Camera traps as seen by wildlife managers

— An insight into Swedish wildlife managers' views on camera traps and other technological tools and methodologies in an adaptive wildlife management framework

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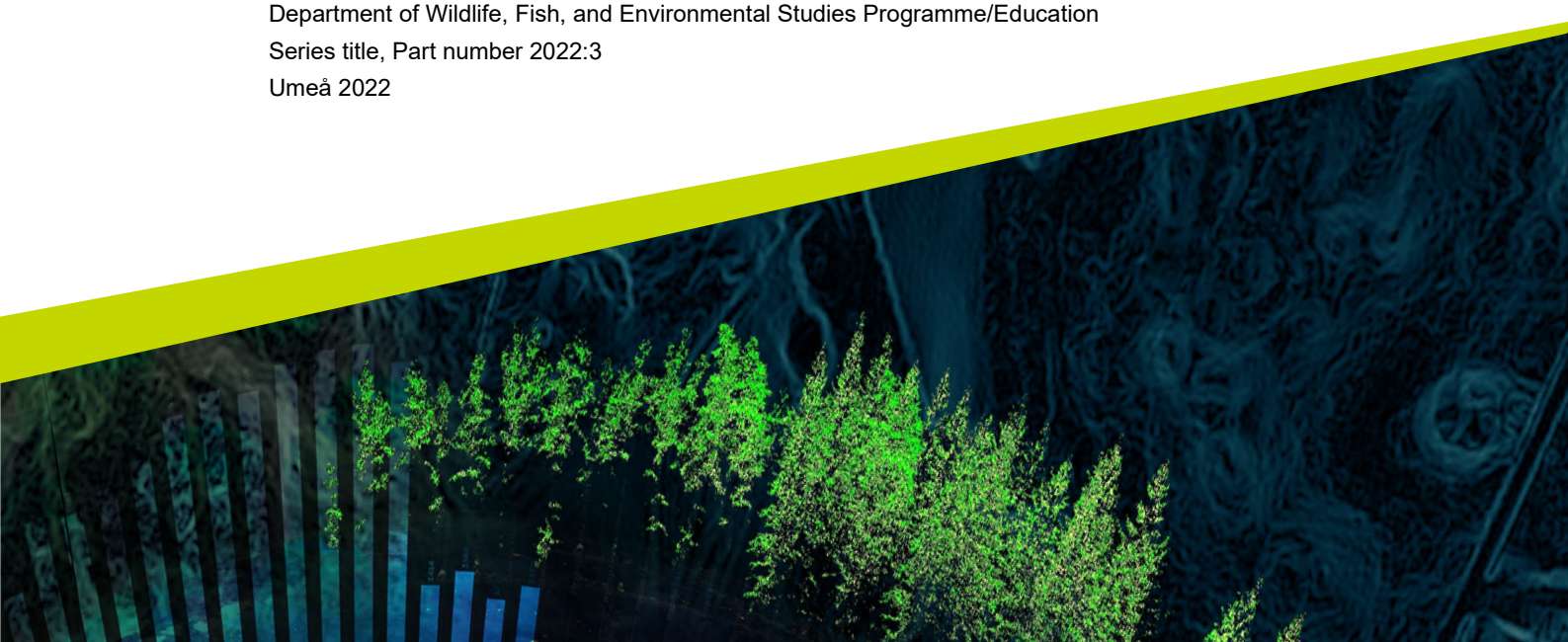

Camera traps as seen by wildlife managers – An insight into Swedish wildlife managers' views on camera traps and other technological tools and methodologies in an adaptive wildlife management framework

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Abstract

Sweden strives for adaptive wildlife management. With the introduction of new technologies and methodologies, adaptive management must be resilient and efficient in implementing and trying these, to truly stay adaptive. One of the most widely used technologies within Swedish wildlife management is camera traps, as they are a relatively cheap and unintrusive means of monitoring wildlife. In this report, I focus on the practical and theoretical development and implementation of camera traps. By conducting qualitative, key informant interviews with Swedish wildlife managers, I provide insight into managers' thoughts on and experiences with implementation of camera traps specifically and new technologies and methodologies more generally, and into their views on the challenges that Swedish wildlife management may face today, and in the future. The analysis revealed concerns in communication of information, knowledge, experiences, and technology uses between involved stakeholders, as well as issues in the coordination of methodological and technological development and implementation. Efficient communication and coordination are vital in maintaining a functional approach to adaptive wildlife management with fundamental knowledge amongst all stakeholders. The adaptive management framework and practical implementation needs careful work to obtain these functions. The analysis also revealed frustration amongst wildlife managers concerning the legislation around the use of new technologies. As adaptive management is reliant on a trial-and-error approach, legislation must be adapted to allow for new tools and methods to be tried in order to meet current and future management demands.

Keywords: Camera trap, adaptive wildlife management, governance, legislation, technology, implementation.

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Abbreviations

LST	Länsstyrelse, County Administrative Board
SEPA	Naturvårdsverket, Swedish Environmental Protection Agency
SJF	Svenska Jägareförbundet, Swedish Association for Hunting and Wildlife Management
SLU	Swedish University of Agricultural Sciences

1. Introduction

1.1. Technology in monitoring

Within modern wildlife management, technology is evolving quickly with wildlife managers using unmanned aerial vehicles (Mangewa et al. 2019), GPS tracking (Dennis & Shah 2012; Pacheco 2018) and many other technological tools. Camera traps are widely used in wildlife management, as they are a low cost, non-invasive tool in wildlife monitoring (Wearn & Glover-Kapfer 2017). Research on technological advancements in wildlife management is continuously developing improved methods to monitor wildlife to assess populations, behaviour, distribution, abundance, and community structure (Burton et al. 2015).

Currently in Sweden, such technologies are used in a variety of ways in wildlife management. Big game monitoring in Sweden uses a number of methods in data collection for population analysis: mainly observations, camera traps and tracking- and harvest data. Observations are used within ungulate management as a base, together with harvest data, for harvest estimations. This provides data for a time/effort analysis (Jägareförbundet 2017; Eriksson & Kindberg 2019). Camera traps are used in all management but foremost in large carnivore (lynx, wolf, bear, and wolverine) management. County administrative boards use previous experiences, knowledge, and reports of observations as grounds for camera trap placement (Länsstyrelsen Värmland n.d.) and tracking manually as well as with drones, to some extent, to monitor these species (Naturvårdsverket n.d.a). These analyses strive to provide reliable estimations of population composition and size to determine harvest quotas and other management actions.

As large predator management, and especially wolf management, is a highly polarized debate today (Hallgren & Westberg 2015; Dalerum et al. 2020; Bergheden 2021; Nilsson 2021) - populations of large carnivores, especially wolf, are considered small by some, and too large by others (Dalerum et al. 2020; Bergheden 2021; Riksdagsförvaltningen & Strandhäll 2021). This puts high demands on management, and thereby monitoring, as the debate climate demands efficient and reliable management results.

