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Comparing Conceptualizations of Urban Climate Resilience in Theory and Practice

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Abstract: In the face of climate change, scholars and policymakers are increasingly concerned with fostering "urban resilience". This paper seeks to contribute towards a better understanding of synergies and differences in how academics and local decision-makers think about resilience in the context of climate change. We compare definitions and characteristics of urban climate resilience in the academic literature with a survey of 134 local government representatives from across the U.S. Our analysis shows discrepancies in how academics and practitioners define and characterize urban climate resilience, most notably in their focus on either "bouncing back" or "bouncing forward" after a disturbance. Practitioners have diverse understandings of the concept, but tend to favor potentially problematic "bouncing back" or engineering-based definitions of resilience. While local government respondents confirm the importance of all 16 resilience characteristics we identified in the academic literature, coding practitioners' free response definitions reveals that they rarely mention qualities commonly associated with resilience in the scholarly literature such as diversity, flexibility, and redundancy. These inconsistencies need to be resolved to ensure both the usability of climate resilience research and the effectiveness of resilience policy.

Keywords: climate change; resilience; urban resilience; resilient city; climate resilience; adaptation

1. Introduction

There is a critical relationship between cities and climate change. On the one hand, urban areas are major contributors to climate change, being responsible for the majority of global energy consumption and greenhouse gas emissions. On the other hand, densely populated urban areas are particularly vulnerable to climate change impacts including sea-level rise, storm surge, heat waves, droughts, and shifting diseases, with vulnerable populations in cities likely to be disproportionately impacted [1,2]. Moreover, due to the heat island effect, urban areas are already experiencing amplified warming effects [3], which will probably continue as the climate warms [4]. In short, climate change is likely to exacerbate existing urban problems and vulnerabilities, placing additional pressure on already strained municipal capacities [5,6].

Confronted with these challenges, cities cannot simply sustain the status quo [7]. This realization has led academics and policymakers to look for new ways to frame development and operations in a manner that helps cities build the capacities needed to effectively and efficiently prepare for climate change impacts [8]. Increasingly, these conversations are turning to the concept of resilience [9]. This 'resilience turn' in urban policy is evident in both the academic literature (Figure 1) and in major policy initiatives like the Rockefeller Foundation's "100 Resilient Cities".

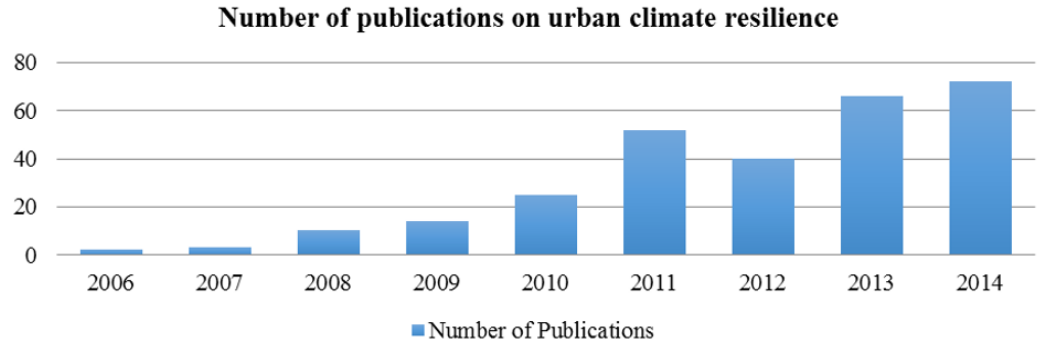

Figure 1. The rise of resilience in climate change research: graph shows the number of citations in Web of Science for each year with the terms "urban resilience" and "climate change" in the title, keywords, or abstract.

The concept of resilience is not new. It has a long history of use in engineering, psychology, and ecology [10]. The urban climate change literature draws heavily on ecological resilience theory originally developed by Holling [11]. In his conceptualization, resilience refers to an ecosystem's ability to "persist" in the face of a disturbance or change, but this persistence does not necessarily mean that the system remains static [11]. Holling and colleagues used this dynamic ecological resilience concept as the foundation for broader theories of change for social-ecological systems [12].

The explosion in popularity of the term "resilience" has been accompanied by an equally remarkable proliferation of definitions of resilience. Some argue that the concept's very popularity is owed at least in part to the fact that the meaning of resilience is "infinitely malleable" [13]. Yet scholars have expressed concern that as resilience becomes ubiquitous, the term may lose any real meaning or cause confusion [14]. In this regard, resilience may be comparable to other increasingly ambiguous yet fashionable concepts like sustainability [15]. Undoubtedly, one of the strengths of resilience theory is its applicability across disciplines and ability to serve as a boundary object [16]. This malleability can be a barrier to interdisciplinary collaboration, however, if every discipline has its own idea of what resilience means [17]. The absence of an accepted definition has not stopped researchers from proposing various process- and outcome-focused system characteristics that supposedly enhance climate resilience [9]. However, the lack of a unified understanding of resilience has made it difficult to operationalize the concept or to develop metrics for resilient systems [9,15].

