Name of the case study	**Unjárga/Nesseby - Moth larvae outbreaks and the adaptation of local sheep farming and reindeer herding livelihoods – Norway [Resilience]**
What about this case makes it interesting? How does this case contribute to understanding of resilience and/or regime shifts in the Arctic?	The moth larvae outbreaks in Unjárga/Nesseby, which were most likely caused by a milder climate and changing seasonality, have never been as extensive as during the period between 2005 and 2009. These outbreaks have resulted in land-use changes (reduction in grazing land) affecting both sheep and reindeer; resulted in extensive deforestation of the birch forest area, damaged heath and berry plants and has had an impact on moose and ptarmigan populations through the reduction in the choice of feed. Consequences of climate change and changes in land-use create a set of exposure-sensitivities for both sheep farmers and reindeer herders. At the same time, these outbreaks have caused the amount of wavy hairgrass to increase significantly. This grass is a useful species for sheep and reindeer. They have found that grazing by sheep and reindeer together, gives a possibility to cope with the moth outbreak situation. Most sheep are gathered from their pastures when the autumn sets in. The reindeer migrate through the sheep grazing areas in Unjárga/Nesseby municipality after sheep are gathered from their pastures and could clearly benefit from fresh wavy hairgrass, sustained by the earlier grazing of the sheep.
Main Contributors	Grete Hovelsrud, Nordland Research Institute, Nordland University Julia Olsen, Nordland Research Institute, Nordland University **Key references: Cite in the text using (1), (2), (3) etc. and provide a reference list at the bottom of the template.** (1) Rybråten and Hovelsrud **(2)** Rybråten
Reviewed by (name and affiliation)	

Category (mark with X)	**Resilience/ Adaptability**	**Loss of resilience**	**Transformation**
	X		

Case study details:	**Country**	**Place**	**Scale – space**	**Scale – time**	**Sector(s)**	**Other (e.g. disturbance)**
	Norway	Unjárga/Nesseby Municipality			Herding – sheep and reindeer	Moth outbreak

Drivers (mark with X in appropriate boxes)	**Climate**	**Geopolitical**	**Mineral/ oil extraction & infrastructure**	**Tourism**	**Shipping**	**Biological invasion**	**Rapid demographic change**	**Other:** ***state here***
	X							X moth outbreak

	Biophysical	**Social**
1. Basic description of coupled social-ecological system in focus **(**What are the key components and stake holders) If possible draw a systems diagram or conceptual map of the case – this can be a series of diagrams to capture different periods in the case and the drivers/ actors/ events that characterize the period.	**a) What types of ecosystem(s) and other major biophysical features are present?** Terrestrial Ecosystem: Birch forest and species dependent on it. Forest (the birch forest area), pastures for sheep and reindeer and the mountain plains **b) How are the case boundaries defined in terms of ecosystems or biophysical characteristics?**	**c) Who are the key groups of people in this case?** Coastal Sámi community with its 879 inhabitants and represented by sheep farmers and reindeer herders. There are 879 inhabitants (2009) in Unjárga/Nesseby municipality. 70 % of population is considered to be Sámi (2). The number of sheep farms has doubled from the 1950s to the current 13 sheep farms with more than 1,300 sheep and 70 people. **d) What kinds of livelihoods are important in the system?** Most employment positions are in service, tourism and public sector. Nevertheless, sheep farming, reindeer husbandry, and fisheries are important livelihoods in the municipality. Two land-based primary industries: sheep farming and reindeer herding. Combining reindeer herding, Agriculture, Coastal fisheries, hunting and gathering has been fundamental for local population for centuries. Nowadays this combination of activities does not provide the same level of livelihood, but is important for the local residents. **e) What institutions are key to this case? If possible define what scale it addresses.** Unjárga/Nesseby municipality The Norwegian Reindeer Husbandry Administration Increasing farmers' and herders' engagement in decision-making processes through hearings and open meetings.

		f) How are the case's boundaries socially defined, and how do these social boundaries relate to biophysical boundaries? Unjárga/Nesseby municipality is located in the inner part of the Varanger fjord in eastern Finnmark, northern Fennoskandia. Close to the Russian border.

