2 *Business Adaptation Limits and Resilience to Climate Change Adversity*

Business strategy scholars have long been interested in the ability of firms to cope with adverse conditions in their operating environments. Previous research has considered both internal adversity such as structural and leadership changes or performance shortfalls, and external adversity such as competition, stakeholder demands, or other aspects of firms' regulatory and institutional environments (Linnenluecke, Griffiths, & Winn, 2013; Sutcliffe & Vogus, 2003). The concept of *organizational resilience* has been used more recently to describe firms' capabilities to maintain or regain functioning in spite of major mishaps or in the presence of continuous stress (Hollnagel, 2006; Sutcliffe & Vogus, 2003). Firms may build resilience through *adaptation*, defined by Levinthal (1994) as a "change in a significant organizational attribute, such as a basic business strategy or organizational structure in response to environmental change".

Organizational resilience: **A firm's ability to maintain or regain functioning in the presence of continuous stress or despite a major mishap.**

Despite the extant research, there remain questions regarding how the nature and magnitude of adversity experienced by a firm may affect its ability to adapt and thereby maintain resilience. In particular, adaptation to adversity stemming from the natural environment, including from climate change, land use, and land cover change, or shifts in hydrological cycles, may be significantly limited (Adger & Barnett, 2009; IPCC, 2014a; Risky Business Project, 2014). We use the term *nature adversity intensity* to describe the *magnitude* of unfavorable chronic conditions generated by the natural environment that can hinder firm operations (U.S. Environmental Protection Agency, 1998). While firms may be able to cope with low to moderate

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levels of nature adversity, their adaptive actions may become unfeasible and/or ineffective at higher levels of adversity. Firms may thus reach an *adaptation limit* (Dow et al., 2013), or a point at which available adaptation may no longer be sufficient to maintain their core business. Firms may therefore need to undertake more in depth or transformative change (Kates, Travis, & Wilbanks, 2012; Linnenluecke & Griffiths, 2010) or risk jeopardizing long-term survival. Yet the mechanisms by which they may reach adaptation limits and undergo potential transformation have not yet been adequately described in the organizational context (Beermann, 2010).

> ***Nature adversity intensity*: The magnitude of unfavorable changes in natural environment conditions that can hinder a firm's operations.**
>
> ***Adaptation limit*: A point at which available adaptation may no longer be sufficient for a firm to maintain its core business.**

There are also unanswered questions regarding how the interplay between adaptation and the wider resource contexts of a firm may affect resilience. In particular, we do not yet have a good understanding of the potential interdependencies between firm adaptation and the *nature* context in which actions are implemented (Starik & Kanashiro, 2013; Winn & Pogutz, 2013). Yet adaptation effectiveness may hinge upon the impacts that these very actions might have on resources within local ecosystems (ecosystem services), and firms might in turn *rely* on these resources for adaptation (Nelson, Adger, & Brown, 2007; Starik & Rands, 1995).

In examining these questions we draw on resilience theory from socioecology and develop several lines of inquiry. We first apply the theory's conceptualization of adaptation as a cyclical process regulated by external disturbances. We do this to consider how nature adversity intensity might drive firms to reach adaptation limits in different phases of their adaptive cycle. Nature adversity intensity at low to moderate levels may at first drive a firm to adapt through actions that attempt to sustain its core business. However, it may find that its ability to do so eventually becomes constrained as higher levels of adversity intensity start to undermine the viability of adaptive actions. We then consider how firms may have the opportunity to undertake more transformative change upon reaching adaptation limits. Through such change, they may be able to maintain and strengthen resilience despite heightened nature adversity intensity by adopting organizational forms that reduce vulnerability to adversity intensity. Finally, we also

Table 2.1. ***Definitions of the main concepts used in Chapter 2***

Concept	Definition	Reference
Adaptation	Change in a significant organizational attribute, such as a basic business strategy or organizational structure in response to environmental change	Levinthal (1994)
Adaptation limit	Point at which available adaptation is no longer sufficient to maintain a firm's core business	Adapted from Dow et al. (2013)
Nature adversity intensity	Magnitude of unfavorable chronic conditions generated by the natural environment that can hinder a firm's operations	Adapted from U.S. EPA (1998)
Impoverished regime	A set of equilibrium states having persistently low potential, low connectedness, and low resilience, and that may be difficult to reverse	Gunderson and Holling (2002); Walker et al. (2009)
Regime shift	Persistent change in a system's structure and function	Stockholm Resilience Center (2015)
Resilience	Capacity of a system to absorb disturbance while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks	Walker et al. (2004)
Equilibrium state	Stable combination of key attributes that constitute a system (e.g. components, functions, structures, and processes)	Beisner et al. (2003); Gunderson (2000)
Transformation	Process by which a system reorganizes itself with entirely new components, functions, structures, and processes	Folke et al. (2010); Walker et al. (2004)

seek to shed light on the potential interdependencies between firms and their local ecosystems. Organizational resilience may be contingent on how a company manages the broader ecosystems in which it operates because of the impacts its actions can have on those systems. This may be the case in particular for a firm that heavily depends on ecosystem services for its core business or for adaptation (see Table 2.1 for summary definitions of the chapter's main concepts).