Prior studies have reviewed the academic literature on urban resilience [7,9,18], but it is unclear how scholarly definitions and characteristics compare with those of practitioners. In this paper we attempt to address this gap and advance our knowledge of how climate resilience is understood in both theory and practice. We compare definitions and characteristics of urban climate resilience from a recent review of the academic literature and a survey of local government practitioners from across the U.S. Our analysis reveals some important inconsistencies in how the scholarly literature defines and characterizes urban climate resilience as opposed to how practitioners view the topic, particularly as it relates to recovering and "bouncing back" versus transformation and "bouncing forward". In addition, practitioner survey responses show a much wider range of interpretations of what resilience means in practice than what is commonly discussed in the scholarly literature. Collectively, the practitioners seem to favor "bouncing back" or engineering definitions of resilience, which we argue could be problematic. Survey results also suggest that practitioners see all sixteen characteristics of resilient systems that we identified in the literature as important, but we find considerable variation in the extent to which practitioners include these characteristics in their own definitions of urban resilience. Ultimately, understanding these synergies and differences in how academics and practitioners are thinking about climate resilience can lay the foundation for more usable resilience research, which is crucial given the scope of the urban climate change challenge.

2. Materials and Methods

To examine how practitioners and academics conceptualize resilience, we combined an extensive literature review with the results of a 2014 survey of U.S. local government officials. For the literature review, we drew from a broader review of the urban resilience literature [18], which looked at 172 articles from 1973 to 2013 with the terms "urban resilience" and "resilient cities" in the title, abstract, or keywords in order to identify how resilience was conceptualized across the literature. We reviewed these articles, as well as the studies they frequently cited, to identify a list of potential characteristics of resilient urban systems. We then developed a survey instrument to gauge how urban climate change resilience is defined and characterized by practitioners and how this compares to definitions and characteristics in the literature. It should be acknowledged that since urban resilience research and practice is rapidly evolving, new definitions have likely emerged since the research was completed.

The survey of local practitioners was conducted as part of a larger project funded by The Kresge Foundation to assess the range of climate adaptation resources and services available to support local climate adaptation (for more information see Nordgren et al. [19]). The online survey was developed and administered by the researchers in collaboration with three nonprofit organizations: ICLEI-Local Governments for Sustainability USA (ICLEI), the Urban Sustainability Directors Network (USDN) and the National League of Cities (NLC). The survey instrument, which was built using Qualtrics software, was reviewed by members of the Kresge Foundation, the project's expert advisory committee, and survey experts at the University of Michigan's Institute for Social Research. The survey was also piloted with students at the University of Michigan and local government staff members from three communities around the U.S. The final survey was distributed by ICLEI, NLC, and USDN through their membership lists, and ran from 27 March 2014 to 6 May 2014.

We are unable to calculate exactly how many individuals received the survey, since membership in the three organizations administering the survey overlap. However, we estimate that around 1200 distinct individuals working for local governments received the survey. A total of 446 began taking the survey and 291 completed more than three-quarters of the questions. A total of 134 completed the final two questions on resilience that are pertinent to this analysis. Importantly, the survey sample is not representative of the population of cities in the U.S., since communities elect to be members of each of these three organizations. Nevertheless, the survey as a whole did succeed in capturing a wide range of communities: respondents represented 41 states and were well distributed in terms of local jurisdiction size and geographic features. Respondents' roles in their communities also varied with the largest group (30 percent) working in the energy or environment field (i.e., energy, environmental services, parks, or sustainability staff), followed by 24 percent that serve as elected officials, and 12 percent that work in local government administration.

The survey included a total of 24 questions, but for the purposes of this study, we were primarily interested in the two questions that focus on conceptualizations of resilience. The first of these was a free response question asking respondents, "What do you think it would mean for your local jurisdiction to be resilient to climate change?" A total of 134 respondents provided a response to this question. The second question asked, "In your opinion, how important are each of the following characteristics in making your local jurisdiction more resilient" and then asked respondents to rate the importance of 16 different characteristics on a five-point scale (1—unimportant, 2—slightly important, 3—important, 4—very important, 5—critical). A total of 199 respondents filled out this question. The characteristics were drawn from and defined based on the literature review and chosen because of their common association with resilience. Respondents were also given the opportunity to fill in and rate a self-determined "other" characteristic.

We coded all responses to the question where respondents were asked to define resilience (question one), looking for the presence of the 16 resilience-based characteristics identified in the literature. We also coded the definitions for whether they focused on "bouncing back" or "bouncing forward", explained in Section 3.1. All responses were coded independently by two researchers

(inter-coder agreement was 94.27%; the inter-coder reliability percentage includes all instances where both researchers agreed that a characteristic was either present or absent in the definition), after which the discrepancies were discussed and reconciled.

3. Results: Definitions of a Climate Resilient City

Definitions of urban climate resilience in the scholarly literature differ, but they do have some commonalities. All definitions identified in our analysis (Table 1) are broad, defining resilience in terms of a generic capacity to deal with climate impacts and disturbances. One key distinguishing factor is the extent to which the definitions incorporate change, as opposed to resistance or recovery. This tension is also evident in the definitions provided by practitioners in the survey. Overall, we find much more variation in the practitioners' definitions of resilience than what exists in the scholarly literature.

Table 1. Definitions of urban climate resilience from the academic literature (Definitions taken from review conducted by Meerow et al. (2016) [18]).

