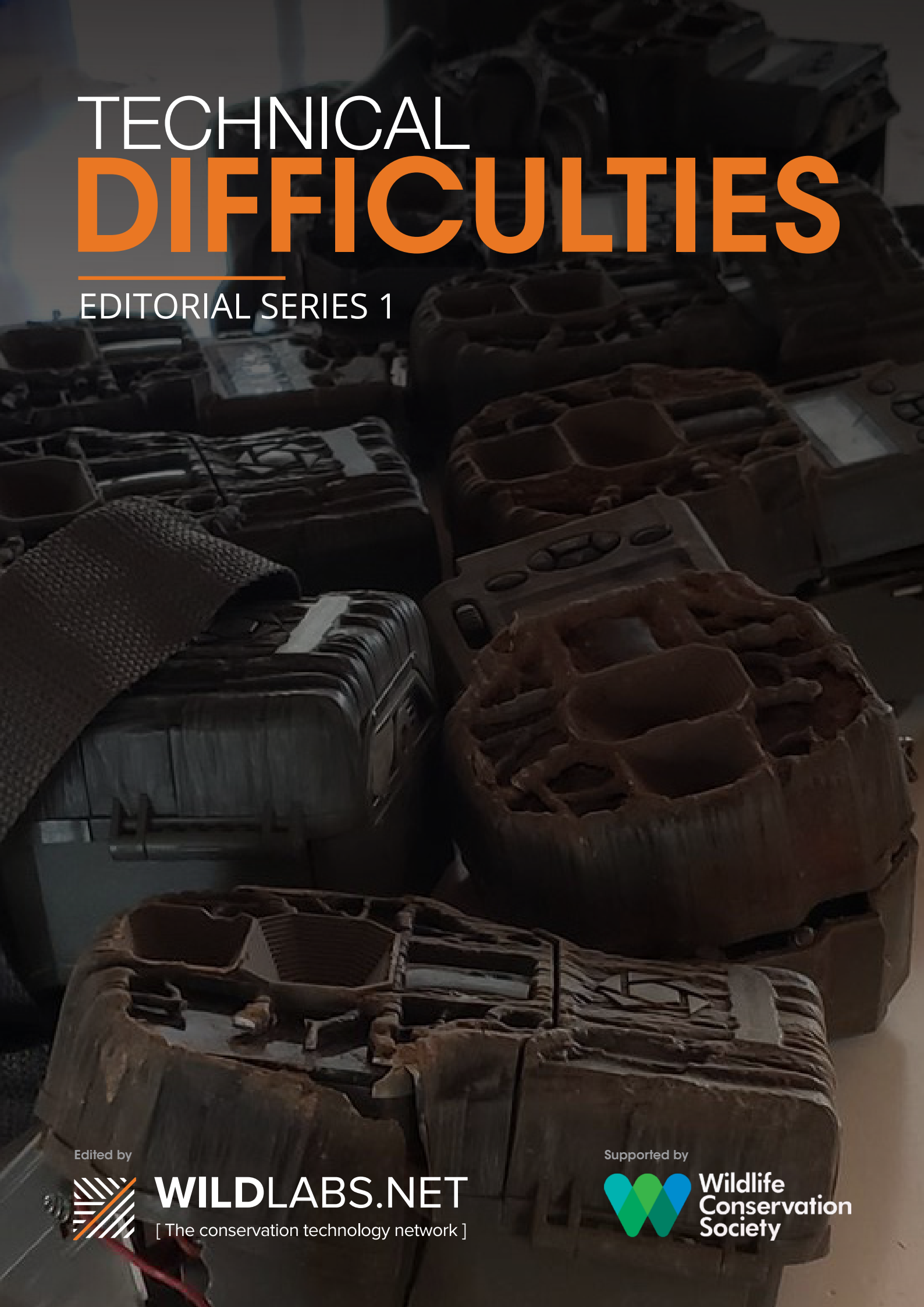

TECHNICAL DIFFICULTIES

EDITORIAL SERIES 1

Edited by

WILDLABS.NET

[The conservation technology network]

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TECHNICAL DIFFICULTIES

Welcome to the first **WILD**LABS Editorial Series, Technical Difficulties: Conservation Tech Challenges, Failures, and Lessons Learned.

Throughout this connected series of pieces written by conservation technology community members, we'll explore both the value of encountering challenges and failures in our work, and discuss how failures in conservation tech can lead to successes and solutions.

The challenges explored span a wide variety of technologies, environments, species, and career paths, and capture a snapshot of the **WILD**LABS community's enormous wealth of expertise.

You'll hear about experiences like baboons and elephants breaking tech gear, pangolins evading camera trap surveys, wildlife falling victim to poachers in spite of tracking efforts, setbacks in project and tool development leading to new connections, and much more.

We hope that their stories of experiencing and overcoming challenges will prove to be a valuable resource for others facing similar challenges. Additionally, we hope this collection of stories will inspire our community by showcasing the unique, innovative, and diverse work happening in conservation tech around the world.

This editorial series would not have been possible without the generous support of the Walton Family Foundation and WCS. The cover image is by Sara Beery.

Ellie Warren

Editor, Technical Difficulties

Photo by Save the Med Foundation

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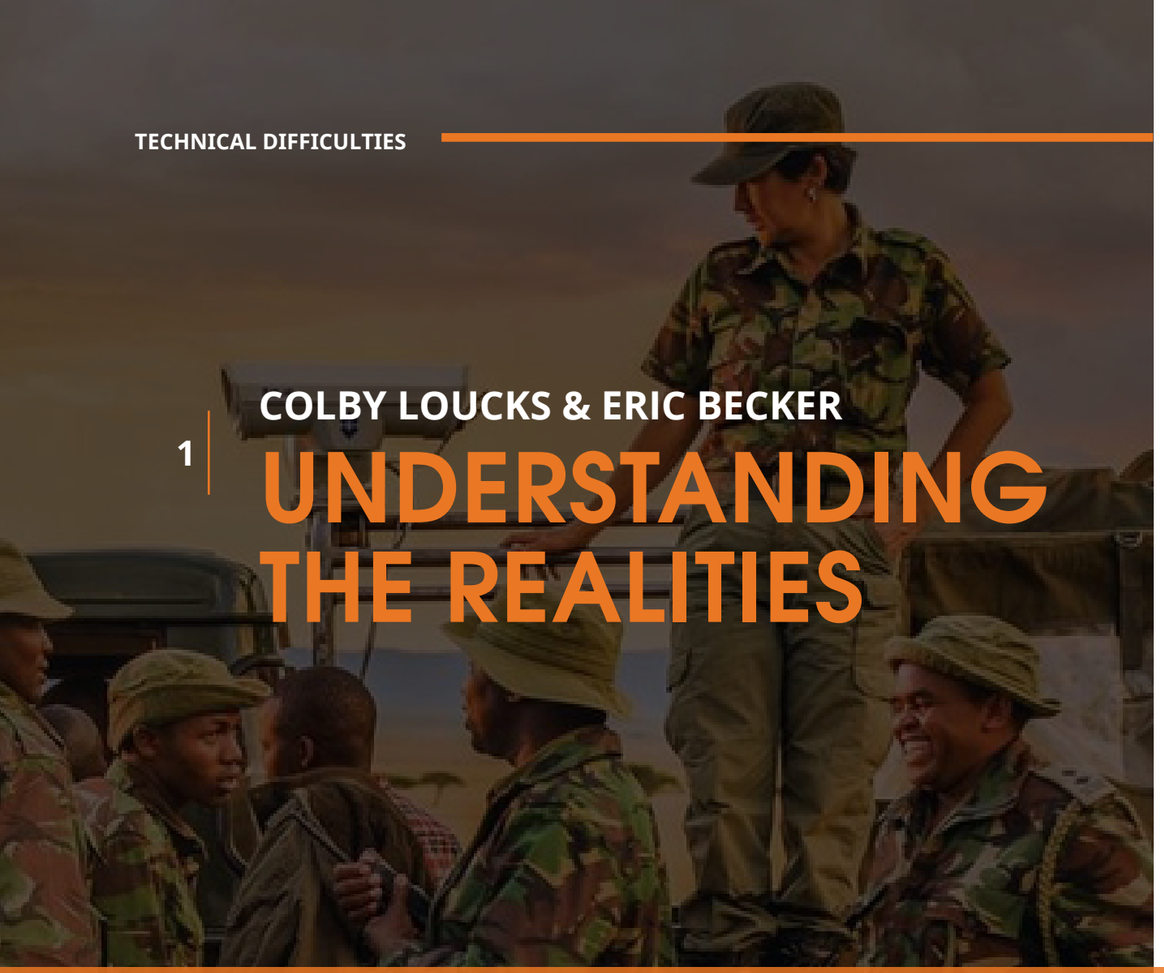


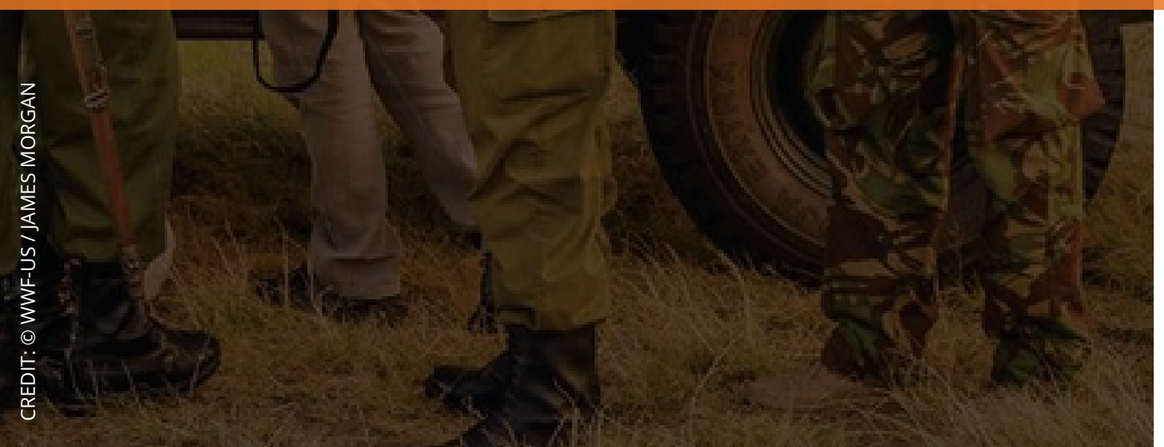
COLBY LOUCKS & ERIC BECKER

1

UNDERSTANDING THE REALITIES

‘An experience with outsiders “parachuting in” with technology that ends up being ineffective can cause government agencies and other partners to become jaded about the overall effectiveness of conservation technology, and this makes it even harder to launch another tech project - even one that could have more chances of success.’

Colby Loucks & Eric Becker



CREDIT: © WWF-US / JAMES MORGAN

In their three-part interview series, **Colby Loucks** and **Eric Becker** share the failures they’ve encountered and learned from throughout six years of working on the WWF-US Wildlife Crime Technology Project.

David and Colby Loucks getting ready to install the mobile FLIR camera system at the Mara Conservancy, Maasai Mara National Reserve. As part of WWF’s Wildlife Crime Technology Project. © WWF-US / James Morgan

From insects nesting in enclosures, elephants knocking down equipment, weather interfering with projects, park infrastructure limiting technological impact, and untested technologies pushing the boundaries of trust from on-the-ground partners, Colby Loucks and Eric Becker have navigated and learned from a wide variety of challenges during their six years of work on the WWF-US Wildlife Crime Technology Project.

Whether matters of inconvenience or large-scale missteps with long-term impacts on on-the-ground project sustainability and growth, all of these experiences have helped Colby and Eric strengthen WWF’s conservation technology work with a better understanding of what it takes to keep technology functioning in spite of difficult environments and wildlife, and to build the infrastructure and trust needed to make conservation tech work impactful over time.

Over the course of three articles based on interviews with Colby and Eric, we’ll discuss the wide range of challenges met by the WWF-US Wildlife Crime Technology Project, and the lessons that others can apply to their own conservation technology work .

Read on to see what they’ve shared with us about meeting the challenges they’ve faced together in the field.

In 2012, WWF was the recipient of a $5 million grant from Google.org, to be used in the fight against poaching. Google.org’s support allowed us to launch the Wildlife Crime Technology Project (WCTP), the vehicle through which WWF and our partners have explored and implemented technological solutions to stop poaching. We realized that we needed to rapidly pivot from a top-down technology-driven approach to a bottom-up problem-driven approach if we were to make a meaningful impact on the poaching crisis. Consequently, we set out to test an umbrella of technologies. Some were successful. Some were failures. Some of the successes started with failures.

A significant portion of this grant went toward attempting to use drones to stop poachers in Africa. But this idea came from a faulty thought process: we were trying to find a problem that fit the technology we already had, when it would’ve been more effective to consider how the problem could be best addressed - even if that meant not using state-of-the-art technology. If you’re more interested in putting a certain technology to work than in solving the problem at hand with the right tools, you run the risk of using the “sexiest” new tech tools as novelties rather than actual solutions.

In the end, the drones simply didn't have capacity to cover the kind of ground needed to effectively survey and monitor such a large space. Back then, the battery life of the drones we were using limited us to about one hour in the air. It was like looking through a soda straw at a tiny portion of the landscape.

The drones' failure was a result of not having initial conversations about whether this was the right solution at the right time, and not doing enough testing beforehand to be sure it'd be effective once on the ground (or, in the case of drones, in the air). Drones can be incredibly useful under the right circumstances, especially as they continue to improve with time; within the past five years, battery power alone has seen huge improvements for drones. So the issue isn't always as simple as the chosen technology being the wrong option for a project - sometimes the real issue is that your idea, as good as it may be, is further along than the technology. With time to catch up, that technology could end up being the right option somewhere down the road.

A similar issue occurred as we were seeking to test the ability of small, portable radar units to identify and detect poachers. We worked with a park in southern Africa to install a network of

Sometimes the real issue is that your idea, as good as it may be, is further along than the technology.

these sensors. However, the prototype almost immediately failed. We had rushed testing the prototype into the field without the proper vetting, costing us time and money in the end.

When failures like these happen, tech projects can do more damage than good and negatively impact relationships with on-the-ground partners. We wasted the nature reserve staff's time, and when the technology did not work as expected, they also became skeptical of using this and other technology in the future. An experience with outsiders "parachuting in" with technology that ends up being ineffective can cause government agencies and other partners to become jaded about the overall effectiveness of conservation technology, and this makes it even harder to launch another tech project - even one that could have more chances of success. Based on these failures, we have learned to vet our technology in

Ranger at the Mara Conservancy at Maasai Mara National Reserve Kenya, as part of WWF's Wildlife Crime Technology project.
© WWF-US / James Morgan

On June 1, 2015, WWF Staff tested the forward looking infrared (FLIR) camera system on a farm in Maryland. Eric Becker stands near the FLIR camera while Colby Loucks walks through a field, acting as a poacher, for testing purposes.

© WWF-US / Eric Kruszewski

more controlled field environments (in our case, in the United States) and do it repeatedly to ensure that it works before we reach out to our partners to deploy the technology.

Before traveling to any potential conservation tech site, you should try to keep a bigger picture of potential issues and impacts in mind before investing in technology. It's nice to have solutions in mind, but you need to visit the site and put in the time upfront to understand the realities on the ground first. The challenges and issues faced by the rangers and communities you're working with may be very different from what you imagined or expected while thinking up the perfect way to deploy your new technology.

For example, you might think that if park rangers only had access to the latest technological solutions, they'd be able to put them to use immediately to detect poachers or locate snares. But if you go along on a patrol with those rangers, you might realize that their most urgent priorities aren't high-tech tools, but basic and essential equipment like better flashlights for night patrols, better boots for covering long distances, or high-quality tents to keep them out of the elements while patrolling.

You may also find that some parks don't have the infrastructure and capacity to support a high-tech solution at scale yet. A state-of-the-art detection and alert system does no good if a lack of connectivity prevents it from being effective, if they don't have working radios to speak to each other, or if there aren't enough operational vehicles for rangers to respond to alerts in the first place. In some locations with massive need and massive poaching presence, technology has potential to have an impact the day we turn it on, but it makes no difference if the rest of the park and staff aren't ready to support and maintain it in the long-term. Ensuring that park infrastructure is able to support new technology before trying to use it on the ground can save invaluable time, money, and effort.

That's not to say that these parks can't still benefit from technology! Instead of aiming to change their methods entirely, you should aim to use your technology and support to enhance their existing techniques. If rangers have the best success catching poachers by sitting in silence and waiting to ambush the culprits, tethering a drone overhead that will alert nearby poachers to their presence in that area isn't going to work.

Understanding their needs and techniques means accepting that sometimes the most successful solution won't be the fanciest, most exciting, or most high-tech option. The most successful thing we've done in our work with anti-poaching thermal cameras was simply putting a camera on a basic tripod, and then adding a motor to it to make scanning the area easier and less labor-

intensive. Just helping the rangers see people from farther away at night made a huge difference, and hundreds of poachers have been arrested because of this fairly simple tool. Brainstorming with your partners on the ground from the beginning will help you find solutions that fit their work instead of forcing them to change their work around some new technology. And importantly, this will also allow you to manage expectations at the start, plan for sustainability and maintenance, avoid huge disappointments and risks, and address the issue at hand all at once.

