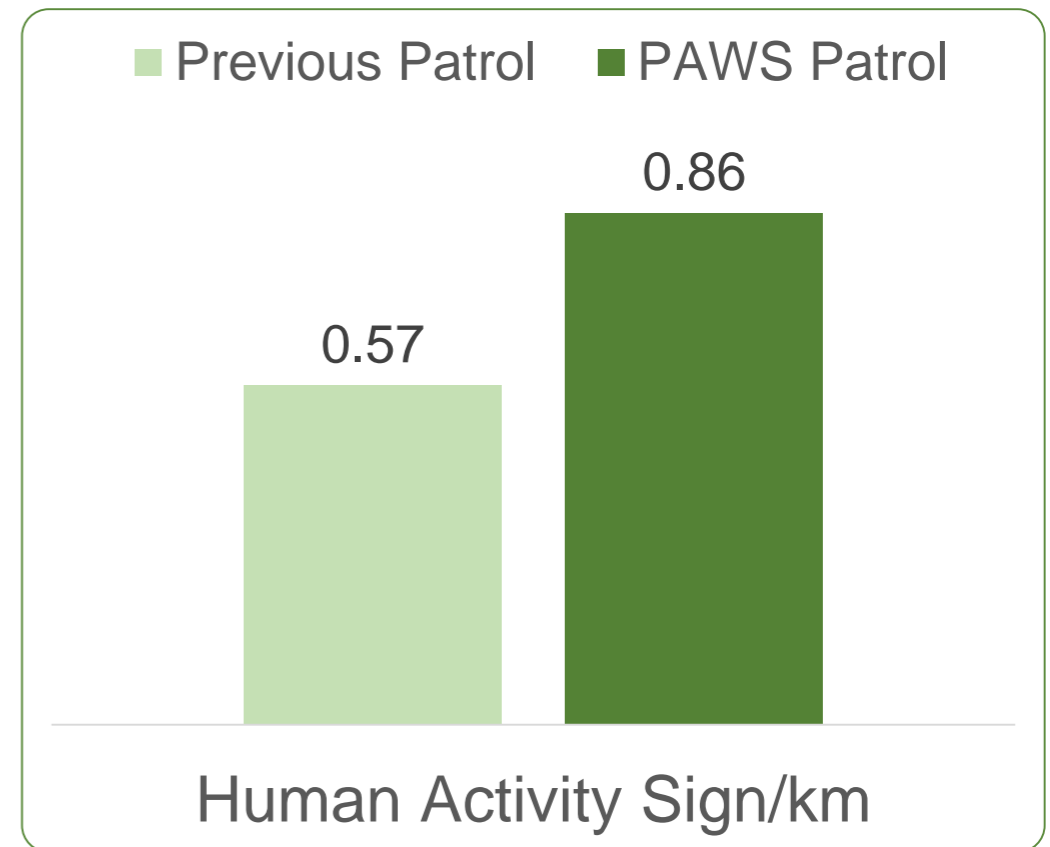
Game Theory + Poacher Behavior Prediction + Forest Street Map



PAWS: Preliminary Evaluation



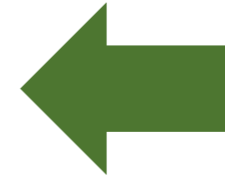
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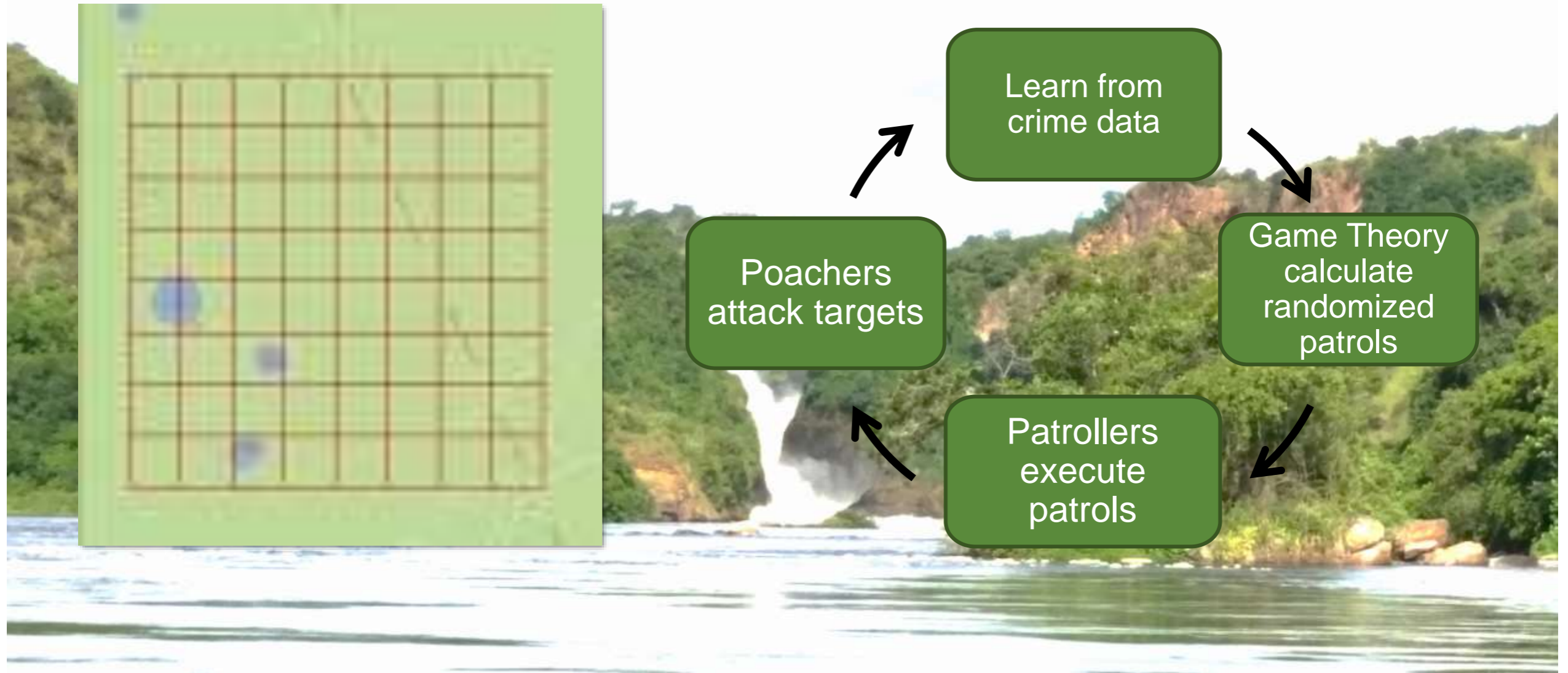
PAWS: Applying AI for protecting wildlife



