

- The Origin of Science
- The Kalahari San Master Trackers and the
- The Future of Tracking Science



The Origin of Science

- Wallace Paradox: How did the evolution of the human brain enable us to do physics and mathematics?
- Need to show that tracking involves the same reasoning processes as physics and mathematics.



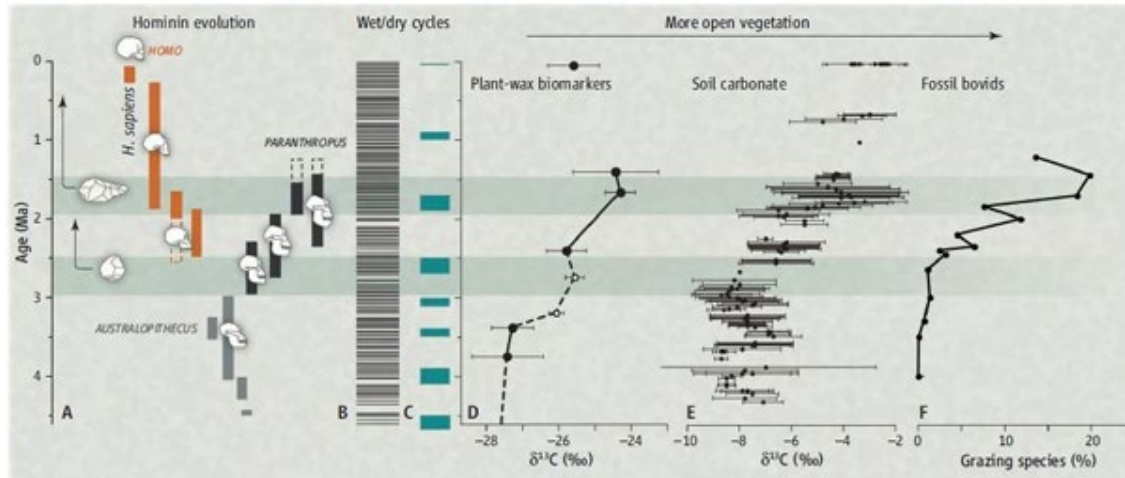
Simple, Systematic and Speculative Tracking

From Inductive-Deductive to Hypothetico-Deductive Reasoning



Climate Change towards more open vegetation

- Makgali Paleo Lake
- Kalahari Sands most extensive in the world
- Wet/dry cycles



The Invisible World

- Karl Popper: A theoretical science explains the visible world by a postulated invisible world.
- Observable properties of the visible world may be regarded as *signs* of invisible structures or processes.
- Nuclear particles cannot be seen. Physicists can only see *signs*, such as “particle tracks.”



The Visual Imagination

- Novel Prediction in Tracking.
- Anthropomorphic Representation.
- Imagine yourself being the animal, feeling like you become the animal – “What would I do if I were the animal?”
- Imre Lakatos: Novel Predictions in Modern Science.



Example of Novel Solution in Mathematics

Creating a New Axiomatic Assumption

MAT201/000/81



UNIVERSITY OF SOUTH AFRICA

DEPARTMENT OF MATHEMATICS, APPLIED MATHEMATICS
AND ASTRONOMY

MATHEMATICS (MAT 201)

SOLUTIONS TO ASSIGNMENT 01 (AND 02)

By solving this system of linear equations, we obtain $\xi_1 = \xi_2 = \xi_3 = 0$. So $\text{Ker}(u) = \{0\}$ and u is therefore injective.

According to Theorem 4.8, page 118, of MAT 103,

$$\dim(\text{Ker}(u)) + \dim(\text{Im}(u)) = 3.$$

So, $\dim(\text{Im}(u)) = 3$ (because $\dim\{0\} = 0$).

Hence $\text{Im}(u) = \mathbb{R}^3$ from which it follows that u is surjective. We have thus proved that u is a bijective endomorphism and therefore an automorphism.