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We therefore propose to extend the budding literature on organizational resilience to nature adversity by incorporating key concepts from resilience theory in socioecology. First, we identify the mechanisms by which organizational resilience may fluctuate as a firm adapts to changing levels of nature adversity intensity. Second, we suggest that the existing conceptualization of organizational resilience could be expanded to include transformative change, which may allow a firm to mitigate the operational impacts of reaching adaptation limits. Finally, we explicitly draw out the relationship of "mutual impact and dependence" (Winn & Pogutz, 2013) that a company may share with its broader ecosystems and consider the implications that this interdependency might have for both organizational and ecosystem resilience.

Introducing Resilience Theory: Resilience and the Adaptive Cycle

While resilience is still a relatively new concept in the organizational literature, it has been explored in a number of other fields (Lengnick-Hall & Beck, 2005; Linnenluecke & Griffiths, 2013; Vogus & Sutcliffe, 2007; Yang, Bansal, & DesJardine, 2014). These include disaster risk and emergency management (Bruneau et al., 2003; Rose & Liao, 2005), supply chains (Fiksel, 2003), psychology (Luthar, Cicchetti, & Becker, 2000), and socioeconomic systems (Levin et al., 1998; O'Brien, Sygna, & Haugen, 2004) among others.

In business management literature, scholars have mainly examined resilience in the context of high-reliability organizations (Weick & Sutcliffe, 2001) or in the context of firm responses to quick-onset extreme weather events (Linnenluecke & Griffiths, 2012). As defined above, organizational resilience represents ability to maintain or recover (and even improve) functioning despite the presence of adverse conditions (Sutcliffe & Vogus, 2003; Weick & Sutcliffe, 2001). Resilience is therefore conceptualized as a relatively stable quality that is put to the test once a discontinuity occurs. Firms that adapt and return to their original equilibrium are deemed to exhibit resiliency.

This definition contrasts with the most recent developments on resilience theory in socioecology, which is distinct in its assumption that a given system may actually exist in multiple possible equilibriums (Gunderson, 2000). The field of socioecology studies the interdependencies and

co-evolution of systems of people and nature (Stockholm Resilience Center, 2014). Systems may therefore include natural systems such as ecosystems, social systems such as organizations, or linked social and natural systems, termed "socioecological systems." As such, systems in socioecology are complex, open, and adaptive: they are made up of a large number of interacting components that collectively exchange resources with their external environment while constantly adjusting to changing external conditions (Frederick, 1998; Maguire et al., 2006; Valente, 2010).

In resilience theory, adaptation is conceptualized as a process or *adaptive cycle* along which a system progresses through different equilibrium states. Equilibrium states are stable combinations of the key attributes that constitute a system (e.g. components, functions, structures, and processes) (Beisner, Haydon, & Cuddington, 2003; Gunderson, 2000). In contrast to the current conceptualization of organizational resilience, a system's resilience in socioecology is therefore more dynamic: it is determined by the type and level of adaptation that the system is undergoing during a given phase of the adaptive cycle. Resilience in socioecology can formally be defined as "the capacity of a system to absorb disturbance while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker, Holling, Carpenter, & Kinzig, 2004).

Resilience in socioecology is defined as "the capacity of a system to absorb disturbance while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks."

A system's adaptive cycle is structured along four main phases: exploitation, conservation, release, and reorganization (see Table 2.2 for a summary of these phases) (Gunderson & Holling, 2002). The ecological example of mixed spruce and fir tree forests in the Eastern United States can serve to illustrate the different phases of the adaptive cycle (Holling, 2001). In these forests, long periods of growth and maturation are followed by rapid periods of destruction triggered by intense disturbances, which then lead to periods of revival and forest regrowth (Holling, 2001). In this example, wildfires and insect outbreaks play the role of disturbance agents (Holling, 2001). The dynamics in these ecosystems constitute a natural phenomenon that is an important part of forest renewal and regeneration (Holling, 2001).

Table 2.2. *Adaptive cycle's four main phases*

Phase	Main features and resilience level
Exploitation	Rapid growth and high susceptibility to external disturbance High resilience
Conservation	Gradual system expansion Medium resilience that can decline
Release	Rapid disbanding of resources accumulated in the system Low resilience
Reorganization	Reassembly of system components and resources Increasing resilience

Adaptation is a cyclical process that is regulated by external disturbances. A system's adaptive cycle is structured along four main phases: exploitation, conservation, release, and reorganization.

