**Balancing Stakeholder Interests**

**for Sustainable Wolf Management in Sweden**

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**Abstract**

Historical records estimate there were over one thousand wolves in Sweden; however, the population almost went extinct by the mid-20th century, largely due to hunting. After the implementation of the Hunting Act (jaktlagen) in 1966, the wolf population has gradually recovered to a current level of about 355 individuals. This recent increase in the wolf population has evoked a serious divide in the Swedish society between “pro-wolf” stakeholders and “anti-wolf” stakeholders with literally every citizen belonging to one of the two camps. As the responsible sector for wildlife management, the Swedish Environmental Protection Agency has struggled with ways to find a viable and acceptable size of the wolf population in Sweden, but there is still no consensus. In this paper, we reveal five main stakeholder groups in what concerns the wolf population in Sweden: 1) environmentalists, 2) urbanites, 3) hunters, 4) livestock owners, and 5) reindeer herders. We describe their attitudes about the desired wolf population, distill eleven major interests regarding the corresponding environmental, economic, and social issues, and propose a framework to integrate those attitudes. The relationship between the attitudes, the interests, and the wolf population size can be formalized by a mathematical model using *satisfaction functions.* We argue that this framework can be a helpful tool to understand the relationships between stakeholder interests and their attitudes towards the wolf population in Sweden and to de-emotionalize and organize the respective policy dialogue.

**Key words**

wolf population, conservation, wildlife management, stakeholder conflict, satisfaction function, consensus solution

**1. Introduction**

The wolf population in Sweden was estimated to be approximately 1,500 individuals around 180 years ago (Sjölander-Lindqvist, 2011). By the 1960’s, wolves almost went extinct in Sweden. Following the implementation of the Hunting Act (jaktlagen) in 1966, the wolf was protected and its population has gradually recovered to a current level of about 355 individuals (Naturvårdsverket, 2017). During the last four decades, the reappearance of wolves has induced a series of social problems and severe debates in society (Ednarsson, 2006; Ericsson & Heberlein, 2003; Eriksson, 2013; Karlsson & Sjöström; Rogers, 2014; 2007; Stohr & Coimbra, 2013). In 2009, the Swedish Government approved 27 wolves to be culled in a licensed hunt in early 2010 (Arnbom, 2011). This decision triggered an outburst of social debate on the wolf issue. While more than 6,700 hunters joined the wolf culling, more than 7,600 people protested against the licensed hunt and signed a petition to the European Union to stop it (Schiller, 2011). In a nutshell, the question of the Swedish wolf population has polarized the country into two camps (Eriksson, 2016), one primarily concerned with biodiversity and environmental protection (Sjölander-Lindqvist, 2011), and another one claiming to defend local lifestyles and livelihoods, which are put at risk because of wolves spreading (Sjölander-Lindqvist, 2011; Sjölander-Lindqvist and Cinque, 2014).

The impact of wolves on the Swedish environment, economy, and society are multi-fold. *Environmentally*, as a top predator, wolves are regarded as an important part of a healthy ecosystem with a rich biodiversity. In their absence, the population of other species, such as deer and moose, raise unchecked, which then has cascading effects on the ecosystem (add the ref. and talk about the controversy). Furthermore, humans have an affinity toward nature as expressed in the concept of *biophilia* (Wilson, 1984, Kellert, et. al., 1995); and, the presence of wolves represents that whole, untamed, and natural system. *Economically*, wolves prey on both large and small wild animals, including deer and moose, which are also hunted by humans (Kojola et al. 2004; Viltskadecenter, 2014). Hence, in a simplified view of the ecological relations, wolves are seen as direct competitors with hunters for game animals. In addition, wolves may prey on livestock and reindeer, and may hurt and kill hunting dogs, causing economic loss to hunters, livestock owners, and reindeer herders. Besides the direct costs the wolves cause, Swedish taxpayers are also concerned with the opportunity costs of the tax revenue used to finance the protection measures against wolves, such as electronic fencing, compensation to livestock owners and reindeer herders for their loss of livestock and reindeers attacked by wolves, as well as other measures the Swedish Government takes to alleviate the negative effects of wolves in Swedes. If not used for the wolf management, then these resources could be used in other sectors of the society, for example, for education or public health. On the other hand, wolves may become an attractive factor for ecotourism, which might bring revenue to rural areas. *Socially*, hunters, livestock owners, and reindeer herders argue that their traditional activity, including recreation, lifestyle, and social bond and identity, can be harmed by wolves, and hence the entire rural culture could be threatened (Sjölander-Lindqvist, ‎2011). Hunting is a traditional activity in Sweden, not only for getting food from the game, but also for entertainment. Through hunting, hunter communities establish and uphold social relationships and networks. Most reindeer herders are Samis. Samis have been herding reindeers for about two hundred years in the north of Sweden. Despite that a large fraction of the Sami population now lives in cities and have other occupations, the preservation of the traditional Sami culture is considered to depend on the preservation of reindeer herding.