Authors	Definition
Brown et al. (2012) [20]	"The capacity of an individual, community or institution to dynamically and effectively respond to shifting climate circumstances while continuing to function at an acceptable level. This definition includes the ability to resist or withstand impacts, as well as the ability to recover and re-organize in order to establish the necessary functionality to prevent catastrophic failure at a minimum and the ability to thrive at best. Resilience is thus a spectrum, ranging from avoidance of breakdown to a state where transformational change is possible." (p. 534)
Henstra (2012) [21]	"A climate-resilient city . . . has the capacity to withstand climate change stresses, to respond effectively to climate-related hazards, and to recover quickly from residual negative impacts" (p. 178).
Leichenko (2011) [9]	"The ability of a city or urban system to withstand a wide array of shocks and stresses" (p. 164)
Lu and Stead (2013) [22]	"the ability of a city to absorb disturbance while maintaining its functions and structures" (p. 200).
Thornbush et al. (2013) [23]	"a general quality of the city's social, economic, and natural systems to be sufficiently future-proof" (p. 2).
Tyler and Moench (2012) [6]	"In the case of urban climate adaptation, an approach based on resilience encourages practitioners to consider innovation and change to aid recovery from stresses and shocks that may or may not be predictable...three generalizable elements of urban resilience: systems, agents and institutions." (p. 312)
Wamsler et al. (2013) [8]	"A disaster resilient city can be understood as a city that has managed . . . to: (a) reduce or avoid current and future hazards; (b) reduce current and future susceptibility to hazards; (c) establish functioning mechanisms and structures for disaster response; and (d) establish functioning mechanisms and structures for disaster recovery" (p. 71).
Wardekker et al., (2010) [24]	"A resilience approach makes the system less prone to disturbances, enables quick and flexible responses, and is better capable of dealing with surprises than traditional predictive approaches . . . a 'bottom-up' way of thinking about adaptation that aims to promote a system's capability of coping with disturbances and surprises" (p. 988)

3.1. "Bouncing back" or "Bouncing forward"?

The academic literature makes a major distinction between "engineering resilience", which is about resisting change and returning to a prior state of equilibrium following a disturbance, and "ecological resilience", which focuses on maintaining key functions while accepting that it is not always possible or desirable to return to previous conditions [25,26]. This division is also framed as "bouncing back" versus "bouncing forward" [27]. Prominent resilience scholars, such as the leaders of the international *Resilience Alliance*, advocate for the latter conceptualization. They argue that the concept of resilience, particularly ecological resilience, is better suited for complex systems that are in a constant state of flux, and must therefore adapt to change and uncertainty. Cities are certainly complex and dynamic systems [28], and indeed, Meerow et al.'s [18] review found that the majority of urban resilience definitions are more closely aligned with ecological resilience. Despite this recognition, engineering resilience continues to persist in many fields, including disaster management, economics, and public policy [29].

That said, there still seems to be some disagreement within the urban climate resilience literature as to whether resilience is about resisting impacts and change or embracing them. Looking at the definitions identified in the literature (Table 1), Henstra's [21] seems more aligned with engineering resilience since it emphasizes the capacity to "withstand" and "recover". In contrast, Brown et al. [20] include reorganization and even "transformational change" as part of their definition of resilience, which is more consistent with 'bounce forward' or ecological resilience.

This divide is also evident in the different definitions of resilience provided by survey respondents, with engineering, equilibrium perspectives predominating. According to our coding, 35 definitions suggested that resilience was about bouncing back, 15 indicated that it could be about improving and bouncing forward, and seven indicated that both could be important. In the remaining definitions it was impossible to determine the respondent's position. Five respondents specifically mentioned "bouncing back", another emphasized a "return to normalcy", two equated resilience to stability, and several others highlighted minimal disruption or "community changes" as being key to a resilient urban system.

Of the 15 that provided definitions related to bouncing forward or improving, two explicitly mentioned the ability to "bounce forward" and several others saw resilience not just in terms of persisting under changing climate conditions, but actually adapting, improving and thriving. These definitions are more closely aligned with resilience as defined in the social-ecological systems literature.

3.2. Unpacking Practitioners' Definitions of Urban Resilience

One of the most striking results of the survey was the variation in the responses practitioners provided when asked what resilience would mean in their local jurisdiction (Table 2). While academics see resilience as omnipresent [30], several practitioners claimed not to know what it means, others noted that it was not acknowledged in their community, and one even dismissed it as "meaningless jargon". In contrast, other respondents called resilience "critical" and "absolutely imperative". Some definitions focused on very specific threats or sectors, like "heavy rain", "hurricanes", or "public transportation", whereas in other cases resilience was more generic, such as "improvement in quality of life." In fact, livability or quality of life was mentioned in almost 10 percent of responses. For more than 20 percent of respondents, resilience had an economic component, whether in terms of general economic prosperity or specifically in terms of reducing the cost of climate impacts. Other common themes (found in at least 5 percent of responses) were health, education and learning, sustainability, self-sufficiency, advanced planning, and the importance of assisting vulnerable populations.

Table 2. Illustrative [a] definitions of urban climate resilience from local practitioner survey.

