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WILD CARDS IN NATURAL RESOURCE PLANNING: HIGH IMPACT SURPRISES THAT SHAPE THE FUTURE

ABSTRACT

Wild cards are improbable, high impact events. Such events, like the COVID-19 pandemic, have the ability to shape policy by upending entire systems and paradigms. Unfortunately, long-term planning and policymaking rarely account for wild card events. Instead, planning and policymaking typically assume that existing trends will continue without major disruption. Moreover, adequately planning for potential wild card events is challenging because they are inherently difficult to predict. However, planning for wild card events in natural resources and environmental policymaking is vital as global developments, such as climate change, create more extreme conditions and challenges. This review, (1) defines and characterizes wild cards, (2) explains three distinct types of wild cards, (3) explores strategies to identify, assess, manage, and monitor wild cards, and (4) concludes by summarizing the importance of incorporating an analysis of wild cards in natural resource and environmental planning.

INTRODUCTION

Change in socio-ecological systems can be slow and incremental or abrupt and discontinuous. The COVID-19 pandemic has been a crash course in the latter: despite repeated warnings from public health experts about the possibility of a global pandemic,¹ business-as-usual has been thoroughly disrupted by a low probability event with extraordinary, far-reaching impacts. A survey of 32 big picture thinkers—scholars, scientists, authors, entrepreneurs, and others—found a wide range of possible positive and negative changes that could result from the pandemic—including dramatic impacts on communities, technology, health, science,

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1. See generally DAVID QUAMMEN, SPILLOVER: ANIMAL INFECTIONS AND THE NEXT HUMAN PANDEMIC (2012); ALI KAHN & WILLIAM PATRICK, THE NEXT PANDEMIC: ON THE FRONT LINES AGAINST HUMANKIND'S GRAVEST DANGERS (2016); MICHAEL T. OSTERHOLM & MARK OLSHAKER, DEADLIEST ENEMY: OUR WAR AGAINST KILLER GERMS (2017).

government, politics, economics, and lifestyles.² The higher-order consequences of these changes will continue to emerge for years to come.³

While specific wild cards, like a global pandemic, are improbable, wild cards occur more frequently than people realize. For example, hardly anyone—including financial experts, academics, politicians, and banking CEOs—foresaw the 2008 global financial crisis (Great Recession).⁴ The Great Recession was the longest and most serious economic crisis since the Great Depression. Its aftershocks have shaped the economic prospects for many and affected political and social attitudes, lifestyles, consumption patterns, fertility, and much more.⁵

Low probability, high impact events, such as the COVID-19 pandemic and the Great Recession, are referred to as wild cards in Futures Research.⁶ The term “wild card” originates from card games in which wild cards are those which “turn up unexpectedly and infrequently, but can result in major shifts in the outcome of the game.”⁷ Other terms for these surprising and highly disruptive events include strategic surprises,⁸ discontinuities,⁹ unknown unknowns,¹⁰ and extreme events.¹¹ The most significant wild cards shape the future in momentous ways, upending entire systems and paradigms. However, natural resource and environmental planning and

2. *Coronavirus Will Change the World Permanently. Here's How*, POLITICO MAG. (Mar. 19, 2020, 7:30 PM), <https://perma.cc/L2GT-2F26>; see also Jen Schwartz, *Introducing 21 Ways COVID Changed the World*, SCI. AM. (Mar. 1, 2022), <https://www.scientificamerican.com/article/introducing-21-ways-covid-changed-the-world/>.

3. “Higher-order” consequences are impacts of the direct consequences of a wild card event. For example, the Covid-19 pandemic caused significant economic distress for many families in developing countries (a direct consequence), which led to an increase in child marriage to relieve financial pressure on these families (a higher-order consequence). See, e.g., *COVID-19: A Threat to Progress Against Child Marriage*, UNICEF (Mar. 2021), <https://perma.cc/L7A5-QKVV>.