Nguyen

Game Theory + Poacher Behavior Prediction

Predicting Poaching from Past Crime Data



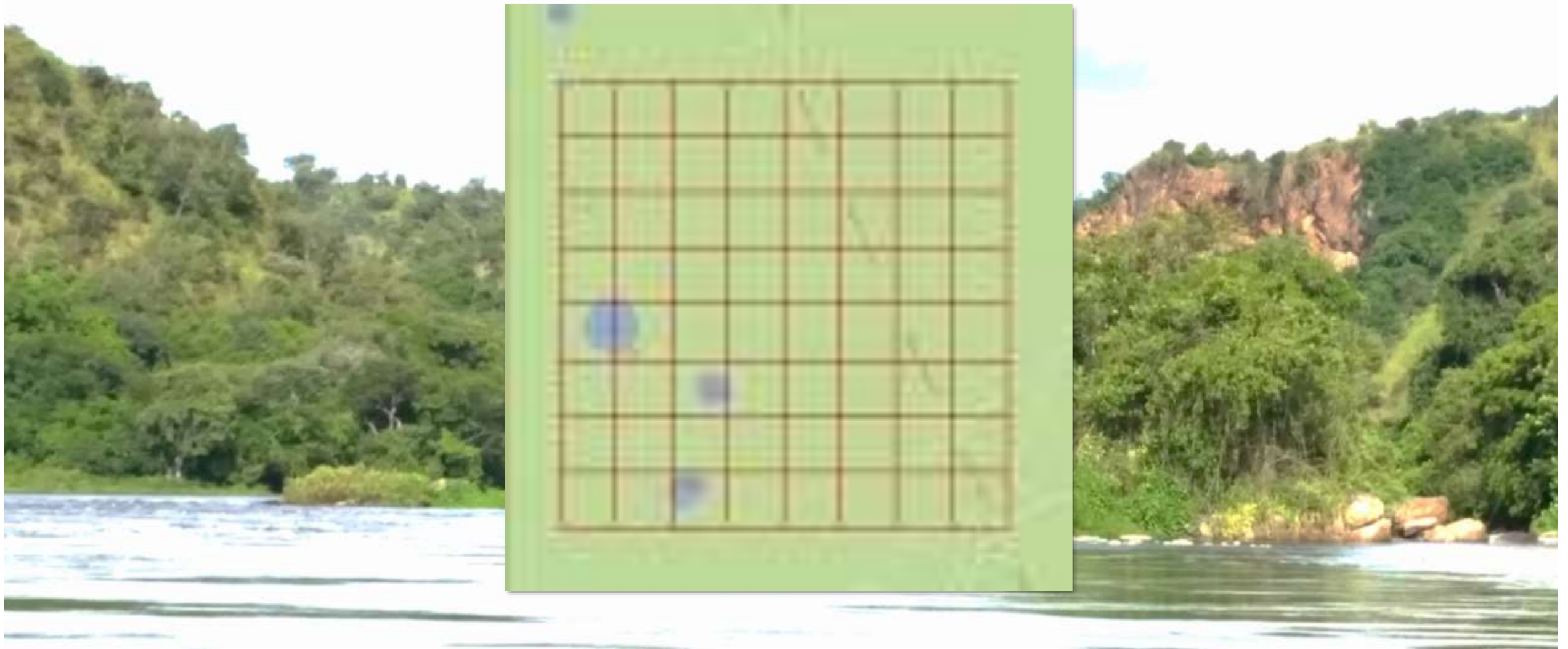
PAWS: Applying AI for protecting wildlife