The **exploitation phase** of the adaptive cycle is characterized by rapid growth (Allen, Angeler, Garmestani, Gunderson, & Holling, 2014). In this initial phase, a system is highly influenced by external disturbances since it initially has low interconnectedness between its various components (Gunderson & Holling, 2002). Progressively, the system becomes dominated by components that have high adaptability to these disturbances (Gunderson & Holling, 2002). These components in turn collectively and rapidly expand the system by securing resources critical to system functioning (Allen et al., 2014). Resilience is high in this phase of the cycle thanks to the system's high adaptability and capacity to maintain functioning (Gunderson & Holling, 2002). During the exploitation phase in the forest example, the landscape is initially sparse and exposed. The ecosystem is then progressively colonized by highly adaptable species such as grasses and shrubs, which eventually pave the way for young, growing trees.

The **conservation phase** of the adaptive cycle is characterized by a more gradual expansion of the system (Allen et al., 2014). As interconnectedness within the system grows, functions and processes become more established and those components having greater adaptive efficiency are retained (Gunderson & Holling, 2002). The system as a whole is thus able to bring external disturbances under control and

gradually continue accumulating resources (Gunderson & Holling, 2002). During the conservation phase in the forest example, the ecosystem evolves toward a denser mature forest (Holling, 2001). At first, the slow maturation rate of trees helps to control the amount of foliage in the forest (Holling, 2001). This reduces the amount of fuel available for fire in the forest. This also allows insectivorous birds to prey on insects, reducing their populations (Holling, 2001). As a system continues along this trajectory, however, it may also become less flexible, thus reexposing potential vulnerabilities to external disturbances (Holling, 2001). Resilience might be reduced in this phase, as the system may lose its ability to withstand new waves of increasing disturbances. In the forest example this rigidity becomes progressively manifest as the increasing density of the forest structure reduces the effectiveness of insect predation by birds and increases the fuel available for fire (Holling, 2001). As a result, the forest may no longer be able to suppress insect or fire outbreaks as effectively.

The **release phase** of the adaptive cycle is characterized by the rapid disbanding of resources accumulated in the system (Allen et al., 2014). This phase is triggered when external disturbances reach a high point of magnitude that overwhelms the system's capacity to maintain functioning (Holling, 2001). In other words, external disturbances cross a threshold that induces the system to reach an adaptation limit. During the release phase, adaptability collapses, functions and processes break down, and the system reaches its lowest level of resilience. In the forest example, the ecosystem eventually becomes limited in its ability to control insect populations and the potential fuel for wildfires (Holling, 2001). A release phase is then triggered when a significant insect outbreak or wildfire occurs, decimating the forest (Holling, 2001).

Finally, the **reorganization phase** of the adaptive cycle is characterized by a reassembly of system components and resources (Allen et al., 2014). Existing resources left over from previous exploitation and conservation phases consolidate, allowing the system to reset and transition to another exploitation phase as it closes the previous adaptive cycle (Allen et al., 2014; Holling, 2001). Resilience increases again in this phase, as the system is once again highly influenced by external disturbances, favoring high adaptability (Gunderson & Holling, 2002). In the forest example, reorganization leads to renewal and regrowth as the ecosystem enters a new cycle, with banks of residual seeds eventually enabling the regeneration of young, growing trees.

Resilience and Transformation

Rather than just resetting a system, however, the reorganization phase of the adaptive cycle may also involve the association of entirely novel components and resources (Gunderson & Holling, 2002). A system may thus experience a regime shift, which fundamentally alters its nature (Walker et al., 2004). The *transformation* of a system in this way can be defined as the process by which a system reorganizes itself with entirely new components, functions, structures, and processes (Adger, 2009; Folke et al., 2010; Walker et al., 2004). A system may be driven to undergo transformation particularly if external disturbances render a return to its original regime untenable (Walker et al., 2004). As the system enters the exploitation phase of a new adaptive cycle, it may therefore begin building resilience to an entirely different set of external conditions.

The *transformation* of a system is the process by which a system reorganizes itself with entirely new components, functions, structures, and processes.

Such transformations have been identified in a number of socio systems, where strategic investments, divestments, and structural changes have been implemented in order to transition a system toward a new regime (Walker et al., 2004; Walker, Abel, & Anderies, 2009). For example, Cumming (1999) describes how changes in land use during the 1990s transformed the region of southeastern Zimbabwe from an economy focused primarily on agriculture to one primarily focused on wildlife. Extensive livestock production from both cattle ranching and subsistence agriculture, complemented by marginal dry-land crop production, originally constituted the predominant form of land use in the region. From 1992 to 1994 an extended drought decimated livestock and crop production. From there, many large commercial ranches removed both remaining livestock and internal fences to transform themselves into joint wildlife conservancies (Cumming, 1999). Some subsistence farmers subsequently negotiated to join their land to these conservancies (Cumming, 1999). As a result, multiple uses of biodiversity services, including safari hunting, game cropping, and ecotourism replaced livestock production as the principle livelihood activity (Cumming, 1999).

