Rewilding sustainability transitions: A socio-techno-ecological systems perspective on the Swedish wild berry industry

Paul Plummer[a], Johnn Andersson[a], Thomas Lennerfors[a], Petter Forsberg[b]*

[a] Division of Industrial Engineering and Management, Department of Civil and Industrial Engineering, Uppsala University, Sweden

[b] Research Institutes of Sweden (RISE)

*Corresponding author: paul.plummer@angstrom.uu.se, +46 (0) 72 5241898

1. Introduction

A shared concern over climate change, biodiversity loss and other environmental problems is at the heart of sustainability transitions research. As we strive to understand and promote shifts to radically different modes of production and consumption, the broad social and environmental values captured by the notion of "sustainability" guide our investigations and explicitly serve as normative goals for the research effort (Van Den Bergh, Truffer, and Kallis 2011). But at the same time, the transitions literature is dominated by an analytical perspective that focuses on society and technology, while the natural environment is strikingly absent from theoretical frameworks and analytical approaches. Key concepts such as niches and regimes, production and consumption systems, and innovation systems have a rich socio-technical texture (Rip and Kemp 1998; Geels 2002; Bergek et al. 2008; Hekkert et al. 2007), but fail to capture how ecosystems enter into transition processes. In essence, transitions are conceived as socio-technical phenomena, while nature is treated as a contextual background.

Somewhat surprisingly, this paradoxical feature of transitions research has been subject to little debate within the transitions community. A socio-technical systems perspective permeates the literature, and there have been few explicit calls or attempts to reframe transitions as socio-techno-ecological phenomena (Ahlborg et al. 2019a; Jagt et al. 2020). Nevertheless, there are clear arguments as to why an advancement towards analytical frameworks that pay more attention to the natural environment could be worthwhile. Ecological elements influence innovation dynamics and thus play an important role in how transitions to new modes of production and consumption unfold (Vermunt et al. 2020; Andersson, Hellsmark, and Sandén 2018). In addition, the "more sustainable" environmental impacts associated with transition outcomes may have vastly different characteristics depending on the realised transition pathway, and these differences are not made explicit in socio-technical systems frameworks that treat nature as a contextual background (Olsson, Galaz, and Boonstra 2014).

The need to pay more attention to the natural environment when analysing transitions is particularly salient in empirical domains where the production and consumption systems in focus are closely intertwined with ecosystems. One such domain is the agro-food sector, which is increasingly investigated by transitions researchers (El Bilali 2019; 2020; Vermunt et al. 2020; Melchior and Newig 2021). The value chains that define this sector are inseparable from the natural environment, since the starting-point for most food products is a production process that occurs within ecosystems rather than technical facilities.[1] While these ecosystems are for the most part managed through, or at least influenced by, agricultural practices, they are nevertheless defined by characteristics that are not captured by socio-technical systems frameworks. To fully capture the dynamics of transitions in the agro-food sector, and beyond, there is accordingly a need to open up the traditional conception of transitions and advance towards a socio-techno-ecological systems perspective.

While reframing transitions as socio-techno-ecological phenomena is a bold and long-term academic project, our ambition in this paper is humble. We aim to take a small step towards a socio-techno-ecological perspective on transitions, first by reviewing the reasons for such an advancement, and then by sketching the outlines of an analytical framework that includes representations of ecological elements and highlights their role in production and consumption systems. To illustrate the value of a socio-techno-ecological perspective, we apply our analytical framework to a case study on the Swedish wild berry industry. This industry is directly dependent on forest ecosystems and thus makes a good case for illustrating how ecological elements can be accounted for in transitions studies.

The Swedish wild berry industry is also empirically interesting since it is characterised by both potential and problems in relation to the normative values associated with sustainability. On the one hand, the industrial activity is limited in relation to opportunities offered by the vast wild berry resource. Only a few percent of the available berries are harvested each year, most of the harvest is exported to foreign countries, and few Swedish actors refine berries into value-added products (Casimir et al. 2018). This suggests that the industry may expand to increase its supply of nutritious berry-based products, while driving economic development in rural areas in northern Sweden where most berries are harvested. On the other hand, a number of problems characterise the current industrial configuration, including the precarious position of migrant workers that pick berries, and the environmental impacts of harvesting and subsequent processes in the value chain (Axelsson and Hedberg 2018; Eriksson and Tollefsen 2018; Hamunen et al. 2019). Nevertheless, the Swedish wild berry industry has been subject to little research that adopts a systems perspective on production, consumption and innovation.

---

[1] It should be acknowledged that technologies, such as power-to-food concepts, which bypass nature in the production of food are under development, albeit at an early development stage.

As we apply our analytical framework to this case, our aim is to illustrate the socio-techno-ecological characteristics of production and consumption systems. Although we thereby shed some empirical light on the Swedish wild berry industry, an extensive analysis of innovation dynamics and structural transformation is beyond the scope of this paper. The case findings should accordingly be seen partly as an illustration of the importance of accounting for the natural environment when describing and analysing production and consumption systems, and partly as a starting-point for future research that aims to inform policymakers and other actors seeking to develop the Swedish wild berry industry.

After this brief introduction, we elaborate on the arguments for paying more attention to the natural environment in transitions research and sketch the outlines of a socio-techno-ecological systems framework (Section 2), before describing our research case and methodology (Section 3). Thereafter, we apply our analytical framework to the Swedish wild berry industry (Section 4). We end with a discussion of how the paper may serve as a stepping-stone towards a more comprehensive reframing of transitions as socio-techno-ecological phenomena and support future research into the innovation dynamics which shape the future of the Swedish wild berry industry (Section 5).

2. Bringing nature into research on sustainability transitions

In this section, our ambition is to reframe production and consumption systems, which lie at the heart of transitions research, as socio-techno-ecological phenomena (Figure 1). We begin, however, by reviewing ongoing scholarly efforts that point in similar directions and the key arguments behind such endeavours.

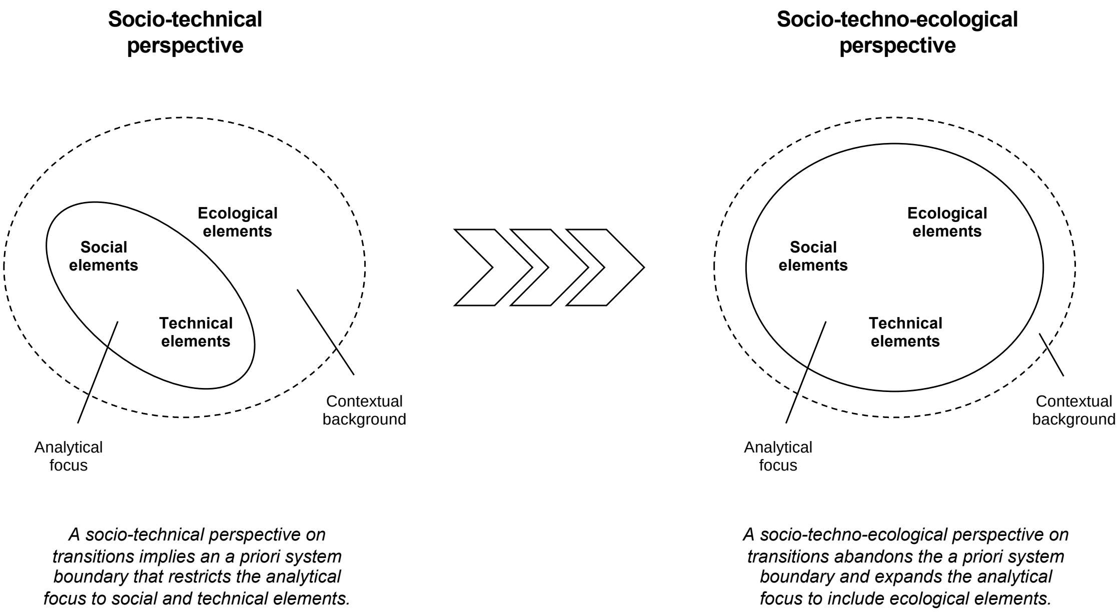

Figure 1. The advancement towards a socio-techno-ecological perspective on sustainability transitions.

2.1. *Ongoing scholarly efforts, and key arguments, to advance towards a socio-techno-ecological perspective on sustainability transitions*

The lack of attention to nature in transitions research is addressed as a part of an increasing dialogue with scholars who share an interest in transformative change towards sustainability but adopt a socio-ecological systems perspective (Patterson et al. 2017; Ollivier et al. 2018; Olsson, Galaz, and Boonstra 2014; Ahlborg et al. 2019; Smith and Stirling 2010). While much of this literature focuses on similarities and differences across the two fields, and attempts to integrate ideas from one field to the other, scholars also call for analytical perspectives that pay symmetrical attention to society, technology and ecology (Olsson, Galaz, and Boonstra 2014; Ollivier et al. 2018), at least in formative stages where the research focus and design is developed (Ahlborg et al. 2019). In addition, transitions scholars studying nature-based solutions to urban sustainability problems have recently proposed nature-based innovation systems as an analytical approach tailored to such technologies (Jagt et al. 2020). But while this approach strives to account for the role of ecological elements in innovation processes, and thus constitutes an important contribution to the development of a socio-techno-ecological perspective on transitions, it remains focused on, and tailored to, a specific empirical domain.

