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Chapter 62

WILDLIFE/ROADKILL OBSERVATION AND REPORTING SYSTEMS

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SUMMARY

Wherever wildlife habitat and roadways overlap, roadkill seems inevitable. Observing and recording carcasses resulting from wildlife–vehicle collisions (WVC) provides data critical for sustainable transportation planning and species distribution mapping. Across the world, systems have been created to record WVC observations by researchers, highway maintenance workers, law officers, wildlife agency staff, insurers and volunteers. These wildlife/roadkill observation systems (WROS) can include mobile recording devices for data collection, a website for data management and visualisation and social media to reinforce reporting activity.

62.1 The specific purpose and goals of the WROS may vary among systems but should always be clearly defined.

62.2 Extensive social networks are needed for comprehensive observation systems.

62.3 Adopt a methodical approach to developing a wildlife/roadkill observation system.

62.4 Analysis and visualisation of data collected within a WROS should correspond to the goals of the system.

62.5 Address issues in reporter bias by using standardised data collection methods or post hoc analyses.

62.6 The advantages and disadvantages of opportunistic and targeted data collection must be carefully considered when developing a WROS.

Volunteer science and web-based information tools have advanced to the point where transportation or wildlife agencies and their allies can develop, support or implement WROS to improve the sustainability of transportation systems. However, while numerous WROS have been developed and implemented around the world, the full potential of many systems has not been realised because they were not developed or maintained according to the basic principles outlined in this chapter. We provide suggestions and guidance useful for updating existing systems and developing new ones.

Handbook of Road Ecology, First Edition. Edited by Rodney van der Ree, Daniel J. Smith and Clara Grilo.

INTRODUCTION

Reporting the occurrence of wildlife on roads, whether alive or as carcasses resulting from wildlife–vehicle collisions (WVC), has recently exploded as an area of road ecology research and practice and has spawned a new type of volunteer involvement. Globally, there are dozens of web-based systems for reporting WVC (Table 62.1). Many have appeared over the last 5 years, and they vary in their specific purpose, taxonomic breadth and use of social networks for collecting data and outreach. A few use smartphone-based applications to facilitate data entry from the field, and some use social media and communication tools to receive observations (Table 62.1).

Web-based reporting of wildlife observations, including WVC, is a rapidly growing source of data for understanding the impacts of roads on wildlife and, in some cases, mitigation effectiveness. The largest system in the world conducted by government agencies is that of Sweden's national police, which collects and reports accidents involving 12 species of wildlife (Table 62.1). The largest, longest-running system that relies on volunteer observers reporting any species is the 'California Roadkill Observation System' (CROS), run by the Road Ecology Center at the University of California, Davis (UC Davis, Table 62.1). In the latter case, data is collected from all roads as well as on targeted 'transect' roads, which have been selected for regular surveys.

There are four main ways that observations are recorded (Table 62.1): (1) inclusion of historical records of accidents or carcasses that preceded the web-based system; (2) form-based reporting on a website, including drop-down menus; (3) smartphone application-assisted web systems; and (4) social media sites, such as Twitter and Facebook. There are two main types of data collection strategies: opportunistic/random observations and transect/targeted route observations (Lesson 62.6). In the first case, observers report carcasses wherever and whenever they are seen (e.g. EWT, South Africa). In the second case, observers regularly drive, walk or cycle routes and report carcasses and, less usually, absence of carcasses ('null' observations, e.g. Road Ecology Center for Maine, United States).

Existing WROS can consist of tens of thousands of data points (Table 62.1) and represent a potential source of 'big data' for road ecology, community ecology, biodiversity mapping and other scientific/engineering disciplines. Big data refers to data sets that are large and usually geographically extensive and so require novel solutions for storage, analysis, processing and visualisation. At a global level, WROS provide the largest known, continuous source of data on animal occurrence and distribution while also providing opportunities for tissue sampling of genetics, disease and other testing (Textbox 62.1). It is important to carefully structure the informatics (i.e. collection, management and sharing) systems for these observations to facilitate analyses and other uses of the data.

The aims of this chapter are to highlight key issues that should be considered during the planning, design and implementation phases of WROS to ensure the data collected are accurate, reliable and useful to multiple end users. Many WROS systems around the world have been unsuccessful because the lessons we outlined in this chapter were not adequately considered.