Previous studies on the wolf issue in relation to stakeholders in Sweden have touched upon a broad span of perspectives. Some studied people’s positive and negative attitudes regarding the wolf population (Frank et al., 2015; Gangaas et al. 2015; Heberlein & Ericsson, 2008; Karlsson & Sjostrom, 2007). Sjögren-Gulve and Hörnell-Willebrand (2015) studied the ecological condition wolves need to survive and thrive within the natural and social limitation of rural areas. Some studied the communication and deliberation between the stakeholders and the decision makers, and gave suggestions from a communicative and political perspective (von Essen, 2016; von Essen, & Allen, 2015; von Essen et al., 2015). Some pointed at the entangled complexity of culture, history, politics, and ethics underneath the issue and the deficiency of decision makers to sufficiently address these aspects in the conflicts (Sjölander-Lindqvist, 2008; Sjölander-Lindqvist & Cinque, 2014; Sjölander-Lindqvist et al., 2015; Eriksson, 2017). Some researched into the economic impact, which wolves caused to people affected (Naughton-Treves et al., 2003; Nyhus et al., 2003; Treves et al., 2009).

However, none of these studies has developed a systematic framework that would take into account ecologic, economic and social perspectives at the same time. The absence of a systematic framework hinders people involved in the conflict to see the entire picture with all perspectives being considered simultaneously. Moreover, since the question of an optimal wolf population in Sweden touches upon people’s feelings and beliefs, it has become an emotional, rather than a rational issue (Jordan, 2015).

To tackle the complexity of this issue with conflicting interests and to inform sustainable wolf management, integrated modeling and analysis is needed (Peter & Swilling, 2014). Integrated modelling is an over-arching way of thinking within which other research approaches can fit (Loorbach & Rotmans, 2006). Moreover, the modelling framework can facilitate the emergence of a “shared understanding” of the complexities of the issue, enable participation (Voinov & Bousquet, 2010; Wiek et al., 2012), and help decision makers negotiate multiple facets of the problem.

The main purpose of this study is to structure the discussion on the wolf population size in Sweden by bringing together the viewpoints of different stakeholder groups into a comprehensive and formalized preference modeling framework. This framework is used to gauge the level of disagreement between stakeholder groups and to map the range of solutions within which the compromise is to be found. The framework is intended to enhance the understanding of relationships between different aspects of the wolf problem and balance different interests.

Lastly, we argue that the approach presented here for the case study of wolves in Sweden can also be used for other wildlife management problems where conflicting stakeholder interests need to be recognized and reconciled.

**2. Stakeholders, their attitudes and interests**

We undertook an extensive literature review to find the concerns of the main stakeholder groups touched by the wolf population in Sweden. We used the literature review to pinpoint the stakeholders’ interests on and attitudes towards the wolves. We also we carried out interviews with some representatives of the identified stakeholder groups. The interviewees included (how many?) representatives from environmental nongovernmental organizations, hunting organizations, farmers with livestock, Samis with reindeers, and natural and social scientists who are working on this issue in Sweden. The questions for interviews are mainly about the attitudes towards wolf population in Sweden and the concerns and interests relating to the wolf population.(make an appendix of the questions)

**2.1 Classification of stakeholders**

Previous studies have identified key stakeholder groups in the context of the wolf population management all around the world with an emphasis on Europe and America. People living in urban areas, not owning livestock or reindeer, and who are not hunters, have been categorized as the *general public* (Dressel et al., 2015), *urban public* (Williams et al., 2002), *urbanites* (Heberlein & Ericsson, 2005), or *urban residents* (Bruskotter et al., 2007). People associated with organizations that advocate wolf reintroduction, have been categorized as *conservationists* (Bisi et al., 2010; Dressel et al., 2015; Johansson & Karlsson, 2011; Rogers, 2014), *conservation groups* (Stohr & Coimbra, 2013), *environmentalists* (Sjölander-Lindqvist, 2011), or even *ecowarriors* (Sjölander-Lindqvist et al., 2015).

People practicing hunting activities are usually categorized as *hunters, with* or *without dogs*, or simply just *hunters* (Dressel et al., 2015; Johansson & Karlsson, 2011; Sjölander-Lindqvist, 2011; Sjölander-Lindqvist et al., ‎2015; Stohr & Coimbra, 2013; Williams et al., 2002). People owning livestock and living in rural areas are categorized as *farmers* (Dressel et al., 2015; Johansson & Karlsson, 2011; Sjölander-Lindqvist, 2011; Sjölander-Lindqvist, ‎2014; Williams et al., 2002), or *farm animal owners* (Stohr & Coimbra, 2013). People involved in reindeer herding in northern Sweden are often loosely described as *Sami* *people*, or just *Samis* (Rogers, 2014; Sjölander-Lindqvist et al., 2015), although nowadays most Samis are not reindeer herders.