In general, the limitations of a socio-technical perspective are rarely discussed critically in the transitions community. In fact, the latest STRN research agenda does not even comment on the possibility of including representations of ecological elements within key concepts and analytical frameworks (Köhler et al. 2019). This is somewhat surprising, given that there are clear arguments as to why such advancement towards a socio-techno-ecological perspective on transitions would be worthwhile.

On the one hand, it is important to account for the role of nature in transition processes. This is particularly evident in the growing body of literature that engages with transitions in agro-food systems (El Bilali 2019; Vermunt et al. 2020) and nature-based solutions to urban sustainability problems (Jagt et al. 2020). In these empirical domains, the technology in focus is directly intertwined with managed and unmanaged ecosystems, which clearly highlights that a socio-technical perspective is too narrow. But also in more general terms (Andersson et al. 2018), society and nature are interdependent and cannot be analysed in isolation (Anderies 2014; Redman and Miller 2015; Liu et al. 2007). While ecological elements can be more or less direct and important in relation to socio-technical elements, a serious ambition to account for the role of nature in transition processes accordingly calls for a socio-techno-ecological perspective.

On the other hand, it is equally important to account for the role of nature in transition outcomes. Transitions research is normative in the sense that it aims to understand and promote change in a particular direction. Arguments regarding the desirability of different futures are at least partly derived from the way alternative modes of production and consumption influence nature. However, a socio-technical perspective on transitions does not capture the environmental impacts associated with transition outcomes (Olsson, Galaz, and Boonstra 2014), and at times the desirability of a particular development trajectory is seen as a given, rather than contested and subject to continuous debate (Stirling 2011). Although transitions research should not be conflated with technology assessment, which is the focus of a separate research community, informing the participatory processes needed to define and promote desirable development trajectories requires that transitions scholars engage both with transition processes and their outcomes (Andersson, Hellsmark, and Sandén 2021). Since a socio-techno-ecological perspective would make the influence of transition outcomes on nature more explicit, it would arguably be better suited to such tasks.

It should be acknowledged, however, that time and resource constraints always call for difficult choices in the research process. In an interconnected reality, where system boundaries are open rather than closed, there will always be a need to disregard some factors that are relevant for the phenomenon in focus, in order to highlight others that are more meaningful and decisive. For some transitions studies, this may warrant that nature plays a minor role. What is problematic, however, is that the socio-technical perspective makes an a priori exclusion of ecological elements, rather than letting their potential inclusion in a given study be a matter of setting system boundaries that specify the focus and scope of the investigation based on relevance and importance. When we argue that the transitions community should advance towards a socio-techno-ecological perspective, it is therefore not our intention to suggest that all studies must pay equal analytical attention to social, technical and ecological elements. Our point is rather that there should be symmetrical attention at the explorative stage of framing the research focus and scope (Ahlborg et al. 2019). In the following section, we will develop an analytical framework that reframes the production and consumption systems in focus in transitions research as socio-techno-ecological phenomena.

2.2. Reframing production and consumption systems as socio-techno-ecological phenomena

Sustainability transitions research is concerned with transformative change in production and consumption activities related to different societal functions such as energy and transport (Köhler et al., 2019). In principle, these functions can be defined at vastly different levels of abstraction, ranging from individual technical artifacts to the global economy as a whole. However, transitions scholars are most often interested in investigating change at a meso-level that captures transitions related to a set of technologies, an industry or an economic sector. To account for their dependence on interlinked heterogenous elements, such empirical domains are often conceptualised as production and consumption systems (Bergek, Jacobsson, and Sandén 2008; Geels 2004; Coenen and Díaz López 2010).

Specifying a production and consumption system for the purposes of an investigation is a matter of setting system boundaries in functional, structural, spatial and temporal dimensions (Sandén and Hillman 2011; Andersson, Hellsmark, and Sandén 2021). A functional boundary describes 'what the system does' in terms of an abstract value chain of interlinked processes involved in the creation and use of some focal product. A structural boundary describes 'what the system is' by defining its constituent elements and their relationships. A spatial boundary describes 'where the system is' by restricting it to a specific country or region. In addition, a temporal boundary may be used to highlight 'when the system is', that is, the time period which is the focus of description and analysis.

What makes the production and consumption systems in focus in transitions research socio-technical is that the structural boundary already at the outset restricts the system to social and technical elements. Reframing production and consumption systems as socio-techno-ecological phenomena is accordingly about relaxing this restriction and allowing the system to include elements which represent relevant parts of the ecosystems in which it is embedded. In other words, our aim is to add an ecological dimension to the socio-technical space in which the structure of production and consumption systems is found in the extant literature. Below, we first provide a brief account of how socio-technical structure is conceptualised and then proceed to elaborate on the ecological dimension of socio-techno-ecological systems.

Although transitions scholars use slightly different categories to explain and conceptually organise the structure of socio-technical space (Bergek, Jacobsson, and Sandén 2008; Geels 2004; Hughes 1987; Rip and Kemp 1998; Sandén and Hillman 2011; Wieczorek and Hekkert 2012), they seem to agree on a limited number of distinguishable elements. Drawing on these insights, we begin by acknowledging that there is a technical and a social dimension. In the former, we find technical elements such as artifacts and knowledge that serve as means that are converted to ends in processes of production and consumption. Going further, we may also distinguish between goods, waste, tools and infrastructure as different types of artifacts, and between tangible and intangible knowledge. In the social dimension, we find human beings that can be represented either as individuals or as parts of collectives such as organizations (e.g., households, firms, universities, research institutes, government agencies and non-governmental organizations), networks and markets (Powell 1990). Other social elements can be found in the institutions that emerge as human beings interact (Giddens 1984). These can be understood as shared meanings and agreements that exert a regulative, normative and cognitive influence on the behaviour of individual and collectives of human beings. They include policies, such as formal laws, regulations and standards, as well as culture, in the form of informal routines, norms and beliefs. Notably, money, in the form of payments or accumulated financial capital, also belongs to the social dimension, since it is fundamentally an agreed upon relational property between actors (Graeber 2011).

Recent work has also taken steps towards a more rigorous understanding of the many ways in which socio-technical structure can be configured in production and consumption systems (Andersson, Hellsmark, and Sandén 2021). For example, a system can in the technical dimension be more or less diverse in relation to alternative value chains, and more or less specialised in relation to complementary value chains. Similarly, a system may in the social dimension exhibit different levels of distribution and concentration in relation to the operation and ownership of production and consumption processes. In addition, important configurations arise in the spatial dimension, where system structure can be more or less concentrated to a specific region.

When it comes to adding an ecological dimension to socio-technical space, there are at least two different approaches. To begin with, nature can be seen as a source of means, or inputs, to processes of production and consumption. This points to concepts such as natural resources and ecosystem services, which are widely used in science and beyond (Fisher, Turner, and Morling 2009; Schröter et al. 2014). However, adopting such concepts in this context would bring a bias towards parts of nature that are supportive of production and consumption, which raises the question of how to account for ecological elements that may hinder the system function.[2] In contrast, nature can also be seen as a diverse domain which is intricately involved in production and consumption processes, whil representations may be based on its inherent characteristics. The resulting ecological elements can influence and be influenced by the system function in multiple ways. Ecological elements may provide resources and services, constitute factors that hinder the performance and transformation of production and consumption activities, and be subject to degradation due to overexploitation, waste and emissions. What is crucial about this approach is that the role of ecological elements is not made explicit in their representations, but rather becomes a circumstance that may be found through analytical efforts. Notably, this is more in line with the way social and technical elements are generally represented in socio-technical systems frameworks.

In our efforts to represent ecological elements, we therefore adopt the second approach discussed above and look to the inherent characteristics of nature. Our starting-point is the broad research community that engages with ecology. Scholars in this tradition use the notion of ecosystems to capture systems of non-human organisms and their physical environment, and have also developed general representations of their constituent elements (Willis 1997; Chapin et al. 2011). Here, a first distinction is made between elements that are biotic (living) as opposed to abiotic (non-living). Biotic elements can be further broken down with respect to their role in the ecosystem: producers are plants and algae that convert solar energy to chemical energy through photosynthesis; consumers are different types of animals that depend upon the producers since they feed on chemical energy, either

[2] In fact, accounting for nature by including natural resources and ecosystem services as ecological elements corresponds to only accounting for supportive policies, rather than any policy that exerts an important influence on the system function.

as herbivores, omnivores or carnivores; and decomposers are fungi and certain bacteria that feed on, and recycle nutrients from decaying organic matter. While these categories are useful in other types of research, they do not seem to add much value when analysing transitions. What may be worthwhile, however, is to distinguish between plants and animals as two different biotic ecological elements. This is because animals, or at least more complex species with developed neural systems, may experience both pleasure and pain, which raises ethical concerns that are rarely seen as relevant for plants. When it comes to abiotic elements that constitute the physical non-living environment, complexity abounds; the atmosphere, hydrosphere and lithosphere, as well as the complex flows and interactions between them, are seen as parts of ecosystems. Capturing the nuances of abiotic elements is, however, clearly beyond the scope of transitions research, and it may often suffice to refer to them as physical environments.