Textbox 62.1 The importance of sampling roadkill otters for evaluating pollution and parasites in the United Kingdom

The Cardiff University Otter Project has collected otter carcasses (95% from roadkill) in the United Kingdom for 20 years, across a period of population expansion, and from 2010 has examined approximately 200 carcasses per year. At the top of the aquatic food chain, and a wide-ranging predator, otters form an excellent 'sentinel' for environmental health, enabling researchers to determine spatial and temporal variation in contaminants (Chadwick et al. 2011) and parasites (Chadwick et al. 2013) of relevance to human as well as animal health. Making use of roadkill is particularly important when studying elusive species, such as the otter, that are otherwise difficult to monitor and can offer insights into population structure and behaviour (Hobbs et al. 2011) as well as basic biology (Sherrard-Smith & Chadwick 2010).

LESSONS

62.1 The specific purpose and goals of the WROS may vary among systems but should always be clearly defined

The rationales for creating a WROS include informing transportation mitigation planning (Gunson et al. 2011), improving driver safety (Bissonette et al. 2008) and contributing to biodiversity observations (Elmeros et al. 2006). The purpose of a system often drives its

Table 62.1 Examples of wildlife/roadkill observation systems from around the world.

	System name (country)	URL	Description	Data collection and feedback methods
AQ2	National Wildlife Accident Council (Sweden)	http://www.viltolycka.se/hem/	Operated by the Swedish National police, it is the largest of its kind in the world, with over 200,000 records of WVC in the last 5 years. Online reporting and data display have been in place since 2010, but data are available back to 1985	Collection: website, iOS and android apps Feedback: real-time map of WVC on web of specific species, plus data downloaded to app to alert drivers of proximity to a recent WVC
AQ3	California Roadkill Observation System and Maine Audubon Wildlife Road Watch (United States)	http://wildlifecrossing.net	Operated by the UC Davis Road Ecology Center, and beginning in 2009, this was one of the first in the world to use web reporting of roadkill by any organisation or individual. It allows entries for any species in California or Maine using websites for each of these states and as of October 2014 had greater than 30,000 entries on transect and non-transect routes	Collection: website Feedback: regular updates (last 30, 90 days) on a map of WVC, searchable by species. Lists and photo gallery of observations. News page on website
	Idaho Fish and Wildlife Information System (IFWIS) (United States)	https://fishandgame.idaho.gov/species/roadkill	Operated by the Idaho Department of Fish and Game, for all wildlife species in Idaho since 2011. As of October 2014, there were greater than 22,000 entries	Collection: website by registered users or phone number Feedback: none available
AQ4	Animals under the Wheels (Belgium)	http://waarnemingen.be	Operated by Natuurpunt of Belgium and since 2013 has collected greater than 14,000 roadkill observations (as of October 2014). Volunteers can report observations for any Belgian wildlife species on transect or other routes	Collection: website by registered users, iOS and android app Feedback: data on most observed species and top observers, species identification offered
AQ5	Project Splatter (United Kingdom)	http://projectsplatter.co.uk/	Operated by scientists at Cardiff University and since starting in 2013 has collected greater than 10,000 entries of roadkill (as of October 2014). Volunteers can report ad hoc observations for any UK wildlife vertebrate species	Collection: website via form, Facebook, Twitter (@ProjectSplatter), iOS and android app and email to projectsplatter@gmail.com Feedback: weekly report on most observed species and top observers via social media, https://www.facebook.com/SplatterProject13. Map of WVC, updated maps every 30–90 days.

