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Managing for Resilience: Lessons from Ecology

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MANAGING FOR RESILIENCE
LESSONS FROM ECOLOGY*

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Abstract. Understanding and developing resilience is becoming increasingly important in business for both leaders and organizations. Resilient organizations can successfully navigate uncertainty and change. Resilience, however, is a poorly understood attribute. We thus turn to ecosystem resilience theory to understand the concept of resilience. We identify four lessons that can be adapted from management for ecological resilience to management for business resilience: 1) resilience can be positive or negative depending on the nature of the function it supports, 2) diversity of individuals, departments, flows of information, perspective, and other attributes contributes to resilience, 3) because we have imperfect knowledge about the timing and nature of a given disturbance and thus imperfect knowledge about the exact components of diversity that will promote resilience in the face of it, there is a benefit to preserving diversity, even if it reduces efficiency under static conditions, and 4) to the extent that disturbances are unavoidable, emphasis should be placed on low-level adaptability to support high-level resilience of function. In managing for resilience, the leader can apply these lessons both by promoting diversity (of functional redundancy and response diversity) throughout all levels of the organization and by focusing on development of flexibility, nimbleness, and adaptability. This work has led us to develop seven theoretical propositions on leadership for resilience that can spur further research to integrate ecology and business leadership perspectives.

Keywords: resilience; ecology; leadership; diversity

INTRODUCTION

Leaders in business, industry, and government are coming to the realization that society and its economic constructs necessarily operate within natural boundaries and that, by acting as if they do not, business-as-usual has caused or exacerbated the pressing economic, social, and environmental crises of our time (Anderson, 1999; Anderson & White, 2009; Edwards, 2005; Fullerton, 2015; Hawken, 1993; Hawken, Lovins, & Lovins, 1999; Rockstrom et al., 2009; Steffen et al., 2015). A logical extension of this new realization is that nature itself may provide guidance for the sustainable operations of businesses (Edwards, 2005; Fullerton, 2015; Hawken, 1993; Hawken et al., 1999). After all, nature has been thriving within boundaries for eons. Ecology is the scientific study of "nature's economics," and it has articulated the principles under which the global recycling of matter and consumption of energy are sustainable. By understanding and adopting principles of natural design and organization as articulated by ecology, it is anticipated that

businesses can adopt practices that will allow them to thrive while at the same time help solve economic, social, and environmental crises (Edwards, 2005; Fullerton, 2015; Hawken, 1993; Hawken et al., 1999).

One critical and perennial challenge business leaders face is coping with disturbances, shocks, disruptions, or other unforeseen or unpredictable events that upset the normal course of business (collectively referred to hereafter as "disturbance") (Cork, 2010; Parker, 2010). Although the specific timing and nature of a disturbance is often impossible to predict in advance, the fact that a disturbance *will* occur sooner or later is assured. Resilience to disturbance is thus an essential, though poorly understood, attribute (Cork, 2010; Parker, 2010). Understanding it is critical because it allows individuals, organizations, communities, nations, and the global community to successfully navigate uncertainty and change and to rebound from setbacks. For example, resilient individuals can successfully guide themselves through adversity such as trauma or unexpected loss. Resilient organizations can successfully emerge from operational disturbances such as downsizing, mergers, or acquisitions. Resilient organizations, communities, nations, and the global community alike can successfully emerge from market and non-market disturbances such as the economy, climate change, terrorism, or war.

Cork (2010, p. 3) states, "It is easy to find lists of actions to take to improve … resilience but it is difficult to find empirical or theoretical underpinnings for this advice." We respond by applying ecosystem resilience theory to leadership for business resiliency. Ecosystems in nature routinely experience disturbances such as fires, floods, wind storms, and pests, and the results usually appear devastating from our human perspective. However, ecosystems also routinely rebound to a level of functioning that is comparable to the pre-disturbance state. If one returned many years later to an area that had been disturbed by fires, floods, wind storms, or pests, one would probably find it looking "healthy" and "normal." But ecosystems sometimes also demonstrate a lack of resilience to disturbances such as invasive species and nutrient pollution. If one returned many years later to an area that had been disturbed by invasive species or nutrient pollution, one might find it still looking "unhealthy." The insights gained from studying non-resilient ecosystems are just as valuable, therefore, as the insights gained from studying resilient ecosystems. Thus we ask the question: can we learn from what makes an ecosystem resilient (or not) to disturbance and apply such lessons in order to build more resilient business leaders and organizations?

It is important to emphasize that we should selectively apply and adapt what we learn from nature to improve the resilience and sustainability of our human constructs. We should not attempt to simply mimic nature because, in contrast to the popular romanticized characterization of nature as happily "in harmony," much of what it actually takes to maintain something akin to "harmony" in nature comes in the form of persistent stress, starvation, and lonely or violent death. To appreciate the magnitude of the unpleasantness involved, one need only consider the fact that for an ecosystem that is approximately in equilibrium (and most are), each adult organism—be it plant, animal, fungi, or bacteria—will on average manage to replace only itself over the course of its lifetime (any significant departure from this would cause disequilibrium). This one-for-one replacement is such despite each individual's prodigious production of offspring, the impressively vast majority of which fall short in some dreadful way or another. Thus, just as it has arguably been a mistake in the business and economic literature to completely ignore lessons from nature (Jørgensen, Fath, Nielsen, Pulselli, Fiscus, & Bastianoni, 2015), we believe it would also be a mistake to let the pendulum swing too far in the opposite direction. We should learn from nature; we should not attempt to mimic it.

