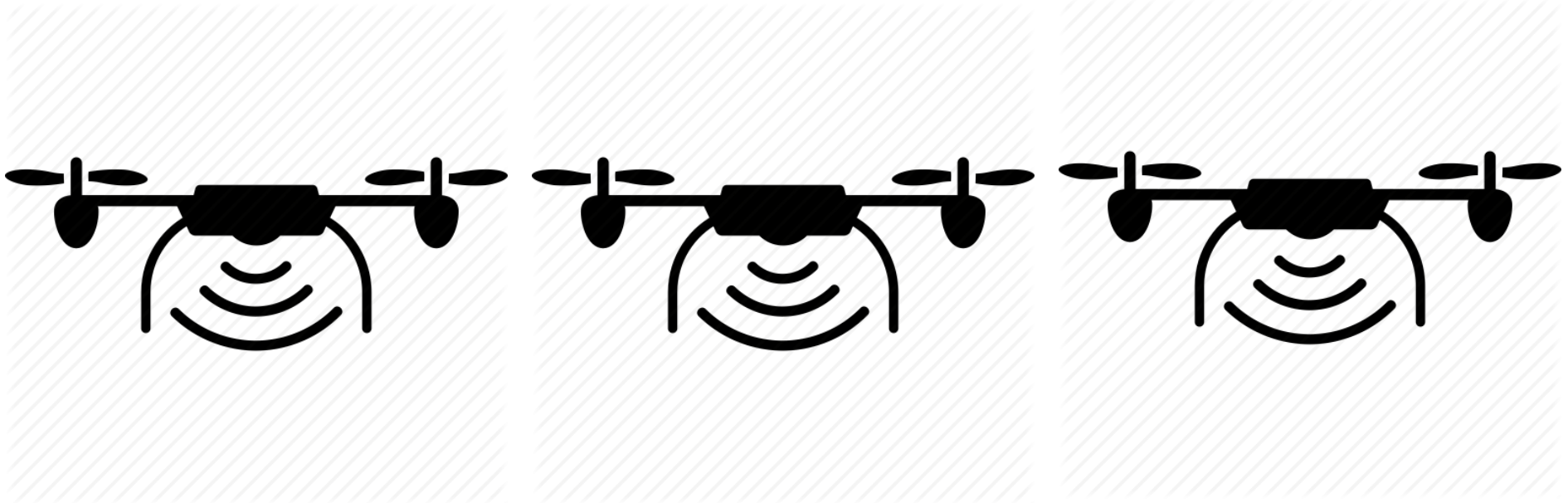


Contribution of RPAS in Research and Conservation in Protected Areas: present and future

Jesús Jiménez López

Background

- A protected area
- is a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008)

Background

- **Current state** of protected areas:
- 15.4% of the land area and 8.4% marine areas. (Juffe-Bignoli et al. 2014)
- Size of wildlife populations has been estimated to have decreased by 52% in the period 1970 to 2012.
- Habitat change and fragmentation, severe pollution particularly in freshwater ecosystems, overexploitation of resources, climate change and the impact of invasive species on indigenous populations have been identified as the main threats to biodiversity.

Background

- Protected areas are reference sites for monitoring and managing biodiversity.

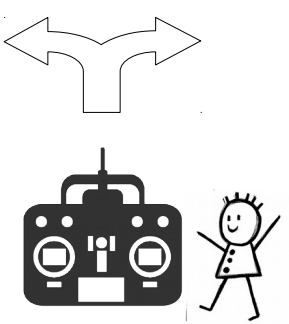
- Technological advances supporting conservation:

  - Remote sensing.
  - Wildlife tracking devices.
  - Camera traps.
  - Computers, statistical tools and methods.
  - Sensors
  -
  - Robots: Remotely Piloted Aerial Systems (RPAS)

Background

Remotely Piloted Aerial Systems (RPAS)
Drones Unmaned Aerial Vehicles (UAVs)
Unmaned Aerial Systems (UAS) Multicopters
Copters Helicopters