The ecological dimension also gives rise to additional configurational properties of system structure. Much work remains to identify useful categories for the purposes of transitions research, but an initial, and somewhat obvious, observation is that the ecological configuration of a production and consumption system can be more or less (ecologically) sustainable. At a high level, we may distinguish between systems that are degenerative, regenerative and restorative in relation to ecological elements. Value chains in degenerative systems influence ecological elements, by extracting resources and services as well as emitting waste, in a way that over time diminishes their capacity to support production and consumption processes. Put differently, they are based on extractive or unsustainable technologies. In contrast, value chains in regenerative systems influence ecological elements in a way that maintains their characteristics over time. They are, accordingly, based on more sustainable, or even circular, technologies. Value chains in restorative systems, lastly, go even further by influencing ecological elements in a way that (given some normative position) enhances their characteristics in a way that increases their capacity to support production and consumption processes. Put differently, they are based on technologies that aim to restore ecosystems, perhaps due to historical use of unsustainable technology (Palmer, Zedler, and Falk 2016).

In contrast to a socio-technical perspective, socio-techno-ecological systems of production and consumption accordingly opens up for including any *type* of structural element. However, there is still a need to describe which parts of the comprehensive socio-techno-ecological space are included in a given system (Figure 2). The point of departure for setting this structural boundary is the system function, that is, the included set of production and consumption processes. It is by pointing to the relation between structural elements and these processes that the relevance and importance of including specific elements is identified and justified. Nevertheless, there is no simple recipe for determining where the structural boundary should be drawn. While formal systems theory often proposes system boundaries that include elements involved in reciprocal interaction with respect to its function – in this case elements that both influence and are influenced by production and consumption processes – the fact that socio-techno-ecological systems are open rather than closed makes it impossible to derive boundaries based on this principle alone (Andersson, 2020). Over sufficiently long time scales, all parts of the system context influences its function, and vice versa. A potential approach is to add a time frame, within which unidirectional and reciprocal interaction may be differentiated. But nonetheless, boundary-setting based on formal criteria arguably remains cumbersome, at least for transitions-oriented research. However, given that the socio-techno-ecological systems framework outlined here is supposed to be employed as a practical tool, rather than constitute a formal theory, it may suffice to adopt a more informal principle. We therefore suggest that the structural boundary should be set to include elements that are involved in, and may change as a result of, the processes captured by the system function. What this means in practice for a particular study is a matter of defining the research scope.

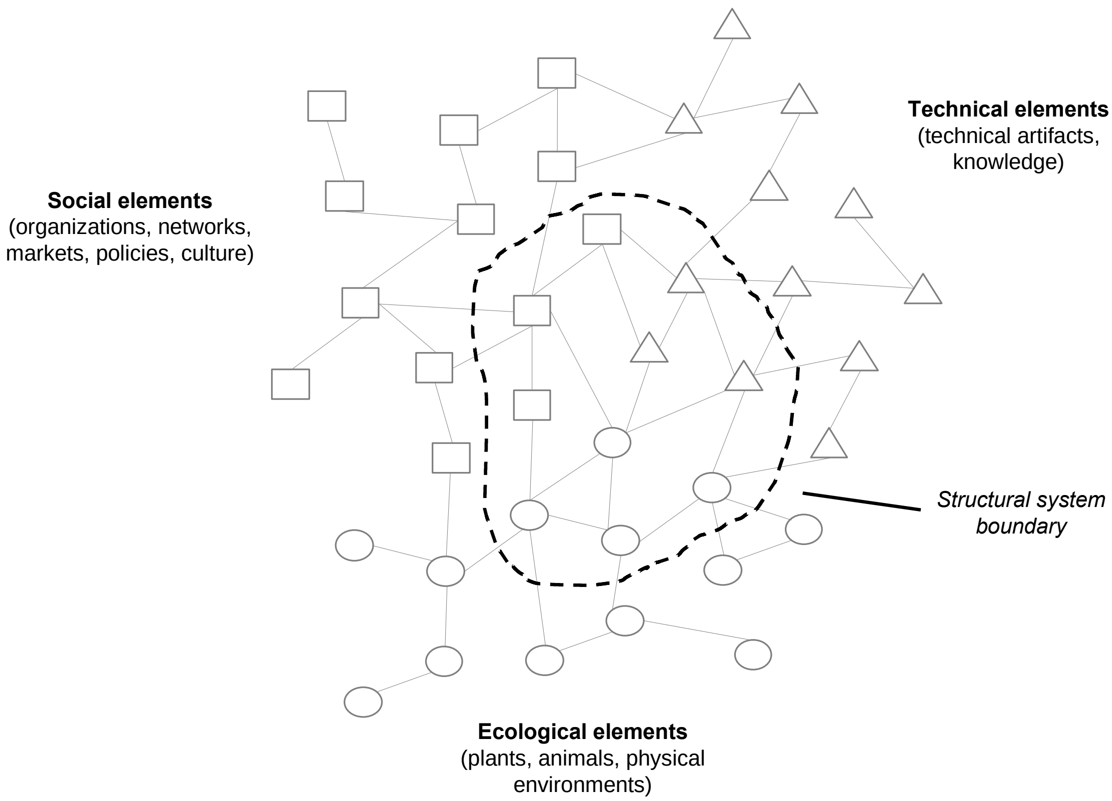

Figure 2. Structural elements and boundaries in socio-techno-ecological systems of production and consumption

Finally, it should be acknowledged that this section has painted a somewhat static picture of production and consumption systems. In reality, innovation processes constantly propel system transformation in a way that may result in growth, reconfiguration or even decline. Indeed, it is the pace and directionality of innovation processes that are primarily of interest to transitions scholars. It is, however, beyond the scope of this paper to elaborate on the need to adapt existing analytical frameworks used to study the dynamics of transitions. Instead, our focus now turns to illustrating the ideas presented in this section by applying them to a case study on the Swedish wild berry industry.

3. Research case and methodology

The empirical case we use to illustrate our socio-techno-ecological analytical framework is the Swedish wild berry industry. Despite growing in forests which are now largely managed, wild berries have thrived naturally in northern Europe throughout history, which makes this case rich for exploring the role of ecological elements within production and consumption systems. The wild berry case is also empirically interesting in relation to the sustainability of the overarching agro-food system, which an increasing number of transitions scholars are investigating (El Bilali 2019a; 2019b). For example, the vast wild berry resource presents opportunities such as contributing towards healthy diets without the environmental impacts of cultivated berry production (i.e., land, water and fertiliser use), and generating socio-economic activity in rural areas facing depopulation due to out-migration (Amcoff and Westholm 2007). On the other hand, there are concerns surrounding the precarious position of migrant berry-pickers within the industry, wild berries' status as a common pool resource, and the environmental impacts of harvesting and subsequent processes in the value chain (Axelsson and Hedberg 2018; Eriksson and Tollefsen 2018; Hamunen et al. 2019).

A number of research threads surround this case, one of which investigates the health benefits of consuming berries like lingonberries and bilberries. Such research often focuses on the antioxidant properties of berries, where there is interest in preventative impacts for certain cancers, cardiovascular disease and diabetes (Zafra-Stone et al. 2007; Cassidy 2018; Ulbricht et al. 2009). Another area of research explores labour issues connected to the industry's transnational migrant workforce, where there have been cases involving trading companies going bankrupt, and pickers not earning enough to cover the expenses of their trip (Axelsson and Hedberg 2018; Carmo and Hedberg 2019).[3] But aside from a handful of reports which offer valuable insights (Casimir et al. 2018; Uddstål 2014; Jonsson and Uddstål 2002; Livsmedelsföretagen 2013; Paassilta et al. 2009), there is a lack of research which explores the wild berry industry from a systems perspective in relation to production, consumption and innovation. By applying a socio-techno-ecological analytical framework to wild berry case our aim is thus to highlight the importance of accounting for ecological elements within production and consumption systems, while also generating a better understanding of the wild berry industry and how it may develop in the future.

[3] Regulatory measures were introduced in the 2000s to avoid such situations, including a mandatory minimum wage, checks to ensure workers are being paid correctly, and requirements for trading companies to prove that they have sufficient capital to operate (Axelsson and Hedberg 2018).

The empirical methodology we applied was a case study using a combination of quantitative and qualitative data collection (Yin 1984). Our case was instrumental insofar as it was used to illustrate and develop our proposed analytical framework (Stake 2005). The sources of data we drew upon were peer reviewed articles, grey literature, interviews, company websites and official government statistics. All sources were used to build a holistic understanding of the value chain in focus and its social, technical and ecological characteristics. Interviews were conducted over video conference and recorded digitally before being transcribed into text. A total of five semi-structured interviews were conducted, each with a duration of one hour, along with one expert consultation in the form of an online workshop. Two interviewees were involved in purchasing berries for a large Swedish retailer, one was the CEO of a berry wholesaling company, one was a business policy expert within a trade association, and one was an employee of a region in northern Sweden. Official statistics were gathered from government databases and compiled to produce figures on migrant worker flows, annual yields and distribution of berries, and import and export figures for fresh and frozen berries.

Our analytical procedure began with identifying value chain processes based on the collected data, which allowed us to conceptualise the wild berry industry as a production and consumption system. For each value chain process we then described social, technical and ecological elements and interactions between them. Although we considered the value chain as a whole, the focus of our analysis was on the earlier stages located within Sweden, where ecological elements are particularly influential. These processes come under the headings of natural production, picking, and cleaning and freezing in Section 4. To a lesser extent, we also looked at more downstream processes in the value chain under the heading of processing, distribution and consumption. Our system's functional boundary was equivalent to the activities taking place across these value chain processes, with the berries themselves constituting the focal product of production and consumption. The structural system boundary then reflected the social, technical and ecological elements involved in each process. The spatial boundary of our system was in one sense global, reflecting the international flows of workers and goods in the industry, however our empirical focus was primarily on Sweden. In terms of the system's temporal boundary, while we explored the historical emergence of structural elements going back at least one century, are main focus was on developments in the last two decades.