The stakeholder classification above is a convenient way to identify a minimal representative number of stakeholder groups in the Swedish society, without compromising the diversity of viewpoints. After a thorough literature analysis and the discussion with a number of experts and stakeholders, in this paper we have decided to use the following five stakeholder groups: 1) *environmentalists, 2) urbanites, 3) hunters, 4) livestock owners,* and *reindeer herders* (Table 1). Furthermore, urbanites and environmentalists having mostly positive attitudes to wolves are further aggregated into a “pro-wolf” stakeholder group, while hunters, livestock owners and reindeer herders having generally negative attitudes towards wolves are aggregated into an “anti-wolf” stakeholder group. Some individuals with neutral attitudes also exist in these groups. However, we set our study boundary to only include the stakeholders who are in conflicts with others in this issue. So the categorization of “pro-wolf” and “anti-wolf” reflects quite well the polarization in the Swedish society (von Essen & Hansen, 2015).

Table 1. Swedish stakeholder classification used in this study

|  |  |  |
| --- | --- | --- |
| **Stakeholder** | **Definition** | **Attitude towards wolves** |
| Environmentalists | People from organizations, which advocate wolf reintroduction | Strongly positive (pro-wolf) |
| Urbanites | People living in urban areas, not owning livestock or reindeer, and not hunters | Generally positive (pro-wolf) |
| Hunters | People practicing hunting activities | Strongly negative (anti-wolf) |
| Livestock owners | People owning livestock and living in rural areas | Negative (anti-wolf) |
| Reindeer herders | People involved in reindeer herding in northern Sweden (mostly Samis) | Strongly negative (anti-wolf) |

**2.2 Stakeholders’ attitudes towards wolves**

The Swedish environmentalists, in general, are strong advocates to increase the number of wolves, mainly because they think that wolves are vital for a healthy ecosystem, have their own right to exist, and simply that they are wonderful animals that need to be preserved in the country for future generations (Castle, 2015; Price, 2013). They have launched various social movements to promote the wolf reintroductionpopulation recovery (check the ref.). In particular, they protest against the licensed hunting of wolves when the licensed hunting is being discussed(The Local, 2014change the ref.). Most urbanites are either neutral or positive towards wolves, for similar reason as environmentalists.

People in rural areas, in particular in areas inhabited by wolves, are in general more negative (Christopher et al., 2002; Ericsson & Heberlein, 2002; Ericsson, 2004). Livestock (primarily sheep) owners and hunters are typically most negative toward wolves (Dressel et al., 2015; Røskaft et al. 2007). Hunters claim that wolves compete with them for prey, reducing the amount of game animals, and wolves may also kill hunting dogs, often seen as family members (Rogers, 2014). Livestock owners claim that wolves hurt their livestock (Creel & Christianson, 2007; Muhly et al., 2010). Since the 1970s, Swedish livestock owners have been receiving a compensation from the government for economic losses caused by wolves (Bostedt & Grahn, 2008). However, the compensation is always considered insufficient. Reindeer herders, mainly Samis in the north of Sweden, rely on herding reindeer to maintain their lifestyle and to preserve their herding culture. Wolves attacking reindeer scatter them over a large area, causing troubles for reindeer herders (Rogers, 2014).

In general, attitudes of stakeholders towards wolves are influenced by several factors. Because this paper studies the sustainable management of wolves, we want to classify the factors by three categories indicating the three pillars of sustainable development. The factors in each category are listed according to the frequency with which they appear in our literature study and the importance of their influence on the attitudes perceived by stakeholders and the experts in the interview. The *first category* of attitudes is *based on environmental concern, which involves knowledge and views on biodiversity and ecological sciences.* The factors affecting this attitude include education (Ericsson et al., 2004; Johansson et al., 2012; Karlsson, 1999), age and cultural background (Ericsson et al., 2004; Rogers, 2014), direct experience (Johansson et al. 2012; Karlsson, 1999), media, different worldviews and social ideology (Sjölander-Lindqvist, 2008; Herlitz & Peterson, 2011), protection campaigns (Majić and Bath, 2010), information programs (Frank et al., 2015; Nyhus et al. 2003; Røskaft et al. 2003; Treves and Karanth 2003), and dialogues and communication (Hallgren & Westberg, 2015; von Essen & Allen, 2015).

The *second category* of attitudes is based on *economic considerations*. The main factors affecting this attitude are the proximity to the territory inhabited by wolves (Broberg & Brännlund, 2007; Ericsson et al., 2008; Heberlein & Ericsson, 2008), experienced economic losses (Bostedt, 1999), owning a hunting dog (Rogers, 2014), the increasing wolf abundance (Dressel et al., 2015; Treves et al, 2013; Williams et al., 2002), the increasing number of attacked animals (Rogers, 2014), policies such as compensation, licensed hunting, and subsidized fencing (Williams et al., 2002).

The *third category* of attitudes is *based on social concern*. The main factors affecting this type of attitudes include the belonging to a certain social group (Eriksson, 2016; von Essen & Allen, 2015; Naughton-Treves et al., 2003), policies on wolf management (Williams et al., 2002), societal trends or the generational value shift (Inglehart 1995), urbanization and decreasing employment in agriculture, which trigger some complain in the rural area about the sacrifice of rurality for urbanization (Bisi et al. 2007; Røskaft et al. 2007).