"To be able to bounce back—with seemingly little or no negative effect—from heavy rains and flooding. To have our city infrastructure built and ready to take on heavy rains and drastically fluctuating temperatures, with little or no impact."
"Achieving the goal of climate change resilience will mean the city can reduce the sensitivity of vulnerable communities to extreme weather events while increasing their capacity to bounce back from such an event. In the long term, this is made possible when city departments will work together to develop a City Climate Resiliency Plan with specific goals and actions. This will have to include the coordination and communication with regional partners."
"Have the ability to bounce forward from climate change impacts to create a more sustainable community."
"Our community could become one that reflects a quality of life that includes the well-being of human and other species. It means a commitment to collaboration, learning new skills and recognition that we are far better together."
"To not suffer economic damage every time a severe weather event hits our city. That we are able to lessen the costs of repairs and shrink the time needed to make those repairs. And to help our residents recover more quickly or suffer less impact from storms."
"It would mean that we are better prepared to respond to the extreme weather events and their consequences that will occur as a result of climate change in all areas of municipal infrastructure and operations, including but not limited to water/wastewater/stormwater, emergency management, public health, public works, urban forestry, parks and recreation, and facility management. It would also mean we are incorporating reasonably foreseeable weather scenarios into our planning and budgeting processes. It would also mean we are better prepared to help our citizens respond to the impacts of climate change, especially those least able to take action on their own, e.g., low-income households, the elderly, the young, those with respiratory and other health problems."
"Be more attractive to certain kinds of businesses. Hopefully prevent poor decisions on location of development for the future."
"We don't even know what you mean by resiliency—sounds like meaningless jargon to us. We have real issues to pursue like public safety and economic development—things that matter now to our residents. Even given unlikely worse case scenarios, our need to react is limited, and not cost effective at this time."

[a] These eight definitions were chosen from the 134 different responses provided by survey respondents to highlight their variation, and do not represent all conceptualizations.

4. Results: Characteristics of a Climate Resilient City

In our review of the academic literature we identified 16 characteristics of urban systems and processes that supposedly foster resilience (Table 3). Hypothesized characteristics of resilient processes include: inclusivity, transparency, and equity in stakeholder engagement approaches [9,31,32], as well as processes that are flexible, forward looking, and iterative [6,33–35]. Resilience processes are also valued for being knowledge or information driven, meaning that they integrate traditional, as well as scientific knowledge into their frameworks and approaches and provide equitable access to information for all parties interested [36–38]. Research in the climate, urban, and resilience fields has postulated that there may be general characteristics of resilience, as well as generic/general forms of adaptive capacity that promote resilient systems [39–43]. Examples of general resilience characteristics include: diversity, iterative/feedback mechanisms, transparency, collaboration and integration, social-ecological integration (also coined environmental focus), efficiency, and adaptive capacity enhancement [42,44,45]. There is also a series of characteristics that are believed to be important for assessing specific resilience to unique climate impacts. Examples include redundancy in the case of drought, robustness in the case of hurricanes and extreme winds, and decentralization in the case of flooding [46–48].

When asked to rate the importance of these 16 characteristics (Table 3), survey respondents collectively indicated that they were all important. The mean score for all 16 was high (Figure 2), with very few respondents indicating that any of the characteristics were "1—unimportant" or only

"2—slightly important" (Figure 3). Additionally, only five respondents listed an "other" characteristic, which could suggest that they were satisfied with the list. There is, however, some variation in the perceived importance of the characteristics. For example, *robustness* had the highest average rating, over 4 (very important), and the largest number of respondents who rated it 5 (critical). In contrast, *decentralization* had the lowest average ranking, although the mean score is still above 3 "important).

Table 3. Sixteen Resilience Characteristics from the literature.

Characteristic	Definition	Illustrative [a] Sources
Robustness	Ensuring municipal-wide infrastructure and organizations can withstand external shocks and quickly return to the previous operational state	[49,50]
Redundancy	Having back-up systems, infrastructure, institutions, and agents	[20,49,51–54]
Diversity	Ensuring a diverse economy, infrastructure, and resource base (e.g., not relying on single mode of operation, solution, or agent/institution)	[6,22,49,51–53,55]
Integration	Making sure that plans and actions are integrated across multiple departments and external organizations	[6,56,57]
Inclusivity	Ensuring that all residents have access to municipal infrastructure and services, including providing an opportunity for all people to participate in decision-making processes	[6,57,58]
Equity	Ensuring that the benefits and impacts associated with actions are felt equitably throughout the municipality	[49,59]
Iterative Process	Creating a process whereby feedback and lessons learned are continually used to inform future actions	[6,20]
Decentralization	Decentralizing services, resources, and governance (e.g., solar or wind energy; stronger local governance)	[51,58,60]
Feedback	Building mechanisms so that information is rapidly fed back to decision-makers or system operators	[51,53]
Environmental	Protecting natural systems and assets	[20,49]
Transparency	Ensuring that all municipal processes and operations are open and transparent	[6,58]
Flexibility	Making municipal operations and plans flexible and open to change when needed	[51,58,59]
Forward- Thinking	Integrating information about future conditions (i.e., population, economy, weather) into community planning and decision-making	[6,24]
Adaptive Capacity	Ensuring that all residents have the capacity to adapt to climate change	[24,61]
Predictable	Ensuring that systems are designed to fail in predictable, safe ways	[6,51]
Efficiency	Enhancing the efficiency of government and external operations	[49,50]

[a] References are meant to be illustrative, and do not represent an exhaustive list of studies that mention these characteristics.