Nguyen

Poacher Behavior Prediction

Predicting Poaching from Past Crime Data



Poacher behavior prediction



Nguyen

Data from Queen Elizabeth National Park, Uganda

Number of poaching attacks over 12 years: ~1000



Ranger patrol frequency

Animal density

Distance to rivers / roads

How likely is an attack on a grid Square

Area habitat

Area slope

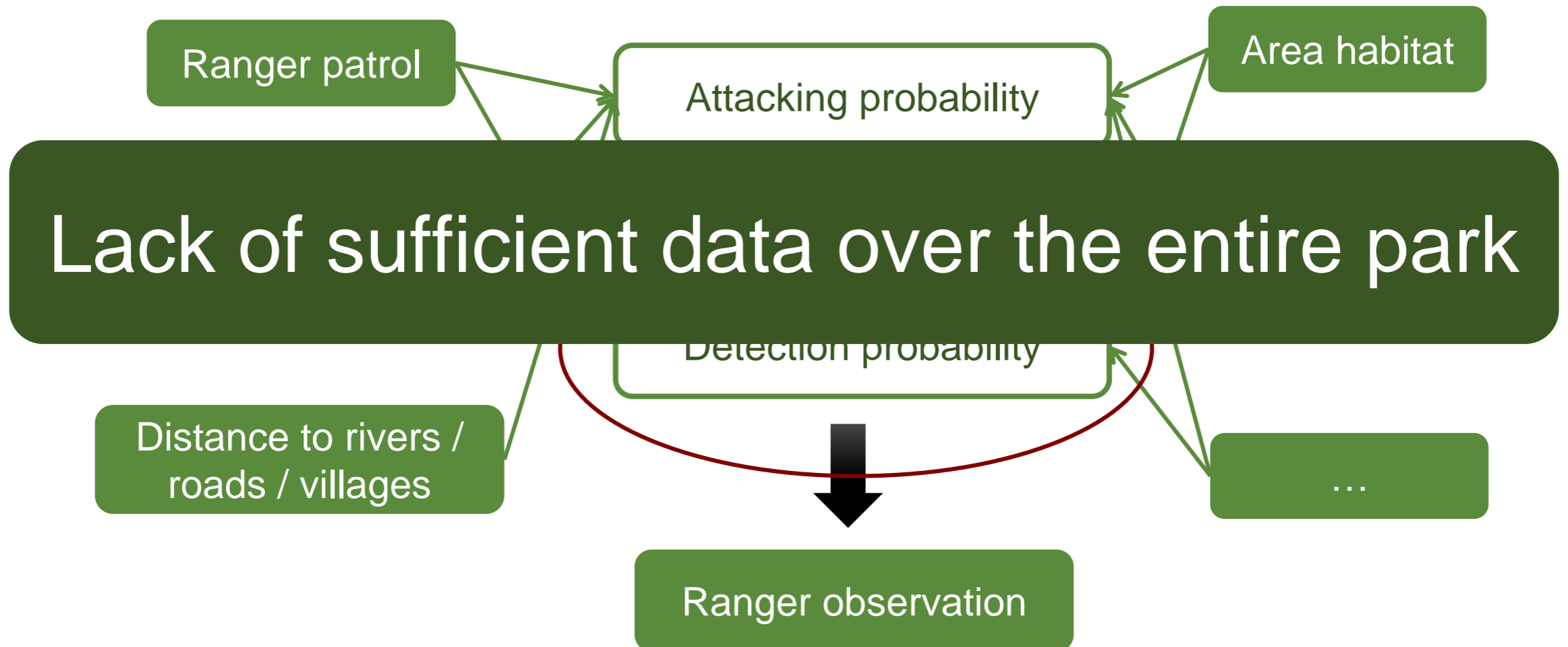
...

Initial Attempt Behavioral Game Theory Models: Dynamic Bayes Net



Nguyen

Adversary's probability of choosing target j =
$$\frac{e^{SEU^{adversary}(x, j)}}{\sum_{j'=1}^M e^{SEU^{adversary}(x, j')}}$$



Poacher Behavior Prediction



Kar



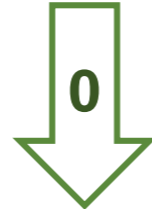
Ford

Poacher Behavior Prediction

Ensemble of Decision Trees (with feature boosting)



Classifier 1



Classifier 2



Classifier 3



Majority



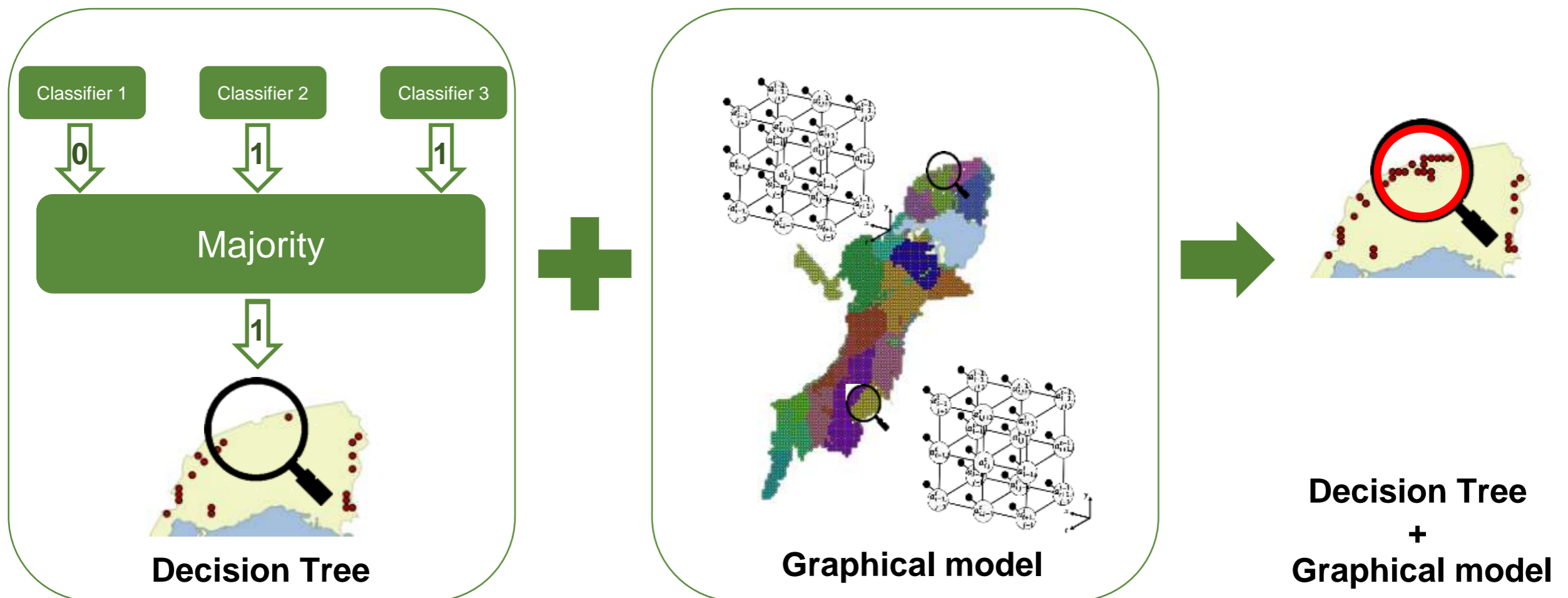
Boost Decision Tree Ensembles with Graphical Models



Gholami

Nguyen

- Boost in “heavily monitored” regions of the park:
 - Improve accuracy
 - Learn local poachers’ behavior; distinct parameters

