DJI ENTERPRISE

DJI DRONES: ELEVATING THE ENVIRONMENT

INTRODUCTION

In a world that's getting increasingly battered by the climate crisis and ecological degradation, drones have emerged as indispensable tools for scientists and environmental agencies looking to obtain geo-referenced data quickly and understand the physical, biological, and social changes affecting our planet.

Drones are not only democratizing access to geospatial information but they are also allowing climate experts to communicate the complex nuances of our changing world in a form that even non-technical audiences can understand – visually.

This paper shines a light on conservation-based case studies and applications that highlight the broad potential for drones in monitoring the environment and contributing to a greener tomorrow.

CLIMATE EMERGENCY AND THE RISE OF DRONES

Humanity faces many challenges today. Extreme events are becoming more intense and occurring more often. Energy-related carbon dioxide emissions are at an all-time high, while an increase in water pollution is destroying our ecosystems. Glaciers and ice sheets worldwide are melting, putting as many as 410 million people at risk from sea level rises.

These urgent and interconnected challenges have heightened the need for an evidence-based, data-driven approach toward a green-tinted recovery. In adopting the UN-approved 2030 Agenda for Sustainable Development, world leaders were in consensus that access to high-quality, timely, reliable, and disaggregated environmental data was necessary for policymaking and giving the right direction to conservation efforts.

Up until a few years ago, governments and scientific organizations at local, national, regional, and global levels were forced to rely on traditional sources of environmental data collection, namely low-resolution satellite imagery, costly aerial surveys, and time-consuming and laborious ground surveys.

It didn't help that manual data collection came with the risk of exposing workers to hazardous conditions. Meanwhile, remotely-sensed satellite data offered very little flexibility in terms of acquisition features and frequency of capture, often missing out on fine-scale surface variations.

As drone technology developed, it overcame all these limitations. Drones were able to obtain data more swiftly, help respond to disasters and emergencies more effectively, and minimize the safety risks associated with work conditions.

Think about it: Would you rather send a ground team to the swampy forests of eastern Africa where the presence of crocodiles, snakes, and aggressive hippos impedes an accurate assessment of forest health, especially when you have the option to deploy drones outfitted with cutting-edge visible and infrared cameras to identify the canopy species and density from a safe distance?

DJI DRONES AND THE ENVIRONMENT

With their unrivaled safety record, DJI drones are capable of carrying a multitude of sensors, high-resolution cameras, and survey-grade mapping payloads. These solutions facilitate frequent and consistent environmental monitoring, conservation, and green energy efforts. In addition, our drones are cost-effective, which makes climate monitoring and reporting viable even for those agencies that must work within limited budgets.

Today, DJI drones are being used globally to support scientific research that strives to understand the changing climate and the world around us.

As the case studies that follow would illustrate, our drones are helping protect fragile ecosystems from rising sea levels, natural disasters, and deforestation. DJI drones are monitoring and helping to protect threatened species. In addition, we are supporting and maintaining new green infrastructure, while helping existing infrastructure become greener and avoid industrial disasters.

We are joined in our quest to benefit society by countless third-party developers and innovators who are leveraging DJI platforms to develop ingenious methods that target particular conservation actions, such as fighting wildfires, monitoring whale health, planting seeds from the sky to repopulate forest land, and collecting air samples in the Amazon rainforest.

ADVANTAGES OF DRONE USE

Each organization has its own reasons for deploying drones. But some common characteristics that are driving the demand for DJI drones in support of local, regional, and national decision-making on the environment can be summed up as:

Flexibility to carry different sensors (multispectral, thermal, LiDAR, etc.) and advanced cameras for wide-ranging, high-resolution data acquisition

Better situational awareness through real-time results through on-demand data acquisition

Dramatic increase in worker safety by flying a machine to a hazardous area, instead of sending personnel into the impacted site

Easy access to rough terrain and the ability to monitor even large swathes of land, such as forests

Reduction in data acquisition cost, and further cost-savings through more effective data collection in the first go (minimizes the need for site revisits)

Ability to monitor sensitive ecological areas and endangered species without disrupting their ecosystem

Rapid documentation of highly accurate, geo-referenced data leads to spatially denser information on multiple scales

