Unmanned Aerial Vehicles as a Tool for Managing African Elephants

Wildlife Manager Training & Field Trials, Tarangire National Park, Tanzania November 13-17, 2014

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Biodiversity & Wildlife Solutions

mara elephant project

A Collaborative Project of the United Republic of Tanzania; Tanzania Wildlife Research Institute (TAWIRI); Ministry of Natural Resources and Tourism (MNRT) Wildlife Division (WD)–Problem Animal Control Unit; Tanzania

National Parks (TANAPA); Eastern Africa Farmers Federation (EAFF); Mara Elephant Project; and RESOLVE's Biodiversity & Wildlife Solutions & WildTech Project

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Training Wildlife Managers as UAV Pilots

Quadcopter unmanned aerial vehicles (UAVs) are showing promise as a tool for wildlife managers to move elephants away from farms and communities, reducing human-elephant conflict and creating safer conditions for managers in the field. We conducted field trials and training for ten rangers, game officers, and game scouts at Tarangire National Park, Tanzania from November 13-17, 2014. Using two models of the DJI Phantom UAVs, we trained wildlife managers in the use of UAVs as a tool to help them achieve their mission goals. The wildlife managers were trained as pilots, gaining familiarity with the aircraft, covering pre-flight, flight, and post-flight operations, and emphasizing safety. We practiced maneuvers and tactics that are useful for moving elephants in a safe manner, including 'herding' maneuvers and tactics, moving vehicle deployment, and chili-powder and strobelight deployment. The wildlife managers gained a solid base of flight skills to work from and practice, an understanding of what it will take to become an effective UAV pilot when working with elephants, how to maintain the equipment, and how to humanely and safely use this tool to support their missions.

The workshop was led by Marc Goss, who has trained several rangers with the Mara Elephant Project to fly similar UAV models. The course was designed to get the rangers to think like pilots; that is, being responsible for your craft, thinking ahead to avoid obstacles, and combining several basic maneuvers to complete a mission. Marc used a 'military-style' approach when teaching the rangers, which they responded to well.

Field Trials with Elephants

The proof-of-concept flights demonstrated the potential utility of the UAVs for managing HEC. The wildlife managers and officials from TAWIRI, TANAPA and Wildlife Division were present to observe the response of elephants to two UAVs in three field trials. The rangers and scouts were able to see first-hand how effective the drones were, and the tactics needed to herd elephants.

Response to UAVs

Three daytime-field trials were conducted, one with a family group in open bush, one with two bulls in thick bush, and the third with four bulls in an open savanna. In all

cases, the elephants were observed browsing and grazing, and had little to no response to the arrival of our vehicles. Responses to the drones were similar in all three tests, with elephants taking flight almost immediately, with no vocalizations, and their flight was sustained, the last trial with bulls being moved for over twenty minutes. No chili powder or strobe lights were used in any of the trials.

The flights demonstrated that elephants in two different areas (Maasai Mara and Tarangire National Parks; the former trial being conducted in September 2014) could be effectively herded using UAVs. Further field trials are required to understand the full range of conditions under which the UAVs may or may not be effective, including while they are feeding in crops and at night. However, the strong reaction and ability to continuously move them for up to 20 minutes showed that they respond strongly to the UAVs when they are flown with effective herding tactics. The rangers said that they had never seen elephants react to a mitigation tactic that quickly before. The government officials said that they believed the UAVs had good potential as an HEC mitigation tool for use by wildlife managers.

Data Sheets

Data sheets were designed prior to the training to help collect information about each flight which can be used to determine the overall effectiveness of the UAVs with elephants over time. TAWIRI provided input on both the content and Swahili translations that we can fix before the UAVs go into heavy usage. We also discussed with the Rangers how to fill out the sheets, and decided that having a pre-determined person responsible for filling out the data sheet would be the most surefire way to make sure they are filled out in the excitement of the mission. TAWIRI also offered some support for the data sheets, and there was preliminary discussion of having a TAWIRI scientists in the vehicle to document the mission. Having someone with previous experience in data collection would allow us to create a more detailed data sheet as well.

Lessons Learned & Improvements for the Future

This formal training workshop, as far as we know, was the first training of its kind anywhere in the world. Our review of the training has provided us several lessons learned and suggestions for future improvements. While the Rangers came away from the training with a good foundation of piloting skills, the length of training and program should be longer. This would allow for more practice flying with elephants and learning night and crop operations and tactics. The workshop occurred after the harvest season so crop raiding was at a minimum, limiting opportunities for field practice in crops and at night.