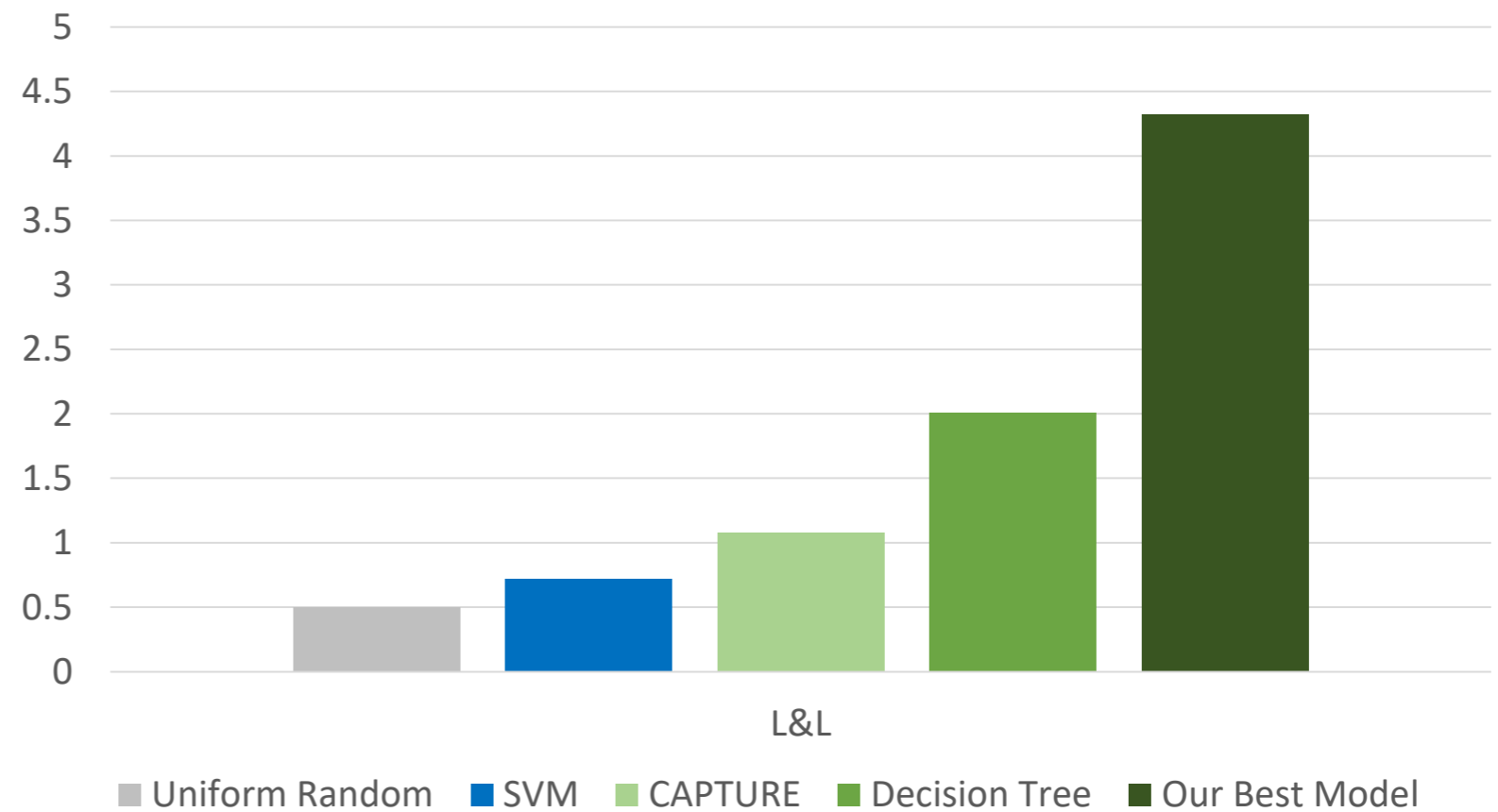


Poacher Attack Prediction

Poacher Behavior Prediction



Results from 2015



Real-world Deployment (1 month)

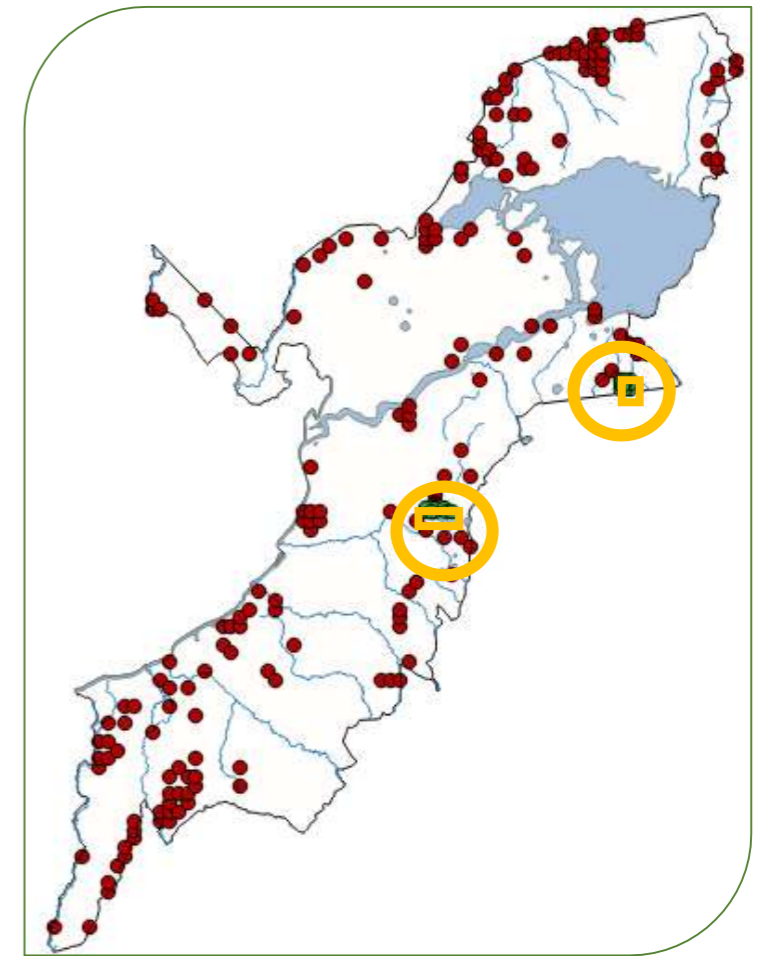
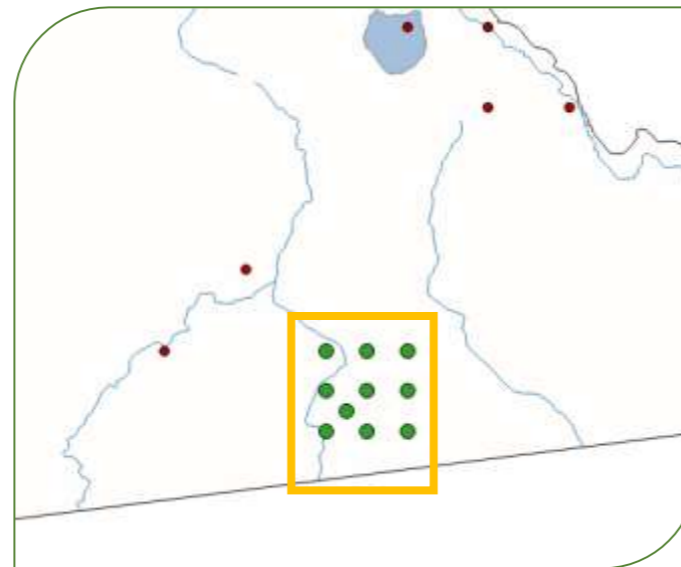
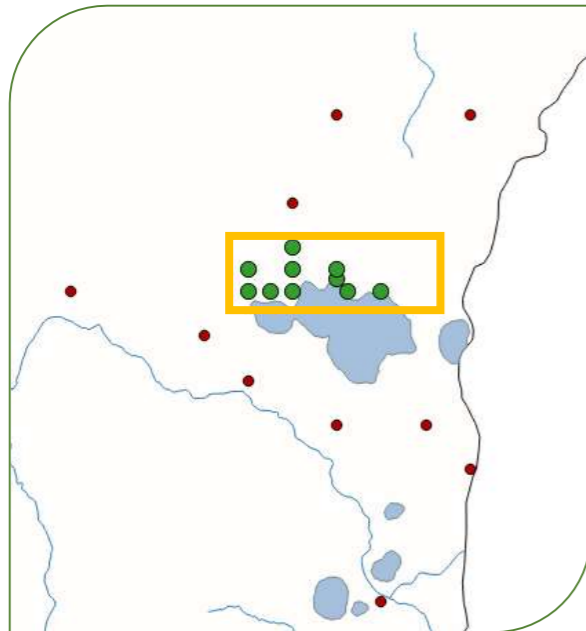