Flexibility to repeat surveys and inspections as frequently as needed to spot changes, ensure compliance, and determine future trends

More effective visual presentation of the climate emergency through high-resolution images and videos that inspire change

Significant enhancement in the richness of data and more informed decision-making on environmental issues through an evidence-based approach

Ability to gather centimeter-level data irrespective of weather conditions such as cloud coverage, haze, fog, and dust

Opportunity to synthesize drone data into wider remote sensing workflows and visualize the geographical dimensions of climate change more effectively

Enhanced involvement of local communities in conservation efforts

Let’s now understand how organizations across the world are using drones as a force for good for Mother Earth, the environment, and the wildlife with the help of real-world applications.

CASE STUDIES

SAVING BABY DEER FROM CERTAIN DEATH

Every year, thousands of fawns are accidentally killed by farmers and their mowers as they tend their fields. It is estimated that as many as 90,000 baby deer become a victim of this gruesome fate in Germany alone.

The problem is that the breeding season of female deer clashes directly with the grass-mowing season of farmers. It becomes almost impossible for a mower operator to recognize the tiny figure of a baby deer tucked away in the tall grass. To make matters worse, when confronted with danger, a fawn's natural instinct is to remain completely still making it that much harder for the operator to avoid killing or seriously maiming them.

To confront this issue, a German volunteer group, Flugmodus e.V, has turned to drone technology. The organization has been leveraging the powerful visual and thermal cameras mounted on DJI Mavic 2 Enterprise Advanced (M2EA) drone so that farmers can quickly and easily spot fawns in their nests.

KEY CHALLENGES

- Manually checking fields for deer nests is both labor-intensive and a hit-and-miss process
- Newborn fawns do not have a distinct scent for dogs to follow
- Corpses of inadvertently killed fawns can pollute the cut grass, which is used as livestock feed

HOW DJI #DRONESHELP

- Drones identify fawns hidden within the grass through their thermal signatures
- With the powerful zoom capabilities of the M30T's or the M2EA's visual camera, a real-time comparison with the thermal imagery can be done to confirm the location of the deer nest
- Drones can be programmed to survey large fields autonomously

PROTECTING KENYA'S ELEPHANTS FROM ABOVE

Elephants are important ecosystem engineers and help maintain the biodiversity of forests and savannas. And yet, every year, 35,000 elephants are lost to poaching, despite an international ban on the ivory trade.

According to the International Union for Conservation of Nature (IUCN), the population of African forest elephants has decreased by more than 86% over 31 years, while African savanna elephants have fallen by at least 60% over the last 50 years.

To combat this poaching epidemic, elephant protection organizations in Kenya are leveraging DJI Mavic 2 Enterprise series drones that come with 30x zoom and thermal imaging capabilities, which can be used to locate poachers both during the day and at night.

And the results speak for themselves. The Mara Elephant Project, for example, has arrested hundreds of poachers and seized over 1,000 kg of ivory since its launch, with its CEO Marc Goss stating, "We have reduced the percentage of illegally killed elephants from 83% to 44%, meaning that elephants are more likely to live out their lives naturally in the wild."

KEY CHALLENGES

- Ground patrolling is both difficult and risky for personnel
- Law enforcement remains ineffectual in the absence of surveillance documentation

HOW DJI #DRONESHELP

- Live video can be relayed to ground-based conservation teams who are stationed safely miles away
- Hard evidence in the form of photos and videos can be shared easily with forest rangers and police

DEMOCRATIZING OCEANOGRAPHY AND WHALE RESEARCH

Environmental researchers around the world are concerned about the conservation and management of endangered whales because these majestic creatures play a significant role in the health and stabilization of the world's oceans – both in life and death.

As they live, whales act as marine ecosystem engineers, regulating a wide variety of oceanic organisms. And when they die, their massive carcasses sink to the seafloor and provide essential nutrients to deep-sea life.

But as important as studying whale health is, scientists have traditionally relied on samples from dead, stranded, or captive animals, which is in no way a true representation of the normal population.