Herding Skills & Tactics Important

The link between the maneuvers during practice sessions, and how they translated into effectively and safely (for both humans and elephants) moving elephants was not made clearly enough. Flying skills, such as the quick stop and fast-turning sweeps

(the 'TAWIRI turn'), are essential to master for herding elephants safely and efficiently, but we saw during the third day during an elephant simulation drill that they had not yet mastered these flying skills or tactics to the rangers. More emphasis on 'herding' tactics with practice in the field is recommended. Subsequent training and practice sessions should be established for the rangers after the workshop so that they can continue to build their pilot skills. Perhaps working with a particularly proficient ranger-pilot who can continue to train the others is an optimal approach.

Maximizing Flight Time

A key consideration is how to arrange each day so that there is not too much downtime between flying sessions, due to limited battery life. Maximizing flight time is a goal. However, the number of batteries and chargers available to us was deemed insufficient for this particular training. This can be mitigated easily in future trainings by using parallel charging boards that allow charging of up to 6 TX60 batteries per charger.

Identifying Ace Pilots – Training the Trainers

Trainers should identify the best potential pilots over the first flight sessions and may want to focus the training on these individuals (especially if batteries and UAVs are limited), allowing them more time with the controls in their hands. These 'Ranger Pilots' would then become proficient enough to teach others in their unit after the workshop. This specialist group could also become *de facto* response units, assigned to different Tanzanian regions or ecosystems and traveling to HEC hotspots with habitual raiders during the crop-ripening season. TAWIRI felt that working closely with Village Game Scouts was a good approach as they are closest to the crop raiding and can respond fastest, they are part of the local communities, and they are not transferred from one area to another as some rangers are at times.

Training UAVs

The four UAVs at the training handled crashes well, and all were still functioning at the end, but damage to UAVs during training could be minimized in the future by having cheaper 'training drones'. If UAVs are donated, this approach will not leave a battered squadron with the rangers. New prototypes, especially those that are water- and dust-proof and crash-resistant, may make this approach cost-effective.

Night-Flying

Night operations will be essential for crop-raiding mitigation as most raiding occurs after dark. Safe operation and night-herding tactics are both essential part of a robust training course. We conducted one night flying training session, and while it went well and the UAVs were easy to see in the night, obstacles were difficult to discern. A strobe on the front would help illuminate some obstacles, and perhaps elephants, and will help the rangers tell the direction the drone is facing. Effective night tactics might include carrying out broad sweeps that are increasingly further and further from the pilot that will herd elephants away from the operator across a

broad front. This may be particularly effective if elephants begin to associate the UAV with chili powder and strobelights. Another potential tool may be to use a second UAV that hovers at 30 m with a FLIR that can tell the operator on a tablet where the elephants are and that also tracks the other UAV to allow for efficient herding. Rangers also suggested a large spotlight attached to the vehicle to provide more light on the field of operation. If elephants can be 'trained' to associate UAV noise and lights with chili-powder and strobe lights then the efficacy of night operations may be greatly enhanced.

UAV Flight Profiles

The difference in handling and maneuverability in the two UAV models employed (DJI Phantom FC4 and Vision) was much more noticeable when flying with the elephants. The newer model has been made to fly more stable, with a focus on cinematography, rather than fast flying, and wasn't able to keep up with the older version during flights. This should be something to consider going forward with custom models and the E2D2 prototype design. Even a slight decline in maneuverability plays a more significant role in the UAVs effectiveness than previously thought, so longer battery life and other high-weight attachments may not be worth it if the drone is incapable of nimble and fast-reacting herding of elephants.

Safety Considerations

No injuries to people or elephants were sustained in this training, other than an accidental drop of chili powder on trainees and officials. Marc Goss spent considerable time teaching safety protocols and airspace guidelines to the rangers, including assessing the flight situation prior to takeoff, landing if aircraft are heard or seen, landing if birds of prey are interacting with the UAV, avoiding obstacles and people, maintaining momentum of herding on agitated elephants, and not harassing young elephants.

Three situations in future trainings must be carefully addressed to avoid safety incidents:

1) One is the need for careful deployment and management of chili powder on the UAVs and in the trucks. The chili has a tendency to get everywhere if not properly handled and contained, and incautious release of UAVs can cause chili to get in operators' eyes.
2) The second is the release of the UAV in the moving vehicles by the co-pilot. The release must occur after the motors have gained sufficient power to lift the UAV straight up, releasing it early may cause the UAV to slide downwards and backwards into the truck, potentially injuring personnel. The pilot and co-pilot must communicate well on this, and the pilots must watch the UAVs throughout the mission, not face forward all the time, unless tracking the UAV on a tablet video.