Kar



Ford

- Two 9-sq. km patrol areas
 - Where there were infrequent patrols
 - Where no previous hot spots



Real-world Deployment: (1 month)



Real-world Deployment: Results

- Two 9 sq KM patrol areas: Predicted hot spots with infrequent patrols
- Trespassing: 19 signs of litter etc.
- Snaring: 1 active snare
- Poached Animals: Poached elephant
- Snaring: 1 elephant snare roll
- Snaring: 10 Antelope snares
- Hit rates (per month)
 - Ours outperforms 91% of months



Historical Base Hit Rate	Our Hit Rate
Average: 0.73	3

Real-world Deployment: Field Test 2 (6 months)

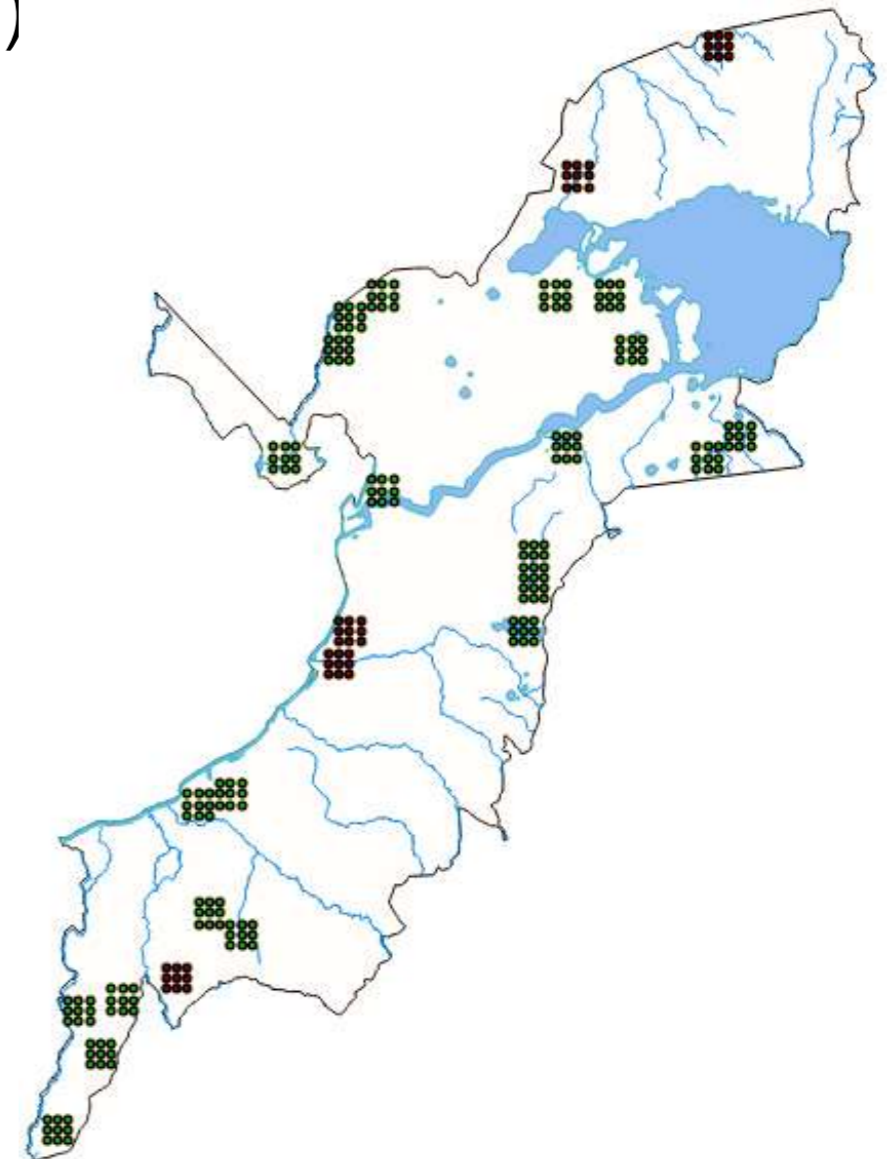


Gholami



Ford

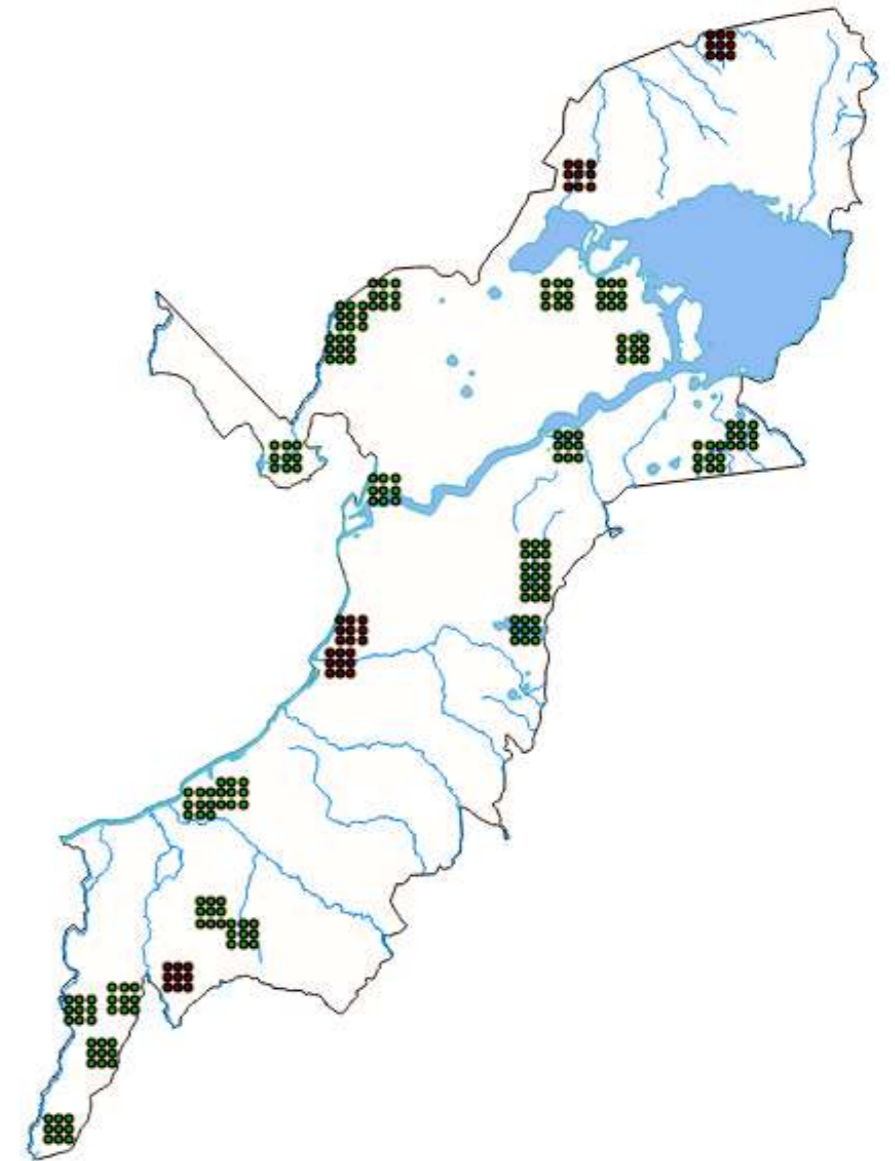
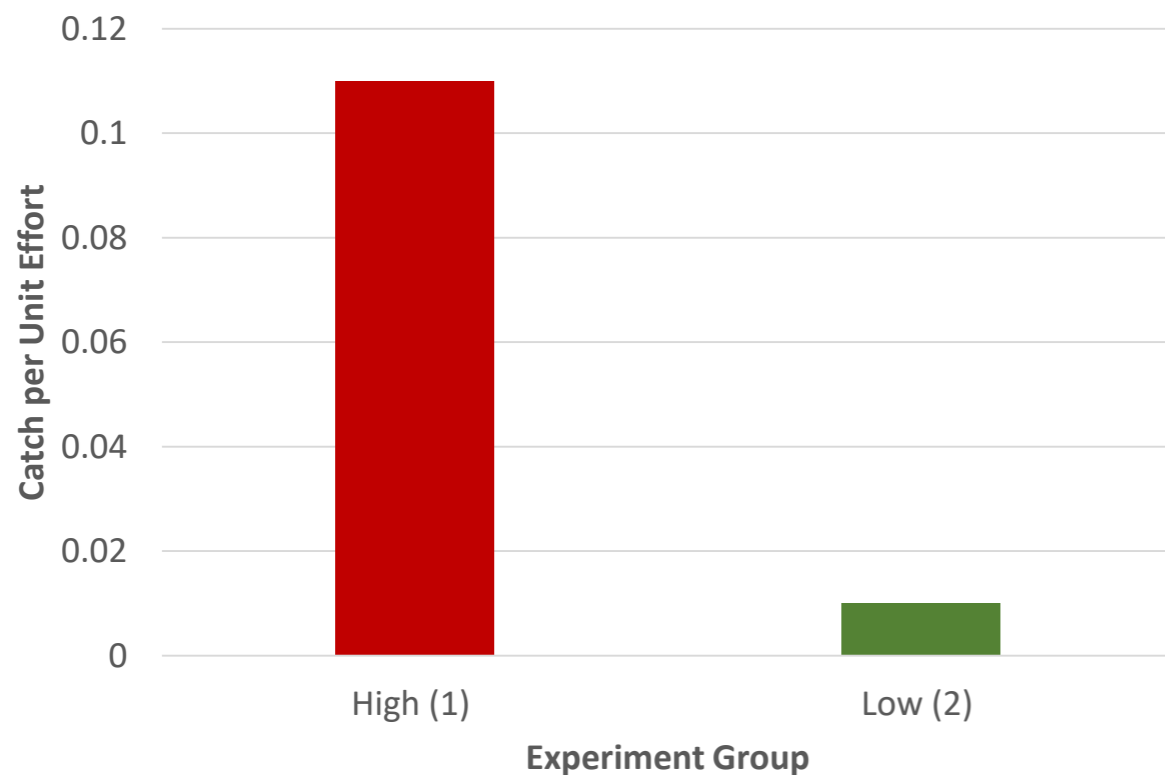
- 2 experiment groups (27 areas of 9 sq KM each)
 - **1: HIGH: 5 Areas**
 - **2: LOW: 22 Areas**
- Rangers trained; unaware of this classification