In this article, we will begin with definitions of resilience, disturbance, and shock from the relevant fields of ecology and business. Next, we review the ecology literature on resilience as well as the business leadership literature on resilience at both the individual and organizational levels. We then identify practical lessons that can be gleaned from ecology resilience theory to inform leadership for resilience. Finally, we will develop for further research theoretical propositions that integrate the ecology and business leadership perspectives.

RESILIENCE DEFINED

There are numerous definitions of resilience. All of them refer to the ability to recover following a disturbance. Some argue that the definition of resilience is bounded by a return to the pre-disturbance state (Powley, 2012; Powley & Piderit, 2008), whereas for others the definition of resilience can include an improvement over the pre-disturbance state (Sutcliffe & Vogus, 2003). The meaning of the word resilience can also take on many definitions depending on the discipline or perspective from which it is being discussed. In ecology literature, for example, resilience is defined as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same [identity, structure, or function]" (Holling, 1973, p. 14). In business

leadership literature, resilience is defined as "… the ability to absorb strain and preserve (or improve) functioning despite the presence of adversity … (with) an ability to recover or bounce back from untoward events … (and) an ability to learn and grow from previous episodes" (Weick & Sutcliffe, 2007, p. 71). Within business strategy literature, Hamel and Valikangas (2003, pp. 53–54), suggest that

> Strategic resilience is not about responding to a one-time crisis. It's not about rebounding from a setback. It's about continuously anticipating and adjusting to deep, secular trends that can permanently impair the earning power of a core business. It's about having the capacity to change before the case for change becomes desperately obvious.

For the purposes of our discussion, we define resilience as *the ability of an individual or system to rebound from a disturbance to a level of functioning that is equal to or better than the level of functioning prior to the disturbance.*

DISTURBANCE DEFINED

Pickett and White (1985, p. 7) define an ecological disturbance as "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment," although we might now extend that iconic definition to include persistent factors that have similar effects. Examples of disturbances abound and include forest fires, hurricanes, blights, habitat fragmentation, eutrophication, over-hunting, volcanic eruptions, invasive species, and more. In a similar vein, the business literature focuses on shocks to the system and driving forces of change. Examples of these shocks or driving forces of change include crises, disasters, technology, globalization, competition (related to competitors, customers, suppliers, and markets), the economy, legislation, and more. We therefore use the term disturbance to refer to ecological disturbance as well as driving forces of change or shocks in business.

It is important to note that disturbances may be short-lived, as with forest fires, outbreaks of pests, and wind storms, and as with economic downturns, fickle consumer preferences, and personnel changes. But disturbances or shocks may also persist, such as with habitat loss, the introduction of invasive species, and the loss of predators, and as with regulatory changes, technological innovations, and changing market conditions. In the latter case, the disturbance becomes the "new normal" and the question of resilience shifts from "will the ecosystem function

or business recover" to "will the ecosystem function or business persist in the new normal."

ECOLOGY & RESILIENCE

Before we discuss ecological resilience, it is important to correct a common misconception about the way nature works. Because we as a species are so accustomed to cooperating and collaborating with our fellow human animals on common goals, it is easy to imagine that the individual plants, animals, etc. that comprise an ecosystem work together to maintain their ecosystem's integrity. After all, the reasoning goes, it is in the interests of all those individual organisms that their ecosystem should maintain its status quo; if the ecosystem is destabilized, they and their offspring are likely to suffer. But this view is incorrect. In nature, it's "every individual organism for itself," except in the rare cases where cooperation has evolved (e.g., as it has among humans), and even then, cooperation is only among a small subset of organisms within an ecosystem (e.g., you surely will not find humans cooperating with weeds, rodents, or bed bugs, nor will you find dolphins cooperating with seaweed, honey bees cooperating with mushrooms, wolves cooperating with eagles, and so on).

Ecosystem resilience, therefore, is never a "goal" for which individual organisms collectively strive. Instead, ecosystem resilience is an "emergent property" of the births, deaths, and actions of individual organisms, each of which is more or less adapted to make best use of limited resources to maximize its reproductive output. How and why ecosystem resilience so reliably emerges when nothing in the ecosystem is "trying" to make it resilient is a source of active research (e.g., Harfoot et al., 2014); one possibility is that over millennia, ecosystems comprised of individual organisms whose actions were collectively destabilizing simply did not persist, leaving us with fairly resilient ecosystems today.