Problems may arise, however, when external disturbances trigger a release phase, but the system does not possess adequate residual

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resilience to reorganize itself. The transition between the conservation and release phases or the point at which a system reaches an adaptation limit therefore represents a critical juncture. This is because a system's level of resilience at this point may determine the nature of the regime into which it can reorganize itself. In other words, if the system possesses adequate residual resilience, it may transition back into its original regime or into a novel one and begin rebuilding resilience. If not, the system risks losing its key attributes, collapsing its adaptive cycle, and potentially flipping into an *impoverished regime*. An impoverished regime can be defined as a set of equilibrium states that have persistently low potential, low connectedness, and low resilience, and thus may be difficult to reverse (Gunderson & Holling, 2002; Walker et al., 2009).

Catastrophic shifts in certain ecosystems – for example, coral reefs – illustrate this type of transformation (Scheffer et al., 2001). Coral reefs are characterized by their abundant biodiversity (Scheffer et al., 2001). However, they are vulnerable to irreversible shifts into impoverished algae-dominated ecosystems due to a combination of disturbance factors (Scheffer et al., 2001). These include warming ocean temperatures and increasing acidity, hurricanes, nutrient runoff from land-use change, and overfishing (Nyström & Folke, 2011; Scheffer et al., 2001). Such shifts have already been documented for coral reefs in parts of the Caribbean and elsewhere (Nyström & Folke, 2011; Scheffer et al., 2001).

Having introduced the main dimensions of resilience theory in socioecology, in the remining sections of this paper we build upon this theory to discuss how firms may be driven to reach potential adaptation limits, particularly when faced with growing nature adversity intensity. First, we highlight how firms and ecosystems share an open systems nature. Then, our discussion focuses on how the attributes of these core open systems drive a firm's adaptation dynamic to slow-onset nature adversity conditions.

Nature Adversity Intensity as a Driver of Business Adaptation Limits

We propose that resilience theory – taken from the field of socioecology, which views adaptation as a cycle driven by chronic disturbances – can help shed light on the mechanism by which the intensity of nature adversity drives a firm's adaptation. Resilience theory was first developed

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by ecologists to explain how ecological systems (ecosystems) adapt to external stressors (Holling, 1973). We borrow logics from resilience theory to explain how firms may respond to increasing nature adversity intensity. This use of analogical reasoning follows the tradition from management scholars – and those from other social sciences – to apply concepts and vocabulary from theories that model natural systems to understand patterns of managerial behavior and strategy-making (Cornelissen, 2005; Cornelissen & Durand, 2012; Okhuysen & Bonardi, 2011; Oswick, 2011; Poulis & Poulis, 2016; Weick, 1989).

Our analogical reasoning is based on fundamental structural similarities between firms and ecosystems that make the application of resilience theory useful in understanding organizational responses to ecological adversity intensity. First, both ecosystems and firms share an open systems structure in that they exchange resources with their external environment. Second, survival-seeking adaptation in response to external stressors takes place within both ecosystems and firms. Third, both ecosystems and firms may exhibit differences in their capacity to absorb varying levels of ecological adversity intensity. Additionally, our view of firms as open adaptive systems follows well-established perspectives in the organizational sciences (Frederick, 1998; Katz & Kahn, 1966; Maguire et al., 2006; Morel & Ramanujam, 1999; Valente, 2010). Firms differ from natural ecosystems, however, in possessing intentionality, foresight, the capacity to learn, and the ability to be governed by rules that are self-evolved (Holling, 2001; Lansing, 2003; Maguire et al., 2006; Valente, 2010). In contrast to ecosystems, firms may therefore have the agency to actively manage their adaptive responses to external stressors based on their perception of nature adversity intensity.

Both ecosystems and firms share an open systems structure in that they exchange resources with their external environment. Survival-seeking adaptation in response to external stressors takes place within both ecosystems and firms. However, firms differ from natural ecosystems in possessing intentionality, foresight, capacity to learn, and ability to be governed by rules that are self-evolved.

Prior work in business strategy literature considered firms to be complex, open, and adaptive systems (Frederick, 1998; Maguire et al., 2006; Morel & Ramanujam, 1999; Valente, 2010). It is therefore plausible that firms may also progress through the different stages

of their own adaptive cycles as they attempt to cope with changes in their operating environments. Linnenluecke and Griffiths (2010), in particular apply the adaptive cycle in the context of firm adaptation to rapid-onset extreme weather events. Under stable predisturbance conditions, a firm may go through exploitation and conservation phases, thus growing, expanding, and accumulating resources and capabilities geared toward achieving a certain level of core business performance (Linnenluecke & Griffiths, 2010). However, firms may become exposed to sudden and high-impact extreme weather events such as storms, droughts, or floods (Linnenluecke & Griffiths, 2010). Such natural disasters may overwhelm their coping capabilities by damaging physical capital, disrupting processes or supply chains, inducing hefty recovery costs, and creating a general climate of uncertainty.

Firm may thus experience a sudden decline in performance, akin to a rapid release phase (Linnenluecke & Griffiths, 2010). If resilience is high enough, the firm may nonetheless restore performance to predisturbance levels through reorganization (Linnenluecke & Griffiths, 2010). As a firm starts to re-accumulate resources and reestablish functions and structures, it may close its previous adaptive cycle and enter subsequent exploitation and conservation phases. In this example, external disturbance, in the form of a sudden crisis event, such as a natural disaster or economic meltdown, represents a punctuated and delimited moment in time. Firms build requisite coping capabilities *in the absence of* or *before* a disturbance event. Firm resilience is then put to the test in the aftermath of adverse events in enabling (or not) a return to initial equilibrium (see Chapters 4, 5, 8, and 9 for a detailed examination of business responses to natural disasters).

