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The Challenges, Responsibility, and Need to Track Human-Coyote Conflicts in California

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ABSTRACT: A common adage is "you can't manage what you can't measure." How applicable this saying may be to wildlife conservation and management is debatable; however, understanding the "where," "who," and "why" of human-wildlife conflict can help managers evaluate and prioritize incident response and conflict mitigation efforts. It is critical to note that no tracking or reporting system is capable of effectively capturing all human-wildlife incidents. The format and functionality of the tracking system, how the system is advertised to the public, and who manages the system are all important factors in the accessibility, utility, and success of each tracking system. Here, we examine three different systems for tracking reported human-coyote incidents and encounters in California: 1) the Wildlife Incident Reporting system, operated by the California Department of Fish and Wildlife; 2) Coyote Cacher, operated by the University of California - Agricultural and Natural Resources Cooperative Extension; and 3) iNaturalist, a citizen science initiative, operated by a non-governmental organization. We find that because each system offers different incentives to the public (and poses different potential challenges or barriers to reporting), each receives a significantly different volume of coyote reports. Each system provides a unique perspective of reported human-coyote conflicts in California. Understanding these differences and being cognizant of the inherent or potential limitations of a reporting system are crucial for integrated, scientifically defensible, and robust wildlife management, effective policy development, and informed decision-making.

KEY WORDS: *Canis latrans*, coyote incident report, human-wildlife conflict, predators, reporting, socio-economic studies

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INTRODUCTION

A common adage attributed (but likely misattributed) to the management expert Peter Drucker is, "you can't manage what you can't measure." Authors in both the popular and scientific press have often taken this adage at face value, despite evidence (even from Drucker's original works) that the relationship between managing a resource and measuring that resource is much more complex than can be conveyed by a single phrase (Drucker 2009). This is particularly the case when managing a resource involves human emotions, attitudes, values or behavior. Such social and cognitive factors are difficult to measure, assess, and as historically noted (see Lapiere 1934, Wicker 1969), to reconcile attitudes with behaviors. As human emotion and behavior are often at the heart of wildlife management decisions, particularly in the prevention, mitigation, and response to human-wildlife conflict, measuring the human dimensions that may influence and shape these actions is critical (Manfredo 2008).

Conflict with coyotes (*Canis latrans*) in the U.S. state of California is an excellent example of challenges associated with measuring human-wildlife conflict. Perceived or actual conflict with coyotes is a major concern for wildlife conservation and management in California, particularly in southern California (Baker and Timm 1998, Baker 2007). Different stakeholder groups have different perspectives on how to respond to potential conflicts with coyotes, particularly around the acceptability of lethal control. However, regardless of the type of response (co-existence, non-lethal, or lethal control), the first challenge of responding to conflict is knowing where and when it occurs.

One solution to this challenge available is the use of coyote reporting tools. Several different institutions, ranging from governmental to nongovernmental entities, offer online tools for the public to submit reports of encounters with coyotes. These reporting tools can be valuable outreach resources for connecting the public with state and local agencies, or neighbors, to share sightings of coyotes. The value of these reporting tools for research purposes is less clear. For example, Mueller et al. (2019) found that reports from the popular wildlife reporting tool, iNaturalist, underestimate the true spatial distribution of foxes and coyotes. Reporting becomes further complicated with multiple reporting systems operating for the same geographic location, which is the case in California.

The human dimensions of human-coyote conflict make the reporting of coyote incidents even more of a challenge. Humans respond differently to different types of risks, including risks associated with environmental and wildlife issues (Griffin et al. 1999, Trumbo 2002, Slimak and Dietz 2006, Slovic 2007, Dickman 2010, Kahn et al. 2010, Fiorino 2012). Social trust is an important concept associated with risk (Siegrist and Cvetkovich 2000, Siegrist et al. 2000, Poortinga and Pidgeon 2003, Earle 2005), particularly whether or not an individual trusts the agency, or entity, responsible for managing the risk. Lastly, there is an economic component of risk. Some populations are more vulnerable to conflict with wildlife and have fewer available resources to commit to mitigating risks from wildlife (Dickman 2010).