3) The third situation, one of great importance, is *ensuring that the pilots have sufficient skill to continuously herd the elephants away from the operator and other people*. Their herding skills must be such that they maintain pressure, at close distance (but not too close as to hit obstacles or be swatted by a trunk), to keep up the motivation and action of the elephants to move away from the vehicles, people, communities, and farms. Poor piloting skills, interruption in herding pressure, or other actions that may lead to elephants turning back or towards people can result in injury or death from aggravated and frightened elephants. This is a key consideration.

Airspace Guidelines

The Tanzanian Civil Aviation Authority representative said that as long as operations were under about 100 feet (33 m) and if pilots always landed the UAV if airplanes or other aircraft were seen, heard, or suspected of being in operation nearby, then use of UAVs for HEC mitigation was not an aviation concern at this point. Pilots have no need to ever go above 100 ft and should be trained to avoid this action. Rangers should also alert local airstrips and operators of their use of UAVs and their safety protocols. For example, an ultralight for wildlife surveys was in operation at an airstrip near the training site at Tarangire and they should be informed of UAV mitigation and training activity.

Experienced & Skilled Trainers are Essential

Marc Goss and his MEP ranger were excellent teachers and led the training very well. Looking ahead to future trainings with Tanzanian partners and perhaps with Kenya Wildlife Service and wildlife managers in Nepal, we strongly recommend that Marc Goss should take the lead in those trainings as he knows the UAVs and elephant herding tactics and behavior very well, easily has the most experience in herding with UAVs in the world, and has an excellent rapport with rangers. While he has a good relationship with KWS, a Nepal training will require someone in an organizational role, such as Eric Wikramanayake, who can bring key political figures to the workshop and remain in a supportive role after the training. There should also be an effort to bring more women wildlife managers and officials to these trainings.

Further Training is Essential for Success

Our Tanzanian partners have requested that further trainings occur in the near future, either by some of our staff training some 'ace' pilots in the field, having a liaison in the field while conducting operations for a certain period of time, or having some rangers visit the Mara Elephant Project camp for further training in the near future.

Best Practices

We did not use chili flakes with seeds in the training as the ecologist from TANAPA did not want chili seeds strewn on the landscape to turn into an invasive species. This is a good best practice – powder and dry grass to attain the proper texture works fine. We also covered best practices for interacting with elephants – elephants

should never be touched or injured by the UAVs; one should always avoid harassing young elephants, especially dropping chili powder near them, as distressed young elephants may make mother elephants act defensively, either creating chaos or attacking – both actions that do not help herding elephants in a particular direction – and creating a dangerous situation; matriarch and mother elephants may be good to target appropriately to get the herds to move out in an organized way; a rapid, pronounced, and sustained (one cannot let off) 'harassment' is likely essential to move elephants effectively; after elephants associate UAVs with chilies, and if they move with just UAVs about, the use of chili should be curtailed as a humane best practice.

Recommendations based on discussion with participants

- Next Generation HEC Management UAV Prototype recommended features
    - Weatherproof (water- and dust-proof) is essential, motors need to have rubber seals and vents covered
    - Strong strobe/spotlight for operation at night – will help pilot during night flights and deter elephants
    - Chili dropper (although DO believe bags and duct tape are easy and problem-free and materials are easy to get, also chili will not linger on UAVs)
    - Improved to increase visibility and know which way it's pointing from far away (more color?)
    - Include VHF indicators, strobe lights, or glow sticks for easy night recovery
    - Autopilot
    - Increase size of drone to improve visibility – This could hamper maneuverability though, so we continue to recommend DJI model size or smaller.
    - Propeller protectors for safety and to reduce damage
- UAV sound not audible enough at 300 meters – Need to increase the sound if possible, presently close herding is essential to move elephants and they seem to respond even if UAVs are at distance
- Short battery life – Rangers asked for 1 hour
- Parallel charging board for multiple battery charging, truck-adaptable
- More batteries
- Solar recharging system for batteries – possibly on UAV to charge while flying?
- More UAVs
    - Cheaper UAV for initial trainings
- More spare parts
- Good ziplock bags, with real locking zippers and Gorilla Tape or good duct tape
- Small screwdriver set for UAV maintenance and repair
- Binoculars for rangers

- FLIR/night vision to practice flying at night
- Large smartphone tablets for viewing UAV location and view
- Glowsticks
- Large torch on vehicles to light up area around UAVs at night
- Superglue
- Conserving/reducing costs
    - Should be reduced in subsequent trainings in Tanzania as research fees are covered already
- Consider specialist training for smaller group of rangers who can respond to hotspots around TZ ecosystems
- Recruit more women participants

