Biodiversity Journal, 2017, 8 (1): 79–86 **MONOGRAPH**

Preliminary observations on the use of drones in the environmental monitoring and in the management of protected areas. The case study of "R.N.O. Vendicari", Syracuse (Italy)

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ABSTRACT The possible utilization of UAS (Unmanned Aircraft Systems), also called drones, as means for the environmental monitoring and the management of protected areas has been investigated. The study was carried out in "R.N.O. Vendicari", Syracuse (Sicily, Italy) in relation to the problems of the fruition's management of the protected area. Some operational proposals on the use of drones for these aims are suggested and the preliminary results are presented.

KEY WORDS UAS; Sicily; Protected areas; Environmental monitoring; Management; Drone.

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INTRODUCTION

The study of ecology, especially environmental monitoring, has benefited, since the 60s of last century, of the latest technologies and of the technical innovations openig up new possibilities in many theoretical and applied branches of the natural sciences. Since the 80s of last century, a further contribution to research in this field has been made with the use of two new technologies: the GPS (Global Positioning System) and the GIS (Geographical Information System).

In the last decade even the use of Unmanned Aircraft Systems (UAS) seem to have had the same kind of impact in the scientific and applied areas (Anderson & Gaston, 2013; Chabot & Bird, 2015). The use of drones has strongly increased due to their ease of use and the lowering of the costs of these remotely piloted aircrafts. On board they can, carry small computers, cameras and various sensors. These can be easily used by non-specialists, who can then use them in many work activities to collect data by multiparameter sensors (Thamm & Judex, 2006). In general, the use of these resources has helped in increasing, as never before, the acquisition of both qualitative and quantitative environmental and spatial data (Marris, 2013). Applications to this data can be broadly divided into two categories: research applications and direct conservation applications (Sandbrook, 2015).

Apart from the research applications, also the control of the risk areas or of protected ones, will certainly benefit from the use of these unmanned aircraft systems, supporting operators and ensuring that the management and monitoring of these areas are more reliable convenient and accurate (Krämer

& Thamm, 2006; Kohl & Wich, 2012). This is part of the ongoing relationship between the effort to safeguard protected areas and their fruition (West et al., 2006).

The extension of the R.N.O. “Oasi faunistica di Vendicari” (Southern Eastern Sicily) and its criticality along with the continued reduction of the supervisory staff, make it difficult to continosly monitor. The aim of this paper is to determine whether the use of UAS could make the monitoring and the control of this area easier by reducing costs and at the same time ensuring that the interventions of the teams on the ground are more efficient.

In this work we use the word drone or UAS for all types of aircrafts without an on board pilot, although in the literature these vehicles are often classified and designated by various other names (Anderson & Gaston, 2013).

MATERIAL AND METHODS

Study area and management issues

The Oriented Natural Reserve “R.N.O. Oasi faunistica di Vendicari”, instituted by D. A. 14 March 1984 in accordance with L. R. 98/81, is located in the southeast of Sicily, between Noto and Pachino in the province of Syracuse, and occupies an area of about 1,517 hectares (Fig. 1). Its perimeter is included in those of the ZPS ITA090029 - Pantani della Sicilia sud-orientale, and of the SIC and ZPS ITA09002 - Vendicari, instituted in accordance with Directive 1992/43/EEC and with Directive 2009/147/EC. The reserve is also included within the area identified by IBA (International Bird Areas) criteria cod. IBA 1998–2000: IT167 “Pantani di Vendicari e di Capo Passero”, and in the Ramsar area “3IT043 Vendicari”, in accordance with D.P.R. 448 of 13 March 1976, because it is recognized as a key area for the resting and the migration of migratory birds.

The reserve is a coastal area of great natural and landscape value, characterized by high plant and animal biodiversity thanks to the variety of habitats (rocky and sandy coasts, brackish and freshwater swamps, salt marshes, Mediterranean scrub, scrubland and cultivated areas), due to the presence of various types of substrates, as well as edaphic and hydrogeological relationships. This did not prevent

Figure 1. Geographical framing, maps and logos of The Oriented Nature Reserve “R.N.O. Faunistic oasis of Vendicari”, Syracuse (Sicily, Italy).

about half of the reserve's territory to be used for agricultural activities (AA.VV., 1991).

