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Moen, Jon; Forbes, Bruce C.; Löf, Annette; Horstkotte, Tim

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14 Tipping points and regime shifts in reindeer husbandry

A systems approach

Jon Moen, Bruce C. Forbes, Annette Löf and Tim Horstkotte

Introduction

Change is pervasive in both nature and society. Some changes are slow and gradual while others are fast or discontinuous. The occurrence of fast and abrupt shifts has been the focus of much discussion in recent years as they challenge our understanding of system dynamics, pose massive governance challenges and are associated with high risks for human well-being (e.g., Galaz et al. 2016; Ratajczak et al. 2018; Turner et al. 2020; Lenton 2020). Many examples of abrupt changes and regime shifts have been documented in ecological systems, including rapid collapses of fish, mammal and bird populations, and changes in disturbance regimes such as wildfires and insect outbreaks (Ratajczak et al. 2018; Biggs et al. 2018). Sometimes abrupt change, whether in nature or society, is attributed to delayed policy responses and slow implementation rates (Martin et al. 2020), or changes in human behaviour (e.g., Gladwell 2000). While considerable effort has been devoted to predicting future abrupt changes in various systems (e.g., Scheffer 2009), most methods rely on statistical analyses of long-time series, which are seldom available (but see, e.g., Galaz et al. (2009) on the potential of 'mining' digital information in order to detect early warning signals). Increasing our understanding of abrupt change in different systems at different scales alongside societies' abilities to navigate such dynamics, or transform if needed (Moore et al. 2014), therefore remains a topical task. In this chapter, we adopt a systems approach to reindeer husbandry. The chapter is intended to be a synthesis**,** drawing on the previous chapters and other research, to identify and discuss the prevalence of tipping points, the potential for regime shifts and alternative states of reindeer husbandry as a coupled social-ecological system and livelihood.

Terminology of change – tipping points

The terminology pertaining to abrupt changes is diverse and sometimes confusing. Abrupt changes can, in general, be defined as changes that occur over shorter time periods relative to typical rates of changes for a given system

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(Ratajczak et al. 2018). Many different concepts have been used to describe this, partly because it is a developing research field and partly because the concepts originate from different disciplines. Some of the common concepts include regime shifts, critical transitions, tipping points, punctuated equilibria, alternative stable states, thresholds, collapses, surprises and state shifts (see Milkoreit et al. 2018 for an overview). All of these concepts emphasize different aspects of change, but some general themes emerge: the existence of multiple states of a system, internal feedbacks that regulate these different states, non-linearity of changes and potential difficulties in reversing them.

In this chapter, we will use the concept of tipping points and adhere to the definition of Milkoreit et al. (2018: 9):

> A point or threshold at which small quantitative changes in the system trigger a non-linear change process that is driven by system-internal feedback mechanisms and inevitably leads to a qualitatively different state of the system, which is often irreversible. This new state can be distinguished from the original by its fundamentally altered (positive and negative) state-stabilizing feedbacks.

This shift between system states across a tipping point is sometimes called a regime shift (Biggs et al. 2018).

The non-linear changes and state shifts described above are characteristic of a system, which can be defined as a 'set of things – people, cells, molecules, or whatever – interconnected in such a way that they produce their own pattern of behavior over time' (Meadows 2008). While the concept of a system may resonate well within natural sciences, some researchers within social sciences and humanities are less attracted, claiming, for instance, that system boundaries are seldom defined (see, e.g., Byrne 1998; Olsson et al. 2015). This is, of course, true, but the focus in systems analysis is on the interactions between the agents or entities in the system and not the borders themselves.

Another helpful heuristic is to distinguish between tipping points and transformations. The former are typically considered innate to system dynamics while the latter entail specific focus on the component of human agency and intent (Löf 2010). Although natural resource management in many regards has moved beyond rigid command-and-control approaches, and although it is well known that policy interventions rarely generate the intended results, tipping points and transformative potential go hand in hand. For example, recognizing the risk of undesirable alternative system states can induce transformative action otherwise considered too costly, while other tipping points can actively be sought to push and change system dynamics along what is perceived as more sustainable pathways (Westley et al. 2011).