4. Paul Krugman, *Botching the Great Recession*, N.Y. TIMES (Sept. 12, 2018), <https://www.nytimes.com/2018/09/12/opinion/botching-the-great-recession.html> (explaining use of the term “Great Recession”); see also Spyros Makridakis et al., *Why Forecasts Fail: What to Do Instead*, 51 MIT SLOAN MGMT. REV. 83, 83–90 (2010).

5. DAVID B. GRUSKY & BRUCE WESTERN & CHRISTOPHER WIMER, *THE GREAT RECESSION* 3–20 (2011).

6. See, e.g., John L. Petersen, *The ‘Wild Cards’ In Our Future: Preparing for the Improbable*, 31 FUTURIST 43, 43–47 (1997); Elina Hiltunen, *Was It a Wild Card or Just Our Blindness to Gradual Change?*, 11 J. FUTURES STUD. 61, 61–74 (2006). Futures Research or Futures Studies is a transdisciplinary field of inquiry that studies possible, plausible, and preferable futures. See generally WENDELL BELL, *FOUNDATIONS OF FUTURES STUDIES I: HISTORY, PURPOSES, KNOWLEDGE* (1997).

7. Diane S. Srivastava, et al., *Wildcards in Climate Change Biology*, 0 ECOLOGICAL MONOGRAPHS 1, 2 (2021).

8. See generally H. Igor Ansoff, *Managing Strategic Surprise by Response to Weak Signals*, 18 CAL. MGMT. REV. 21, 21–33; Peter Schwartz & D. Randall, *Ahead of the Curve: Anticipating Strategic Surprise*, in *BLINDSIDE: HOW TO ANTICIPATE FORCING EVENTS AND WILD CARDS IN GLOBAL POLITICS* 93–108 (Francis Fukuyama ed., 2007).

9. See generally Robert U. Ayers, *On Forecasting Discontinuities*, 65 TECH. FORECASTING AND SOC. CHANGE 81, 81–97 (2000); Ph. W. F. van Notten, A. M. Slegers & M. B. A. Van Asselt, *The Future Shocks: On Discontinuity and Scenario Development*, 72 TECH. FORECASTING AND SOC. CHANGE 175, 175 (2005).

10. See generally Leena Ilmola & Elena Rovenskaya, *Three Experiments: The Exploration of Unknown Unknowns in Foresight*, 106 TECH. FORECASTING AND SOC. CHANGE 85, 85–100 (2016).

11. See generally Vicki M. Bier et al., *A Survey of Approaches for Assessing and Managing the Risk of Extremes*, 19 RISK ANALYSIS 83, 83–94 (1999).

forecasting rarely account for wild card events. Instead, such planning and forecasting typically assumes a continuation of existing trends without major disruption—i.e., an essentially surprise-free future.¹² Ignoring the possibility of wild cards in planning ensures that decision makers will periodically be confronted with—and unprepared for—unanticipated and highly disruptive change. Although individual wild cards are rare, extensive empirical research has shown that people consistently underestimate the total number and frequency of wild card events and the significant impact they have on socio-ecological systems.¹³

Wild card events have shaped natural resource and environmental planning, management, and policy throughout history because of their ability to disrupt business-as-usual. For example, the extraordinary 1910 fire season in the western United States profoundly influenced wildfire policy for decades.¹⁴ The publication of and prodigious public response to Rachel Carson’s highly influential *Silent Spring* (1962) is another example.¹⁵ *Silent Spring* is often credited as sparking the modern environmental movement and the countless direct and indirect changes that followed.¹⁶ More recently, the pandemic has also disrupted environmental and natural resource planning and management—from public participation processes to wildfire management.¹⁷ Thus, it seems likely that future wild cards will continue to shape and disrupt natural resource planning and management in significant and unexpected ways.