This changed in 2020 when nonprofit Ocean Alliance started using a modified DJI Inspire 2 drone to collect blow samples from whales as they came up to the surface to exhale. The 'Snotbot' would hover above a surfacing whale and collects samples from its 30-feet-high sneeze, before returning safely to researchers who are positioned about half a mile away.

Ocean Alliance has continued to pioneer drone use in marine research in 2022 by becoming the first group to successfully drop data tags on the backs of whales. Not only is this new solution non-invasive and relatively stress-free for all involved, it's smarter, faster, and cheaper than the traditional approach.

KEY CHALLENGES

- Conducting whale biopsy with a special crossbow to collect data is both dangerous and inconsistent
- Attaching tags to whales with a pole is costly, slow, and dangerous
- Chartering marine vessels and equipment for marine research is extremely expensive, restricting the field to a privileged few

HOW DJI #DRONESHELP

- Drones enable marine research to be conducted in a non-lethal, non-invasive manner
- Collecting data through drones is affordable, replicable, and scalable for researchers everywhere

COUNTING THE LION'S WHISKERS WITH DRONES

Wherever they live, lions play the all-important role of regulating the food chain and controlling the herbivore population of their habitat. But the king of the beasts has been getting hammered across its range – mainly through snaring, conflict with cattle farmers, and poaching of their prey. So much so, the African lion sits on IUCN's Red List of vulnerable species.

To track lion populations and keep a tab on their health, wildlife biologists need to look for a 'whisker pattern'. Because just like humans have unique fingerprints, lions have distinctive whisker arrangements on their faces.

Now, you can imagine how difficult it must be for researchers to get close enough to lions to capture really detailed photographs that record their whisker prints, and then track those lions as they age over time.

On the other hand, small drones, such as the DJI Mavic 2 Zoom, can do this easily with 48MP super-resolution cameras and optical zoom capabilities. Unsurprisingly, the method has been able to get the most accurate counts of carnivores on the border between Uganda and Congo.

KEY CHALLENGES

- Traditional wildlife surveying techniques such as 'call up' surveys and counting footmarks can be widely inaccurate
- Getting close enough to capture a lion's unique whisker print is highly dangerous

HOW DJI #DRONESHELP

- Remotely-sensed data keeps both lions and humans safe
- The animals are left undisturbed during the data capture process since trials show lions get habituated to a drone flying at a distance easily

STUDYING PROCREATING PENGUINS FOR OCEAN HEALTH

If we were to sum up the importance of penguins in one sentence, we'd say: penguin health equals ocean health. Unfortunately, climate change is threatening up to half of the king penguin populations, leading scientists to keep a tight watch over the aquatic flightless birds.

Every Antarctic summer (roughly October through February), researchers would descend on the icy snow-covered desert of Antarctica to study the penguins. They would tag a bunch of birds by hand, and go back every subsequent year to locate as many of them as possible. By extrapolating on the number of tagged penguins counted year by year, they could estimate the overall population of a given rookery.

A more efficient method came to light in 2017 in the form of DJI drones. Point Blue Conservation Science, a nonprofit focusing on penguin ecology, began to conduct drone surveys to capture penguin colonies. Today, innovations in autonomous flying allow Point Blue to survey colonies spread over 2 sq km, housing as many as 300,000 nesting pairs, in just three hours. After that, machine learning algorithms show their magic, automatically detecting and classifying penguins captured in the drone data.

"Our method reduces survey time by limiting redundant travel while also allowing for safe recall of the drones at any time during the survey. Our approach can be applied to other domains, such as wildfire surveys in high-risk weather conditions or disaster response," says Mac Schwager, a Stanford University professor who helped Point Blue adopt DJI drones.

KEY CHALLENGES

- Manually tagging penguins is tedious and time-consuming
- Helicopters are too expensive, noisy, and intrusive for aerial surveys

HOW DJI #DRONESHELP

- Drones can collect excellent data automatically in a fraction of the time
- Multiple drones can be deployed to survey larger colonies

MONITORING POLAR BEARS DURING DENNING SEASON

Polar bears may have emerged as the poster child of climate change. But their importance does not end with an ability to invoke a strong emotional response to the climate emergency. Polar bears are at the top of their food chain and are critical for the overall health of the marine environment.