[15]

For u to be surjective it must be shown that $\exists \alpha$ so that

$$\forall (x_1, x_2, x_3) \in \mathbb{R}^3 \exists (x_1 - 2\alpha, \alpha, \frac{1}{2}x_3 - \frac{1}{2}\alpha) \in \mathbb{R}^3 \Rightarrow$$

$$u(x_1 - 2\alpha, \alpha, \frac{1}{2}x_3 - \frac{1}{2}\alpha) = (x_1, x_2, x_3)$$

$$\forall y \in \mathbb{R}^3 \exists x \in \mathbb{R}^3 \Rightarrow u(x) = y. \checkmark$$

we get
Solving for α , $2x_1 - 4\alpha + \frac{1}{2}x_3 - \frac{1}{2}\alpha = x_2$

$$\therefore \frac{9}{2}\alpha = 2x_1 - x_2 + \frac{1}{2}x_3 \checkmark$$

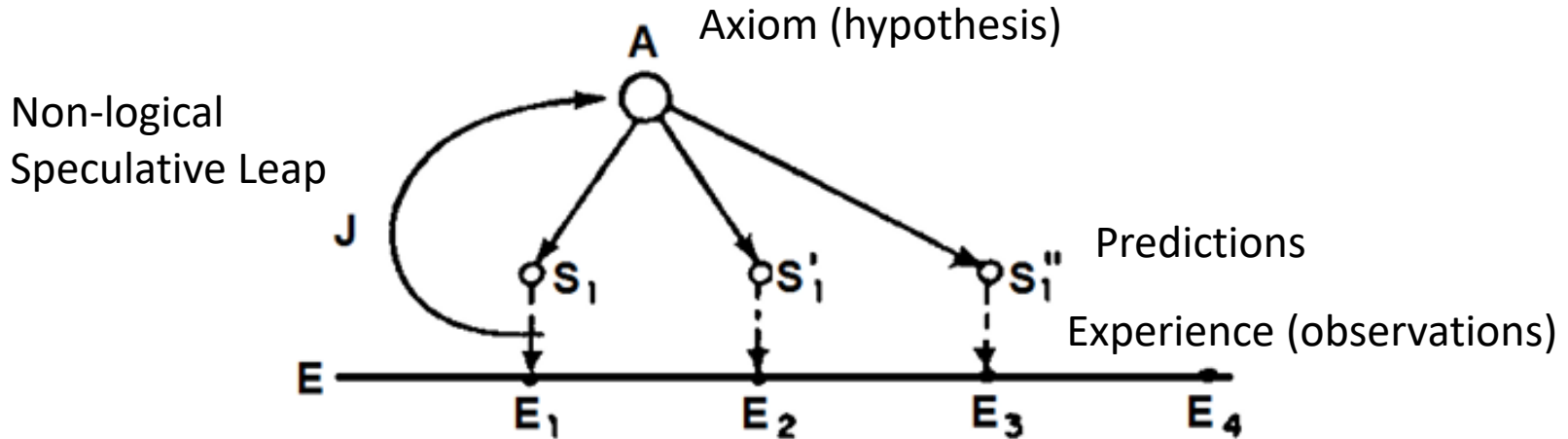
$$\therefore \alpha = \frac{4}{9}x_1 - \frac{2}{9}x_2 + \frac{1}{9}x_3.$$

How did you get this?
It is quite ingenious

assume $x_2 = u(\alpha)$
then for this to

be the case,
it can be shown
that
 $x_1 = u(x_1 - 2\alpha)$
 $x_3 = \dots$

Einstein's model for constructing a theory



Einstein's schematic model for constructing a theory (after Holton, 1986).

Resolving a Paradox

- Solving the Caracal tracks and the Mathematics problem required the *same imagination and reasoning process*.
- To resolve a Paradox or Anomaly between Observation and Theory requires a new Axiomatic Assumption.
- Einstein: Cannot be deduced from experience – must be freely invented.
- Einstein: “no logical path... only an intuitive (psychological) connection”... a “free creation of the human mind” - the “free play” of the imagination.
- Peter Medawar: not illogical but non-logical, i.e. outside logic.