4. A socio-techno-ecological systems perspective on the Swedish wild berry industry

In this section, we will review and analyse the Swedish wild berry industry using the socio-techno-ecological systems framework outlined in Section 2.2. The narrative departs from the value chain processes which are equivalent to the system function. For each of these processes we will describe the most influential social, technical and ecological structural elements and how they interact with one another to form the Swedish production and consumption system for wild berries.

4.1. Natural production

The first value chain process we discuss is natural production, where wild berries grow as a part of forest ecosystems. As the name suggests, this is a process occurring in nature without direct human intervention. However, most berries grow in forests which are shaped by management practices (Nilsson et al., 2021). The Swedish forestry act (*Skogsvårdslagen*) stipulates that land owners must reforest all felled areas, and along with intensified management practices this has seen Sweden's total forest stock more than double in the past century (Swedish Forest Agency 2020). Compared to old-growth forests, managed forests have lower biodiversity in terms of species richness, and forestry practices also influence the natural production of berries (Paillet et al. 2010). For example, logging and prescribed burning have been shown to negatively impact bilberry growth (Granath et al. 2018; Paillet et al. 2010). The process of natural production thus takes place within ecosystems which are intertwined with the sociotechnical domain.

The most naturally abundant wild berry species are the bilberry, or European blueberry (*Vaccinium myrtillus*), which covers 11% of Sweden's forests, and the lingonberry (*Vaccinium vitis-idaea*), which covers another 7% (Skogsdata, 2020). Many other wild berry species also grow in smaller quantities, such as the cloudberry, wild strawberry, black and red currants and wild raspberry. The plants themselves are typically low-lying woody shrubs which bear fruit during the summer months. In the case of bilberries, plants mainly reproduce vegetatively and can live up to 30 years (Nestby et al. 2011). While plant coverage is quite stable over time, the annual growth of wild berries fluctuates heavily depending on factors such as weather conditions. This is shown below in Figure 3, which charts the annual growth of bilberries and lingonberries in Sweden over a ten-year period.

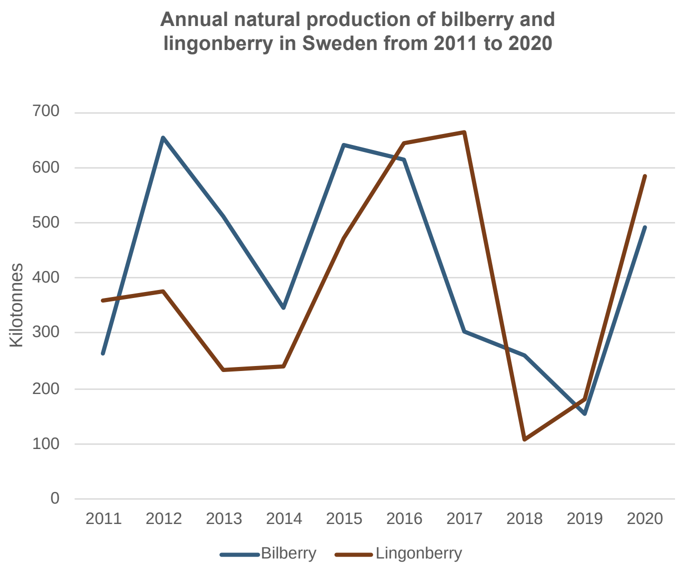

Figure 3. The annual natural production of bilberry and lingonberry in Sweden from 2011 to 2020. Based on data from Forest statistics (2017, 2021).

Wild berries grow across the entire length of Sweden, with the average regional distribution shown below in Figure 4. The largest quantities of berries are found in the spruce and pine dominated forests of northern regions, where they constitute an important food source for animals such as brown bears and deer (Hertel et al. 2018; Spitzer 2019).[4] Berries in more northerly regions tend to contain higher concentrations of anthocyanins, which are coloured pigments stored in the skin of the berries which give them their distinctive red, blue or purple colour (Åkerström 2010). These pigments' best known ecological function is to act as a visual marker to attract pollinators, and some anthocyanins are also thought to protect berries against UV radiation, with higher concentrations in northern berries thus potentially linked to their latitude.

In the process of natural production, we thus see a number of ecological elements interacting with one another, as well as with the sociotechnical domain, to generate the vast quantities of wild berries which are the focal product of the production and consumption system.

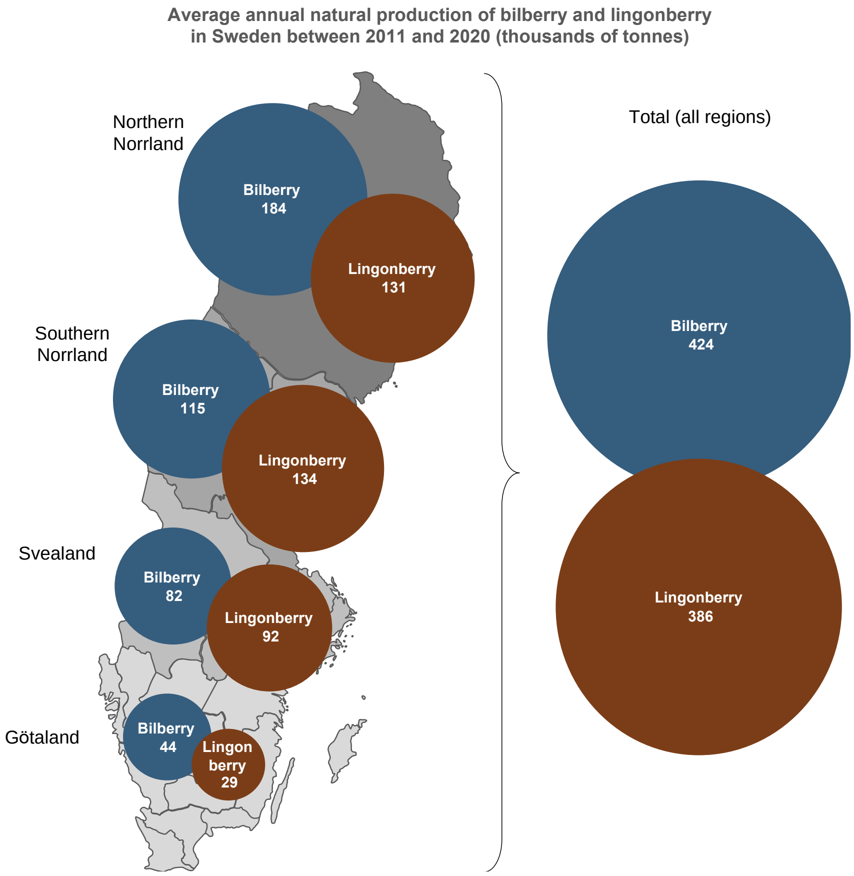

Figure 4. The average annual natural production of bilberry and lingonberry in Sweden between 2011 and 2020. Based on data from Forest statistics (2017, 2021).

[4]A link has been shown between bilberry abundance and the weight and reproductive success of female brown bears (Hertel et al. 2018).

4.2. Picking

We now move on to discuss picking, which is the process of harvesting berries for human purposes. A key institution enabling this part of the production and consumption system is the Swedish right of public access (*Allemansrätten),* which guarantees 'The freedom for everyone to roam… to make use of the water in lakes and streams… and to harvest some wild growing products' (Sténs and Sandström 2014, p.2). This right is impactful as it enables commercial picking on private land, giving the wild berry industry broad access for its operations (Barklund 2009). While this arrangement has been contested, parliamentary motions aimed at introducing formal agreements with landowners for commercial picking have been rejected by a political majority (Sténs and Sandström 2014). Still, only a small portion of the annual berry growth is harvested, with estimates putting this at around 2-5 percent, although this figure is likely to fluctuate depending on natural production (Figure 3) and on numbers of migrant pickers entering Sweden in a given year (Figure 5) (Uddstål 2014; Casimir et al. 2018).

A main technological element of the picking process are the tools used for collecting berries. These are generally handheld devices consisting of a handle, a plastic or wooden case, and a metal or plastic comb, which pulls berries free without damaging the surrounding plant. A simple rake and bucket are also used in some cases. During the berry season, pickers work intensively from morning to night. Interviewees have described the process on the ground as pickers scanning the area at all times, picking uphill where possible to reduce back strain, and only picking easily accessible berries to be more efficient. At the end of the day, pickers report to a collection point where their berries are weighed and logged.