The overall climate is rather dry, characterized by mild winters with little rainfall and hot, dry summers. Average annual rainfall does not reach 400 mm per year, with a maximum of just over 60 mm in October, December and January, and values close to zero in the summer months (June to August). The average annual temperature is 18.2 °C. The coldest months are January and February with a monthly average of 11.9 °C. Quite high temperatures are reached in July and August with average monthly respectively being 25.3 °C and 26.2 °C (AA.VV., 1991). The reserve falls within the lower dry thermomediterranean bioclimatic belt (Scelsi & Spampinato, 1998).

The management plan of "Pantani della Sicilia sudorientale" (2009), approved under the condition with D.D.G. 673/2009 of Regional Councillorship of Land and Environment, highlights several critical aspects of the R.N.O. mainly related to agricultural activities, but also to the high human pressure linked to its touristic fruition, especially in the summer months; during just 2014 an estimate of, by defect, more than 120,000 visitors visited the beaches of Vendicari (Iuvara, 2015). The damages caused to the protected areas by an excessive fruition have already been studied and documented (Muhar et al., 2002).

Technical characteristics of the utilized materials

The drone used is the Phantom 3 Professional (Fig. 2). The technical characteristics of the drone and its equipment are summarized in Table 1.

Regulatory information on UAS flights

The only current regulation for UAS flights is the Unmanned Aircraft Systems Regulation of ENAC (Civil Aviation Authority) (2nd edition published in 16 July 2015 and updated in 21 December 2015).

There are several types of the UAS and there are different classifications in which they are grouped per weight, range, use, etc. (see Anderson & Gaston, 2013 for a review). Among the different UAS types, the two most common are those weighing less than 300 grams and 2 kg. The lightest models (weighing less than 300 g) are characterized by low flight range (under 10 minutes) combined

Figure 2. The Phantom 3 Professional built by DJI.

with lower quality of photographs. For this reason we have chosen to operate the flights using a drone belonging to the second category (whose operations are regulated by art. 12 of ENAC Regulation): the model Phantom 3 Pro. This has an upper flight range of up to 20 minutes and is equipped with a camera with 4k resolution, which has a high level of image definition. These characteristics make it appropriate for the purposes of the present study.

For whichever flight scenario, it is mandatory that the driver is recognized by ENAC (art. 21) through the adequate certification. The drone must also be insured.

Based on the experience and on the fact that the ENAC regulations are constantly evolving and clear guidelines have yet to be enacted, we propose the following methodological process consisting of a series of good practices to be followed in the case of any flight plan processing:

Download from the Aviation website (www.aeronautica.difesa.it) the updated version of the Italian Aviation Map (CAI) in which the obstacles to the flight and the zone types to air controlled traffic (VFR Visual Flight Rules) are shown.

Identify the flight area and take action based on the type of the overfly zone. The prohibited airspaces, according to paragraph 4 of the article 24 of the ENAC Regulation, are those within the ATZ (Aerodrome Traffic Zone) of an airport, or located at a distance of less than 5 km from an airport and those within the active regulated areas and the prohibited areas. In the latter all protected areas are included and so it is to necessary to request the prior authorization of the Managing Authority. When obtained this authorization must also be requested from the ENAC Authority (article 24, paragraph 6 of ENAC Regulation).

The visual flight (Visual Line of Sight or VLOS) must always be performed by a pilot with Attestation of Pilot of UAS (article 21, paragraph 1 of ENAC Regulation) and with a medical certification of class II issued by the standards relating to the license LAPL (Light Aircraft Pilots Licence) (article 21, paragraph 2 of ENAC Regulation). The pilot must be accompanied by a qualified observer (article 5 of ENAC Regulation).