Ensuring any technology solution is easy to maintain in the field also goes a long way toward preventing failures. CR-123 lithium ion batteries have defeated some of our best laid plans. For example, we once donated some night vision equipment to partners in Africa. What we failed to realize is that the CR-123 batteries used in this equipment were difficult to buy in many African countries, making the sustainability of this equipment a challenge. Further, developing or sourcing as many parts locally helps to ensure that any future repairs or improvements can be done through local expertise and supply lines.

On a similar note, you want to be aware of how government or partnership buy-in and local

Ensuring any technology solution is easy to maintain in the field also goes a long way toward preventing failures. CR-123 lithium ion batteries have defeated some of our best laid plans.

technology expertise can impact your project's longevity, timeline, and impact. In many countries where we work, there are taxation challenges related to importing technology or technology components into the country. Taxes alone could increase the costs of the project by 20-30%. We learned the hard way that ensuring local or government support may be critical to getting tax exemptions, but in turn, that process is likely to add weeks, months (even years) to the timeline of your technology project.

Having the IT or local capacity at your project site will also be essential to maximizing the performance and impacts of your project. We've

Mara Conservancy field technician installing mobile FLIR camera unit at Mara Conservancy at Maasai Mara National Reserve. As part of WWF's Wildlife Crime Technolgy Project. © WWF-US / James Morgan

Ranger anti-poaching unit at the Mara Conservancy at Maasai Mara National Reserve Kenya, as part of WWF's Wildlife Crime Technology project.

© WWF-US / James Morgan

had challenges in some project sites where the 'system goes down' – and no one knows what to do or are afraid to do anything that might break it. We are often able to fix the problem remotely; frequently, that fix is to just cycle power (turn everything off, turn everything on). But the anti-poaching systems could be down for any time between days to weeks before we are able to help solve the problem. Having a local technology expert is one way to ensure the seamless operations of technology projects.

Planning ahead and taking steps to understand the places you're working in, the people you're working with, and the realities of the challenges they're facing are all absolutely key to mitigating risk, maintaining trust of partners, and ensuring that technology is a useful tool rather than an expensive hindrance. And when failures do occur, recognizing what you can learn from that experience will improve that understanding and strengthen your next efforts. Every success we've had is built on encountering challenges along the way. We are now at the point where we've collected 6+ years of failures from across a number of technology projects, and these continue to inform our work today.

ABOUT THE AUTHORS

COLBY LOUCKS

VICE PRESIDENT, WILDLIFE CONSERVATION PROGRAMME WWF-US

Colby Loucks leads WWF's Wildlife Crime Technology Project, harnessing new technologies and the internet to improve our ability to track and manage wildlife, stop poaching, and reduce human-wildlife conflict. Colby has expertise in GIS, conservation biology, and landscape ecology.

ERIC BECKER

CONSERVATION ENGINEER, WWF-US

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ERIC BECKER & COLBY LOUCKS

CLEARED FOR TAKEOFF

‘For minor mishaps, superglue can be a surprisingly useful part of your repair kit. But for specialized parts and equipment, adhering to the wisdom of “two is one and one is none” will save you a lot of trouble. We had periods of downtime during our drone testing that could have been avoided if we had spare parts and knew when things were not working.’

Eric Becker & Colby Loucks

In their second case study, **Eric Becker** and **Colby Loucks** discuss the unique challenges presented by working with drones, and their advice for effectively incorporating drones into projects.

Eric Becker, WWF’s Conservation Engineer, holding a drone in his lab at home in North Bethesda, MD, United States. © WWF-US/Nathan Mitchell

In part one of this series, we discussed the importance of choosing the right technology to solve the right problem, and just as importantly, at the right time. Not every technological solution, regardless of the hype or promise surrounding it, will be ready to live up to your biggest ideas yet. When we tested drones for the WWF-US Wildlife Crime Technology Project as part of our poacher detection efforts, consumer drone technology was still in its infancy. But as we previously shared, just because technology has not yet caught up to your idea doesn’t mean your idea will never be possible. A realistic sense of what is achievable right now with the tools available to you will help you avoid disappointment down the road.

With drones, as with most conservation tech, things have come a long way since then and continue to improve. We’re seeing these tools become more accessible for conservation, with greater possibilities for usage in the field. At the time of our work, drones were limited by battery life and short flight times, cost, available sensors, type of airframe, and payload capacity (how much they can carry). In particular, battery life and short flight times severely limit what you can achieve across a vast landscape in need of broad and consistent monitoring.

For protecting vast areas, most people think of the capabilities brought by large, multi-million dollar military drones that can fly for hours or days at a time, and carry expensive sensors. While these types of drones would be able to monitor areas like the ones in which we work, they are unrealistic for conservation teams to acquire and operate. Again, maintaining realistic expectations not only about what technology exists, but what technology is actually available to you at this time will keep your projects within reason. For conservationists looking to use drones, a critical point in expanding your options is to look beyond consumer drones and consider open source, customizable, and industrial platforms.

There will be pros and cons to any drone options you choose, and there will be uses for each option that make sense, while others don’t fit as well. Flight time is constantly improving for newer drones, and a wider variety of power options exists than you may expect. There are hybrid electric/combustion engines that can power drones for hours. Likewise, fuel cells can also improve battery life for drones, but are expensive. Tethered drones that are powered from the ground can fly for almost indefinite amounts of time, but are limited by the location of the ground power generator. (As we shared in part one, this option, despite the long flight time, won’t be of any use if it gives away the location of a ranger team or can’t effectively survey the area.)

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The options for the types of drones and airframes themselves are also diverse and accompanied by pros and cons depending on the ease of use, flight time, and necessary payload. There are several airframe configurations, but the main ones are fixed wing (airplane) or multi-rotor (helicopter). Hybrid airframes, on the other hand, take off like a helicopter and fly like an airplane. Fixed wing drones are more efficient than their counterparts because they move through the air to generate lift, and only require power to propel the plane forward. On the other hand, they require an area to take off and land, so you must have the space to create a makeshift runway. This type of drone can typically carry heavier payload; however, they need to be constantly moving through the air to generate lift, so depending on your monitoring needs, this may not allow you to focus on one small area effectively.

Meanwhile, multi-rotors require constant power to maintain lift and movement in any direction. This is typically what limits flight time, and those limitations are important to note since these are the types of drones people tend to buy. This type of drone is extremely easy to operate compared to the alternatives. They can take off and land vertically requiring little to no runway, and they can stop and hover over an area, allowing them more mobility within the space you're monitoring. In spite of this, because of their power restraints, they do have a limited coverage area, the very issue we encountered in our work.

Trying to really understand how you're using this technology and why will help you maintain those realistic expectations and work within them, not against them.

Finally, hybrid airframes combine the benefits of both fixed wing and multi-rotor drones. Their ability to take off vertically like a helicopter and fly like an airplane provides the best of both worlds in terms of mobility, and improves crucial factors like flight time and payload capacity.

Another factor to consider about your conservation technology tools is what actually makes them useful. Trying to really understand how you're using this technology and why will help you maintain those realistic expectations and work within them, not against them. We think of drones as flying tripods, not as a stand-alone technology. The payload is really what makes them useful. Drones move your camera or sensor around in 3D space, allowing you to collect data, track wildlife, or monitor and patrol an area. At the same time, the exact thing that makes drones useful can also become part of their limitations. In this case, if the drone is a tripod for carrying other technologies, that tripod has limitations due to payload capacity and flight time, regardless of whether that technology is capable of doing exactly what you need it to do.

Testing the ability of drones to identify intruders at a park in Zimbabwe in 2017.

CLEARED FOR TAKEOFF

A drone takes flight in Zimbabwe: "We think of drones as flying tripods, not as a stand-alone technology. The payload is really what makes them useful."

For example, in my [Eric's] experience using drones to map a lake region in a protected national park, the software used was more than capable of returning beautiful, accurate maps and 3D models of the surveyed area. But the limitations of flight time and battery power complicated what seemed to be a straightforward project, with the drone requiring frequent trips back to base and running through 24 batteries. Because the drone could only fly for approximately 15 minutes at a time before the batteries were drained, and because the time and distance needed to return the drone to base also had to be taken into account for the batteries' lifespans, the effort took far longer than anticipated: six hours of flight time. In this case, the chosen drone was capable of serving as a tripod for the needed technology, but its limitations resulted in an inefficient process. Considering the pros and cons of different models and uses could help you maximize efficiency and minimize the impacts of current limitations. For this particular project, a fixed wing drone may have resulted in less flexibility of movement, but would have provided more efficient flight times and used less battery power.

Considering the pros and cons of different models and uses could help you maximize efficiency and minimize the impacts of current limitations.

Similarly, factoring in the pros and cons of the technologies you're using with your drone can help you factor in issues like weight and flight time needed for a project. You may also find that not every technology is right for use with a drone, or find that drones open up entirely new possibilities for your technology in spite of any limitations. And like drones themselves, sensors and onboard processing power are constantly improving, making more advanced uses possible in the future.

Drones are also a unique technological tool because they come with the expectation of one particular type of failure: crashing. All drones tend to crash, and every use of a drone comes with the risk of a costly failure. In spite of your best planning and training, and no matter how much consideration you've given to choosing the right tool, you should still approach every single drone flight with the expectation that it may crash.

Anyone working with drones will learn a lesson about their proclivity for crashing very quickly. I personally absorbed this lesson during my very first on-the-job engineering experience, when an expensive military drone with a 20-foot wingspan took off for my first test flight, and proceeded to nosedive at full-speed into the ground. The state-of-the-art tool was now a splintered wreck. Witnessing a drone's catastrophic failure was clearly not uncommon for those with experience, as demonstrated by the calm, emotionless reaction of my supervisor: "Let's go get the trash can."

While not every crash will result in such disaster, expect repairs for drones to be a constant necessity. With so many moving parts, things are bound to go wrong. This means that any work involving drones requires multiple spares, sources for replacement parts, good communications with the end-user to tell you when things break, and local maintenance capability and expertise. Drone propellers will break, batteries will fry, landing gear won't work, software will go awry; in any case, your advanced preparations will eventually be needed to get your drone functioning again. For minor mishaps, superglue can be a surprisingly useful part of your repair kit. But for specialized parts and equipment, adhering to the wisdom of "two is one and one is none" will save you a lot of trouble. We had periods of downtime during our drone testing that could have been avoided if we had spare parts and knew when things were not working.

Drones also come with a host of restrictions and regulatory issues to navigate, and these vary depending on the type of drone and the region you're working in. Around the same time that we began testing drones, many countries started implementing restrictions on drones. In most cases, a licensed pilot who completed a local drone training course will have to operate the drone. In some regions and countries, however, restrictions may be even tighter, and some places have banned them completely. Before planning a drone-based project, be sure you understand what is and isn't allowed, how much time and effort may be involved in navigating any restrictions and required trainings, and whether the pros and cons of that significantly impact your project's timeline or chances of success.

A herd of elephants (Loxodonta africana) in the Maasai Mara, Kenya. © WWF-US / James Morgan

Similarly, drone regulations may impact the design and functionality of the actual tools you choose. Most off-the-shelf drones are built for aerial cinematography, and are designed to meet the current flight regulations. These regulations require visual line of sight (meaning the pilot can see the drone) and limit the altitude to 400ft. These regulations inform everyone's product design, so most off-the-shelf drones have limited range on wireless connectivity, as well as software limits on altitude.

While working with drones has its challenges, the successes and possibilities that come from finding the right uses for drones are incredibly worthwhile. Lessons learned from struggling with drones in the past inform more successful human-wildlife conflict and wildlife crime efforts now. In one impressive example of using FLIR technology and drones together in Malawi, drones were able to not only detect elephants that had broken through a fence, but herd them away from the area, preventing further damage and conflict. And in an exciting ongoing effort, drones and high-tech radar are being developed to detect snares in the landscape, even through foliage. This project is pushing the boundaries of current drone capabilities and driving forward the potential for effective drone usage in the fight against poaching and wildlife crime, making great use of drone technology's many strengths. And with the right understanding of drones' limitations, realities, and future innovations, you may find a bold, creative, and effective use for drones, too.

Lessons learned from struggling with drones in the past inform more successful human-wildlife conflict and wildlife crime efforts now.

ABOUT THE AUTHORS

ERIC BECKER

CONSERVATION ENGINEER, WWF-US

Eric Becker researches and develops sensor based systems to detect poachers in protected areas in Africa and Asia to stop wildlife crime. Eric also leverages advancements in the Internet of Things to find energy-efficient, low-cost methods and systems to scale up technologies to solve the planet's most urgent issues.

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VICE PRESIDENT, WILDLIFE CONSERVATION PROGRAMME WWF-US

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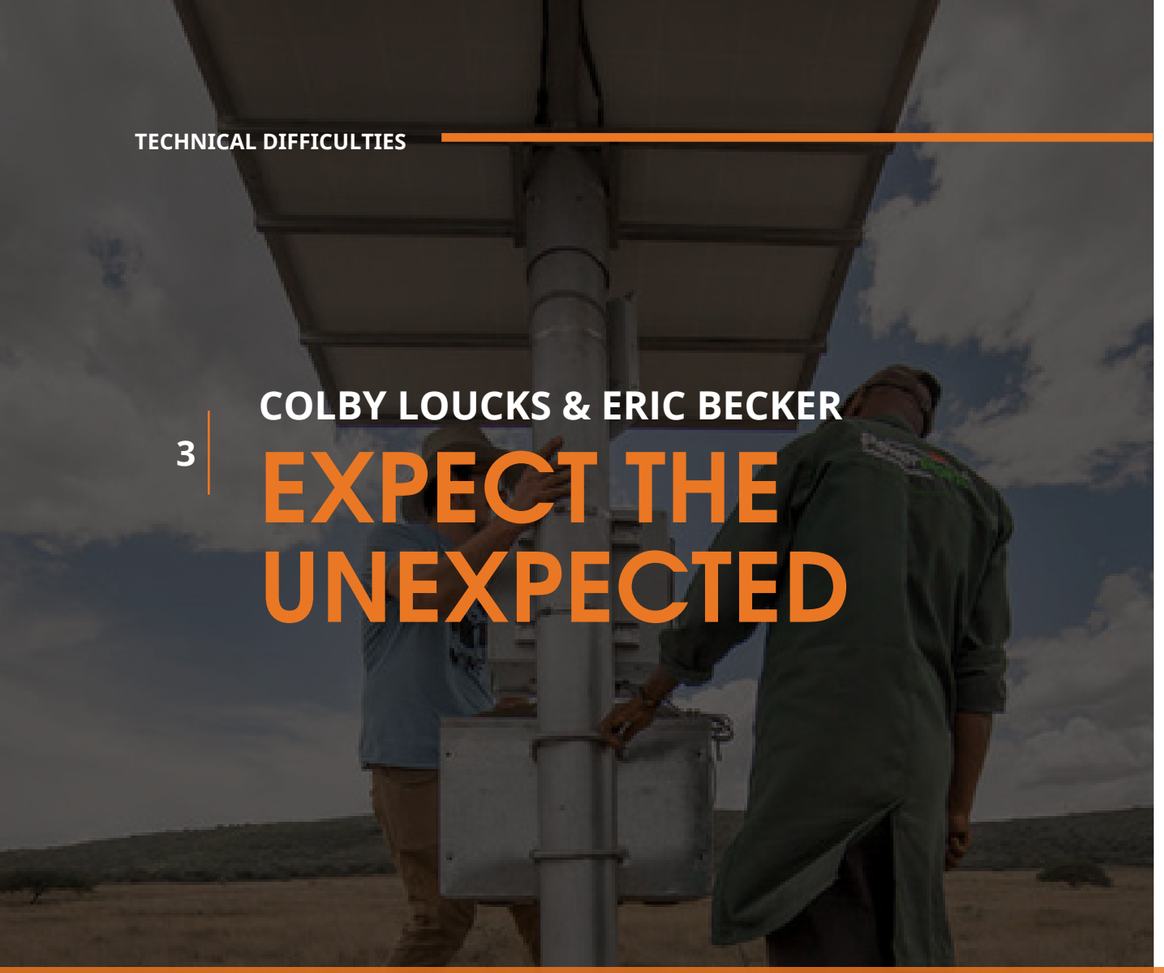
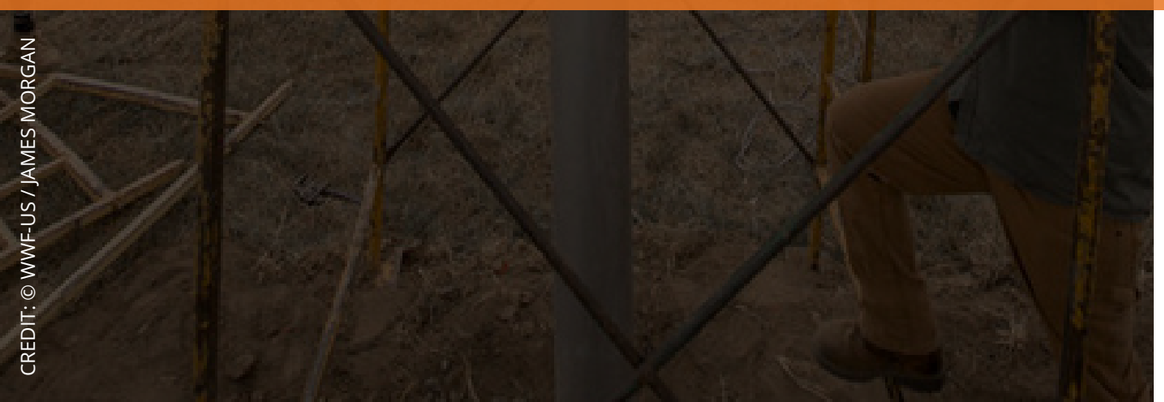
COLBY LOUCKS & ERIC BECKER

EXPECT THE UNEXPECTED



‘When planning ahead for challenges you may encounter, it’s also worthwhile to remember that the local people you work with on the ground will always have the best understanding of the environments’ realities. Building and supporting capacity locally, relying on their expertise, and learning from their experiences and previous challenges will only strengthen your plans, and possibly help you avoid irreparable failures.’