While the original commercial berry pickers were Swedes who benefited from the supplementary income source this offered htem, most of the current commercial pickers are seasonal migrant workers (Sténs and Sandström 2014). Pickers have travelled from eastern European countries like Poland and Ukraine from the 1970s and onwards, with Ukrainians still representing the second largest group of non-EU pickers (Figure 6). The majority of today's migrant pickers come from southeast Asian countries, by and large Thailand. This was originally a loosely regulated workforce, with farmers from northeast Thailand entering Sweden on tourist visas from the 1980s onwards. In recent decades, the process has become more formalised, with temporary working visas granted to pickers, whose contracts and travel are arranged by staffing agencies in Thailand. Pickers are usually required to pay large upfront sums to these agencies, with many taking out loans to cover the costs (Carmo and Hedberg 2019). Figure 5 below shows significant fluctuations in the numbers of non-EU berry pickers entering Sweden over a ten year period. An interesting question we have not yet been able to address is what causes this fluctuation, and why there is an apparent mismatch between these figures and the natural production rates shown Figure 3.

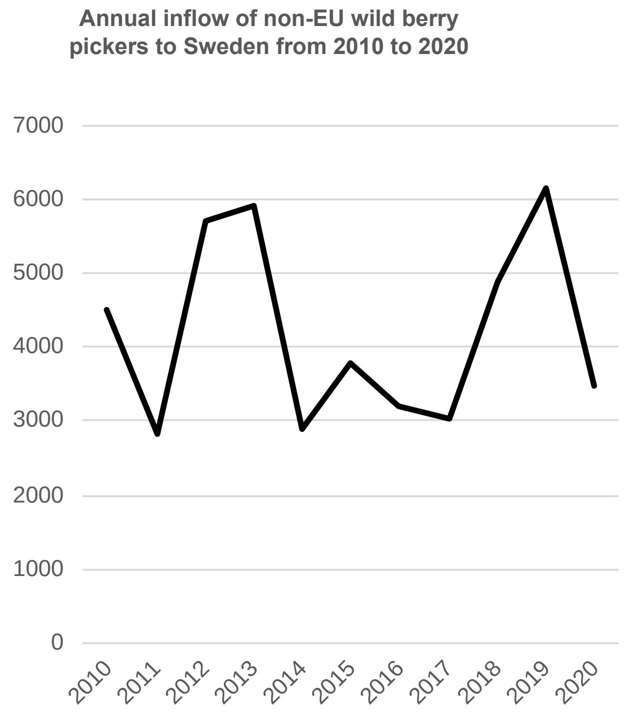

Figure 5. The annual inflow of non-EU wild berry pickers to Sweden from 2010 to 2020. Based on statistics from the Swedish Migration Agency (2021).

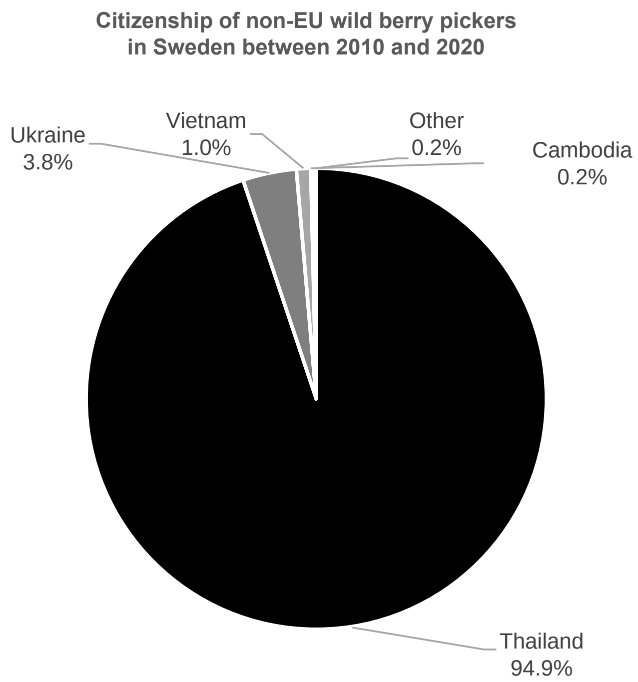

Figure 6. Citizenship of non-EU wild berry pickers in Sweden between 2010 and 2020. Note that nearly all pickers from Vietnam and Cambodia came to Sweden in 2010 and 2014, respectively. Based on statistics from the Swedish Migration Agency (2021).

This value chain process involves ecological elements coming into direct contact with socio-technical elements represented by pickers and their tools. Interesting dynamics emerge here, as annual berry yields, largely shaped by natural forces, influence economic outcomes for pickers and the difficulty of their labour. In an effort to gain more control over this dynamic, there are examples of actors experimenting with remote sensing technology to determine picking locations and exploring the possibility of using cultivation practices to increase yields and limit annual variation (Nestby et al. 2011). Such examples can be linked to the fact that ecological elements have a particularly influential role in these earlier stages of the value chain.

4.3. Cleaning and freezing

Cleaning and freezing is the process of preparing picked berries for further processing or consumption. Most berries are cleaned and frozen at the facility of a wholesaler in Sweden, with the remainder shipped to countries like Finland and the Baltics for processing (Casimir et al. 2018, Figure 7). Prior to the establishment of large-scale freezing facilities in Sweden during the mid-twentieth century, the predominant method for preserving berries was air drying, and the historical popularity of berry jams can also be linked to the preservative power of adding sugar (Jonsson and Uddstål 2002). There are a few dominant berry wholesaling companies in Sweden, who own processing facilities equipped with high-tech equipment such as blast freezers and optical sorting machines (Frostab AB 2021; Blåtand 2021).

Specific processes for cleaning and freezing berries can vary between facilities. In one facility, berries are frozen immediately upon arrival to preserve their chemical properties (Frostab AB 2021). This is important when berries are intended for the bio-extraction industry, where their anthocyanin content is of primary commercial significance (see Section 4.4). In another facility, where berries are intended for the food and drink industry, they are refrigerated throughout the cleaning process and frozen after packaging (Blåtand 2021). The cleaning process generally consists of several steps, an initial mechanical process to remove debris such as twigs and leaves, followed by an optical sorting process to detect mismatches in shape, size and colour and remove smaller debris like stones. Final cleaning steps can then include metal detection, x-ray scans and visual inspection, after which berries are packaged on automated production lines, often into 25kg sacks for industrial customers (Blåtand 2021; Frostab AB 2021).

The process of cleaning and freezing berries thus involves converting them from a natural product determined by ecological factors into an industrial commodity which satisfies regulatory and commercial criteria. The characteristics which afford berries success in an ecological context are here recontextualised as they move towards more socio-technically dominated parts of the production and consumption system. The natural fragility of berries also shapes the technologies involved in cleaning and freezing.

4.4. Processing, distribution and consumption

Processing, distribution and consumption are processes in which cleaned and frozen berries are converted into refined end products and distributed for final consumption. Despite the fact that berries are commonly associated with food and drink products, most of Sweden's bilberries (80%) are sold to the bio-extraction industry (Casimir et al., 2018). There is a large consumer market for bilberry bio-extract based products in East Asian countries like Japan, which has been a major driver for the growth of the Swedish wild berry industry in recent decades (Paassilta et al., 2009). The bio-extraction industry purchases frozen berries and soaks them in alcohol to extract anthocyanins from the skins. This value-added extract is then used in health supplements in the form of pills and powders, and as an additive in cosmetics. An omega-3 rich oil can also be extracted from bilberry seeds which is used in cosmetics (Uddstål 2014). Because there are no bio-extraction companies in Sweden, such processing takes place in China and other European countries like Italy and Norway. This is represented in Figure 7 below, showing Swedish exports of bilberries and lingonberries between 1995 and 2020, with Norway and China representing the largest customers for frozen bilberries. Figure 7 also shows substantial exports of fresh bilberries to Baltic countries, which are also likely destined for the bio-extraction industry after being cleaned and frozen.

When it comes to wild berry-based food and drink products, there is an established processing industry and consumer market within Sweden. The processing, distribution and consumption of wild berry-based food and drink products is thus more domestically focused than the bio-extraction industry. There are large actors such as Orkla Foods and Finnerödja, medium sized actors such as Hafi and Glommersbär, and numerous actors with small-scale operations producing wild-berry based food and drink products for both the Swedish and international market (Casimir et al. 2018). More than half of these products are bilberry-based, with lingonberry-based products comprising another fifth. Apart from whole fresh and frozen berries, popular products include jams, juice concentrates, berry soups and dried berries. Berries are also used as ingredients in other food products, such as flavoured yoghurts and mueslis. A variety of processing steps follow for these products. For juices, steps include crushing, pressing, filtration, pasteurisation and concentration. For syrups and jams the berries are cooked and sugar is added. Fermentation takes place for berry wines, and air drying for dried berries.

While some parts of the Swedish food and drink industry, particularly small-scale actors making premium products, use berries harvested in Sweden, large volumes are imported, often from countries with lower prices and more consistent supply. This is shown below in Figure 8, which charts Swedish imports of bilberries and lingonberries between 1995 and 2020. The fact that Sweden imports berries who grow in abundance domestically can be linked to the fact that Swedish wholesalers supply the bio-extraction industry, which pays a premium for berries with a high anthocyanin content. Along with higher labour costs in Sweden, this means that base prices for Swedish berries are higher than other European countries, where supply is also often more consistent (Casimir et al. 2018). Sweden also imports fresh, frozen and processed American blueberries (Statistics Sweden 2021). Notably, these are often mistaken for bilberries, even though they are a different species which is farmed rather than harvested in the wild. The confusion is not only due to their similarities, but also to the fact that they go under the same name in Swedish (i.e., *blåbär*).