Only 22,000-31,000 polar bears remain on Earth. So, the World Wildlife Fund (WWF) is naturally interested in monitoring their population closely, especially during the denning season.

The problem is, the Arctic islands of Wrangel and Herald, where pregnant polar bears like to den, are not hospitable for people. They are famous for frosty weather, frequent snowstorms, strong northerly winds, and complete darkness during the night.

Expectedly, drones are the only solution that allows scientists to watch the wildlife without disturbing pregnant bears. As Leonid Zaika, head of the Department of Ecotourism Development of the Wrangel Island Nature Reserve, puts it, “The resulting photo and video material are of great scientific value and with its help, specialists will understand the age and condition of the animals, and the distinctive features of their behavior.”

KEY CHALLENGES

- Helicopters are expensive and inefficient in spot- ting den holes
- Pregnant bears prefer the upper slopes of the Arctic mountains, making surveying even more difficult

HOW DJI #DRONESHELP

- Thermal imaging drones locate dens easily because they are warmer than ambient temperature
- Drones with zoom cameras can capture photos from a distance that doesn’t disturb the bears

IMPROVING CROP QUALITY AND YIELD RATE FOR FARMERS

Changing weather patterns, extreme events, compromised biodiversity, and increasing pollution levels –all have a huge impact on agricultural production. And so, to manage the threat to global food security, the use of technology in farming has become more important than ever.

In 2021, DJI drones completed agricultural missions covering a total of 66.7 million hectares of farmland. What does this mean for sustainable development?

Replacing traditional machines with drones can reduce carbon emissions by 51.45 kg CO_2e (carbon dioxide equivalent) per hectare. For 66.7 million hectares, that's equal to 3.43 million tons of CO_2e. This is the same about of carbon that 1.27 million vehicles would emit or 161 million trees would absorb in a year.

Further, drones also help farmers to save around 435 liters of water per hectare compared to manual farmland management operations. For 66.7 million hectares, that's equal to saving 29 million tons of water – aka the water intake of 52.72 million residents in a year.

KEY CHALLENGES

- Traditional farm operations rely on intense manual labor
- Farmers are exposed to a variety of chemical hazards that can impact their health and safety

HOW DJI #DRONESHELP

- Drones can deliver seeds, fertilizer, pesticides, desiccants, etc., in a precise manner to help farmers beat harvest goals
- Multispectral drone sensors can spot problem crops as much as two weeks before physical signs emerge

HELPING FIREFIGHTERS WITH PRESCRIBED BURNS

Climate change is increasing the frequency and severity of wildfires, putting our ability to protect people and property from blazes to test. Fortunately, new technologies such as prescribed burn drones are emerging to meet these challenges.

Prescribed burning is a critical component of wildfire prevention in which fires are deliberately started under controlled conditions to reduce fuel build-up. Traditionally, this has been done using handheld drip torches or through helicopter missions. But IGNIS, a sophisticated system for carrying out prescribed burns using the DJI M600 drone, is enabling firefighters to undertake this important activity without any boots leaving the ground.

In only six months of procuring the system, nonprofit environmental protection agency The Nature Conservancy (TNC) used it to deliver prescribed burns to more than 7,000 acres of land.

Meanwhile, Sam Lindblom, Director of Land Management and Fire Program Manager, Virginia, calls IGNIS “the biggest change to how we work” in decades. “I wish I had six more of these units to fulfill all the requests for burns.”

KEY CHALLENGES

- Controlled burning by hand limits operations to relatively small areas
- Helicopter missions for larger burns are extremely expensive and come with added safety risks to personnel

HOW DJI #DRONESHELP

- Firefighters can conduct missions from a position of relative safety
- Since drone technology is cost-effective, it can be used to carry out both medium and large-sized burns

TURBOCHARGING AERIAL FIREFIGHTING TO SAVE MILLIONS

A popular misconception about drones is that they interfere with the operations of firefighting helicopters. While that may be true for unauthorized civilian drones, the reality is that drones equipped with laser rangefinders and infrared cameras are helping first responders to detect, contain, and even extinguish fires faster than ever.