As with any relatively newly introduced method, concerns have been raised about the implementation of new monitoring technology: For example, as

standardization in the use of camera traps may be difficult to achieve, bias can be present (Burton et al. 2015; Meek et al. 2015; Hofmeester et al. 2019). Other issues has been reported with data management with camera trap data, as data sets can be very large (Hofmeester et al. 2019). Practical implementation is also an issue when introducing new methods and tools (Pacheco 2018).

Management practices change with the implementation of new technologies, amplifying monitoring capacity (Verma et al. 2016) but also forcing current management practices to be questioned and reviewed. As a consequence, field monitoring of animals and animal tracks may not be as crucial in wildlife management anymore as it has traditionally been, public-wildlife relations may change (Pacheco 2018), affecting management practices, and the manager-wildlife relation may change as management becomes more technology- and desk based (Pacheco 2018). With emerging technology and practice, development and applicability in practical management may not be synchronised (Meek et al. 2015). With more and more technological advancements in wildlife monitoring, questions emerge on how this might affect our management practices. This study will, through qualitative research, explore Swedish wildlife managers' views on what impact camera traps may have on wildlife management practices.

1.2. Swedish wildlife management

Wildlife management in Sweden is executed on multiple levels. Swedish wildlife management is to some extent decentralized. This report will focus on two managing authorities with Parliament designated management responsibilities: the national authority, Swedish Environmental Protection Agency (SEPA, in Swedish: Naturvårdsverket), and the regional authorities, the county administrative boards (in Swedish: Länsstyrelserna, 21 in total). SEPA implements policy set by the government and parliament and is responsible for management and conservation on a national level. SEPA produces a national wildlife management strategy based on government policy that is then implemented regionally by county administrative boards (Sæther et al. 2019). The management strategy is to be based on the latest scientific knowledge. Emphasis is put on SEPAs role in supplying managers with knowledge on methods and tools to be used within wildlife management (Naturvårdsverket 2015). Another organization included in this report that is involved in wildlife management in general and hunters in particular is the Swedish hunters union, or the Swedish Association for Hunting and Wildlife Management (in Swedish: Jägareförbundet). They are, by governmental designation, responsible for helping government distribution of information, wildlife monitoring and coordination with hunters (Proposition 2008/09:210 2009).

1.3. Legislation surrounding technology in wildlife management

Recent changes in the handling of information that may harm personal integrity have affected camera trap use by both government officials and private citizens. GDPR, or the General Data Protection Regulation, by the European parliament regulates the use and handling of personal information ((EU) 2016/679 2016).

For members of the general public to use camera traps certain requirements must be met: personal integrity must be considered, meaning the camera must be placed in a way that minimizes risk of capturing a person on photo or video. Additionally, the camera trap user must have valid arguments for why the camera trap is used. The landowner must also give permission for camera trap use. The camera trap must be marked with the user's contact information and there must be visible signs informing that there is a camera in the area. Other than these requirements, individuals do not need permits for camera trap use since GDPR was implemented ((EU) 2016/679 2016; Naturvårdsverket n.d.b).

For government authorities, permits are required for camera trap use. The legal basis for camera trap use in wildlife management, here defined as camera surveillance, by government authority is government authority practice, i.e., monitoring and management of wildlife with camera traps. In the case of county administrative boards it is to monitor large carnivores (SFS (2001:724) 2002) and to prevent conflict between human and large carnivores (NFS 2007:10 2007). The same basic principles of ((EU) 2016/679 2016) apply with some exceptions. One example of such an exception in Swedish large carnivore management is monitoring of wolverine dens as information on den locations is confidential (Länsstyrelsen Värmland n.d.).

As for the use of drones in monitoring, government authorities need to apply for site- and time bound permits. Individuals are prohibited to use drones in hunting situations (SFS (1987:259) 1987) but are, within limits (Transportstyrelsen 2021), allowed to use them otherwise. Drones in wildlife management allow managers to monitor relatively large areas and have proven to be a valuable tool in monitoring of medium to large animals (Mangewa et al. 2019). It may be an important tool in future Swedish wildlife management. The use of a large toolbox can help in making wildlife monitoring and management as efficient and resilient as possible, but one also needs a good governance framework to fully utilize the toolbox. Governance frameworks with efficient legislation to adapt to ever changing conditions and an evolving management is key in functional adaptive management (Riley et al. 2003).

1.4. Adaptive management

Adaptive management allows managers and policy makers to adapt management after prevailing circumstances. Adaptive management is founded on the understanding that our knowledge on ecosystems and the processes within is incomplete. Ecosystems are under constant change and we need to adapt and correct management accordingly (Williams 2011). With this, management and governance can be tailored based on local, regional, and national prerequisites and changes. Complex interactions between human and nature shape our world. With relatively rapid changes in landscape structure (forestry, urbanization, infrastructure etc) and with climate change, management is forced to keep up (Chaffin et al. 2016).

SEPA strives for implementation of adaptive management in Swedish wildlife management (Naturvårdsverket 2015). Emphasis is put on large carnivore management being adaptive (Proposition 2008/09:210 2009). Adaptive management in practice for large carnivores includes county administrative boards being responsible for hunting quotas and local management decisions with SEPA having overarching responsibility (Proposition 2008/09:210 2009). For other large game management, adaptive management in practice is defined as a combination of available management theory and practice with continuous evaluation based on new learnings and changes in prerequisites such as populations, environment, and available tools, to meet management goals (Näringsdepartementet 2012; SLU 2019). With this in mind, I argue that monitoring is the foundation on which adaptive? management is built. Data to estimate current population structures, sizes and compositions gives us the foundation we need to apply methodologies, analyses and other management tools (Williams 2011; Näringsdepartementet 2012; SLU 2019).

Adaptive management allows stakeholders to keep up with the prevailing prerequisites and increase resilience to changing prerequisites, in wildlife management. However, adaptive management requires effective communication and coordination between stakeholders, managers and policy makers to fully utilize available tools and knowledge (Riley et al. 2003; Hallgren & Westberg 2015). For adaptive management to work, stakeholders, wildlife managers and legislators experiences must be heard throughout the communication chain (Hallgren & Westberg 2015). To achieve this, one could argue that wildlife managers and legislators working with wildlife management questions need to find a balance between bottom-up, top-down, decentralized as well as centralized governance.

