

Empowering the Steel Industry as a Stakeholder:
Environmental Management and Communication
through a Social-Ecological System Approach

Alicia Berg
Stockholm Resilience Centre - Stockholm University
Sustainable Enterprising Masters Program

Key words: ecosystems, ecosystem services, resilience, social-ecological systems (SES), systems perspective, the Corporate Ecosystem Services Review (ESR).

Summary

This paper explores a case study of a Swedish tool steel company undergoing a transition from traditional environmental management practices to an enterprise identifying its place as part of a social-ecological system. The Corporate Ecosystem Services Review (ESR) was utilized by the company to begin this process by focusing on ecosystem services to determine how an ESR approach contributes to environmental management in practice. What resulted moved beyond the ESR to a tailored methodology, the internalization of a systems perspective, and a proposed new environmental management system.

The results of the study provide a concrete, effective method for internalizing a systems perspective through a focus on ecosystems and presents a case for further analysis into what made it successful. It also provides an example of translating theory into practice, illustrating how a company can engage in sustainable development by valuing and managing the resilience of social-ecological systems through identifying their place in that system. The value of the results can be high for the case study company as well as for business in general.

Acknowledgements

The author would like to thank supervisors Dr. Sophie Carler, Cecilia Johnsson, Per Eiritz and Johan Mossfeldt for their strong support, time and talents. In addition, Jernkontoret, Uddeholms AB and Stål & Verkstad provided the unique opportunity to undertake this research. Also providing valuable insight and assistance were Dr. Lisa Deutsch and Dr. Cathy Wilkinson of the Stockholm Resilience Centre, Helén Axelsson of Jernkontoret, Louise Hård af Segerstad of Albaeco, and Anna Sjörs from Hagfors Kommun.

A special thank you to Per Eiritz and Patricia Edvardsson of Stål & Verkstad and FEM, who began and strongly supported the journey to this paper. And to Maria Jepson, Helena Andersson and Bosse Lindqvist for being generous with their time and introducing the author to the steel industry.

Finally, a thank you to the employees of Uddeholms AB in Hagfors for their hospitality and kindness.

But most importantly, this work would not have been done without endless support and love from Marcus and Karl-Erik Berg.

Contents

1 INTRODUCTION6
2 THEORETICAL FRAMEWORK.....7
3 CASE STUDY INFORMATION AND METHODS.....9
4 RESULTS13
5 DISCUSSION.....18
6 CONCLUSIONS21
7 REFERENCES22

APPENDIX A24

1 INTRODUCTION

It is becoming increasingly clear that environmental degradation is affecting human life and well-being often in complex and unpredictable ways. The aftermath of natural disasters such as hurricanes Katrina (2005) and Sandy (2012) in the United States, provide data quantifying the extent of our inherent reliance on and vulnerability to nature. However, environmental management in the private sector has traditionally focused on the effects humans have on nature, such as emissions, rather than our dependence upon or vulnerability to natural systems.

As a departure from this impact-only focus, concepts such as ecosystems, and ecosystem services point to a combined system of humans and nature, or social-ecological systems (SES). The uncertainty of social-ecological change and complexity of these systems is the focus of a resilience perspective. From these approaches, environmental change and degradation, which can lead to costly and irreversible effects for both human life and for business operations, can be better understood, anticipated, adapted to and mitigated. Companies can use these concepts to participate in sustainable development in a way that strengthens their future by accepting uncertainty and identifying their dependence as well as impact on ecosystems.

In 2008, the World Resources Institute published the Corporate Ecosystem Services Review (ESR), a tool for companies to bridge the gap between understanding ecosystems and application into their organizations (WRI 2008). Examples of companies utilizing the ESR to focus on ecosystems vary from car makers (Nissan 2013) to wine producers and other agricultural industries (Sandhu et al. 2012). It has been estimated that over 15,000 printed copies and 30,000 electronic copies of the ESR have been accessed (WRI 2010).

Several other publications, tools and organizations have been developed with the same goal of ecosystem valuation. Examples include the Economics of Ecosystems and Biodiversity report for Business (TEEB 2010), United Nations Environment Program's Ecosystem Management Program (UNEP 2009), and the Guide to Corporate Ecosystem Valuation (WBCSD 2011). Research, such as that by Daily and Matson (2008), has pointed to natural capital and financial institutions with regards to incorporating the value of ecosystem services and biodiversity.

And while several thousand copies of the ESR have been accessed in five languages (WRI 2010), only 300 companies have undergone the proposed methodology of that tool (WRI 2012). Thus it would appear that although business and industry recognize the importance of valuing ecosystem health and function and international organizations and research institutions support efforts to focus on ecosystem management, translating this value into business operations has not yet been achieved on a large scale, including within the Swedish steel industry.

The objective of this paper is to provide an example of resilience in practice as a means of strengthening environmental management, through a focus on social-ecological systems, the ESR, and a Swedish steel company. This paper aims to address: how an ESR approach contributes to environmental management in practice. And, what do the results of the fieldwork provide to address the gap between the theory of resilience of social-ecological systems and practical implementation within a company.

2 THEORETICAL FRAMEWORK

Private sector engagement in incorporating ecosystems into environmental management practices has increased in recent years (WRI 2012). Marking the beginning of this trend was the publication of the Millennium Assessment (MA) in 2005. The MA identified and evaluated global ecosystems and their services, with 60% of those services found to be damaged or in the process of degradation (MA 2005).

An ecosystem is "a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit" (MA 2005). One indicator of ecosystem health is the quality and quantity of ecosystem services, the benefits humans derive from ecosystems, such as water, soil production and air purification (MA 2005). Functioning ecosystems form the base for human well-being and are part of social-ecological systems, or interdependent systems of humans and nature (Berkes and Folke 1998).