Aircraft: technical specification	
Weight (including battery and propellers	1280 g
Diagonal size (including propellers)	590 mm
Max Ascent Speed	5 m/s
Max Descent Speed	3 m/s
Hover Accuracy	Vertical: +/- 0.1 m (when Vision Positioning is active) or +/- 0.5 m; Horizontal: +/- 1.5 m
Max Speed	16 m/s (ATTI mode, no wind)
Max Service Ceiling Above Sea Level	6000 m (Default altitude limit: 120 m above takeoff point)
Operating Temperature	0°C to 40°C
GPS Mode	GPS/GLONASS
Camera: technical specification	
Sensor	Sony EXMOR 1/2.3" Effective pixels: 12.4 M (total pixels: 12.76M)
Lens	FOV 94° 20 mm (35 mm format equivalent) f/2.8, focus at 8
ISO Range	100-3200 (video) 100-1600 (photo)
Shutter Speed	8s -1/8000s
Image Max Size	4000 x 3000
Still Photography Modes	Single Shot; Burst Shooting: 3/5/7 shots; Auto Exposure Bracketing (AEB): 3/5; Bracketed Frames at 0.7EV Bias; Time-lapse.
Video Recording Modes	UHD: 4096x2160p 24/25, 3840x2160p 24/25/30; FHD: 1920x1080p 24/25/30/48/50/60; HD: 1280x720p 24/25/30/48/50/60;2.7K: 2704 x1520p 24/25/30 (29.97)
Remote Controller and APP: technical specification	
Operating Frequency	2.400 GHz-2.483 GHz
Max Distance	Up to 5 km or 3.1 miles (unobstructed, free of interference)
Mobile App	DJI GO
Latency	220ms (depending on conditions and mobile device)
Required Operating Systems	iOS 8.0 or later; Android 4.1.2 or later

Table 1. Technical specification of: Aircarft, Camera and Remote controller of Drone used.

Perform a pre-flight checklist, which includes: checking weather and of environmental conditions; evaluting flight risks (obstacles, buildings, towers, high tension cables, etc.); checking of integrity and efficiency of the drone.

Informations on operated flights

The flights are performed according to the requirements of the ENAC Regulation respecting the condition laid down for flight in VLOS, according to article 24, paragraph 2 (maximum height 150 m and ray of maximum distance from operator of 500 m) and also according to article 27 paragraph 2 (Horizontal safety distance of at least 150 m from the groups of people, and at least 50 m from individuals).

The experience was carried out during the first decade of August 2015, from 10.00 to 11.00 a. m., the climatic and weather conditions optimal, wind speeds below 10 kph, temperature 31 °C, Magnetic Storm 3Kp.

Using as a starting point the Marianelli houses of the Regional Azienda of the State Forests (Fig. 3), which is located roughly in the centre of the reserve, two flight plans were scheduled.

The two flights were scheduled for control of the north side and the south side of the reserve and for the overfly of some fixed points allowing to monitor the access roads and check for unauthorized access to the reserve beaches. Moreover, it was possible to verify the number of bathers and monitor any behaviour prohibited by the Regulation of the reserve in the Calamosche (Fig. 4) and Eloro beaches (Fig. 5).

Operatively, in the two flights the drone remained at a maximum height of 70 m and at a 150 m distance from people for privacy and security reasons.

The first flight (Fig. 6) flew over the south and the southeast zones of the reserve and lasted about 18 minutes, covering a linear path of approximately 4,600 m. with relative displacement of the operator to ensure that the aircraft was always.

During the overflight of the zones, live video and photos were taken. The images were seen by the reserve supervisory staff and then the filming were also observed offline and subjected to analysis and processing by the reserve managers. Particular attention was paid to the overflights of Calamosche beach due to the strong inflow of swimmers at this time. A first live estimate of presence of people on the beach was made and later, in offline mode, an accurate count of the number of swimmers was done. These two numbers were compared with the number of appearances detected by supervisory staff based on daily records of access to reserve. This made it possible to verify the percentage of users who had used the not controlled accesses of the reserve.

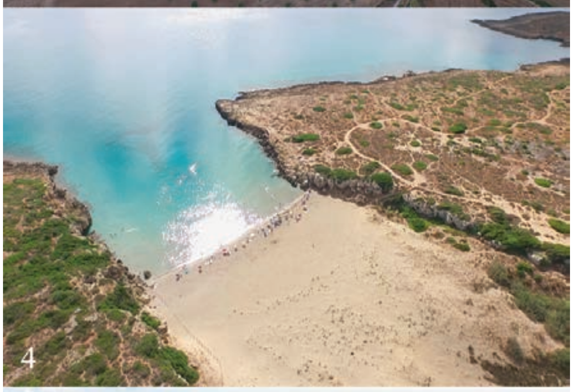

Figure 3. The starting field of the drone, the Marianelli houses of the Regional Azienda of the State Forests photographed by drone.
Figure 4. The Calamosche beach photographed by drone.
Figure 5. The Eloro beach photographed by drone.