1.5. Governance definitions

Governance, or organizational management, is defined by the manner in which management is structured and the systems and processes lying foundation for the

management to be applied (International Bureau of Education 2015). Bottom-up governance is defined by governance and management decisions established on a local scale to be brought further up through the chain of command. Top-down governance and management is established at the higher levels of command, be it national, international, or global. The decisions are then implemented down through the chain of command to a local level (Eicken et al. 2021).

These definitions are closely related to the definitions of the terms centralized and decentralized governance. In decentralized governance, authority lies at a local level or at other stakeholders lying furthest from the centre of the organization, or government. In centralized governance regimes, decision making authority is situated at the top of the organization (Cummings 1995). Wildlife management in Sweden has multiple governing authorities and organization with different roles in management. It could be argued that, as an underlying assumption to this study, all have their purpose and all need to cooperate to make wildlife management efficient and reliable within the adaptive management framework. It could be further argued that the management is polycentric, with decentralized monitoring and management by the county administrative boards with national level management that is, in turn, governed by SEPA.

1.6. Aim and research questions

> (Hallgren and Westberg, 2015 p. 166) "… conclude that the concept of AM [adaptive management] can only be realised if the management process is supported by communication that facilitates exploration, understanding and coordination of the knowledge contributions of the actors involved in the process".

Adaptive management could be the most favourable of management and governance approaches, but it puts high demands on practitioners. Technological implementation forms the foundation of adaptive management as new methods and tools need to be tested continuously to maintain functional adaptive management (Hallgren & Westberg 2015). This study aims at exploring issues, advantages and disadvantages perceived by Swedish wildlife managers in the implementation of technology and methodology in general, with focus on camera traps in particular, in wildlife monitoring and management in an adaptive management context. Camera traps are one of the most widely used technologies in monitoring of wildlife in the field today as they are easy to handle and relatively cheap (Burton et al. 2015; Meek et al. 2015; Wearn & Glover-Kapfer 2017). As of this, focus lies on camera traps in this report as they are deemed one of the most likely technologies to be used by most wildlife managers.

The goal is to provide an insight for managers, researchers, and policy makers within governance into how current management is viewed upon by those working with practical wildlife management and wildlife management questions, and for

others working with implementation of adaptive management where similar issues within the management may be present. By conducting interviews and reviewing available scientific literature, the goal is to gain an insight in the views of practitioners of wildlife monitoring at multiple management levels. The research questions to be address in this report are thus: What are wildlife managers' expectations for, and practical experiences with, the use of camera traps and related technologies in wildlife monitoring in Sweden? How does the use of camera traps change previous management practice? Where do they see the potential and obstacles for these technologies to contribute to adaptive management?

2. Method

2.1. Approach

In order to gain an understanding on the broad, yet complex questions of this report, a qualitative approach with semi-structured interviews was chosen. Interviews allowed me and the interviewees to explore the questions and subjects related to the main focus of the report. This exploratory approach was used to find perspectives and ideas not previously considered in my research process. For this analysis, where insight into new perspectives was the goal, the exploratory approach allowed for examination of views not previously considered. The study was based on key informant video interviews with stakeholders involved in practical wildlife management within Swedish wildlife management.

2.2. Data collection

Interviewees were chosen based on three aspects: (a) their employer, to represent three key stakeholders in wildlife management and camera trap use, (b) their role in wildlife management with camera trap usage being most widely used in carnivore management, all but one interviewee was in some way involved in carnivore management. The last interviewee was responsible for camera trap data management at their organization, and (c) their knowledge on wildlife management practices. All interviewees were considered key informants as they were fundamental in their respective area or department (Lavrakas 2008). The interviewees provided practical experiences with wildlife management as well as a birds eye view on both regional and national level in their respective field.

Semi-structured interviews were conducted, audio-recorded, transcribed and qualitatively analysed to give a nuanced understanding (Lester et al. 2020) of the role of technology in wildlife management. The semi-structured format gave the interviewer and interviewee capacity to focus on relevant subjects and points that came up, as the subjects examined could be rather complex with many different viewpoints that may be difficult to fully explore in more structured interview formats (Barriball & While 1994; Verma et al. 2016). The interviews were not

aimed at finding the answers for any of these questions but to explore different viewpoints and aspects of technology within wildlife management for analysis and for future in-depth research.

An iterative approach was used throughout the data collection and analysis process to find key points in the material. This implied that the focus of the report was continuously evaluated based on new findings and points of interest to get the most out of every interview. This allowed for further investigation of these points in the interviews because of the semi-structured interview format and in the following exploratory analysis (Taylor-Powell & Renner 2003).

2.3. Interview participants

Initially, ten potential interviewees were contacted; of these, eight were interviewed. The interviewees held different positions within Swedish wildlife management. Four of the interview participants were employed by different county administrative boards, one participant was employed by SEPA, one was employed half time at a county administrative board and half time at SEPA and two were employed by the Swedish Association for Hunting and Wildlife Management (see Table 1). Geographically, interviewees from the county administrative boards were located from southern to northern Sweden, those working at SEPA, and the hunters association had responsibilities regarding nationwide questions. All interviewees were in some way involved in data gathering for wildlife management. SEPA and the county administrative boards are both government agencies while the Swedish Association for Hunting and Wildlife Management is a hunters' union with some Parliament-designated responsibilities within Swedish wildlife management (Sæther et al. 2019).

Table 1 Interviewee employers. (Abbreviations: LST-County administrative board, SEPA-Swedish Environmental Protection Agency, SJF-Swedish Association for Hunting and Wildlife Management)

Interviewee	1	2	3	4	5	6	7	8
Employer	LST	LST	SEPA	SJF	SJF	LST/SEPA	LST	LST

2.4. Interview format

With an exploratory approach, open ended questions were used to invoke discussion and reflection surrounding the subjects by the interviewees and additional associations enabling in-depth engagement with the interview topic (Taylor-Powell & Renner 2003; Lester et al. 2020). As a base for the semi-structured interviews, a script loosely guided the interview to cover all pre-

determined key subjects but also allowed for more in-depth discussions, reflecting aspects of technology use that the interviewees themselves felt were important. The idea of a questionnaire for baseline understanding complemented by discussions to fully explore interviewees views, was used to gain a broader understanding on a multitude of viewpoints within the report scope. Pre-determined subjects included interviewees' uses of technological tools in wildlife management, different technologies' impact on wildlife management, interviewee perceptions of strengths and weaknesses in today's wildlife management and views on future wildlife management. The questions were designed to allow for a multitude of relevant discussion topics, rendering a broad platform for subsequent exploratory analysis. For detailed interview guide, see appendix 1.

Interviews were conducted from late September to early November 2021. Interview times varied between 45 minutes to one hour. All interviews were held on Zoom (Zoom 2021) and recorded using the Zoom recording function. The recordings were then transcribed verbatim using the Word Office 365 transcription function (Microsoft 365 2021). After transcription, all transcripts were proofread and compared to the recorded material.