Resilience of social-ecological systems has emerged from analysis of purely ecological systems (Holling 1973) to a means of analyzing ecological system dynamics to enable management of these systems so they may retain their valuable life-supporting functions (Folke 2006, Walker and Salt 2006). For a social-ecological system to be resilient, it must be able to withstand unexpected change yet still retain its function, using change as opportunity for development (Holling 1973, Folke 2006).

A resilience perspective offers a departure from traditional environmental management practices, such as ISO 14001 environmental management systems, by focusing on the dynamics of humans and nature as parts of a system, rather than focusing solely on effects of human activity as seen in nature:

"Resilience thinking is all about seeing the system - the social-ecological system that we're all a part of - as one interlinked system...If we accept this premise it changes the way we look at the world" (Walker and Salt 2006, p.32).

As part of this system, humans both impact and are affected by changes in the environment. Environmental change can take place at varying rates and degrees, posing challenges to prevention and mitigation efforts (Walker and Salt 2006). Focusing on the resilience of social-ecological systems allocates for the anticipation of unexpected change and the need for a larger scope of consideration:

"A management approach based on resilience, ...would emphasize the need to keep options open, the need to view events in a regional rather than a local context...not the assumption that future events are expected, but that they will be unexpected" (Holling 1973, p.21).

A resilience approach has been taken to assess entire countries, such as Australia (Cork et al. 2008) to local municipalities such as Eskilstuna in Sweden (Stockholm Resilience Centre 2013). Resilience in practice has been a recent focus of research such as Walker and Salt (2012), as well as tools including the Resilience Assessment (Resilience Alliance 2007) and social-ecological inventories (Schultz et al. 2007). Walker and Salt establish the difference between resilience in theory and in practice:

"Resilience thinking is the capacity to envisage your system as a self-organizing system with thresholds, linked domains, and cycles. Resilience practice is the capacity to work with the system in order to apply resilience thinking, to manage its resilience"
(Walker and Salt 2012, ch 1.7).

Key to adopting a resilience approach is a systems perspective. This can be adopted through identifying the components of a system, how they are connected and the function of the system itself (Meadows 2008).

"The systems-thinking lens allows us to reclaim our intuition about whole systems and hone our abilities to understand parts, see interconnections, ask "what if" questions about possible future behaviors, and be creative and courageous about system redesign"
(Meadows 2008, p 6).

This paper addresses the gap between the theory of resilience of social-ecological systems in practice and the adoption of such an approach within a company. General insight into practice is provided through a case study of a large, private, multinational company, with specific insight into the Swedish steel industry and the use of the ESR. The results of the fieldwork were analyzed in relation to resilience of social-ecological systems in practice and illustrate an evolution of traditional environmental management to a process which facilitated a systems perspective crucial to managing the resilience of ecosystems and ensuring a responsible operating future.

3 CASE STUDY INFORMATION AND METHODS

Case study research, participatory action research and interpretive policy analysis were chosen as the research methods for this paper. For a period of three months a single, in-depth case study was carried out within the Production/Environment department (P/ED) of Uddeholms AB in Hagfors, Sweden (Figure 1). The approach to the case study was participatory action research and interpretive policy analysis was used to analyze data.



Figure 1. Case study site in Hagfors, Sweden (Google maps).

3.1 Case Study Description and Background

Nestled between the river Uvån and lake Värmullen in Hagfors, Uddeholms AB is a tool steel company originally founded in 1668 (Figure 2). Tool steel from Uddeholms AB is used in the manufacture of cars, computers, mobile phones, appliances and industrial machinery, among many other products. The company employs a staff of 3,000 worldwide with 900 in Hagfors and competes in over 100 global markets with 100,000 customers (Uddeholms AB 2011). The location in Hagfors is optimal for water usage with water for production (Appendix A) and cooling taken in from upstream Uvån and released into Värmullen (Figure 3).



Figure 2. Company logo (Uddeholms AB)



Figure 3. Map of lake Värmullen and river Uvån in relation to Uddeholms AB (Eniro).

An environmental management system is in place at Uddeholms AB which includes ISO 14001 certified routines for environment and quality as well as 50001 certification for energy management that is on track to be implemented. There is a separate department for environment (P/ED) with three employees, which supports the operational management system of the company. Uddeholms AB reports annually to local and national authorities regarding environmental impacts of operations and must apply for permits under the jurisdiction of the Swedish Environmental Court. Monitoring of water, air, soil and noise is taken at a frequency ranging from every other hour to several times per year.

3.2 Case Study Method

A single case study was chosen over a multiple case study approach due to a combination of the company being the first in its industry in Sweden to attempt to integrate the ESR, as well as a company whose structure and function can be seen as representative of other steel companies. Therefore, it would represent both a "unique case" as well as a "representative case" (Yin 2003). In addition, the case study design is 'holistic', in that the company and its management system are studied as a whole, rather than consisting of sub-systems (Yin 2003).

3.3 The ESR Tool

Use of the Corporate Ecosystem Services Review (ESR) formed the basis for the fieldwork. This tool was chosen as it was the original tool published following the 2005 Millennium Ecosystem Assessment (MA) and is currently being used by over 300 companies (WRI 2012). In addition, the methodology presented in the ESR (Figure 4) is reiterated in other publications on ecosystem services and business, such as The Economics of Ecosystems and Biodiversity, or TEEB.