The second flight (Fig. 7) flew over the north and northeast zones of the reserve and lasted about 19 minutes, covering a linear path of approximately 3,640 m.

The flight arrangements were the same used in the previous flight. This time, however, in addition to verifying and counting the number of bathers on the beaches of the northern side of the reserve, the position of the parked cars along the access road to the beach was also detected to verify possible grounds for refusal to circulation of any rescue vehicles.

In addition, the flight was scheduled to overfly the houses subject to legal seizure to check the possible construction of new buildings or extensions to existing ones.

RESULTS

The use of the drone inside the R.N.O. Vendicari has been very satisfactory. From a technical point of view, it has been appreciated the extreme ease and immediacy of the procedures of setup and starting (Watts et al., 2010). In fact, the positioning of the batteries on the drone is as simple as changing the battery on a mobile phone, to start the program on the Control Pad less than five minutes are needed, this perspective is a positive factor because the operativity of the drone is virtually immediate and therefore also in emergency circumstances its use would be valid.

Another positive factor has been the battery life of the drone that has allowed about 20–25 minutes of flight and operation in total autonomy and no maintenance, allowing a very thorough reconnaissance of the areas of the reserves examined.

It allows for high quality shooting of video and photographs allowing it to reach a level of detail in the images which was more than satisfactory. Also the streaming link between operator and drone is never lost even when up to several hundreds of meters away, similary the flight controls sent interactively by the operator of the drone were executed without delays.

Interesting was also the simulation carried out deliberately to lose contact between the drone and the operator. In this case the software implemented in the aircraft enabled it to return to land independently and at the same starting point. This proves that, even in difficult situations such as problems caused by the weather or by the operator, the drone would not be lost and there would be no accidents on landing, thanks to its excellent emergency system.

On the contrary, there are some ethical and technical disadvantages in the use of the drone. The ethical and social implications (safety, privacy, psychological wellbeing, data security and understanding of conservation problems) in the use of the drones are recently examined by Sandbrook (2015). In particular, with regards to privacy, the main problem is whether it is ethical to monitor people without their knowledge, because this practice could represent an infringement of human rights (see Finn & Wrigth, 2012 for a detailed analysis), although these aspects of privacy have been already invaded with the use of satellite monitoring and fixed cameras. In the case of protected areas, this practice has the deliberate intention of law enforcement and it should be incorporated, with full reason and legality, into the reserve regulation, but on public land it shows some illegality profiles (Sandbrook, 2015). Even the question of confidentiality of data is relevant and needs for regulation.

The risks of misuse of drone technology for the surveillance have been already highlighted and some solutions have been proposed to avoid conflicts with local people (West et al., 2006; Paneque-Galvez et al., 2014). The main recommended solutions are transparency of information and the adoption of communally-agreed rules. The use of fear as a tool of conservation raises obvious ethical questions (Sandbrook, 2015).

Also like all electronic devices even UAS are exposed to hacker risk, which would allow an attacker to take control of the aircraft by changing course with possible serious consequences (Hartmann & Steup, 2013).

As regards the technical problems, the main one is detected in the operating limits of the batteries of the drone that do not allow their use with temperatures above 40 °C. During the performed flights, the weather conditions and the time (early morning between 10.00 and 11.00 a. m.) fell extensively in the tolerance range of the batteries, while in the same location, in the following weeks and in the first hours of the afternoon, the temperature had reached the tolerance limit of the instrument and therefore no flight could not have been carried out.

