

Research Note

Comparing webshare services to assess mountain bike use in protected areas

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ABSTRACT

Mountain biking is increasing within protected areas worldwide with social and environmental impacts. Monitoring recreational activities can be difficult, but nowadays massification of GPS use and track's sharing can provide new tools to help do so, lower resource consumption. This study compares GPSies.com and Wikiloc.com to evaluate the similarity between both, as data sources' and if this information can be used to spatialize and measure use intensity of mountain biking in Sintra-Cascais Natural Park's (PNSC), Portugal. Virtually all mountain biking GPS tracks available for Sintra and Cascais area of PNSC were downloaded, rasterized and analyzed using GIS software. Although GPSies provided almost twice the amount of tracks and was proved to be the best webshare service for PNSC's mountain biking, overall results from using either one of those services were similar. Results and Conclusions reveal that voluntarily given data can be adequate and should be used to monitor recreational activities within recreational and protected areas, and webshare services are a valid data source for such studies.

MANAGEMENT IMPLICATIONS

The increasing use of protected areas for recreational activities requires better and faster monitoring technics to help park managers deal with, and avoid, unwanted impacts. Previous work showed that GPS tracks voluntarily uploaded or created in sport dedicated webshare services might be a good information source to spatialize recreational activities. This study compares data from two webshare services, GPSies.com and Wikiloc.com, regarding mountain biking in Sintra-Cascais Natural Park (PNSC). Although the amount of data for PNSC's from both services is different, similar results can be drawn, providing quality information for monitoring purposes, on a low human and time resources budget. Crossing that information with road networks, habitat charts, among others can help park managers to identify where unwanted conflicts and impacts are more likely to occur. This approach can provide support to park authorities' decisions and actions for the sustainable use of recreational activities within protected areas.

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1. Introduction

Protected areas' (PAs) main objective is to protect nature and cultural heritage, while allowing people its use for recreation and tourism (Cessford & Muhar, 2003; Wolf et al., 2014). One way to achieve this goal is to monitor visitors, providing essential information for decision making. This could contribute to promote PA's sustainable use supported by good recreation planning and management while guaranteeing a good recreational experience

(Cessford, Cockburn & Douglas, 2002; Kajala et al., 2007). Especially on PAs nearby big cities, due to their importance for city dwellers' well-being (Kajala et al., 2007), the pressure and stress are not limited to weekends or particular seasons (Arnberger & Brandenburg, 2002). This pressure is also intensified by the growing number of people looking for PAs for an increased number of activities (Buckley, 2003).

Recent studies have addressed the importance of using remote monitoring technologies (Eagles, 2014) like GPS (Wolf, Hagenloh, & Croft, 2012), and public participation for gathering geographic information (Wolf et al., 2014). These allow monitoring a large number of visitors, to collect data on their number and spatial distribution, that otherwise would be harder to obtain and further away from the truth (Eagles, 2014). It also helps to manage social

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conflicts' (Wolf et al., 2014) and create use maps that can be useful for environmental monitoring campaigns, especially in PAs where use intensity varies in a small area (Wolf et al., 2012). When GPSies was tested as a tool to monitor mountain biking (MTB) in Arrábida's Natural Park (PNArr), Portugal, creating a realistic MTB spatialization without the need for many resources (Nogueira Mendes et al., 2012), it proved to be a promising method.

One of the increasingly popular activities in PAs worldwide is MTB (Wolf et al., 2014). It helps improving physical health, social cohesion and connection to nature but it also has environmental and social impacts (Wolf et al., 2014). MTB is a social activity (Taylor, 2014; Wolf et al., 2014) and its practice increases alongside technological advances, allowing mountain bikers to reach places where they could not go before, posing a management problem (Chavez, Winter, & Bass, 1993). For these reasons, there have been many recreational ecology studies on this subject. Environmental impacts, according to Marion and Wimpey (2007), Pickering, Rossi, & Barros (2011), fall upon vegetation, soil and fauna. Many impacts are related to trail construction (Marion & Wimpey, 2007; Ballantyne, Gudes, & Pickering 2014) and Technical Trail Features (Leung et al., 2014; Kollar, 2011). Other issues include informal trails and habitat fragmentation (Ballantyne, Gudes, & Pickering, 2014), but with good management and correct usage can be substantially avoided (Marion & Wimpey, 2007) and will not be bigger than hikers' or horse riders' (Marion & Wimpey, 2007; Thurston & Reader 2001), although often times their tracks are longer than other users' (Arnberger & Hinterberger, 2003). Safety issues have

also been addressed due to the idea that bikers are safety hazards, even though Cessford (2003) has found that hikers that encounter bikers along the trails are not less satisfied with their experience.