Over 160 definitions of ecosystem resilience exist in the ecological literature (Grimm & Wissel, 1997), but the vast majority are variations on a theme pioneered by Holling (1973, p. 14) as quoted above: ecosystem resilience is "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same [identity, structure, or function]." For example, an eastern U.S. forest's *identity* includes the species it contains; its *structure* includes the abundances of those species and their interactions (e.g., who eats whom?); and its *function* includes chemical transformations, transfers of nutrients and energy, and services like soil retention, carbon storage, and decomposition. Ecologists

commonly visualize ecosystem resilience using the metaphor of a ball that can roll across a series of hills and valleys (Fig. 1). Without any outside disturbance, the ball—or ecosystem—comes to rest in a valley, which represents its particular identity, structure, or function (though not necessarily all of these at once). Different balls in different landscapes could be used to depict different aspects of a single ecosystem, each of which may be more or less resilient than other aspects. A disturbance will tend to push the ball—or ecosystem—away from its equilibrium and up one of the neighboring hills. Greater ecosystem resilience is depicted by higher or steeper hills, such that the ball—or ecosystem—will tend to return to its initial equilibrium after the disturbance, i.e., it will roll back to the bottom of the valley from where it started (Fig. 1, left panels). However, if the disturbance is too great or if the ecosystem resilience is too low, then the ball—or ecosystem—will cross over the threshold into a new equilibrium, i.e., to a new identity, structure, or function, i.e., it will roll to the bottom of a *different* valley (Fig. 1, right panels).

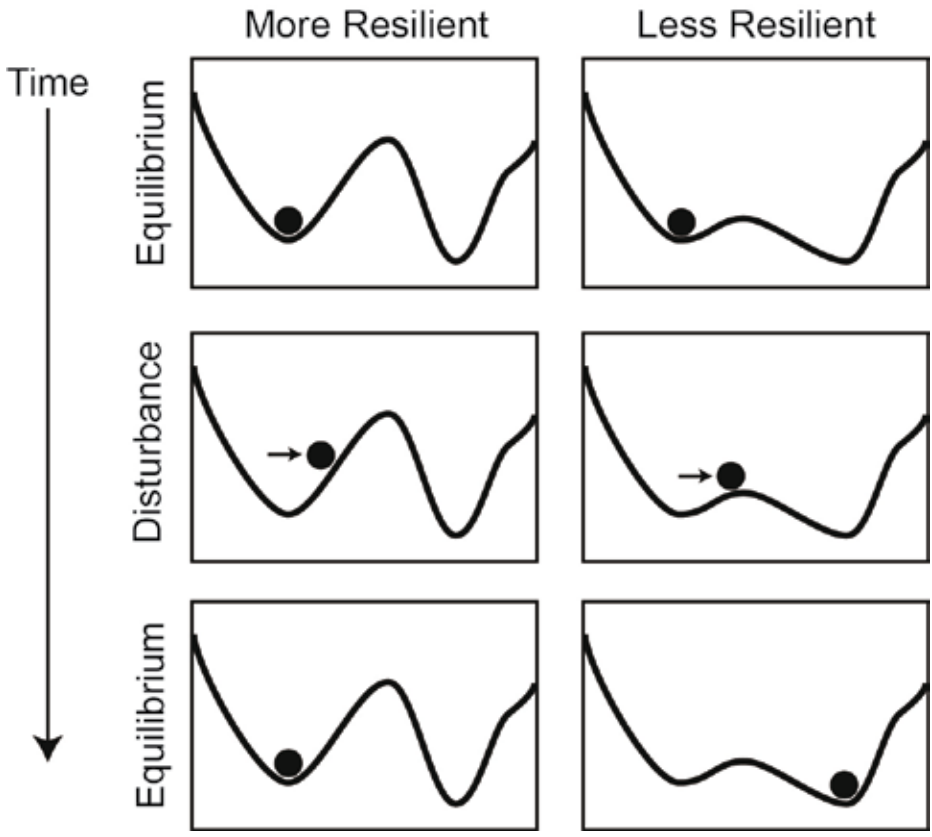

Figure 1. Ball and valley metaphor for ecosystem stability and resilience. The shape of the landscape reflects its degree of resilience, and the arrow represents a disturbance. The size of the arrow is the same in both cases to suggest a similarly-sized disturbance affecting both the more- and less- resilient systems (left- and right-hand panels, respectively). The more-resilient system is represented by the taller hill, which the disturbance is unable to overcome. The less-resilient system is represented by the smaller hill, which the disturbance is able to overcome. After the disturbance (bottom panels), the more resilient system has returned to its original equilibrium (i.e., its original identity, structure, and function), whereas the less-resilient system has moved to an alternate stable state (i.e., it now has a different identity, structure, or function compared to what it had before the disturbance).

For example, even though humans often perceive forest fires as one of the most devastating events that can occur to an ecosystem, forest types in which fire has been an historically recurring phenomenon are composed of plant species that are adapted to capitalize on the conditions immediately following a fire to propagate the next generation (Bond & Keeley, 2005). Thus, the regenerating forest usually retains the identity, structure, and function of the pre-fire forest, i.e., it is resilient to fire or, to use the ball and valley metaphor, the ball remains in the same valley in response to the disturbance. In contrast, fertilizer additions (such as through atmospheric deposition of nitrogen downwind from industry) can drastically change the identity, structure, and function of a wild ecosystem by changing the costs and benefits of different nutrient acquisition and nutrient use traits (Scheffer & van Nes, 2007). Not only does the identity of the main plant species often change in response to fertilization, there are often fewer species in total as well (Suding et al., 2005), with obvious implications for the herbivores, pollinators, and predators that rely on the plant community. Thus, few ecosystems are resilient to fertilization or, to use the ball and valley metaphor, the ball is pushed to a different valley in response to the disturbance.