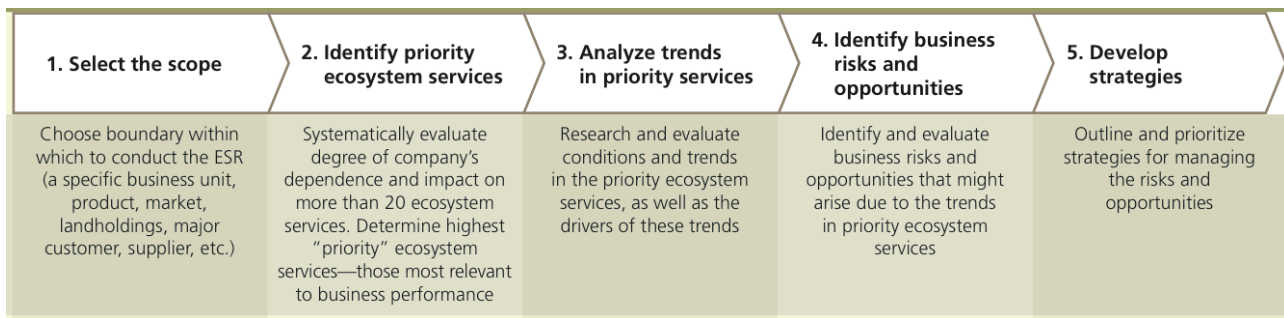


Figure 4. The ESR 5 step methodology (WRI 2012).

As part of the case study Uddeholms AB, led by the author who was familiar with social-ecological systems and the ESR, completed the first three steps of this methodology. Given the set time of three months for the case study, it was agreed to limit the method to only one priority ecosystem service with which to proceed to step three. The scope of ESR step one and selection of the priority ecosystem service was done by the P/ED. Following ESR step three, the company proceeded only with the goal of strengthening environmental management by using an ecosystems perspective. No other external publications or tools were utilized.

3.4 Participatory Action Research

Participant-observation was used to gather data. The author acted as a facilitator and led the first three steps of the ESR. The company then led the direction of the fieldwork and the author drove discussion with questions to clarify decisions made by the participants from the company. Facilities tours were provided for observation of production units and processes.

Participatory action research was chosen as the form of research for this case study as it highlights practical application:

"PAR (participatory action research) combines theory and practice in cycles of action and reflection that are aimed at solving concrete community problems..." (Sage Handbook of Qualitative Research 4 2011, p.387).

The prescribed combination of action and reflection was set by the frequency of site visits being once per week, to allow the P/ED of Uddeholms AB to discuss internally the processes and data emerging from the fieldwork methodology. This proved to be key for allocating time for the company to enable themselves to lead the fieldwork following ESR step three, as participants had been discussing the fieldwork between site visits and utilizing each other as well as other departments for data gathering.

3.5 Data Collection Method and Interpretive Policy Analysis

Field notes were chosen as the main means of data collection for the case study and were handwritten on site, later typed into a summary of day's events and organized by site visit. These included observations, with recurring concepts such as 'water', 'risk', 'ecosystems' and 'systems', highlighted as they were recorded. Informal interviews were conducted frequently, especially when other departments of the company were approached by the P/ED for information. The author asked questions to identify and clarify internal policy and procedure that appeared to be understood by the

participants, but not by the author. Participants were asked to describe their experience of the methodology at the end of the fieldwork.

The 'Uddeholms AB Model' (Section 4.3, Figure 5) is a visual representation of the proposed new environmental management system. It is both a data source as well as a result of the case study. This was created during the latter course of the fieldwork in a meeting held by the P/ED, including a representative from operational management and the author.

Documentation was requested by the author throughout the fieldwork to obtain information regarding the company's operational management system which includes the environmental management system, as well as environmental legislation requirements and routines. Publicly-available documents included the Environmental Report, Swedish Environmental Court records for water permits, Environmental Impact Description report, ISO 14001 documentation, and water investigation report. The author was given access to internal documentation, from which handwritten notes were taken, including an operational site map, a risk assessment report on water, internal email communication, and the company's tool to track performance, known as the business score card.

Interpretive policy analysis (Yanow 2000) was used to analyze the data collected and included analyzing of documentation, reviewing of field notes which included documented observations and informal interviews. This method was chosen as it focuses on observation and identification of key words among different actors (Yanow 2000).

3.6 Methods Critique

Although the limitations imposed on the case study of one ecosystem service and a partial ESR methodology provided benefits to the outcome of the fieldwork, it is not known how Uddeholms AB would experience the entire methodology of the ESR, nor how, nor if the other six priority ecosystem services can be incorporated the same way as water. As the time frame for the work was limited to three months, the outcome of the 'Uddeholms AB Model' or the experience of the company integrating the proposed new environmental management system is also not known. The use of a single case study meant comparison with another company in the same industry or located in another country is not provided, thus results may not be of value for business as a whole.

4 RESULTS

The purpose of this study was to examine how an ESR approach contributes to environmental management in practice. The results of the study are threefold: 1) an adapted ESR method for incorporating an ecosystem perspective into the company was developed, 2) this process internalized a systems perspective critical for understanding and managing the resilience of social-ecological systems and 3) a proposal for a new environmental management system was developed. Results are presented below following these three categories.

4.1 An Adapted ESR Method

The ESR was adapted to the needs of Uddeholms AB while still helping the company: "...identify the connections between a company's impact or dependence on ecosystem services and potential business risks or opportunities" (WRI 2012, p8). This process was initially guided by the ESR, but later led and created internally by the company and facilitated by the author (Table 1).

Table 1. Fieldwork Methodology. Methodology used during the case study by the author and Uddeholms AB to integrate a social-ecological system approach into the company.

Fieldwork Methodology	ESR Step One	ESR Step Two Dependence and Impact	ESR Step Three Drivers, Conditions	Exploring Risk Assessment	Exploring ISO 14001 routines	Implementation
Methodology Description	Section of Scope	The Dependence and Impact Assessment Tool	Identification of Drivers, Conditions	Existing internal structures, personnel, routines identified and considered. External tools for risk assessment sought.	Consultation with personnel in Operational Management. Review of databases, reporting structures.	Proposing a new system for Environmental Management

First, Uddeholms AB's production site in Hagfors was selected by the P/ED as the scope of the ESR. Second, completion of the Dependence and Impact Assessment Tool identified seven priority ecosystem services (those for which both dependence and impact for the company were high). From these seven, the P/ED (as per author-imposed limitation) chose freshwater from Uvån for use in ESR step three. This was due to: 1) water quantity needed immediately as well as long-term for operations, and 2) water connects other ecosystems and services, such as air purification in the form of a 'sink', which raised the possibility for extending the scope of review in the future.