Colby Loucks & Eric Becker



CREDIT: © WWF-US / JAMES MORGAN

In this final part of their case studies, **Colby Loucks** and **Eric Becker** reflect on how wildlife and weather can cause unexpected challenges in the field, and share advice on planning your conservation tech work with the unexpected in mind.

Simple and affordable grease can prevent wildlife from climbing poles supporting your technology.

Beyond the challenges of technological failings and infrastructure, conservationists working on the ground will also be familiar with the unique challenges posed by wildlife and the environment itself. When it comes to adapting to these issues as they arise, taking the time to understand the realities on the ground is still essential.

In many cases, we’ve found that low-tech, local solutions have helped with failures caused by wildlife. For example, after installing a system of masts that held technology and communications equipment at some rhino reserves in Kenya, baboons began climbing the towers and eventually broke a solar panel that provided power. In addition, openings in the tower structure allowed bees to build nests in the towers.

Our partners at the Kenya Wildlife Service found innovative and relatively easy solutions to these challenges, such as greasing the poles to prevent baboons from climbing them and filling in all equipment openings with expandable caulk to keep out insects. Insects and spiders pose a major problem to enclosures, battery boxes, camera traps, and any other equipment with openings. Making sure you cover any opening with screen mesh in the first place can help alleviate this issue and save you the trouble of sending out rangers covered head to toe to knock bees out of enclosures, or worse, tech systems shorting out and needing troubleshooting and repairs because insects have damaged it.

We’ve also faced issues with elephants knocking down masts as they sought to rub against them. And in some cases, elephants were knocking down poles that were connected through a fiber optic network, meaning that repairs were quite complicated and time-consuming, and required a certain level of on-the-ground expertise to fix. Solving this problem required a bit more effort than merely putting grease onto equipment, but it was still resolved with a fairly low-tech solution: installing ‘elephant fences’ around every permanent technology installation, and strapping the fiber optic gear to sturdy trees instead of masts.

Planning to encounter failures in conservation tech work means accepting that wildlife and the environment will continually surprise you, presenting new challenges that you never would have anticipated while engineering a tool in the comfort of a workshop, or strategizing the tool’s deployment while in an office in the middle of the city. When planning to put solar panels into action in the field, few would expect baboons to take over those panels for their own purposes. You learn from these experiences on the ground, you

solve them with what's available to you, and you get better at anticipating surprising challenges the next time around.

While it can be difficult to anticipate just how wildlife will damage, repurpose, or otherwise disrupt your technology, anticipating challenges caused by environmental factors like weather is a bit easier if you take the time to understand the location you'll be working in. Like problems with wildlife, some of this knowledge can only be acquired from experience and time on the ground - reading about a rainy season is very different from finding yourself with equipment completely soaked through by floods and rain, with no chance of drying out in such wet conditions.

When selecting the right technological tools and forming a deployment strategy, make sure you ask yourself questions about the environment at every step of the way. Does this region have a rainy season? A dry season? Will that impact either your technology or the wildlife you're trying to study or protect? Are there times of year when other researchers and conservation teams avoid certain regions because of difficult or impossible working conditions? Are there times when certain parks or protected areas might be completely closed because of weather conditions? What are the major environmental challenges in the area, like wildfires or floods? What are the highest (and lowest) temperatures your equipment will likely be exposed to, and will that impact their performance? Is your tool's enclosure designed in a way that will trap heat and cause problems, or do you know if your batteries can withstand cold temperatures over long stretches of time? Considering these questions far in advance of deployment will help you choose the right tools, plan ahead for malfunctions caused by environmental factors, and form strategies for protecting technology from issues like water damage and high temperatures.

> Some of this knowledge can only be acquired from experience and time on the ground.

It's also helpful to build setbacks into your project plan and budget, because even the best research and planning in the world won't stop unexpected challenges entirely. The total cost and time needed to achieve success of technology solutions that work in the field is likely to be much greater than anticipated. A large number of potential pitfalls, delays, and unexpected costs result from the hurdles of working with and integrating technology components like radio, radar, batteries, machine learning algorithms, and software, and from the human elements of conservation tech work, like managing personnel and training teams on the ground.

Example of an elephant fence to deter elephants from destroying technology equipment in Ol Pejeta Conservancy, Kenya. The fence is electrified, and is high enough that elephants cannot step over it, keeping them a safe distance away from the mast, solar panels, and other technology.

A low-tech way to dry out wet equipment, assuming conditions are dry enough to build a fire.

When planning ahead for challenges you may encounter, it's also worthwhile to remember that the local people you work with on the ground will always have the best understanding of the environments' realities. Building and supporting capacity locally, relying on their expertise, and learning from their experiences and previous challenges will only strengthen your plans, and possibly help you avoid irreparable failures.

ABOUT THE AUTHORS

COLBY LOUCKS

VICE PRESIDENT, WILDLIFE CONSERVATION PROGRAMME WWF-US

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CHRISTIE SAMPSON

THE DEATH OF GIANTS

HOW A MOVEMENT STUDY UNCOVERED A NEW POACHING THREAT

'While we didn't meet our original goals, the collapse of our project actually lead to revelations that initiated anti-poaching and conservation efforts across the country, ensuring that this region's elephants will be more effectively protected'

Christie Sampson

Christie Sampson shares how the devastating experience of losing collared elephants to an unexpected poaching threat lead to an improved understanding of wildlife crime in the region, and spurred strengthened anti-poaching efforts to protect critical elephant populations.

Preparing to collar an elephant. Credit: Christie Sampson

The first time one of the elephants in our project was poached was gut-wrenching. Watching that last data point come in after spending weeks capturing elephants to attach the GPS collars, and months monitoring their movements through the patchwork of landscapes across Myanmar, was a loss of not only an important part of our study, but also an animal who we had come to know.

Poaching wasn't supposed to be occurring in our study area. In fact, one of the reasons we were working in the Bago Yoma was because it was deemed to be safely positioned far enough away from locations elsewhere in the country where reported poaching syndicates and smugglers were threatening endangered species. Unfortunately, the loss of that first elephant was only the beginning.

Myanmar is often considered one of the best places for Asian elephants to make a stand, with elephants in this region slowing the overall population decline rates occurring across their thirteen range countries. Despite increasing pressures from expanding development and agriculture, Myanmar contains some of the largest remaining swaths of unfragmented habitat for elephants and other wildlife in the region. Many of the country's large forested systems connect to other complexes in neighboring countries, linking populations together across geopolitical boundaries and making the preservation of the animals and habitats there a top priority for conservationists.

Myanmar's wild elephant population collapsed from around 10,000 individuals in the 1940s to an estimated 1,430–2,065 individuals in the early 2000s. This loss has been attributed to many factors, the first being the extensive campaign to capture live elephants for use in the timber industry. Historically, timber was a major economic pillar for the country. Methods used to capture the individual animals included the using a kyone (also called khedda), a stockade trap which could result in over a 70% mortality rate. But following the timber export ban initiated by the government in 2013, live capture was considered less of a threat, though animals were still illegally captured and sent to other countries for the tourism industry.

Assessing how impacts from habitat loss affected elephants and addressing human-elephant conflict became focal points in the effort to conserve the remaining population. That's what we were there to study. Using GPS collars to monitor

movement, we hoped to uncover how elephants used the landscape, and find ways for them and their human neighbors to coexist.

This is not to say that poaching was completely off the radar. The Myanmar government's wildlife officials were aware of poaching within the country's borders, particularly along the western border at the beginning of our project. The conservation agency TRAFFIC had also published a report several years earlier in 2008, assessing the risk of the ivory and live animal trade to the country's elephant population and highlighting the threat that the illegal wildlife product trades posed.

Because only male Asian elephants have large tusks, and proportions of males with and without tusks varies between 10% -90% in different populations, some elephants were thought to be at less risk for poaching for ivory. Of the elephants captured and collared for our study, only one had tusks, so we began the project without too much concern for the threat of poaching.

But then we began losing the elephants. At first we hoped it was an issue with the collars; a flaw in the components design did end up leading to a significant number of collar failures over the course of the study. However, when the ground team went to check that first site, they found what was left of the elephant we were tracking.

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The first photos we received were snapped on an old cell phone, showing a grainy black lump in the general outline of an elephant. We thought perhaps the poachers had tried to burn the elephant to hide the crime. But later when the ground team was able to send video of the site, what we thought was a burned exterior was actually a mass of insects feeding on the areas where the poachers had removed the skin of the elephant.

Elephant skin removed by poachers for the illegal wildlife product trade. Credit: Dr Zaw Min Oo

When animals with collars were poached, we were able to find the elephant carcasses quickly, in some cases arriving before the poachers could remove the skin or before the skin could be packaged for transport.

Credit: Christie Sampson

Eventually, we lost 7 of the 19 elephants we collared in the first 2 years of our study to poachers. They had expanded from killing elephants for their ivory, now poaching them to meet growing consumer demands for elephant meat and other body parts, especially skin.

Surveys of wildlife markets around Myanmar in 2014 documented the explosion in the elephant skin trade, especially in areas such as Mong La along the border with China. The sale of skin was previously suggested to be a by-product of poaching for ivory. But the elephants we were finding were often tuskless males or females and were largely intact, though some villagers caught by police reported receiving meat as payment for helping poachers locate elephants.

The idea that poachers were targeting females as well as males was particularly sobering. Breeding age female elephants drive population stability, and the loss of these individuals can have longterm and devastating consequences for species survival. Our plan to use movement data to help wildlife managers develop strategies for humans and elephants to live together instead revealed that any animal could be marked for death.

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ecology of a critical elephant population failed, this research provided data that spurred both the Myanmar government and conservation organizations to action. When animals with collars were poached, we were able to find the elephant carcasses quickly, in some cases arriving before the poachers could remove the skin or before the skin could be packaged for transport. Our team members on the ground gathered information and located dozens more poached elephants, many of them skinned, which we wouldn't have even been

An elephant skull after being stripped of its skin and tusks by poachers. Credit: Dr Zaw Min Oo

A collared elephant at home in Myanmar. Credit: Christie Sampson

looking for previously. This included the discovery of an entire herd of approximately 20 individuals that had been killed along the western coast. Additionally, our collaborators launched a massive campaign to raise awareness for poaching and the illegal wildlife trade, Voices for Momos, that has reached millions of people. The failure of our planned study also changed how we were working in the country and with the people of Myanmar. It led to a new series of programs integrating people and technology, and projects working with local organizations and communities trying to identify the drivers of poaching and find local solutions to a worldwide problem.

While we didn't meet our original goals, the collapse of our project actually lead to revelations that initiated anti-poaching and conservation efforts across the country, ensuring that this region's elephants will be more effectively protected from this destructive threat. It's difficult to imagine more devastating circumstances of failure in conservation than losing the very wildlife we were studying and protecting to such violence. But the actions resulting directly from our discovery of this threat show that even the most devastating of circumstances can lead to positive impact, a vital message for conservationists fighting the ongoing battle against wildlife crime.

ABOUT THE AUTHOR

CHRISTIE SAMPSON

POSTDOCTORAL SCHOLAR, UNIVERSITY OF CALGARY

Christie Sampson is an Eyes High Postdoctoral Scholar at the University of Calgary, a Research Associate with the Smithsonian Conservation Biology Institute, and an Adjunct Faculty member at Clemson University. Her research currently focuses on using interdisciplinary tools to support the conservation of endangered species and habitats around the world.

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JULIANA MASSELOUX

PANGOLIN IN A HAYSTACK

'While elephant charges, malfunctioning equipment, biting insects, and adverse weather can complicate field work, the biggest hurdles I've had to face have been related to human logistics. Keeping an open mind and a flexible schedule is the best advice I can offer.'

Juliana Masseloux

CREDIT: JOHN CHRISTIAN S. YAYEN

In this fifth case study, **Juliana Masseloux** discusses her challenges in working with camera traps to study elusive and rare animals like the pangolin, and shares her best advice for others who are dealing with difficult-to-study species.

What do forest elephants, palm civets, pangolin, and cheetahs have in common?

Well, for one, they're all species I've studied. And secondly, they're all very elusive species. Your chances of encountering one on a given day even in prime habitat is fairly low - all of these species are rare, nocturnal, and/or very shy. I've spent over two years working in what could be considered prime pangolin territory and have only seen one in the wild, and that's considered lucky.

In the "old days," field biologists would need to track these species for months through dense jungle, muggy swamps, or sweltering savannahs just to catch a fleeting glimpse, or more likely, a few tracks and half-decayed dung samples. Your best bet for gathering solid data about movement and behavior ecology was to capture and collar these animals, which usually still required post-capture follows by foot or by air. It was exhausting, expensive, and time-consuming work for very little data - not a great recipe for funding-limited NGOs and grad students.

Now, advances in technology and ecological statistics have opened up a myriad of ways to remotely survey wildlife and conduct robust analyses while minimizing cost and effort. Camera traps, drones, and genetic sequencing are becoming cheaper and more powerful every year. New tools are emerging at a breakneck pace, to the excitement of ecologists and technophiles everywhere, and opening up new frontiers of research. And importantly, the increasing affordability of these tools and advancements in remote-work capabilities are making the field more accessible to lower-income and minority communities who have traditionally been excluded.

So what's the secret to studying elusive wildlife? There's no one answer, and it depends largely on your focal species. What works for one species may not work for another. Counting spoor along a transect works great in the dry, open savannahs of East Africa, but not so well in the dense rainforests of Southeast Asia.

Even camera traps aren't always a perfect fit. If your species is too rare or wide-ranging, only long-term or large-scale studies will capture enough data for a robust analysis. They also tend to have a high rate of malfunction in humid and insect-infested areas, not to mention occasional damage from a curious animal. I've lost a frustrating amount of potential data to a curious macaque who decided to change the camera angle three days after set-up.

Placing cameras close to human settlements also comes with its own set of problems. If local residents aren't on board with the study or engaged in illegal activities, they're likely to steal or damage any camera they come across, even if the data isn't being used for law-enforcement purposes.

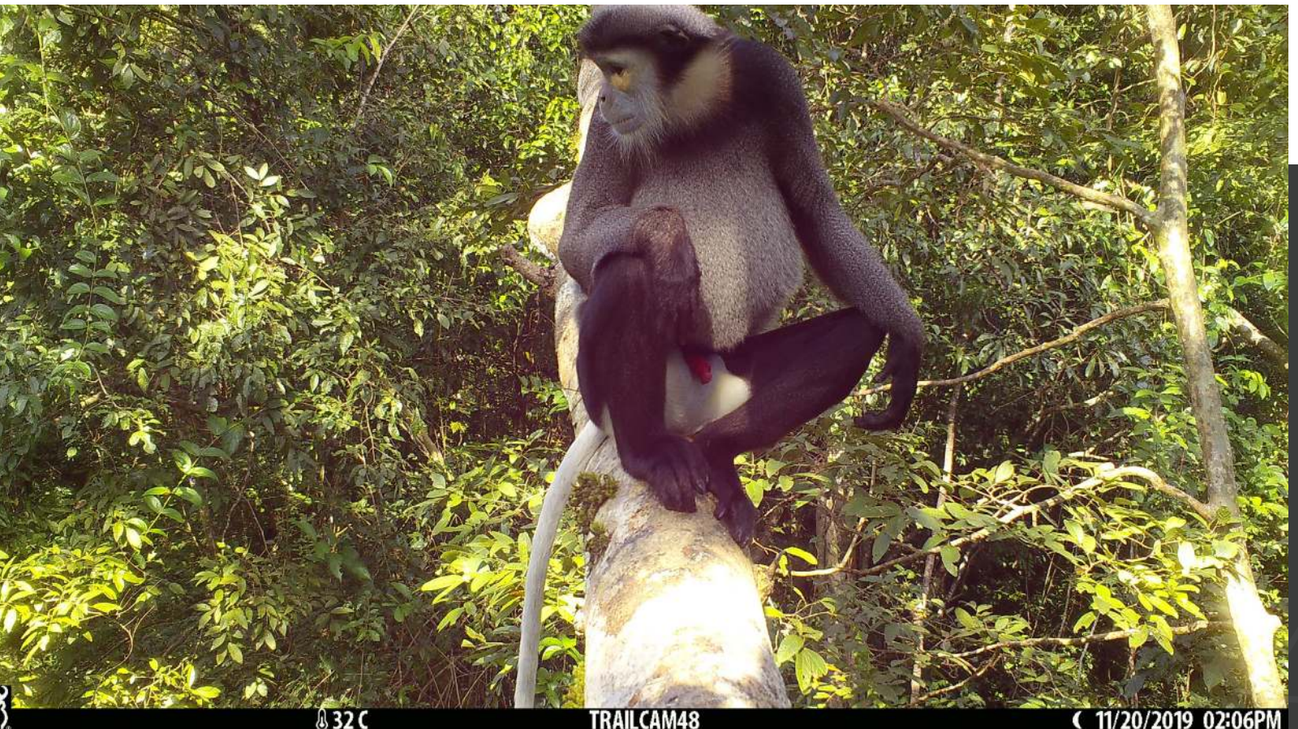
My advice is simple: when it comes to technology, expect it to fail. Keep duplicates of everything on hand, as many as you can afford. Back up your data in at least two different places; actually, make that three. You know that external drive is going to fail one day. Always keep a torch and extra batteries on you. Being stuck in the forest without a working GPS miles from your campsite an hour before dawn is not a good time - especially when there are leopards nearby.