Recalling that ecosystem resilience is an emergent property and not a goal of natural systems, ecologists have identified characteristics of ecosystems that tend to make them more resilient. In a word, *diversity,* as mediated by "functional redundancy" and "response diversity" (Desjardins, Barker, Lindo, Dieleman, & Dussault, 2015) is key. *Functional redundancy* contributes to ecosystem resilience when a diversity of organisms perform the same function, such as when multiple plant species all provide food for herbivores. *Response diversity* contributes to ecosystem resilience when different organisms respond differently to a disturbance. For example, plant species have a spectrum of responses to drought: some "drought tolerant" species are adapted to survive a drought while "drought intolerant" species wilt and die. In an ecosystem with sufficient *response diversity* to drought, *functional redundancy* in plant

species will allow the drought-tolerant species to compensate for the poor production of the drought-intolerant species (Tilman & Downing, 1994). To be clear, the drought-tolerant species would "compensate" not because they were "trying" to maintain ecosystem function but because individual plants are more or less adapted to make best use of limited resources to maximize their reproductive output. When the drought-intolerant species succumb, the drought-tolerant species simply capitalize on the increased resource availability. The emergent property is that an ecosystem function (food for herbivores) is resilient to a particular disturbance (drought).

As the example above illustrates, resilience at one level (the function of food production for herbivores) often requires the temporary loss of resilience at another level (the identity and structure of plant species in the community). In hindsight and in this particular example, this may seem obvious and unproblematic (and it is), but many disagreements about resilience in ecology (both theoretical and empirical) arose from the different emphases different researchers placed on the resilience of identity, structure, function, or their sub-components without being very clear about it (DeLaplante & Picasso, 2011). Many researchers now believe that ecological resilience at one level actually *requires* instability at one or more levels below (Desjardins et al., 2015), but it is too early to say if such a relationship will prove to be true in all cases.

LEADERSHIP & RESILIENCE

Resilience is a concept that is also present in business literature. Within this context, resilience is studied at the individual and organizational levels. For the purposes of this article, we are interested in leadership and resilience in particular.

Individual Resilience

The majority of research on individual resilience and leadership is rooted in the psychology literature. Individual resilience is the positive behavioral adaptation one encounters when exposed to a disturbance, although this literature uses the terms "threat" or "trauma" (Luthar, Cicchetti, & Becker, 2000; Luthar & Cicchetti, 2000). This literature focuses on both the antecedents and the outcomes of the individual's response when faced with a threat or trauma.

Early research viewed individual resilience as personality traits or attributes of the individual, and these were referred to as protective factors

(Luthar et al., 2000; Luthar & Cicchetti, 2000; Richardson, 2002; Wright, Masten, & Narayan, 2013). Some of the protective factors explored in these studies include self-esteem, self-efficacy, communication skills, relationships with caregivers, and whether the attributes were innate or acquired (Richardson, 2002).

The next wave of individual resilience research viewed individual resilience as a process and focused on *how* the previously mentioned protective factors were acquired; that is, how individuals acquire the necessary self-esteem, self-efficacy, communication skills, or relationships with caregivers to contribute to the development of resilience (Moenkemeyer, Hoegl, & Weiss, 2012; Richardson, 2002; Wright et al., 2013).

Another wave of research sought to identify mediators or moderators that intervene in the aforementioned process (Wright et al., 2013). Studies of this nature examined variables such as timing, relevance, and setting of the threat or trauma and its impact on resilience, suggesting that resilience processes can be identified and changed (Masten, 2011).

More recently, research has also drawn across disciplines, such as ecology, engineering, public health, management, psychology, biology, and neurobiology, in an effort to develop an interdisciplinary and integrative resilience metatheory (Masten & Obradović, 2008; Norris, Steven, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Richardson, 2002; Wright et al., 2013). This research suggests that resilience is a multilevel phenomenon linking genes, neurobiological adaptation, brain development, and behavior (Wright et al., 2013) and that humans have an innate energy or force that drives them toward self-actualization, or an innate capacity to transform and change (Richardson, 2002).

These progressive waves of research have led Sutcliffe and Vogus (2003) to conclude that there are at least two building blocks to the process that creates individual resilience: adequate resources and an active mastery motivation system. These two building blocks supersede any efforts to reduce risk or adversity. Adequate resources refers to the availability of various forms of physical and non-physical capital that allow an individual to develop competence. An active mastery motivation system refers to the experience of past successes and failures that can motivate future action. "… resilience is enhanced both when individuals have access to human, social, and material capital and when they have experiences that add to their growth, competence/expertise, and efficacy" (Sutcliffe & Vogus, 2003; p. 100). Competence thus leads to success and motivation which further develop competence in a self-reinforcing cycle (Sutcliffe & Vogus, 2003). The research therefore

suggests that, whether resilience is understood as a personality trait, as a process of acquisition of personality traits that function as mediators and moderators in the process, or as an interdisciplinary concept, adaptability and flexibility are critical requirements in responding to threats or trauma (i.e., disturbance).