Like other recreational activities mountain biking has also become another motive for social networking. Dedicated local or national web forums, blogs and Facebook are nowadays completely connected through dedicated apps like Endomondo, GPSies, MapMyRide, Runtastic, Sports-tracker, Strava, Wikiloc. It is becoming easier, cheaper and more common for joggers, bikers, etc. to record their tracks and share them in sport dedicated webgis services and sites. GPS Loggers and smartphones equipped with assisted GPS make movement data easily accessible and a resource that can be uploaded and managed in online services (Garbe, 2010). Depending on the website characteristics, tracks can be available for free download by anyone.

After the first analysis using GPSies' datasets to spatialize MTB in PNArr (Nogueira Mendes et al., 2012, 2014), we now use Portuguese Sintra-Cascais Natural Park (PNSC) MTB to compare different webshare services' ability to create a reliable spatialization of recreational activities and provide useful information to park managers. Knowing in advance that the use of these apps and webshare services, like in any other social media on the web, depend on popularity among users, popular apps/websigs in one place or region may be of no use on any other place. Thus this type of comparison test becomes useful in terms of management for recreational and PAs.

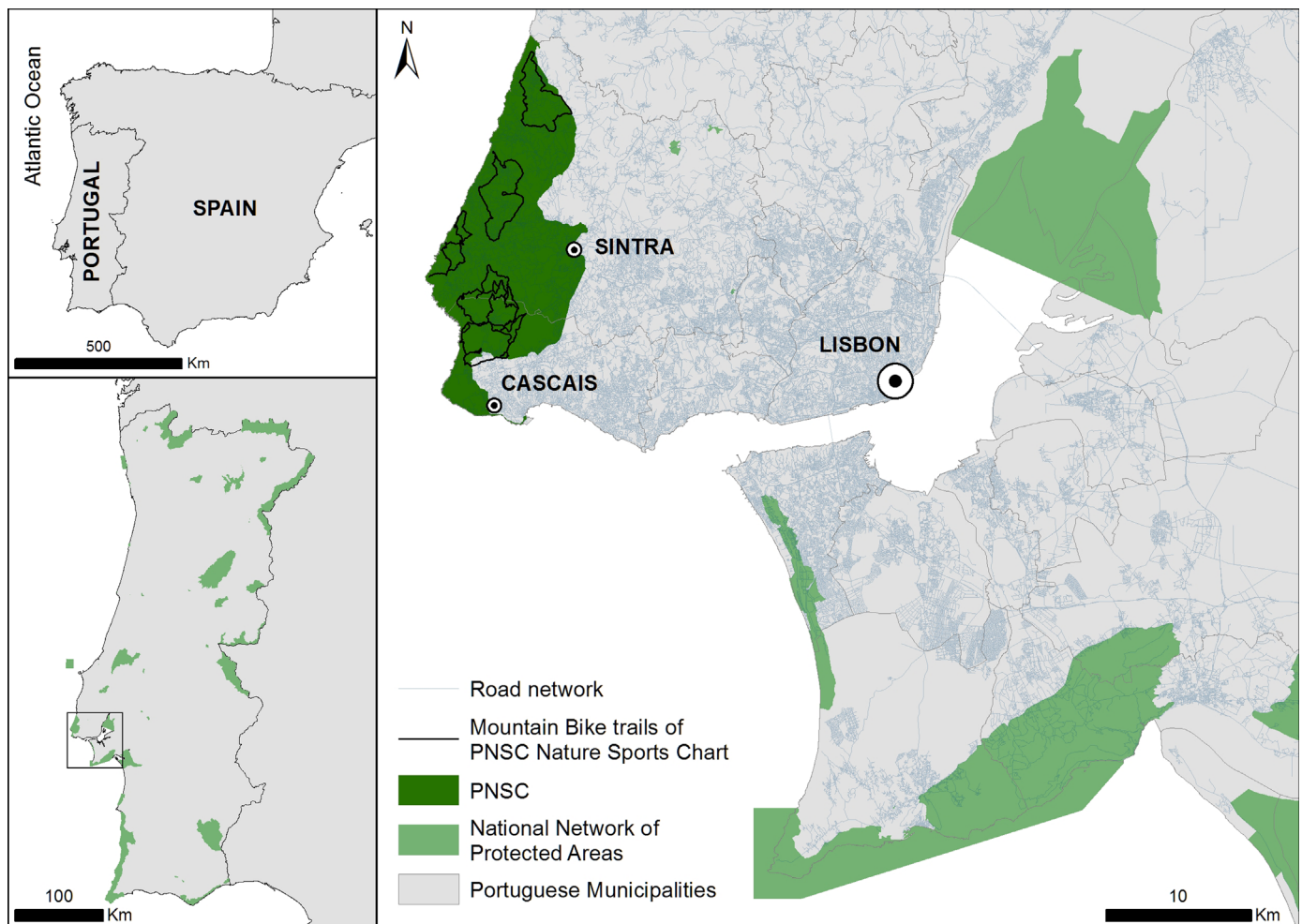


Fig. 1. Location of PNSC, within Lisbon metropolitan area, and the mountain bike trails included in its nature sports chart.

2. Methods

2.1. Study site

The PNSC (Fig. 1) is located within Sintra and Cascais municipalities, in Lisbon's Metropolitan Area, which has 2.8 M inhabitants. Created in 1994 and being part of the National Network of Protected Areas, it is one of the Portuguese PAs closest to the Portuguese capital and the one with the highest resident density and visitor's number all year round. With 14,583 ha and maximum altitude of 528 m, it has a wide variety of ecosystems, some with high value, included in Natura 2000 Network. Sintra Village and the surrounding areas are classified as UNESCO's World Heritage under the Cultural Landscape category (Baltazar & Martins, 2005).