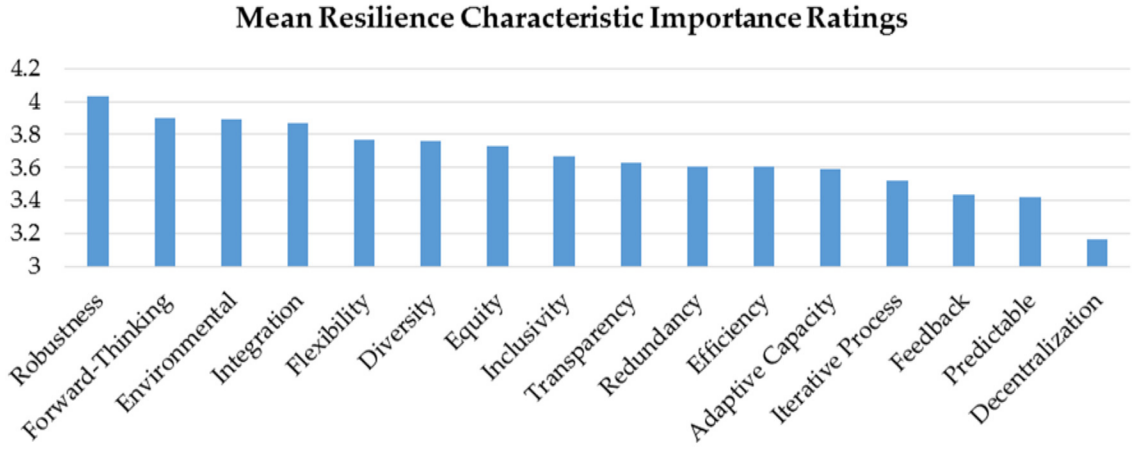

Figure 2. Mean resilience characteristic importance rating.

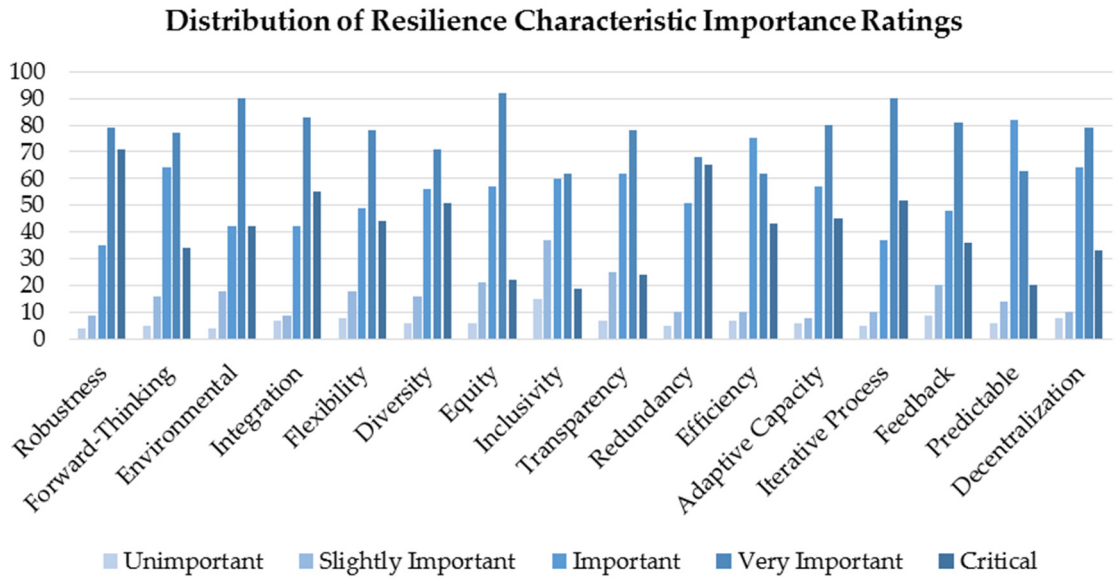

Figure 3. Distribution of resilience characteristic importance ratings.

A careful review of survey respondents' collective rating of the 16 characteristics (Figures 2 and 3) combined with those included in their free responses (Figure 4) points to key differences in what practitioners and the scholarly literature view as resilience. For example, some of the most commonly cited characteristics in the academic literature, such as *diversity*, *redundancy*, *flexibility*, *decentralization*, *and adaptive capacity*, were not among the highest rated by local government respondents. Conversely, practitioners emphasized the importance of *robustness*, yet there is debate in the literature about the universal desirability of this attribute. There were other characteristics commonly mentioned in the literature that practitioners simply did not focus on, including being *predictable* or safe-to-fail, *iterative*, having good systems for *feedback*, and *transparency*. Where scholars and local government respondents did seem to agree was on the importance of supporting *environmental* systems, *equity*, and *integration*.

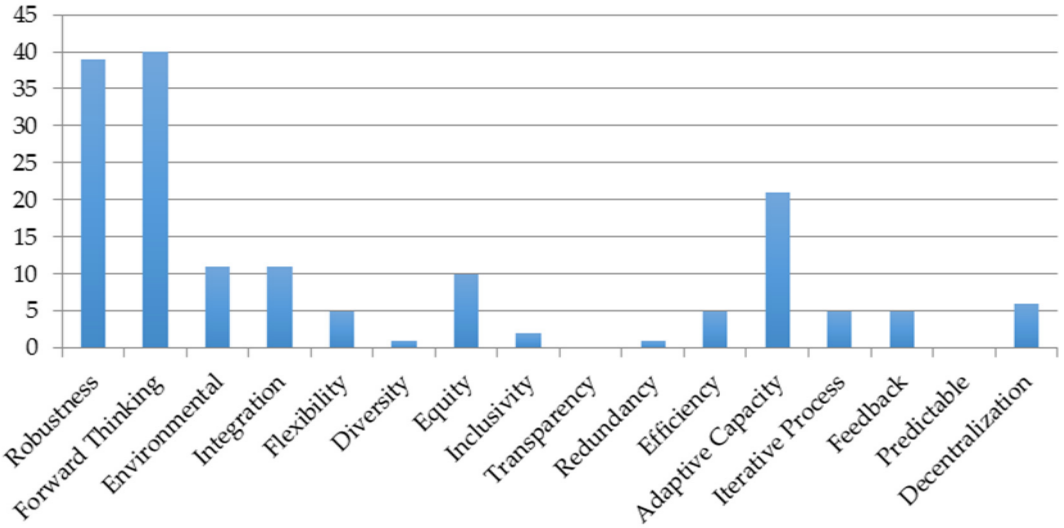

Figure 4. Number of practitioner definitions referencing resilience characteristics based on coding.