2.5. Ethics

Complying with GDPR regulations ((EU) 2016/679 2016) and ethical aspects, all interviewees were sent a document informing them about the purpose and thematic focus of the interview, data handling, handling of personal information and their rights regarding interview material. Prior to the interviews, the interviewees all consented to this document. All interview data was stored anonymously, and all interviews are presented anonymously in the report as names of interviewees would not contribute to addressing the research questions, but could infringe interviewee privacy.

2.6. Analysis

Interview transcripts constitute the primary data in the analysis, supplemented by notes taken during the interviews. Initially, the analysis was exploratory to fully understand the material before being coded and further analysed (Taylor-Powell & Renner 2003; Verma et al. 2016; Lester et al. 2020). A thematic analysis approach enabled framing of analysis theme (Vaismoradi et al. 2013) and pragmatic coding of transcripts from the interviews. Thematic analysis is used as a way of identifying patterns and themes within the dataset. By using this approach with this dataset, I was able to focus on interesting findings within the data post-interview and identify themes after all interviews were conducted for a full understanding of the material,

instead of depending on a more detail-oriented approach that would have unduly narrowed down the analysis content and limited the analysis to details rather than giving a broader understanding. Using NVivo (QSR international 2021), the transcripts were imported in a database, sorted, and relevant parts within each transcript were coded based on content.

As part of the analytical process, a mind map was created to frame and connect themes brought up in the interviews. This mind map was used to structure and simplify themes and subjects for further analysis. In the figure: purple represents administrative subjects, dark blue represents management, analysis and presentation of data captured in monitoring, light blue represents subjects surrounding communication and coordination within and between organizations and other stakeholders, pink represents practical and theoretical implementation of technologies and methodologies within wildlife management, and yellow represents alternative camera trap uses.

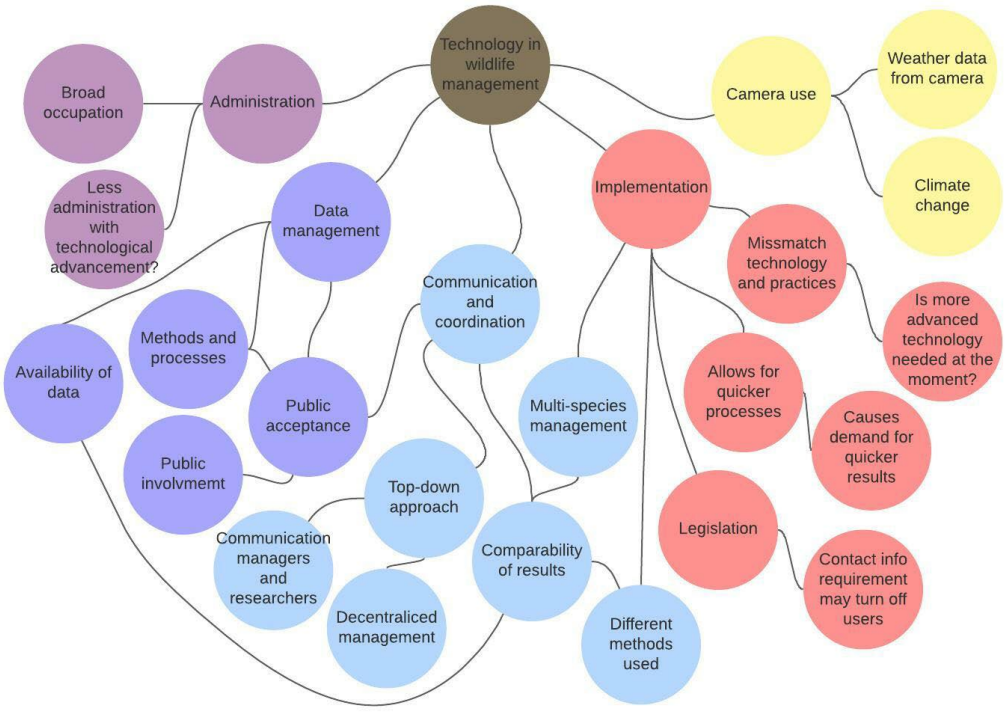

Figure 1. Conceptual mind map used in framing themes from interviews.

2.7. Coding categories

NVivo allowed for structured coding and analysis of the material. Transcripts were read through; topics and themes were identified based on content (Taylor-Powell & Renner 2003), and coding categories were created to capture and organise

this content. In total, I created 22 main coding categories including subcategories within the transcribed material (Table 2). Coding categories were defined to allow for analysis of all relevant aspects of the interview discussions. Some categories were defined prior to the interview relating directly to the research questions, categories such as "communication", "future wildlife management" and "implement technology" were directly defined pre-interview. Other categories emerged from the data, such as "data management" and "engage public". Some categories were deliberately broad to capture themes, whereas others were narrow to provide analysis with detailed viewpoints, opinions, and facts. The coding categories created that spanned broad categories such as "communication" allowed for a multitude of aspects, and thus an overarching understanding, as more specific codes such as "data management" captured detail-oriented issues.

Table 2 Coding categories with subcategories and explanations.

Coding categories	Subcategories	Content explanation: Coded text refers to…
Communication		Communication connected to wildlife management
Data management		Management of monitoring data for analysis
Effects of using camera traps	Negative, Positive	How camera traps have affected their users and wildlife management
Engage public		Effects of, and thoughts on, engagement of public in management practices
Future wildlife management		What does the interviewee think the future holds and what do they hope for?
Has technology affected their work?	Yes, No	How technology in general has affected their work and approach to wildlife management
Implement technology	Challenges	Statements regarding practical and theoretical implementation and its challenges
Methods		Methods used, and thoughts on future and past methods within wildlife management
Perceived mismatch	Yes, No	Mismatch between available technology and implementation in practice
Standardization		Standardization of methods and tools within wildlife management
Technology used	Camera traps, DNA analysis, Drones, GPS	Thoughts on technology used in the past, today and in the future

Lastly, themes and viewpoints from the interviews that were deemed to provide a greater insight into challenges in management practices were further investigated using existing scientific literature (Taylor-Powell & Renner 2003; Lester et al. 2020) and are presented in the Discussion section. Overall, the study identifies issues that require further research, future challenges, and other perspectives on the use of technology and camera traps in the Swedish wildlife management.