This PA is one of the two in Portugal that owns a Nature Sports Chart (CDN) which regulates recreational and sports activities inside the park. Published in 2008 and currently being revised, it allows for a series of activities, as Hiking, Climbing, Horse Riding, Mountain biking, Speleology, etc. For MTB, it allows competition or recreational use, in pathways and forest roads, offering 7 cross country individual and circular trails, ranging from 15 km to 25 km (Fig. 1) (Regulamento da Carta de Desporto de Natureza do Parque Natural de Sintra-Cascais de 18 Janeiro, 2008).

Mountain bikers' of PNSC were profiled within a field survey dedicated to this activity in 2014/15 (Campelo, 2015). Results have shown that the average biker is 30–54 year old, married men and mostly living within the park municipalities or surrounding ones. Most ride in the park once or twice a week, in groups of 2–5 bikers, and although mainly on Sunday mornings, MTB is an activity that runs all week, day and night. Users think of themselves as experienced mountain bikers and invest a significant amount of money in this sport. For these users, mountain biking is both a training and social event. Most PNSC's mountain bikers upload their tracks onto webshare services such as GPSies, Endomondo, Strava and Wikiloc (Campelo, 2015).

Despite the CDN, all involved stakeholders (park managers and local authorities, mountain bikers, dwellers and other users) acknowledge that the number of MTB users is very high and that the amount of trails used is much higher than the official offer, including not only pathways and forest roads but also informal or illegal trails. Such use produces several conflicts and sometimes excessive behaviors, with trespassing being one of the most critical.

2.2. Web share data gathering and analysis

Among the several webshare services (webgis services that enable data sharing) available nowadays, GPSies.com and Wikiloc.com are two of the oldest ones, created in 2006 and holding 3.9 M and 4.8 M tracks respectively (by August 2016). GPSies runs on Leaflet (an open-source JavaScript library for mobile-friendly interactive maps) and Wikiloc runs with Google since 2008. Both services offer live track can run off-line through dedicated apps for Android and IOS devices.