Due to these social factors, reporting information may be weighted to certain populations: those that may perceive coyotes to be a threat and also have the resources to access reporting tools. It is expected that different reporting tools will give different impressions of human-coyote encounters, and understanding how reporting data is measured will be crucial in interpreting such data. However, media, policy- and decision-makers, stakeholders, and members of the public often request reporting data from city and state reporting systems without a full understanding of the complexities and limitations of these reporting tools. The following analysis provides a brief investigation of different coyote reporting tools, as well as the appropriate uses of such tools.

METHODS

Three reporting tools are examined here: 1) the Wildlife Incident Reporting (WIR) system (CDFW 2020), 2) Coyote Cacher (UC Cooperative Extension 2020), and 3) iNaturalist (California Academy of Sciences and National Geographic 2020). Each of these reporting tools allows for citizens to report coyote incidents, but with each reporting tool developed by a different institution for different purposes. Since each tool has different objectives and measures, this analysis defines a coyote "incident" as any encounter that the public chooses to report through one of the tools. While combining all types of incidents into one measure masks the complexities of managing coyotes (for example, a coyote sighting versus a coyote attacking a pet require different responses), this preliminary analysis is primarily concerned with human reporting behavior. Future research can examine how the reports of incidents and encounters differ between the reporting tools.

The WIR system is developed and maintained by the California Department of Fish and Wildlife (CDFW) as a tool for reporting human-wildlife conflict. The WIR system allows the public to submit a report that is then assigned for review by a CDFW staff member. The public can use the WIR to submit reports for any wildlife species in California into the WIR system. Reports that do not require a response from CDFW (such as a sighting of a wild animal) are archived for record keeping. Reports that do require a follow-up response (such as of a sick or injured animal, or wildlife causing property damage), or for when a response is requested, are assigned to a CDFW wildlife biologist or wildlife officer for investigation based on geographic location of the reported incident. In cases of wildlife causing property damage ("depredation") whereby a depredation permit is requested, CDFW uses the WIR to generate and issue the permit. In California, a depredation permit is not required to lethally take a coyote that has caused property damage including injury or death to a domestic animal (pet or livestock).

Coyote Cacher is developed and maintained by the University of California's Cooperative Extension to research information about coyote encounters. While individuals outside California are able to use Coyote Cacher, the geographic focus of the tool is California and the majority of users reside in the state. Coyote Cacher allows residents to submit reports of coyote incidents. Coyotes are the only wildlife species for which a report may be submitted by a public user. There is a mapping component where users can view their geographic location (neighborhoods) and sign up for email alerts to stay informed about coyote reports in their area. Several local governments in southern California have adapted Coyote Cacher into their coyote management programs as a reporting tool.

The third tool, iNaturalist, is a resource developed and maintained by the California Academy of Sciences and National Geographic. iNaturalist is an online community for users to submit photos and sightings of wildlife from around the globe. Users can submit reports for any wildlife species for any geographic location, not just the state of California. One goal of iNaturalist is to facilitate and support robust citizen science. Researchers can query reports and download data submitted by users.

Reporting data for coyote incidents were collected for the years 2017-2019 for the three reporting systems. Since users can submit a report for each incident, the mean number of incidents per user was calculated. The years 2017-2019 were chosen in order to ensure three complete years of information from each system (Coyote Cacher was developed in 2016). For comparative purposes, data for black bears (*Ursus americanus*) were also collected from iNaturalist and the WIR Incidents that did not provide longitude and latitude coordinates or were not located in California were excluded from analysis. To examine how much of the variation, or "noise," in the data is due to differences between reporting tools, the data from the WIR and iNaturalist for black bears was graphed (Figure 1). The total number of reports (summed across the three tools) for each California county was compared to various socio-economic characteristics of the counties to examine whether such factors explained any variance in coyote reporting (Table 1). Socio-economic characteristics of California counties were taken from the American Community Survey conducted by the U.S. Census Bureau (2018). Analysis was performed using ArcGIS and R (ESRI 2020, R Core Team 2020).