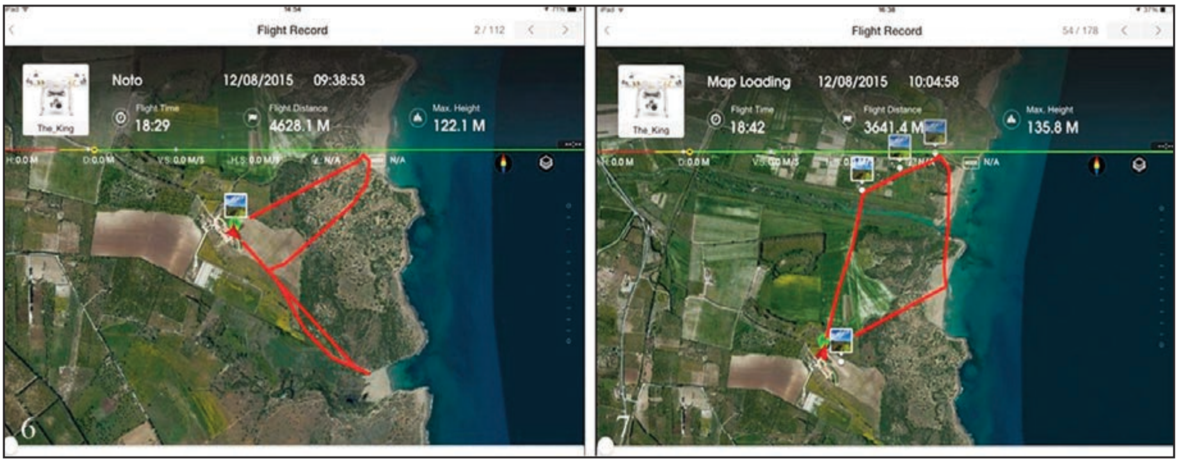

Figure 6. Flight plan number 1, with full telemetry, itinerary direction of Calamosche beach. The red line indicate the path of drone. Figure 7. Flight plan number 1, with full telemetry, itinerary direction of Eloro beach. The red line indicate the path of drone.

This is a significant problem because it does not allow monitoring of users of the reserve in the period that is experiencing the greatest influx of visitors.

CONCLUSIONS

Although the use of drones for conservation is in its infancy and there is currently limited evidence regarding their effectiveness as a conservation tool (Sandbrook, 2015), in our case study the use of unmanned aircrafts has proved a very useful tool for the reserve operators for the ease of use of the drone and for the results obtained from the flights.

In addition, his low cost could favourably influence the choice by the administration in the purchase and use of this instrument, which could validly help the reduced number of supervisory staff of the reserve in the surveillance action. Moreover, the possibility to program the flights on predetermined paths and at set intervals during the day represents a further advantage linked to the use of drones for the monitoring of protected areas.

In any case, the drone could not be used as a substitute for the control actions and for intervention of operators but should be used only as a support means for operator on site, who could be relieved from unnecessary patrols and would thus be able to intervene more timely and precisely in places where the aerial monitoring would show violations, misconduct, etc.

Also valuable would be its contribution to the prevention and deterrence of the fires and of the harmful actions. In fact, the overflight at low altitude is immediately noticed, and induces in people a more cautious and respectful attitude because the drone allows, thanks to high image quality, the precise recognition of people and/or vehicles who are offenders of the reserve regulation. This last point regards the regulatory and ethical aspects is one on which we must reflect carefully (particularly as it regards the privacy and confidentiality of the data) and probably it will be necessary to operate changes of the laws, rules and regulations regarding the use of drones in the monitoring and control of protected areas. For example, given that the ENAC Regulation is still being defined and applied throughout the national territory, it would be desirable that it is update to provide different rules for overflights of natural areas and reserves, since most are sparsely populated. This would help reduce some constraints and thus allowing to increase productive use of drones for the environmental monitoring (Rango & Laliberte, 2010). But all this should not discourage the researchers to try and use this new technology and assess the benefits that this can bring especially in the field of environmental protection.

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REFERENCES

AA.VV., 1991. Le Riserve di Sicilia. Vendicari. Edizioni Arbor, 143 pp.

Anderson K. & Gaston K.J., 2013. Lightweight unmanned aerial vehicles will revolutionize spatial ecology. Frontiers in Ecology and the Environment, 11: 138–146.

Chabot D. & Bird D.M., 2015. Wildlife research and management methods in the 21st century: Where do unmanned aircraft fit in? Journal of Unmanned Vehicle System, 3: 1–19.

D. A. Assessorato Regionale Territorio e Ambiente della Regione Siciliana, del 14 marzo 1984. Istituzione della riserva naturale Oasi faunistica di Vendicari, published in S.O. G.U.R.S. n. 21 of 19 May 1984.