In early 2015 GPSies had 2,801,207 tracks, with a total 452,105,234 km, available worldwide. Of these, 229,014,549 km were marked by their uploader as bicycle suitable (GPSies 2015). By March 2015 Portugal had 99,650 submitted tracks and 66,804 tracks available for download guaranteeing the 7th place in the top countries with the most available tracks, ahead of United Kingdom, Belgium or Switzerland (GPSies 2015). For Wikiloc the corresponding information is not available with the same detail, but by the end of 2015 it held 4.0 M, double of the tracks held by April 2014 (Wikiloc, 2016).

In order to compare GPSies and Wikiloc information on MTB activity within PNSC, queries were made to both services using

Sintra, Cascais and MTB as search criteria. A search radius of 5 km was also used in GPSies. Other popular and more recent webshare services like Endomondo, Strava, MapMyRide, Runtastic, Sports-tracker were not used since those do not allow for massive download of tracks. Being more recent and following the current trends on many other social media and web services, the ability to share (i.e. download) GPS tracks is restricted among registered friends.

GPSies queries can provide up to 250 tracks by query that can be downloaded in .gpx, .kml, and .kmz formats. Wikiloc limits the download to a few .gpx tracks per user/day, which required tracks to be downloaded during several days in order to have a comparable dataset. To avoid any discrepancies due to different data gathering periods, only tracks that were available on October 9th, 2013, when the GPSies queries were downloaded, were used.

Tracks in .gpx were later converted into shape files using QGIS 2.0 and then Imported to an ArcGIS 10.0 project. Duplicate tracks from both queries (Sintra and Cascais) for Wikiloc and GPSies were deleted and final datasets were plotted against PNSC limits. Following Nogueira Mendes et al. (2012), a fishnet grid of 50 m was used to retrieve use intensity within the park by counting the number of tracks that crossed each cell. Final grids for each dataset were rasterized with the same pixel size in order compare both datasets.

The first comparison was done in terms of "use"/"no use" of each grid, after a binary reclassification of each dataset. ArcGIS raster calculator was used to perform this analysis (GPSies binary raster was subtracted by Wikiloc) resulting in a quality information map of MTB use on each data source were differences among GPSies and Wikiloc tracks were highlighted.

A second analysis was made in order to compare relative use intensity of each cell among each dataset. Original raster datasets for each webshare service were reclassified in 10 quantiles of equal intervals for use intensities between 1 and the maximum number of tracks. One extra category was defined to include cells with no use, i.e. were no MTB tracks have been recorded in order to keep this information available for the analysis. New raster datasets were compared with combine tool from spatial analyst extension for ArcGIS 10.0, resulting in 40 output classes according to the unique combination of input values (0–10 for each dataset), performing the comparison in terms of quality and quantity of information.

3. Results and analysis

As shown in Table 1, GPSies generated more data than Wikiloc (417 vs 214 tracks) with an average of 42 and 40 km per track respectively. Average km/track were also in line with Campelo (2015) that addressed a deeper analysis on GPSies that covered the entire area of PNSC with 8 more queries with a 5 km search radius, gathering 1998 tracks with an average of 41 km in length. For Arrábida Natural Park a PA also within Lisbon metropolitan area, Nogueira Mendes et al. (2014), found 2 432 tracks with an average 47.7 km submitted from October 2006 to April 2014 to GPSies. The fact that the amount of information on GPSies was higher than Wikiloc might be justified by the fact that this

Table 1
GPSies and Wikiloc datasets concerning number of tracks, total km, and km/track.

	GPSies Sintra + Cascais	Wikiloc Sintra + Cascais
Number of tracks	417	214
km	17,676	8467
km/track	42	40