Rotor-wings



Fixed-wing

Applications

Wildlife Monitoring and Management

Infrastructure and risk assessment

Monitoring and mapping of terrestrial and aquatic ecosystems

Surveillance and support for compliance with laws in protected areas

Ecotourism

Environmental management and decision support

Considerations

Impact of RPAS on wildlife and ecosystems

Legal barriers

Applications: Wildlife Monitoring and Management

Wildlife Monitoring and Management

- Population dynamics
- Species Distribution
- Density and abundance estimation

Target species

- Terrestrial and aquatic mammals
- Birds
- Nesting sites

Research

- Comparative studies: RPAS vs tracking devices (Mulero-Pázmány et al. 2015)
- Novel methods: VHF tracking (Bayram et al. 2016) , biooacustic monitoring (Wilson, Barr, and Zagorski 2017), nesting status inspection, etc.
- Software development: automatic detection and counts, statistical models (Lhoest et al. 2015; Abd-Elrahman, Pearlstine, and Percival 2005; Gemertet al. 2015, Chabot and Francis 2016, Christiansen et al. 2014)**.**

Considerations

- Cost-effective wildlife census campaigns. :)
- Non-invasive and reliable monitoring technique ? Disturbance :(
- Animal movement and remote sensing (follow-me, tagged species, mapping) :)

Table 1.: WILDLIFE MONITORING AND MANAGEMENT

Study	Aims	Country	Place	Target	RPAS platform	Payload	Costs
(Mulero-Pázmány et al. 2015)	Telemetry/RPAS SDM comparative study	Spain	Doñana N.P.	*Bos taurus*	Fixed-wing: Easy Fly plane, Ikarus autopilot, Eagletree GPS logger	Panasonic Lumix LX-3 11MP	$ 6500
(Hodgson, Peel, and Kelly 2017)	Comparative survey RPAS/land based observation; abundance estimation	Australia	North Stradbroke Island	humback whales	Fixed-wing: ScanEagle	Nikon D90 12MP, Standard Definition Electro-Optical Camera	?
(Hodgson, Kelly, and Peel 2013)	Dugongs detection	Australia	Shark Bay Marine Park	Dugong	Fixed-wing: ScanEagle	Nikon D90 12MP	?
(Wilson, Barr, and Zagorski 2017)	Bioacustic monitoring	USA	State Game Lands	Birds	Rotor-wing: DJI Phantom 2	ZOOM H1 Handy Recorder	?
(Bayram et al. 2016)	VHF collars tracking	?	?	Bears (Ursus)	Rotor-wing: DJI F550	Telonics MOD-500 VHF, Uniden handheld scanner	?
(Christie et al. 2016)	Abundance estimation	USA	Aleutian Islands	Steller Sea Lion (Eumetopias jubatus)	Rotor-wing: APH-22	?	$ 25.000
(Christie et al. 2016})	Abundace estimation	USA	Monte Vista National Wildlife Refuge	Grus canadensis (sandhill cranes)	Fixed-wing: Raven RQ- 11A	?	$ 400
(Wich et al. 2016)	Sumatran orangutan nest detection	?	?	?	Fixed-wing: Skywalker 2013	Canon S100	?
(Andel et al. 2015)	Chimpanzee nest detection	Africa	Loango National Park	Chimpanzee (Pan troglodytes)	Fixed-wing: Maja	Canon Powershot SX230 HS	$ 5000
(Koski et al. 2009)	Marine mammals monitoring	USA	Admiralty Bay	Marine mammals	Fixed-wing: ScanEagle	NTSC Video Camera	?
(Andrew and Shephard 2017)	Semi-automated image processing tools to detect and map sea eagle nests	Australia	Houtman Abrolhos Islands	White-bellied sea eagle (Haliaeetus leucogaster)	?	?	?
(Longmore et al. 2017)	Software development to help detect animals in thermal images	UK	Arrowe Brook Farm Wirral	Wildlife	Rotor-wing: 3DR robotics Y6	FLIR, Tau 2 LWIR Thermal Imaging Camera Core	?
(Martin et al. 2012)	Estimate the distribution of organisms using statistical models	USA	?	Manatee (*Trichechus manatus latirostris*)	Fixed-wing: Nova 2.1	Olympus H E-420	?