Organizational Resilience

Studies of the organizational unit of analysis and its resilience literature draw primarily from network and complexity theories found mainly in the organizational theory and organizational development and change literature. As in ecological science, this literature views organizational resilience as a process within a system, not as a goal or outcome (Fiksel, 2003; Venkataraman, Walker, Heugten, Baird, & de Vries, 2014), and finds that organizational resilience is an adaptive capacity that develops over time (Sutcliffe & Vogus, 2003). Organizational resilience consists of two parts: planned (first-order) and adaptive (second-order) resilience (Lee, Vargo, & Seville, 2013; Venkataraman et al., 2014). Planned resilience is proactive and developed prior to a disturbance to the system whereas adaptive resilience is reactive following a disruption to the system.

Studies of planned or first-order organizational resilience (planning prior to a disturbance) have found that diversity or variety (especially in range of responses) and interconnectedness are critical building blocks for resilience (Everett, 2013). Diversity of responses requires developing new capabilities and competencies while retaining old behaviors (Weick, Sutcliffe, & Obstfeld, 1999); thus, a large repertoire of behaviors and strategies aids in building resilience (Reinmoeller & van Baardwijk, 2005; van Dyck, Frese, Baer, & Sonnentag, 2005). Interconnectedness includes connections to other people who share the same goals, values, and purpose, and allows opportunities for engagement. For example, the networked organization allows a hub-affiliate relationship that involves the collaboration of numerous independent affiliates or partners working together on a common project or for a common purpose (Everett, 2013). While perhaps not the most efficient design structure, it allows for the coexistence of a range of behaviors and provides points of connection or cohesion in goals, values, and purpose, thus creating a very resilient organization.

Studies of adaptive or second-order resilience (response following a disturbance) (Dickens, 2015; Hopkin, 2014; Venkataraman et al., 2014) share themes of shared connections, diversity in responses, and learning and adaptability. Shared connections suggest that the organizations have

points of connection that provide unity, such as a mission, values, or purpose. Diversity in responses suggests that employees are trained to develop a number of capabilities that provide flexibility. Learning and adaptability suggest that organizations learn from experience, adapt, and improve with each successive disturbance (Sutcliffe & Vogus, 2003).

Taken together, the individual and organizational resilience literatures reflect themes of diversity in responses coupled with learning and adaptability while only the organizational literature suggests the need for individuals to have shared connections or purpose in order to enhance organizational resilience.

Finally, Staw, Sandelands, & Dutton (1981) resolve that organizational resilience cannot be explained at one level of analysis such as individual resilience or organizational resilience. Rather, they conclude that resilience is the result of an interplay of forces at the individual, group, and organizational levels.

LESSONS FROM ECOLOGICAL RESILIENCE APPLIED TO LEADERSHIP FOR RESILIENCE

Our goal in this article is to learn from ecosystem resilience theory and make micro-level applications to management and leadership. In this regard, there have been many successful examples of lessons from nature being borrowed and adapted to business in product design (Benyus, 1997; Braungart & McDonough, 2002), economic systems (Jørgensen et al., 2015), and the discipline of industrial ecology. Of particular interest is prior work applying ecosystem resilience theory to business. Mannen et al. (2012) conclude that the application of permaculture principles to human organizational systems would create resilience and emergence in organizations. Similarly, Fiksel (2003, 2015) notes that characteristics of living systems (diversity, efficiency, adaptability, and cohesion) can be applied to industrial systems (e.g., communication and transportation) to create resilience. That is, Fiksel (2003, 2015) suggests that diversity in form and behavior, efficiency of resource consumption, adaptability to new pressures, and the strengthening of points of cohesion will contribute to the resilience of systems. Bodin and Wiman (2004) find that while these interdisciplinary domain transfers may not always be straightforward, they can help us see a concept from a new perspective and lead to additional transfers to new fields.

We focus on management and leadership to extend prior work in applying ecosystem resilience theory to business. Consider these business examples of resilience, or lack thereof. Bouquet and Renault (2014)

found that of the one hundred largest companies in 1900, only sixteen companies still remain today—Ford is the only company in the same industry and the other fifteen have adapted their business to changing times; as such, these sixteen companies have been resilient over time. The researchers concluded that the eighty-four remaining companies that are no longer in business shared three common characteristics: commitment to an aging system and way of thinking, denial of a changing market, and limited innovation (Bouquet & Renault, 2014).

In similar fashion, Borders and Barnes & Noble together owned forty percent of the book-selling market in the 1990s (Johnson, 2011). However, the failure to overcome change and adapt to new technology led to the total liquidation of Borders. Borders increased the sale of CDs and DVDs but did not have an online presence until 2008, while consumers were already gravitating to online digital systems (Johnson, 2011).

These examples demonstrate the importance of understanding leadership for resilience. We believe that ecosystem resilience theory, which has been successfully applied in the human management of ecosystems such as forests, wetlands, and agricultural systems, may be instructive in the theory's application in a business management and leadership context. We point to four lessons for business that can be gleaned from the application of resilience theory in ecosystem management.

Lesson 1: Resilience can be positive or negative.