MTB Tracks of Sintra-Cascais Natural Park

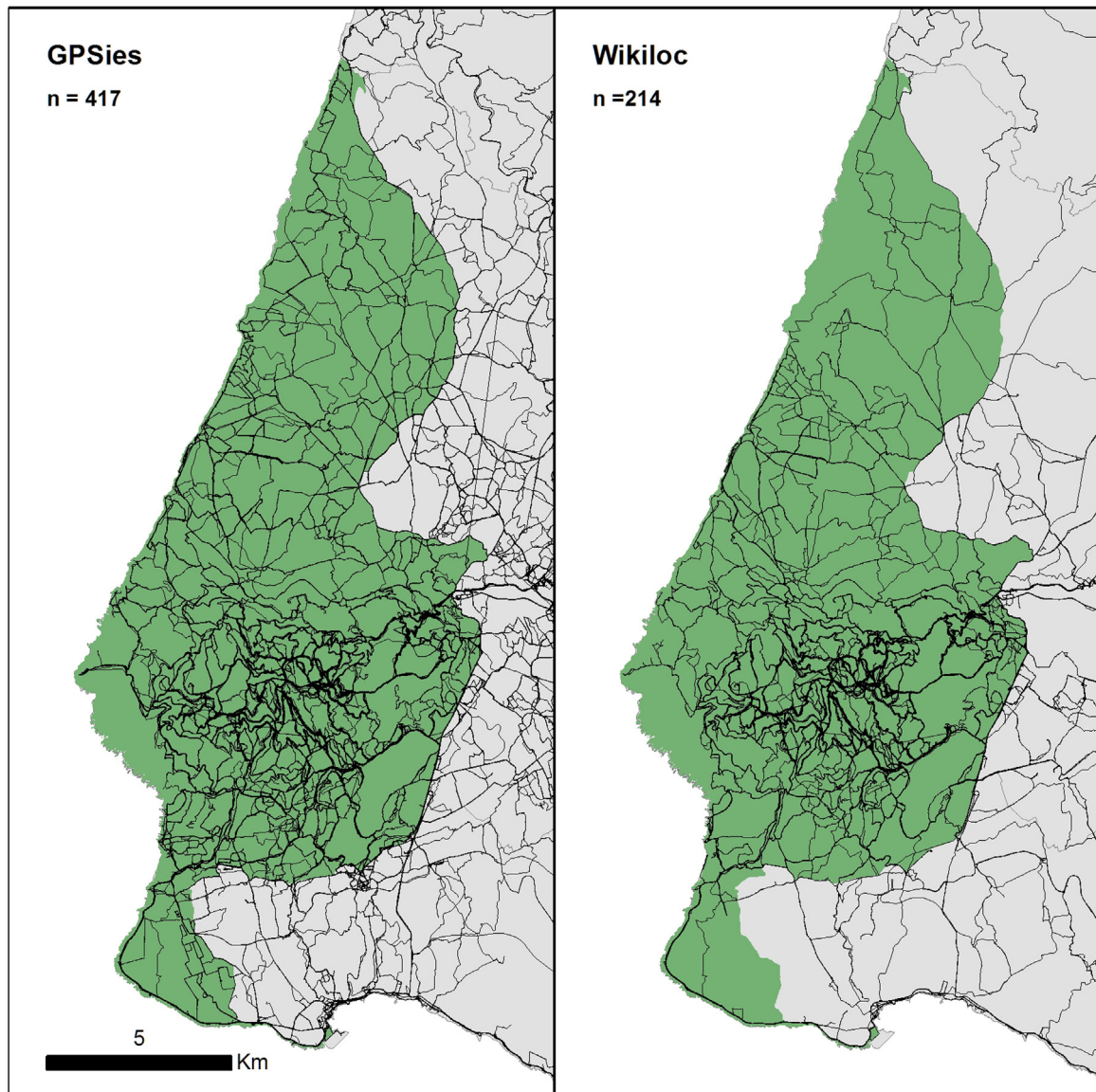


Fig. 2. GPS Tracks retrieved on October 9th, 2013 from GPSies and Wikiloc for Sintra and Cascais.

webshare service is older than Wikiloc and well spread among the biker's community in Portugal. On a preliminary field survey in 2014 with 146 answers' in PNSC (Campelo, 2015), 60% of the bikers acknowledge to record and to upload their MTB rides to these webshare services. While Strava was the most used service, GPSies was 3 times more used than Wikiloc.

For both services, results show a clear difference between the official offer of park's CDN MTB trails (Fig. 1) and trails being used (Fig. 2). Despite the apparent differences, both services present MTB as an activity occurring in the entire area of the park, but with a clear core area, i.e. more concentration around Sintra Serra – the Cultural Landscape of Sintra and Roca cape. On a first approach, the difference between track numbers on each dataset doesn't seem to be crucial in terms of MTB use in the study area.

Fig. 3 presents use intensity for both datasets. Again it reveals a similar distribution of mountain biking along the PNSC territory with GPSies providing more detail in areas of the park with less use.