D.P.R. 448 del 13 marzo 1976. Esecuzione della convenzione relativa alle zone umide d'importanza internazionale, soprattutto come habitat degli uccelli acquatici, firmata a Ramsar il 2 febbraio 1971, published in G.U.R.I. n. 173 of 3 July 1976.

Directive 92/43/EEC of the European Parliament and of the Council of 21 May 1992, on the conservation of natural habitats and of wild fauna and flora. Official Journal of European Union L 206, 22/07/1992.

Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009, on the conservation of wild birds. Official Journal L 20/7, 26/01/2010.

Finn R.L. & Wright D., 2012. Unmanned aircraft systems: Surveillance, ethics and privacy in civil applications. Computer Law & Security Review, 28: 184–194.

Hartmann K. & Steup C., 2013. The vulnerability of UAVs to cyber attacks. An approach to the risk assessment. In: Podini K., Stinissen J. & Maybaum M. (Eds.), 2013 5th International Conference on Cyber Conflict (cycon): 23 pp.

Kohl L.P. & Wich S.A., 2012. Dawn of drone ecology: low-cost autonomous aerial vehicles for conservation. Tropical Conservation Science, 5: 121–132.

Krämer A. & Thamm H.P., 2006. Application of a Remote Controlled Ultralight Air Vehicle (UAV) for Park Management and Visitor Monitoring. In: Siegrist D., Clivaz C., Hunziker M. & Iten S. (Eds.) (2006). Exploring the Nature of Management. Proceedings of the Third International Conference on Monitoring and Management of Visitor Flows in Recreational and Protected Areas. University of Applied Sciences Rapperswil, Switzerland, 13–17 September 2006. Rapperswil: 329–330.

Iuvara G., 2015. La presenza umana a Vendicari. Grifone, 24: 8–9.

Legge Regionale n. 98 del 6 maggio 1981. Norme per l'istituzione nella Regione siciliana di parchi e riserve naturali, published in S.O. G.U.R.S. n. 23 of 9 May 1981. Management Plan of “Pantani della Sicilia sudorientale"”2009, approved under the condition with D.D.G. n. 673 of Regional Councillorship of Land and Environment of 30 June 2009.

Marris E., 2013. Drones in sciences: Fly, and bring me data. Nature, 498: 156–158.

Muhar A., Arnberger A. & Brandenburg C., 2002. Methods for Visitor Monitoring in Recreational and Protected Areas: An Overview. In: Arnberger A., Brandenburg C. & Muhar A. (Eds.), Monitoring and Management of Visitor Flows in Recreational and Protected Areas. Conference Proceedings, Bodenkultur University, Wien: 1–6.

Paneque-Galvez J., McCall M.K., Napoletano B.M., Wich S.A. & Koh L.P., 2014. Small drones for community-based forest monitoring: An assessment of their feasibility and potential in tropical areas. Forests, 5: 1481–1507.

Rango A. & Laliberte A., 2010. Impact of flight regulations on effective use of unmanned aircraft systems for natural resources applications. Journal of Applied Remote Sensing, 4: 043539: 1–12.

Regolamento ENAC per mezzi aerei a pilotaggio remoto. 2a edizione del 16 luglio 2015, emendamento 1 del 21 dicembre 2015, 36 pp.

Sandbrook C., 2015. The social implications of using drones for biodiversity conservation. Ambio, 44, Suppl 4: 636–47.

Scelsi F. & Spampinato G., 1998. Caratteristiche bioclimatiche dei Monti Iblei. Bollettino dell’Accademia Gioenia di Scienze Naturali, 29 (352): 27–43.

Thamm H.P. & Judex M., 2006. The “low cost drone” an interesting tool for process monitoring in a high spatial and temporal resolution. In: ISPRS Mid-term Symposium 2006, Remote Sensing: From Pixels to Processes“, Enschede, 8–11 May 2006, the Netherlands.

Watts A.C., Perry J.H., Smith S.E., Burgess M.A., Wilkinson B.E., Szantoi Z., Ifju P.G. & Percival H.F., 2010. Small Unmanned Aircraft Systems for Low-Altitude Aerial Surveys. The Journal of Wildlife Management, 74: 1614–1619.

West P., Igoe J. & Brockington D., 2006. Parks and people: the social impact of protected areas. Annual Review of Antropology, 35: 251–257.