2. Timeline Draw a timeline of *key* events/ developments to the case. Points to include: Make clear the period of time over which the change is being considered. Provide a brief description of event/ actors, and ecological impacts. Mark particularly significant events with *. Consider both biophysical and social dimensions. Additional points that	

can be considered: Is it possible to identify periods of change from one type of system to another, transformations? Identify disturbances or events that challenged, built, or reduced resilience or adaptive capacity in the system.		
3. Disturbances What are the key disturbances in the system (present and past)	**a) Have there been major biophysical disturbances that are relevant for the case?** Radical change in the birch forest: Forest death over large areas; heath and berry plants have been damaged; negative effects on moose and ptarmigan population.	**b) Have there been major social disturbances that are relevant for the case?**
4. Drivers of change Clarify what impacts these drivers have on the SES and if these are direct or indirect	**a) What are the key biophysical drivers of change?** An increase in mean annual and minimum winter temperature, mild winters. The recent extensive and long-lasting moth larvae outbreaks in Unjárga/Nesseby, most likely caused by climate warming. If the moth attacks the birch tree three years in a row, the tree will probably die. These outbreaks have resulted in land use changes (reduction in grazing land and forest) affecting both sheep and reindeer and create a set of exposure-sensitivities for them.	**b) What are the key social drivers of change?**
5. Sources of adaptive capacity:	**a) Within the ecosystem?**	**b) Within society (e.g. people, social capital, management, institutions, infrastructure):**

What factors allow(ed) the system to adapt to disturbances in the past and present? Give a brief assessment of recent or on-going changes (+/-/0 = increasing/ reducing/ not affecting adaptive capacity)	Vegetation will be more diverse. Other grass species, herbs and plants entering the area.	(+) Sheep farming and reindeer herding livelihoods are well adapted to the sub-Arctic seasonal changes. (-) However the changes caused by the moth larvae outbreaks are not to be found in the historical repertoire of the livelihoods. Flexibility among both animals and owners will likely have a positive effect on their ability to adapt to climatic changes. *(+/-) "To increase the adaptive capacity of livelihoods, several factors have to be present and combined. As we have seen, the adaptive capacities of sheep farming and reindeer herding livelihoods depend, to a high degree, upon the animals' ability to adjust to change. The degree to which the sheep and the reindeer manage to adjust to the recent changes in pasture conditions, will affect the livelihoods of sheep farmers and reindeer herders who depend on these animals well-being and survival". (1)* *(+) "Farmers' and herders' increased engagement with decision-making processes, through hearings and open meetings, may be seen as an adaptive strategy to avoid the loss of grazing land for their animals".(1)*
The next two sections break down the information in Section I. While it is not necessary to fill these sections, if you have additional information pertinent to specific rows below feel free to enter the material.		
II.1-8 SES, resilience and adaptive capacity		
	Biophysical	**Social**
II.1. Where do we find changes and	**a) Within nature** Moth outbreaks resulted in changes in pasture conditions. At the same	**b) Within society** Joint grazing of sheep and reindeer gives a possibility to cope with the

resilience in the face of change?	time those outbreaks have caused the amount of wavy hairgrass to increase significantly. This grass is a useful species for sheep and reindeer.	moth outbreak situation and make good use of the moth affected parts of their pastures. Most sheep are gathered from their pastures when the autumn sets in. The reindeer migrate through the sheep grazing areas in Unjárga/Nesseby municipality after sheep are gathered from their pastures and could clearly benefit from fresh wavy hairgrass, sustained by the earlier grazing of the sheep.
II.2. What are the system's key components?	**a) Key Ecological components (e.g. lakes, coastal zones, caribou)** Forest (the birch forest area), pastures for sheep and reindeer and the mountain plains	**b) Actors in society (e.g. individuals, groups, public or private organizations)? How are people organised – by geography, livelihood, family, etc.?** Coastal Sámi community presented in the case by reindeer herders and sheep farmers.
II.3. What are the key linkages? E.g. ecosystem services, resource extraction. These linkages should exist. If there are not mutual links between social and ecological components the case is not a social-ecological system.	**a) From nature to society (e.g. ecosystem services)**	**b) From society to nature – modifying nature, extracting resources (e.g. hunting, mining, water pollution)** Sheep farming, reindeer husbandry, fisheries, hunting and gathering are important part of local livelihoods.
II.4. What are key interactions?	**a) What are the key ecological interactions within the case?** Usage of same pastures of both sheep and reindeer. Most sheep are gathered from their pastures when the autumn sets in. The reindeer migrate through the sheep grazing areas in Unjárga/Nesseby municipality after sheep are gathered from their	**c) What collaborations, conflicts, or other key linkages exist between actors?** Farmers and herders are engaged in the local decision-making process. *"Being reliant upon a terrestrial natural resource, both reindeer herders and sheep farmers retain important knowledge concerning their natural surroundings. With an experience-based understanding of their*