Table 2 shows the results obtained from the raster calculator. 87% of the cells, whether they are "use" or "no use", include

equivalent information on both datasets (differences are of about 10% of the cells used just by GPSies and 3% of the cells used just by Wikiloc). Even being GPSies an older webshare service, and with more submitted tracks for the study area, the systematic search on other services such as Wikiloc can highlight relevant results (Fig. 3).

The reclassification of both dataset's fishnet grid in 10 quantiles (Fig. 4) not only supported the finding of a similar distribution of use intensity along the territory, but also a similar relative distribution of the number of cells per quantile. Over 82% of the 60,626 cells of PNSC fishnet grid reveal the exact same information (concerning the use/no use, but also concerning the relative use intensity) on both datasets. Even so, there are some differences that could be important in terms of the park management.

GPSies dataset reveals more use in Wikiloc q0 and q2 with more 10.204% and 0.892% respectively, while the opposite occurs in q1, q3, q4, q5, q6, q7 and q8 with differences between 0.007% and 2.873%. For both datasets the two most used cells are exactly the same: located at the crossroad between the road to Peninha Sanctuary and Capuchos Convent (two of the main monuments of

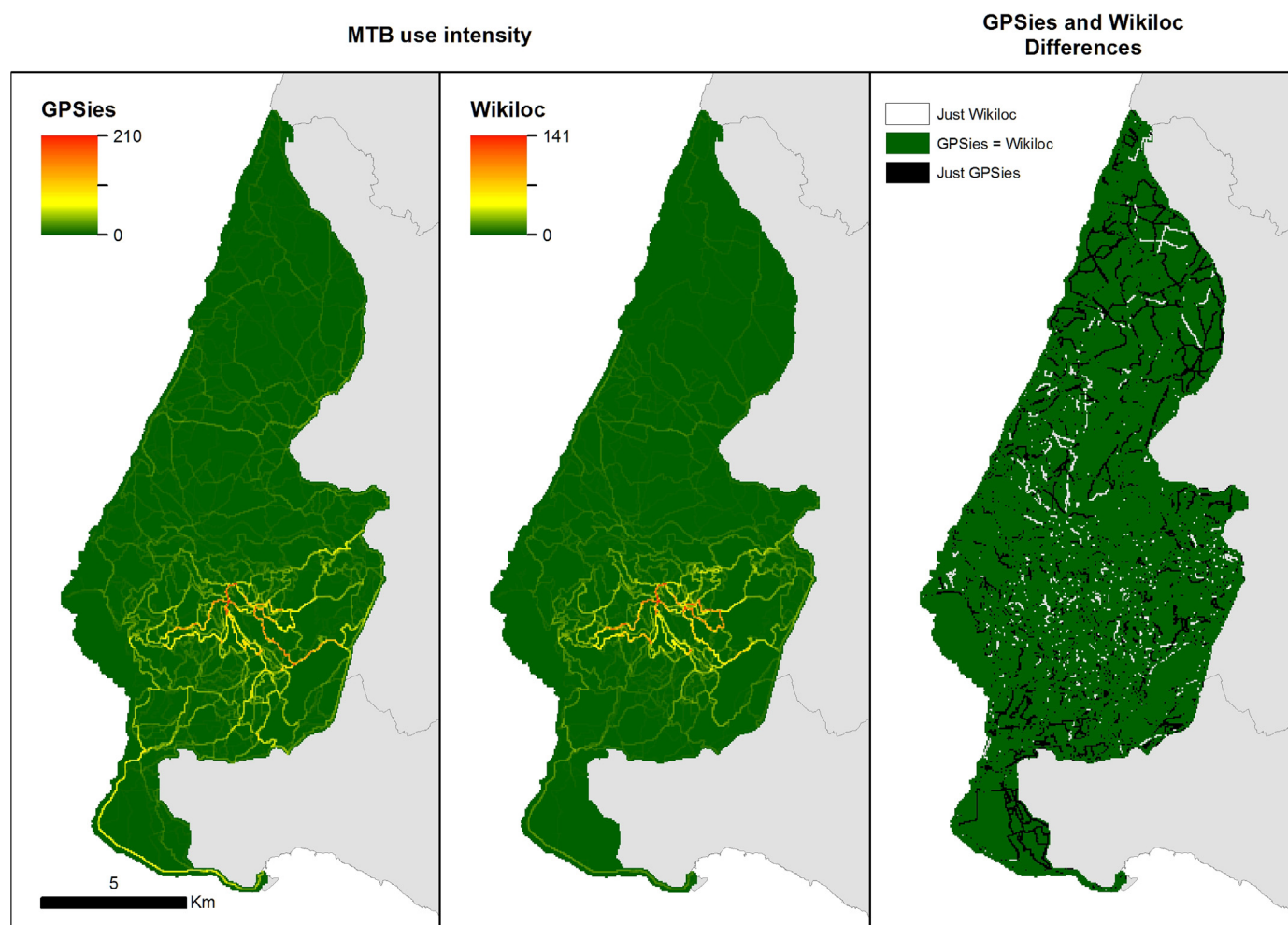


Fig. 3. Use intensity of the MTB tracks from GPSies and Wikiloc datasets and differences in relative territory use by each dataset.

Table 2

Quality comparison on use/no use between data gathered on mountain biking from GPSies and Wikiloc for Sintra-Cascais Natural Park. Results were obtained by subtracting Wikiloc from GPSies binary raster on ArcGIS 10.0 raster calculator from spatial analyst extension.

GPSies	-	Wikiloc	Result	Grids No.	Grids (%)	Interpretation
1	-	0	1	6 186	10	Use exclusively within GPSies dataset
1	-	1	0	52,698	87	Identical use within GPSies & Wikiloc datasets
0	-	0				
0	-	1	-1	1 742	3	Use exclusively within Wikiloc dataset