Real-world Deployment: Field Test 2 (6 months)

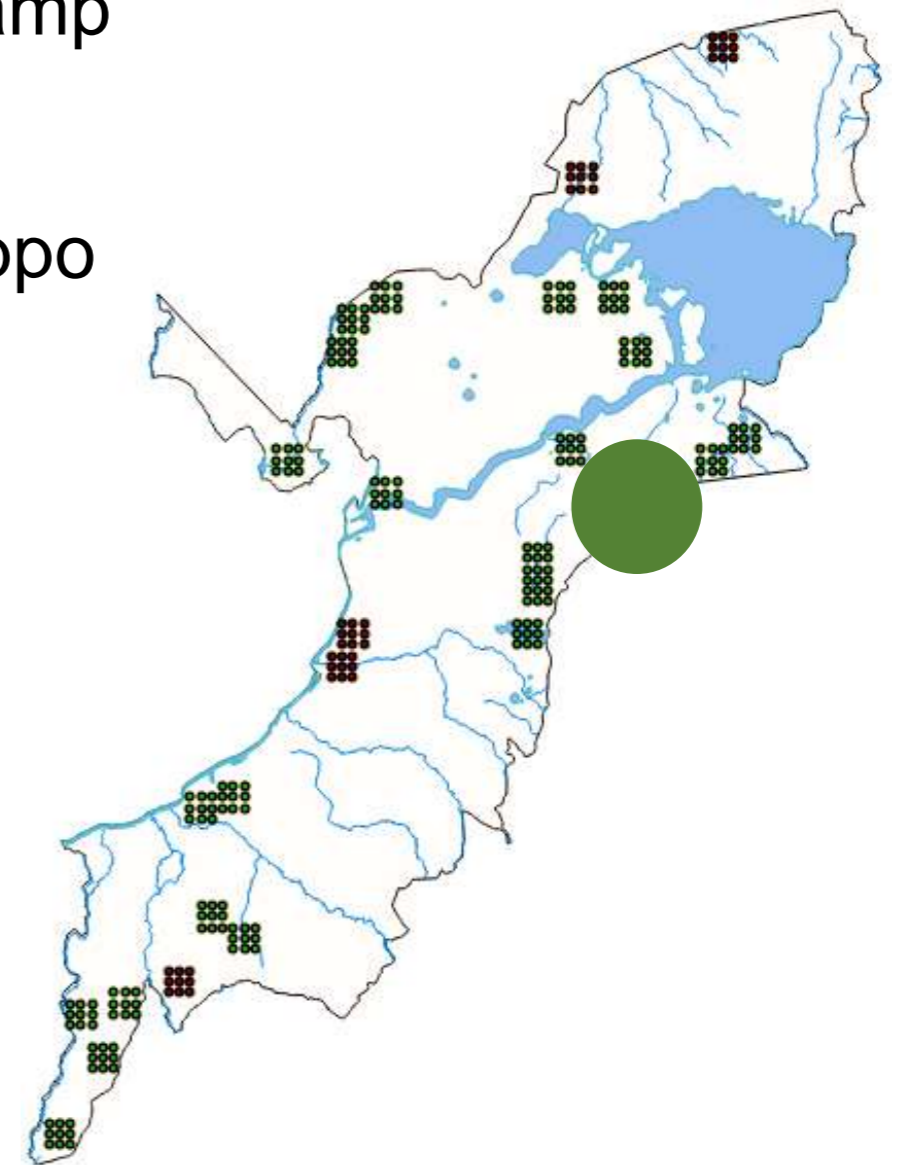
- Catch Per Unit Effort (CPUE)
 - Unit Effort = km walked
 - **Our high CPUE: 0.11**
 - **Our low CPUE: 0.01**

Historical CPUE: **0.04**



Field Test Side Effects: Queen Elizabeth National Park

- Rangers followed poachers' trail; ambushed camp
 - Arrested one (of 7) poachers
 - Confiscated 10 wire snares, cooking pot, hippo meat, timber harvesting tools.
- Pursuit of poachers
- Signs of road building, fires, illegal fishing



Next Steps

- Deployments in other parks
 - Murchison Falls National Park, Uganda (WCS); Cambodia (WWF)
 - Inclusion for general deployment worldwide