Local communities are also a great resource for both qualitative and quantitative studies. They tend to be the most familiar with the local flora and fauna and can provide unique insights into local ecology and hotspots. Engaging communities in local conservation work improves the likelihood of long-term project sustainability and future cooperation as well.

Unfortunately, law-enforcement agencies in some areas, especially near or within protected areas, tend to frown upon collaborating with anyone known or suspected of engaging in illegal activities. This can become tricky to navigate when trying to hire or engage locally while not angering the people in charge of your research permits or transportation. While elephant charges, malfunctioning equipment, biting insects, and adverse weather can complicate field work, the biggest hurdles I've had to face have been related to human logistics: navigating local politics, adapting to regional customs (gift chickens and bootlegged moonshine), obtaining permits in a timely manner, keeping your tracker out of the bars the night before a 14-day field trip, etc. Keeping an open mind and a flexible schedule is the best advice I can offer in this respect.

My advice is simple: when it comes to technology, expect it to fail. Keep duplicates of everything on hand, as many as you can afford.

An arboreal camera trap in Vietnam captures a black-shanked douc-langur (Pygathrix nigripes)



My impossibly fortuitous encounter with a white-bellied pangolin (Phataginus tricuspis) in Gabon (2017)

All in all, the most effective studies thus utilize a number of methods and resources. Not only is this likely to provide a richer picture of the local faunal community than a single method alone, it also provides a back-up source of data in case one method fails. As the proverb goes, best not to put all your eggs in one basket in case it gets knocked over by a macaque. Establish your analytical methods a-priori. Even if you don't get enough detections, you can always simplify the analysis, but you can't upgrade to more complex methods if you're missing important site-level data.

Final bit of advice? Take care of yourself. Working in conservation and research, especially with elusive and hard-to-study species, is frustrating. You might not get as much data as you wanted, or run into political or logistical complications. Maybe you get sick or injured, obliterating weeks of valuable field time. Whatever the case, when things don't go according to plan, it's easy to get overwhelmed and spiral into a place of frustration, anger, and helplessness. Having a back-up plan or two helps keep you centered and reduces the stress of one thing going wrong, but sometimes it's also necessary to take a step back and take care of yourself. Take a couple days off. Treat yourself to something nice, even if you don't feel you deserve it.

Then, when you've had a little time to breathe, you can look at the situation with a clear head and find the angles and options that weren't there before.

Maybe you'll even find a pangolin.

ABOUT THE AUTHOR

JULIANA MASSELOUX
INDEPENDENT CONSERVATIONIST

Juliana Masseloux is an international wildlife conservation biologist who has worked on wildlife and research projects across the world. She is currently collaborating with the Zoological Society of London in Thailand, and aims to continue working in Southeast Asia with a focus developing sustainable community-driven and science-backed conservation initiatives for combating illegal wildlife trade and human-wildlife conflict.

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ELLIE WARREN

TRACKING THUNDERBIRD

LESSONS IN RISK, LIMITATIONS AND OPTIMISM

‘Surrendering to hopelessness is easy in the face of such overwhelming damage. Simply understanding the enormity of the problem can push the limits of our optimism. In spite of this, the conservation technology community is ready to lead, and the biggest failure of all would be wasting the opportunity to do so.’

Ellie Warren

In this case study, **Ellie Warren** discusses how the loss of one tagged sea turtle represents the wider challenges faced by conservation efforts, and how the collaborative nature of the conservation technology can help us find reasons to be hopeful even in the face of failure.

Photo by Save the Med Foundation

Is it possible for conservationists to believe in the myth of “the wild” anymore?

Who but conservationists can better understand the ways in which the natural world has diminished by human impact? Our species has forced its presence into the lives and environments of wildlife around the globe, to the farthest reaches of this mythical “wild” that we still envision as existing somewhere beyond our society’s borders. But plastic pollution turns up in previously untouched corners of Antarctica, migrations pass through cityscapes filled with lights that throw birds off course and into the windows of skyscrapers, large carnivores that should be the unimpeded champions roam the outskirts of cities and freeways, and vast open oceans shrink to the spaces between shipping lanes full of noise and regions full of indiscriminately deadly fishing gear.

Conservation technology offers to us a fuller understanding of our impacts. We can map the shrinking forests lost to land development or climate-driven disasters. We can track the ranges of wildlife and see where they intersect with our own. We can survey populations to observe their declines.

On a more optimistic note, conservation technology offers to us the promise of future solutions to these same problems. If we do not understand our impacts, we cannot fix them. Likewise, if we do not accept the failures and limitations of our knowledge and current solutions, we cannot hope to improve the world that we have so drastically changed. By only acknowledging the successes of conservation technology and positive stories of progress in conservation, do we buy into that myth of “the wild,” banking on the idea that we can still preserve nature as some standalone world independent of our own? And by allowing technology to show us stories of conservation failures, can we begin to see a clearer picture of what we have already done to nature, and what needs to be done?

The sad story of Thunderbird the sea turtle is an example of all these things: “the wild” that doesn’t exist anymore, the failure of a conservation effort to protect endangered wildlife, and the promise of conservation technology to turn this unfortunate lesson into something hopeful.

In July 2020 in Mallorca, an endangered Loggerhead sea turtle was found in ghost fishing gear, the abandoned tools of the fishing trade that

entangle countless other marine megafauna every year. An appropriate name, considering ghost gear allows human impact to linger, haunting wildlife long after we've left that area behind. Thunderbird was lucky enough to be rescued by the Save the Med Foundation from what is too often a fatal trap for other endangered sea turtles. At the Palma Aquarium rescue centre, Thunderbird received care and recuperated from her run-in with ghost gear, making a full recovery. Dr. David March of the universities of Exeter and Barcelona attached a satellite tag to Thunderbird's shell in preparation for her re-release back into the sea.

As one of several turtles tagged for the "Oceanographic Turtles" programme, jointly conducted by the Balearic Islands Coastal Observing and Forecasting System (SOCIB), Alnitak, Palma Aquarium Foundation, and the University of Exeter, and with the support of NOAA NMFS, Thunderbird would provide insights into migration paths and turtle behaviour. The satellite tag returned data on location, depth, and water temperature, and researchers used the critical data from tagged turtles to collaborate with fishermen on developing the risk management measures needed to prevent things like bycatch fatalities and collisions.

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When Thunderbird was returned to the ocean with her new satellite tag, this seemed to be a conservation success story. Though this turtle had nearly been killed by human impacts, humans had also saved her, and would now provide data to help us understand and protect her species. By all accounts, the tale of Thunderbird should've had a happy ending. It doesn't. But that doesn't mean the story is any less worthwhile.

Thunderbird was not returned to "the wild" as we'd like to believe - she was returned to an ocean that, despite her lucky survival the first time around, was still just as full of danger caused by humans. To make her way out of the Mediterranean and

At the Palma Aquarium rescue centre, Thunderbird received care and recuperated from her run-in with ghost gear, making a full recovery. Photo by Palma Aquarium Foundation

Photo by Save the Med Foundation

through Gibraltar Strait, Thunderbird had to navigate the Alboran Sea, a path that led her directly through an area with strong currents and marine traffic. Because of the risk that she'd be caught or injured again by a collision, the local network of the Mediterranean Ghost FADs were asked to be on alert, with Thunderbird's tracking data providing invaluable information that could allow intervention in the case of another incident.

Thunderbird successfully made it into open waters, and the team anticipated that she would swim toward America, as many loggerhead turtles living in the Mediterranean are born in Florida or the Caribbean. To their surprise, Thunderbird instead took a path along the West African coast, likely because she was one of a small number of Western Mediterranean turtles born in Cape Verde. This data, then, could also be invaluable for understanding migrations along this path.

Because of the satellite tag, the research team could see that Thunderbird was frequently diving near the sea bottom along the West African Coast. But in February 2021, the satellite tag stopped

By comparing their fishing vessel data to Thunderbird's recent satellite tag data, the team found that her last recorded dive was in the path of known trawling vessels.

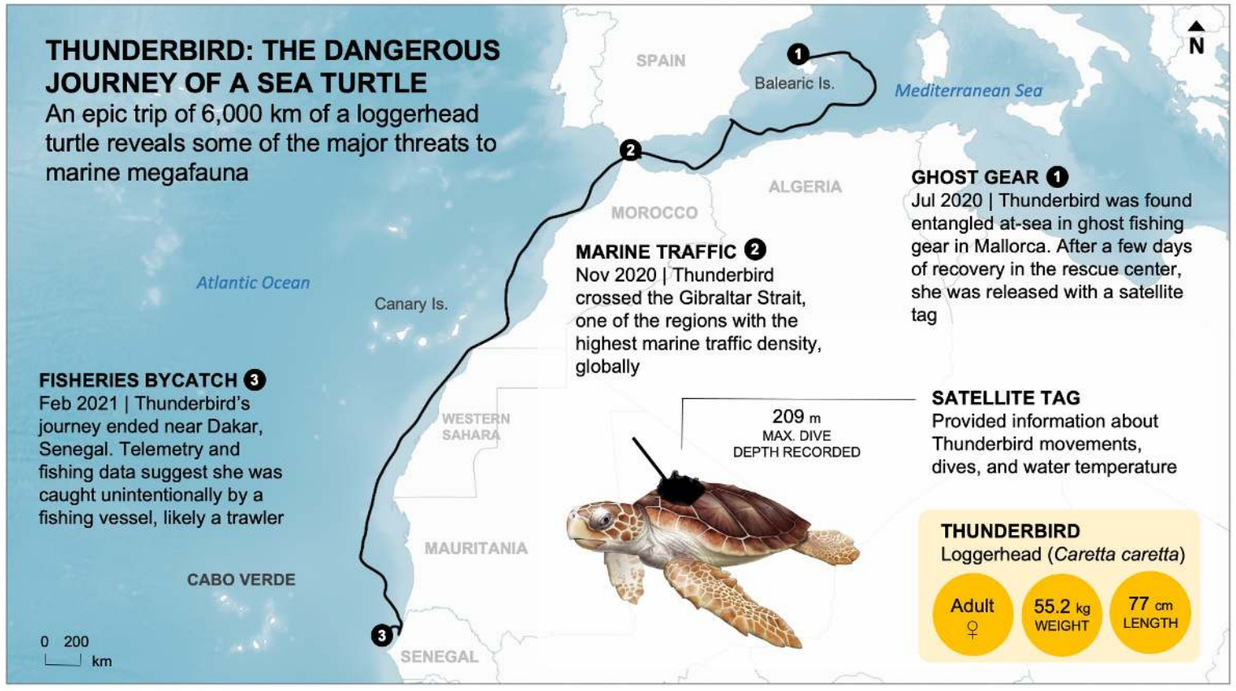
returning data, its last two locations shown as near Senegal, and finally, in Dakar - on land near the main harbor.

It seemed possible that the tag was malfunctioning; after all, technological failures of biologging gear aren't uncommon. Another type of technology was called into action to cross-reference the turtle's last known locations - the Global Fishing Watch portal. By comparing their fishing vessel data to Thunderbird's recent satellite tag data, the team found that her last recorded dive was in the path of known trawling vessels. These vessels use gear that drag along the seafloor, often causing damage to marine environments and catching species like sea turtles unintentionally. The results of this bycatch are often fatal.

While it's possible that Thunderbird could've been found with a damaged satellite tag and re-released alive, it's also very possible that she died as bycatch. And while we all hope that Thunderbird somehow survived, her survival alone would not

Thunderbird's story shows that, even with the help of human intervention and technology, the risk to wildlife caused by human impacts is constant, unavoidable, and sometimes inevitably fatal.

Photo by Palma Aquarium Foundation



Source: SOCIB, GEBCO, GADM.

Infographic: Dr. David March (IRBio-UB/UOE).

necessarily make this story less devastating. After being saved from human impacts once, outfitted with conservation technology to track her path, and successfully navigating yet another dangerous area full of vessels and risks with humans standing at the ready to intervene if necessary, the fact that Thunderbird still suffered from yet another bycatch event demonstrates just how severe our impacts have been on "the wild."

After being rescued once, no wildlife should face double jeopardy, finding themselves up against the exact same threat mere months later. But that is exactly what happened, and it happens to countless other animals who, unlike Thunderbird, aren't monitored, and can't tell us their story through data. Thunderbird's story shows that, even with the help of human intervention and technology, the risk to wildlife caused by human impacts is constant, unavoidable, and sometimes inevitably fatal.

While the loss of a tagged animal along its migration path, so close to making it home, may seem like a failure, that is not why I've chosen to write about Thunderbird in this series. From

a research perspective, the data returned by Thunderbird's satellite tag was not a failure at all. Her journey - and its unfortunate end - did, in fact, lead to a better understanding of turtle migrations, showing just how present danger is to these endangered species. That data will be much more useful to conservation in the long-run than simply understanding turtle behavior during their migrations; truthfully, there will be no more turtle migrations at all if we do not understand and address that danger in the first place. And because researchers like Dr. March aim to use turtle tracking data to work with fishermen on collaborative solutions, Thunderbird's experiences certainly demonstrate where risk mitigation strategies and response tactics can be improved to prevent incidents like this.

There is no failure in this project from a technological perspective, either. The satellite tag did exactly what it was designed to do - report back Thunderbird's location, right until the end of her journey.

But this story represents a much more ominous failure, and a much more difficult one to address. The failure is in our own expectations. We expect a rescued turtle to become a sign that our conservation efforts are working. We expect human intervention to offset the rest of the damage caused by humans. We expect that understanding data from conservation technology will translate to impact, hoping that the rest of the world will care about the stories told by that data. And we expect that there is still a natural world for us to protect - a world that is safe for wildlife if they can only make it there, and if we can only help them along the way. If all of the collaborations at work here to rescue, track, and recover Thunderbird were still unsuccessful, even with the help of technology, then what else possibly could have made a difference?

Surrendering to hopelessness is easy in the face of such overwhelming damage. Simply understanding the enormity of the problem can push the limits of our optimism. In spite of this, the conservation technology community is ready

Photo of Thunderbird by Miquel Gomila

We cannot solve these problems overnight, and there is no magic technological solution that can reverse the damage already done by humans. But there is hope in every story of conservation failure, if you know where to look.

to lead, and the biggest failure of all would be wasting the opportunity to do so.

We cannot solve these problems overnight, and there is no magic technological solution that can reverse the damage already done by humans. But there is hope in every story of conservation failure, if you know where to look. In Thunderbird's story, I see hope in the fact that data from her satellite tag and data from Global Fishing Watch were able to provide a clearer picture of her fate. That technology allows us to understand our impacts, however negative, is at least a starting point. And as technology becomes more and more interconnected, I see hope for better solutions in the future - tools and systems that could allow us to intervene more efficiently, and detect and avoid bycatch in the first place while better protecting environments where endangered species live and migrate.

Dr. David March and his partners are already working to reduce bycatch, adapt fishing gear and methods, and monitor unregulated and illegal fishing in a project funded by the MAVA Foundation and run by the University of Barcelona and Birdlife International. Working with a coalition of partners based in West Africa and internationally, this project will also help to identify bycatch hotspots that pose major threats to wildlife like Thunderbird. This kind of collaborative effort can amplify conservation technology's impact. On a wider level, it serves as an example of how accepting the failures and realities of our own impact can pave the way to progress.