Next, during ESR step three other companies, local authorities and organizations were identified as external stakeholders, which began discussions on risk and natural disaster mitigation. Also, the location of the company gained new value for maximizing water intake and output, pointing to intra-corporate advantages for water costs and the discovery of a lack of data collection for site-wide water usage. After this step, the company then complemented the ESR with existing risk assessment and ISO 14001 routines. Only one risk assessment on water was found, exposing the need for more robust and detailed assessment of water dependence and use.

During this phase of the adapted methodology, communication between production units regarding water dependence and use identified an internal water system involving all employees and units of production. Water was translated to a 'critical production input'. Though many external tools for assessing water risk are available, none were identified as the right fit for the company. Exploring ISO 14001 routines was the penultimate step in the adapted methodology, which found that water is

a key environmental aspect with current ISO reporting and routines, however, not translated into company-wide management policies or practices.

Lastly, the adapted ESR methodology combined the ecosystem approach of the ESR with existing internal structures and routines for environmental management, resulting in the creation of proposal for a new environmental management system, or the 'Uddeholms AB Model' (Figure 5). The main difference between this new environmental management system and the current one is the direct path of environmental management to company-wide goals and unit-specific targets as well as the ecosystem approach. An example of this is the change of 'freshwater ecosystem management' into a company goal of 'securing production'.

4.2 A Systems Perspective

Evidence of the internalization of a systems perspective, essential for addressing the resilience of social-ecological systems (Walker and Salt 2012), was seen in author observations of language and in the 'Uddeholms AB Model' (Figure 5) itself that was created by the company: 1) Components of an internal system were identified as well as, 2) how these components were connected, followed by 3) characterization of the overall system function and boundaries (Meadows 2008).

The focus on water as an important resource for the company brought about the identification of an internal system of water use and recirculation. From the beginning of the fieldwork, employees from the P/ED began communicating with other units about water as an ecosystem service, discovering 1) how and to what extent all units are dependent upon water. This led to the initiation of data collection on internal water use and recirculation, which 2) describes the relationship between different production units and provides data on 3) site-wide water dependence and use for production.

Step three of the ESR helped the company identify an external system of stakeholders which they were a part of, including other companies and legislation. Employees began speaking frequently about 'systems' when exploring ISO 14001 routines and the company's existing environmental management system, though it was not discussed by the author. Internal and external systems came together in the 'Uddeholms AB Model', where internal systems of water use will be guided by an annual evaluation of external systems of stakeholders, legislation, and the condition of priority ecosystem services. Table 2, below, presents author observations of this process and field notes for each step of the adapted ESR methodology.

Table 2. Integrating Ecosystems: from Impacts to Systems. A chronology of the fieldwork including results leading up to the creation of the 'Uddeholms AB Model'.

Fieldwork Methodology	ESR Step One	ESR Step Two Dependence and Impact Assessment Tool	ESR Step Three Drivers, Conditions	Exploring Risk Assessment	Exploring ISO 14001 routines	Implementation
Methodology Description	Section of Scope	The Dependence and Impact Assessment Tool	Identification of Drivers, Conditions	Existing internal structures, personnel, routines identified and considered. External tools for risk assessment sought.	Consultation with personnel in Operational Management. Review of databases, reporting structures.	Proposing a new system for Environmental Management
Results: Fieldwork Notes and Outcomes, Internal and External Documentation	Uddeholms AB production site in Hagfors selected by the Production/Environment department.	Identification of 7 priority ecosystem services. Production/Environment chose freshwater from Uvån for use in ESR step 3 due to: water quantity needed immediately as well as long-term for operations. Water connects other ecosystems and services, such as air purification. This can aid in extending scope of review in the future.	Other companies, local authorities and organizations were identified as external stakeholders, which began discussion on risk and natural disaster mitigation. The location of the company gained new value for maximizing water intake and output, pointing to intra-corporate advantages for water costs. Discovered lack of data collection for site-wide water usage.	Only one risk assessment on water was found, raising need for more robust and detailed assessment of water dependence and use. Communication between production units regarding water dependence and use identified an internal water system involving all employees, units of production. Translated to a 'critical production input'. Many external tools for assessing water risk available, but none the right fit.	Water is a key environmental aspect with current ISO reporting and routines; however, not translated into company-wide management policies or practices.	The 'Uddeholms AB Model' for a proposed new environmental management system including existing environmental reporting and routines. It is new because of the direct path of environmental management to company-wide goals and unit-specific targets. Also, the ecosystems approach. An example of translating freshwater ecosystem management into a company goal: 'securing production'.
Results: Author Observations	Participants said the ESR was easy to read and seems possible to undergo, but hard to understand at this stage how the company can use it in practice.	Discussion of water was concrete, clear and participants were confident of information written into the Dependence and Impact Assessment Tool (ESR). Other ecosystem services, such as air quality regulation, were more difficult to discuss or provide information for.	Raised awareness that little information exists on water intake from Uvån.	A search for risk assessment led to the understanding that the individual production units of the company differ greatly from each other, thereby risk assessment should be an end result rather than a means of incorporating an ecosystem service into operations.	For time and resource efficiency, incorporating ecosystem services into environmental management would require consideration for reporting and certification routines already in place, such as ISO 14001. It was determined not possible to incorporate an ecosystems approach using solely ISO routines.	Though never discussed by the author in advance, participants are now referring to 'systems', how water use in each unit is part of a larger system and how Uddeholms AB is part of a system of ecosystem stakeholders.
Results: Observed Repeated Language	ecosystems, ecosystem services, environmental aspects, Värmullen, cooling water	ecosystem services, water, dependence, risk, Uvån	Uvån, stakeholders, dialogue, legislation, communication, costs, risks	Uvån, costs, risk, units of production, internal water system, critical production input, communication	key environmental aspects, management systems, dependence, communication	systems, securing production

4.3 A New Environmental Management System

Resulting from the fieldwork methodology and the insight into their social-ecological system, Uddeholms AB created a proposal for a new environmental management system to practically apply a social-ecological system approach (Figure 5).