This paper defines classes of wild cards and related future-shaping events and reviews strategies for identifying and assessing them. The primary focus is on wild card thinking and analysis in Futures Research, with perspectives from other fields including resilience science, forecasting, strategic planning, risk assessment and management, asset management, and management science. The first section defines and characterizes wild cards generally. The second section focuses on describing and distinguishing three specific categories of wild cards, along with

12. See U.S. FOREST. SERV., *FUTURE FORESTS OF THE NORTHERN UNITED STATES* 13–21 (Stephen R. Shifley & W. Keith Moser eds., 2016); U.S. FOREST. SERV., *THE SOUTHERN FOREST FUTURES PROJECT: SUMMARY REPORT 1* (David N. Wear & John G. Greis eds., 2012); U.S. FOREST. SERV., *FUTURE AMERICA’S FORESTS AND RANGELANDS* 1–2 (2010) (providing examples of major forest planning and forecasting efforts that exclude wild cards in their long-range forecasts and scenarios).

13. See, e.g., Makridakis et al., *supra* note 4; AMOS TVERSKY & DANIEL KAHNEMAN, *JUDGMENT UNDER UNCERTAINTY: HEURISTICS AND BIASES* 3–20 (1974).

14. STEPHEN J. PYNE, *FIRE IN AMERICA: A CULTURAL HISTORY OF WILDLAND AND RURAL FIRE* 255 (1982); see also Michael Kostas, *Huge Western Fires in 1910 Changed US Wildfire Policy. Will Today’s Conflagrations Do the Same?*, *INSIDE CLIMATE NEWS* (Sept. 11, 2020), <https://perma.cc/EPU6-F9K6> (describing that the wildfires of 1910 killed at least 85 people, incinerated entire towns, and scorched more than three million acres. In the aftermath of this unprecedented destruction, the US Forest Service pursued an increasingly aggressive approach to eradicate fire from the nation’s forests, leading to the “10 a.m. policy” of 1935 with the goal of extinguishing every wildfire by the morning after it was first spotted. A zero-tolerance approach to wildfire dominated U.S. wildfire policy throughout the 20th century).

15. See generally RACHEL CARSON, *SILENT SPRING* (1962).

16. See generally MARK H. LYTLE, *THE GENTLE SUBVERSIVE: RACHEL CARSON, SILENT SPRING, AND THE RISE OF THE ENVIRONMENTAL MOVEMENT* (2007).

17. Kristin Floress & Alice Cohen, *Pandemic-era Participation in Public Lands Governance: Lessons from the USDA Forest Service*, 2022, 4 *FRONTIERS IN SUSTAINABLE CITIES* 1, 1 (2022); Bill Avey, *Anchor Point: The Multiplication of Risk Related to the COVID-19 Pandemic*, 80 *FIRE MGMT. TODAY* 4, 4 (2022).

strategies to identify, assess, manage, and monitor them. The final section summarizes the importance of incorporating an analysis of wild card events in natural resource strategic planning.

A. Defining and Characterizing Wild Cards

Researchers in different fields have defined wild cards in various ways. An early, and common, definition of a wild card is “an event having a low probability of occurrence, but an inordinately high impact if it does [occur].”¹⁸ While low probability and high impact are typical hallmarks of wild cards, not everyone agrees.¹⁹ For example, futurist Elina Hiltunen defines wild cards as momentous events that unfold rapidly but may not be low probability.²⁰

Many additional attributes have been proposed to describe and distinguish different types of wild card events. For example, wild cards may:

- emerge rapidly²¹ or unfold over longer periods;²²
- arise in any domain, i.e., society, technology, the economy, the environment, politics, etc.;²³
- be preceded by precursor events that could indicate a growing likelihood of the wild card²⁴ or have essentially no potential for advanced detection;²⁵
- be positive or negative in their direct effects²⁶, and often have both
- positive and negative higher-order impacts;²⁷
- have both short-term and long-term effects;²⁸
- result from planned events (e.g., a major technological innovation produced by R&D), unplanned events (e.g., a natural disaster),²⁹ or from unanticipated consequences of planned or unplanned events;

18. John D. Rockfellow, *Wild Cards: Preparing for the Big One*, 28 *FUTURIST* 14, 14 (1994).

19. JOHN L. PETERSEN & KARLHEINZ STEINMÜLLER, *WILD CARDS*, (Futures Research Methodology—Version 3.0 CD-ROM, rel. 2009, J. C. Glenn & T. J. Gordon eds.).