	The Endangered Wildlife Trust (EWT) (South Africa)	http://endangeredwildlifetrust.wordpress.com/category/wildlife-and-transport-programme/	Operated by the South African non-government organisation (NGO), the Endangered Wildlife Trust (EWT) collects roadkill observations via phone, email, smartphone apps and social media tools from volunteer observers or organisations. It allows entries for any species in southern Africa and has greater than 4000 entries as of October 2014 dating back to 2011	Collection: website via form https://www.ewt.org.za/WTP/DataForm.html, iOS and android app and email to roads@ewt.org.za Feedback: monthly blog, http://endangeredwildlifetrust.wordpress.com; newsletters, https://www.ewt.org.za/WTP/news.html; Twitter feed, @EWtRoads; Facebook groups, https://www.facebook.com/EndangeredWildlifeTrust https://www.facebook.com/groups/roadecology/ A number of other South African wildlife observation reporting platforms include roadkill as a category (e.g. Africa Live, iSpot, Latest Sightings Facebook)
AQ7	Animal–Vehicle Collisions (Czech Republic)	http://www.srazenazver.cz/en/	Operated by the Czech Republic Transport Research Centre and began with entries from a police database of traffic accidents going back to 2007. It allows entries for 12 species by any organisation or individual and has greater than 7000 entries as of October 2014	Collection: website by registered users Feedback: map of location of WVC
	Road Kill Survey (Ireland)	http://www.biology.ie/home.php?m=npws	Operated by Biology that has used web and map-based tools since 2005. Volunteers and organisation can report roadkill from a list of 22 species and species groups (e.g. 'bats'), and it has 2700 entries dating back to 2002	Collection: website by non-registered users Feedback: map of location of WVC, searchable by species and date

AQ6

methods for data collection and determines the types of data collected. This not only makes development of the purpose very important, but potentially can constrain uses of the data for other functions.

There is a clear need to develop a goal or purpose statement for a WROS. This can begin with a fairly broad goal for the system and include a series of objectives that clearly link to types and modes of data collection. For example, one broad purpose statement that reflects the goals of most WROS is: *This system is designed to monitor the occurrences of roadkill in order to improve safety for drivers, reduce impacts to wildlife populations, and contribute to the understanding of regional biodiversity*. The statement has four main objectives, each of which is important to different stakeholders and requires different emphases in data collection, analysis and reporting (Fig. 62.1).

62.2 Extensive social networks are needed for comprehensive observation systems

Broad and inclusive networks are required for a WROS to grow and persist. Also called 'crowd-sourced science', volunteer science networks (sometimes called 'citizen science') consist of managers and scientists from transportation and wildlife agencies, NGOs (Chapter 60), colleges and universities and the general community. Volunteer science provides a large and robust pool of enthusiastic people interested in problem solving and data collection. Furthermore, volunteer science has facilitated analysis of ecological processes operating at broad spatial and temporal scales, far beyond the limit of traditional field studies (Wilson et al. 2013). Some of the largest systems in the world rely primarily on volunteer effort to develop