Applications: Monitoring and mapping of terrestrial and aquatic ecosystems

Wildlife Monitoring and Management

- Mapping and habitat monitoring
- Discrimination, classification, inventory
- Ecosystem dynamics

Target ecosystems

- Forests
- Aquatic ecosystems
- Wetlands

Research

- Novel methods: vegetation cover (USGS, 2014), erosion dynamics (Casella et al. 2016,), restoration (Zahawi et al. 2015)
- Invasive species: spread (Zaman, Jensen, and McKee 2011), satellite, unmaned / manned aerial vehicles comparative studies (Müllerová et al. 2016), detection rate under different conditions (Per-roy, Sullivan, and Stephenson 2017)

Considerations

- High spatial and temporal resolution :)
- Relative small areas :|
- Mini multispectral sensors :|
- Computer demanding, complex :(

Table 2.: MONITORING OF TERRESTRIAL AND AQUATIC ECOSYSTEMS

Study	Aims	Country	Place	Target	RPAS platform	Payload	Costs
(Perroy, Sullivan, and Stephenson 2017)	Tropical invasive plants	USA	Pahoa, Hawai	*Miconia calvescens*	Rotor-wing: DJ Inspire-1	DJI FC350 camera	?
(Szantoi et al. 2017)	Habitat Mapping	Indonesia	Gunung Leuser National Park	Orangutan (Pongo abelii)	Fixed-wing: Skywalker	Canon S100	$ 4000
(Casella et al. 2017)	Coral reef mapping	French Polynesia	Tiahura,; Moorea	Coral reef	Rotor-wing: DJI Phantom 2	Modified GoPro HERO4	$ 1678
(Casella et al. 2016)	Monitoring coastal erosion dynamics in shorelines	French Polynesia	Tiahura; Moorea	Coral reef	Rotor-wing: Mikrokopter Okto XL	Canon G11	$ 7500
(Müllerová et al. 2016)	Monitoring plant invasion	?	?	Exotic species	Fixed-wing: VUT 712 713 720	Canon S100	?
(Ventura et al. 2016)	Marine fish nursery areas mapping	Italy	Giglio Island	Marine fish nursery areas	Rotor-wing: homemade prototype	Mobius HD, GoPro HERO3 Black Edition	$ 100
(Ivošević et al. 2015)	Habitat monitoring and modeling in restricted areas; RPAS performance test & South Korea & Chiaksan National Park;Taeanhaean National Park	South Korea	Chiaksan National Park;Taeanhaean National Park		Rotor-wing: DJI Phantom 2 Vision+	Full HD videos 1080p/30fps and 720p/60fps	?
(Lisein et al. 2015)	Discrimination of deciduous species; Forest inventory	Belgium	Grand-Leez	English oak, birches, sycamore maple ,common ash and poplars	Fixed-wings: Gatewing X100	Ricoh GR2 GR3 GR4 10 megapixels CCD	?
(Puttock et al. 2015)	Characterization of ecosystems affected by beaver activity	UK	Devon Beaver Project site	Eurasian beaver (*Castor fiber*)	Rotor-wing: 3D Robotics Y6	anon ELPH 520 HS	?
(Zahawi et al. 2015)	Characterization of tropical forest structure for restoration actions	Costa Rica	Devon Beaver Project site	Several species	Rotor-wing: 3D Robotics Y6	Canon S100	$ 1500
(Bustamante 2015)	Forest monitoring	Brasil	Riverine Forests (Permanent Protected Areas), Rio de Janeiro, Barrãcao do Mendes, Santa Cruz and São Lorenço	Riverbank forests	Rotor-wing: DJI Phantom Vision 2S	RGB digital camera 14MP	$ 9700
(Gini et al. 2012)	3D modeling and classification of tree species	Italy	Parco Adda Nord	Several species	Rotor-wing: Microdrones TM MD4-200	RGB CCD 12 megapixels Pentax Optio A40; modified NIR Sigma DP1 with a Foveon X3 sensor	?
(Miyamoto et al. 2004)	Classification of species in wetlands	Japan	Kushiro Wetlands	Several species	Helium balloon	NIKON F-801, NIKKOR 28 mm f/2.8	$ 1600
(Casella et al. 2017)	Mapping coral reefs	?	?	?	Rotor.wing: DJI Phantom 2	GoPro HERO4	?