20. Hiltunen, *supra* note 6, at 64.

21. Petersen, *supra* note 6, at 43; Hiltunen, *supra* note 6, at 64.

22. van Notten et al., *supra* note 9; see also Victor van Rij, *New Emerging Issues and Wild Cards as Future Shakers and Shapers*, in *RECENT DEVELOPMENTS IN FORESIGHT METHODOLOGIES* 68–69 (Maria Giaoutzi & Bartolomeo Sapio eds., 2013).

23. See Oliver Markley, *A New Methodology for Anticipating STEEP Surprises*, 78 *TECH. FORECASTING & SOC. CHANGE* 1079, 1096 (2011); Aharon Hauptman et al., *Wild Cards in Transport*, 3 *EUR. J. FUTURES RSCH.* 6, 7 (2015).

24. PETER SCHWARTZ, *INEVITABLE SURPRISES: THINKING AHEAD IN A TIME OF TURBULENCE* 3 (2004).

25. NASSIM NICHOLAS TALEB, *THE BLACK SWAN: THE IMPACT OF THE HIGHLY IMPROBABLE* xxii (2nd ed., 2010).

26. See Sandro Mendonça et al., *Wild Cards, Weak Signals and Organizational Improvisation*, 36 *FUTURES* 201, 202 (2004); C. L. Walsh et al., *Are Wildcard Events on Infrastructure Systems Opportunities for Transformational Change?*, 67 *FUTURES* 1, 3 (2015).

27. Petersen, *supra* note 6; see also David N. Bengston et al., *Abrupt Climate Change: Exploring the Implications of a Wild Card*, 124 *FUTURES* 1, 2 (2020).

28. Mendonça et al., *supra* note 26; Sirkka Heinonen, *The Dance of the Black Swans*, in *BLACK SWANS: WHAT WILL CHANGE THE WORLD NEXT?* 23 (Ruth Urbom trans., 2013).

29. Aharon Hauptman & Karlheinz Steinmüller, *Surprising Scenarios: Imagination as a Dimension of Foresight*, in *ENVISIONING UNCERTAIN FUTURES: SCENARIOS AS A TOOL IN SECURITY, PRIVACY AND MOBILITY RESEARCH* 58 (Roman Peperhove et al., eds., 2019).

- have reversible or irreversible impacts;³⁰ range from local to global in scale;³¹
- have high credibility in the eyes of experts but low credibility for non-expert stakeholders and;³²
- be paradigm-shifting and system-changing.³³

This last point refers to an extremely impactful type of wild card. Such wild cards have “the power to completely upset many things and radically change many people’s thinking and planning.”³⁴ Others have suggested that wild cards have the potential to disrupt the evolution of systems³⁵ and have referred to high impact wild cards as “paradigm busters.”³⁶ Existential threats are a special type of wild card, distinguished by their extreme impacts.³⁷

B. Three Types of Wild Cards

Since the possibility of advanced detection is likely to be the most relevant factor in developing appropriate proactive strategies, it makes the most sense to classify wild card events based on their potential for advanced detection. For example, wild cards that can be identified in advance with some degree of certainty will require different policies and management strategies than ones that are extremely difficult or impossible to detect in advance. The three classes of wild cards

30. Hiltunen, *supra* note 6, at 66.

31. Christopher J. Smith & Alexandre Dubois, *The ‘Wild Cards’ of European Futures: Planning for Discontinuities?*, 42 FUTURES 846, 852–853 (2010); Marcus Barber, *Wildcards—Signals from a Future Near You*, 11 J. FUTURES STUD. 75, 83 (2006).

32. Markley, *supra* note 23, at 1079.

33. Daria A. Pavlova et al., *The Role of Wild Cards Analysis in Foresight Studies: The Case of Russia 6* (Nat’l Rsch. Univ. Higher Sch. Econ. Basic Rsch. Program Working Papers Series, 2018); Mendonça et al., *supra* note 26.