However, the mechanism by which firms may be driven to reach adaptation limits may be different when external disturbances are considered in the form of **slow-onset *continuous* stress**. Indeed, nature adversity intensity can also be characterized by *gradual* slow-onset changes in natural environment conditions that are both exogenous and unfavorable to the firm. For example, nature adversity intensity in the agriculture sector may take the form of changes in temperature and precipitation patterns (Risky Business Project, 2014). In the case of coastal industries, sea-level rise may constitute a salient indicator of nature adversity intensity (Risky Business Project, 2014). Nature adversity intensity may therefore be persistent and potentially impact firm performance at every stage of the adaptive cycle while also being

out of a firm's immediate control. Managers may therefore need to adapt continuously to these conditions, without necessarily being certain that their efforts will be viable or yield requisite adaptive benefits at all levels of nature adversity intensity.

Besides natural disaster-related adversity, nature adversity can also be characterized by the intensity of *gradual* slow-onset changes in the natural environment conditions both exogenous and unfavorable to a firm.

Low to moderate nature adversity intensity may at first drive a firm during the exploitation and conservation phases to select and then reinforce adaptation that attempts to sustain their core business. Such protective adaptation may enable a firm to continue pursuing its core business at the same or even extended levels (Busch, 2011; Hoffmann, Sprengel, Ziegler, Kolb, & Abegg, 2009), thus allowing it to grow and expand. Protective adaptation may also have the benefit of leveraging existing or familiar competencies. Adaptation can therefore rapidly become routine, allowing firms to be more effective in countering nature adversity intensity at low to moderate levels.

Protective adaptation seeks to enable firms to continue pursuing their core business at the same or even extended levels. The need for protective adaptation may be stimulated when the reliability of ecological resources possibly critical to a firm's core business are threatened.

These arguments are consistent with prior research on organizational adaptation to climate change, which is one of the few areas where scholars have specifically considered how firms cope with natural environment dynamics. Prior work suggests that the need for protective adaptation may be stimulated when firms face increasingly unfavorable climate conditions (Berrang-Ford, Ford, & Paterson, 2011; Haigh & Griffiths, 2012; Tashman & Rivera, 2016). This especially might be the case if firms have a high dependency on their core business, have previously experienced unfavorable climate conditions, and are relatively certain of being exposed to such conditions in the future (Busch, 2011; Hoffmann et al., 2009). In particular, if the reliability of ecological resources that may be critical to a firm's core business is threatened, then the firm may focus protective adaptation on securing access to these resources (Tashman & Rivera, 2016).

A good example of this adaptive strategy can be found in the ski industry, where variability in natural snowfall affects the length of

Table 2.3. *List of Chapter 2 propositions*

Proposition 1	As nature adversity intensity increases from low to moderate levels, firms are more likely to engage in increasing levels of protective adaptation.
Proposition 2	As nature adversity intensity increases from moderate to high levels, firms are more likely to engage in decreasing levels of protective adaptation.
Proposition 3	Firms experiencing or anticipating adaptation limits at moderate levels of nature adversity intensity are more likely to pursue transformation strategies.
Proposition 4	Firms responding to nature adversity intensity may undertake protective adaptation that has deleterious impacts on local ecosystem services.
Proposition 5	The degradation of local ecosystem services may feed back to constrain firms in their ability to continue pursuing protective adaptation and hasten their attainment of adaptation limits.

the ski season (Hoffmann et al., 2009; Tashman & Rivera, 2016). Ski resorts adapt to the unreliability of this key resource by implementing artificial snowmaking, which can supplement and even replace natural snow cover, or by developing ski runs in more climatically favorable areas, where resorts can capitalize on longer lasting snow cover (Scott & McBoyle, 2007; Tashman & Rivera, 2016). Overall, our previous discussion suggests the following proposition (see Table 2.3, at the end of this chapter, for a list of all the propositions developed from our discussion in this paper):

> **Proposition 1:** As nature adversity intensity increases from low to moderate levels, firms are more likely to engage in increasing levels of protective adaptation.

However, as the intensity of nature adversity reaches a certain threshold, the ability of a firm to continue pursuing protective adaptation may start to reach its limits. Critical core business resources may continue to be threatened, but now the viability of the adaptation itself in terms of feasibility and effectiveness may start to be compromised as well. Rather than enabling firms to negate or avoid the threats of nature adversity intensity altogether (Busch, 2011; Weinhofer & Busch, 2013),

protective adaptation may therefore only shield them temporarily from these threats.