To understand and describe abrupt changes, it is important to identify key external drivers (i.e., pressures outside the defined system, such as climate or policy change, which are two relevant examples in relation to reindeer

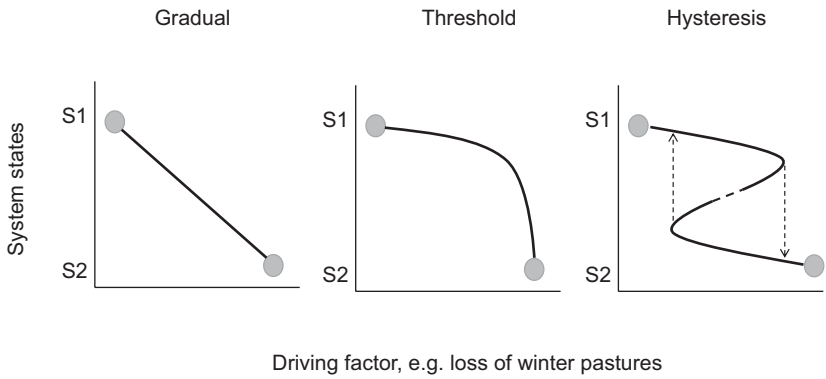

Figure 14.1 S1 and S2 are different system states, for instance, a system based on natural pastures vs a system based on supplementary feeding or ranching. The line represents the response to a driving factor. A gradual response suggests a direct and immediate impact, while a threshold suggests that the system can buffer changes in the driving factor to some extent. A hysteresis effect suggests that there is a threshold, but also that the shift to the alternative state changes the feedbacks in the system so that it is very difficult to reverse the process.

husbandry). Ratajczak et al. (2018) give a good overview, and here we will only touch briefly on the types of relationships between external drivers and system responses. The simplest gradual responses (except no response, of course) are linear or unimodal changes (Figure 14.1). Such responses also imply that the system may recover along the same trajectory if the driver is relaxed or changed. The system may also be able to buffer a change in a driver until a threshold is reached, beyond which the system rapidly or abruptly shifts into a new state. A threshold response may also include hysteresis, where the conditions have changed so much that it is very difficult for the system to recover to the original state even if the driver of change is relaxed. Ecological examples of hysteresis effects that are relevant for reindeer pastures and have lasted for centuries include harvesting trees for firewood in treeline areas which changed the microclimate and prevented trees re-establishing when logging ceased (Karlsson et al. 2007), and long-term grazing and trampling effects in historical reindeer milking pens which changed nutrient regimes and prevented shrubs from invading the herbaceous vegetation even when these sites were no longer in use (Egelkraut et al. 2018).

Van Ginkel et al. (2020) consider different kinds of tipping points. It is clear that the ecological part of a social-ecological system can change abruptly in response to different drivers, for instance as a result of reinforcing feedback loops, such as where global warming melts permafrost causing emissions of greenhouse gases from degrading organic soils which in turn causes stronger

global warming (e.g., Hollesen 2015). There may also be shifts originating from the social part of the SES, for instance where a new behaviour, idea or technology is adopted by a large majority, or when adaptation actions fail to meet policy or management objectives (van Ginkel et al. 2020).

It has been suggested that primary industries, such as forestry, agriculture and reindeer husbandry, may be especially at risk of crossing tipping points (Yletinen et al. 2019). This is because they are, to varying degrees, affected by human activities, the ecosystems that they rely on may be severely changed, and they are often dependent on anthropogenic inputs that are holding the system close to critical thresholds (see, e.g., Rist et al. 2014). Maintaining these systems in a production state has been compared to Sisyphus continuously pushing a boulder up a mountain (Rist et al. 2014). Using the lenses of tipping points and regime shifts, this chapter focuses on reindeer husbandry as a social-ecological system**,** highlighting the inseparability of humans, reindeer and the environment, and conceptually explores the macro-level of emergent phenomena, such as abrupt changes to the livelihood. It is important to note that pastoral systems such as reindeer herding differ from other primary industries in that they have inbuilt mechanisms to reduce vulnerability and deal with different forms of uncertainty, for example, through seasonal and local mobility (Galvin et al. 2009; Horstkotte et al. 2014). However, this assumes the existence of alternative pastures that are both accessible and diverse (Löf 2013) and makes herding practices totally dependent on competing for land users' consideration (Chapters 4 and 8).