34. Edward Cornish, *The Wild Cards in Our Future*, 37 FUTURIST 18, 19 (2003) (explaining that these are events or developments that have the potential to cause human extinction or the collapse of civilizations. This type of wild card event has received considerable attention from risk analysts and other scholars). Past events that have been described as wild cards have been diverse and can be categorized as falling within multiple broad sectors or domains—social, technological, economic, environmental, and political. Table 1 provides examples of past wild card events, where each has created direct and indirect cascading effects that may extend to all parts of socio-ecological systems. A selection of possible future wild cards is listed in Table 2, however, many more could be listed.

35. Sandro Mendonça et al., *Venturing into the Wilderness: Preparing for Wild Cards in the Civil Aircraft and Asset-management Industries*, 42 LONG RANGE PLANNING 23, 23–24 (2009). Mendonça et al. give the example of the 9/11 terrorist attacks as a wild card that touched many domains of society, including precipitating transformations in the evolution of national security systems. One of the key recommendations of the 9/11 Commission was creation of the Department of Homeland Security, initiated by the passage of the Homeland Security Act of 2002 (Public Law 107-296), which brought together 22 separate agencies and offices into a single, Cabinet-level department. *Id.*

36. Gill Ringland et al., *Shocks and Paradigm Busters (Why Do We Get Surprised?)*, 32 LONG RANGE PLANNING 403, 411 (1999). Ringland et al. give the example of how the wild card of the dissolution of the Soviet Union caused many paradigms of the bipolar world of the Cold War to be overturned. A specific example given by Ringland et al. is the shift from heavy US Government funding of research and development to stay ahead of the Soviet Union in technology, to private enterprise being the main driver for technological innovation after the breakup of the Soviet Union. *Id.*

37. See Seán Ó hÉigartaigh, *Technological Wild Cards: Existential Risk and a Changing Humanity*, in THE NEXT STEP: AUGMENTED HUMANS AND EXPONENTIAL LIFE 2–3 (BBVA Open Mind, 2017).

discussed in this section include: *In Plain Sight*, *On the Horizon*, and *Over the Horizon*.

1. *In Plain Sight*

Wild cards that are hiding “in plain sight” are significantly more likely to be detected in advance. Experts in relevant fields, and others willing to consider their existence, can see wild cards hiding in plain sight because (1) they know similar events have occurred in the past, or (2) early warning signals indicate their likely arrival. Subject matter experts are typically aware that *In Plain Sight* wild card events will happen, even if the precise timing of such events is unpredictable. The COVID-19 pandemic is a prime example of an *In Plain Sight* wild card because epidemiologists and other public health experts had been warning about the inevitability of a pandemic and the need to prepare for it for many years.³⁸

In Plain Sight wild cards have been discussed extensively in diverse fields and have been termed “anticipatable surprises”,³⁹ “inevitable surprises”,⁴⁰ “predictable surprises”,⁴¹ “type II” wild cards,⁴² and high-probability, high-impact events that are often ignored (HPHIs or “hippies”).⁴³ Policy analyst Michele Wucker carried out a detailed analysis of *In Plain Sight* wild cards from a business perspective.⁴⁴ She uses the term *Gray Rhinos*, for high probability and high impact events that most people fail to see, or refuse to recognize in advance, even when they are rapidly approaching like a charging rhinoceros. According to Wucker, people typically ignore *Gray Rhinos* due to various cognitive biases that blind us to the likelihood of their occurrence.⁴⁵

2. *On the Horizon*

Wild cards that are “on the horizon” are significantly less likely to be detected in advance. Experts rarely see *On the Horizon* wild cards coming because they are not preceded by clear, early warning signals. If precursor signals do exist, they are buried in a low signal-to-noise ratio and searching for them is like looking for a needle in a haystack. Still, *On the Horizon* wild cards may be discernable with great effort—through a combination of imagination, appropriate methods, specialized knowledge, and perhaps luck. Researcher and scholar Ferenc Toth termed this type of wild card *conjecturable surprises*: events for which there are few,

38. QUAMMEN, *supra* note 1; KAHN & PATRICK, *supra* note 1; OSTERHOLM & OLSHAKER *supra* note 1.

39. Ferenc L. Toth, *Dealing with Surprises in Environmental Scenarios*, in ENVIRONMENTAL FUTURES: THE PRACTICE OF ENVIRONMENTAL SCENARIO ANALYSIS 174 (Joseph Alcamo ed., 2008).