If we cannot preserve a natural world that has already been destroyed, we can perhaps use technology to recreate it to the best of our ability for wildlife. It is still possible to shape our own human world around the habitats and ranges of wildlife, if we choose to do so. The ocean will never be free of fishing vessels and pollution, and "the wild" will never be free of human impacts again. But if technology could, for example, inform where and when we fish, directed by factors like migration paths and the likelihood of bycatch, would that not be a better world for wildlife?

And would it not be a better world for us, knowing that the wild still exists in some form, somewhere out there, because we chose to make it so?

ABOUT THE AUTHOR

ELLIE WARREN

WILDLABS COORDINATOR, WWF

Ellie Warren creates content and supports the conservation technology community at WILDLABS through virtual events, fellowships, and community engagement. She currently works as WILDLABS Coordinator at World Wildlife Fund, and has a background in English, nonfiction writing, and screenwriting.

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DAVID SAVAGE

WHAT'S THE WORST THAT CAN HAPPEN?

'A researcher always has to consider whether, by protecting a sensor system from the elements, they are reducing its ability to provide ecologically useful information.'

David Savage

In this Technical Difficulties case study, **David Savage** discusses lessons learned from working with bioacoustic tools in the field and dealing with damages caused by environmental factors and wildlife.

A Wildlife Acoustics Song Meter 4 that has had its foam windscreens gnawed away by an animal.

My conservation tech experience has been primarily focused around the use of acoustic sensors. I've used most of the on-the-market solutions at least once, with extensive experience with Wildlife Acoustics products. I've deployed and serviced Song Meter 2s, 3s, 4s, and Audiomoths, as well as used Song Meter Mini and Micro units and frontier labs BARs as product demos. I've also been involved with deployments in a number of locations ranging from Hawaii to Colombia to the US Midwest, either directly in terms of deploying and servicing sensors, or indirectly in terms of analyzing data and consulting with people doing the fieldwork.

One of the biggest points of failure we've dealt with in our work is sensors breaking. Whether it's due to constant rain overwhelming the hydrophobic membrane in a microphone or curious wildlife nibbling on what may seem to them to be an oddly shaped and colored branch, the environments in which we deploy conservation tech have proven time and again to be inhospitable to those technologies. This can become an issue when one loses significant portions of data due to microphone failures that cannot be detected until after the fact (that is, either when a sensor is serviced and damage can be seen visually, or once data analysis identifies periods of time when a microphone may have failed).

A Wildlife Acoustic Song Meter 2 that has been clawed or gouged by an unknown animal. This kind of damage can lead to water intrusion.

In any of these situations, the first challenge has always been to identify points of failure to begin with. First, to identify that a failure has occurred, then to identify—or at least develop a reasonably and carefully considered hypothesis about—the underlying causes of this failure. Sometimes this is easy, especially when the sensor can be inspected directly; other times, it is much more difficult, as when an expert must communicate with a field tech by phone or video call from a remote location.

Any response to sensor damage has to follow the same principles followed by any human system seeking to improve its resilience. First, prevent damage wherever possible; second, improve the ability of the system to respond to disturbance. We see the same concepts show up in, for example, discussions of climate change and their uses of the concepts of both mitigation and adaptation. In the case of conservation tech, this has often been a question of trial and error. Sensor hardware is extremely variable and so are the natural systems within which it exists. Moreover, a researcher always has to consider whether, by protecting a sensor system from the elements, they are reducing its ability to provide ecologically useful information.

If you're already losing data, the worst that any attempted solution can result in is a continued loss of data.

For example, in cases where a microphone is being damaged by constant rain, it may make sense to place a physical barrier of wood, metal, or plastic above the microphone like a roof or hat. However, doing so brings with it a new host of concerns, including whether the sound of raindrop impact on the cover will mask key signals, or whether the cover itself will prevent the sensor from picking up aerial sound sources as effectively. Each of these is a unique concern, created by a combination of a study site, with its specific opportunities and limitations; a sensor platform, with its advantages and vulnerabilities; and a research question, with the particular aspects of performance one needs to preserve or is willing to sacrifice. Because of this, there are very rarely, if ever, pre-established guidelines that are applicable to a particular case. It falls to each individual researcher to attempt to determine a solution.

A Wildlife Acoustics Song Meter 3 that has been covered in seabird guano while deployed at a colony in Tierra del Fuego. While this unit is still functional, birds can and do get very close to sensors and this can damage them.

A broken Wildlife Acoustics Song Meter 2 Microphone that has been broken by impact, likely from an animal. Luckily, the sensor we deployed this microphone on was recording in stereo and we got good data on the other channel until we could swap in a fresh unbroken microphone.

If anything, that has been the biggest lesson I have learned from trying to deal with these sensor failures: don't be afraid to just try stuff. For example, it turns out that dipping the foam windguard of a microphone in local water and allowing it to dry before installing can reduce animals gnawing on a microphone at some sites in the US Midwest.

This was an idea that originated with a late-night session of brainstorming and was eventually tried based on the immortal phrase: "Eh, what's the worst that can happen? It doesn't work." If you're already losing data, the worst that any attempted solution can result in is a continued loss of data.

The second and final piece of advice I would offer is: trust yourself. Nobody is going to know the specific combination of specific deployment location, technological system deployed, and the research question or conservation problem that the deployment is trying to tackle any better than you will. This means that, much as it might be appealing to seek out additional expertise - and goodness knows I've wanted the reassurance of second or third opinions a lot of the time - sometimes you just have to follow your own intuition and, as mentioned above, go through a process of trial and error.

ABOUT THE AUTHOR

DAVID SAVAGE

PHD CANDIDATE, PURDUE UNIVERSITY

David Savage is a PhD candidate at the Center for Global Soundscapes, part of Purdue University's department of Forestry and Natural Resources. His work focuses on applications of technology, especially acoustic sensors, to improve policymaking and conservation decision-making, especially in agricultural systems.

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ALINA PETER & KRISTEN SNYDER

A DEPLOYMENT CHECKLIST

INSIGHTS FROM THE SERENGTI

'Trialing and deploying new tech requires resources, input, and patience from numerous team members – it's hard to imagine any project succeeding without support across the broader team. Excellent and early communication is essential for building interorganizational support.'

Alina Peter & Kristen Snyder

In this contribution from **Alina Peter** and **Kristen Snyder**, you'll receive a practical checklist of factors and questions to consider at various stages of your conservation technology project, all learned from challenges encountered in their work at the Grumeti Fund.

Applying technology for conservation is an integral component of our work at Grumeti Fund, in the western Serengeti of Tanzania. We use tech to support nearly every aspect of our operations, from using EarthRanger as the centralized system to make operational decisions and evaluate outcomes, to deploying satellite collars to prevent human-elephant conflict, to using cameras for intrusion detection and ecological monitoring.

Conservation tech has improved our efficiency and capacity, but the ride has not always been smooth! We have experienced significant failures – cases where equipment failed, permissions were not granted, or environmental or organizational conditions critical for success were only discovered in their absence.

As our conservation tech program has grown, we have learned essential lessons about what is needed for new projects to avoid common challenges on their way to becoming successful. Here is our tech deployment checklist – the key aspects that we consider prior to a new deployment.

Reach out for recommendations

When selecting equipment for new programs, recommendations and feedback from other organizations have been invaluable. This has been particularly true for tech that is well established and used widely. Not every tool will be right for every species or environment, even if it's an excellent piece of equipment.

Gathering real user feedback when selecting tools like camera traps and satellite collars will help you find options that are ideal for local conditions. We most often ask contacts for feedback on what their goals and expectations were for the tech, reliability and performance, ease of use (deployment and troubleshooting), operational costs, and any significant limitations or barriers to use they experienced along the way.

Survey options outside the conservation space

For new applications of tech in the conservation sphere, we have found that it is vital to explore as many options as possible inside and outside the conservation space. Development for certain tech may be further along in other sectors. Fully understanding your options can help you prevent wasting time, energy, and resources in the long run.

Is there broad organizational support?

A large reason for the success of our conservation tech program at Grumeti is because of the coordinated support these programs receive

across all levels of the organization. In our experiences, having leaders who incorporate conservation tech into the larger organizational vision and are invested in securing funding and developing relationships has been critical to the success and longevity of programs.

Equally as important has been the support from colleagues. Trialing and deploying new tech requires resources, input, and patience from numerous team members – it's hard to imagine any project succeeding without support across the broader team. Excellent and early communication is essential for building interorganizational support. This may sound simple, but it's easily overlooked when working in a fast-paced environment where teams are over-extended - as they often are in the conservation sector!

Our smoothest deployments and most successful programs are those in which the team has a good understanding of the project's significance, value, timeline, and their own role within the project. This means helping the team maintain realistic expectations for required inputs, timelines, and outcomes, and allowing ample opportunities to provide feedback or make adjustments so that the tech works within operational constraints.

Is internal capacity aligned with the tech requirements?

In our experience, on-the-ground capacity is the greatest factor that determines whether deployment of new technology will be sustainable. It is critical to consider existing skillsets and whether those are compatible with what you are trying to implement, or whether it's feasible to develop the required skills.

Our conservation tech program's greatest asset is having qualified, technically trained individuals on-site, ready and able to take responsibility for maintenance and troubleshooting. Intimate knowledge of the deployment site, capacity to evaluate equipment from a technical perspective, rapid responses when issues arise, ability to physically handle and repair devices, and a common spoken language are just a few of the benefits.

Are the developers committed to long-term support?

Even with in-house technical expertise, ongoing support from developers when trialing or deploying new tech is always important. Failures are part of development, and refinement is always needed. Relationships with developers can make or break a project, ultimately deciding whether this process is exciting and productive or extremely frustrating. We look to work with developers who are responsive and not over-extended, set realistic expectations, and are passionate about the tech in development.

What permissions are required?

The permissions process for certain types of tech can require lengthy lead times; furthermore, if the tech is new, the process may be unclear.

In Tanzania, for example, deploying satellite collars can require up to 8 months of advance planning to secure the necessary permits, and permits must be renewed annually. Likewise, drones are not currently a feasible piece of tech to use for our routine management needs because of the difficulties in obtaining permissions and the very short renewal period.

We try to learn as much as possible about the permissions process before committing to implementing a new tool. Building in additional lead time is also important, as is expecting things not to go exactly according to plan, a critical lesson for anyone working in the ever-evolving world of conservation tech.

We have also learned that, as exciting as some tech may be, there is a need to be practical and to know when the requirements for implementation outweigh the potential applications.

Are there external factors that could lead to underperformance or failure?

Environmental conditions, community support, security risks, sensitivity among stakeholders – these are all factors that can present challenges to successful deployments. It's unlikely that we will ever be aware of all these factors in advance of a new deployment, but we have learned to minimize risks by utilizing internal expertise and seeking feedback from other organizations.

An elephant cow, Mkomre, who is fitted with a GPS collar to better understand elephant utilization of human dominated areas, and to prevent human-elephant conflict.

Credit: Kristen Denninger Snyder

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In advance of constructing a trial electric fence for black rhino security and aimed at preventing human-elephant conflict, we conducted extensive due diligence to select an appropriate and effective design, and to implement the necessary protocols to maintain the fence and monitor and prevent negative ecological impacts. We learned from the successes and challenges of other organizations, and harnessed internal expertise to modify the design and protocols to suit local circumstances.

We were introduced to the 'elephant short fence' design at Lewa Wildlife Conservancy, which we ultimately decided best suited our management goals. We anticipated that a variety of factors like flooding could damage the fence, making maintenance difficult and impairing the integrity of the fence. To make maintenance simple and fast, the Conservation Management team suggested fitting the bottom of fence posts with metal spikes that could be driven into the ground (rather than digging holes and placing posts in concrete). This design has had the added benefit of making the fence more flexible, leading to less damage overall.

In Tanzania, for example, deploying satellite collars can require up to 8 months of advance planning to secure the necessary permits, and permits must be renewed annually.

On the other hand, prior to deploying camera traps for ecological monitoring along the reserve boundary, we did not effectively utilize internal resources or seek extensive feedback on the deployment – if we had, we likely could have avoided the very painful theft of many camera traps! With input from the law enforcement and community outreach teams, we likely would have selected alternative camera trap models that were more discrete (efforts to disguise the cameras were ineffective), or changed the deployment locations.

While some of this advice may seem straightforward to experienced conservation tech users, their simplicity is precisely why these points are so important to keep in mind, as the fundamental considerations of deployment can so often be taken for granted. The difference between successfully navigating a challenge - or avoiding a failure altogether- frequently comes down to thoughtful and thorough planning with your team. Whether it's your first time or 500th time deploying conservation technology in the field, time spent considering the big picture and small details of your deployment will never be time wasted.

A DEPLOYMENT CHECKLIST

The fence along Ikorongo GR is of the 'elephant short fence' design, which we were introduced to at Lewa Wildlife Conservancy. This design features angled outriggers which are electrified and prevent elephants from accessing unelectrified components (like poles), and pushing the fence over. Credit: Han Olff

We have used a variety of camera traps for different purposes. Pictured here are participants in the Women in the Field course practicing setting up cameras to monitor wildlife. Credit: Kristen Denninger Snyder

ABOUT THE AUTHORS

ALINA PETER

CONSERVATION TECH SPECIALIST, OPS ROOM COORDINATOR, GRUMETI FUND

Alina Peter's role includes reviewing reports from the scouts in the field, ensuring Earthranger and all integrated tech (radios, collars, vehicles & camera traps) are functioning, managing the radio network and coordinating any active operations. Alina has an MBA in IT Management.

KRISTEN SNYDER

HEAD SCIENTIST RISE, GRUMETI FUND

As Head Scientist, Kristen leads the applied research program Research and Innovation for the Serengeti Ecosystem (RISE). Kristen's research background is in HWC and co-existance, which she addresses using an interdisciplinary suite of tools including household surveys, camera traps, animal movement, spatial modeling, and remote sensing.

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GAUTAM SHAH

THE PATH TO SUCCESS

‘Entrepreneurship is a very personal experience. Those in conservation will also understand the pressure that comes with being passionate about your work, and how failure in something you’re passionate about can feel deeply personal. It is impossible to decouple yourself from the ups and downs of your business.’

Gautam Shah

Internet of Elephants founder **Gautam Shah** shares the lessons learned from challenges throughout his unique career path as an entrepreneur working and engaging the public in conservation tech stories.

The moment my parents understood my career choice: when National Geographic published a short piece on me.

For most of my life, I was anything but an entrepreneur. I spent 15 of my first 20 professional years working at Accenture, a huge IT consulting firm which doesn’t breed (nor does it need to) entrepreneurial thinking. In between 2 stints at Accenture, I was independent for 5 years but couldn’t handle the uncertainty of where the next project would come from. So when I made the decision to quit Accenture and get into wildlife conservation, being an entrepreneur was the last thing on my mind. I just figured I’d get a job at a large conservation NGO or something like that, following a standard career path into this field.

But there are many career paths into conservation, and many ways to contribute your own strengths and skills to conservation efforts, something the conservation technology community knows well.

As I started to network and better understand what role I could play in the conservation sector, it became clear to me that my best bet was relying on my experience in IT and applying that expertise to wildlife conservation. But I could no longer code or build anything myself, and I definitely didn’t want to be the CIO of a large organization like, for example, WWF. Instead, I thought of the different ways I felt technology could make a difference,

Internet of Elephants officially started with a Hackathon we ran in Chicago in 2015.

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and married those with career paths I thought I'd be happy following.

When the idea of applying the Internet of Things to relationships between people and individual animals came about, it struck me that the only way that I was going to get that plan off the ground was doing it myself. And so it was that my life in wildlife conservation and entrepreneurship started at the same time.

Entrepreneurship is not often a career path lacking its fair share of challenges. The difficulties, setbacks, and risk of failure are also not unlike those found in the conservation field. By combining the two, it's no surprise that I've encountered struggles along the way, and hopefully these experiences can connect with those in the conservation technology community, regardless of what career path has led you here.

One of my biggest personal challenges has been overcoming the wider perception that IT is just considered a cost and not an opportunity. This perception was particularly difficult to cope with at the beginning of my career, when funders didn't see the value in investing in technology as opposed to the other programs they were funding. It was merely thought of as an administrative cost. I think that perception is changing, and while that change itself will inevitably lead to new challenges, they don't necessarily impact me as much at this stage of my career path.

In building Internet of Elephants, I encountered the difficulties that come with launching an ambitious effort, be it a business venture or a conservation project. IoE's beginnings were full of excitement - we had built up a team of developers in Kenya, and I remember the happiness of having a little office, a team, and the freedom to experiment and make things without relying on 3rd party agencies.

But after 6 months or so, it was clear that our skill and experience levels weren't enough to do what we needed to do. Worse, we weren't in a position to train and upskill. But I couldn't let them go, and we suffered as a team for a year. A bit of advice helped me come to terms with the choices in front of me when one of our advisors told me, "If something is inevitable, better to deal with it right away." I made the tough decision to let them go, and when I did, my immediate feeling was that the experiment was over and that IoE had failed.

But what actually happened was that my stress levels reduced, my freedom to make the right decisions increased, our small team became more

When AR technology was first introduced, AR elephants were an easy way to draw a crowd.