4.1. Tensions between Resilience Characteristics in Theory and Practice

In the urban resilience literature, *robustness* is about a system's ability to resist change or disturbance: it is essentially about "strength" [22]. In the survey, the characteristic *robustness* was

defined as "ensuring municipal-wide infrastructure and organizations can withstand external shocks and quickly return to the previous operational state". *Robustness* is very similar to the notion of engineering resilience. If *robustness* is seen as a desirable characteristic of a system, it implies a wish to maintain the status quo. This is not controversial when thinking about certain scales or engineered systems; no one wants a building to collapse in a hurricane. But there are many other more problematic, but nonetheless robust, aspects of modern cities (i.e., inequality or the reliance on fossil fuels). Many critics of resilience discourse and policy argue that resilience, particularly when applied to social systems, is inherently conservative and often employed to prevent positive transformations [62–64]. In response to these criticisms, some resilience scholars have incorporated transformation into their conceptualizations of resilience [65]. In academic theory, the trend seems to be away from static, engineering resilience with its emphasis on robust systems [6] towards these more flexible and adaptive forms of resilience. However, the high importance ascribed to *robustness* by survey respondents, as well as the numerous references in the definitions to "bouncing back", suggest that it persists as a dominant line of thinking in 'on-the-ground' urban resilience activities.

According to the local practitioners surveyed, the characteristic *forward-thinking* was second only to *robustness* in terms of average importance. For the purposes of the survey, *forward-thinking* was defined as "Integrating information about future conditions (i.e., population, economy, weather) into community planning and decision-making." In the definitions written by practitioners, almost one in ten specifically mentioned the future, and nearly 15 percent of responses suggested the need for advanced planning. For example, one respondent defined resilience as "No surprises for changing landscape. Advanced planning to make us better prepared". Another wrote " . . . as change occurs, it has been anticipated and planned for such that no or minimal disruption occurs."

While the academic literature also emphasizes preparing for future changes, some resilience scholars caution against too much emphasis on prediction or the use of single scenarios to understand future threats. Instead, focus is placed on techniques such as scenario planning [7] and the selection of actions that will perform well under a wide array of potential future conditions (known as robust actions in the scholarly literature) [66]. This assessment did not evaluate the types of tools or techniques that local practitioners are using as part of their advanced planning, but we would argue that it is important to provide practitioners with appropriate tools and the support needed to effectively utilize them.

Another area of discrepancy relates to the relative importance of *adaptive capacity*. In the urban climate resilience literature, building resilience is often equated with enhancing *adaptive capacity* [9]. However, survey respondents did not rate *adaptive capacity* among the most important characteristics. Furthermore, the term *adaptive capacity* was not explicitly used in any respondents' definitions; however, 21 respondents did allude to it.

In the academic literature, *flexibility* is one of the most commonly cited resilience characteristics [9]. *Flexibility* means that a system can function under different circumstances and absorb change [6]. In the survey, *flexibility* was defined as "making municipal operations and plans flexible and open to change when needed". Unfortunately, efficient adaptation and *robustness* against certain threats may come at the expense of the *flexibility* to deal with unexpected future changes [35]. If practitioners are primarily focused on *robustness*, as the survey results suggest, urban systems may not be sufficiently flexible to deal with unexpected climate impacts or other stressors. There were two respondents who explicitly called out *flexibility*: One noted that moving towards climate resilience would mean "increasing flexibility" and another stated that resilient jurisdictions should "exhibit nimble behavior". Overall, however, *flexibility* was not highlighted in the practitioners' definition of resilience. This seems logical given that local institutional structures and decision-making processes are rigid, making it difficult to create flexible, adaptive systems capable of integrating emerging information and changing as needed. Going forward, devising solutions to build more flexible systems will likely remain an important area of research.

Like *flexibility*, *diversity* is frequently cited in the literature as a key characteristic of resilience. This relates back to ecological theory, which suggests that biodiversity enhances the ability of an ecosystem to withstand change [51]. Looking specifically at the urban climate change context, Tyler and Moench [6] differentiate between "spatial diversity", meaning system components are widely distributed to reduce the likelihood that the whole system is impacted by a single disruption, and "functional diversity", where there are multiple avenues for meeting critical needs. *Diversity* can also be applied to governance systems, with the idea being that polycentric systems that engage a wide array of stakeholders are more resilient [9]. For the purposes of the survey, *diversity* was defined more broadly as "Ensuring a diverse economy, infrastructure, and resource base (e.g., not relying on single mode of operation, solution, or agent/institution)." Given the emphasis on *diversity* in the resilience literature, it was surprising that more respondents did not rate it as important, and only one explicitly mentioned *diversity* in their definition.