Social tipping points

Much of the research on tipping points has focused on ecological or social-ecological systems (SES; Biggs et al. 2018) or on earth system changes (e.g. Lenton 2020). There are fewer studies on social tipping points, at least under that umbrella term. There is much research in social sciences and the humanities about, for instance, behaviour, values, norms, institutions, stability and change that is highly relevant, but it is not possible to summarize it in this chapter. However, we will briefly introduce the subject of social tipping points and relate them to concepts of transformation.

The concept of social tipping points became well known through the popular book by Gladwell (2000). He argues that tipping points in social contexts are governed by three different rules, or agents of change, which he called the Law of the Few, the Stickiness Factor and the Power of Context. In short, this means that whether or not change comes about is often dependent on very persuasive or connected individuals (cf. network theory) who can package information so it attracts people's attention, plus the time has to be right to receive the information or idea. A typical example might be the rapid spread of demonstrations for increased action to combat climate change by the Fridays for the Future movement, which was initiated by a single teenager (Greta Thunberg). These conditions are, however, very difficult to govern, or plan for. Governance scholars highlight different institutional capacities and responses that can increase the

ability to navigate abrupt change. For example, the importance of monitoring early warning signals through innovative approaches (see Galaz et al. 2009), preparing for change so that when a window of opportunity arises the institutional side is ready to act (Gelcich et al. 2010), or simply recognizing transformation as a policy option which widely differs from typical incremental responses (Löf 2010; Westley et al. 2011). Transformation in this context thus entails a component of intentionality and gains recognition through, for example, the literature on sustainability transitions (Avelino et al. 2016).

While the literature is vast and spans many different disciplines and fields, much seems to converge around highlighting the role of *ideas* (and essentially politics) in explaining both unwanted stability (or negative resilience) and the potential for transformative change. In particular, the materiality and structural dimensions of ideas, manifested for example in policy discourses (Schmidt 2011), socio-technological systems (Sovacool et al. 2020), epistemic communities and coalitions between different actors (Meijerink 2005) and, more broadly, the formal and informal institutionalization of certain ideas and perspectives (Otto et al. 2020), are key in understanding transformation and transformative potential (for a discussion see also Chapters 7 and 8).

In summary, a tipping point can be connected to, or caused by, changes in both the biophysical environment and socio-economic conditions. Changing environmental conditions can cause an existing portfolio of policies or behaviour to fail (van Ginkel et al. 2020), and changing values or norms can cause changes in the environment through resource use and extraction patterns, for instance in terms of public perceptions of sustainable land use (Chapter 8).

Risks of future regime shifts in reindeer husbandry

Many of the trends and external factors described in the chapters in this book may push reindeer husbandry across a tipping point so that it enters into a new regime or state, one which differs from how it is practised today. The 'ideal' or traditional state of reindeer husbandry is based on free-ranging animals, the use of natural pastures, and governed by traditional knowledge, although the exact details vary between different regions and countries due, for instance, to different forms of governance, quality and amount of pasture, local history and pressures from other land users (see Chapter 1 for a general description). Alternative states that have been raised and discussed in earlier chapters include reliance on supplementary feeding to compensate for losses of pastures (Chapter 12), fenced herds to protect from predation (Chapter 6), becoming a meat-processing industry based on more centralized herding practices (e.g., Landauer et al. 2021) or a total loss of reindeer husbandry. All of these alternative states are seen as undesirable by the herders (e.g., Axelsson Linkowski et al. 2020; Landauer et al. 2021). We will discuss some of the drivers and state shifts on a general level, although we also acknowledge that trends and threats vary over the reindeer husbandry area in Fennoscandia.