During the burnout phase of the 2017 North Umpqua Fire in Oregon, smoke limited visibility to 100 feet and grounded all manned aircraft. Since $50 million worth of property and infrastructure were at risk, the US Department of the Interior (DOI) decided to scan the area with an infrared drone. The drone soon discovered a spot fire and several resources were dispatched to contain it before it got out of control.

Something similar happened when a fierce forest fire broke out in south China in October 2020. A DJI M300 RTK drone was deployed to access areas where helicopter pilots would face constraints. The drone's powerful sensors not only uncovered new spot fires otherwise obscured by smoke, but the video captured by the aircraft also helped to discover a water source close to the fire.

KEY CHALLENGES

- Manned aircraft surveys are expensive and cannot access all areas
- Monitoring active fire sections manually put crew at risk

HOW DJI #DRONESHELP

- Drones can enhance situational awareness in a cost-effective manner
- Limits exposure and reduces risk to pilots and wildland firefighters
- Drones can fly even when manned aircraft cannot, including in low-visibility conditions and during heavy gusts of winds

ENSURING ACCESS TO SAFE WATER THROUGH INEXPENSIVE TESTING

It's no secret that climate change can negatively impact water utility operations, water quality, and ecosystem protection efforts. This is why "access to clean water and sanitation for all" has been listed as one of the 17 SDGs set out by the UN.

The US Environmental Protection Agency (EPA) also mandates regular water sampling so it can monitor and improve Americans' access to safe water. However, traditional water sampling techniques, such as dipping a sample container, scoops, bailers, buckets, etc., come with several shortcomings including cost and data contamination.

This can change with Nixie, a novel water sampling system designed to mount on DJI drones. Conceived by a New York-based Reign Maker, Nixie's method of using a drone to plunge a sampling bottle 2 feet into the water can accelerate sampling times dramatically.

And as Jessica Chosid, CEO of Reign Maker, explains, "New York City collects 14,000 water quality samples a year. On average, it costs NYC over $100 per sample. With Nixie drone water sampling, the cost can be as low as $10 per dip."

KEY CHALLENGES

- Conventional methods are time-consuming, logistically complex, labor-intensive, and heavily dependent on the use of boats
- Manual water sample collection is prone to human error

HOW DJI #DRONESHELP

- The time of water sample collection can be reduced by 75%
- More consistent and efficient sampling can be done at a fraction of the cost

MEASURING AIR QUALITY WITH GAS SENSORS

Air pollution and climate change are intimately connected. While many air pollutants are making climate change worse, extreme weather, in turn, has its own negative impact on air quality. This is why governments across the globe keep tabs on air quality to protect the health of citizens and make more informed policy decisions about pollution.

Ukraine's most polluted city, Kyiv, conducted an interesting experiment in 2021. To verify whether air quality improves with altitude, the builder of a high-rise apartment, decided to deploy a DJI M300 RTK drone equipped with gas sensors.

The builder specifically wanted to understand how pollution levels vary depending on height and proximity to nearby pollution sources, such as busy roads. Drones were the only solution that could show the distribution of pollutants vertically.

Interestingly, the study did find a correlation between altitude and carbon monoxide (CO) concentrations. The highest CO concentration was detected at 30-80 meters from the ground, which corresponds to the 25th floor of a building. The second-highest concentration was found around traffic lights, arguably because more toxic gases are released when cars accelerate after stopping.

Air quality analyzing drones can similarly be used for monitoring gas and emissions in industrial areas.

KEY CHALLENGES

- Weather balloons are ineffective at lower altitudes
- Flying weather balloons in densely populated areas with wires, poles, telecom towers would be difficult

HOW DJI #DRONESHELP

- Drones can hover over a specific point for a long time, allowing for more accurate and precise measurements
- Several gases present in the air can be measured in real-time and their distribution visualized through a 3D image

STRENGTHENING THE RESILIENCE OF SINKING WEST AFRICAN NATIONS

Frequent flooding, erosion, and pollution cost West African nations of Togo, Benin, Côte d'Ivoire, and Senegal billions of dollars in GDP every year. The problem of erosion is particularly staggering in Benin, with the country losing an average of 4 meters per year along 65% of its coast.