Thematic Presuppositions

- Underlying Simplicity, Symmetry and Unity.
- Unifying “Law-Like” Generalities in Tracking.
- Non-logical Aesthetic sense may be innate.
- Gerald Holton: non-testable Thematic Presuppositions (such as simplicity, symmetry and unity) may guide and narrow down options.

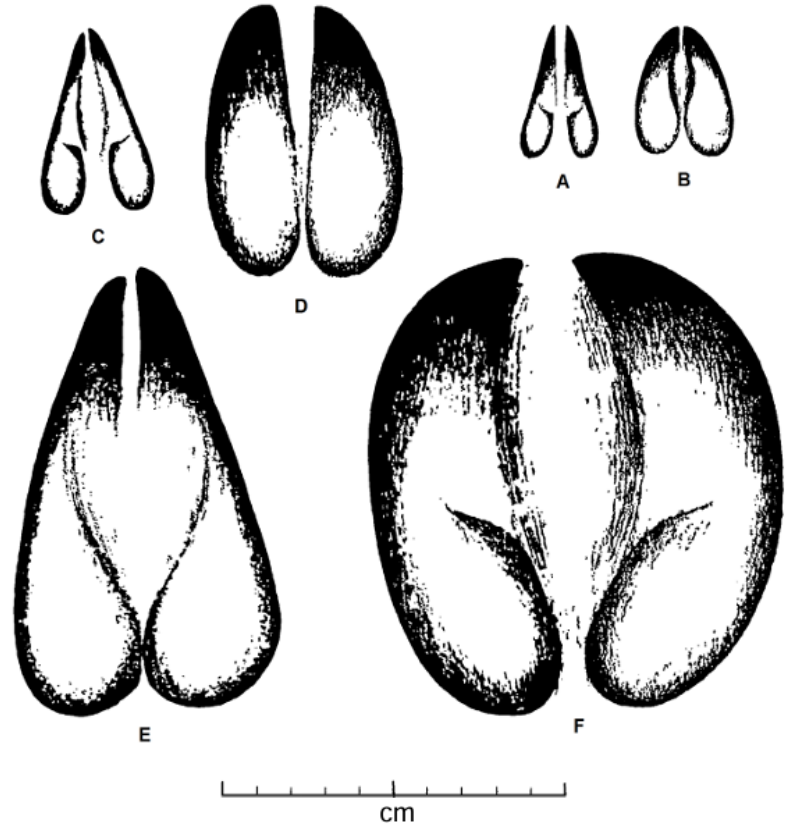


Fig. 3: The right fore tracks of (A) steenbok (B) duiker (C) springbok (D) kudu (E) gemsbok and (F) eland

Aesthetic Sense in Science

- Jacques Hadamard, *Psychology of Invention in Mathematics*: for example, Henri Poincaré - *Sense of beauty* and involves period of *subconscious incubation*.
- *Subconsciously*, the human mind may be able to generate a huge number of combinations until it selects one that “fits” the data and resolves a paradox, resulting in a flash of inspiration - the “Aha” moment.
- Peter Medawar: The *intensity of the conviction* that a hypothesis is true has no bearing on whether it is true or not.
- Mathematical Beauty vs. *Scientific Beauty*: Testable Novel Predictions