Related to the concept of spatial diversity, scholars have argued that decentralized systems are more resilient than centralized ones because when something disrupts a central unit, the entire system is jeopardized, whereas in a decentralized system it only impacts a small portion. In the literature, arguments are made for *decentralization* in both physical systems (like electricity generation) and governance [35,67]. Admittedly, some resilience scholars caution that decentralized governance may not be universally preferable [14,68,69]. Survey respondents clearly rated *decentralization*, defined in terms of "decentralizing services, resources, and governance, e.g., solar or wind energy; stronger local governance", as less critical for resilience than all the other 15 criteria. Similarly, none of their definitions mentioned *decentralization*.

For most resilience scholars, a certain level of functional *redundancy* is thought to enhance resilience; the argument being that when you have units with overlapping functions, if one falters, it can be easily substituted [24]. The definition provided for *redundancy* in the survey was "having back-up systems, infrastructure, institutions, and agents". Like *diversity*, *redundancy* is a characteristic that can be applied to both technical systems, like electricity infrastructure, and social networks. Only one respondent mentioned *redundancy* in their definition, and then only in the context of "water and power systems".

This mismatch between theory and practice with respect to *redundancy* could stem from the fact that *redundancy* has a somewhat negative connotation, and supporting it may seem to conflict with cost or even eco-efficiency [20,49]. In fact, scholars have cautioned that *efficiency* may be at odds with *redundancy* [70] and that "efficiency, as traditionally conceived, does not necessarily promote resilience" [71]. Yet *efficiency* still tends to have a positive connotation in popular discourse, and is sometimes cited in the literature as a characteristic of resilient urban systems [22].

Some urban resilience scholars such as Ahern [51] have argued that resilient systems should be "safe-to-fail" as opposed to "fail-safe". In the survey, this was represented by the characteristic *predictable*, defined as "ensuring that systems are designed to fail in predictable, safe ways". Looking specifically at urban climate resilience, Tyler and Moench [6] define "safe failure" as "the ability to absorb sudden shocks (including those that exceed design thresholds) or the cumulative effects of slow-onset stress in ways that avoid catastrophic failure. Safe failure also refers to the interdependence of various systems, which support each other; failures in one structure or linkage being unlikely to result in cascading impacts across other systems." Practitioners did not seem to consider this characteristic to be important, and "predictability" or "safe-to-fail" was not mentioned in any of the resilience definitions. In fact, one respondent even commented "why would anyone design a system to fail", indicating the mismatch between what theoretically is conceived of as being important to resilient systems and what is achievable in practice.

According to the literature, efforts to build resilience should be conducted iteratively, providing opportunities for participants to take stock of what has been learned and apply that knowledge to the next step [6,20]. As defined in the survey, an *iterative process* is "one whereby feedback and lessons learned are continually used to inform future actions". This characteristic emphasizes the

importance of learning, which "includes not only the mobilization and sharing of knowledge but also such factors as basic literacy and access to education. These kinds of factors have been identified empirically as contributing to community resilience to disasters" [6]. Iterative learning is also an important part of the popular adaptive management approach, which is closely tied to resilience theory [59]. While the *iterative process* characteristic was not rated as important, on average, as other characteristics, the terms "understanding", "education" or "learning" did appear in almost 10 percent of respondents' definitions. For example, one respondent wrote that resilience means "a commitment to . . . learning new skills", another "an educated community", and still others noted that residents need to be educated on climate change.

Implementing tight *feedbacks*—or as defined in the survey: "building mechanisms so that information is rapidly fed back to decision-makers or system operators"—can support the iterative process, learning, and ultimately, the resilience of urban systems [24,70]. As previously noted, a number of practitioners referred to education or learning in their conceptualizations of resilience, but none of them mentioned *feedback* directly. On average, respondents also rated this characteristic relatively low in importance.

Transparency and *inclusivity* are also both process- or governance-related characteristics. The meaning of *transparency* as described in the survey is "ensuring that all municipal processes and operations are open and transparent". Survey respondents were prompted to think of *inclusivity* as "Ensuring that all residents have access to municipal infrastructure and services, including providing an opportunity for all people to participate in decision-making processes". While *transparency* and *inclusivity* are not as commonly associated with resilience theory as other characteristics such as *diversity* and *flexibility*, both are mentioned in the literature as being important for continued engagement and good governance. For example, Tanner et al. [58] note that a "delivery of climate resilient urban development relies on a municipal system that maintains a relationship of accountability to its citizens, and is open in terms of financial management, information on the use of funds and adherence to legal and administrative policies." Researchers also emphasize the importance of inclusive, participatory decision-making processes that engage those groups most heavily impacted [6]. This emphasis was not mirrored in practitioners' definitions of resilience; neither *transparency* nor *inclusivity* were mentioned in any of the survey responses.

4.2. Synergies between Theory and Practice

While we do see a number of inconsistencies and unresolved issues with respect to resilience characteristics in the academic literature and amongst the surveyed practitioners, there are some promising areas of agreement. Within the urban climate change literature, the concept of resilience is most often traced back to the field of ecology, and therefore the relationship between humans and the environment are often central to definitions of resilience. The survey results reveal that practitioners also consider being *environmental*, defined as "protecting natural systems and assets", as quite important for resilience. It was, on average, the third highest rated characteristic. Moreover, several respondents specifically mentioned "ecosystem health", "ecosystem integrity", "ecosystem services", "natural resources", and "biodiversity" in their definitions of resilience.