3. Results

The qualitative analysis of the interview data highlighted many important aspects of the role of camera traps in wildlife monitoring and adaptive management. In this results section, I organise the presentation of these findings according to three themes:

- Hopes and expectations in relation to camera trap use
- Obstacles, challenges and emerging opportunities
- The need for coordination and communication

3.1. Hopes and expectations in relation to camera trap use

3.1.1. Camera use

Key informants concurred that cameras were continuously getting cheaper and better, but that they were still not cheap enough to be used in abundance. They felt that the most efficient and economical way of using cameras was to use them more or less opportunistically. To use camera traps in grids required a lot of cameras and a lot of time to collect data for analysis. Instead, cameras were used where managers knew relevant wildlife was, based on previous knowledge, observations, and reports. Often, camera traps were used in combination with other means of monitoring such as DNA analysis and tracking.

> "And now we are investigating a change of methods to monitor carnivore species, from using snow tracking, towards using, for example, DNA supplemented by camera traps" – Free translation from Swedish, Interviewee 1[1]

County administrative boards, hunting teams and other actors differed in their procedures and expertise in efficient use of technology, in particular with camera traps, which were the most widely used technological tool. Neighbouring county administrative boards could have vastly different practices in using camera traps. While some had camera stations in small huts, others might use a more opportunistic approach where they put up traps in areas and along wildlife trails,

[1] All quotes are free translations from Swedish; see Table 1 for a list of interviewees.

where wildlife observations had recently been reported along with continuous evaluation of methodologies and tactics to further understand wildlife behaviour. Key informants reported that camera trap use and use of other technologies allowed them to expand their understanding of monitored wildlife. With camera trap data, both pictures and video sequences, managers could gain understanding in wildlife behaviour and biology. With this understanding, management and monitoring evolved, leading to great improvements, but also new challenges, as I will show in the following section.

3.1.2. New technology allows for quicker processes…

In the context of Swedish moose management, where quotas are mainly based on data from älgobs and previous hunting statistics (Jägareförbundet 2017) as well as supplementary methods, interviewees reported that truly factual quotas were only completed about one month after the yearly moose hunt started. Harvest quotas were up until then based on last year's harvest and on a general sense on whether the population had increased or decreased. This issue was identified not just for moose but for other wildlife in Sweden as well. Of those mentioning it in the interviews, all concurred that introduction of more efficient technology would lead to more efficient wildlife management and more precise estimates and results. They identified that this also introduced another issue: with the capacity to more quickly get data and process these data, a demand for quicker results emerged.

> "…there is an expectation from the public and media that we should have the knowledge, and we should have the data, preferably quickly." –Interviewee 6

3.1.3. … which causes demand for quicker results

Interviewees identified issues with pressure to produce results more quickly. From this, a problem emerged where they had tools to more efficiently produce better results, but they also were pressured to expedite the process. Time for reflection and consideration in management, monitoring and analysis processes were shortened. This led, paradoxically, to a risk for lesser quality results. Interviewees highlighted that not only the large predator population debate, but also the debates on moose and wild boar populations were becoming more polarized. Hunters, landowners, environmentalists among other stakeholders all had opinions on correct population sizes. With lesser quality results in management of these species in particular, polarization might increase.

3.2. Obstacles, challenges and emerging opportunities

3.2.1. A mismatch between technology and practices

With introduction of emerging and evolving technology, those involved in the implementation faced the challenge of calibrating introduced technology to current practices. A lot of current practices were based on data spanning a long time back to when monitoring began, for some species from the beginning of the 20th century. One interviewee described including data from camera traps in the current phase of technological transition as difficult as some methods in use or previously used had "barnsjukdomar" or "teething problems". Old methods and old data that could have biases from the beginning of data collection laid the foundation to some of the tools and methods used in management now. Calibration was sometimes needed in understanding new technologies in comparison to those already in use. This was identified as a main contributing factor to slowing down introduction and implementation of new technologies as well as new methodologies in wildlife management. Understanding of older methods in relation to emerging methods helped understanding and thus implementation of the new methods.

Issues in introduction and implementation also included communication between those working with development and those implementing these developments in practice. Interviewees emphasized that practical implementation, introduction of technologies and methodologies, and pushing development forward was mainly done on a personal interest basis. Those with a knack for, and interest in, technology within wildlife management were the ones identified as most likely to initiate research into new technologies and methodologies. With this, there was a concern for imbalance between management bodies. One county administrative board could have widely updated practices with up-to-date scientific methods and technologically advanced tools, while the neighbouring county administrative board might fall behind. Questions were raised regarding this phenomenon. If it was further pushing management evolution as no one wanted to be left behind. If the adaptive management framework worked in catching this. Or, if the rate of management evolution simply varied from county to county.

3.2.2. Is more advanced technology needed at the moment?

Interviewed managers found themselves trading off the purchase of many cheaper cameras against fewer, more expensive ones with more advanced features and better image quality. An issue some managers faced was that it was difficult to fully take advantage of the more expensive cameras because of limitations in expertise. Some reportedly had expensive cameras with functions like MMS, but could not use those functions properly as training lacked. They instead had these cameras as emergency cameras, not utilizing the cameras' full potential, but instead used cheaper cameras in day-to-day work.

Some key informants experienced difficulties in implementing technology and in identifying relevant technology for a specific application, such as MMS connected camera traps. They knew there were tools to solve a certain task or use a certain feature, but experienced lack in capability of finding the tools. Technological understanding varied, along with ability to implement unknown technology in their work and inability to find relevant technology. Some therefore questioned the need for new technology and methodology at the moment. Some found themselves in a situation where tools and information to efficiently use current technology were lacking. Meantime, some interviewees found themselves frustrated by the inertia in having their opinions on current and new technology heard. This frustration was connected to slow implementation speed of technological tools and methods. They could have suggestions for improvements or introduction of tools and methods but felt that the baseline knowledge was lacking, resulting in slower implementation.

3.2.3. Legislation

Interviewees all expressed various degrees of frustration regarding legislation surrounding the implementation of new technologies. They reported that hunters and hunting teams hesitated to use camera traps because they either thought it was illegal or because of the mandatory documentation needed on the camera trap. A camera trap has to have contact information including the name of the person placing the camera (see Section 1.4). Some interviewees had experiences of hunters not being willing to provide this, who were therefore not willing to set up camera traps. Interviewees suggested the use of the hunter-ID instead, as authorities had access to these databases, but the general public did not. The interviews found that this was an ongoing debate, but legislation was not keeping up in a satisfactory way.

As private individuals such as hunters reportedly felt, to some extent, discouraged to use camera traps, wildlife managers felt discouraged to use drones. Drones could be a good tool in getting an overview of an area, but managers had to apply for site-bound permits. Response time in urgent wildlife monitoring situations where, according to key informants, affected negatively by this. Monitoring was thus not maximizing its potential. In that instance, interviewees reported frustration in speed and efficiency in which legislation was updated to meet new demands.

To counter these effects that were slowing down the uptake and use of new technologies in wildlife monitoring, interviewees suggested adaptation with broader legislation definitions to allow new technologies to emerge. Legislation that could provide managers with the opportunity to try new technologies and methods as they emerged. At the same time, interviewees were conscious about ethical aspects that required caution and empirical grounds to new practice trials.