Top Down Causality - Non-Reductionist

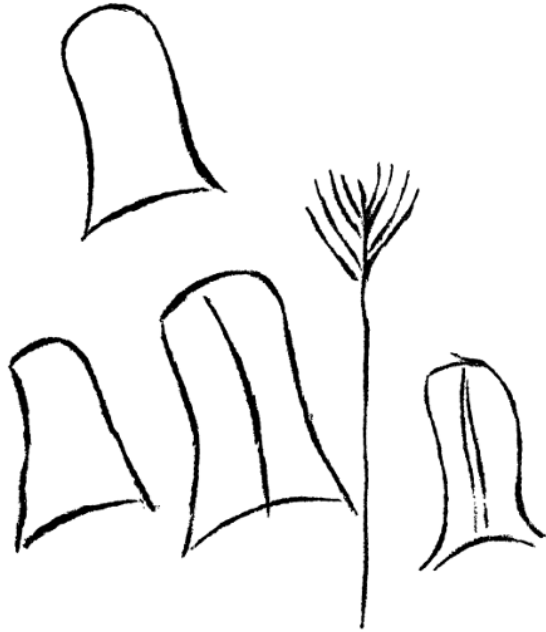
- George Ellis: Top-down causality - Higher-level feedback alters lower-level actions. For example, software determine particle flow in hardware.
- Brain plasticity – For stroke, physical exercise result in new neural pathways. For Bipolar (Hypomania), you can manage depression with positive thinking and exercise, changing the chemical (Serotonin) imbalance in the brain.
- Levels of Feedback: Different individuals may produce different hypotheses, which require critical discussion between individuals, testing of novel predictions, and competing Scientific Research Programmes (Lakatos).
- *Scientific creativity*, resulting in *novel predictions*, may be unique to humans.

Rock Art as Evidence of Science



An early Magdalenian painting in the cave of El Castillo, north-west Spain

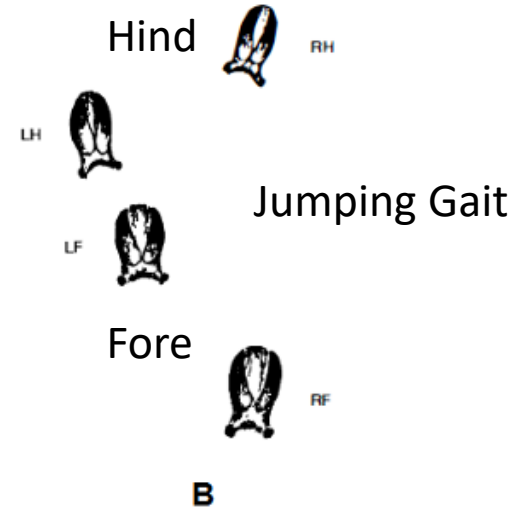
Evidence of Tracking in Prehistoric Art



Hoof track in
soft substrate



A



Tracks of a large ungulate jumping in soft substrate – persistence hunting?



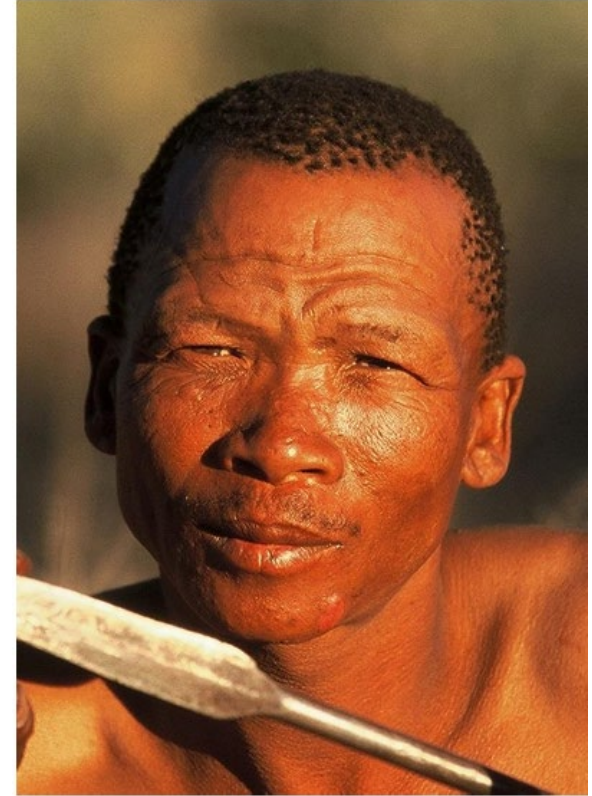
The Kalahari San Master Trackers



Lone Tree: From 1985

Focus on Individuals

!Nam!kabe	/Uase
!Nate	Karoha
Kayate	NxjouKlau
Boroh//xao	





































The Future of Tracking Science

A photograph of two men from the Hamar tribe in Ethiopia. They are shirtless and wearing traditional animal skin loincloths. They are looking at a small green GPS device held by one of the men. In the background, another man is visible, and the sky is a clear, bright blue. The image illustrates the integration of modern technology with traditional communities.