	pastures and could clearly benefit from fresh wavy hairgrass, sustained by the earlier grazing of the sheep. **b) What are the most important biophysical tele-connections to distant systems?**	*environment, as well as the weather patterns and climate variations pertaining to it, changes 'out of the ordinary' (where 'ordinary' refers to a wide variety of expected conditions) are noted, assessed and eventually responded to. The highly visible and wide-ranging moth larvae outbreaks recently causing extensive reduction in the birch forest area over large areas in Unjárga/Nesseby and adjacent municipalities, have resulted in a broad engagement and comprehensive discussions among local inhabitants, in the media and among natural scientist".(1)* **d) Between local actors and distant actors?**
II.5. Culture	**a) How is the relationship between society and nature viewed?** **b) What meanings are attributed to nature and to interactions with nature?**	**c) What are key cultural features of relevance for the case?** Economic and cultural significant of primary industries continue to be important. *"Most of the abundant cultural remnants inland of the peninsula originate from the Varanger Sámi and from their long-established utilization of the area. Thus, the inland area of the Varanger peninsula has been, and still is, an important resource area for the Sámi population in the region. Keeping domesticated reindeer was common practice among the coastal Sámi" (1).* **d) What are key cultural practices and beliefs related to nature?**
II.6. Disturbance What are important types of stress & shock	**a) Describe important biophysical or ecological shocks and stresses (e.g. floods, storms, etc).** The moth attacks on the birch forests have a great impact on the ecosystem as a whole. The wide-ranging moth larvae outbreaks have caused death and reduction in the birch forest area over large areas, loss of pastures and damage in heath and berry plants. The moth eggs are extremely cold-tolerant and can survive when temperatures as low as approximately –35_C for winter moth and – 36_C for autumnal moth.	**b) Describe important social shock and stresses (e.g. austerity policies, changes in government policy, introduction of new technologies, etc)**
II.7. What are key	**a) What types of ecological processes (e.g. loss of**	**b) What types of slow social processes (e.g. aging,**

slow variables Changes that occur over decadal or longer time scales	**permafrost, shifts in species composition) are driving important long-term changes in ecological structures and processes?** The death of birch forest has a negative impact on the moose and ptarmigan populations through the reduction of the choice of feed. Changes in temperature and humidity may lead to increasing number of insect and to arriving of new insect species that might affect sheep and reindeer. Reduction in grazing land, forest regrowth, increased tree line elevation and predator increase. The tree line has extended An expansion of and increased growth in dwarf birches (*Betula nana*) in the pastures, causing the animals to avoid areas obstructed by birch regrowth.	**population growth, loss of language) are driving important changes in social institutions and behaviours?** Local cabin development and associated human traffic may affect their animals grazing land.
II.8. Relationships with ecological regime shifts	**a) Are ecological regime shifts driving further ecological change or pressure?** The moth larvae outbreaks in Unjárga/Nesseby most likely caused by milder climate and changing seasonality have never been as extensive as during the period between 2005 and 2009. If moth attacks the birch tree three years in a row, the tree will probably die. - The moth attacks leads to reduction in the birch forest and pasture. The death of birch forest has a negative impact on the moose and ptarmigan populations through the reduction of the choice of feed. - Reduction in grazing land, forest regrowth, increased tree line elevation and predator increase. the tree line has extended - An expansion of and increased growth in dwarf birches (*Betula nana*) in the pastures, causing the animals to avoid areas obstructed by birch regrowth.	**c) Can social stresses or major changes be attributed to ecological regime shifts?** The moth outbreak will have impact on sheep and reindeer access to food and their wellbeing. It will also change the vegetation that will eventually become more diverse. Farmers and reindeer herders have already noticed other grass species, herbs and plants entering the hairgrass dominated areas. The livelihoods of sheep farmers and reindeer herders will depend on ability of sheep and reindeer to adjust and cope with the recent changes. The moth larvae outbreaks damage heath and berry plants that makes some travel long distances to pick berries elsewhere. The death of birch forest has a negative impact on the moose and ptarmigan populations through the reduction of the choice of feed. Due to uncertain consequences of moth larvae outbreaks on moose stock, Unjárga/Nesseby municipality reduced hunting quotas in the