Training Program

Day 1

- Introduction to the use of UAVs as a tool to achieve goals of wildlife manager missions – the objective is the mission of moving elephants away from crops and people, not flying or retrieving the UAV
- The importance of safety and safe-flying guidelines
- Familiarize rangers with the basic parts and controls for both models by laying one out on a table and explaining each component
    - UAV
    - Transmitter
    - Batteries
- Demonstrate flight controls (with UAV off) by having rangers use the controls and trainer moves UAV in accordance
    - Good for showing how the forward direction changes based on the UAV orientation
- Teams assembled for first flights - lasted approximately 2 hours, until batteries ran out. Batteries were shuttled to the chargers as soon as they died and this helped increase the training time significantly. In the future there should be parallel charging boards available to increase charging efficiency
    - 2 Rangers per trainer
    - It is important to have the rangers assemble and care for the UAV themselves, so that they become responsible for the device
    - Basic flight maneuvers
        - Power on, take off, hover, land
        - Power on, take off, yaw 360, land
        - Power on, take off, fly forward, turn and fly back, land
        - Power on, take off, fly a square/rectangular pattern, land
    - Moderate flight maneuvers
        - Quick stops
        - Continuous turns using yaw and forward direction
    - Advanced flight maneuvers – These were done in succession, so that each ranger flew while the others watched

        - Sweeping – maneuver used in herding elephants, **A FAST SHORT BACK AND FORTH SWEEP WITH A MID-SWEEP HALF TURN (FACING THE OTHER WAY) IS AN ESSENTIAL SKILL AS IT ALLOWS RANGERS TO HERD ELEPHANTS EFFECTIVELY AND IT CREATES A LOT OF NOISE, THIS MANEUVER IS CALLED THE 'TAWIRI-TURN'**
        - **BEING ABLE TO USE BOTH CONTROLS SIMULTANEOUSLY TO CARRY OUT REFINED AND COMPLEX MOVEMENTS IS AN ESSENTIAL SKILL AND SHOULD BE A FOCUS OF TRAINING**
        - Focus on smooth changes in direction
        - The rangers did not master these maneuvers during the workshop and more practice is required
    - Maintenance
        - Cleaning out motors
        - Replacing damaged props
        - Cleaning off dirt, moisture, chili, and plant material
        - Looking at fuselage to see if it has become unaligned
        - Inventorying all parts in case
        - Unplugging batteries
- Break for Lunch / Re-charge batteries
    - Obstacle course was set while the batteries finished charging
- Obstacle course session
    - Focus on flying around and behind objects
    - Smooth movements
    - Flying with confidence
    - When a Ranger completed the first course, he graduated to a more difficult one

Day 2

- Proof of Concept Demonstration for government officials and 5angers
    - Daytime testing of UAVs without chili on 3 elephant groups during morning (family group in open bush, bull herd in dense bush, bull herd in open savanna)
    - Allowed rangers to see the UAVs in action and response of elephants
- Discussion on improvements for UAV with all participants
- Flight session
    - FPV flight training (using camera on tablets on control device)
    - Free flight – practicing maneuvers
    - Civil Aviation Authority flights
- Night flight session
    - Free flight
    - Hand-held FLIR to see the UAVs at night – didn't work well, but could see trees etc., could be mounted as FPV on the UAV

Day 3

- Herding Practice at distance and close using staff (David, Nathan, and rangers as 'elephants')
    - Sweeping maneuvers --> practicing smooth banking and combination moves
    - Depth perception/ when is the UAV in the right position
    - How close to the elephant does one have to be to motivate it to move, rangers were elephants to understand the noise and annoyance of UAVs
    - Optimal height and obstacle avoidance
        - Used stick to mimic the highest point of an elephant
    - Keeping effective pressure to move elephants with the UAV in the right direction without interruption or back-tracking – maintaining herding tactics and proximity and height is essential
- Chili Powder-Deployment
    - Mixing the right texture of flakes and powder (one can use dry grass with powder if necessary)
    - Preparing the bag and attaching to the drone with issues of placement, hole size, release in the air, release of UAV to avoid chili in the eyes, chili in the eye first aid, best types of bags to use
    - Wind considerations when deploying chili
    - Discussion of tactics in chili deployment
        - Focus on matriarch
        - Don't go after juveniles
        - Fast and substantive approach and deployment right away, sustained
- Battery charging for both UAV types
- Data collection for research
- Flying in trucks
    - Team work between driver, pilot, co-pilot and data collector
        - Nathan and David stayed back and let them work together to fly and located the UAV while the truck was moving
    - Takeoffs from a moving vehicle
    - Considering the wind, judging it from a moving vehicle
    - Flying while moving --> pilots and co-pilots need to watch the drone, not the controller, unless using a video tablet
    - Landing in the vehicle/on a specific spot

Participant List

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Mwinyimtama		

Bull elephants fleeing from UAVs in third field trial.

D. NJAPIT

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