THE PATH TO SUCCESS

The peak size of the IoE team, all together in Kenya in 2019.

nimble, and we started to get stuff done faster and better. Through this experience of what I at first believed to be a failure, I realized that our operational model might be better off this way, without having a bigger team as part of the payroll, allowing our small team to use our resources to the best of their ability to produce results. And just as importantly, I also realized that the value proposition of IoE is not necessarily about actually building the experiences; it's more about conceptualizing them, designing them, and then working with other organizations better suited to building them.

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IoE has continued to make progress since then, exploring innovative ways to connect people to conservation with technology. Through Internet of Elephant's current efforts to engage the public with conservation through immersive game-based storytelling, we've encountered a new layer of challenges relating to people rather than the technology itself. Now, many of my personal challenges relate to changing the way people see public engagement, as well as the traditional approaches that have been used to achieve it.

First of all, engagement and behavior change aren't easy to quantify, and so it is difficult to articulate the value proposition and importance. Rarely do you find an impact investor or foundation's charter specifying it as a priority.

And secondly, there is a lot of discomfort with change. Despite the fact that half the world plays videos games as a form of entertainment, people aren't yet sold on games being used for conservation purposes. Or perhaps the public simply doesn't get it. Adapting conservation engagement and messaging to a relatively new medium (and a time-consuming one to create, at that) is scary. On the other hand, if I were pitching wildlife films to share these stories, someone may like or dislike the story itself, but no one would question the familiar method.

So as much as innovation is touted as critical to conservation success, we haven't found that the

risk appetite matches the desire to innovate.

When faced with such a large task of changing public perceptions and engagement methods, honestly, it's tough to keep going at times. It wears you down to keep trying to convince people of your ideas, your intentions, your "theory of change." It's tough to put 18 months of effort into a project, release it, and then watch as very few people engage with that project because you don't have the marketing muscle to get it out there.

Not every challenge is something that can be immediately overcome through hard work or lessons learned. I don't think I've actually met these challenges yet or moved beyond them. What I have done is continue believing in the importance of what we are trying to do, even if I don't always believe in myself as the one to do it. And I've been lucky enough that our first and lead investor has always been there with us, as convinced as I am about how successful we could be in the future, even if we haven't experienced it yet.

And I do believe that those successes are coming, and that they will be built from what I've learned along the way throughout challenging times. To reach the point where success could become possible, I needed to learn the realities about marketing. I needed to learn the realities about raising investment. I needed to learn the realities of my own strengths and weaknesses as a leader. My previous career didn't prepare me for the challenges of being an entrepreneur and I simply needed to experience it to know. I'm less naive now, have a better vision for what we should be doing and how we should be spending our energy, have a strong network of people that I have built up over the years, and feel much better about what the next few years could look like.

For those embarking on their own career paths in business, conservation, or some combination of the two, my advice comes back to understanding yourself and the work you are ultimately trying to do. One important factor to avoiding failure, in my opinion, is to understand your own risk appetite. What are you willing to risk personally to achieve your goals? There is no right answer to this, but it is important in understanding what type of entrepreneur or leader you will be, who you need to surround yourself with, and how you will lead. At the same time, if your answer doesn't match what you need it to be, explore where you can find the support you need, be it through courses and schools, acquiring new skills and techniques, or meeting people who can push you and help you along the way.

The CEO of National Geographic Society at the time, making special mention of our work at their largest gathering.

The second is that ideas are easy to come by and easy to generate. More difficult is figuring out the business model and distribution. This is even more relevant for social businesses, as you now have to worry about achieving social impact in addition to financial sustainability - there are a lot of metrics to consider. In fact, I'm kind of jealous of those who can simply think about a single bottom line. You don't have to get these things right immediately, but you should build enough time into your work to be able to invest in experimentation with them so that you have time to improve or pivot if needed.

Third is to understand your support system. How can you avoid carrying the entire burden of your endeavor on your shoulders? Who is there to help you make decisions, take responsibility for some hard things alongside you, and give emotional support when you're down? There are of course all sorts of pitfalls to partnerships, especially amongst friends, but I often feel that I wish I had waited to start IoE until I had someone to do it with, rather than carry the entire thing on my own. Thank goodness for my wife and our lead investor (and not necessarily just for the money), or else we would have shut down years ago.

Entrepreneurship is a very personal experience. Those in conservation will also understand the pressure that comes with being passionate about your work, and how failure in something you're passionate about can feel deeply personal. It is impossible to decouple yourself from the ups and downs of your business. That notion comes with its own set of good and bad factors. I personally love knowing that I'm working on something I fully believe in, and that I have the luxury of having that choice. But at the same time, when things don't go well, it is normal to take that as a reflection on yourself. Some people are better than others at just letting that slide off of them instead of weighing them down.

Not every challenge is something that can be immediately overcome through hard work or lessons learned.

No matter where you are in your career path, or what challenges you've faced along the way so far, simply reframing your own experiences with failure (or perceived failures) can help you cope with difficulties and make progress. Even if you have not yet seen the successes that may yet come from the lessons you've learned, simply believing in the value of those lessons will make you stronger and help you continue following your passions down an impactful career path.

ABOUT THE AUTHOR

GAUTUM SHAH
FOUNDER, INTERNET OF ELEPHANTS

Gautam Shah, a National Geographic Fellow, is the founder of Internet of Elephants, a social enterprise that develops groundbreaking digital tools to engage people with wildlife. Through unique mobile games, augmented reality and data visualizations that use GPS and other data gathered about animals, Internet of Elephants tells the stories of individual animals studied by conversation organizations and researchers all over the world. In doing so, Internet of Elephants hopes to catalyze whole new approaches to engaging the public with wildlife.

ELLIE WARREN & SARA BEERY

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THE PROMISE AND THE PITFALLS OF MACHINE LEARNING FOR CONSERVATION

'Even if you're not seeing a 99% accuracy rate, being able to say, 'Look, we only have to manually label 15% of our data now because of the ongoing work we're putting into this' should feel like a success, especially compared to time-consuming alternatives without machine learning tools.'

Sara Beery

In this case study, **Ellie Waren** and **Sara Beery** sit down for a conversation about the sky-high hype and inevitable disappointment when it comes to our expectations for machine learning in conservation.

MegaDetector detects humans, vehicles, and animals in camera trap data.

Machine learning is often touted as conservation technology's silver bullet, the tool that will make our work infinitely easier, faster, and more effective. But those who work with machine learning can tell you from experience that it's far from a magic solution, and in fact, the hype surrounding machine learning's potential can make its failures feel that much worse.

As someone who is far from an expert in machine learning, I sat down with AI for Conservation expert Sara Beery, part of the team that created Microsoft AI for Earth's MegaDetector, to discuss machine learning's unique challenges, and how learning from those challenges can help make this tool more useful and accessible to conservationists and ecologists.

In speaking with Sara, one common theme keeps rising to the surface of our conversation: when machine learning tools fail to deliver consistent results, i.e. when a model achieves very high accuracy on a prototype dataset but doesn't work in the field, the cause is often that the prototype data wasn't representative of the end use case. This means that when the model "fails" it's really being asked to do something significantly outside the scope of what it has been trained to do. And because many of us don't yet understand exactly what machine learning is capable of, we're more likely to buy into hype and sky-high expectations, resulting in a feedback loop that leads us to expect near-perfect performance, and then feel disappointed by the inevitable letdown.

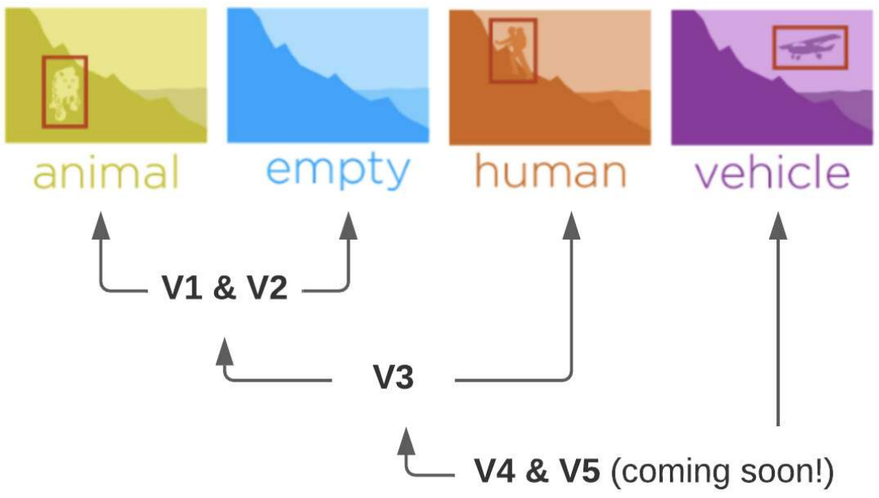
"A huge part of the problem comes down to the data we're using to train and test these models," says Sara. "Beginners expect that training a ML model is the challenging part, but really, the training isn't that hard. The real challenge is that data curated for ecology tends to be project-specific, covering limited geographic areas or taxonomic groups, and collected from project-specific sensors. To build a one-size-fits-all machine learning model, you would need to collect a dataset that covers all possible use cases - which in a changing world is essentially impossible."

So how does that relate to our expectations for machine learning, built around incredible promises like 99% accuracy? "In almost every paper that promises those kinds of results for the ecological community at large, the data they have built their model on will not support their broad claims. It is entirely possible to attain 99% accuracy in a highly controlled setting - fixed sensors, time periods, sensor placement strategies, etc. It's not that they're not getting great results, and it's not that the machine learning model itself is doing anything wrong. The problem is that it's never going to work that well for anyone else or any other project, making it "fail" when used in the real world. They're not testing the model in a way that shows how it will work for other potential users, and the media hype makes it seem like 99% accuracy for one project means 99% accuracy for everyone,

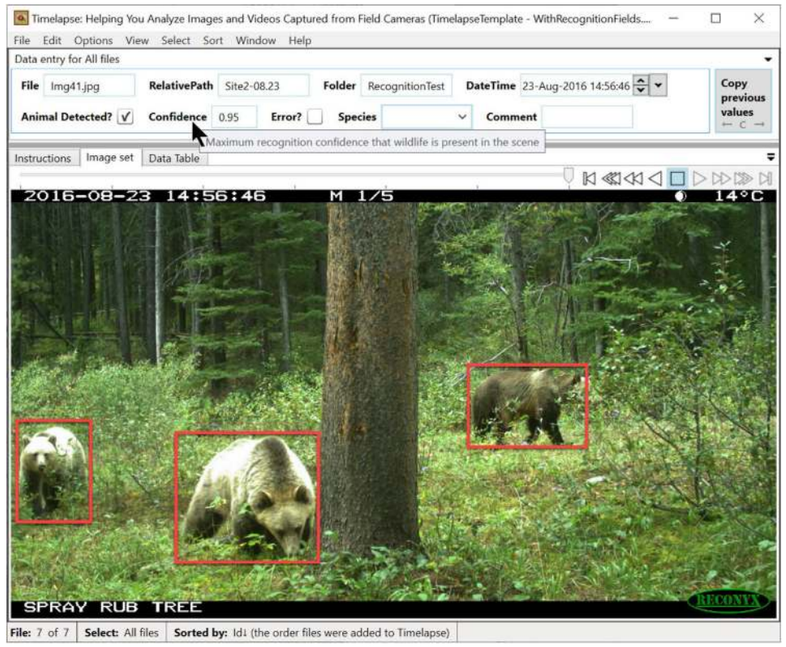
with no additional effort. That disconnect between expectations and reality is what makes us perceive anything less than almost perfect results in actual practice as a failure, when in fact, a slightly-less-perfect machine learning model can still save you a lot of time and effort."

Tools like MegaDetector, which detects humans, vehicles, and animals (here "animal" is a single, generic class) in camera trap data, save users time combing through massive amounts of empty photos. A significant amount of effort has gone into making the results of the model easy to analyze for any new project, vital when using a machine learning model in practice. The user-friendliness comes from MegaDetector's ability to pick out wildlife - any wildlife - from enormous datasets without needing to retrain the model for new projects. However, when it first became available to users, Sara says, "It took a lot of handholding for each group. We'd walk people through the process of using it, and there was a lot of uncertainty at first about the pain points and how to put it into practice most effectively. It's built to be easy to use and work as well as possible off the shelf, anywhere in the world and for any animal taxa. That said, every user has different needs and requirements depending on their study, so each user has to weigh their own pros and cons when it comes to how they use the model. No two user's needs are the same. For example, if you're surveying something like invasive rodents on islands, any sighting of a rodent is highly significant, so you want to be sure that you're not missing detections. For this use case, you'd use a lower confidence threshold on model detections, which reduces the risk of missing one but requires humans to filter through a larger number of false positives.

> It's not that they're not getting great results, and it's not that the machine learning model itself is doing anything wrong. The problem is that it's never going to work that well for anyone else or any other project, making it "fail" when used in the real world.



The MegaDetector has grown over time to meet the needs of the community, with human and vehicle classes added once it was determined that those categories would also generalize well to novel deployments and regions. The main goal of this model is to provide a tool that is as useful as possible for as many researchers as possible, hence restricting the class set to what has been found to work across diverse camera trap data held entirely out of the training set.



MegaDetector has been integrated into several popular data management tools for camera trap data, such as Timelapse. By meeting the ecological community where they already are, and building our models into tools they already use, we make machine learning much more accessible.

Because the MegaDetector doesn't predict the species of detected animals, if you're looking for one specific species that's elusive or rare in your area you're still going to be combing through large numbers of animal images in your dataset searching for your subject species. MegaDetector saves time by eliminating empty images that don't contain wildlife, but it doesn't mean you won't still have to do further data processing."

When considering what machine learning tools will most successfully meet your needs, Sara recommends considering your priorities, resources, and the risk associated with errors for your study. "With any trained machine learning model, you can pick an operating threshold that will trade off between recall, avoiding missed detections but resulting in more potential false positives to analyze, and precision, where your predicted results are more accurate, but you may have a higher risk of missing something important. Knowing which one of those options will lead to the right tradeoff between human processing effort and risk for your study is something you'll learn from experience, and it's based on knowing how to match your tools to the question you're trying to answer."

But to those without previous experience in meeting machine learning's intrinsic challenges, the perception of failure can creep in simply from being forced to consider these factors. "People get frustrated by the fact that off-the-shelf tools can't do exactly what they want immediately," says Sara. "People expect 99% precision because that's what they're seeing reported in papers. But your expectations for use should include investing the time to carefully analyze how well any off-the-shelf tool works for your data, learning how to fine-tune an existing model for your specific project if you need specific predictions (like species, gender, age, or behavior), and committing to iteratively fine-tuning that model and doing continual quality control for new seasons or new deployments."

Adjusting your perspective can play a big role in helping you see the value of your own efforts and avoiding the urge to see a lack of perfection as failure. "Even if you're not seeing a 99% accuracy rate, being able to say, 'Look, we only have to manually label 15% of our data now because of the ongoing work we're putting into this' should feel like a success, especially compared to time-consuming alternatives without machine learning tools. For example, MegaDetector user Beth Gardener at the University of Washington told us, 'We had a big image processing party last week [...]

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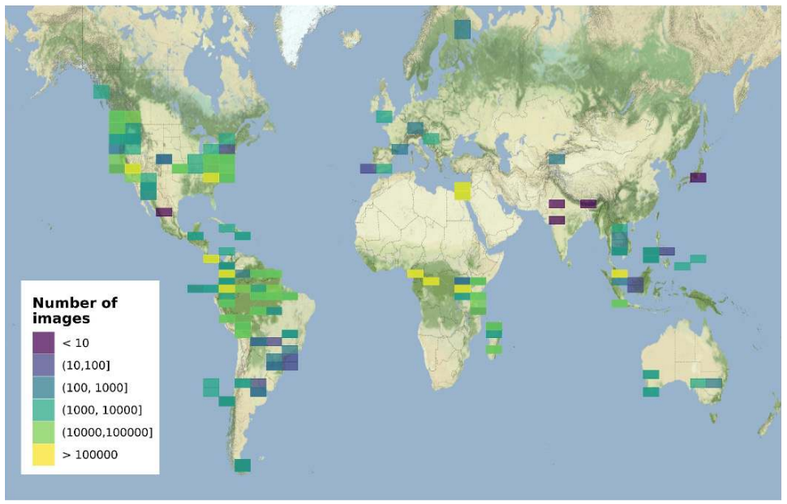
Because of the MegaDetector; ~6 of us processed over 100,000 images in one day. That would have taken weeks or months before.' I count that as a considerable success for AI, and I expect that as our research and our access to data improves that we will make experts increasingly efficient in processing their large datasets."