To help these countries meet the challenges posed by climate change and preserve their coastline, the World Bank is running the West African Coastal Areas Management Program (WACA). DJI drones have emerged as an integral part of this program since they can survey highly-dynamic and sensitive areas such as shorelines in a non-intrusive manner.

The data collected by drones will complement the findings of a bathymetric survey conducted to acquire sub-water topographic data. Together, they will form the base of coastal simulation models which will be used to improve strategic shoreline planning and community monitoring efforts.

"Our goal is to empower the locals to undertake survey missions every year and help them build a database of annual variations in the coastal areas. This will inform their planning process," a drone operator associated with the project explains.

KEY CHALLENGES

- Need for flexibility in terms of deployment and cost-effectiveness
- Spotty cellular coverage and no reliable GNSS base station

HOW DJI #DRONESHELP

- Flexibility to operate even in hot, tropical climates with high winds
- RTK sensors onboard DJI drones can deliver centimeter-level surveying accuracy without additional equipment

HOW US STATES ARE USING DRONES TO MAXIMIZE ENVIRONMENTAL PROTECTION

SOURCE: ENVIRONMENTAL COUNCIL OF THE STATES (ECOS) 2021 GREEN REPORT

Many US states use drones within their environmental programs to boost emergency preparedness and response, inspect and monitor water quality, monitor hazardous sites, conduct more accurate volumetric reporting, support mapping, and more. Presented here are select application highlights from their wide-ranging drone programs.

Michigan: Tire Pile Estimation

Michigan's scrap tire program has typically required three to five inspectors to manually climb tire piles and measure their volume. Now, drones are used to generate 3D maps of tires on sites throughout the state, allowing the Michigan Department of Environment, Great Lakes, & Energy (EGLE) to improve the volume determination significantly.

North Carolina: Estuarine Benthic Habitat Mapping

The North Carolina Department of Environmental Quality (NCDEQ) notes that a two-person team using a DJI Phantom 4 Pro drone can produce data for 600 acres per day compared to traditional methods of 10 acres per day – saving the agency almost $400,000 and boosting performance by 5,900%. The state reports it took 30 years to map the first 90% of the state's estuaries and 12.5 days to map the final 10% as a result of using DJI drones.

New York: Mapping Shoreline Erosion

When an event with extremely high water and heavy winds eroded dunes along Lake Ontario in 2017, the New York State Department of Environmental Conservation (DEC) found that it was able to acquire all necessary data regarding the shoreline after just 30 minutes in the sky. Before using drones, a two-week survey mission would have been necessary to obtain a proper and accurate assessment.

Oklahoma: Improved Drinking Water Inspections

The Oklahoma Department of Environmental Quality (DEQ) says there have been several instances where DJI drones have identified finished water storage facilities with open hatches and/or damaged or missing vents and screens. These deficiencies posed a potential pathway for contaminants to enter finished water and would have gone uncorrected as they were not observable from the ground.

Alaska: Accessing Previously Inaccessible Sites

In 2019, the Alaska Department of Environmental Conservation (ADEC) used DJI drones to obtain the first-ever image of an extremely rugged and remote portion of a watershed for a public water system. Routine watershed inspections are required for filtration avoidance drinking water treatment requirements. However, this portion of the watershed had remained inaccessible until then.

Wyoming: More Accurate Reclamation Bond Estimates

The Wyoming Department of Environmental Quality (WYDEQ) uses drone surveys to evaluate current mined surface areas and volumes to update reclamation bond estimates. More accurate volumetric reporting has resulted in a more accurate calculation of bonds.

Montana: Ensuring Permit Conditions Followed

The Montana Department of Environmental Quality (MDEQ) uses drone to fly safely over mining sites spanning several hundred acres. This is done to ensure opencut minerals are extracted in accordance with rules to provide adequate protection of environmental resources and successful reclamation of the affected land back to a productive post-mining land use.

Arkansas: Examining Harmful Algal Blooms

The Arkansas Department of Energy & Environment (ADEE) is using drones to study and examine the status of harmful algal blooms, including migration spread and distribution in the state's rivers and streams.