One lesson is that there is nothing inherently "good" or "bad" about ecosystem resilience in and of itself (Desjardins et al., 2015). We may uncritically assume that ecosystem resilience is good because we tend to imagine pristine ecosystems when we consider the concept, just as we may imagine the resilience of a vibrant, useful, and ethical business to be a good thing. But many heavily invaded ecosystems that have lost function and that are difficult to perceive as anything but "bad" may also have a frustrating degree of ecosystem resilience: it is difficult to "restore" many invaded ecosystems. In such cases, we may deem ecosystem resilience to be bad, just as we may deem the frustrating degree of resilience of the dysfunction that can sometimes develop within a business's management or corporate culture to be bad. Understanding resilience, therefore, helps us to promote resilience when it would be good and to undercut it when it would be bad.

We can also point to examples of both positive and negative resilience in business. Consider, for example, Caswell-Massey, a retail provider of luxury personal care products. The company was founded in 1752 as

an apothecary selling medical supplies. Over time, the company was resilient to changing market conditions and expanded into personal care and hygiene products, fragrances, and cosmetics, and it remains successful to this day. In contrast, Buckley (2010) highlights the resilience of a dysfunctional global financial system and notes the fact that it benefits international banks and the elites in emerging economies while simultaneously being dysfunctional and unfair to the citizens of those same economies. He argues that the global financial system is volatile, unstable, and narrowly efficient, yet it is resistant to change and is thus highly resilient. He termed this "negative resilience" (Buckley, 2010), but a clearer term might be "unwanted resilience."

Proposition 1: Resilience will preserve a system's function, structure, and/or identity.

Lesson 2: Diversity leads to resilience.

A second lesson from the application of resilience theory to ecosystem management is that when natural systems are stripped of their diversity in an attempt to increase their predictability and efficiency for human use, those systems are also stripped of their resilience (Anderson & White, 2009; Reinmoeller & van Baardwijk, 2005). Recall that resilience via diversity is mediated by functional redundancy and response diversity.

An excellent example is the prevalent use of monocropping systems in modern agriculture, in which huge fields are planted with a single genetic strain of a single plant species (e.g., corn), purged of all other plant species (e.g., weeds), and chemically amended (e.g., with fertilizers and pesticides) in ways that also simplify (or destroy) the soil and insect communities. Modern agriculture has massive externalities in terms of pollution, common resource depletion (e.g., ground water), and the market subsidies that help make the system profitable. These systems, however, lack the resilience of the natural systems they replaced. Although disturbances such as blights, drought, and frost may impact diverse natural systems, their impacts are mild compared to the catastrophic effects of those disturbances on a monocropped system, in which the entire simplified ecosystem collapses. In short, while management decisions that reduce diversity may provide short-term benefits, they may come at a long-term cost.

Functional redundancy in business is routinely purged to maximize efficiency under controlled conditions, analogous to monocropping in agriculture. However, if reducing diversity comes at the expense of resilience, then the benefits must be integrated with the costs that come from a lack of resilience. For example, downsizing or organizational

restructuring may lead to an increased profit of $1 million a year, but if it causes a lack of resilience that costs the company $10 million to disturbances that, although unpredictable, tend historically to occur every five years or so, then the short-term gain from the structural simplification might be a long-term loss. Worse, the lack of resilience could lead to the company's demise if it were unable to respond to a major disturbance. Of course, by their very nature, the occurrence, timing, severity, and duration of disturbances are difficult to predict, and so there may always be a tendency to favor demonstrable short-term benefits of diversity reductions that increase efficiency and to discount the costs of possible disturbances. Like ecology literature on resilience, we find that efficiency and optimization are ideal in a static system (Hamel & Valikangas, 2003). In a complex and dynamic system, however, an overemphasis on efficiency comes at the expense of diversity and interconnectivity and, as a consequence, resilience (Anderson & White, 2009; Reinmoeller & van Baardwijk, 2005). Indeed, the history of business is replete with examples of companies that shuttered for lack of resilience to disturbance as described above.

To illustrate resilience theory and diversity in strategic management, Porter (1979) first pointed to the risk of having too few suppliers or buyers. By relying too heavily on one or a few suppliers and buyers, businesses become vulnerable to impacts related to the supplier or buyer.In order to minimize risk, companies were thus advised to maintain several suppliers and buyers. Similarly, businesses have often found success by maintaining diversified portfolios rather than by being focused on a single line of business. As in the case of buyers and suppliers, having multiple businesses in a corporation's portfolio spreads risk and makes the company less vulnerable. In fact, some ecologists, taking a cue from business, have described the combined phenomena of functional redundancy and response diversity as "the portfolio effect" for this very reason (Tilman, 1999).

Additional examples of resilience theory and diversity can be found in local economies. Research shows that big box retailers decrease the number of small locally-owned businesses in the big box retailer's industry, decrease the unique character of communities, and increase homogeneity (Good Jobs First, n.d.; Mitchell, 2012; Montgomery, 2013). Studies have also concluded that big box retailers reduce the number of people employed in a given area, depress average wages, increase poverty, decrease natural resources and open spaces, and increase taxpayer burdens due to an increase in the number of low wage workers utilizing public assistance (Good Jobs First, n.d.; Mitchell, 2012; Montgomery, 2013). Furthermore, when big box retailers close shop and leave behind

vacant retail space, communities lose property taxes and jobs and incur other additional hidden costs (Good Jobs First, n.d.; Schindler, 2012).