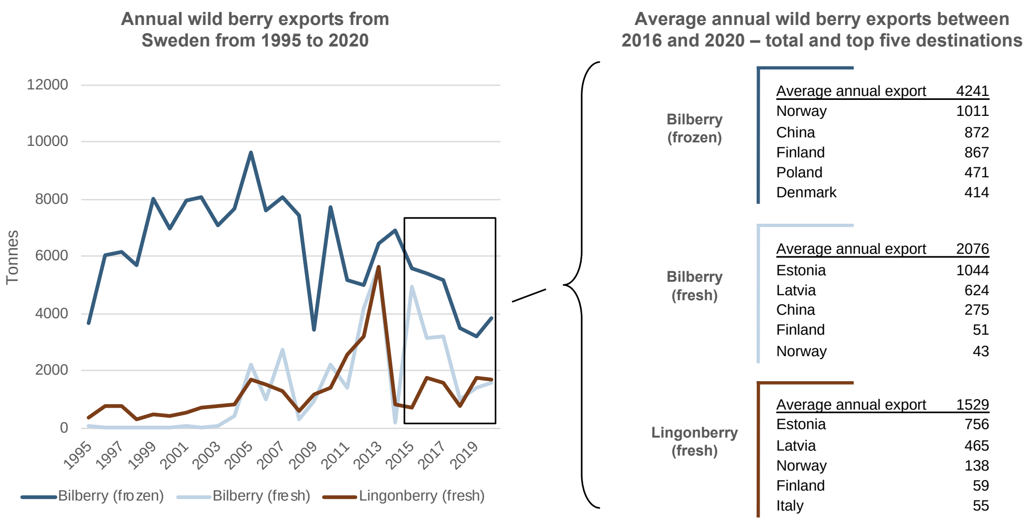

Figure 7. Annual wild berry exports from Sweden from 1995 to 2020 as well as average annual wild berry exports between 2016 and 2020 (total and by destination). Based on official trade data from Statistics Sweden (2021).

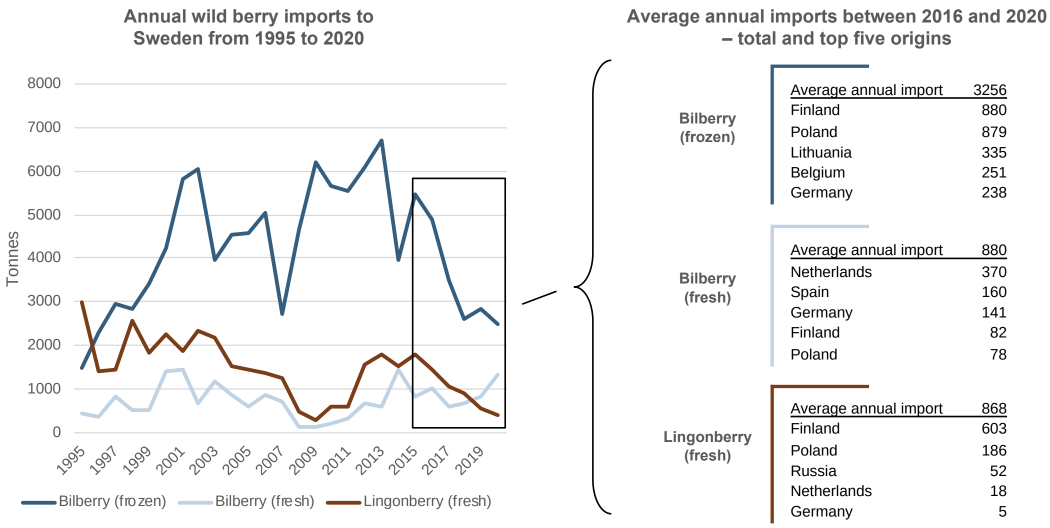

Figure 8. Annual wild berry imports from Sweden from 1995 to 2020 as well as average annual wild berry imports between 2016 and 2020 (total and by destination). Based on official trade data from Statistics Sweden (2021).

Within these final value chain processes, as berries are converted into consumer commodities, socio-technical elements such as processing technologies and consumer practices become increasingly influential within the system, while ecological elements become more remote. Nonetheless, an important link remains between the ecological and the socio-technical within these value chain processes. Namely, the anthocyanin content of bilberries, which is a result of the ecological conditions in which they grow, is the largest driver of international demand for Swedish wild berries. In this sense a property of the berries which confers them ecological success also shapes the socio-technical structure of the production and consumption system.

5. Discussion

In our analysis we found that each of the value chain processes within the Swedish wild berry industry is shaped, to varying degrees, by social, technical and ecological elements, and that all of these elements have an important role in realising the system function, which we defined as the production and consumption of wild berries. In our view, this indicates that adopting a socio-techno-ecological perspective can generate insights about the structure of production and consumption systems which would be less apparent if using a purely socio-technical perspective. In this section, we begin by elaborating on the findings of our analysis and connect these to arguments for including ecological elements in the analytical frameworks used in transitions research. A further question we explore is how the results produced by a socio-techno-ecological analytical perspective might differ when studying more managed agricultural systems, or production and consumption systems in different sectors. Finally, we reflect on the limitations of our study and identify areas where further conceptual development and empirical validation would be beneficial.

In our analysis of the value chain process of natural production, the inclusion of ecological elements allowed us to better understand the context in which wild berries grow as part of forest ecosystems, where they interact with other species like pollinating insects and herbivores, as well as with the socio-technical domain represented by the Swedish forestry sector. Social, technical and ecological elements all proved to be significant for understanding this value chain process in relation to the system function. The abundance of wild berries in Swedish forests, the high anthocyanin content of northern bilberries, and the annual variability of berry growth are all influential factors which were illuminated through analytical attention towards ecological elements. At the same time, our analysis of natural production showed that socio-technical elements like harvesting techniques and government policies strongly shape the forest ecosystems in which berries grow. Within this value chain process we thus see an entanglement between socio-technical and ecological elements which reflects a key argument for moving towards a socio-techno-ecological perspective within transitions research. Namely, that in an Anthropocene era, when even weather patterns are shaped by anthropogenic influence, it appears increasingly untenable to analyse human and ecological systems in isolation from one another (IPCC 2021).

When analysing subsequent value chain processes we again found that ecological elements had an important influence in relation to the system function, which a purely socio-technical perspective may have missed. For example, instances in which the wild berry industry was thrown into crisis, as pickers were not earning enough to cover the expenses of their trip, were precipitated by the natural variability of berry growth. Equally, the economic incentives which attract so many migrant pickers to Sweden are explained by the abundance of berries which this natural variability can also generate. Technical elements surrounding the picking process are also better understood in relation to the ecological characteristics of berries. For example, the fact that low-tech tools are used for picking relates to the landscape in which berries grow, which does not lend itself to mechanised harvesting. Processes for cleaning and freezing berries are also more fully understood in relation to ecological elements of the production and consumption system, insofar as these are necessary in order to retain some of the ecological characteristics of the berries while removing others, and are also designed in relation to the natural fragility of berries.

As well as helping to more fully understand the operation of value chain processes in the production and consumption system as it currently exists, we would argue that providing an account of ecological elements within the Swedish wild berry industry is equally important for understanding how it is likely to develop in the future. The key here is that the industry is based on a localised resource that cannot be moved or manipulated, which would by definition transform it to something else. This gives rise to a set of boundary conditions such as production variability and spatial diffusion, which will be essential to account for in any attempt to advance or transform the wild berry industry. Understanding these boundary conditions, and their influence on the industry as such, is thus analogous to understanding the characteristics of ecological elements and their linkages to the socio-technical domain. A socio-techno-ecological perspective can thus make the influence of nature on innovation dynamics more explicit, and can therefore inform the processes needed to define and promote desirable development trajectories within a variety of sectors.

Concerning the question of how a socio-techno-ecological analytical perspective might deliver different kinds of results if applied to more managed agricultural systems, a number of possibilities arise. While socio-technical elements would likely have a more prominent role in these production processes, it seems that a socio-techno-ecological analytical perspective could nonetheless offer a range of valuable insights. For example, by accounting for how factors such as soil fertility, pollinator health and climate change influence and are influenced by social and technical elements. Considering production and consumption systems in different sectors, there also seems to be a number of contributions a socio-techno-ecological perspective could make. As we argue in our introduction, ecological elements influence innovation dynamics in sectors like energy and transportation, and moreover, the ecological sustainability of different transition outcomes receives insufficient attention within socio-technical frameworks.

Reflecting upon the limitations of our study and how further conceptual development and empirical validation could address these, there are a few important points to be addressed. On one level, our paper has paid limited attention to the attempted inclusion of nature in other research domains like actor network theory, where there may be valuable lessons for further developing socio-techno-ecological analytical frameworks. Furthermore, as our empirical case was primarily presented as a means to illustrate our analytical framework, we did not go into a detailed analysis of innovation dynamics and structural transformation within the Swedish wild berry industry, and the overall depth of our analysis of social, technical and ecological elements was similarly limited. Proceeding from the analysis presented in this paper, future research might thus build a more detailed understanding of structural elements and innovation dynamics to highlight development pathways within the Swedish wild berry industry. Further development of the socio-techno-ecological perspective based on additional case studies may also provide additional concepts, vocabularies, and lenses through which to pursue transitions research.