Sintra UNESCO heritage site) that gives access to some of the most famous MTB downhill/freeride trails of Sintra like *Dimas*, *Pontes*, *Monge* and *Kamikaze*, and where there is also a small parking space.

4. Discussion

Nowadays' massification of GPS access and use of tools and Web 2.0 technology, where users are able to alter and participate in the content, like Wikipedia, OpenStreetMap, transformed the sports' dedicated webshare services in a useful tool for PAs' managers. One major advantage of gathering data this way is the

low resource consumption. The acquired data can provide important information on the territory's use and help describing the users' profile (Garbe, 2010; Nogueira Mendes et al., 2014) and preferences. Information from webshare services is voluntarily made public by the users, meaning that gathering it doesn't cross ethical boundaries, such as privacy issues. As referred by Wood, Guerry, Silver, and Lacayo (2013) crowd-sourced information can be a reliably proxy for empirical visitation rates.

Both data sources (GPSies and Wikiloc) proved to be a fair representation of MTB's spatialization in Sintra-Cascais Natural Park. Both showed a dense web of trails being used, showing the inefficiency of CDN's offer in response to this activity's pressure and users expectations. Some trails are informal/illegal, opened by mountain bikers without a proper permit like those used for downhill/freeride which is a banned activity within Park. Intersecting these spatialization maps with land record's datasets, official road networks and habitat charts can be used by park managers to find where trespassing occurs, where informal or illegal trails exist and where environmental impacts might happen, respectively.

All stakeholders acknowledge the need for management measures in order to reduce MTB social and environmental impacts in PNSC. These services can therefore be a valid method to help managers to monitor this PA's MTB. Since it has a higher amount of data GPSies provided a higher resolution and almost all trails and paths used for MTB found on Wikiloc are also present on GPSies. The number of Km/ track found in both datasets being so similar, also supports the data similarity. Analysis of the results from the