40. SCHWARTZ, *supra* note 24, at xvii.

41. See generally MAX H. BAZERMAN & MICHAEL D. WATKINS, PREDICTABLE SURPRISES: THE DISASTERS YOU SHOULD HAVE SEEN COMING, AND HOW TO PREVENT THEM (2004).

42. Markley, *supra* note 23, at 1096.

43. Owen Harries et al., *Global discontinuities*, in BLINDSIDE: HOW TO ANTICIPATE FORCING EVENTS AND WILD CARDS IN GLOBAL POLITICS 143–152 (Francis Fukuyama ed., 2007).

44. See generally MICHELE WUCKER, THE GRAY RHINO: HOW TO RECOGNIZE AND ACT ON THE OBVIOUS DANGERS WE IGNORE (2016).

45. *Id.* at 48–49.

if any, prior indications but “they could be postulated in a concerted and well-targeted process.”⁴⁶

An example of an *On the Horizon* wild card is the 1941 Japanese surprise attack on the US naval fleet at Pearl Harbor. In hindsight, there were weak signals suggesting the plausibility of the attack which, at least in theory, could have been anticipated.⁴⁷ However, it is a considerable challenge to sort through thousands of signals, separate the few meaningful signals from the noise, and then connect the dots in a timely manner.⁴⁸ Nevertheless, imagination coupled with the right analytical methods might have alerted military commanders to the possibility of the attack and helped them prepare for it. For example, war-gaming is a long-standing military technique to explore and develop plans for unlikely scenarios.⁴⁹ Clearly, having an open mind and a willingness to consider a wide range of possible futures is needed to anticipate *On the Horizon* wild cards.

3. *Over the Horizon*

Finally, wild cards “over the horizon” defy advanced detection by even the most creative minds and cutting-edge techniques. Wild cards of this type have been called “out-of-the-blue surprises,”⁵⁰ “unknown unknowns,”⁵¹ and “unknowable unknowns.”⁵² The statistician Nassim Nicholas Taleb famously referred to unforeseeable wild cards as *Black Swans*—rare outliers beyond the realm of our experience, with extreme impacts that are unpredictable.⁵³ As a result, people often devise explanations in the aftermath of these events, making them seem predictable.⁵⁴

While *Over the Horizon* wild cards are impossible to identify in advance, identifying past wild cards and hypothetical cases may help planners and policy makers anticipate *Over the Horizon* wild cards in the future. For example, astrophysicists have identified a possible past *Over the Horizon* wild card: an ancient supernova that was 65 million light-years away from Earth that may have irradiated

46. Toth, *supra* note 39, at 177.

47. Abraham Ben-Zvi, *Hindsight and Foresight: A Conceptual Framework for the Analysis of Surprise Attacks*, 28 *WORLD POL.* 381, 387 (1976); Robert Lempert et al., *Confronting Surprise*, 20 *SOCIAL SCI. COMPUT. REV.* 420, 422 (2002).

48. George S. Day & Paul J. H. Schoemaker, *Driving Through the Fog: Managing at the Edge*, 37 *LONG RANGE PLANNING* 127, 133 (2004).

49. Robert Lempert, *Can Scenarios Help Policymakers Be Both Bold and Careful?*, in *BLINDSIDE: HOW TO ANTICIPATE FORCING EVENTS AND WILD CARDS IN GLOBAL POLITICS* 109–119 (Francis Fukuyama ed., 2007). “In 1940, future general Matthew Ridgway wrote a war-game scenario about a surprise attack on the U.S. fleet at Pearl Harbor. Ridgway’s fellow officers refused to play out the war game because they regarded it as a ‘possibility so improbable that it did not constitute a proper basis for maneuver.’ *Id.* at 113.