In addition, fundamental uncertainties associated with the identification and interpretation of nature adversity intensity thresholds can induce adaptation limits (Dow et al., 2013). Indeed, nature adversity might exhibit variability in intensity, particularly at a local scale, that is difficult to predict (Linnenluecke & Griffiths, 2012; Winn, Kirchgeorg, Griffiths, Linnenluecke, & Gunther, 2011). Nature adversity intensity may also interact with other biophysical, socioeconomic, and technological constraints to shape the point at which adaptation limits are reached (IPCC, 2014a,b). Therefore, identifying a given adaptation as effective for a given level of nature adversity intensity might be contingent upon a large variety of different factors. Managers could thus find it difficult to perceive and anticipate corresponding adversity intensity thresholds until after the moment when these are actually crossed (Brozovic & Schlenker, 2010; Nelson et al., 2007).

As the intensity of nature adversity increases beyond this threshold, from moderate to high levels, firms may find their ability to adapt is more severely constrained, as protective adaptation reaches physical limits and starts to fail. Over time, business managers are also likely to show an increasing level of fatigue, which in turn limits their willingness to sustain a high level of adaptation efforts in the face of worsening nature adversity intensity conditions that show no end in sight. Additionally, since protective adaptation may have become routine, managers may also lack the flexibility or ability to implement the more in-depth adaptive changes needed to fit the severe level of adversity intensity being experienced. For these reasons, managers may be unable to effectively achieve adequate adaptive benefits at more intense levels of nature adversity and may be compelled to forgo protective adaptation.

Over time, business managers are also likely to show an increasing level of fatigue, limiting their willingness to sustain a high level of adaptation efforts in the face of worsening nature adversity intensity conditions that show no end in sight.

An example of adaptation limits can be found in the impacts of the recent drought on agriculture firms in California's Central Valley. Agriculture firms in this area have traditionally coped with recurrent drought by using irrigation that relies on a complex network of reservoirs,

canals, and aqueducts, which store spring snowmelt from high in the Sierra Nevada and Cascade mountain ranges and release it when it is needed most, during the summer months (Nijhuis, 2014). However, recent historic levels of drought intensity and prolongation coupled with shrinking snowpacks and earlier snowmelts due to warmer winters, have decimated water reserves and crippled the irrigation efforts used by these firms to adapt (Nijhuis, 2014). We therefore put forward the following proposition:

> **Proposition 2:** As nature adversity intensity increases from moderate to high levels, firms are more likely to engage in decreasing levels of protective adaptation.

Nature Adversity Intensity and the Potential for Organizational Transformation

As a firm reaches potential adaptation limits and forgoes protective adaptation, a release phase may be triggered in the adaptive cycle. As adaptation fails and/or is abandoned, a firm might begin to lose resources, processes, and functions, affecting core business performance. At this point, its level of residual resilience may determine how quickly it will be able to transition into a reorganization phase as well as the outcome of that phase.

Specifically, a firm may face three broad potential trajectories. Along the first, if residual resilience is high enough, the firm may recover and resume business as usual under its original operational regime. As it reenters the exploitation phase, however, now aware of the heightened risks posed by nature adversity intensity, it may need to modify selected adaptation strategies so as to build adequate resilience to this altered operating environment. Along the second potential trajectory, residual resilience might be so low, or nature adversity intensity so severe, as to preclude recovery to its original operational state. As a result, the firm could shift to a more impoverished operational regime, one that may be difficult to reverse; or it might be acquired by another company; or it might cease operations altogether.

Going back to the California drought example, with the failure of irrigation resources and systems from prolonged and more intense drought, some agriculture firms have been turning to alternative adaptation. These include supplementing water resources with groundwater,

investing in water efficiency, or transitioning to more drought-resistant crops (Fishman, 2015). For others, however, irrigation failure has meant leaving fields fallow – even on the order of 430,000 acres, in 2014 (Nijhuis, 2014) – or going out of business altogether (Sahagun, 2015).

Along the third potential trajectory, a firm may undertake transformative change and shift to an entirely new operational regime, possibly enabling it to avoid the threats of future nature adversity intensity altogether. It would then re-enter the exploitation phase under a new regime, one in which it starts to build resilience to an entirely different set of external challenges. These new conditions might eventually push the firm to transform yet again, thus allowing for repeated and successive cycles of innovation and renewal.

Anecdotal evidence suggests that in certain industries some firms follow this third trajectory. In the ski industry for example, some resorts are diversifying their efforts toward rebranding as year-round tourism destinations or investing in real estate development (Branch, 2014; Scott & McBoyle, 2007; Tashman & Rivera, 2016). In the wine industry, which is dealing with drought and warmer temperatures in certain regions, some vintners are relocating to more northern latitudes or expanding their businesses into hoteling (Finz, 2013; Hannah et al., 2013). Finally, small farms being affected by adverse climate conditions are diversifying their revenue streams into agro-tourism and farm stay businesses.