The attitudes categorized above indicate their interests related to the wolf population. We assume that the attitudes towards wolves are driven by the interests involved in the issue. Thus, we can make an analytical framework to describe the relation between the attitudes and the interests, and using this framework find a balance of the interests and hopefully can improve the understanding of the situation.

**3** **Mathematical formalization**

In this section, we suggested relevant components of a satisfaction function for each stakeholder group with respect to the number of wolves. Next, we aggregated these components into a single satisfaction function for each stakeholder group, based on weights assigned to each component, which is different for each stakeholder group. Then we analyzed feasible wolf population size using the constructed satisfaction functions, delivering the same satisfaction to all stakeholders and analyzed its sensitivity with respect to model parameters.

**3.1 Partial Satisfaction functions**

We designed functions to describe the satisfaction level regarding the wolf population in Sweden. These satisfaction functions are similar to utility functions, which are broadly used for economic analyses. Utility functions have been used to study conflicting interests between different stakeholders in fisheries management (Dankel et al., 2007), water (Randhir & Shriver, 2009), carbon storage, timber production and biodiversity in northern hardwood forests (Schwenk et al., 2012), horseshoe crab harvest (McGowan et al., 2015), food production systems (King et al., 2015). In economics, utility is a measure of the satisfaction or happiness people get from goods or services. Parada Daza (2004) designed a new utility function called *emotional well-being function,* which considers economic, instinctive, social, religious, ethical, and esthetic values. In this paper, we propose use another variation of utility functions, designed to reflect attitude, which we refer to as *satisfaction functions*.

We think that the satisfaction levels are tightly linked to the attitudes. *Attitude* is defined as an individual’s psychological tendency to evaluate a particular objective as favorable or unfavorable, and consisting of cognitive, affective, and conative components (Ajzen & Fishbein 2005; Dressel et al., 2015; Eagly and Chaiken, 1993). A certain attitude may not lead to a certain behavior, but it can be a factor of rational and irrational judgment towards current policies. In this study, we assume that the stakeholders may build their attitudes upon their interests on the presence of wolves in the environment. A satisfaction level can reveal how well our attitudes fit with reality and how successful certain policies meet the requirements of the stakeholders, thus also making itself a pointer in the direction of future policy making.

The satisfaction level is arbitrarily set between 0 and 1 as natural bound for simplicity (1 meaning full satisfaction in which case further improvements have no effect on stakeholder’s happiness). Other intervals could also be used, although it would not change the overall results.

In Table 2 we propose curves[[1]](#footnote-1) with which we approximate the relations between the satisfaction level of one (or more) stakeholder group(s) regarding certain aspects of the problem and the number of wolves in the environment. The choice of these curves was guided by the satisfaction of stakeholder groups at benchmark values of wolfs population size (absence of wolves, carrying capacity, Favorable Reference Population[[2]](#footnote-2)). These benchmark satisfaction levels were obtained through interviews and literature reviews. Only approximate calibration of partial satisfaction functions defining these curves was possible at this stage, as appropriate data are lacking.

The carrying capacity of wolves in Sweden has been estimated to be around 10,000 (Persson, 1996). However, in 1800, the wolf population in Sweden was about 1,500 and that was considered too many for the country and the wolves were taken as pests. Sand et al. (2014) suggested that the carrying capacity in Sweden is about 1,200 wolves outside the reindeer herding area. We consider 1,200 wolves as a reasonable carrying capacity in our model, although it should be reconsidered as more scientific data become available in the future. We also assume that when stakeholders form their attitudes towards the population of wolves, they would use the same carrying capacity for all the interests, which means the upper limits of the wolf population in all the satisfaction function are set uniformly to 1,200.

Table 2. Choice of partial satisfaction functions (dependent on the wolfs population size)