6. Conclusion

In this paper we have argued that sustainability transitions research should advance towards analytical frameworks which pay more attention towards ecological elements. In an effort to initiate this shift, we began by outlining the contributions this could have for transitions research, and addressed the fact that limited attention has been paid to such questions within the transitions literature. Our arguments for this analytical shift revolved around the idea that transitions towards more sustainable systems of production and consumption are both shaped by and assessed according to interactions with ecological elements. We then sketched the outlines of a socio-techno-ecological analytical framework, where we showed how existing transitions frameworks can be adapted to be more accommodating of ecological elements, particularly at the stage of setting structural system boundaries. In order to illustrate and test this analytical framework we applied it towards a case study of the Swedish wild berry industry. We conceptualised this industry as a production and consumption system with distinct value chain processes, where we were able to distinguish between social, technical and ecological structural elements and describe the role they had in terms of realising the system function. Finally, we discussed our results in relation to arguments for a shift towards analytical frameworks which pay greater attention towards ecological elements within transitions research. While this paper represents an experimental first step in this direction, we believe that with further empirical validation and conceptual development a socio-techno-ecological analytical perspective can contribute meaningfully towards the future of transitions research.

References

Frostab AB. 2021. “Production.” 2021. https://www.frostab.se/production.

Ahlborg, Helene, Ilse Ruiz-mercado, Sverker Molander, and Omar Masera. 2019a. “Bringing Technology into Social-Ecological Systems Research — Motivations for a Socio-Technical-Ecological Systems Approach.” *Sustainability*. https://doi.org/10.3390/su11072009.

Åkerström, Andreas. 2010. *Factors Affecting the Anthocyanidin Concentration in Fruits of Vaccinium*. Swedish University of Agricultural Sciences.

Amcoff, Jan, and Erik Westholm. 2007. “Understanding Rural Change—Demography as a Key to the Future.” *Futures* 39 (4): 363–79. https://doi.org/https://doi.org/10.1016/j.futures.2006.08.009.

Anderies, John M. 2014. “Embedding Built Environments in Social-Ecological Systems: Resilience-Based Design Principles.” *Building Research and Information* 42 (2): 130–42. https://doi.org/10.1080/09613218.2013.857455.

Andersson, J., H. Hellsmark, and B.A. Sandén. 2018. “Shaping Factors in the Emergence of Technological Innovations: The Case of Tidal Kite Technology.” *Technological Forecasting and Social Change* 132: 191–208. https://doi.org/10.1016/j.techfore.2018.01.034.

Andersson, Johnn, Hans Hellsmark, and Björn A. Sandén. 2021a. “The Outcomes of Directionality: Towards a Morphology of Sociotechnical Systems.” *Environmental Innovation and Societal Transitions* 40: 108–31. https://doi.org/10.1016/j.eist.2021.06.008.

———. 2021b. “The Outcomes of Directionality: Towards a Morphology of Sociotechnical Systems.” *Environmental Innovation and Societal Transitions*.

Axelsson, Linn, and Charlotta Hedberg. 2018. “Emerging Topologies of Transnational Employment: ‘Posting’ Thai Workers in Sweden’s Wild Berry Industry beyond Regulatory Reach.” *Geoforum* 89 (December 2017): 1–10. https://doi.org/10.1016/j.geoforum.2018.01.003.

Barklund, Åke. 2009. “The Swedish Forestry Model.” *Royal Swedish Academy of Agriculture and Forestry*, 1–16.

Bergek, Anna, Staffan Jacobsson, Bo Carlsson, Sven Lindmark, and Annika Rickne. 2008. “Analyzing the Functional Dynamics of Technological Innovation Systems: A Scheme of Analysis.” *Research Policy* 37 (3): 407–29. https://doi.org/10.1016/j.respol.2007.12.003.

Bergek, Anna, Staffan Jacobsson, and Björn A. Sandén. 2008. “‘Legitimation’ and ‘Development of Positive Externalities’: Two Key Processes in the Formation Phase of Technological Innovation Systems.” *Technology Analysis & Strategic Management* 20 (5): 575–92. https://doi.org/10.1080/09537320802292768.

Bergh, Jeroen C.J.M. Van Den, Bernhard Truffer, and Giorgos Kallis. 2011. "Environmental Innovation and Societal Transitions: Introduction and Overview." *Environmental Innovation and Societal Transitions* 1 (1): 1–23. https://doi.org/10.1016/j.eist.2011.04.010.

Bilali, Hamid El. 2019. "Research on Agro-Food Sustainability Transitions: A Systematic Review of Research Themes and an Analysis of Research Gaps." *Journal of Cleaner Production* 221: 353–64. https://doi.org/10.1016/j.jclepro.2019.02.232.

Bilali, Hamid el. 2019a. "Research on Agro-Food Sustainability Transitions: A Systematic Review of Research Themes and an Analysis of Research Gaps." *Journal of Cleaner Production* 221: 353–64. https://doi.org/10.1016/j.jclepro.2019.02.232.

———. 2019b. "The Multi-Level Perspective in Research on Sustainability Transitions in Agriculture and Food Systems: A Systematic Review." *Agriculture (Switzerland)* 9 (4). https://doi.org/10.3390/agriculture9040074.

Bilali, Hamid El. 2020. *Transition Heuristic Frameworks in Research on Agro-Food Sustainability Transitions*. *Environment, Development and Sustainability*. Vol. 22. Springer Netherlands. https://doi.org/10.1007/s10668-018-0290-0.

Blåtand. 2021. "Berry Processing Factory." 2021. http://www.blatand.se/aboutblaatand/berryprocessingfactory/?lang=en.

Carmo, Renato Miguel, and Charlotta Hedberg. 2019. "Translocal Mobility Systems: Social Inequalities and Flows in the Wild Berry Industry." *Geoforum* 99: 102–10. https://doi.org/https://doi.org/10.1016/j.geoforum.2018.12.002.

Casimir, Justin, Johanna Östlund, Emma Holtz, Haris Hondo, Lovisa Eliasson, and Susanna Moore. 2018. *Biovetenskap Och Material Jordbruk Och Livsmedel Småskalighet Som Ett Medel För Att Bana Väg För Framtidens Livsmedel?* (RISE) Research Institutes of Sweden.

Cassidy, Aedín. 2018. "Berry Anthocyanin Intake and Cardiovascular Health." *Molecular Aspects of Medicine* 61: 76–82. https://doi.org/https://doi.org/10.1016/j.mam.2017.05.002.

Chapin, F Stuart, P A Matson, Peter Morrison Vitousek, and Melissa C Chapin. 2011. *Principles of Terrestrial Ecosystem Ecology*. New York: Springer.

Coenen, Lars, and Fernando J. Díaz López. 2010. "Comparing Systems Approaches to Innovation and Technological Change for Sustainable and Competitive Economies: An Explorative Study into Conceptual Commonalities, Differences and Complementarities." *Journal of Cleaner Production* 18 (12): 1149–60. https://doi.org/10.1016/j.jclepro.2010.04.003.

Eriksson, Madeleine, and Aina Tollefsen. 2018. “The Production of the Rural Landscape and Its Labour: The Development of Supply Chain Capitalism in the Swedish Berry Industry.” *Bulletin of Geography* 40 (40): 69–82. https://doi.org/10.2478/bog-2018-0015.

Fisher, Brendan, R. Kerry Turner, and Paul Morling. 2009. “Defining and Classifying Ecosystem Services for Decision Making.” *Ecological Economics* 68 (3): 643–53. https://doi.org/10.1016/j.ecolecon.2008.09.014.

Geels, Frank W. 2002. “Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-Level Perspective and a Case-Study.” *Research Policy* 31 (8–9): 1257–74. https://doi.org/10.1016/S0048-7333(02)00062-8.

———. 2004. “From Sectoral Systems of Innovation to Socio-Technical Systems: Insights about Dynamics and Change from Sociology and Institutional Theory.” *Research Policy* 33 (6–7): 897–920. https://doi.org/10.1016/j.respol.2004.01.015.

Giddens, Anthony. 1984. *The Constitution Of Society*. Cambridge, UK.: Polity Press.

Graeber, David. 2011. *Debt: The First 5,000 Years*. New York, USA: Melville House Publishing.

Granath, Gustaf, Jari Kouki, Samuel Johnson, Osmo Heikkala, Antonio Rodríguez, and Joachim Strengbom. 2018. “Trade-Offs in Berry Production and Biodiversity under Prescribed Burning and Retention Regimes in Boreal Forests.” *Journal of Applied Ecology* 55 (4): 1658–67. https://doi.org/https://doi.org/10.1111/1365-2664.13098.

Hamunen, Katri, Mikko Kurttila, Jari Miina, Rainer Peltola, and Jukka Tikkanen. 2019. “Sustainability of Nordic Non-Timber Forest Product-Related Businesses – A Case Study on Bilberry.” *Forest Policy and Economics* 109 (April): 102002. https://doi.org/10.1016/j.forpol.2019.102002.

Hekkert, M.P., R.A.A. Suurs, S.O. Negro, S. Kuhlmann, and R.E.H.M. Smits. 2007. “Functions of Innovation Systems: A New Approach for Analysing Technological Change.” *Technological Forecasting and Social Change* 74 (4): 413–32. https://doi.org/10.1016/j.techfore.2006.03.002.