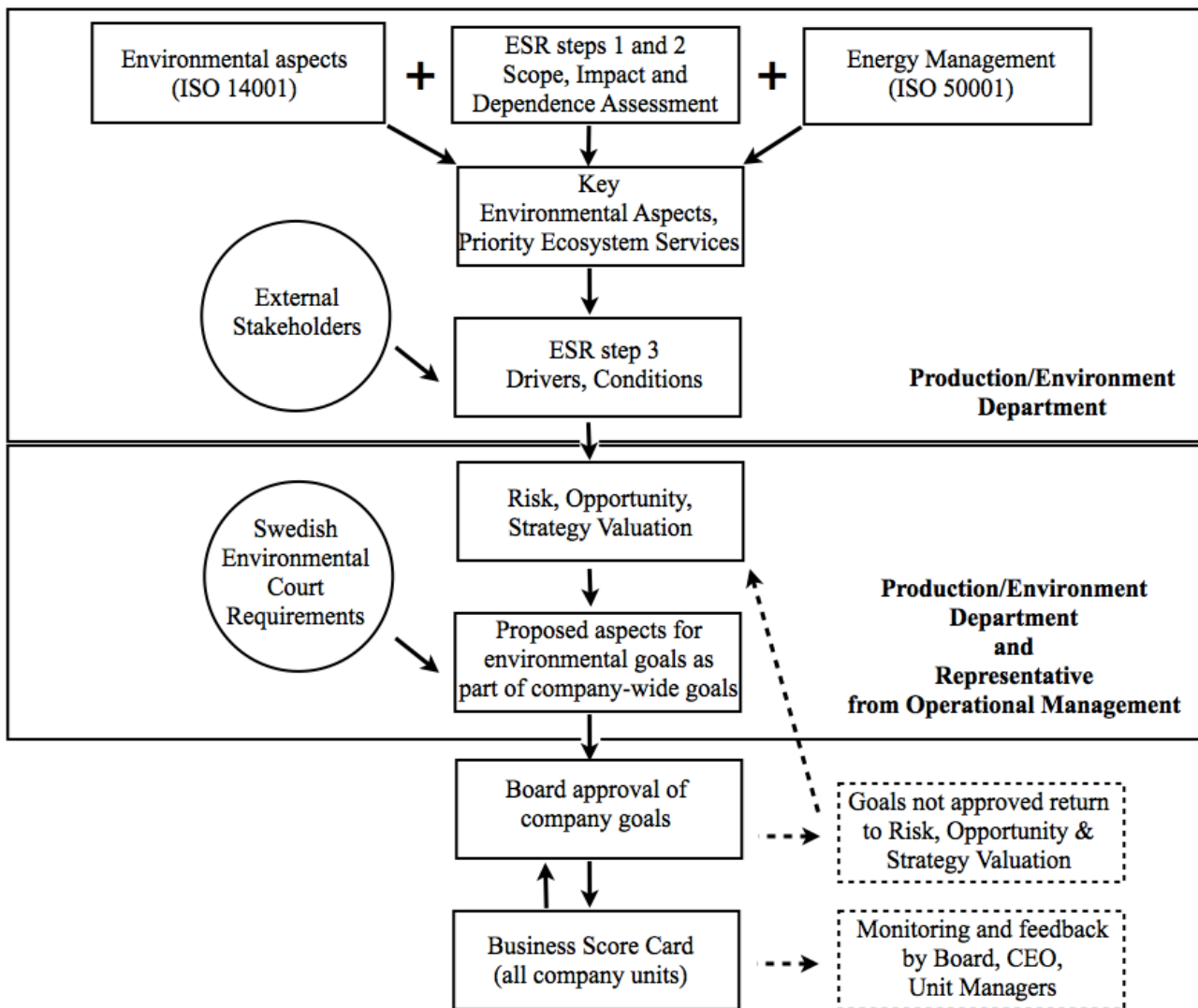


Figure 5. Graphic representation of the proposed new environmental management system at Uddeholms AB, referred to as the 'Uddeholms AB Model' by the company.

Beginning with a yearly review of environmental aspects per ISO 14001 routines, selection of scope for assessment of dependence and impact on ecosystem services via ESR steps one and two will take place simultaneously, as well as a review of the future ISO 50001 energy management system. This is done by the P/ED. Following this review, key environmental aspects and priority ecosystem services will be selected for further review via ESR step three, which determines the drivers and conditions of the priority services and key aspects.

Once this information has been collected, identifying risks and opportunities for strategy valuation will be undertaken by the P/ED together with the Operational Management department. The critical next step in the new environmental management system occurs when the risks, opportunities and strategies from the previous step are translated into the existing procedure for proposing company-wide goals. These goals are also influenced by requirements from the Swedish Environmental Court.

Proposed goals move to the Board of Directors for approval and upon approval become company-wide goals which stipulate specified targets for each unit of the company. These targets are documented and monitored via the business score card, which is used by every department and unit at the company to track and document progress towards targets throughout the year. Should proposed goals not be approved, they will return to the risk, opportunity and strategy valuation stage for reconsideration. Adopted goals are continuously reviewed and feedback is provided by the Board of Directors, CEO and unit managers.