50. Toth, *supra* note 39, at 177.

51. See generally Ilmola & Rovenskaya, *supra* note 10.

52. See generally M. A. Maes & M. R. Dann, *Freak Events, Black Swans, and Unknowable Unknowns: Impact on Risk-Based Design*, in *14TH INTERNATIONAL PROBABILISTIC WORKSHOP* 15–30 (R. Caspele et al. eds., 2017); JACK MANHIRE, *UNKNOWABLE UNKNOWNNS OF TAX REFORM: WICKED SYSTEMS, CLOUD SEEDING, AND THE BORDER ADJUSTMENT TAX* (Tex. A&M Univ. Sch. of Law Legal Stud. Rsch. Paper No. 17–19, 2017).

53. TALEB, *supra* note 25, at xxii.

54. *Id.*

the planet, destroyed the ozone layer, and caused a mass extinction event in the Late Devonian epoch 359 million years ago.⁵⁵ Such an example illustrates the powerful impact an *Over the Horizon* wild card can have. Specifically, when a social or ecological system crosses a threshold or tipping point that was unknown, the system can behave in an entirely new and unforeseen way.⁵⁶

C. Wild Card Strategies

Developing effective strategies for anticipating and proactively addressing potential wild card events is challenging due to their nature. Regardless of their specific characteristics, wild cards involve surprise. This section reviews strategies that have been proposed or implemented to identify and prepare for each of the three categories of wild cards identified in the preceding section. The basic strategies include (1) identification, assessment, and monitoring systems for *In Plain Sight* wild cards, (2) tapping into imagination and creativity to identify *On the Horizon* wild cards, and (3) building resilience into organizations and social-ecological systems for *Over the Horizon* wild cards (Table 3).

1. Strategies for *In Plain Sight* Wild Cards

The core strategy for addressing *In Plain Sight* wild cards is to create processes to identify, analyze, and monitor them. Most approaches that do this rely heavily on the informed opinion of experts in relevant fields, making identification relatively straightforward. For example, Hauptman, Hoppe, and Raban developed and tested an expert-based approach to identify and assess possible wild cards related to transportation.⁵⁷ Their approach involved first identifying a wide range of potential wild cards through a combination of scanning future-oriented publications, interviewing subject matter experts, and brainstorming sessions with experts.⁵⁸ Second, Hauptman et al., surveyed experts to select and assess 14 wild cards.⁵⁹ Each wild card was rated for likelihood of occurrence in different timeframes, positive or negative impact, overall impact on each sub-sector within transportation, timeframe for impacts to occur, geographic scope, resilience or vulnerability of each sub-sector to the wild card, importance to prepare for the wild card, and suggestions for early warning signals for each potential wild card.⁶⁰ Finally, each wild card was linked to threats and opportunities for the European transport sector identified in a SWOT analysis—a technique to identify strengths, weaknesses, opportunities, and threats.⁶¹ Limitations of this method include that it was labor-intensive, involved significant input from busy experts, and it was a one-time effort rather than on-going.

Markley discussed several methods for identifying wild cards that have “a high probability and high impact as seen by experts if present trends continue, but

55. See generally Brian D. Fields et al., *Supernova Triggers for End-Devonian Extinctions*, 117 PROCEEDINGS NAT'L ACAD. SCI. U.S. 21008 (2020).

56. See generally Hauptman et al., *supra* note 29.

57. See generally Hauptman et al., *supra* note 23.

58. *Id.* at 2–3.

59. *Id.* at 3.

60. *Id.* at 3–4.

61. *Id.* at 13.

low credibility for non-expert stakeholders of importance.”⁶² For example, snowball sampling of experts in relevant fields could be conducted to identify potential wild cards; this could be followed by a protocol consisting of a series of questions for experts that explore a wild card’s nature, disruptive impacts, probability of occurrence, reasons for low credibility among non-experts, and how it might attain high credibility among non-experts.⁶³ One of Markley’s concluding recommendations was to establish a cooperative clearinghouse to share intelligence on probable wild cards and proactive policy responses.⁶⁴ Others have proposed similar approaches for identifying and monitoring potential wild cards.⁶⁵