The city of Detroit, Michigan presents an example of a community's economic base that lost diversity and relied heavily upon the dominance of the automobile manufacturing industry to the exclusion of all others (Galster, 2012). Numerous examples exist where the manufacturing-based economies of small towns across the northeastern United States were devastated when factories downsized or closed. These communities lost resilience through decreased diversity and increased homogeneity in their economic base. Lack of diversity in a city's economy makes it difficult to rebalance the industry mix (Lin, 2015). Over time, however, small and medium size businesses have begun to emerge in Detroit's struggling downtown economy. This may be due to in-place infrastructure and low-cost property (speculation) to give a small business lower overhead when starting a new enterprise. The rebuilding of Detroit began by revitalizing the downtown area with a focus on knowledge- and service-based economic activity (Harpel, 2011; McDonald, 2014). Once again, small locally-owned enterprises brought diversity to the local economic landscape. This diversity leads to resilience that is more robust in response to changes in economic demand as the failure of one enterprise will not drastically influence widespread economic stability in the region.

The cases of economic reliance on big box retail and manufacturing industries suggest that the functional and response diversity provided by vibrant locally-owned businesses, as opposed to homogenous businesses or industries, contributes to a community's economic resilience in times of disturbance or shock. As Detroit gradually rebuilds over time, gentrification in recently economically depressed areas could attract an influx of larger corporate entities. Interestingly enough, this may reduce the viability of small businesses in the community, thereby reducing the overall resilience of the local economy once again.

Proposition 2a: Increased functional redundancy and response diversity will lead to increased organizational resilience.

Proposition 2b: Increased functional redundancy and response diversity will lead to increased economic resilience.

Proposition 2c: There is an inverted u-shaped relationship between efficiency and a business function, such as profitability, because increased efficiency comes at the cost of reduced resilience.

Lesson 3: Diversity is valued and preserved at all levels.

A third lesson from the application of resilience theory to ecosystem management is that attempts to manage for resilience to a *particular* kind of disturbance often undercut resilience to *other* types of disturbance, especially those that are unpredictable or novel (Folke, Carpenter, Walker, Scheffer, Chapin, & Rockstrom, 2010; Desjardins et al., 2015). "Resilience thinking" advocates for less emphasis on maintaining ecosystems within a particular stability domain and for more emphasis on adapting with transitions to other stability domains and encouraging diversity—even diversity that has no *apparent* connection to resilience, on the assumption that it *probably does* have a connection to resilience that we just have not appreciated yet. More precisely, resilience thinking recognizes that if we are ultimately interested in ecosystem *function*, its resilience may *require* a lack of ecosystem resilience in identity and structure. That is, because the timing and nature of disturbances are difficult to predict and because the virtues of particular functional redundancies or response diversities may be difficult to perceive in advance of a particular disturbance, there is always potential value in diversity at all levels.

Recall that there is a tradeoff between efficiency and resilience (Anderson & White, 2009; Reinmoeller & van Baardwijk, 2005). As businesses seek to become more efficient in the short-term, they may be risking resilience in the long-term because there are unknown mediators and moderators in the resilience process that may be purged through attempts at efficiency. Corporate downsizing, layoffs, and restructuring serve as good examples. Research has shown that companies often hire temporary employees with complementary skill sets after a layoff to help the business move toward a new strategy, and that as many as 30% of companies that lay off workers rehire them as contract workers because they need the workers' skills (Cascio, 2002). Thus, when resource efficiency is required, it may be beneficial to cross-train employees to compensate for both tangible and intangible human resource skills lost in downsizing or restructuring. In this example, the leader's job is to recognize pockets of talent and resources and move them as needed to increase adaptability and resilience. Unlike natural systems in which different species are "locked" into particular roles, a resilient business can shift people and departments.

Proposition 3a: Reductions in resources will lead to reductions in diversity.

Proposition 3b: Reductions in resources will lead to reductions in resilience.

Lesson 4: Emphasis is placed on adaptability rather than on avoiding disturbance.

A fourth lesson from the application of resilience theory to ecosystem management is that our inability to predict or control disturbances should motivate us to promote resilience. An excellent example comes from the forest fire suppression regimes that the U.S. put in place after World War II. Ironically, successful forest fire suppression has led to increased fuel loads, which create conditions for high-intensity fires where there would have otherwise been low-intensity fires (Dombeck, Williams, & Wood, 2004). Although these ecosystems had been resilient to low-intensity fires, high-intensity fires often disturb soil properties and destroy soil seed banks to such an extent that resiliency is reduced.

For business, this suggests that while we may try to control disturbances when possible, we should focus more energy on developing our capacities to learn and adapt, if only because we will frequently not succeed in predicting and/or controlling disturbances. More subtly, attempting to avoid disturbance may promote conditions—analogous to increased fuel loads—that diminish resilience to the disturbances that cannot be avoided (and such disturbances will surely come eventually). Accepting disturbances may therefore be a necessary part of the process to build adaptability and increase resilience (Cork, 2010). "At best[,] we can reduce the uncertainties we face not by controlling the natural systems we interact with, but by developing our own capacities to learn and adapt" (Desjardins et al., 2015, p. 156). This supports earlier literature which suggests that strategic resilience can be planned and cultivated for the competitiveness and survival of the organization (Burnard & Bhamra, 2011) and that adaptive organizations stay on the "edge of chaos" between order and disorder, constantly poised for continuous change (Brown & Eisenhardt, 1997). Thus, there is a need to develop adaptive management, a learning process that builds upon current knowledge to reduce future uncertainty. As Hamel and Valikangas (2003) stated, resilience is about developing capacity to change. That is, the best protection against disturbance is the development of flexibility, nimbleness, and adaptability.