Empowering Communities & Preserving Biodiversity

Our vision is to develop a Worldwide Environmental Monitoring Network.

CyberTracker is being used worldwide by indigenous communities, in protected areas, scientific research, tracking science, community science, environmental education, forestry, farming, social surveys and crime prevention.



The planet saw its hottest days on record



The health of the environment is deteriorating at an alarming rate

70% Decline of wildlife populations since 1970

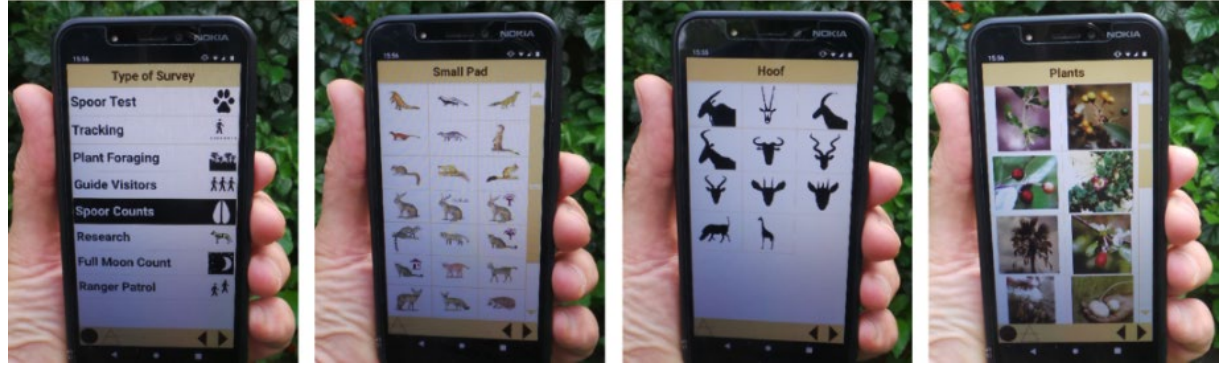
1 Million animal and plant species may go extinct



Challenges

- Not enough professional ecologists and scientists
- Technical skills are scarce in conservation
- Conservation projects cannot afford expensive solutions

CyberTracker mobile uses a simple Icon UX design for nonliterate indigenous and local communities to collect complex biodiversity data