Hertel, Anne G., Richard Bischof, Ola Langval, Atle Mysterud, Jonas Kindberg, Jon E. Swenson, and Andreas Zedrosser. 2018. “Berry Production Drives Bottom–up Effects on Body Mass and Reproductive Success in an Omnivore.” *Oikos* 127 (2): 197–207. https://doi.org/10.1111/oik.04515.

Hughes, Thomas P. 1987. “The Evolution of Large Technological Systems.” In *The Social Construction of Technological Systems*, edited by W.E. Bijker, T.P. Hughes, and T.J. Pinch. Cambridge: MIT Press.

IPCC. 2021. "IPCC 2021 Summary for Policymakers." https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf

Jagt, Alexander P N van der, Rob Raven, Hade Dorst, and Hens Runhaar. 2020. "Nature-Based Innovation Systems." *Environmental Innovation and Societal Transitions* 35. https://doi.org/10.1016/j.eist.2019.09.005.

Jonsson, Lena, and Roger Uddstål. 2002. "En Beskrivning Av Den Svenska Skogsbärbranschen." https://doi.org/ISSN 1403-6398/ ISBN 91-973519-5-4.

Köhler, Jonathan, Frank W. Geels, Florian Kern, Jonathan Köhler, Frank W. Geels, Florian Kern, Jochen Markard, et al. 2019. "An Agenda for Sustainability Transitions Research: State of the Art and Future Directions." *Environmental Innovation and Societal Transitions* 31 (January): 1–32. https://doi.org/10.1016/j.eist.2019.01.004.

Liu, Jianguo, Thomas Dietz, Stephen R. Carpenter, Marina Alberti, Carl Folke, Emilio Moran, Alice N. Pell, et al. 2007. "Complexity of Coupled Human and Natural Systems." *Science* 317 (5844): 1513–16. https://doi.org/10.1126/science.1144004.

Livsmedelsföretagen. 2013. "Guld i Gröna Skogar: Bärpockning Från Självförsörjning till Industri."

Melchior, Inga C., and Jens Newig. 2021. "Governing Transitions towards Sustainable Agriculture—Taking Stock of an Emerging Field of Research." *Sustainability (Switzerland)* 13 (2): 1–27. https://doi.org/10.3390/su13020528.

Nestby, R, D Percival, I Martinussen, N Opstad, and J Rohloff. 2011. "The European Blueberry (Vaccinium Myrtillus L.) and the Potential for Cultivation." *European Journal of Plant Science and Biotechnology* 5 (January): 5–16.

Nilsson, Per, Cornelia Roberge, Jonas Fridman, and Sören Wulff. 2021. "Skogsdata 2021." *Sveriges Oficiella Statistik*. https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/skogsdata/skogsdata_2021_webb.pdf

Ollivier, Guillaume, Danièle Magda, Armelle Mazé, Gael Plumecocq, and Claire Lamine. 2018. "Agroecological Transitions: What Can Sustainability Transition Frameworks Teach Us? An Ontological and Empirical Analysis." *Ecology and Society* 23 (2). https://doi.org/10.5751/ES-09952-230205.

Olsson, Per, Victor Galaz, and Wiebren J. Boonstra. 2014. "Sustainability Transformations: A Resilience Perspective." *Ecology and Society* 19 (4). https://doi.org/10.5751/ES-06799-190401.

Paassilta, M, S Moisio, L Jaakola, H Häggman, and Oulu University press. 2009. "Voice of the Nordic Wild Berry Industry: A Survey among the Companies." *Oulu University Press*, 84. https://www.nordgen.org/ngdoc/plants/Wild_berry_report.pdf.

Paillet, Yoan, Laurent Bergès, Joakim Hjältén, Péter Ódor, Catherine Avon, Markus Bernhardt-Römermann, Rienk-Jan Bijlsma, et al. 2010. "Biodiversity Differences between Managed and Unmanaged Forests: Meta-Analysis of Species Richness in Europe." *Conservation Biology* 24 (1): 101–12. http://www.jstor.org/stable/40419635.

Palmer, Margaret A., Joy B. Zedler, and Donald A. Falk. 2016. *Foundations of Restoration Ecology*. Washington: Island Press.

Patterson, James, Karsten Schulz, Joost Vervoort, Sandra van der Hel, Oscar Widerberg, Carolina Adler, Margot Hurlbert, Karen Anderton, Mahendra Sethi, and Aliyu Barau. 2017. "Exploring the Governance and Politics of Transformations towards Sustainability." *Environmental Innovation and Societal Transitions* 24: 1–16. https://doi.org/10.1016/j.eist.2016.09.001.

Powell, Walter W. 1990. "Neither Market nor Hierarchy: Network Forms of Organization." *Research in Organizational Behavior* 12: 295–336.

Redman, C.L., and T.R. Miller. 2015. "The Technosphere and Earth Stewardship." In *Earth Stewardship: Linking Ecology and Ethics in Theory and Practice*, edited by Ricardo Rozzi, F. Stuart Chapin, J. Baird Callicott, S.T.A. Pickett, Mary E. Power, Juan J. Armesto, and Roy H. May Jr. Cham, Switzerland: Springer International Publishing.

Rip, Arie, and René Kemp. 1998. "Technological Change." In *Human Choice and Climate Change*, edited by S. Rayner and E.L. Malone, 2:327–99. Columbus, OH: Battelle Press. https://doi.org/10.1007/BF02887432.

Sandén, Björn A., and Karl M. Hillman. 2011. "A Framework for Analysis of Multi-Mode Interaction among Technologies with Examples from the History of Alternative Transport Fuels in Sweden." *Research Policy* 40 (3): 403–14. https://doi.org/10.1016/j.respol.2010.12.005.

Schröter, Matthias, Emma H. van der Zanden, Alexander P.E. van Oudenhoven, Roy P. Remme, Hector M. Serna-Chavez, Rudolf S. de Groot, and Paul Opdam. 2014. "Ecosystem Services as a Contested Concept: A Synthesis of Critique and Counter-Arguments." *Conservation Letters* 7 (6): 514–23. https://doi.org/10.1111/conl.12091.

Smith, Adrian, and Andy Stirling. 2010. "The Politics of Social-Ecological Resilience and Sustainable Socio-Technical Transitions." *Ecology and Society* 15 (1). https://doi.org/10.5751/ES-03218-150111.

Spitzer, Robert. 2019. "Trophic Resource Use and Partitioning in Multispecies Ungulate Communities." https://pub.epsilon.slu.se/16431/1/spitzer_r_191114.pdf.

Stake, Robert E. 2005. "Case Studies." In *Sage Handbook of Qualitative Research*, edited by Norman K. Denzin and Yvonna S. Lincoln, 3rd ed. Thousand Oaks, California: Sage Publications.

Sténs, Anna, and Camilla Sandström. 2014. “Allemansrätten in Sweden: A Resistant Custom.” *Landscapes (United Kingdom)* 15 (2): 106–18. https://doi.org/10.1179/1466203514Z.00000000029.

Stirling, Andy. 2011. “Pluralising Progress: From Integrative Transitions to Transformative Diversity.” *Environmental Innovation and Societal Transitions* 1 (1): 82–88. https://doi.org/10.1016/j.eist.2011.03.005.

Swedish Forest Agency. 2020. “Forest Management in Sweden Current Practice and Historical Background.” *Rapport*, 96.

Uddstål, Roger. 2014. “Slutrapport För Projekt Bärkraft År 2011 - 2013.” https://docplayer.se/2810089-Kontaktperson-datum-beteckning-sida-roger-uddstal-projektledare-2014-05-07-1-25-slutrapport-for-projekt-barkraft-ar-2011-2013.html.

Ulbricht, Catherine, Ethan Basch, Samuel Basch, Steve Bent, Heather Boon, Dilys Burke, Dawn Costa, et al. 2009. “An Evidence-Based Systematic Review of Bilberry (Vaccinium Myrtillus) by the Natural Standard Research Collaboration.” *Journal of Dietary Supplements* 6 (2): 162–200. https://doi.org/10.1080/19390210902861858.

Vermunt, D. A., S. O. Negro, F. S.J. Van Laerhoven, P. A. Verweij, and M. P. Hekkert. 2020. “Sustainability Transitions in the Agri-Food Sector: How Ecology Affects Transition Dynamics.” *Environmental Innovation and Societal Transitions* 36 (August): 236–49. https://doi.org/10.1016/j.eist.2020.06.003.

Wieczorek, A. J., and M. P. Hekkert. 2012. “Systemic Instruments for Systemic Innovation Problems: A Framework for Policy Makers and Innovation Scholars.” *Science and Public Policy* 39 (1): 74–87. https://doi.org/10.1093/scipol/scr008.

Willis, A. J. 1997. “The Ecosystem: An Evolving Concept Viewed Historically.” *Functional Ecology* 11 (2): 268–71. https://doi.org/10.1111/j.1365-2435.1997.00081.x.

Yin, Robert K. 1984. *Case Study Design and Methods*. Los Angeles: Sage. https://doi.org/10.1080/00224549809603263.

Zafra-Stone, Shirley, Taharat Yasmin, Manashi Bagchi, Archana Chatterjee, Joe A Vinson, and Debasis Bagchi. 2007. “Berry Anthocyanins as Novel Antioxidants in Human Health and Disease Prevention.” *Molecular Nutrition & Food Research* 51 (6): 675–83. https://doi.org/https://doi.org/10.1002/mnfr.200700002.