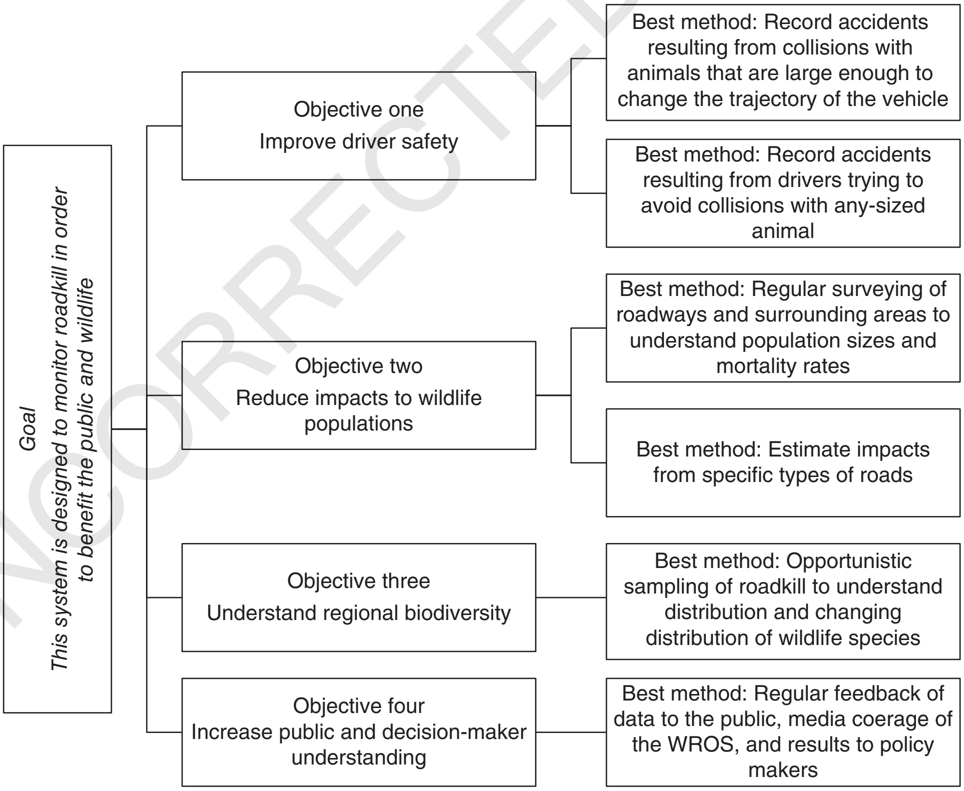

Figure 62.1 Linking goals, objectives and data collection methods to reporting activities in a WROS. The goal and the corresponding objectives and methods in this example are typical of many WROS. The 'best method' is most appropriate for the corresponding objective but may also contribute to other objectives.

reliable, verified wildlife data (Schmeller et al. 2009; Ryder et al. 2010; Cooper et al. 2014). These volunteers are often professional biologists making wildlife observations 'on the side' and contributing these observations to various WROS (e.g. CROS, United States). One perception of volunteer science-gathered data is that it may suffer from observer bias and identification error (Cooper et al. 2014). However, this has not often been the case and inaccuracies may be outweighed by the size of data sets available from volunteers (Schmeller et al. 2009; Ryder et al. 2010). As the volunteer science movement becomes an industry, it is anticipated that data collection will become more streamlined and standardised, with the volunteer scientist benefitting from the knowledge that they have helped advance in a scientific field they are passionate about.

Social media platforms (e.g. Facebook, Twitter) have revealed public concern about the rate of animals killed on roads and have become valuable volunteer science tools (e.g. Project Splatter, Table 62.1). In addition to the actual collection of WVC data, social media can raise concern and awareness over WVC and their impacts on biodiversity, thereby encouraging more individuals across broader geographic areas to collect WVC data.

When it comes to submitting WVC data, public choice may influence the researcher's choice of platform, of which there are many (Table 62.2). Ideally, photographs of the animal(s) should accompany the submission of an observation, with the location (preferably the GPS coordinates) and date/time of the observation. Photos do assist the WROS with species identification and allow the scheme to quantify the accuracy of submissions. While many new technologies are available for data collection, we recognise that some data collection may still rely on analogue devices such as paper and pen.

To allow for maximum public participation, we recommend a combination of platforms (e.g. smartphone application, social media and email) be adopted for collecting the data. The most robust data for examining long-term abundance trends and identifying hotspots are those that record observations of both the presence and absence of roadkill on set transects (Chapter 13). As such, contributors should be encouraged to submit null observations on defined journeys. This approach has been adopted at certain times of the year, for example, by the Belgian 'Animals under the Wheels' programme (Table 62.1) who run a 'report your commute' campaign to gain high-quality standardised survey data but also to re-inject enthusiasm into the volunteer base.

62.3 Adopt a methodical approach to developing a wildlife/roadkill observation system

Developing a successful WROS depends on a wide range of activities and skills. This lesson lists the five critical features of a WROS and can be thought of as a checklist for existing schemes as well as guidelines for new WROS.

Table 62.2 Digital technologies available for WROS observation reporting by the public.

Platform	Hardware/technology required	Advantages	Disadvantages
Smartphone application	Smartphone/tablet	Data easily submitted by participant, usually providing an immediate and accurate data point	Not all cell phones and tablets support applications, and these applications must be frequently updated
Instant messaging/SMS message	Cell phone/tablet	Relatively accessible to all in possession of a cell phone, or tablet report usually immediate	Not all cell phones and tablets support photographic submissions or GPS locations
Social media (e.g. Facebook/Twitter)	Web-based (phone, tablet or PC)	Data easily submitted by participant	Does not always provide a GPS point and not always immediate
Email	Web-based (phone, tablet or PC)	Data easily submitted by participant	Does not always provide a GPS point and not always immediate

Communicate complex ideas simply and completely to everyone from politicians to scientists. If the purpose of the WROS is to understand and resolve the impacts of roads and traffic on wildlife to meet safety and conservation goals, then effective messaging to many types of audiences through social and traditional media is important to support the WROS itself as well as the conclusions generated from the data.