Affordable – mobile phones and tablets

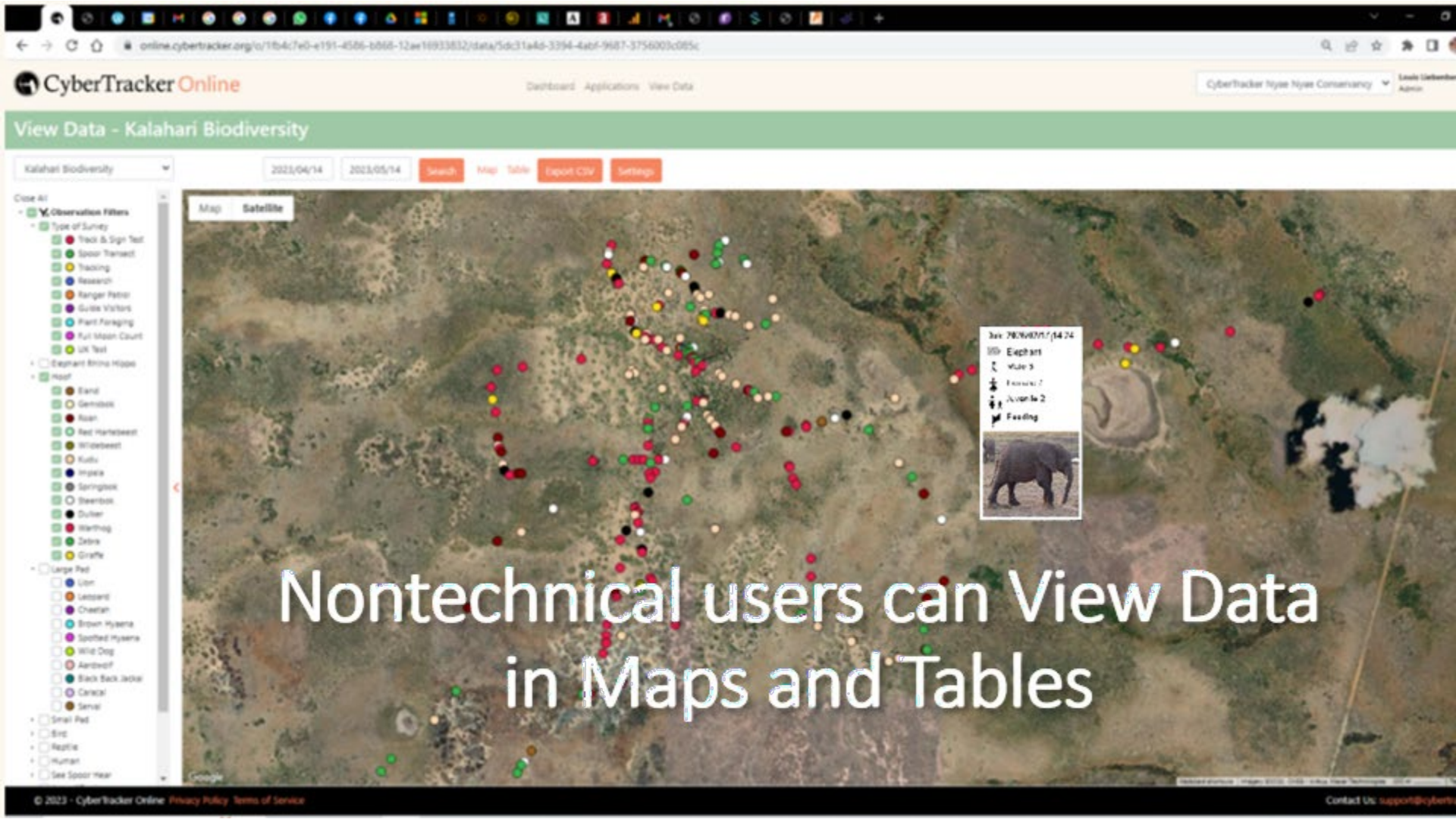
Easy to Use by nonliterate expert trackers