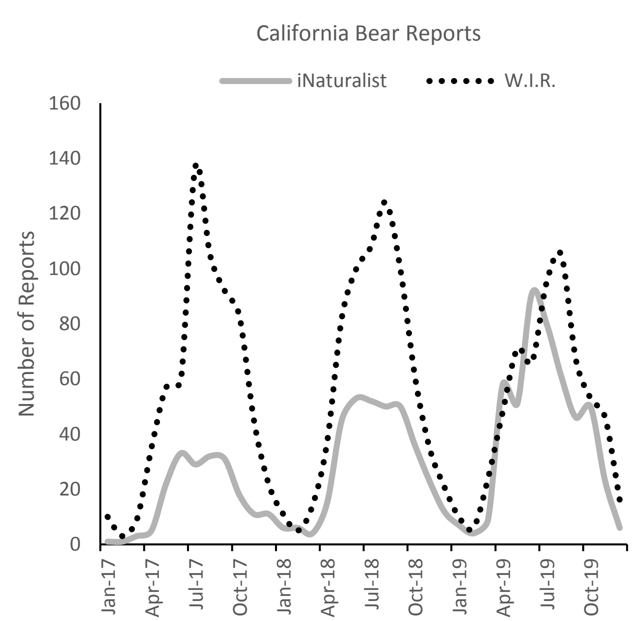

Figure 1. Bear reports by reporting tool.

Table 1. Correlation of county socio-economic factors with coyote reports.

Characteristic	Correlation	p-value
Population (log)	0.767	<0.001
Median Income ($)	0.629	<0.001
Difficulty with English (% of Residents)	0.423	<0.001
County Area (km^2)	0.178	0.181
Median Age (years)	-0.255	0.053
No Internet (% households)	-0.609	<0.001

Coyote reports and county population were log transformed.

RESULTS

Between 2017 and 2019, there was a wide range of reports across the three reporting tools (Table 2). Coyote Cacher had the most reports (over 7,500), while the WIR system had the fewest with just over 1,200 reports. On average, iNaturalist users reported 2.70 incidents during the three-year period while WIR users reported an average of 1.08 incidents. Not all Coyote Cacher users gave permission for their names to be submitted with their reports, so determining the number of reports per person was not possible.

Table 2. Number of reports and unique users for each reporting tool.

Tool	Total Reports	Incidents/ User
WIR	1,226	1.08
Coyote Cacher	7,587	1.43*
iNaturalist	5,391	2.70

* Not all Coyote Cacher users gave permission for their names to be submitted along with their reports.

Analysis of the number of incidents reported by month does not reveal any clear pattern in reporting trend or coyote activity (Figure 2). For example, the number of reports for Coyote Cacher peak in June 2017, September 2018, and October 2019, while the number of reports for iNaturalist peak in April 2018, April 2019, and December 2019. Throughout the three years, the WIR system consistently had the lowest number of reports of the three reporting tools.

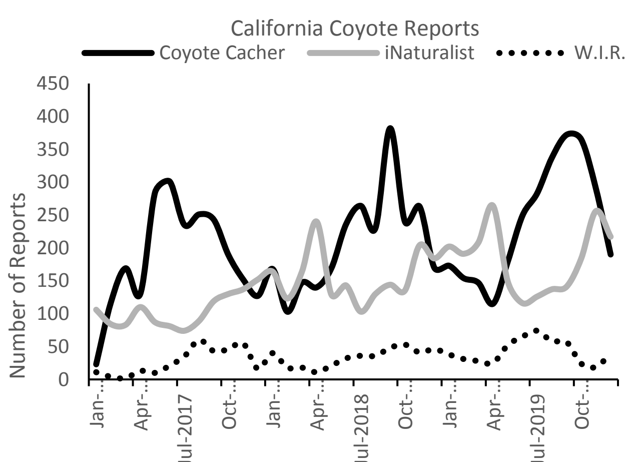

Figure 2. Coyote reports by reporting tool.

For black bears, the WIR system had the most reports. However, both tools showed a similar pattern with peak reports occurring in the summer. This peak in reported activity is likely when bears and humans are most active and thus most likely to encounter one another.

The human population was strongly positively correlated ($r = 0.77$) with the number of coyote reports. The median income of a county also had a strong positive ($r = 0.63$) correlation with reports. The percentage of residents who speak English "less than very well" (U.S. Census Bureau 2018) was positively ($r = 0.42$) correlated with the number of coyote reports.