The potential for firm transformation is seen in the application of resilience theory to organizational systems differs from its application to purely natural systems. As already mentioned, in contrast to natural systems, business organizations and other social systems possess agency (i.e. intentionality), foresight, the capacity to learn, and the ability to be governed by rules that are self-evolved (Holling, 2001; Lansing, 2003; Maguire et al., 2006; Valente, 2010). This means a firm can actively shape the outcomes of its reorganization phase, namely through transformation. A key point of tension is whether transformation happens predominantly in a reactive manner, after adaptation limits are reached, or potentially in a proactive manner, in anticipation of approaching limits.

The potential for firm transformation is seen in the application of resilience theory to organizational systems differs from its application to purely natural systems. Thanks to human agency, a firm may be able to actively shape the outcomes of its reorganization phase, namely through transformation.

The strategic management literature supports multiple possibilities ranging from collapse to transformation. Under the *punctuated equilibrium model*, for instance, organizational transformation happens in short, discontinuous bursts as a result of significant changes in operating conditions or major declines in performance (Romanelli & Tushman, 1994; Tushman & O'Reilly, 1996). Rindova and Kotha (2001) show, for example, how Internet search engine firms were able to regenerate competitive advantage in response to changing market conditions over different periods by morphing their organizational forms. It is possible that firms may undertake transformation only when they experience an extreme need to do so. This is because transformation may involve complex and cascading changes that may be inherently difficult to implement, while also violating elements of organizational identity, which may engender internal resistance (Gavetti, 2012).

Transformation is rare and very challenging because it involves complex and cascading changes that may be inherently difficult to implement, while also violating elements of organizational identity, which may engender strong internal resistance by managers.

However, if firms can anticipate approaching adaptation limits and initiate transformation before these limits are reached, then firms may not need to actually experience a release phase triggered by nature adversity intensity.

Another school of thought regards organizations as potentially able to undertake transformative change in an anticipatory manner (Folke et al., 2010; Rickards, 2013). In particular, Tushman and O'Reilly (1996) define the idea of ambidexterity as "the ability to simultaneously pursue both incremental and discontinuous innovation and change". This means that firms may have a better fit with their operating environments in the short run, while also retaining the capacity to completely reevaluate and reinvent that alignment in the long run as needed (Tushman & O'Reilly, 1996).

A firm's pursuit of an ambidextrous strategy in the face of worsening nature adversity intensity is likely to be more favorable than if it were to persist in attempts to protect core business activities for which viability limits may be approaching.

In response to growing nature adversity intensity, ambidextrous firms may be able to leverage existing processes and resources to adapt

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in the shorter term, while also developing capabilities to innovate and transform toward potentially novel states in the longer term. For instance, managers can encourage the creation of entirely new business lines and diversify away from the core business being affected (Hoffmann et al., 2009). This may be more favorable than persisting in attempts to protect core business activities for which viability limits may be approaching. Ambidextrous firms may therefore have the ability to actively manage their adaptive cycles. If a firm can anticipate approaching adaptation limits and initiate transformation before these are reached, then it might not need to actually experience a release phase triggered by nature adversity intensity. Instead, they may be able to manage the transition directly from the conservation phase to the reorganization phase. Then through transformation, firms may enter a new exploitation phase using a novel set of resources and capabilities without having undergone major declines in performance. Such firms may retain high resilience throughout their adaptive cycles. We therefore put forward the following proposition:

> **Proposition 3:** Firms experiencing or anticipating adaptation limits at moderate levels of nature adversity intensity are more likely to pursue transformation strategies.

Interdependencies between Organizational and Ecosystem Resilience

Having discussed the processes by which a firm maintains or renews resilience in response to nature adversity intensity, we now consider how its embeddedness in wider ecosystems can affect its resilience. This interconnectedness may be particularly salient for a firm having a high dependence on ecosystem services for its core business or for adaptation. Ecosystem services can be formally defined as those services which people obtain from nature: the provisioning (e.g. water resources), regulating (e.g. climate regulation, water quality), cultural (e.g. aesthetic), and supporting (e.g. soil formation) benefits (Millennium Ecosystem Assessment, 2005).

Firms not only rely on ecosystem services but also affect the provisioning of these services (Nelson et al., 2007; Starik & Rands, 1995). In particular, as mentioned above, when reliability of critical ecological resources becomes compromised, a firm may respond by seeking to maintain or augment its usage of these resources (Hoffmann et al.,

2009; Tashman & Rivera, 2016). A firm may find this a cost-effective and expedient strategy, especially if it is able to externalize the costs of consuming these resources (Tashman & Rivera, 2016). In particular, this may be the case if it owns or controls its surrounding ecosystems or if ecosystem services are treated and regulated as public goods (Ostrom, 2010; Tashman & Rivera, 2016). However, at least since Hardin's (1968) *Tragedy of the Commons*, scholars have argued that ecosystem services are rarely infinite. Ecosystem services can be diminished by overexploitation, particularly when access and use by multiple users is difficult or costly to restrict (Ostrom, 2010). Therefore, while ecosystems may possess a certain capacity to sustain services, overconsumption by one or multiple users may eventually lead to deteriorating productivity and function (Folke et al., 2010; Nelson et al., 2007).