Continuous inclusion of broad participant types. People with many skills and education levels and types are required to make a WROS succeed. Social networks of participants (Lesson 62.2) are necessary to provide a stream of data. Web programmers and app designers are essential to design efficient data collection tools and to update them regularly. Transportation and wildlife agency staff should provide important feedback on what kinds of data and analysis are needed for decision support. Statisticians and GIS experts are necessary to ensure the records collected will be sufficient for rigorous data analysis.

Understand and implement principles of scientific data collection. Expectations are growing for WROS to include rigorous methods for data collection to test hypotheses, discover previously unknown relationships and increase understanding of the impacts of transportation systems. Design the system to encourage the collection of high-quality data, allow for verification of data quality and include essential information regarding sampling effort and observer skill that a scientific user is confident that the data and subsequent analysis is robust.

Use web systems, smartphones and social media to improve data collection. The metadata that can automatically accompany every roadkill observation in a web database means that many tools can be used to enter or retrieve the data (Olson et al. 2014). For example, it is theoretically possible to use the metadata attached to an image file sent from a smartphone to automatically create a roadkill record associated with a known user, geolocation and time stamp and potentially other information (such as observation method). What would remain is for an expert user to examine the photograph and update the record to include the animal's identity. Social media tools, such as Twitter or texting, could be used to collect such observations (Tables 62.1 and 62.2).

Data collection is a critical input of WROS. Highway maintenance staff cleaning up WVC carcasses cannot be expected to have the same diligence for taxonomy as a dedicated professional biologist volunteering their time observing WVC. A trade-off exists in the data gathered using different schemes and each poses challenges in terms of data analysis (see Lesson 62.5; and see Bird et al. 2014 for review).

62.4 Analysis and visualisation of data collected within a WROS should correspond to the goals of the system

The data collected in WROS are fundamentally spatial (i.e. the location of animals along a road), and spatial statistics (Chapter 13) are well suited to analyse and interpret the data. For example, spatial statistics are clearly relevant to (i) mapping the distribution and abundance of species (George et al. 2011) and impacts to species; (ii) identifying landscape or other factors, such as vehicle speed or time of day that are related to WVC (Langen et al. 2009); and (iii) statistically determining if WVC are clustered in space and/or time, otherwise known as identifying 'hotspots' (e.g. Barthelmess 2014; Chapter 13).

There are many tools to measure impacts to species from WVC, to determine causes and correlations with WVC and for finding places where transportation agencies can focus remedial action to reduce impacts to wildlife and improve driver safety. Analyses to identify non-random clusters of WVC's (hotspots) have utilised Geographic Information Systems (GIS), a promising tool where statistics have been used to identify spatial clusters (Chapter 13). Examples of analytical approaches and methods include the Nearest Neighbor Index (e.g. Matos et al. 2012); 'SaTScan', borrowed from epidemiological studies, which looks for non-random clusters of events (i.e. disease outbreaks); the Getis-Ord Gi statistic for spatial autocorrelation; and the Kernel density estimator plus method for estimating locations of high densities of events.

Maps can be both informative and evocative and thus useful in public relations, in scientific reporting and in supporting decision-making. Maps should be produced regularly, and a GIS is an efficient method to generate and visually display the data (Fig. 62.2). Maps should be displayed on the WROS website, as well as via other mediums, such as scientific reports and social media. These maps typically display the locations and/or rates of WVC for specific species or groups of species thereby addressing many of the primary motivators for setting up the WROS (Textbox 62.2). AQ8

AQ9 **Figure 62.2** Website graphic of the California Roadkill Observation System (CROS, http://wildlifecrossing.net/california) demonstrating visual display of roadkill data submissions. Source: http://www.wildlifecrossing.net/california/map/roadkill. AQ10

Textbox 62.2 Road watch: Recording roadkill in South Africa

Approximately 14,000 people are killed each year on roads in South Africa, of which collisions between animals and vehicles account for many injuries and human mortalities, as well as extensive vehicle damage. Insurance claims in South Africa suggest that approximately US$150 million is paid each year to drivers due to WVC, though the biodiversity costs of these collisions are never calculated. To address the threat to biodiversity from WVC, the Endangered Wildlife Trust (EWT) launched the Wildlife and Roads Project in 2012.