The loss of pastures due to other land use (Chapter 4) is, of course, a key driver that is affecting, and will continue to affect, reindeer husbandry in many ways. Herders have been forced to adopt a number of strategies to at least partly compensate for the losses (see Uboni et al. 2020 for Sweden and Landauer et al. 2021 for Finland). These include changes in harvest strategies (towards calf slaughter) and herd structure (towards more females in the herd), introductions of modern machinery and equipment to allow the remaining pastures to be used more efficiently, and increased supplementary feeding to compensate for lost pastures (see Chapter 12). Herders have also been forced to abandon traditional rotational grazing strategies that would allow lichens to recover (Axelsson Linkowski et al. 2020). All of these strategies come with increased financial and psychosocial costs (see more below).

The gradual loss of pastures over decades (Chapter 4) may, from a systems perspective, be seen as a 'slow variable'. Slow variables determine the underlying structure of the system, whereas the dynamics of the system arise from interactions and feedbacks between fast variables (Biggs et al. 2012), such as the number of animals slaughtered, economics or weather. A shift from a system based on natural pastures to a system based on feeding, i.e., a form of ranching, may be an example of a regime or state shift. While feeding becomes more common in most of the reindeer herding area in Fennoscandia, such a shift has not yet occurred in most districts. However, in some herding districts, for instance, in the majority of the herding districts in Finland, feeding is a common practice with majority of the reindeer being fed either in the field or in feeding pens, and it has been so since the 1970s (Nieminen 2010; Turunen & Vuojala-Magga 2014; Landauer et al. 2021). In a participatory study with two herding districts in Sweden, herders mapped the key factors influencing their decision-making process with regard to supplementary feeding, including their interrelations, among which parallel land use and governance-related factors alongside herding economy were identified as important in influencing choices about using supplementary feeding (Horstkotte et al. manuscript). However, the study primarily showed the lengths to which herders would go in order to prevent becoming locked into a system based on supplementary feeding.

Predators may also have significant effects on reindeer husbandry (see Chapter 6 for details). Due to successful conservation policies, numbers of large carnivores have increased over the reindeer husbandry area during recent decades from a previous low caused by long-term human persecution. The effects of carnivores on reindeer husbandry are dependent on the management of both the carnivore populations and of coping strategies adopted by the herders, such as supplementary feeding to decrease losses or avoidance of certain areas. Predation may cause direct losses due to mortality, but also more indirect effects by disturbing herds and calving areas, reducing grazing time and increasing energy expenditure, with a consequent decline in the condition of the reindeer. From a systems perspective, losses due to female mortality may cause herds to collapse. The loss of an adult female creates a gap in calf production until that female has been replaced by a new female. High losses due to

predation may thus make it impossible to maintain reindeer numbers and have severe effects on the economy as the potential for harvests declines (Åhman et al. 2014). Coping with predators has also led to a severe physical and mental burden being placed on the herders and may cause young herders to question the long-term sustainability of reindeer husbandry as a livelihood (Vuojala-Magga 2012). In Finland, the compensation scheme for losses to predators may lead to more time being spent finding carcasses to receive compensation than is available for actual herding practices (Heikkinen et al. 2011). In Sweden, where compensation is paid based on numbers of predators and not on confirmed losses, one herder still commented, in relation to predation losses, that 'I am in the business of herding reindeer, not in the business of feeding predators' (J. Moen, *pers. comm.*).

Reindeer husbandry is seen by Sámi herders both as a tradition and as a way of life rather than primarily as an economic enterprise (e.g., Karlsson 2015; Nordin 2007, see also Chapter 8 for a longer discussion). Even so, there is a need for a sustainable economy, and both pasture losses and mortality as a result of large carnivores cause tangible costs. These costs in reindeer herding could be either purely financial or more indirect, such as increased workload or stress (e.g., Uboni et al. 2020). Financial costs include, for instance, costs for supplementary feed, transport of reindeer, use of helicopters for gathering the herds and buying, maintaining and running a fleet of vehicles. The increased use of technologies, such as GPS, drones and GIS, in reindeer husbandry has further required a large monetary input into the herding enterprises. On top of this, transaction costs, i.e., costs associated with defining, establishing and maintaining rights, have increased greatly as consultation processes with other land users, such as forestry, mining and wind power companies, increase (Bostedt et al. 2015).