|  |  |  |
| --- | --- | --- |
| Partial Satisfaction function | Shape | Justification |
| Environmental perspective | | |
| Biodiversity |  | When the wolf population is very small, its contribution to biodiversity is minimal, thus satisfaction level is close to zero. It increases until the size of the wolf population reaches the Favorable Reference Population[[3]](#footnote-3) level and then stabilizes, approaching 1. The sigmoid function assumed as a model is strictly increasing, unlike the satisfaction regarding biodiversity – which is expected to decrease if the number of wolves was higher than carrying capacity. However in this study we consider sizes of wolf population which are much smaller than carrying capacity, so potentially unrealistic shape of sigmoid function has no effect on our conclusions. |
| Biophilia |  | According to the theory of biophilia, we assume that people desire wolves in nature, but the marginal satisfaction would probably decrease until the wolf population reaches some limit size, when the satisfaction levels off. An exponential function is chosen to describe this trajectory. |
| Economic perspective | | |
| Loss of livestock |  | The more wolves are there in a populated area, the more livestock are attacked and killed. The satisfaction would hence have its maximum value when there are no wolves. When there are a few wolves, the satisfaction is relatively high which means livestock owners would presumably have a certain tolerance towards a small number of wolves. As the wolves increase, the satisfaction would approximately continue to decrease towards zero. A function which is smoother than a pure exponential was chosen. |
| Loss of reindeer |  | With a rationale similar to that of loss of livestock, the satisfaction here drops more quickly. Reindeer herders are assumed to be more negative than livestock owners, considering that reindeer herders in general depend solely on reindeer herding, and the damage caused by wolves also involves scattering of the herds, which is costly in itself. |
| Loss of hunting dogs |  | Satisfaction here changes similarly as the above two functions. However, hunters seem, in general, to have the least acceptance of wolves, so the satisfaction here is suggested to drop most sharply. |
| Tax |  | If there are more wolves, taxpayers have to spend more money on protecting the wolves and expenses relating to the compensation, installing fences, etc. Hence, the satisfaction maximizes when the wolf population is zero, and decreases as the wolves increase. |
| Preventative measures |  | Preventive measures are used to protect livestock, hunting dogs, and reindeer from wolf attacks. The compensation for the losses of dead or wounded animals and the damage of infrastructure also belongs to this category. However, the current preventative measures are claimed by the stakeholders to be far too insufficient to cover the whole loss, especially for the emotional and social perspectives. Therefore, more wolves are expected to lead to more losses and less satisfaction. With no wolves, the satisfaction level is assumed to be at maximum. As the wolf population grows, the satisfaction would presumably decrease to zero, when the wolf population is very large. |
| Ecotourism |  | When the wolf population is small and the chance for spotting a wolf or its tracks is low, ecotourism may make little profit. Thus, the satisfaction of the people who run the business and who enjoy the services is very low. As the wolf population grows, the satisfaction increases. However, the satisfaction level would not increase linearly because when there are too many wolves that could be easily observed or encountered, people would become reluctant to pay for ecotourism. So the marginal satisfaction will presumably decrease and the satisfaction level will remain almost constant. |
| Social perspective | | |
| Fear |  | Frank et al. (2015) found that the fear of wolves links to the abundance of wolves. When wolves are absent, there is no fear and the satisfaction is highest. As the population increases, the fear may increase linearly, rendering a linear decrease of the satisfaction. |
| Hunting culture |  | The hunting culture would be best preserved when there is no disturbance, i.e. with no wolves in the vicinity. Thus, the satisfaction is highest without wolves. The satisfaction drops when the wolves increase. When the wolf population is very large, the satisfaction gradually becomes almost zero. |
| Sami culture |  | The satisfaction level for the Sami culture would decrease as the wolf population increases, reaching zero satisfaction at a very larger population. |

**3.2 Total Satisfaction functions for different stakeholders**

Based on stakeholder interactions and expert assessment, weights of different interests, expressed through the satisfaction functions, are given in Table 3. The relative weights given here are conceptual (low, medium, high), which roughly correspond to the importance of the interests rating by stakeholders. The qualitative weights are translated to quantitative numbers, as Low = [0, 0.05), Medium = [0.05, 0.2), and High = [0.2, 1]. For each stakeholder, the sum of the weights is 1.

Table 3. The weights of interests of stakeholders.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Interests  Stakeholders | Biodiversity | Loss of hunting dogs | Loss of livestock | Loss of reindeer | Tax | Preventative measures |
| Environmentalists & Urbanites | High | 0 | 0 | 0 | Low | 0 |
| Hunters | Low | High | 0 | 0 | Low | 0 |
| Livestock owners | Low | 0 | High | 0 | Low | Medium |
| Reindeer Herders | Low | 0 | 0 | High | 0 | 0 |
| Interests  Stakeholders | Ecotourism | Biophilia | Fear of wolves | Hunting culture | Sami culture |  |
| Environmentalists & Urbanites | 0 | Medium | Medium | 0 | 0 |  |
| Hunters | Low | Low | Low | High | 0 |  |
| Livestock owners | Medium | 0 | High | 0 | 0 |  |
| Reindeer Herders | 0 | Medium | 0 | 0 | High |  |

By summing the weights of the different interests, a general satisfaction function for each stakeholder with respect to the size of the wolf population, is formed.

Considering only those interests with non-zero weights, the satisfaction function for *environmentalists* and *urbanites* (the “pro-wolf” group) is summed up as:

*(1)*

The satisfaction function for *hunters* is:

(2)

The satisfaction function for *livestock owners* is:

(3)

The satisfaction function for reindeer herders is:

(4)

The total satisfaction functions of hunters, livestock owners and reindeer herders are similar in shape thus we group them together as “anti-wolf” group and model their joint satisfaction level simply as the average. The satisfaction function for the “anti-wolf” group is:

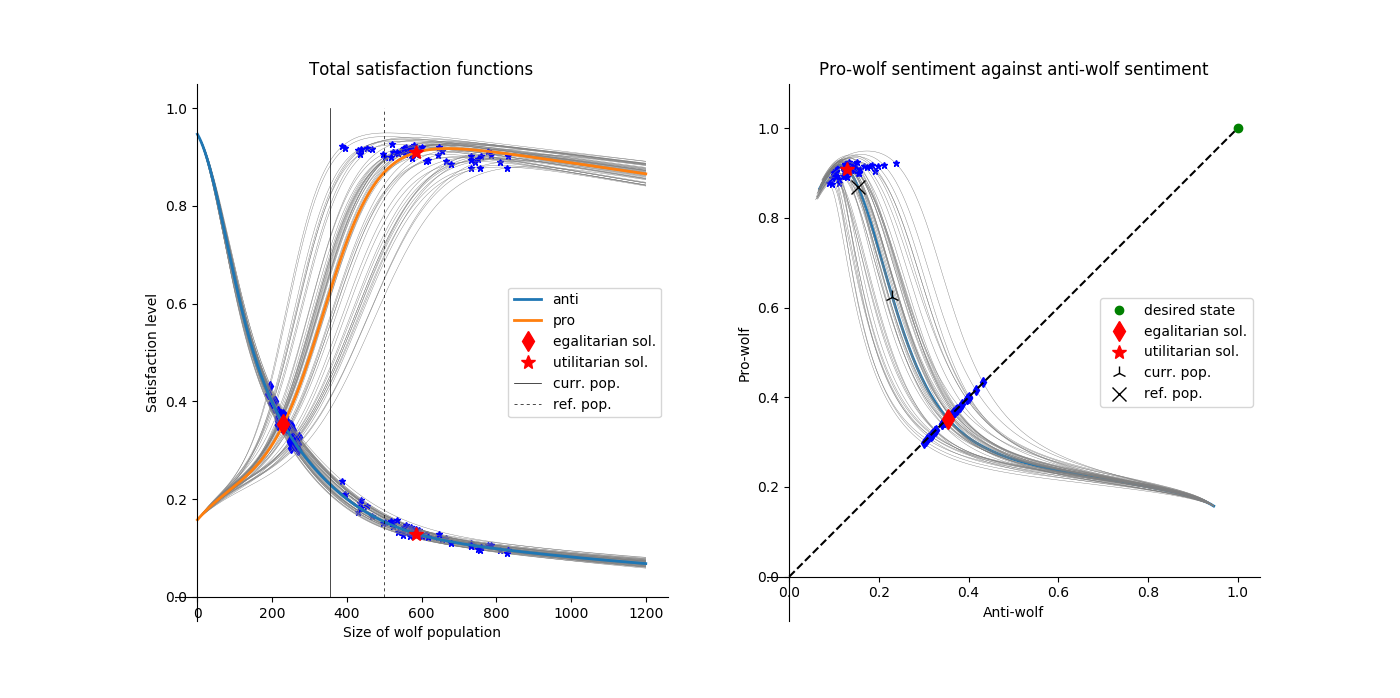
(5)

A group of experts was formed (at the International Institute for Applied Systems Analysis, IIASA) to assess and devise primitive forms of the satisfaction functions we wanted to develop. After the functional forms had been suggested, a meeting with other experts at IIASA was held to evaluate the functions. The experts included ecologists, economists, and systems analysts. With the comments and suggestions from those experts, the final satisfaction functions were decided. The provisional functional forms were assumed to be reasonable for the initial research and the model building.

**3.3 Results**

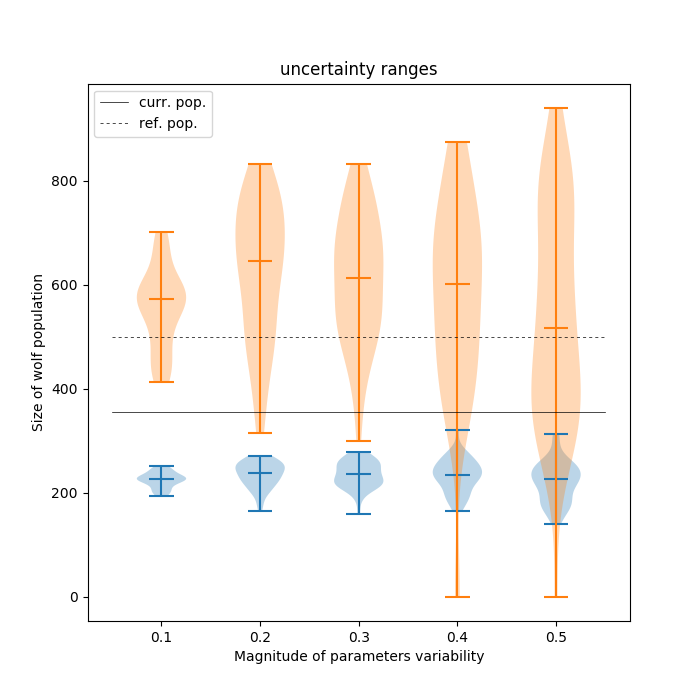
We analyze jointly the total satisfaction level on “anti-“ and “pro-wolf” stakeholders regarding the size of wolf population in order to identify the range within which a compromise solution could be found. We consider two “extreme” concepts of societal satisfaction. The egalitarian approach[[4]](#footnote-4) seeks to maximize satisfaction level of the least satisfied stakeholder group. However, by doing so, it tends to disregard satisfaction of other stakeholder groups. On the other end of spectrum is the so called utilitarian approach[[5]](#footnote-5) aiming at maximization of overall satisfaction of the whole society (defined as the sum of satisfaction levels of concerned stakeholder groups). This approach prioritizes stakeholders whose satisfaction is already high or easiest to improve (relatively to other stakeholder groups) and thus potentially neglects the needs of more dissatisfied stakeholders.