In the beginning of 2014, a smartphone app, *Road Watch*, was launched to enable the public to submit roadkill sightings. This allowed the project to develop a sensitivity map of potential areas where wildlife are threatened by roads and traffic. *Road Watch* has been publicised in press releases and social media, and the Roadkill Research LinkedIn site has over 1000 members from around the globe, the Road Ecology Facebook page has almost 800 regularly contributing members, and an EWT Roads Twitter account was activated in 2014. The project also linked up with other reporting systems such as iSpot and Africa Live. The volunteer database has almost doubled in size from 2013 to 2014, with over 150 volunteers collecting roadkill data, and over 4000 data points for the country.

62.5 Address issues in reporter bias by using standardised data collection methods or post hoc analyses

Considerable investment in both time and money is often needed to initially set up and maintain a WVC data collection system, although free/open-source tools such as *EpiCollect* (an app) and *cartoDB* (mapping) are available, which will significantly decrease the upfront cost of systems. Recruiting and retaining volunteers in a WROS can take considerable time investment. The trade-off in this time allocation, however, is small when considering that volunteers have been shown to collect high-quality, usable data (Schmeller et al. 2009) and can provide extensive geographical coverage of the type that would typically be prohibitively expensive if carried out without volunteers. As such, once established, the system has the potential to be cost- and time-effective as big data are obtained.

A standardised and systematic approach to data collection that is user-friendly (and potentially incorporating a number of platforms) is the ideal, with clear designs of how the data will be analysed and reported. This will assist with data collected from diverse sources that may be biased by taxonomy and/or location. Once the data have been obtained, quality control and assurance steps (e.g. use of photo verification) are needed to reassure users of data quality. While photographs submitted in addition to data will help eliminate identification error, one has to consider the safety of the people reporting the roadkill and other road users. It is therefore important that all projects provide safety information and issue a liability disclaimer.

62.6 The advantages and disadvantages of opportunistic and targeted data collection must be carefully considered when developing a WROS

Opportunistic observations of WVC provide 'presence-only' data, which identifies locations where WVC occur, but not locations where they do not. Opportunistic data should be treated cautiously and either used in 'presence-only' statistical analyses or as a tool to warrant further in-depth data collection. In contrast, targeted data collection on set transects can provide records of where wildlife are not getting killed (e.g. they are safely crossing or do not cross, or roadside fencing or other mitigations are effective), thereby allowing more robust identification of hotspots and the factors influencing them. However, targeted data collection will often be more costly and/or time consuming than opportunistic data collection, and we therefore recommend both data types be collected. The WROS system developed by the Road Ecology Center for Maine, United States (http://wildlifecrossing.net/maine), includes both targeted and opportunistic AQ11 observations by volunteers and allows the reporting of 'no-animal' observations.

CONCLUSION

The flood of options available for reporting wildlife sightings is a growing field, and it is easy to become bogged down by the availability of so many possibilities and examples of implementation. It is therefore important to ensure that clear goals, objectives and desired outcomes are in place before implementation occurs. A WROS should start with a targeted understanding of the methods or components required – that is, what is the 'supply and demand', in short, who will be using the WROS, and what will the data be used for? The combination of goals, objectives and methods should provide the framework for an implementable system that satisfies the users and participants.

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Wildlife Trust and Bridgestone SA for funding. SE Perkins thanks Rita Harris and Darren Westcott of Project Splatter for their assistance with http://www.projectsplatter.co.uk and the Universities Federation for Animal Welfare for funding.

FURTHER READING

Bissonette et al. (2008): Estimated the cost to the public and drivers from deer–vehicle collisions on state highways, which in combination with WVC occurrence data has been very useful in proposing driver safety projects to reduce WVC.

Olson et al. (2014): Outlined methods for collecting WVC data using smartphone technology. Code supplied as an appendix.

Paul (2007): Determined that for a highway in Canada there was no statistically-significant difference between hotspots identified using volunteer-collected data or data collected by professionals.

Schmeller et al. (2009): Surveyed hundreds of volunteer science programmes across Europe and found that the data collected by the thousands of volunteers in these programmes represented millions of Euros of effort and resulted in large, reliable data sets.

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