The increase in costs has consequences for the sustainability of reindeer husbandry and for reindeer herders. For instance, some older reindeer herders find it difficult to motivate young people to take up reindeer husbandry because it is so difficult to meet the costs; this could lead to a demographic tipping point with very few herders and loss of tradition and culture (Lépy et al. 2018; Landauer et al. 2021). Reindeer herders also show significantly higher levels of anxiety and depression compared to both urban and other rural people (Kaiser et al. 2010). The strongest factors related to emotional disorders are work-related, caused for example by large losses due to predators, extreme weather conditions, financial pressure and conflict with competing land users. A combination of the direct and indirect costs may be one reason for an observed change in the number of reindeer enterprises with different herd sizes. In Sweden, both large (more than 500 reindeer) and small enterprises (less than 100 reindeer) have increased since at least the mid-1990s, while the number of medium-sized enterprises has decreased (see Appendix 2 in Uboni et al. 2020 for data sources). This might indicate that enterprises need to have more reindeer than previously to be economically sustainable. However, the right to own and herd reindeer is connected to membership of a herding district and the

ownership of an earmark. Therefore, in order not to lose this right and to give the younger generation a chance to establish as reindeer herders in the future, some enterprises still maintain a small reindeer herd, often in their children's name (e.g., Nordin 2007; Karlsson 2015).

It is difficult for herders and herding enterprises to increase revenue to counteract the increasing financial costs. Pastures are used as a common resource with internal rules regulating access to them within the herding districts, and all the available pastures are used (see Chapter 7; Axelsson-Linkowski et al. 2020). If a herder would like to increase the size of his or her herd, there will be a zero-sum game in which someone else would have to reduce their herd size (Karlsson 2015). The space for larger herds (or new herds) is further reduced by the encroachment of other land users (see Chapter 4). Overall, diminished economy, loss of hope for the future of reindeer herding by the younger generation and reduced physical space for reindeer husbandry may all push the system towards a tipping point.

Some authors have described abrupt changes in SES as collapses, i.e., a complete loss of the system (e.g. Diamond 2005). Cumming and Peterson (2017) defined a system collapse on the basis of four criteria: (i) loss of identity, (ii) rate of loss, (iii) losses of social-ecological capital and (iv) long-term consequences of those losses. It may be illustrative to summarize the potential risks that traditional reindeer husbandry faces in light of these criteria. The loss of identity (i) means that key actors, system components and interactions disappear. One such loss of identity could be the shift from a pastoral system based on natural pastures to a system more akin to ranching, based on supplementary feeding (Chapters 4 and 12; Helle & Jaakkola 2008; Turunen & Vuojola-Magga 2014). This means that important system components, such as pastures, are lost, and that feedbacks affecting both practical herding decisions and economic interactions are changed. The rate of loss or change (ii) may also be high in certain areas, certainly within one generation of herders. For instance, the cumulative impacts of other forms of land use have restricted the usefulness of traditional ecological knowledge (TEK) and the transmission of that knowledge from one generation to the next (Axelsson Linkowski et al. 2020). This is further exacerbated by climate change, with what is considered 'normal' shifting faster than the practice-based knowledge (Löf et al. 2012; Löf 2013). Further, the success of large carnivore conservation since the 1990s has increased the predation pressure on some herds to a point where Åhman et al. (2014) suggested that one of the sub-herds in the Njaarke herding district had already collapsed, as the losses of female reindeer were so substantial that herd size could no longer be maintained (Chapter 6). Losses of social-ecological capital (iii) can, for instance, be connected to the loss of TEK between generations as described above. This is especially critical in a pastoral society that is as much rooted in culture and tradition as it is in the monetary aspects of herding. Finally, consequences are certainly long-lasting (iv); for instance if people give up their livelihood, or if the younger generation does not take up reindeer herding as a livelihood (e.g., Karlsson 2015). Further, the rights to the land (for herding, fishing and hunting)

are tied to reindeer herding and the continued use of the land (Brännström 2017; Labba 2017). A collapse of reindeer husbandry could mean that the usufructuary rights of the reindeer herders become further questioned by other land users, as has already happened in several court cases in Sweden (Sasvari & Beach 2011).

