Drones – our eyes on the environment

Meg Lowman
California Academy of Sciences, San Francisco, CA

Bryson Voirin
California Academy of Sciences, San Francisco, CA

In September 2015, the California Academy of Sciences hosted a Summit on Drones for Research and Conservation in San Francisco, California. Several hundred drone users and manufacturers shared their innovations and the challenges of using unmanned aerial vehicles (UAVs) to explore and conserve the natural world. Attendees were deploying drones for a range of scientific projects. A corporation in Penang (Malaysia) was using drones to map an ecotourism operation in tropical rain forest habitat. Indigenous tribes in the Amazon Basin delineated their territories using UAVs. Marine biologists developed underwater drones to monitor sea life and marine debris. With the help of UAVs, conservationists in Africa successfully herded wild elephants away from towns, decreasing the incidence of lethal human–elephant interactions. Sophisticated drone-mounted sensors such as those that generate normalized difference vegetation index (NDVI) imagery allowed farmers to measure crop stress remotely and efficiently over vast areas, increasing yields while conserving resources. After hearing such innovative case studies, Summit participants agreed that drones have the potential to revolutionize the way scientists and practitioners collect field data.

Drones are democratizing remote sensing – a domain once restricted to experts. One of the chief benefits is that results are immediate and increasingly accessible by citizen scientists. For instance, the nonprofit Digital Democracy (www.digital-democracy.org) works with indigenous communities in the Amazon Basin, using drones to detect illegal logging and habitat infringement. Aerial evidence of such activities can be rapidly, inexpensively captured by UAVs, offering visual proof that can be used in local courts to prosecute offenders. Similarly, the illegal expansion of palm oil plantations can be quickly measured from drone imagery. Drone pioneer Lian Pin Koh (University of Adelaide, Australia) co-founded the nonprofit organization Conservation Drones (conservationdrones.org), which provides UAV-based solutions to global conservation issues.

Drones are not only limited to capturing images and video. Many now offer customizable payloads, allowing a range of onboard sensors and attachments. Autonomous (pilotless) missions are increasing the efficiency and safety of flights. Onboard data processing is an emerging field, and has the potential to promote the creation of "smart" conservation drones. Several companies and nonprofits are leading the way for drone-associated deliveries, with some already transporting medical supplies in Germany and Rwanda.

Despite these success stories, there are major obstacles to the wider implementation of drones for science. In many countries, there are operational restrictions at the local, state, and federal level. Governmental authorities around the world were apparently caught off-guard by the technology's rapid advancement and widespread availability, and are now scrambling to create the necessary legal frameworks to better ensure safe flying. However, because there are no international legal conventions on UAV use, what is emerging is an often complex and onerous set of rules that differ by geographic location, including state and even city. Moreover, owners are often required to obtain permits before bringing their drones through customs at ports of entry, or risk having them confiscated. Vincent *et al.* (*Front Ecol Environ* 2015; doi:10.1890/15.WB.002) provided an almost comical account of the extensive legal requirements to establish a UAV-based research project at a US public university. Similar restrictions are being passed – and often change unannounced – in many other countries.

Clearly there are huge benefits to using drones in scientific research – they are low risk, relatively inexpensive, and generate quick results. Our own use of UAVs has transformed the way we study tropical forest canopies. They allow us to rapidly collect data on phenology, vine growth, diebacks, insect outbreaks, canopy structure, tree diversity, and epiphyte distribution, as well as detecting forest clearing and illegal logging or drilling operations. An added bonus is the inspiration that drones offer to village children in our remote Amazon research area – deploying a drone is a great science lesson and may give youngsters a renewed sense of excitement about STEM topics and conservation as future career opportunities.

Participants at our Summit not only provided concrete examples of drones helping to solve environmental problems, but also strongly endorsed their future applications as a key part of the scientific toolkit. The drone-manufacturing community displayed their latest prototypes, demonstrating that more technological advances can be expected in the near future. We hope that the regulatory agencies governing UAVs develop sensible, practical rules allowing safe and responsible flights for all users, and not overregulating to the point where all but professionally licensed airplane pilots are illegal users. The application of drones for environmental surveillance has enormous potential to advance the capabilities of ecological research.