Proposition 4: Resources are better invested in developing adaptability rather than in developing protective barricades of resistance to or in avoidance of a disturbance.

LIMITATIONS & FUTURE RESEARCH

Our contribution has been the application of ecosystem resilience theory to business leadership for resiliency and the identification of lessons for leaders and their accompanying research propositions. There are, however, some limitations to the generalizability of our research. In our domain transfer of resilience from ecosystems to management, resilience theory appears to apply to the organizational level but is not as relevant to the individual level. That is, the psychology literature appears to be better suited to explaining individual-level leadership resilience, whereas the ecology literature is better suited to explaining organizational-level (system) resilience.

Bodin and Wiman (2004) remind us that interdisciplinary domain transfers are not always straightforward. Desjardins et al. (2015) state that we need to go beyond understanding concepts and properties of resilience and look at the broader picture. There are challenges, however, to extending the resilience concept over a larger domain. First, the definitions are mostly qualitative and abstract, lacking empirical content and are thus difficult to apply to concrete situations (Desjardins et al., 2015). Second, the internal/external dichotomy is problematic. Instead of internal "absorption" of an external shock, maybe "tolerance" is a better metaphor that removes the internal/external distinction (Desjardins et al., 2015).

Further research is needed to develop constructs and testable hypotheses from our propositions. This will allow the lessons and propositions to be further refined for increased relevance to leadership for resilience.

We also see a need for more integration of psychology (individual-level) and ecology (organizational-level) literature on resilience. Although our research does not integrate the psychology and ecology literature and even questions its applicability, it is possible that efforts toward integration could contribute to a better understanding of leadership for resilience.

As stated at the outset of this article, there is a need to develop resilience at the individual, organizational, community, national, and global levels in order to successfully navigate uncertainty and change and to rebound from setbacks. It is possible that the lessons learned from ecosystem resilience theory could be applied at different levels of analysis and could provide insights into managing for resilience in local communities, nations, and the global community. That is, can an

emphasis on building diversity throughout all levels of a community, nation, or global community lead to the increased adaptability and resilience needed to navigate further crises such as those related to the economy, war, terrorism, or climate change?

CONCLUSION

The industrial revolution has led to business and economic models that have caused or exacerbated the pressing economic, social, and environmental crises of our time (Anderson, 1999; Anderson & White, 2009; Edwards, 2005; Fullerton, 2015; Hawken, 1993; Hawken et al., 1999; Rockstrom et al., 2009; Steffen et al., 2015). Recognizing our natural limits and planetary boundaries, businesses are increasingly seeking more sustainable approaches. One direction has been to look to nature for guidance on principles of natural design and organization in order to operate more sustainably. In this era of increasing uncertainty, increased resiliency is one area in which businesses seek to move toward sustainability.

Resilience is the ability of an individual or system to rebound from a disturbance to a level of functioning that is equal to or better than the level of functioning prior to the disturbance. In ecology, ecosystem resilience is an emergent property, not a goal. Ecosystems must exhibit diversity to be resilient. Diversity is mediated by functional redundancy (a diversity of organisms performing the same function) and response diversity (different organisms responding differently to a disturbance).

Our goal in this article has been the application of natural ecosystem resilience theory to business leadership for resiliency. In this pursuit, we caution management scholars not to attempt to mimic nature but rather to view nature as a proven system that is analogous to human constructs in some important ways, and not analogous to human constructs in other ways. To the extent that the analogy is apt, understanding why nature is or is not resilient can shed light on what makes human constructs more or less resilient.

We have taken four lessons from ecosystem resilience theory that can be insightful in managing for resilience. First, resilience can be good or bad. While we may assume that resilience is good because the system is resistant to disturbances, resilience can also be bad if we consider invasive species or dysfunction in a business. Second, the key to resilience is diversity, specifically functional redundancy and response diversity. When a system, or business, is stripped of its diversity (both

functional redundancy and response diversity) in an effort to increase efficiency, it becomes more vulnerable and less resilient. Third, diversity is to be valued and preserved at all levels. It is impossible to predict future disturbances; thus, attempts to manage for resilience to a particular kind of disturbance can undercut resilience to other types of disturbances. And fourth, emphasis should be placed on adaptability rather than on avoiding disturbance. Accepting disturbances may be a necessary part of the process to increase resilience; thus, we should focus more energy on developing our capacities to learn and adapt rather than on trying to avoid disturbance. In managing for resilience, the leader can apply these four lessons by building diversity (in both functional redundancy and response diversity) throughout all levels of the organization and focusing on development of flexibility, nimbleness, and adaptability. Such would form the foundation of a resilience-based business or economic system.

We have also presented research propositions for further study of this application of ecosystem resilience theory to business leadership. We acknowledge that this domain transfer may be more applicable at the system or organizational level than at the individual level of leadership, and we offer several considerations for future research. Ultimately, there is a need to increase resilience at the individual, organizational, community, national, and global levels as we manage for a global sustainable future.

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