Left panel of Figure 1 visualizes the dependence of total satisfaction of the pro-wolf stakeholders (orange line) and anti-wolf stakeholders (blue line) on the size of wolf population. Choice of parameters of partial satisfaction factors comprising total satisfaction functions is presented in Table 4 and the weights of these factors are given in Table 5. The egalitarian solution (marked by diamond) equalizes the satisfaction level of both stakeholder groups suggesting size of wolf population around 200 individuals. However, adopting this solution would result in sharp decrease of satisfaction of pro-wolf stakeholders (from 0.65 to 0.35) while improving satisfaction of anti-wolf group only slightly (from 0.2 to 0.35). The utilitarian solution (marked by star) suggests the size of the wolf population of approximately 600 individuals. It favors the pro-wolf stakeholders (improving their satisfaction level from 0.65 to 0.9) at the expense causing further (but smaller in absolute terms) dissatisfaction among anti-wolf stakeholders (from 0.2 to 0.1). The right panel of Figure 1 presents the comparison of sentiments of pro-wolf stakeholders against the satisfaction level of anti-wolf stakeholders. An ideal situation, when both stakeholder groups are fully satisfied, is marked with green dot. Unfortunately for any size of wolf population the outcome is far away from this ideal (in Euclidean distance) but corresponds approximately to the status quo, i.e., wolf population of about 355 individuals (Naturvårdsverket, 2017), as well as to Favorable Reference Population of about 500 individuals (Bruford, 2015; Sjögren-Gulve & Hörnell-Willebrand, 2015) lay almost as close as possible to the ideal point.



**Figure 1.** Satisfaction levels of anti- and pro-wolf stakeholders. Increasing the size of wolf population to the Favorable Reference Level would significantly increase the pro-wolf stakeholders while leaving still more dissatisfied. Reducing the population size to the point of equal satisfaction would leave both groups equally dissatisfied. No win-win solutions is possible as for any wolf population size the satisfaction profile is far away from a desired state of equal and full satisfaction of both groups.

The parametrization of satisfaction functions used in the analysis described above was chosen according to our best judgement but nevertheless is arbitrary. Therefore, to check whether our analysis of satisfaction levels does not give qualitatively different results under different parametrizations we perform a sensitivity analysis. Gray lines on Figure 2 represent results of analysis repeated 50 times under randomized values of parameters – here drawn uniformly from intervals centered around the original value of parameter ±20%. This sensitivity test suggests that our findings are qualitatively robust, i.e., the conclusions we draw from the analysis are similar, although ranges of potential compromise spanned between egalitarian and utilitarian solutions change somewhat. In particular, the egalitarian solution (blue diamonds) is relatively stable (approx. 200 individuals) while the position of the utilitarian solution (blue stars) varies within range from 400 to 800 individuals. Nevertheless, according to the egalitarian approach the optimal size of wolf population is smaller than current level while utilitarian approach suggests to increase the number of wolves with respect to status quo. As Figure 2 suggests that such robustness of our findings holds true for parameter variability up to 30%. If the uncertainty of parameter values is approximately 40% or larger, then the uncertainty of our findings grows significantly with the egalitarian and utilitarian solutions potentially swapping their relative position.



**Figure 2.** Sensitivity of results on choice of parametrization. On the horizontal axis is the variability of parameters relative to the originally assumed values, on the vertical axis is the optimal size of the wolf population according to the egalitarian (blue ranges) and utilitarian (orange ranges) approaches. The Egalitarian solutions exhibit remarkable robustness to changes in parameter values. Uncertainty of the utilitarian solution grows significantly as we let parameters to deviate from the originally assumed values by 40% or more.

1. **Discussion and conclusion**

This paper presents a novel model for systematic analysis of the attitudes of conflicting stakeholders with different interests relating to the wolf management issue in Sweden. Using a satisfaction function as a tool, one can observe in one figure the changes in satisfaction level of different stakeholders in relation to the wolf population size. As a result, the model in this paper is a complementary approach for synthesizing and analyzing the aspects presented in other studies in this field.

Our model can be seen as a useful tool for communication and collaboration. During the process of designing and modifying the functions, meetings, workshops, interviews, and other forms of unofficial dialogues can be held to further inform the modeling functions. Through these forms of communication and collaboration, stakeholders and experts can convene and discuss around a common platform. Being aware of the satisfaction functions of each other, people may come to understand each other in a more objective and rational way than in traditional meetings, which so far have failed to bring about agreement in the Swedish society. Useful information and knowledge from experts and the government can be shared among stakeholders.