Frustration can also stem from lack of clarity about the common metrics for measuring machine learning's success. "Metrics like accuracy can be misleading depending on your data. For example, if you get 90% classification accuracy from a machine learning model predicting whether an image is of a dog or of a mountain lion, that sounds really great! But if your data is 90% dogs, your model can get that accuracy by predicting 'dog' for every single image. When data is imbalanced, sometimes a class-averaged metric is more interpretable, because it better captures how well the model is doing across all of the possible classes. However, optimizing for class-averaged metrics frequently result in models that make more errors on common species, and if a common species is 90% of your data that's a lot of errors. I recommend users break down performance across classes, and if applicable across sensor deployments, seasons, and regions, to better understand what the model is doing and to decide which images to trust the results for, and which images to send for additional human review."

When building machine learning tools, part of the learning process when it comes to ongoing maintenance and quality control revolves around accepting and dealing with "the drop-off." As Sara explains it, "With camera trap data, you'll never get as good of performance out of your machine learning model as you did last season. You'll always see a drop-off in performance, and if you don't realize that and put in the effort to re-analyze model performance, your results won't be what they should be, and you'll have a poorly-calibrated sense for the trustworthiness of those results. This process can be incredibly frustrating for people who don't realize that quality control and model training isn't a one-time thing."

To demonstrate the constant need to practice diligence and good quality control habits, Sara shares a story from her work with Wildlife Insights, a machine learning platform that seeks to tackle the challenge of robust, global species identification by curating diverse camera trap data from around the world, and simultaneously provides users with a powerful platform for data management and analytics. "This is a case where we thought we'd done our due diligence. We learned that just because something isn't a problem the first time, or second time, or many, many times in a row, that doesn't mean it'll never be a problem." The issue arose when the team started to analyze the performance of a new model version before its release. The new version included a large amount



Wildlife Insights seeks to overcome some of the generalization challenges that machine learning for camera traps face by training ML models on data from researchers around the globe. There are currently over 19M images in the Wildlife Insights database, distributed across the globe. Created by Fabiola Iannarilli, Yale University, on behalf of Wildlife Insights

PROMISES AND PITFALLS OF MACHINE

Tools like MegaDetector, which detects humans, vehicles, and animals (here "animal" is a single, generic class) in camera trap data, saves users time combing through massive amounts of empty photos.

of training data from a new projects, and to everyone's surprise, for no apparent reason, the model began frequently predicting the presence of domestic cats. Lots and lots of cats, on images that were clearly deer or dogs or cows, species the model had handled very well in the past.

"In what seemed like a sudden catastrophic failure, we were getting detections of cats in what felt like almost every photo from certain camera trap projects." To understand what went wrong, we must go back to a potential issue that Sara thought had been thoroughly investigated. "Every camera trap brand has its own logo or watermark on photos. We'd previously wondered if all those different logos would bias our machine learning models or impact performance. But in earlier testing, we found that different logos in different locations in the image frame didn't seem to throw off generalization or make a difference in our results."

The mysterious abundance of cats turned out to be the result of a large project from an urban area that captured lots of cats and used only Bushnell cameras. By some chance, most other projects already in WI were using other camera trap models, so the algorithm learned the "easy" association that an orange Bushnell logo meant the image contained a cat. The team was reminded the hard way how machine learning models will always take the easy way out, and memorize spurious correlations in the data if possible. "This model was so good at everything else, but was making these weird cat errors that just didn't make sense! It took us a while to figure out what had gone wrong. We might've realized that the Bushnell logo was causing the problem sooner if we hadn't already invested time into analyzing whether logos caused issues in previous versions of the model. Because we'd already invested that time and energy, it was easier for us to overlook it because it wasn't on our radar anymore as a potential problem.

Ecologists and conservationists will need to develop an intuition about machine learning, and that comes with use and experience. The goal is to break down knowledge barriers and make it more accessible for ecologists to use practically.

But that's a good example of accepting that just because your model doesn't have a problem with something now, it doesn't mean it'll never have a problem. Don't trust the results of any model without corroborating them; otherwise, you won't recognize those problems when they do pop up." Because the Wildlife Insights team caught the error and were able to determine the cause, they were able to retrain their model after cropping out logos and verify that it fixed the issue. The new model version no longer has a love affair with cats.

With more established and familiar types of conservation technology, like camera traps themselves, the idea of failure may be easier to digest. After all, hardware can malfunction, especially when exposed to the elements and unpredictable wildlife. But with all machine learning's hype as the future of conservation tech, our own expectations may be setting machine learning up to fail. And that's unfair. Machine learning will very likely play a huge role in conservation's future, particularly as tools like MegaDetector and Wildlife Insights make it more and more user-friendly. But like we've come to accept mishaps with hardware, we need to accept machine learning's realities and current limitations in order to realize its full eventual potential.

Equally important is recognizing that machine learning's current capabilities are not its ultimate destination. This technology, like all technologies, will only improve and become more accurate and accessible over time. And with increased accessibility, Sara sees a bright future full of promise for machine learning. "Ecologists and conservationists will need to develop an intuition about machine learning, and that comes with use and experience. The goal is to break down knowledge barriers and make it more accessible for ecologists to use practically. If you give people the skills to experiment with machine learning, you open the door to innovative ideas, and new, exciting human-AI solutions for conservation and sustainability challenges."

ABOUT THE AUTHORS

ELLIE WARREN
WILDLABS COORDINATOR, WWF

Ellie Warren creates content and supports the conservation technology community at WILDLABS through virtual events, fellowships, and community engagement. She currently works as WILDLABS Coordinator at World Wildlife Fund, and has a background in English, nonfiction writing, and screenwriting.

SARA BEERY
PHD CANDIDATE, CALTECH

Sara's research focuses on building computer vision methods that enable global-scale biodiversity monitoring. She works closely with Microsoft AI for Earth and Wildlife Insights (via Google Research) where she helps turn her research into impactful tools for the ecological community. She seeks to break down knowledge barriers between fields. She founded the AI for Conservation slack community (+600 members), and is the founding director for the Caltech Summer School on Computer Vision Methods for Ecology.

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GAYLE PEDERSEN

CAN YOU HEAR ME NOW?

‘The restrictions and discomfort with sharing firsthand experiences with peers on other reserves and parks are shortfalls in our industry, particularly when they are not positive experiences and hence interpreted as failures.’

Gayle Pedersen

Gayle Pedersen discusses how the failure of underlying infrastructure can complicate conservation technology work, and how the culture of avoiding failure publicly prevents conservationists from avoiding the same challenges.

Our collared mother cheetah, whose data allowed us to locate the young injured cheetah.

As the WILDLABS community knows, technology has substantially grown as a tool in conservation and wildlife management, becoming an integral part of our work over the years. Common tools like camera traps and GPS collars allow busy researchers to passively and continuously gather data, allowing consistent monitoring and study. But despite how ubiquitous conservation technology has become in our work, it can make or break projects dependent on budgets and field conditions, meaning the success of our tools and project plans are critical.

And while there are so many reserves and parks utilising technology in their daily operations, many of the people working with technology day in and day out never get around to publishing their trials and tribulations, or sharing their experiences with others if there are no conferences or workshops on the topic. Because of this ongoing culture of avoiding public failure, even navigating fairly basic struggles without the guidance of others who have already dealt with such issues can become a challenge in itself.

In remote locations, even in regions and countries that are otherwise technologically advanced, the most fundamental of technological infrastructure frequently fails field ecologists and researchers. Despite the frequency of these issues, its impacts on our work are not discussed nearly as much as you’d expect.

For years, South Africa’s only energy supplier, Eskom, has been undergoing periods of ‘loadshedding’ where the national power grid is overloaded so electricity provision is suspended around the country on a rolling, daily basis for 2.5 to 5 hours, sometimes more. If you’re fortunate enough to be based in rural areas, as most game reserves are, these power cuts can also lead to cell phone tower blackouts for the duration.

On one such occasion, I just happened to be on a mission with my team to locate a young cheetah and assess a wound she sustained a week prior. Ahead of the long weekend, we needed to report back our observations to decide whether veterinary attention was necessary again. The cheetah in question was still travelling with her mother and siblings (the suspected instigators of the injury), and the mother was equipped with a GPS collar that provided location uplinks in the morning and afternoon. Between those uplinks, the VHF (very high frequency) radio telemetry function was used for pinpointing their location whenever necessary.

It is always preferable to locate a targeted animal as early in the day as possible, in order to allow for time-consuming eventualities and to carry out

operations before the peak heat of the day. On this particular morning, I was able to detect the VHF signal on a mountainside. I pulled my vehicle off the road and we proceeded uphill on foot to assess the injury and accessibility. The feline family was fairly easy to locate, resting in dense bush approximately 90% of the way up the mountain. I was able to get some photographs of the wound in question to confirm the plan of action with superiors. It was also necessary to be able to contact the vet and request that a colleague escort them to my location from the reserve entrance, ensuring the cheetah received timely treatment.

What should have been a straightforward process became a stumbling block as technology failed me.

In the time it took me to locate the cheetahs, scheduled loadshedding had commenced, and the tower for my cellular network provider was down. Though I'd located the cheetahs, I was not able to send photos of the cheetah's injury or communicate with the office. And while two-way radio communications can often serve as a backup in situations like this, I also just happened to be in a bit of a black hole for that method of communication as well.

When communications fail, it is risky to leave the animal in need of care, as there is a chance they will move in your absence. I asked one of my team to quickly go and fetch my vehicle to bring it up to the closer access point at the top of the hill while I continued attempting to make contact. With no other choice, I drove to the office to access the WiFi (courtesy of a generator), confirm the operation is a go, and make arrangements with the vet and his chaperone through the reserve.

Luckily, this situation was not so urgent that such a delay would put the animal at immediate risk, but that is not always the case. Imagine finding wildlife grievously wounded by snares or poachers and you'll understand just how easily a simple technological failure with communications systems could turn catastrophic. And beyond that, having a team in the field with no available methods of communications could put team members in a dangerous situation with no way to reach others for help, a challenge none of us want to face.

The vast landscapes we work in with conservation technology can pose challenges when basic communications infrastructure fails

Our patient awaiting treatment in the field.

In my case, I swiftly returned to the field site to find the cheetahs still relaxing in the shade. But the environment offered us one last reminder of the constant threats of technological failure constantly awaiting us; just as the vet pulled up, a cloudburst arrived out of nowhere, despite the previously blue sky with with 0mm of rain in the forecast. The unexpected turn of the weather soaked myself and two team members as we frantically placed the camera and telemetry radio in plastic bags to keep the valuable equipment dry and functional.

Less than 10 minutes later, the rain cleared up, and the wound treatment was a quick and efficient success. But despite the success of this mission, consider how dependent we were on technology to get us to that point, and how the delays caused by technological failure led to us still being out in the field when the weather changed, further risking our equipment.

> Experiences like this are a valuable reminder of the importance of underlying infrastructure and technological basics that we often take for granted.

And furthermore, consider how, on this occasion, the GPS/VHF collar and radio telemetry - conservation technologies that are still developing and advancing - were far more reliable and effective than the age-old technology of electricity, cell phones, and two-way radios. We may expect our high-tech tools to have a higher capacity for failure than the tried-and-true everyday methods, but experiences like this are a valuable reminder of the importance of underlying infrastructure and technological basics that we often take for granted.

Without ensuring that basic technological needs are met, even the most cutting-edge, top-of-the-line, otherwise effective technologies will also be at risk for failure. This perspective is especially important for those working in protected spaces with rangers and teams on-the-ground. Their long-term ability to deploy, use, and maintain new technological tools in their work may be severely impacted by such simple issues as connectivity infrastructure in the region, a factor over which they have no control.

The restrictions and discomfort with sharing firsthand experiences with peers on other reserves and parks are shortfalls in our industry, particularly when they are not positive experiences and hence interpreted as failures. It's actually one of the biggest problems in wildlife management and conservation, that the politics and secrecy at the

Our patient recovers after communications failures led to a brief delay in treatment.

top of some of these critical parks and reserves prevent operators from openly discussing their successes and challenges so others can learn from them.

As it is, many of my personal stories about overcoming or dealing with what others may view as failure may only be shared with others in my network on a one-on-one basis, and this experience is not unusual for those working in protected spaces. Just as some scientists and reviewers don't like papers reporting the acceptance of the null hypothesis, few want to publicly discuss management failures or oversights, even if withholding those stories dooms someone else to encounter the same problems.

But all of these experiences teach us what works, what should not be repeated, and where we can improve. It could save an ecologist or researcher on another reserve having to tackle the same process of trial and error, saving funds and time. While improving basic infrastructure and technological tools can make a huge difference to our work, changing our culture surrounding experiences with failures also has enormous potential to change the way we do conservation work for the better.

ABOUT THE AUTHOR

GAYLE PEDERSEN

FOUNDER, INTERNET OF ELEPHANTS

Gayle Pedersen is a South African large mammal ecologist who specialises in rhinos and has over 20 years of research, field and laboratory experience spanning 4 continents. Her primary interests lie in wildlife management, illegal wildlife trade, and conservation genetics, with a focus on building collaborations, developing innovative and community-based approaches in response to evolving conservation challenges, and changing the mindset of otherwise disenfranchised stakeholders.

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JOHN CORNELL

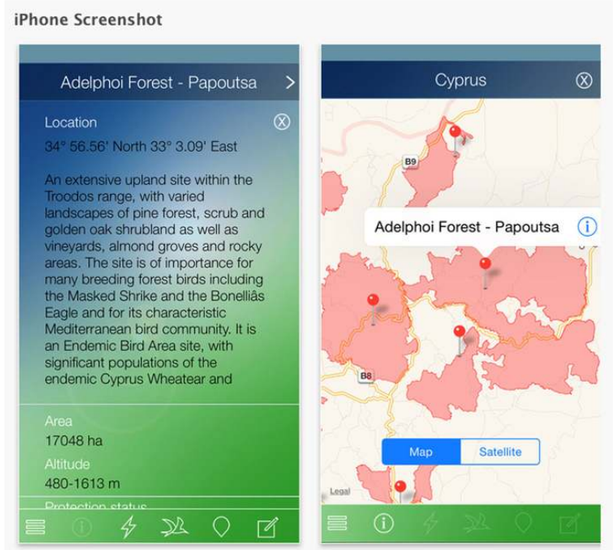
NATUREWATCH

LESSONS FROM THE FIELD OF APP DEVELOPMENT

‘Beware of strangers offering gifts, or in this case if offered pro bono services, be very clear about how these might affect delivery of the product – particularly intellectual property.’

John Cornell

In this final case study, **John Cornell** shares the story of a mobile app, Naturewatch, that ultimately did not deliver what was intended. But through this story of failure, he signposts the key lessons he learnt along the way and offers others the a chance to take a different path in their own work.



While conservation technology itself rapidly changes and evolves, the experience of failure is evergreen.

To conclude the Technical Difficulties Editorial Series, we’ve chosen to once again share an article by John Cornell detailing the lessons learned from his challenges in conservation app development. Originally published to WILDLABS in 2017, app development - and conservation technology in general - has come a long way since we first shared this article and yet the advice contained within it is still as relevant today as it was four years ago.

John Cornell’s article was, in fact, part of the inspiration for the Technical Difficulties Editorial Series, inspiring us to open up a wider conversation in the community about the value of failure. But the fact that we still must encourage people to share their stories of failure, and are often met with reluctance around discussing the topic, shows how far we have to go.

This series has allowed us to open the dialogue about failure in conservation tech within our community, but the conversation is far from complete. Many of our failures still happen behind closed doors, with their lessons learned only by those team members. And yet when the idea of sharing lessons learned from failure arises, most of us agree on the value of those experiences and are eager to learn from others. Clearly a disconnect still exists between our understanding of failure’s value, and our willingness to accept failure ourselves.

As we conclude this series, we hope that the WILDLABS community will continue to embrace these conversations. Just as collaborative projects within the community are a group effort, so is the conversation about failure - we are all working on this together, and we are all helping each other, one story at a time.

Ellie Warren

Editor, Technical Difficulties

In the frenzied rush to embrace the white-hot heat of emerging technologies and apply them effectively to our conservation work, we can sometimes misjudge things, make invalid assumptions or just plain get it wrong. Common sense tells us that introducing new ways of solving old problems will not always deliver the intended outcome first time around and that if it can go wrong, it probably will at some point.