3.2.4. Acceptance of scientific results

Camera traps and other visually bound monitoring technology allowed for greater public acceptance in wildlife management and policy decision making. Interviewees felt that the ability to present visual data, whether it was a basis for complex analysis or not, helped in garnering public acceptance of management decisions. Interviewees stated that sometimes complex and intricate models and analysis processes were counterproductive when presented to the public. Instead, the simplicity of an image of the discussed wildlife in the discussed area or a lack thereof were a better means of communicating the grounds for management decisions. Interviewees reported visual confirmation increased their own, and their results', credibility in a time where public trust in scientific processes are questioned by some.

An issue brought up by one interviewee that may be harmful in terms of trust in science was how managers perceive research themselves, they may refrain from implementing research based on personal opinions on said research. It may have been because of personal agenda, misunderstanding, or according to the interviewee, a consequence of misinterpretation of data based on research method. If the research was not conducted in an area with similar environment, or with prerequisites different from where the manager intended to implement the knowledge, the interviewee had experienced situations where the research was not further considered based on this.

3.2.5. Public involvement

By involving members of the public in citizen science and, for example, hunting team engagement in camera trap placement and data gathering, managers reported that public acceptance of monitoring and analysis results increased. With involvement and insight in processes behind management decisions, understanding and acceptance was greater. Excluding advanced mathematical analysis and similar steps in the process where demands on deeper knowledge were high for proper understanding, involvement throughout other steps in the monitoring and analysis process was seen as positive by those interviewees that had tried these methods of increasing public acceptance. In the case of camera traps, public, such as hunters and hunting teams was sometimes needed in reporting sightings and assisting in field work.

Often, interviewees had experienced resistance from hunting teams that were solely based on a fear of technology. Teams and individual hunters who couldn't properly use camera traps refused to work with them. It was not until after consultation they were open to using technological aids. Interviewees had experienced the positive influence a single hunting team member could have on persuading others in the team to explore technological tools.

3.3. Need for coordination and communication

3.3.1. Availability of data

Camera traps can produce large amounts of data. Processing and storage of these data were two main issues identified facing wildlife managers using camera traps. Data needed to be processed and sorted for relevant implementation and analysis. Interviewees had experienced data collection from camera traps with ten thousand pictures on a camera trap within a week in the field. Monitoring may have been focused on one species, but the obtained data could inevitably contain other species, solar flares, leaves, people, etcetera. Many interviewees mentioned artificial intelligence as a possible tool in data management. At the same time, some considered it almost impossible to implement in practice. The main problems they identified in practical implementation of artificial intelligence was finding a developer for it, and coordination of data management. Communicating what data one possessed and what data one needed, and coordinating this information.

Many interviewees saw the possibility to share data as crucial, but some also identified the issue of stakeholders holding on to data. The interviewee mentioning it had experienced this both themselves and seen other managers holding on to data. With time and resources invested in a dataset, one could be hesitant in giving it away. Communicating incentives with management benefits for all stakeholders included, as well as management and monitoring tool improvement by those developing these, was proposed to help in countering this issue.

A majority of the interviewees saw the need for coordinated data management but some of them were hesitant about its practical implementation. Arguments that cloud-based services and database storage would be expensive and questions on who would manage it were raised. One interviewee actively worked within a project developing a database service with artificial intelligence to store and sort data from camera traps. Another interviewee, employed at the same organisation, had never heard of the project, and doubted that a project like this would even be possible. Communication in the organization was lacking, even with both being employed high up in their respective field within the organization.

3.3.2. Top-down approach

Communication requires coordination of information in order to support adaptive management practice (Hallgren & Westberg 2015). With regard to the national-level coordination of wildlife management, opinions varied. Interviewees with networks of contact spanning the whole chain, from technology and method

developers to hands-on managers, expressed less interest in developing further nationwide management coordination, as they thought coordination was already sufficient. By contrast, interviewees with smaller networks tended to lean more towards the need for more extensive coordination, as they thought current coordination was lacking. However, interviewees with larger networks of contact identified a need for some type of nationwide coordination to establish baseline knowledge. One interviewee compared the nationwide coordination with a jigsaw puzzle: coordinating who has relevant pieces of information, data, or knowledge and where these fit together.

Issues identified that linked to coordination were primarily related to the challenges of using data from multiple sources: Questions were raised by interviewees on how data from different county administrative boards, private sector, and other actors could be used in the same analysis and how experience and knowledge on data management, analysis, methodology and monitoring could be shared. With different environmental and wildlife conditions within managers' respective administrative areas, managers expressed the need to adapt management practices, and with this, adapt collected data for their specific areas management demands. These differences in practices and data obtained required different analytical approaches and data was not always compatible to others' needs and/or practices.

Interviewees concurred that all stakeholders had different prerequisites and needs within their respective wildlife management contexts. Experimentation on local and regional scales was needed to develop efficient, innovative means of management. However, the subsequent steps - the exchange of information, insight into development projects, and general overview - needed improvement. One interviewee said that this did not need to be coordinated through a central governing authority, this could be workshops, forums, or other contexts. By contrast, many pointed out SEPA as responsible for coordination.

3.3.3. Communication managers/managers and managers/researchers

When asking about communication amongst those involved within wildlife management, a gap appeared between interviewees: some reported excellent communication while some reported deeply flawed communication between the scientific community and wildlife managers, and among wildlife managers. A few reckoned communications may have been present in other layers of management but could not specify further. One interviewee said this lack in communication might have been the effect of the county administrative boards having a wide range of tasks at hand with managers responsible for multiple departments. Superiors therefore needed overarching knowledge in a multitude of fields, which was identified as part of the communication issue.

Wildlife managers tended to have superiors without wildlife management background in some cases. Coordination and communication with other stakeholders and management decisions often had to go through these individuals who might be lacking an appropriate level of understanding of wildlife management. This was identified as a source of frustration at times.

Interviewees stating that communication practices were functional mentioned personal interest for scientific innovation as a driver in communication involvement. Split opinions were identified regarding communications not being common practice but based on personal interest and initiative, some mentioned communications initiatives being established as a result of personal interest rather than being promoted by the governance framework. With the introduction of more ecosystem based, multi species management within the adaptive management, interviewees expressed increased demands on communication and coordination within the governance framework.

4. Discussion

4.1. Communication and coordination

Throughout the interviewing process and analysis, it became apparent that the main issue in the technological and methodological implementation in Swedish wildlife management lay within communication and coordination. All issues brought up by the interviewees, except for technical details, could be linked to problems in, or a lack of, efficient communication and higher instance coordination.