Louisiana: Expediting Oil Spill Response

In March 2018, an oil spill occurred in the state at a storage tank site at the same time as heavy rainfall that led to fields flooding. While the water was too shallow for boats, it was deep enough to make driving and walking difficult. By using a drone, the Louisiana Department of Environmental Quality (LDEQ) was able to access and inspect the flooding without compromising the safety of the team and to gather quick observations of the extent of the spill as well as its impact.

West Virginia: Finding 'Hidden' Sites

The West Virginia Department of Environmental Protection (WVDEP) notes that drones have allowed the identification of an early 20th-century oil-tank farm in a now heavily wooded area. With the use of drones, the agency was able to extract detailed elevation data from the site that revealed tank locations and associated earthworks.

Kentucky: Managing Landfills

The Kentucky Department for Environmental Protection (DEP) has been using DJI drones to survey, photograph, and take videos of landfills, open dumps, and hillsides. Capturing images to investigate citizen complaints, the drones also are used in emergency situations like tracking smoke plumes or hazardous waste releases, inspections of facilities, and documenting the before and after of construction and cleanups.

Connecticut: Monitoring Cyanobacteria Plumes

The Connecticut Department of Energy & Environmental Protection (DEEP) uses DJI drones to provide visual support to the water-monitoring program to photo-document cyanobacteria breakouts in a water body. The drones provide video imagery for the program's sampling protocol.

Arizona: Citizen Science Sampling

The Arizona Department of Environmental Quality (ADEQ) shares that an Arizona citizen scientist has developed a sampling harness used to collect E. coli samples through his drone. The state plans to work on replicating this harness and determining the capacity of its current fleet to expand sampling capabilities.

Delaware: Managing Coastal Programs

The Delaware Department of Natural Resources & Environmental Control (DNREC) has created a Digital Elevation Model (DEM) using varying heights of drone imagery. The department also plans to use

Kansas: Monitoring Air Pollution

Kansas has many tallgrass prairies that need to be burned off annually in a short period of time. The Bureau of Air within the Kansas Department of Health & Environment (KDHE) has found that when this occurs, it results in exceedances of air quality standards. Drones have helped the Bureau of Air to conduct sustained monitoring of these burning areas in order to identify NOx concentration and PM in real-time.

Maryland: Ensuring Dam Safety

The Maryland Department of the Environment (MDE) uses DJI drones mainly within its Dam Safety Program. The ability to capture aerial images during routine or emergency operations allows for the observation of defects or variations in the dam's surface that would be difficult to discern by a ground-based observer.

South Carolina: Managing Waste Piles

The South Carolina Department of Health & Environmental Control (SCDHEC) uses drones to document issues at solid waste sites (tire and waste piles). The ability to see the scope and scale of a problem with a detailed orthophoto of the complete site, estimate the volume of the material with 3D mapping and volume calculations, and document the progress of cleanup with regular, repeatable surveys has enabled reductions of scrap tire and waste piles.

Texas: Planning Emergency Response

Using DJI drones, the Texas Commission on Environmental Quality (TCEQ) staff has been able to survey large areas in a short amount of time. Remote imaging also enables staff to assess a hazardous materials situation and plan an emergency response while remaining at a safe distance.

Wisconsin: Detecting Changes in Water Quality

The Wisconsin Department of Natural Resources (WDNR) used DJI drones in the summer of 2019 to map storm damage, allowing federal agencies to quickly and efficiently prioritize relief efforts and clean up. Drones have also been used to map invasive water species and pre-identify their location before sending employees out to physically look at them.

CONCLUSION

The case studies compiled in this paper illustrate only a small sample of the opportunities where drones have been leveraged to elevate the environment.

Drone-based imagery is delivering more accurate measurements of natural phenomena compared to human observation. The cost of data acquisition is also much lower than traditional surveying technologies. And the results, which can often be accessed in real-time, are both visually-compelling and easy for non-experts to understand. Thus, drones can inform green recovery initiatives directly today.

A plethora of applications has cemented the role of drones in building a future where humans live in harmony with nature. But researchers and innovators are keen to explore even newer possibilities with this fast-evolving, transformative technology. Policymakers must facilitate scientific access to drones instead of limiting environmental protection and conservation efforts based on a technology's country of origin.
We may be divided by borders, but we all have only one planet to call home. And we must do everything possible to save it while we still can.

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