Anyone can customise mobile application

CyberTracker Online Requires Minimal Hardware and Technical Support

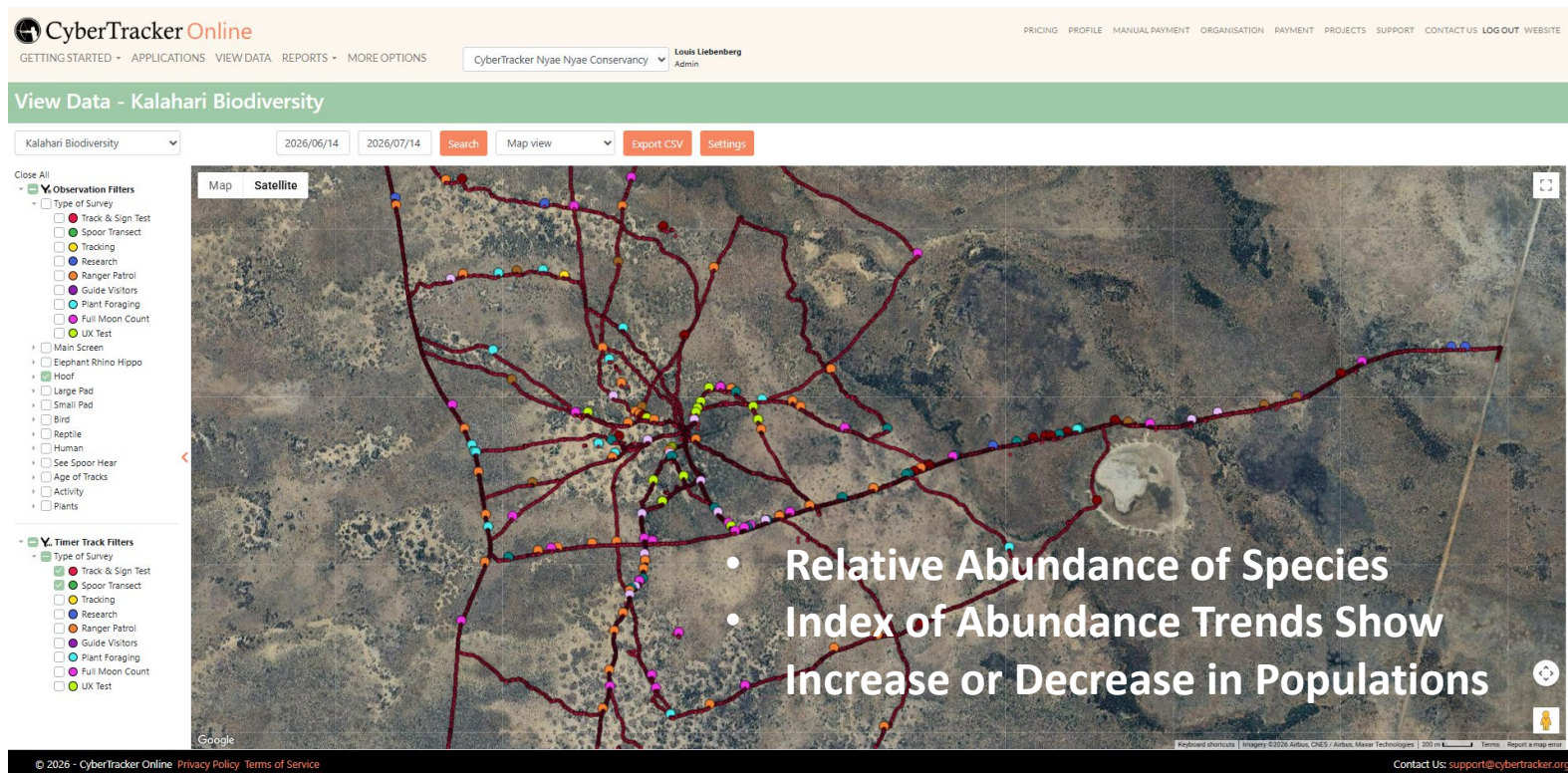


Inexpensive Smartphones for data collection and Tablets to view data



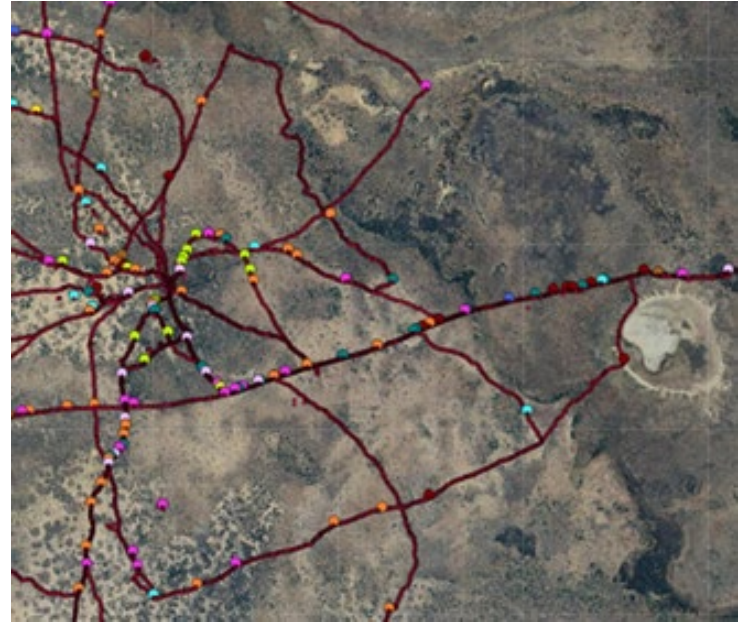
Nontechnical users can View Data
in Maps and Tables