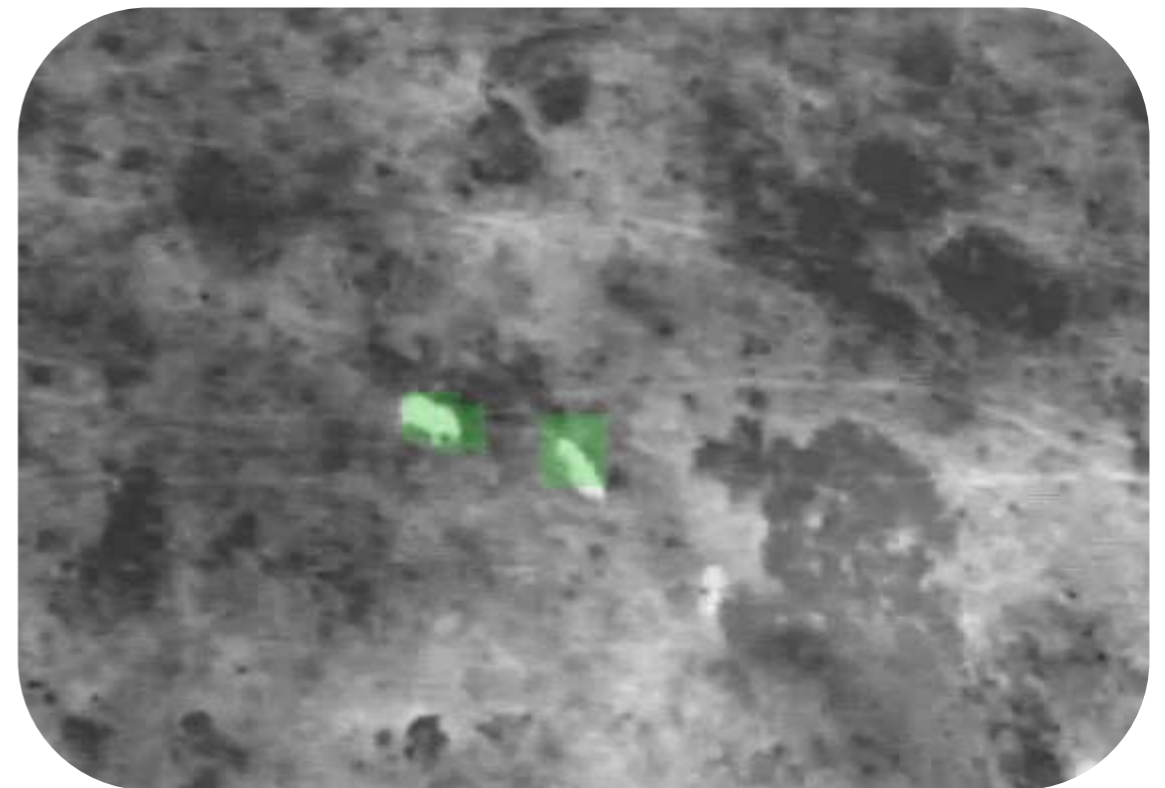
Green Security Games: Patrolling From the Sky



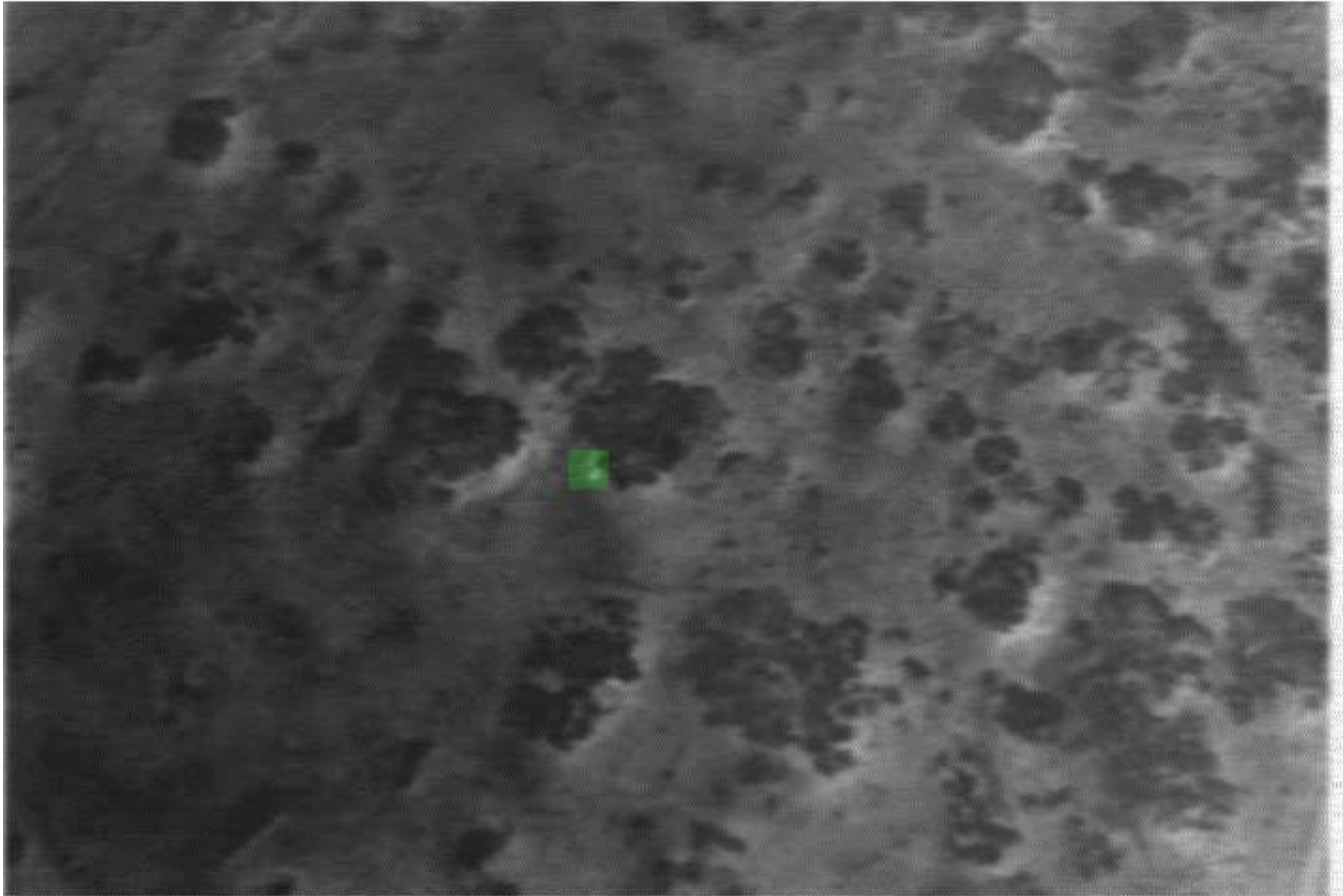
Bondi



Credit:
Arvind Iyer, AirShepherd



Three Poachers Hiding



Towards the Future: AI for Earth

- Significant potential: AI for Earth
- Not just applications; novel research challenges:
 - Fundamental computational challenges from use-inspired research
 - Designing AI for Earth:
 - Interpretability
 - Complementing human autonomy
- Methodological challenges:
 - Encourage interdisciplinary research: measures impact in real world

AI for Social Good





THANK YOU
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