Applications: Infrastructure and risk assessment

Infrastructure and risk assessment

- Inspection
- Preventive measures

Target species

- Birds

Research

- Visual evaluation of linear electrical structures (Margarita Mulero-Pázmány 2014)
- Marks: collisions avoidance with the wiring (Lobermeir et al. 2015)
- Pre-harvest ground nest inspection (Mulero-Pázmány Margarita 2011)

Considerations

- Cost-effective alternative to manual inspection :)
- Others: monitoring facilities and roads crossing sensitive areas, coastal ecosystems where vessels strikes with aquatic species :)
- Persuade birds from approaching power lines, wind turbines, other potential hazards. :)

Applications: Surveillance and support for compliance with laws in protected areas

Surveillance and support

- Law enforcement
- Poaching
- Illegall activities

Target species

- Rhinoceros, others ?.

Research

- Novel methods: detect presence of humans and target species (Mulero-Pázmány et al. 2014)
- Marine protected areas (MPA) ? (Franco et al. 2016)
- Tourist activity surveillance (Sabella et al. 2017)

Considerations

- Relative Low autonomy :(
- FPV, Infrared sensors on night, Video, Sensor resolution :|
- BVLOS forbidden :(
- Cost-effective :|
- Legal barriers :(

Applications: Ecotourism

Ecotourism

- Recreational activities
- Search and rescue (SAR)
- Visitor monitoring

Target

- Tourists

Research

- Sector opportunities (King 2014), regulations (Leary 2017)

Considerations

- Privacy, security :(
- Bussiness :)
- RPAS banned :(
- Regulations :)
- Wildlife disturbance, ecosystem pollution :(

Table 3.: INFRASTRUCTURES AND RISK ASSESSMENT, ECOTOURISM, IMPACT ON WILDLIFE AND ECOSYSTEMS

Study	Aims	Country	Place	Target	RPAS platform	Payload	Costs
(Lobermeier et al. 2015)	Mitigate the risk of collision by installing markers on electrical lines	USA	?	Birds	Rotor-wing: Mikrokopter Hexa XL	KX 171 Microcam	?
(Margarita Mulero-Pázmány 2014})	Bird risk hazards in power lines	Spain	Doñana National Park	Birds	ixed-wing: Easy fly St-330	GoPro HERO2 11MP;Panasonic LX3 11MP	$ 8863
(Mulero-Pázmány et al. 2014)	Anti-poaching	Africa	KwaZulu-Nata	Black rhinocero (*Diceros bicornis*), white rhinocero (*Ceratotherium simum*)	Fixed-wing: Easy Fly St-330	Panasonic Lumix LX-3 11 MP, GoPro Hero2; Thermoteknix Micro CAM microbolometer	$ 15700
(Hansen 2016)	Visitors Surveillance	Sweden	Sweden & Kosterhavet National Park	Humans	?	?	?
(Sabella et al. 2017)	Visitors Surveillance	Italy	R.N.O. Oasi faunistica di Vendicari	Humans	Rotor-wing: DJI Phantom 3	?	?
(King 2014)	RPAS applications in ecotourism activities	Sweeden	Sweeden & Kosterhavet National Park	Humans	?	?	?
(Vas et al. 2015)	RPAS impact	France	Zoo du Lunaret, Cros Martin Natural Area	*Anas platyrhyncho*, *Phoenicopterus roseus*, *Tringa nebularia*	Rotor-wing: Phantom	GoPro HERO3	?
(Weissensteiner, Poelstra, and Wolf 2015)	RPAS Impact	Sweeden	?	Hooded crow (*Corvus corone cornix*)	Rotor-wing: DJI Phantom 2 Vision	?	$ 1000