Research on human-wildlife conflicts seldom focuses on building a systematic framework to analyze the decision making mechanism among the different stakeholders with an emphasis on interests and effects of potential policies. This model with satisfaction functions is a pilot example of such a systematic framework. More systematic methodologies are called for in the future, especially models to simulate the interaction between stakeholders. Furthermore, the framework can be applied to other social issues, such as refugee and immigration issues, with conflicting interests among stakeholders, not only concerning natural resources management.

The current study is mainly limited by a lack of empirical data for model calibration, validation, and verification. The functional forms, the interests of the stakeholders and related weights, and the relationships between satisfaction levels and the wolf population, were drawn and inferred from the limited meetings and discussions we held with experts and stakeholders. The scope of these meetings and interviews is constrained and no sufficient representation at a national level is provided. The size of the stakeholder groups were also neglected in the calculation of the satisfaction function of the lumped pro- or anti-wolf stakeholders and in the comparison of the satisfaction levels of the two camps in the same figure (e.g. Figure 1).

However, as a methodological study, the model is a simplified abstraction of the actual situation, without exhaustion of complete reality. The model is sufficient to demonstrate a systematic framework as a direction for analyzing the existing issue and it is a tool to promote understanding and dialogue between stakeholders.

In conclusion, this paper presents a systematic framework to analyze the attitudes of stakeholders with conflicting interests regarding the wolf management issue in Sweden. The framework is based on a model with *satisfaction functions* as analytical tools for understanding relationships between the attitudes, the interests of stakeholders, and the wolf population. With a theoretical basis from the literature, we developed the satisfaction functions in dialogue with experts and stakeholder representatives. The model shows that the current attitudinal gap on wolves between the two main stakeholder groups (here lumped as “pro-wolf” and “anti-wolf”, respectively) is quite large, and that the conflict between the two groups cannot be solved by simply regulating the wolf population size.

We believe that this kind of modeling approach, at least in principle, can be used as an analytical tool for studying the attitudes and the effects of different policy measures on changes of stakeholder attitudes. It could also serve as a basis for discussion and dialogue between stakeholders, where different viewpoints can be expressed and discussed, with the aim of reaching a more balanced and acceptable solution.

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Appendix

Table 4. Parametrization of partial satisfaction functions. Each partial satisfaction factor is a function of wolfs population size n.

|  |  |  |
| --- | --- | --- |
| Partial Satisfaction factor | Formula | Choice of parameters |
| Biodiversity |  | Factor of biodiversity is modelled with use of sigmoid function. is the location parameter (point at which value of the function is equal to 0.5). We assume which is the Favorable Reference Population[[6]](#footnote-6).  is the shape parameter regulating speed of increase of sigmoid function. Here we assume , so that and . |
| Biophilia |  | is the coefficient describing how quickly the satisfaction function grows from zero (). |
| Loss of livestock |  | *c*2 =0.00001 is the coefficient describing how quickly the satisfaction function decreases from zero. |
| Loss of reindeer |  | *c*3  =0.00005 is the coefficient describing how quickly the satisfaction function decreases from zero. |
| Loss of hunting dogs |  | *c*4 =0.0001 is the coefficient describing how quickly the satisfaction function decreases from zero. |
| Tax |  | *c*5 = 0.0000005 is the coefficient describing how quickly the satisfaction function decreases from zero. |
| Preventative measures |  | =000001 is the coefficient describing how quickly the satisfaction function decreases from zero). |
| Ecotourism |  | is the coefficient describing how quickly the satisfaction function grows from zero (). |
| Fear |  | is the coefficient describing how quickly the satisfaction function decreases from zero (). The value of is set arbitrarily to fit the curve. |
| Hunting culture |  | is the coefficient describing how quickly the satisfaction function decreases from zero (). |
| Sami culture |  | was the coefficient describing how quickly the satisfaction function decreases from zero (). |

1. Their functional forms and choice of parameters are discussed in the Appendix [number of the table here]. [↑](#footnote-ref-1)
2. Favorable Reference Population (FRP) in a given biogeographical region is an indicator for the minimum population size necessary to ensure long-term viability of the species (European Commission, 2005). For the wolves in Sweden the FRP is conceived to be around 500 (Bruford, 2015; Sjögren-Gulve & Hörnell-Willebrand, 2015). [↑](#footnote-ref-2)
3. (Bruford, 2015; Sjögren-Gulve & Hörnell-Willebrand, 2015). [↑](#footnote-ref-3)
4. Egalitarian solution maximizes satisfaction level of the least satisfied stakeholder group. [↑](#footnote-ref-4)
5. Utilitarian solution maximizes the sum (or the average). [↑](#footnote-ref-5)
6. (Bruford, 2015; Sjögren-Gulve & Hörnell-Willebrand, 2015). [↑](#footnote-ref-6)