	b) Are external or internal ecological dynamics potentially or actually producing ecological regime shift(s)?	autumn of 2008. The ptarmigan population has also decreased most likely due to decreasing in the number of rodents, leaving the ptarmigan chicks more vulnerable to predators such as fox. **d) Are there specific social practices that might be contributing to ecological regime shifts** *"The possibility of combining different activities to make practical use of the local landscape remains of great significance to both sheep farmers and reindeer herders" (1).* Flexibility among animals and owners will have a positive effect on their ability to adjust and cope with changes.
II.8 Regime shifts	**If a regime shift exists and is important to this case describe it below.** Please indicate whether the regime dynamics are well-established, contested, or speculative.	
II.8.a. Detailed description of alternate regime shifts A case study can contain more than one type of regime shift	**Briefly describe the structure of each regime. What does each regime look like?** **What are differences in ecosystem structure and function? (e.g. permafrost loss, vegetation change)?** - The moth larvae outbreaks have resulted in land use changes (reduction in grazing land) affecting both sheep and reindeer and resulted in extensive deforestation of the birch forest area. - New grass species, herbs and plants entering the hairgrass dominated areas. **How do the properties and behaviours of regimes differ?** **e.g. collapse of subsistence food sources, fundamental change in types of livelihoods, change in governance institutions, new actors with significant political power who transform decision making)** Some changes in the livelihoods due to adjustments both by animals and local population to changes in the ecosystem	
II.8.b. Feedback mechanisms within the system that maintain each regime	**Ecological feedback mechanisms**	**Social feedback mechanisms** 1. **Joint grazing of sheep and reindeer** gives a possibility to cope with the moth outbreak situation and make good use of the moth affected parts of their pastures. Most sheep are gathered from their pastures when the autumn sets in. The reindeer migrate through the sheep grazing areas in

		Unjárga/Nesseby municipality after sheep are gathered from their pastures and could clearly benefit from fresh wavy hairgrass, sustained by the earlier grazing of the sheep. 2. **Flexibility among both animals and owners** will likely have a positive effect on their ability to cope and adapt to future climate change. However most of the households need more than one income. The resilience incorporated in self-sufficiency and combination of activities. Additional income from alternative activities (fishing, carpentry or teaching) or wage earning spouse ensures increased livelihood flexibility.
II.8.c. What key changes drive regime shifts? Describe how these changes alter the state of the system or feedback processes.	**a) Drivers of ecological regime shifts (either social or ecological).** Milder climate and changing seasonality **b) How do these changes alter biophysical feedback processes?**	**c) Drivers of social regime shifts (either social or ecological).** land use changes (reduction in grazing land) affecting both sheep and reindeer; resulted in extensive deforestation of the birch forest area, damage heath and berry plants and has an impact on moose and ptarmigan populations through the reduction of the choice of feed . **d) How do these changes alter the social feedback processes?**
II.8.d. Ecosystem services substantially impacted by regime shift	**a) Changes in ecological processes that produce ecosystem services**	**b) Changes in demand for ecosystem services (market and non-market)** **c) Changes in the institutional context of ecosystem services** **e.g. changes in access and changes in how ecosystem services are valued as expressed by rules and regulations.** Due to uncertain consequences of moth larvae outbreaks on moose stock, Unjárga/Nesseby municipality reduced hunting quotas in the autumn of 2008.