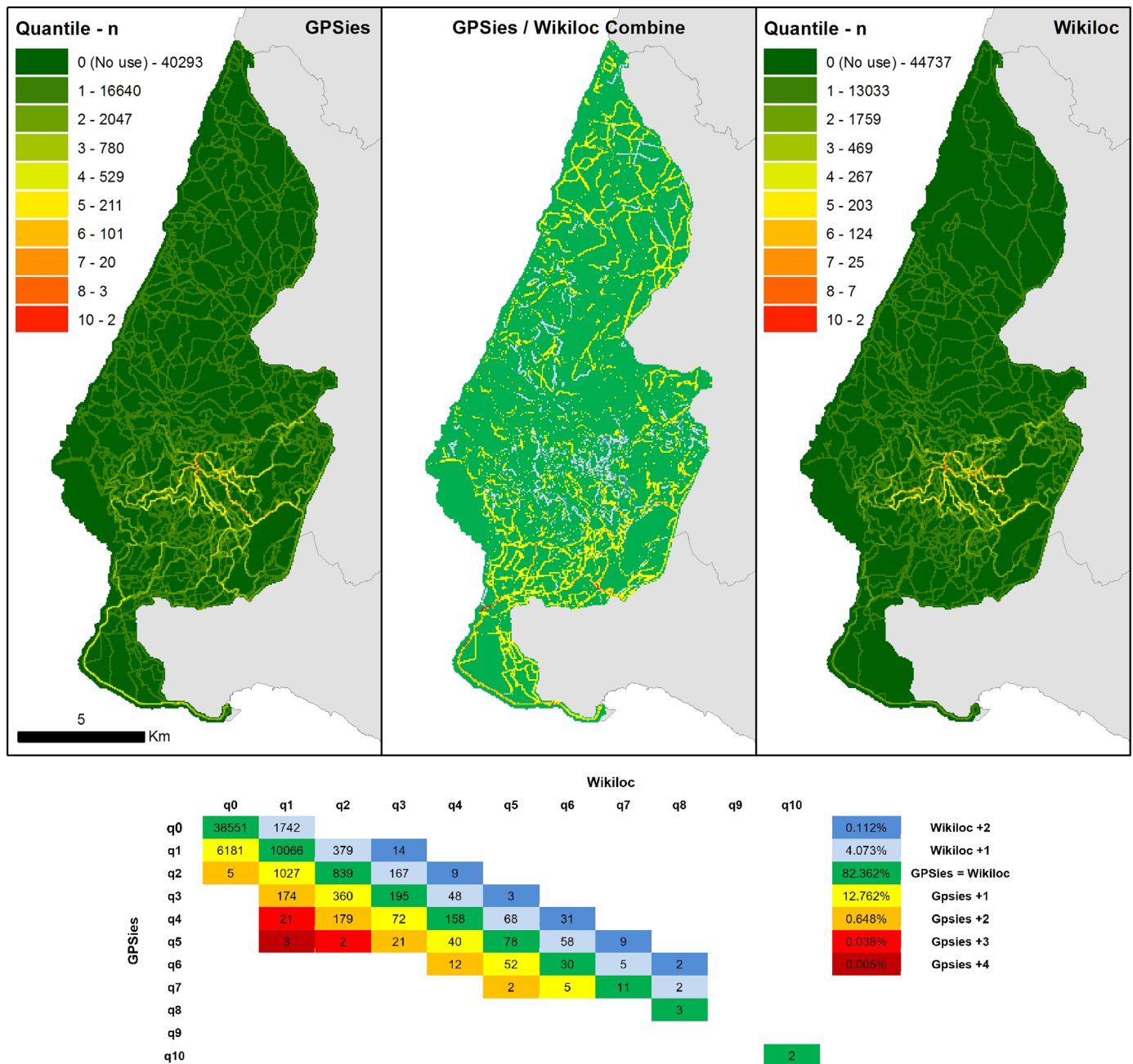


Fig. 4. Use intensity in quantile, of MTB tracks from GPSies and Wikiloc datasets and result from the combine tool. The grey scale represents the quantile difference. Grey cells (with grey numbers) have equal amounts of data on GPSies and Wikiloc datasets; Lighter cells (with black numbers) represent more use within Wikiloc; Darker cells (with white numbers) represent more use within GPSies.

fishnet grid, raster calculator and combine tool support these findings.

5. Conclusions

Sport dedicated webshare services can be a valid, important and cheap tool for PAs' managers, who so many times have few resources at their disposal, by providing useful and important information to help monitor and manage recreational activities in PAs. Because this information is made public by the users themselves, there is no risk of crossing ethical boundaries. Using these services can help managers and researchers to spatialize and to infer use intensity of recreational activities. It can highlights areas

of potential conflicts between users, activities and stakeholders or it could help to define monitoring campaigns and field surveys.

Future studies could test the validity of this approach within other PAs or recreational activities, exploring other results that could be retrieved from webshare services as datasources. Any limitations of this research can be overcome with counters on trails to confirm use intensity results. In addition, comprehensive studies on the webshare services user's profiles should validate these as a proper sample of the entire practitioner's population.

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