5 DISCUSSION

The adapted ESR method used by Uddeholms AB to incorporate ecosystem services into the company facilitated the internalization of a systems perspective, identifying the complexity of internal and external systems. From this a proposal for a new environmental management system was created, combining complexity and the unpredictable nature of ecosystems with a clear approach from the company. This new environmental management system reflects that the company operates as part of a social-ecological system, a critical point of departure for managing the resilience of that system (Walker and Salt 2006) in which both complexity and uncertainty are accounted for.

5.1 An Adapted ESR Method

Understanding the key role ecosystems play for Uddeholms AB was only one important result of the fieldwork; how this took place in a way that concretely affects operations so as to create lasting change is of greater importance for business and further research. The ESR methodology was adapted to the language and management structures of Uddeholms AB, allowing for the internalization of a company-relevant systems perspective. A systems perspective is needed for understanding the complexity of social-ecological systems and managing resilience of those systems for putting resilience into practice:

"...it's not about making things more complicated. It is about enabling you to engage with complexity and focus on what's important. Resilience thinking is a problem-framing approach to your system that seeks to help you decide what's important for the sustainability of the things you value, that you should be focusing on" (Walker and Salt 2012, ch 1.10).

Author observations (Table 2) captured this internalization, with the language of the ESR and the importance of water being clear in the beginning of the process, becoming more complex in terms of data gathering during ESR step three, then both dividing the company in terms of risk assessment and connecting internal management systems as seen in the 'Uddeholms AB Model'. Water gained a substantially greater value for Uddeholms AB, emerging as the most critical resource for daily operations. A concrete example of this change is that freshwater began as an ecosystem service but became a 'critical production input'. Strengthening a freshwater ecosystem, complex in theory, became a way of 'securing future production', making the financial case for managing the resilience of a freshwater ecosystem over the long term.

These developments led to the operational feasibility of addressing water as a natural resource beyond the P/ED as a company-wide issue. As a company-wide issue, water will gain not only a monetary value to the company but also a risk value, requiring long-term investment and management. Thus, the adapted ESR methodology used in the fieldwork both identified complexity and focused the company on a critical production value, as prescribed for resilience in practice (Walker and Salt 2012).

5.2 A Systems Perspective

Understanding how humans and nature are linked in a system is a cornerstone of resilience thinking (Walker and Salt 2006). Though never discussed by the author in advance, the P/ED at Uddeholms AB began referring to 'systems' towards the end of the fieldwork period; how water use in each unit is part of a larger system and how the company is part of a system of ecosystem stakeholders (Table 2). This was perhaps the most important result of the case study as it showed the company

had identified itself as part of a social-ecological system. As part of this system, a wider scope of factors for decision-making (Holling 1973), will lead to lasting change in the way the company operates in regards to the environment.

For example, when considering water use for on-site steel production, outside factors such as external stakeholders, legislation and the condition of the freshwater ecosystem will be included in decision-making. This is reflected in the proposed new environmental management system (Figure 5). The company's dialogue and relationship to other stakeholders as well as legislators will also be driven by a systems perspective as they consider the consequences of decisions by legislators and actions of other stakeholders to the extent by which these affect the ecosystems the company itself is reliant upon.

To effectively work with ecosystem services, it would seem that a company would need to incorporate a systems perspective to manage ecosystems by 'working with' these systems (Walker and Salt 2012) and opening consideration for changes in future system behavior (Meadows 2008). The ESR does not refer to a systems perspective, nor does it have that as a goal. Narrowing the scope of the ESR was an important decision taken by the author as it enabled a focus on methodology, rather than gathering and organizing information on seven priority ecosystem services. By choosing only one ecosystem service, the space for internalization of the process of thinking through an ecosystems perspective and conceptualization of a systems perspective was enabled. This goes in line with participatory action research in alternating action and contemplation (Sage 2011).

A systems perspective is an important first step towards managing resilience of social-ecological systems. Walker and Salt (2012) refer to: "describing the system, assessing its resilience, and managing its resilience" (p.1). Resilient ecosystems can provide for resilient businesses through secure resource production, such as freshwater. Uddeholms AB has described their system and can now begin assessing its resilience. This goes beyond identifying the role of ecosystem services for a business to making the case for investing in resilience of social-ecological systems to ensure a secure operating future for a company.

5.3 A New Environmental Management System

A company does not have to completely overhaul existing routines and environmental management systems to incorporate a social-ecological system approach. Nor does it have to invest a large amount of personnel initially, in contrast to what is prescribed in the ESR (WRI, Table 4, 5 2012). Two employees from the P/ED along with the author began and led the fieldwork through the company in three months, meeting once a week. This process was not only cost-effective, but time efficient in terms of moving directly to identifying 'what is important' (Walker and Salt 2012), such as the company's place in a social-ecological system. To this extent, it is important that a person with competence in social-ecological systems is involved to complement company knowledge and skills.

As a result of the internalized systems perspective (Table 2), Uddeholms AB was able to "...be creative and courageous about system redesign" (Meadows 2008, p 6) and developed a proposal for a new environmental management system, or the 'Uddeholms AB model' (Figure 5). This is a contrast to case study examples presented in the ESR, such as Mondi, RioTinto or Azko Nobel as Uddeholms AB used the ESR to change their environmental management system as a whole rather than to address specific customers, markets or investment projects (WRI 2012, Box 18, p.31).

From the new proposed environmental management system, existing ISO 14001 routines are viewed in relationship to the company's place as part of a social-ecological system, rather than leading the company's environmental management system. One example is that freshwater is currently a key environmental aspect for Uddeholms AB, but the focus is mostly on the operational impact on lake Värmullen and there have been logistical challenges to move this aspect beyond the P/ED to influence decisions in other parts of the company. The proposed new environmental management system considers all units of the company as part of an internal system of water use, dependent upon water from the river Uvån regardless of the unit size or function. And changes in the freshwater ecosystem of Uvån are seen as directly relevant to every unit.