A lack of internet access (percentage of households without an internet subscription) was strongly negatively ($r = -0.61$) correlated with the number of reports. The median age of a county was also negatively correlated with the number of coyote reports ($r = -0.26$). Coyote reports by county were regressed onto the different socio-economic characteristics to see how characteristics explained variance while controlling for the other characteristics (Table 3). Population, difficulty with English, county area, and median age were all statistically significant ($p < 0.05$). The R^2 for the regression model was 0.77.

Table 3. Standardized linear regression of coyote reports regressed onto county socio-economic factors.

Characteristic	Standardized Coefficient	p-value
Population (log)	0.547	<0.001
Median Income	0.186	0.218
Difficulty with English	0.319	0.025
County Area	0.240	0.003
Median Age	0.408	0.003
No Internet	-0.257	0.095

Coyote reports and county population were log transformed. $R^2 = 0.767$

DISCUSSION

The number of coyote incidents reported across the three different reporting systems varied significantly. Between the three tools, Coyote Cacher accounted for more than half of all the reports received between the years 2017 and 2019. Not only did the total number of reports per month differ between the tools, the pattern of when reporting peaked and ebbed also showed variation. While some of the variance between the tools may have been due to their different formats, some variance may have also been due to differences in how people report different species. For example, bear reports from the WIR system and iNaturalist do show a similar seasonal pattern not seen in the coyote reports. From this analysis, it is not possible to determine if the "noise" in coyote reporting is due to inconsistent reporting efforts or to a lack of seasonality in human-coyote encounters.

When the total number of reports is summed for each county, socio-economic characteristics of the county explain the majority (in our model, over 75%) of variance in coyote incident reporting. The number of people living in a county is particularly predictive of the number of reports about coyote incidents. Median age and language fluency also explain a significant amount of variance in reporting.

These results indicate that it is inappropriate to use such reporting tools to predict coyote population for any area and it may be difficult to examine patterns in reported human-coyote conflict. Using any single tool will provide a biased view of the total reporting behavior. With socioeconomic factors (such as perception, tolerance, resource availability) accounting for so much variance in reporting, incident reporting may be more reflective of a county's human population than of its local coyote population.

This is not to say that such reporting tools have no value. Reporting systems can be very useful as outreach and communication tools and for connecting citizens who encounter coyotes or have concerns about human-wildlife conflict with the appropriate city or state agency. As an analogy, a taxi dispatch service or a ride-share application (app) can be an effective way for connecting those who need transportation with those willing to provide such a service. However, data from such a dispatch service or app would not accurately reflect traffic patterns or the number of vehicles within an area. Similarly, such reporting data can also help inform communication and outreach strategies to engage the public regarding reported human-wildlife conflicts. The results also serve as a critical reminder that online reporting tools are not going to reach residents that lack access to internet and other resources. Different means of outreach and communication will be needed in underserved communities and for members of the public with fewer available resources.

Surprisingly, difficulty with English was positively related to the number of coyote reports. More research is needed to determine if there is a third factor explaining this relationship. One possible hypothesis is that counties with a high percentage of residents who have difficulty with English may have higher levels of diversity or many different ethnic communities. Urban and other highly developed areas tend to reflect a more densely populated and diverse demographic (U.S. Census Bureau 2018), and these same areas may reflect greater perceptions of human-wildlife conflict as compared to more rural or natural areas. If certain communities use reporting systems more often than others, this could account for the observed relationship.

Further research can address some of the limitations in this analysis. As discussed, each reporting system categorized reports differently, so this analysis grouped all reports together into a single measure. It would be interesting to separate the reports based on the type of encounter (such as a sighting, general nuisance, or property damage including pet loss). A finer geographic resolution than the county level (such as at a zip code or census block scale) could also be beneficial. There were not enough observations between the three reporting tools for this level of analysis to be conducted at a state-wide level. Lastly, a future study using a survey instrument or interview could delve deeper into who is using reporting tools, how they became aware of such tools, why they choose to report using the tools, and their expected or desired outcome for reporting.

An understanding of human-coyote conflict is needed to mitigate and prevent such conflicts. While tools for the public to report coyote incidents can be effective for outreach and communication, it is important to understand exactly what these reporting tools are measuring and how the data may be appropriately used. Understanding reporting tools and being cognizant of the inherent or potential limitations of a reporting system are crucial for integrated, scientifically defensible, and robust wildlife management, policy development, and decision-making.

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