A firm responding to pressures from nature adversity intensity tends to end up utilizing ecosystem services in a way that exceeds the ecosystems' capacity to sustain it. However, because observable ecosystem change tends to be nonlinear or delayed, managers may find it difficult to make sense of the link between their actions, ecosystem service degradation impacts, and how these impacts may, in turn, feed back to affect them.

It follows that a firm may not be able to continuously carry out an adaptation that increases its usage of ecosystem services without having potential negative spillover effects on the provisioning of these services. Firms responding to pressures from nature adversity intensity may therefore end up utilizing ecosystem services in a way that exceeds the ecosystems' capacity to sustain them. More specifically, as a firm draws on local ecosystems during the exploitation and conservation phases of its adaptive cycle, it may be progressively depleting the stored-up potential in these ecosystems. However, due to the ambiguous nature of ecosystem change, managers may not be able to immediately perceive deleterious changes occurring in ecosystems (Bansal & Knox-Hayes, 2013; Linnenluecke & Griffiths, 2013). Some ecosystems may change in a smooth, continuous manner, while others may remain unchanged until impacts reach a critical threshold, while still others may exhibit abrupt shifts from one state of functioning to another (Scheffer et al., 2001). Observable ecosystem change may thus be nonlinear or delayed and managers find it difficult to make sense of the link between their actions, ecosystem service impacts, and how

these impacts may in turn feed back to affect them (Holling, 2001; Whiteman & Cooper, 2011; Winn et al., 2011).

In addition, even if managers are able to perceive the harmful impacts of their actions, they may still be prone to short-termism (Bansal & DesJardine, 2014). Managers myopically tend to focus on short-run adaptive gains over more long-term and uncertain impacts on ecosystems. They may therefore more easily misinterpret or ignore threats to or declines in ecosystem services and persist in their adaptive efforts (Bansal & Knox-Hayes, 2013; Starik & Rands, 1995). We therefore put forward the following proposition:

> **Proposition 4:** A firm responding to nature adversity intensity may undertake protective adaptation that has deleterious impacts on local ecosystem services.

However, a persistent degradation of local ecosystem services may in turn feed back to affect firm resilience in later phases of the adaptive cycle. When firm impacts are compounded by other types of stress, ecosystem service provisioning may completely collapse. Now, unable to continue drawing on ecosystem services for adaptation, the firm may more rapidly reach adaptation limits and enter a release phase. Furthermore, if it is unequipped to cope with such severe or rapid ecosystem service collapse, its residual resilience may be too low upon entering the reorganization phase. As a result, the firm may be precluded from returning to its original operational regime or from opting for more transformative change, with potential survival consequences. For firms with a high dependence on ecosystem services, adaptation that may appear successful in building resilience in the short term may actually prove to be maladaptive in the long run by unintentionally sabotaging future resilience pathways.

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Cascading breakdowns have been described for a number of socioecological systems, including in agriculture, forestry, and fisheries. In all of these, managers fail to take into account the dynamics of adaptive cycles at the ecosystem level, resulting in maladaptive management decisions and the collapse of the socioecological system (Barnett & O'Neill, 2010; Gunderson & Holling, 2002; Walker & Abel, 2002).

The example of arid rangelands threatened by drought and overgrazing in many parts of the world can serve to illustrate how such collapses might occur (Scheffer et al., 2001). Rangeland managers may at first respond to drought conditions by increasing the grazing of grasslands in order to maintain livestock numbers (Walker & Abel, 2002). However, grasslands may become progressively impoverished, less productive, and more eroded as a result of the compounded impacts of drought and overgrazing (Walker & Abel, 2002). If drought conditions and overgrazing become prolonged, resilience in grassland ecosystems may become so deteriorated as to induce a complete collapse in livestock production (Walk & Abel, 2002). If residual resilience has become too degraded, then the entire rangeland system may be unable to regenerate and shift into an impoverished regime of desertification (Holling, 2001). We therefore put forward the following proposition:

> **Proposition 5:** The degradation of local ecosystem services may feed back to constrain a firm's ability to continue pursuing protective adaptation and hasten its attainment of adaptation limits.

Conclusion

From an organizational perspective, certain industries, especially those which directly depend on natural systems, appear to already be at the forefront of the resilience challenges posed by nature adversity intensity; business strategy scholars are well positioned to tackle and anticipate future research avenues in this area and their potential implications for strategy and management.

In this chapter, we offered our view on two ways in which the research on firms and their natural environment can address these challenges: by building interdisciplinary bridges and by expanding a research agenda on organizational resilience. Specifically, we have sought to propose an extension to the previous literature by encouraging scholars to continue to think about organizational resilience as a dynamic property of a firm, one that integrates processes of both adaptation and transformation and that is longer term and intersystemic in nature.

> **Firms operating in industries that that directly depend on natural systems (e.g. agriculture, forestry, tourism, fisheries, coastal real state, energy production and supply, or food and beverage industries, among others) appear to already be at the forefront of the resilience challenges posed by nature adversity intensity.**

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