TECHNICAL DIFFICULTIES

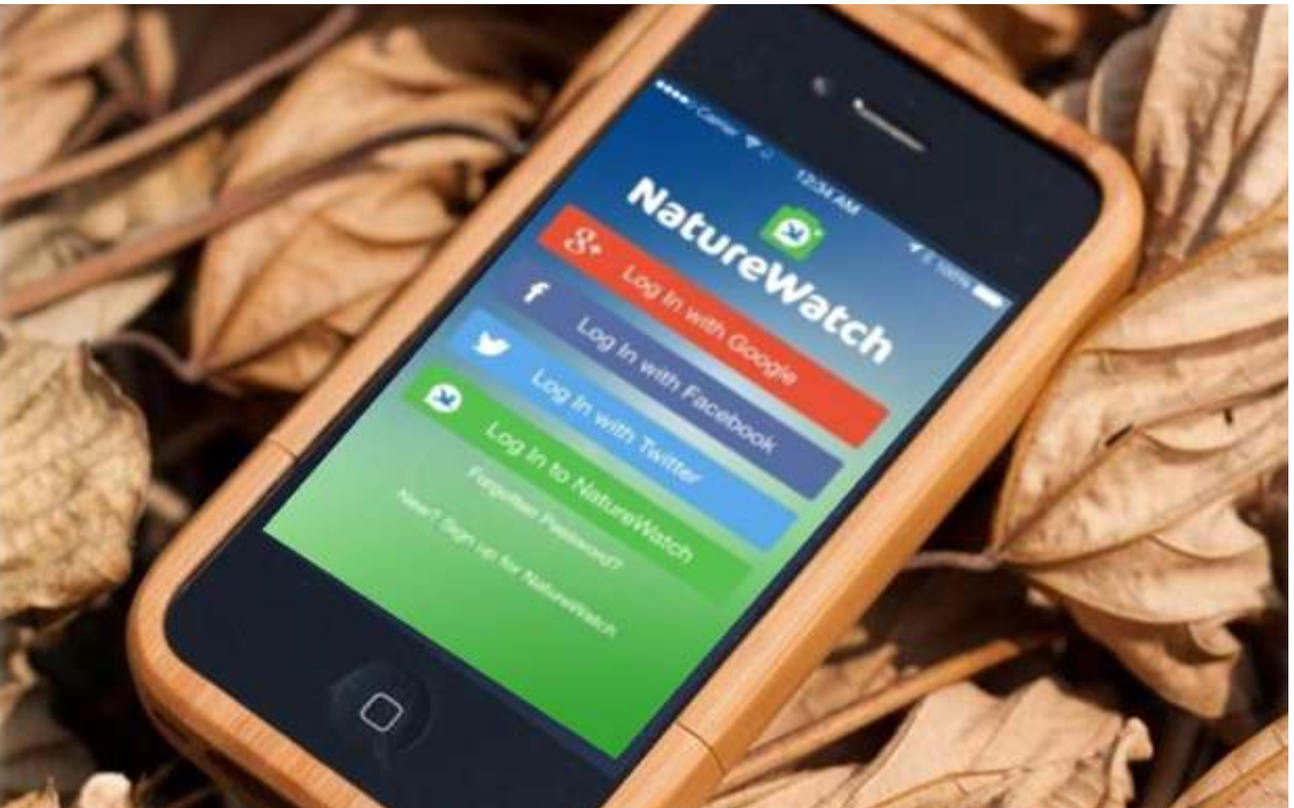
When things do not go according to plan we are often reticent to share the failure with others. It's not in our nature to draw attention to failure, as failure is not rewarded and often can be culturally or institutionally stigmatised. Instead, we are conditioned into promoting our "high five" moments of glory and success, to win and achieve our aims and goals. The difficult road leading to success and the hard won lessons learnt along the way are seldom shared, and unfortunately more typically forgotten. However, acknowledging and exploring failure as an important learning mechanism is something that we should strive for, embrace and share more often. The critically important seeds of lessons learned from failure can be used to grow the heady successes of the future, if we are brave enough to embrace this philosophy and expose our vulnerabilities, letting our failures see the light of day.

With this in mind, I wanted to share with you some of the wisdom gained from the development and deployment of a pilot mobile application that ultimately did not deliver what was intended, but which did offer some valuable lessons and thus provide a different kind of success from the ashes of failure.

It's not in our nature to draw attention to failure, as failure is not rewarded and often can be culturally or institutionally stigmatised.

In 2013, funding was made available in my team for a Citizen Science project, something that would add value to our structured monitoring by augmenting information collected at BirdLife's Important Bird and Biodiversity Areas (IBAs) through engagement with local volunteers. It all sounded very grassroots and sensible, and with mobile applications becoming ubiquitous and smartphones more common in developing countries, we decided to develop a mobile application for use by volunteers and Local Conservation Groups.

I formed a project team at BirdLife getting representation from Communications and Capacity Development Divisions and we began to meet with experts from the field of mobile app development and site monitoring and shape the concept of what we were trying to achieve.



TRACKING THUNDERBIRD

Initial concepts for the app were based around the idea of not just dry and dusty data collection, but fun, engagement with visitors to sites, dog walkers, hikers... in fact, anyone interested in being outdoors and contributing to a community sharing information about places important for nature.

However, this took longer than anticipated and by the time we had anything that looked like a specification it was the spring of 2014.

Initial concepts for the app were based around the idea of not just dry and dusty data collection, but fun, engagement with visitors to sites, dog walkers, hikers... in fact, anyone interested in being outdoors and contributing to a community sharing information about places important for nature. It was not another birding app either; there were already a ton of these and it was not our focus. One of the team came up with the idea that the app might provide a kind of "Trip Advisor" service but for IBAs, and this was met favourably by those offering our team advice on development. So it was decided: the app would try to both collect useful data for the organisation, engage the wider public and also be an information tool for site visitors – a perfect storm of potentially conflicting functionality.

There then followed a standard procurement model of advertising for development in the appropriate places, getting lots of applications and then choosing a suitable developer. By the end of February we were talking to a developer who had a great portfolio of clients and was also suggesting that they would deliver part of the work pro bono. As our development budget was on the meagre side (around £25K for a contractor), we jumped at the opportunity to get some of the work done for free.

After many meetings and sketch ups with the developer the concept was firmed up; a native mobile app was to be developed and made available in six piloting countries initially, with standalone functionality and available on iOS only. We sought to present basic information and maps to users about IBAs and trigger species, but with the functionality to accept photos, comments and threat information from users who after logging in would be able to see the posts of others and thus a social sharing network was also envisioned.

We decided to call the app Naturewatch and aimed it at Partners and their LCGs, but also had broader aspirations for its uptake. A year of development and testing followed with many iterations of functionality constrained by the technical skills of the developer and the demands of the project team to produce something of value to Partners and the Secretariat, but was this a bridge too far?

The long development time began to produce problems as it started to feel as if we were always waiting on something or other to be fixed, amended or figured out and soon came the dawning realisation that while the developer was a professional practice, they had little or no experience of producing an app with the kind of complex functionality (think spatial data, maps and social sharing), that we were seeking and so they were effectively learning on the job.

Lesson 1. Choose a contractor who can demonstrate that they can deliver the technical developments required for the project to succeed. Learning on the job is not an option!

As the development went on over many months and with many challenges, it also felt as if the developer began to lose interest, challenges were not always easily solved and at one point a complete re-think of how the maps would be displayed added more time to the development. We had regular meetings, often face to face (this was a big plus), but over time these too waned as expectations and deadlines for delivery came and went. The developer told us that because they were delivering this project in part pro-bono, that they did have to sometimes prioritise other work.

Beware of strangers offering gifts, or in this case if offered pro bono services, be very clear about how these might affect delivery of the product – particularly intellectual property

Lesson 2. Beware of strangers offering gifts, or in this case if offered pro bono services, be very clear about how these might affect delivery of the product – particularly intellectual property.

By early 2015 the project was out of time and out of money, we were a day late and a dollar short, but still with nothing to show and we had still to test the early version of the app, but soon realised that to do this properly would mean ground truthing in one of the pilot countries, as the UK was not one of the pilot locations and no data or sites were entered for the UK.

Lesson 3. Build-in the ability to test your product properly without having to get on an aeroplane to do it!

A member of the project team, the BirdLife Partner in country and some volunteers, tested the app in Cyprus and while the feedback was generally very positive, the one overarching issue was that not many people had Apple devices and so could not use the app, as it was only available on iOS. This was our first indication that a single platform app, built on iOS was going to be a real barrier to uptake, but our early market research into market share between Android, Apple and Windows devices and specific guidance from the developer had indicated that iOS would be a good single platform option.

It soon became obvious that Partners viewed the tool as another product of the “good idea fairy” from Cambridge and not necessarily something that they either needed or had the capacity to support.

Lesson 4. Build your app on multiple platforms and not just for one or risk excluding large numbers of potential users!

By now it was late spring 2015 and after a few iterations, some testing and some bug fixing the app was made available through the Apple Apps Store and various communications went out to Partners in the piloting countries about using and promoting Naturewatch.

We originally had allocated budget for Partners to use for promoting the app, but this was later withdrawn from all but one when the Partners seemed to not have a communications plan for the tool. Weeks went by and the data did not come flooding in, infact in communications with the Partners we heard the same story about the single platform issue and that there users did not have iPhones. In addition though there was something else going on. Because the development was done and directed in Cambridge, it soon became obvious that Partners viewed the tool as another product of the “good idea fairy” from Cambridge and not necessarily something that they either needed or had the capacity to support.

Lesson 5. Fully involve your Partners from the outset of a project if you want them to value, use and support the thing that you are building. If possible, use existing networks of users, or even better, build your desired functionality into an existing application so that you do not need to build constituency, but instead have a ready-made receptive audience!

By early May 2015 we had launched the app with a news story and promotional video available on the BirdLife main webpage.

The Cambridge BirdLife Secretariat was now actively pushing the app and there was also some evidence of Partner marketing activity, but not at the level needed to really kick it off. Adding in the continued concerns about the availability on a single platform, it felt like we were not going to achieve the uptake in the piloting countries that we had been working towards as a goal over the previous 24 months. After a few months it became clear that we had failed to get any significant uptake or use of the app by the Partners. A few individuals in a couple of the piloting countries were strongly promoting its use, and getting value from it, but with weak local promotion and barriers to uptake, it just foundered on the rocks of apathy and disinterest.

By now the developer was also losing interest in fixing bugs and supporting the app, as they realised that it was not going to form the basis of any future financial opportunities. Although we had talked to them about a phase 2 global version available on Android and iOS, the proposed development costs had somehow tripled from earlier discussions and we could not make the business case or find the additional funding required.

We looked around for the chance to develop the app elsewhere, possibly with another developer or a Partner with interest, skills and resources, but were told by the developer that they co-owned the IPR and would not allow any third-party development. They suggested selling us the rights to develop for a significant amount of money and the relationship at that point became quite strained. They argued that they had put in much more unpaid time than initially envisioned (the pro-bono element) and were looking to recover anything they could from selling the IPR for the code.

A few diplomatic phone calls to the developer and a friendly chat with the BirdLife legal adviser moved the situation on and in the end, the developer agreed to waive the IPR and allow use of the code for any future developments.

Lesson 6. Agree intellectual property rights with your developer before you sign any contract!

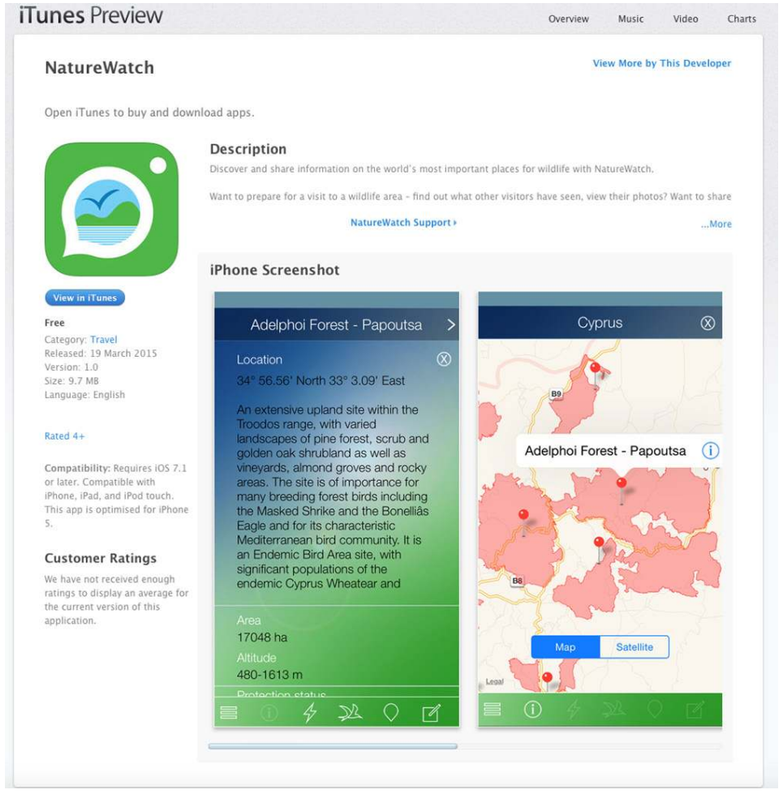
The sting in the tail became clear as the developer handed over the IPR, the code and the simple Content Management System (CMS) to manage the back- end of the app. They told us that they would be pulling the app from their servers – where it had been during the development and testing phase. They also told us that they were going to remove it from their Apple App Store account, and that we needed to create our own Apple account in order to keep it live. With no more funding for the project and dwindling interest from Partners and little support from Directors at the Secretariat, this was the final nail in the coffin for Naturewatch. With the possibility now removed to download and demonstrate the app to others, we were at the end of the road and frustrations within the project team saw its dissolution, as team members got busy with more productive work and drifted away.

Lesson 7. Have a legacy plan for any development to enable ongoing access to what you have put so much time and effort into!

Why the developer chose to pull the app so quickly can only be speculated at, but might have more to do with a perceived reputational risk (association with a non-stellar product) then it did cost or resource implications.

Lesson 8. External developers might have agendas that ultimately conflict with your business needs so remember - caveat emptor!

Between 2013 and 2015 the Naturewatch app was conceived, developed, tested and piloted in six countries globally before being deactivated. While it might be argued that we did successfully pilot a proof of concept app that delivered the functionality envisioned, we did not achieve a lasting legacy from the development, beyond



Between 2013 and 2015 the Naturewatch app was conceived, developed, tested and piloted in six countries globally before being deactivated.

The arena of app development is fast-paced, ever changing and costly and trying to do something with limited budgets, staff and luke-warm interest was never going to end well, unless there was a great deal of right-place-right-time luck involved too.

gaining valuable insight into the landscape of app development for an international audience and all of the challenges and opportunities brought by such an undertaking.

Lesson 9. Have clear aims, goals and objectives in order to feedback in a quantifiable way to your funders on how much success or failure you had!

So we are now in mid 2017 and the need to better understand the conditions at IBAs/KBAs and engage with local audiences around these sites has not changed, if anything it has become a higher priority because of the development of the new standard on Key Biodiversity Areas, agreed with IUCN and others in late 2016.

One irony is that for a number of projects which BirdLife is now involved in, mobile applications are central to the concept of local engagement and data collection and reporting. However, instead of leading from the front with a viable, tested and functional version of the Naturewatch app, BirdLife can only bring the lessons learned from trying to go it alone and start from scratch. There is no Naturewatch 2 to bring to the table, nothing tangible on which we have built and extended our knowledge in this arena. While others have gained ground and understanding in this area of technology, BirdLife are still in the starting gate watching others take the lead.

Lesson 10. Without the encouragement, backing and understanding of what you are trying to achieve within your own organisation, by your organisation, it might be difficult to succeed.

So how does the story end? The story ends with a positive lesson and that is this. The arena of app development is fast-paced, ever changing and costly and trying to do something with limited budgets, staff and luke-warm interest was never going to end well, unless there was a great deal of right-place-right-time luck involved too.

So what is the legacy of this project for BirdLife and the individuals involved? In my mind it is the very lessons gleaned, the hard-won experience and knowledge of how things can go that we will take with us into future projects, It is that knowledge and experience that is ultimately worth far more than the code, because it can help us inform decisions around a multitude of other projects and situations and thus be far more useful than the "product." In the ideal world that none of us inhabit, we would of course want both.

ABOUT THE AUTHOR

JOHN CORNELL

NATURAL ENVIRONMENT TEAM LEAD, GREATER CAMBRIDGE SHARED PLANNING

At the time of writing, John Cornell was the Global Coordinator for Information Management at BirdLife International. He has spent two decades working in conservation, in roles typically focused on the collection, management and presentation of biodiversity data and derived knowledge products and sits at the intersection between the disciplines of conservation biology and geography.

ABOUT **WILD**LABS

It takes a community to create impactful conservation technology applications for real-world use in the field, lab, and beyond.

With huge challenges like wildlife crime and poaching, climate change, deforestation, and extinction threatening ecosystems around the world, it's more important than ever for conservationists to have access to the tools, resources, and networks needed to rise to those challenges.

With collaboration and innovation at the heart of our work, **WILD**LABS is the launching pad for meeting conservation's biggest challenges with conservation technology's boldest solutions.

The **WILD**LABS Community is the central hub for conservation technology online, connecting 5,500+ conservationists, researchers, field biologists, engineers, developers, and conservation technology experts from around the world.

Our editorial resources support our global conservation technology community by bringing new voices, perspectives, projects, and organisations into the **WILD**LABS sphere, highlighting the incredible ways that technology (and the people designing and using it!) shapes conservation efforts worldwide, both in our community and beyond.

Visit our platform at wildlabs.net and YouTube channel to learn more about the community, and follow us on Twitter @WILDLABSNET.

For more information, please contact:

Stephanie O'Donnell
WILDLABS Programme Lead
stephanie.odonnell@wildlabs.net

Ellie Warren
WILDLABS Coordinator
ellie.warren@wildlabs.net

Photo: Kristen Denninger Snyder

Photo: Palma Aquarium Foundation