While resilience theory is often praised for its focus on the interconnections between social and ecological systems, a common critique leveled against resilience theory generally, and urban climate resilience more specifically, is that it fails to address issues of equity [72,73]. These scholars critically ask "resilience for whom?" and argue that because resilience theory traditionally uses a systems approach, it ignores inequalities and trade-offs within the system boundaries [74]. It is therefore interesting that practitioners rated the importance of *equity*, defined in terms of "ensuring that the benefits and impacts associated with actions are felt equitably throughout the municipality", fairly high. While the word *equity* was not used in any of the respondents' definitions, a number of them did specifically mention assisting vulnerable or less powerful groups within their communities. For example, one respondent wrote that resilience "would also mean we are better prepared to help

our citizens respond to the impacts of climate change, especially those least able to take action on their own, e.g., low-income households, the elderly, the young, those with respiratory & other health problems." Another respondent noted, "our priority is to build resilience in our institutions, systems, infrastructure, and communities [that] must protect the poor, elderly, young and ill against hazards and shocks."

The characteristic *integration*, as defined in the survey, requires "making sure that plans and actions are integrated across multiple departments and external organizations." Jabareen [7,75] argues that dealing with the uncertainties and complexities of climate change necessitates an "integrative approach", one that fosters collaboration across a multitude of public and private stakeholders, agencies, and organizations. Additionally, adaptation planning may be more effective if it is integrated into other local plans, with plans at the state or federal level, or combined with efforts of surrounding municipalities [21,76]. A number of the survey respondents specifically mentioned *integration* in their definitions. For example, one noted that resilience suggests an approach "to foster integrative—cross sector, cross discipline—solutions." Another definition did not use the term *integration* but noted that to be resilient they would need to "include climate adaptation in all of our future planning functions—capital plans, resource allocation, stormwater, etc." Similarly, another respondent highlighted the importance of "regular communications between all sectors and with and among the community".

Overall, scholars and practitioners seem to agree on the importance of supporting ecological systems, equity, and integrated planning for urban resilience, so there is some common ground for collaboration or knowledge exchange. However, there are a number of other theorized characteristics that practitioners see as relatively less important, or that have been called into question by other scholars. In particular, practitioners' emphasis on *robustness*, which is associated with an engineering or "bounce back" conceptualization of resilience, may be problematic.

5. Conclusions

Academic researchers and policymakers are increasingly focused on the concept of urban resilience. Arguably, resilience now rivals sustainability as a major organizing principle or "buzzword" for urban research and policy [76]. Resilience is especially predominant in the climate change discourse, since it is fundamentally about coping with disturbances and change [9]. The challenge is that resilience, like sustainability, is a "fuzzy concept" that is not easily defined or measured [77]. Indeed, it is clear from our comparative analysis of the literature on urban climate resilience and the results of a survey of U.S. local government respondents that academics and practitioners define and characterize urban climate resilience quite differently (Table 4). This points to a disconnect between academic theory and practice. Although local government decision-makers generally confirmed the importance of the 16 resilience characteristics commonly discussed in the academic literature (and did not suggest many others), when prompted to define resilience, they did not incorporate most of these characteristics into their definitions. Furthermore, the characteristics that were rated most important on average did not necessarily match those that are cited most frequently in the practitioners' definitions of resilience or those frequently discussed in the academic literature. For example, *diversity*, *flexibility*, and *redundancy* are considered fundamental to resilience in the scholarly literature, yet they are rarely mentioned in practitioners' definitions. Conversely, *robustness*, which is more controversial in the resilience literature, was rated as the most important characteristic in the survey. It is also interesting that many practitioners still use a more engineering, or "bounce back" conceptualization of resilience, while the scholarly literature seems to be moving towards a "bouncing forward" conceptualization. This is consistent with the findings of other studies [29], and bolsters criticisms that resilience policy and discourse is overly focused on maintaining the status quo and therefore inherently conservative [63,78,79]. This is particularly disheartening for those who do not think our cities are currently sustainable and would like to see transformative urban change.

Table 4. Some key differences in how academics and practitioners conceptualize urban resilience.

	Academic Literature	Local Government Practitioners
Resilience as "bouncing forward" vs. "bouncing back"	Majority "bouncing forward"	Majority "bouncing back"
Definition consistency	Some differences, but share a broad focus on coping with climate and disturbances	Huge variation in meaning, perceived importance, scope, and specificity
Commonly cited characteristics	Diversity, flexibility, redundancy, adaptive capacity, integration, inclusivity, equity, iterative process, decentralization, feedback, environmental, transparency, forward-thinking, predictable	Robustness, forward-thinking, environmental, integration, equity
Less frequently cited or contested characteristics	Robustness, efficiency	Decentralization, predictable, redundancy, feedback, iterative process, transparency

These findings highlight several avenues for future research. First, it would be interesting to survey urban climate resilience scholars and ask them to rate the importance of the sixteen characteristics, to allow for more direct comparison between results presented in this paper and the thinking of leading resilience scholars. It would also be useful to conduct a more representative sample of local practitioners in the U.S. and to survey practitioners in other countries to see how their definitions and characteristic ratings compare. This latter point seems logical since many of the academics whose work we reviewed are not from the U.S. Given the recent explosion in resilience research and policy, it would also be useful to rerun the survey and update the literature review to see whether understandings of resilience have changed in the last couple years. Moving beyond this study, there is a clear need to explore why scholars and practitioners have different conceptualizations of resilience and to empirically examine and test resilience characteristics in different urban contexts to see what types of plans and policies are being implemented at the local level to build more resilient communities, how these activities relate to what is known about fostering resilience, and whether they lead to improved outcomes.

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