Automatic Data Analysis using GPS Timer Tracks



Traditional Tracking and Remote Sensing

- Use Remote Sensing to identify Ecozones
- Tracking to Ground Truth Remote Sensing Data
- Extrapolate to Areas not covered by Trackers
- Remote Sensing at 1m to 30cm Resolution:
Trackers add data on small species,
Male/Female for large animals, Behaviour of
Animals, etc



Rare and Endangered Species Threatened by Climate Change



- Tracks of Pangolin and
- Small Spotted Cat in Nyae Nyae Conservancy

Camera Traps to Verify Spoor Data

- Scientist are still not accepting Spoor Data as reliable
- Black Footed Cat Specialist Group did not accept our discovery of Spoor in Nyae Nyae Conservancy
- Camera Trap Data to verify Spoor Data of Rare and Endangered Species





A New Sustainability for Indigenous Communities

- Indigenous Communities paid for Biodiversity Data they collect
- Communities empowered to Analyze their own data
- Greater independence and reduced dependency on outside consultants

UNESCO's tracker training helps safeguard Indigenous knowledge



Kalahari San Master Trackers share CyberTracker with Hadzabe in Tanzania

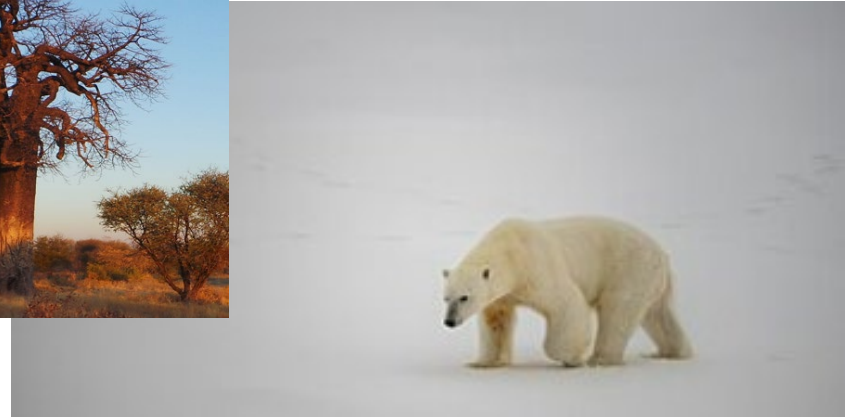
Indigenous Communities & Community Science

- Indigenous Communities share their knowledge with visitors
- Worldwide growth of tracking skills



Scientific Research

Researchers use CyberTracker to study chimpanzees, whales, polar bears, Antarctic sea birds, dolphins, baobab trees, wild dogs, and more...



Conservation Management

- CyberTracker: SMART and EarthRanger in large Protected Areas - requires Technical Support
- New CyberTracker Online for Non-technical Users
- Small Protected Areas.
- Most Endangered Species occur outside large Protected Areas



Beyond Communities & Biodiversity



Farming

Integrated Pest Management reduce the need for pesticides



Forestry & Rewilding

Agroforestry and tree planting



Ebola/Diseases

Used to monitor the spread of Ebola in the Congo

The Future of the Art of Tracking and AI

- The Art of Tracking may be one of the last human skills that AI will be able to replicate (if ever)
- Combining tracking expertise with Domain Specific Symbolic AI on local machines.
- Demis Hassabis, DeepMind: “Einstein Test” for AI?
- Thomas Kuhn: Normal Science (based on accepted theory) vs *unexpected* novelty.





Thank you

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The Origin of Science

can be found at

<https://cybertracker.org/science/the-origin-of-science/>

[Video: Caracal Catch Bird in Mid-Air](#)

BBC Video: The Persistence Hunt

<https://cybertracker.org/video-persistence-hunting/>

Rolex Video: Following the Tracks

<https://www.rolex.org/environment/perpetual-planet/louis-liebenberg-cybertracker-online>



CyberTracker