Applications: Environmental management and decision support

Environmental management and decision support

- Pollution monitoring
- Search and rescue (SAR)
- Disaster management

Target

- Aquatic ecosystems
- Rescue teams

Research

- Novel methods: water sampling (Schwarzbach et al. 2014) , pollution mapping (Zang et al. 2012) , aerobiological sampling (Schmale, Dingus, and Reinholtz 2008), zoonotic risk factors (Fornace et al. 2014)

Considerations

- Environmental quality control and monitoring in protected areas :)
- Fast deployment to handle natural and man-made disaster :)
- Great potential: decision making, wildlife management , SAR, pollution monitoring :)

Table 4.: ENVIRONMENTAL MONITORING AND DECISION SUPPORT

Study	Aims	Country	Place	Target	RPAS platform	Payload	Costs
(Zang et al. 2012)	Pollution monitoring	China	Several cities	Rivers	Fixed-wing	Canon 50D, ACD multispectral camera	?
(Cornell, Herman, and Ontiveros 2016)	Water sampling	USA	Lake Ontari0	?	Rotor-wing: DJI Phantom 3	50mL Falcon tube	?
(McCaldin, Johnston, and Rieker 2015)	Aerial baiting	Australia	Christmas Island	Cat (*Felis catus*)	Rotor-wing: V-TOL Hornet I-II	Canon S100; Drop mechanism with HD Video Recorder	?
(Fornace et al. 2014)	Spatial epidemiology	Malaysia / Philippines	Sabah / Palawan	?	Fixed-wing: Sensefly eBee	16mp	$ 25000
(Van Tilburg 2017)	Search and Rescue (SAR)	USA	Columbia Gorge National Scenic Area	Humans	Rotor-wing: Phantom 3, SAR Bot, Inspire 1	DJI 12MP; VUE PRO 640 thermal imager	?
(Schwarzbach et al. 2014)	Water sampling	Spain	Doñana N.P.	Freshwater ecosystems	Rotor-wing: Helicopter	Water sampling mechanism	?
(Schmale, Dingus, and Reinholtz 2008)	Aerobiological sampling	USA	Virginia Tech's Kentland Farm	Prokaryotic and eukaryotic microorganisms	Fixed-wing: Senior Telemaster	Aerobiological sampling devices	?

Considerations: Impact of RPAS on wildlife and ecosystems

Impact of RPAS on wildlife and ecosystems

- Animal welfare
- Disturbance assesment
- Recommendations

Target species

- Birds
- Aquatic and terrestrial mammals

Research

- Novel methods: comparative study fixed-wing / rotor-wing (McEvoy,Hall, and McDonald 2016) , physiological stress measurement (Ditmer et al. 2015), analisys review (Mulero-Pázmány et al. 2017),

Considerations

- Disturbance effect: Noise > distance > angle of flight
- Disturbance effect: birds > terrestrial mammals > aquatic mammals
- Disturbance effect: life-history stage, level of aggregation
- Best practices |:
- Further trials :|
- Lack of qualified operators :(

Considerations: Legal barriers

Restrictive regulatory framework

Review of the Current State of UAV Regulations **(Stöcker et al. 2017)**

Global drone regulations database

https://www.droneregulations.info/

International Association for Unmanned Vehicle Systems (AUVSI)

http://www.auvsi.org

Conclusions

Consolidation of RPAS in Protected Areas:

Continuous technological advances and applications.

This rapidly expanding confluence of factors encourages the emergence of new scenarios with ethical and legal implications.

Most governments have reacted by setting constraints that could have a negative impact on the capacity to integrate RPAS into the civilian sphere.

Future of the RPAS in protected areas is conditioned fundamentally by political and social factors