Assessing risk is another area that will be strengthened in the new environmental management system, as unit-specific targets will determine the extent and scope of risk assessment. For example, the goal of 'securing future production' (Table 2) will elicit risk assessment at all levels of production. Given the necessity of water for all production units, risk assessment on water will become more robust, giving the company greater capacity to ask and address the "what if" questions about future ecosystem behavior (Meadows 2008).

6 CONCLUSIONS

It has been eight years since the publication of the Millennium Assessment (MA). The concept of Planetary Boundaries has started an international dialogue as to the limits of natural systems and the term 'ecosystem services' is regularly used, from UN organizations (such as UNEP) to over 300 businesses (WRI 2012). And now a Swedish tool steel company has gone a step further by identifying their place as part of a social-ecological system, making them an active and vested stakeholder for managing the resilience of this system.

From this point of view, the company must operate within the limits of maintaining healthy ecosystems. This departure gives viable consideration to the existence of biophysical limits to maintaining a functioning operating space for human development (Rockström et al. 2009). Should all companies, such as Uddeholms AB, operate from a social-ecological systems perspective, operating within Planetary Boundaries for the long term may be within our reach.

Future Study

This case study and research focused solely on ecosystems and Uddeholms AB with regards to resilience of social-ecological systems in practice. The data gathered during the fieldwork were numerous and can be further analyzed using other theories and disciplines such as organizational theory, economics, risk assessment, and business administration to identify both the processes of change the organization underwent and impacts on business operations. Complementing the fieldwork, a Resilience Assessment and/or Social-Ecological Inventory for Uddeholms AB's freshwater ecosystems could be good next steps for research. Alternatively, exploring how this case study can be viewed in terms of transformation in resilience theory can provide insight as to how and why the results were achieved.

The methodology chosen by Uddeholms AB may have the potential to be utilized by other companies, regardless of industry, location or size. Most importantly, industrial companies have a model from which to consider a social-ecological system approach, as it has been shown in this case study that the tools exist now for taking such an approach. Due to the low investment of time or resources of the methodology presented, small and medium enterprises (SMEs) can equally participate.

7 REFERENCES

- Berkes, F., and C. Folke, editors. 1998. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge University Press, New York.
- Cork, S., Walker, B., and R. Buckley. 2008. *How Resilient Is Australia?* Australia 21 Discussion Paper. [online] URL: http://www.australia21.org.au/oldsite/pdf/How_resilient_is_Australia.pdf
- Daily, GC., and PA. Matson. 2008. Introductory Perspective: Ecosystem Services: From theory to implementation. *PNAS* 105: 9455-9456. [online] URL: <http://www.pnas.org/content/105/28/9455.full.pdf+html>
- Denzin, NK., and YS. Lincoln, editors. 2011. *The Sage Handbook of Qualitative Research 4*. Sage Publications, Thousand Oaks, CA, USA.
- Folke, C. 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change* 16: 253-267. [online] URL: <http://www.sciencedirect.com/science/journal/09593780>
- Holling, C.S. 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4:1-23.
- Meadows, DH. 2008. *Thinking in systems: a primer*. Chelsea Green Publishing, Vermont, USA.
- Millennium Ecosystem Assessment (MA). 2005. *Ecosystems and Human Well-Being: General Synthesis*. Island Press, Washington, D.C., USA.
- Nissan Motor Co., Ltd.. 2010. *Ecosystem Services and the Automotive Sector*. [online] URL: <http://www.nissan-global.com/EN/ENVIRONMENT/SOCIAL/BIODIVERSITY/>
- Resilience Alliance. 2013. *Assessing resilience in social-ecological systems: Workbook for practitioners*. Version 2.0. [online] URL: http://www.resalliance.org/index.php/resilience_assessment
- Rockström, J., et al. 2009. Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society*. [online] URL: <http://www.ecologyandsociety.org/vol14/iss2/art32/>.
- Sandhu, H., Nidumolu, U., and S. Sandhu. 2012. Assessing Risks and Opportunities Arising from Ecosystem Change in Primary Industries Using Ecosystem-Based Business Risk Analysis Tool. *Human and Ecological Risk Assessment* 18: 47–68, 2012.
- Schultz, L., Folke, C., and P. Olsson. 2007. *Enhancing Ecosystem Management through Social-Ecological Inventories: Lessons from Kristianstads Vattenrike, Sweden*. *Environmental Conservation* 34: 140-152.
- Stockholm Resilience Centre. 2013. *Resilience Conference: Planetary City Limits*. [online] URL: <http://www.stockholmresilience.org/21/research/research-news/1-31-2013-planetary-city-limits-.html>
- The Economics of Ecosystems and Biodiversity (TEEB). 2010. *TEEB in Business and Enterprise*. [online] URL: <http://www.teebweb.org/publications/teeb-study-reports/business-and-enterprise/>

Uddeholms AB. 2011. Environmental Report for Uddeholms AB 2011. Hagfors, Sweden.

United Nations Environment Programme (UNEP). 2013. [online] URL: <http://www.unep.org/ecosystemmanagement/>

Walker, B., and D. Salt. 2006. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press, Washington, D.C., USA.

Walker, B., and D. Salt. 2012. Resilience Practice: Engaging the Sources of Our Sustainability. Island Press, Washington, D.C., USA.

World Business Council for Sustainable Development (WBCSD). 2011. Guide to Corporate Ecosystem Valuation: A framework for improving corporate decision-making. [online] URL: <http://www.wbcsd.org/Pages/EDocument/EDocumentDetails.aspx?ID=104>

World Resources Institute (WRI). 2010. "Over 200 Companies Now Use the Corporate Ecosystem Services Review". [online] URL: <http://www.wri.org/stories/2010/08/over-200-companies-now-use-corporate-ecosystem-services-review>.