Knowledge and experience are both vital in maintaining functional adaptive management (Williams 2011; Hallgren & Westberg 2015). Without a constant flow of new learnings and understandings, adaptive management will no longer be adaptive (Williams 2011). With a changing climate, human impact on ecosystems at all levels and other possible changes in nature, we need effective? communication practices to handle wildlife management ethically and efficiently (Marmorek et al. 2019).

My analysis suggests that the transfer to a more top-down oriented approach in management could allow for easier communication through established chains of command and more efficient coordination with greater overview. Centralized governance also allows for ease in close communication with the scientific community and ease in implementing new technologies and practices through established communication channels. Close relations with the scientific community give managers up to date knowledge (Naturvårdsverket 2015). In current management, national governance is based on current knowledge, but as the interviews found, many local and regional communication channels are instituted on personal initiative.

These informal, or sometimes formal, communication processes provide vital tools for managers based on the latest scientific knowledge. However, managers might also deliberately choose not to use research findings, as the example of section 3.2.4 shows. This is problematic if widely spread within wildlife management, but one should also see the possibility of it being a singular occurrence. However, my research approach did not allow for any conclusion on this subject.

Public acceptance of scientific results is currently a hot debate. Anti-vaccine and climate change denial movements are widespread (Weisberg et al. 2021). With a constant media flow of varying journalistic quality, many members of the public choose to connect factual truths and personal viewpoints when evaluating research, and not contemplate evidence-based, source-critical arguments. A lot of the misinformation is founded in laypeople's difficulty in understanding intricate and complex scientific methods (Achterberg et al. 2017). Wildlife management is no different. Complex methods and mathematical and statistical analyses may be difficult to interpret and accept without proper fundamental knowledge. Interviewees found that public acceptance of camera trap data analysis varied, as with many other scientific tools, although they found camera traps helpful in that they could present concrete visual evidence. A picture of an animal is difficult to argue against and was in some cases more effective in convincing the public to trust the results.

Some interviewees also worked close to hunters or hunting teams, and within citizen science projects. They unanimously reported that having members of the public involved in the processes increased acceptance. Complex mathematical and statistical models may not be understood but with a greater involvement in providing the data, acceptance of these increased.

Camera traps are mainly used in carnivore management today (NFS 2007:10 2007; Proposition 2008/09:210 2009; Naturvårdsverket 2015, n.d.a). Debates on carnivore population sizes and carnivore management are some of the most, if not the most polarizing in Swedish wildlife management (Hallgren & Westberg 2015; Dalerum et al. 2020; Bergheden 2021; Nilsson 2021). Therefore, extra precautions are needed to not further negatively affect the debate climate. As per my analysis, inclusion of members of the public in scientific processes of monitoring and management could help in acceptance of scientific results and arguments, but the carnivore debate may need further measures of depolarization. These issues may be greater than just human-wildlife coexistence conflicts, they are often deeply rooted in socio-political conflicts (Madden 2004). An approach where stakeholders may participate in practical management could help in increasing awareness and understanding of the carnivorous species. Based on the interview findings, one could thus argue that to see other stakeholders than those directly involved in the official management apparatus as part of the management could help wildlife managers, legislators and others involved to spread awareness and understanding of these species, thereby calming the debate. Inclusion of hunters, environmentalists, livestock owners and other stakeholders in workshops, forums and practical management could be a step in depolarizing the debate and providing those involved in wildlife management with vital insight into the debate, and a way of steering the debate in a constructive direction based on scientific evidence.

4.2. Transformation stages in adaptive management implementation

When implementing a new management or policy process, (Rijke et al. 2013) identifies three transformation stages. Although these stages are identified in urban water management governance, the authors argue for their applicability in a multitude of management and policy contexts. Based on this, we could expect similar process stages in the adoption of adaptive management as an approach to wildlife management, making the stages applicable in these wildlife management scenarios as well. Early transformation stages are identified by exploration of new technologies and processes. Informal networks, decentralised governance and other approaches allow for exploration and development, but centralised governance may enhance innovation detection and implementation to further stimulate coordination:

> "Experimentation, learning and network formation are playing an important role during these early stages of system transformation, because these activities generate the trust in new technologies and collaborations." - (Rijke *et al.*, 2013 p. 68).

(Rijke et al. 2013) further label this stage as the take-off stage. Mid transformation stages are described by (Rijke et al. 2013) as acceleration stages. Here, knowledge, experiences, methods, and technologies are distributed through informal networks. The key here is distribution of information to streamline information and technology resource use. Late transformation stages foremost establish and evolve frameworks for centralised, formal governance to develop and coordinate further adoption of new innovations (Rijke et al. 2013).

In order to fully make use of this conceptual framework, one first needs to identify at what transformation stage in the process they lie: In what implementation phase are we in the adoption of adaptive management, and what is the role of new technologies for monitoring wildlife in this process? Based on the small sample, a complete answer on this question is out of the scope of this report, but the analysis can give us an idea on where in the process we lie. Early transformation stages are defined by exploration of new technologies and processes. Mid transformation stages are defined by communication of information and coordination of information distribution. Based on the interviews, we can assume that are somewhere in the early stages in the transformation process, as grassroots innovation and exploration defines the present, but communication and coordination are still evolving. With this, it is not necessarily helpful to implement top-down coordination on the use of camera trap technologies, as that might unnecessarily constrain the exploration and evolution in ways of using these technologies. Some interviewees expressed a direct need for centralized governance as some saw a need to further governance evolution within the decentralized management approach.

Communication will only strengthen adaptive management if employed correctly. The way new viewpoints from stakeholders are treated and responded to is difficult to govern, but in what way they can be heard is governable.

(Hallgren and Westberg, 2015 p. 166) state

> "…how initiatives to present alternative perspectives are treated through social interaction, and to what extent actors understand and are able to investigate the meaning of disagreements and perspective differences. An agonistic approach to adaptive management would imply that, for an NRM [natural resource management] process to qualify as adaptive, it should include recognition of disagreements and investigation of differences in perspectives.".

Here, they express the need for all parts of the adaptive management communication chain to be heard. Some interviewees expressed frustration in communication within their respective organizations and between organizations. My analysis suggests that we need to see, and act on, improvement potential in informal communication networks and decentralized governance to allow for proper communication and thus, evolution of the adaptive management (Rijke et al. 2013). Forums and contexts in which to allow for this evolution are vital in cultivating a healthy adaptive management approach and practice.