II.8.e. What is (+/-) impacted by changes in ecosystem services directly or indirectly	**a) Impacts from regime shift on ecological components**	**b) Impacts from regime shift on social actors** - Reduced hunting quotas in Unjárga/Nesseby - Local population travels long distances to pick up berries. + Some sheep farmers perceive the moth larvae outbreaks as advantageous. They point to positive effects of increased light and to the favourable fertilization of the soil from the moth larvae faeces. - "*Others consider the ecosystem changes negative, stressing that reduced biodiversity caused by wavy hairgrass monoculture will be a disadvantageous outcome of the widespread moth outbreaks*" (1). Reindeer herders are concerned "*that grass will displace lichen in parts of the winter pasture and thus reduce its nutritional value has been raised*".
II.8.f. Potential cascading effects	**Describe, if any, the likelihood of potential ecological cascading effects to other SES**	**Describe, if any, the likelihood of potential social cascading effects to other SES**
II.8.g. Where do actors intervene to alter regime shift dynamics and who can do the intervening?	**Ecological oriented interventions**	**Socially oriented interventions** Regime shift is most likely happening due to climate change. Flexibility among both animals and owners will help to cope with changes in the ecosystem.

REFERENCES/ SOURCES CITED:

(1)	**Rybråten S. and Hovelsrud G. 2010.** Local effects of global climate change: Differential experiences of sheep farmers and reindeer herders in Unjárga/Nesseby, a coastal Sámi community in Northern Norway. In: Community Adaptation and Vulnerability in the Arctic Regions. Editors G.K. Hovelsrud and B. Smit, Springer Publishers.
(2)	**Rybråten S. 2013** "This is not a wildness. This is where we live." Enacting nature in Unjárga/ Nesseby, Northern Norway. Faculty of social Science, University of Oslo 2013

GLOSSARY OF TERMS IN THE TEMPLATE

Actor	We use this term generally to look for individuals, groups, organisations, and so on that structure actions and/ or are

	stakeholders.
Adaptive capacity	Is the capacity of actors in the system to manage resilience in order to stay within a desired state during periods of change. This is related to the diversity in the system behind the provision of a function.
Disturbance	This refers to any disturbance to the system, regardless of scale, duration, intensity and frequency. See shock and stress.
Driver	Actor or process that directly or indirectly affects change in a social-ecological system. External means that the system in question (the scale being looked at) is unable to affect the driver in question – there is no feedback from the system to the driver.
Ecosystem services	The goods and services humans derive from ecosystems. These include: provisioning, regulating, cultural ecosystem services respectively.
Feedbacks	A change within a system that occurs in response to a driver, and that loops back to control the system. A feedback can help to maintain stability in a system (negative or balancing feedback), or it can speed up processes and change within the system (positive or enhancing feedback). Feedback processes play a very important role in determining system thresholds and in maintaining system resilience.
Institution	Here we refer to the humanly devised constraints that shape human interactions, such as rules, norms and laws. These can be formal or informal. Note that we are not referring here to institutions as organisations.
Regime shift	For complex systems, a substantial and enduring reorganization of the system, where the internal dynamics and the extent of feedbacks undergo change.
Resilience	This is a property, in this context of social-ecological systems. It relates to the capacity of a system to cope with disturbances and recover in such a way that they maintain their core function and identity. It also relates to the capacity to learn from and adapt to changing conditions, and when necessary, transform.
Shock	A sudden, unexpected disturbance. This kind of disturbance is often punctual, and has important impacts on large parts of the system.
Slow variable	When analysing complex system is often useful separating “fast” and “slow” variables. Fast variables often represent the primary concern of ecosystem users, for instance game or crop production. Slow variables shape the behaviour of fast ones but change slowly with respect to the overall dynamics of the system. Examples of slow variables might include permafrost thawing for a social-ecological system of Arctic hunters where the fast variable is game, or soil organic matter for an agricultural system where the fast variable is crop production.
Stress	This is a disturbance that has long persistence and often low intensity in impact.
Social-ecological system	This is an interwoven system of human societies and ecosystems. This concept emphasises that humans are part of nature and that these components function in interdependent ways. In the template identifying these interactions between the components aims to identify the processes and actors/ components that interact and particularly the feedbacks between the human-related components and the ecosystems/ biophysical components.
Stakeholder	See “actor”

Systems Diagram	This is using a diagram to illustrate the configuration of a system. This is done by defining its structure, function, and feedbacks. For a case there may be more than one diagram if the system changes in character (actors, processes, drivers, disturbances, feedbacks etc.) over time.
Timeline	The goal with the timeline is to capture important events – both punctual and over longer periods of time, identifying the causes of these events and the actors/ processes involved. This should be done chronologically and distinguishing events.