An external 'shock' that may change the trajectory of Sámi reindeer husbandry into a new regime would be a shift in recognition and implementation of Indigenous rights. These usufructuary rights exist in parallel with other property rights holders and land owners such as the state, private individuals or companies. Legislation in relation to conflicts between land owners and reindeer herding districts in all three countries is generally weak, and many conflicts have ended up in the courts (e.g. Sasvari & Beach 2011; Brännström 2018, see also Chapter 8). While recent legal developments relating to Sámi rights in Sweden could potentially remedy some of these structural imbalances (Allard & Brännström 2021), the Swedish state's record consistently demonstrates empty talk over actual implementation (Mörkenstam 2019). Moreover, juridification (seeking recognition through the courts when the political system fails) as a strategy is costly, as the courts only try the exact questions that lie before them, and their rulings may therefore not lead to a long-term solution of the conflict (Brännström 2017). The only way to take responsibility for the legal development in the conflict with other land users is through the legislative bodies in the countries. The UN Human Rights Council has also repeatedly criticized the Nordic countries for not sufficiently protecting Indigenous rights (e.g., UN General Assembly, 9 August 2016). Should existing legislation be implemented and complemented with new legislation in which Indigenous rights are strengthened, land use and resource extraction would probably take on new trajectories within the Sámi reindeer husbandry areas in all three countries – as would reindeer husbandry.

In summary, it is clear that there are several routes by which traditional reindeer husbandry can shift into an alternative state. Loss of pastures, increased predation pressure, encroachment by other land users, increasing emotional stress and lack of hope for the future may all drive reindeer husbandry towards a more ranch-like form with supplementary feeding, fencing, and more stationary herds. On top of this, climate change will cause additional stresses on both reindeer and reindeer husbandry as a system (Chapter 5). The system is able to buffer against some of these drivers (e.g., Uboni et al. 2020), but the adaptive space and buffering abilities are limited. Where there is a chance of buffering, state shifts are characterized by thresholds, where change may happen suddenly once the threshold is passed. For instance, loss of quality and quantity of pastures can be buffered by supplementary feed – but only to a certain point, beyond which economy, lack of workforce, or emotional stress may force people to give up herding. Loss of animals to predation may reach a point where it is not possible to maintain herd sizes, as described for Njaarke herding district above. Several of these state shifts may also exhibit hysteresis effects, i.e. difficulties in shifting back. For instance, if people give up herding, traditional

knowledge will be lost (e.g., Axelsson Linkowski et al. 2020), and if pastures are not used, grazing rights may be lost.

So, what can be done to reduce the risk of unwanted state shifts? Reindeer herders have pushed their potential to adapt their livelihood to internal and external changes and continue to do so. Despite the characterization of reindeer husbandry as a 'traditional' livelihood, this does not imply stasis of what reindeer herders define as the identity of their livelihood. However, the cultural markers of free-ranging animals relying on natural grazing grounds provide the basis for the identity and require intact social-ecological relationships within the herding districts, as well as in their interaction with the external society. These system qualities need to be strengthened as they innately provide resilience – such as maintaining and increasing diversity of pastures, securing access to pastures during crises with regard to forage availability and increasing mobility (e.g., through a landscape perspective where migration routes and safe passages are protected). Several of these strategies will demand structural, institutional and legislative changes, but also discursive changes in terms of how we imagine what sustainability is, what constitutes the best use of forested areas and whether herders are considered to be one of many stakeholders – or as the rights holders they really are according to the law.

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