4.3. Centralized governance

When reaching the last transformation stage, stabilization, (Rijke et al. 2013) argue for centralized and formal governance. Focus here lies on establishing a status quo, with a functional adaptive governance framework in place and efficient legislation. Centralization may be more easily governed with an established chain of command and clear communication channels, but I argue for one risking counterproductive effects in adaptive management evolution, while striving for remained status quo in governance, grassroots, bottom-up innovation might be lost. Adaptive management relies on bottom-up innovation functions (Williams 2011). If these are not properly cared for, the trust in adaptive governance risks undermining. In transition from decentralized to centralized governance, one might risk implementing a not fully matured governance framework. This could lead to opposition and distrust in the governance and wildlife management apparatus if not treated carefully.

Based on the interview findings, one could thus argue for the importance for both managers and legislators to see the flexibility and adaptability in decentralized governance. Decentralized, informal governance enables managers to fully adapt management practices to local and regional prerequisites, something that may be necessary in a varied landscape with uncertainties in what the future may hold (Marmorek et al. 2019). Grassroots development and implementation of methods and practices may provide versatile uses of tools already in use. To ensure efficient engagement one needs the right channels for these tools to be revised for potential standardization in nationwide, or regional management practice. Coordination must

work efficiently in all directions within wildlife management: across organizations as well as through communication channels within organizations. Centralization may provide these functions if carefully managed (Cummings 1995). Use of forums, workshops and proper communication channels for innovation is key to obtain these functions within centralized adaptive management governance. The local and regional management innovatory approach within decentralized management can support adaptive management evolution, but a centralized organization handling communication and coordination of innovation is needed to implement these innovations in the rest of the management for further management evolution.

4.4. Future research

To widen insight into implementation of tools and practices within wildlife management and to further analyse implementation and caring of adaptive management, one could broaden the spectrum of interview subjects. Analysis of opinions and perceptions of policy makers, researchers, hunters, and other involved stakeholders would give an overview that may give further insight and answers to additional questions to those asked within this report.

Some interviewees expressed frustration in legislative restrictions in wildlife management evolution. They expressed that new or improved methods and tools were sometimes not implementable within management because of outdated legislation, or legislation not formulated for current technological and methodological evolution of wildlife management practices and tools. Based on this, future research into legislation formulation to allow for wildlife management evolution, within ethical limits, is needed. Adaptive management is dependent on evolution and exploration, legislation must allow for this in order to fully take advantage of the adaptive management approach in wildlife management.

4.5. Methodological reflection

The type of qualitative analysis used in this report is not commonly used in wildlife management research. To fully grasp the content of the analysis, one needs to see it for what it is; an insight into current issues surrounding challenges in wildlife management, as seen by wildlife managers. It requires an open mind by both reader and writer.

Coding categories were defined before and during analysis, as to obtain proper understanding of the material before final analysis of the coded material. A general idea of the research focus was defined before conducting the interviews with the goal of helping define report focus post hoc (Taylor-Powell & Renner 2003). This

would allow previously unknown subjects and themes to be included in the analysis as to not restrict the report with a narrow thesis. In defining coding categories, focus lied in establishing a balance in specificity and to strive for obvious categories easily defined by other readers of the material. Comparability of results may be seen as problematic in qualitative analysis by those not familiar with it. But as (Coffey and Atkinson, 1996 p. 2) state

> "…there is no single right way to analyse qualitative data; equally, it is essential to find ways of using the data to think with".

Qualitative data is, in this report, used to invoke discussion and reflection.

We must see the sample for what it is, and what the purpose of the analysis is; a small, not random, not representative sample with relevant experience and insight to provide constructive discussion. More interviews with a broader array of stakeholders could give a more nuanced view on wildlife management as a whole, but within the scope of this analysis, focus lies in implementation of management practices and tools. The analysis is qualitative, and the purpose of the interviews is to provide insight and reflect (Coffey & Atkinson 1996; Lester et al. 2020) on the current state of Swedish wildlife management to prepare for tomorrow.

4.6. Conclusion

All interviewed stakeholders worked with camera traps or camera trap data in some way. They all saw benefits in introduction of new technologies and methodologies within wildlife management, but also expressed certain areas with deficiencies. All main issues brought up was directly or indirectly linked to communication and coordination amongst wildlife management practice stakeholders, the scientific community, legislators and public. With efficient communication and coordination within the adaptive management framework, use of, and evolution of camera traps and other management and monitoring technologies were seen as vital tools in maintaining functional wildlife management.

Adaptive management is dependent on constant trial and error, and the management framework need to allow for this. Efficient use of bottom-up innovation with centralized coordination for communication of information is key. (Hallgren and Westberg, 2015 p. 173) describe adaptive management as "shared learning". One should put emphasis on "shared" in this statement. Sharing is vital in maintaining a functional adaptive wildlife management practice. Without sharing of knowledge and experience, adaptive management will not evolve as necessary. Adaptive management requires efficient communications with continuous trial and error evaluation (Hallgren & Westberg 2015). As a majority of interview subjects expressed some degree of criticism towards today's communication and

coordination in Swedish wildlife management this is a current issue that may affect future management if not attended to.

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Appendix 1

Intervjufrågor

1. Vad har du för arbetsuppgifter?
    i. När började du på din nuvarande arbetsplats?
    ii. Vad har du för bakgrund inom viltförvaltning?

2. Vad använder du för teknologi kopplat till viltförvaltning i ditt arbete?
    i. Har teknologin påverkat viltförvaltningen i ditt yrke?
    ii. Hur tycker du att det fungerar?
    iii. Vad ser du som fördelar och nackdelar med viltkameror?

3. Hur har det varit innan?
    i. Upplever du att kapaciteten för viltförvaltningen har förändrats med teknologi? I så fall, hur?

4. Hur ser du på framtiden för teknologi inom viltförvaltningen?
    i. I relation till adaptiv förvaltning?
    ii. Hur ser du att teknologin i viltförvaltning kommer att utvecklas?
    iii. Vad hade du velat se för förändring för att möjliggöra användandet av ny teknologi?
    iv. Hade du velat se en förändring för att effektivisera användandet av befintlig teknologi i viltförvaltning?
    v. Vad behöver ni för data från viltkamerorna?
    vi. Får ni den data ni behöver?
    vii. Kan ni få den från viltkameror?
    viii. Standardisering? Många opportunistiskt uppsatta kameror idag

5. Upplever du att det finns ett glapp (mismatch/gap) mellan viltförvaltning i praktiken och tillgänglig teknologi? (om nej => varför? Diskussion)
    i. Hur upplever du detta?
    ii. Vad kan göras åt detta?

iii. Hur tror du att detta påverkar viltförvaltningen?
iv. Hur tror du att den adaptiva viltförvaltningen påverkas av detta?

6. Hur tror du att teknologin kommer förändra viltförvaltningen över ett större tidsperspektiv?
    i. Hur tror du att vår relation till viltet kommer att påverkas med mer kontorsbaserad förvaltning?
    ii. Involvering av allmänheten i datainsamling