World Resources Institute (WRI). 2008. The Corporate Ecosystem Services Review: Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change. Version 1.0. Washington, D.C., USA.

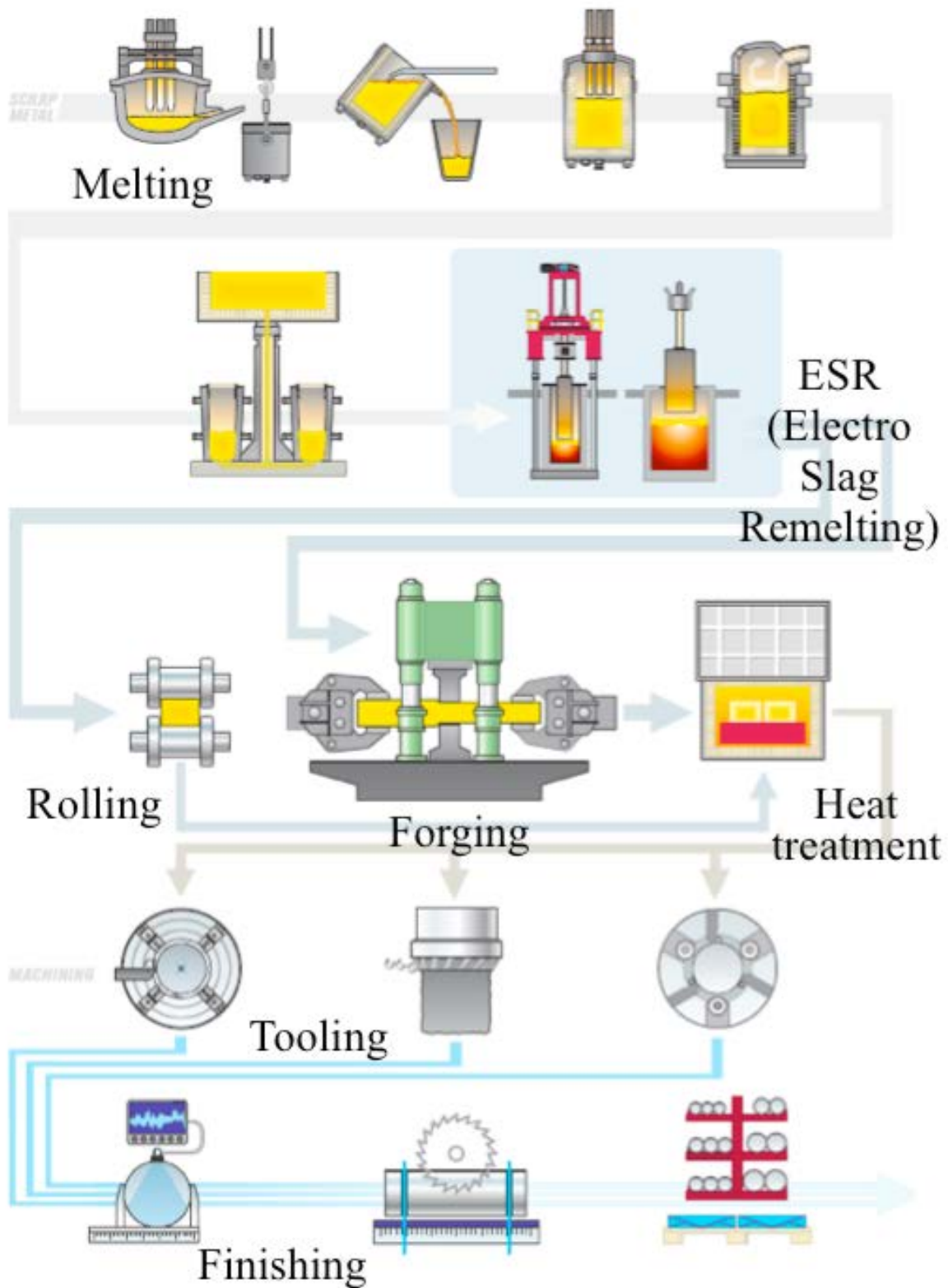
World Resources Institute (WRI). 2012. The Corporate Ecosystem Services Review: Guidelines for Identifying Business Risks and Opportunities Arising from Ecosystem Change. Version 2.0. Washington, D.C., USA. [online] URL: <http://www.wri.org/publication/corporate-ecosystem-services-review>.

Yanow, Dvora. 2000. Conducting Interpretive Policy Analysis. Sage Publications, Thousand Oaks, CA, USA.

Yin, R.K. 2003. Case Study Research: Design and Methods. Third Edition. Sage Publications, Thousand Oaks, CA, USA.

APPENDIX A

Production processes at Uddeholms AB (Uddeholms AB 2011). Processes include melting, electro slag remelting (ESR), forging, rolling, heat treatment, machining and finishing.



THE SWEDISH STEEL PRODUCERS' ASSOCIATION

Since its foundation back in 1747, Jernkontoret has been owned jointly by the Swedish steel companies. Jernkontoret represents Sweden's steel industry on issues that relate to trade policy, research and education, standardisation, energy and the environment as well as taxes and levies. Jernkontoret also manages the joint Nordic research in the steel industry. In addition, Jernkontoret draws up statistical information relating to the industry and carries on research into the history of mining and metallurgy.

JERNKONTORET

Box 1721, SE-111 87 Stockholm, Sweden • Kungsträdgårdsgatan 10
Telephone +46 8 679 17 00 • Fax +46 8 611 20 89
E-mail office@jernkontoret.se • www.jernkontoret.se