Another approach to identifying and assessing *In Plain Sight* wild cards was proposed by Qi and Tapio.⁶⁶ They used two well-established Futures Research techniques: Horizon scanning and the Delphi method.⁶⁷ Horizon scanning was used to collect potential disruptions—i.e., wild cards—that could affect e-commerce in China in the future, and then a Delphi study was carried out to solicit evaluations from an expert panel of the likelihood and impact of the wild cards.⁶⁸ Twenty-seven potential wild cards were identified, categorized, and evaluated.⁶⁹ The authors concluded that anticipating potential disruptions in the external environment to a domain of interest can help decision makers avoid or minimize future risks and threats.⁷⁰

Once *In Plain Sight* wild cards have been identified, various tools can be used to learn more about them and their disruptive potential. For example, the *Futures Wheel* is a highly structured group process that can be used to explore the many possible direct and higher-order implications of wild cards and other significant changes.⁷¹ Planners and decision makers can use the results of a *Futures*

62. Markley, *supra* note 23, at 1079.

63. Leo A. Goodman, *Snowball Sampling*, 32 ANNALS MATHEMATICAL STATS. 148, 148 (1961). Snowball sampling is a nonprobability survey recruitment technique in which research participants are asked to assist researchers in identifying other potential participants from among their acquaintances. Thus, the sample group is said to grow like a rolling snowball. Markley, *supra* note 23, at 1082.

64. Markley, *supra* note 23, at 1095.

65. See, e.g., Petersen, *supra* note 6; Mendonça et al., *supra* note 26.

66. Yuan Qi & Petri Tapio, *Weak Signals and Wild Cards Leading to Transformative Disruption: A Consumer Delphi Study on the Future of e-Commerce in China*, 10 WORLD FUTURES REV. 54, 55 (2018).

67. Horizon scanning, also known as environmental scanning, is a process that involves searching a wide range of information sources for emerging signals of change that may be of significance to planners and decision makers. The signals of change may include trends, countertrends, new developments, and potential wild cards. Chun Wei Choo, *The Art of Scanning the Environment*, 25 BULL. AM. SOC’Y FOR INFORMATION SCI. AND TECH. 21, 21–22 (1999). Delphi method is an expert-based forecasting process in which a panel of experts are surveyed in multiple rounds. Responses for each round are aggregated and shared anonymously with the panelists, who can then adjust their answers in the next round to arrive at a group consensus. HAROLD A. LINSTONE, MURRAY TUROFF, *THE DELPHI METHOD: TECHNIQUES AND APPLICATIONS* 5–6 (1975).

68. Qi & Tapio, *supra* note 66, at 60–5.

69. *Id.* at 68–70.

70. *Id.* at 79.

71. Jerome C. Glenn, *The Futures Wheel*, (Futures Research Methodology—Version 3.0 CD-ROM, rel. 2009, J. C. Glenn & T. J. Gordon eds.). The Futures Wheel is a “smart group” method that uses a structured brainstorming process to uncover and evaluate multiple levels of consequences resulting from all types of change. The output is a map of possible direct and indirect, positive and negative impacts that

Wheel process to proactively consider possible unanticipated consequences of wild cards and better prepare for them. Bengston, Crabtree, and Hujala used this method to explore possible implications of abrupt climate change.⁷² Bengston et. al. uncovered more than two hundred first, second, and third-order impacts that included negative ecological effects, positive economic effects, increased conflict between different stakeholders, and negative effects on rural communities.⁷³ Some of the second and third-order implications were themselves wild cards.⁷⁴

Systems that monitor weak signals of change, including possible precursors of wild cards, have been proposed and written about extensively. In a business context, Ansoff developed a method for early detection of emerging threats and opportunities—strategic surprises—and a strategic issue management system intended to enable a timely response to rapidly emerging strategic surprises.⁷⁵ An example of an early warning signal is tropical forest destruction. Such destruction is a possible indicator of outbreaks of new infectious diseases that could have the potential to become pandemics.⁷⁶ Researcher Mrinalini Watsa and Wildlife Disease Surveillance Focus Group proposed a decentralized system capable of surveilling pathogens in wildlife, in farm animals, and at wildlife markets to provide early warnings of disease spillover to humans.⁷⁷ Another possible *In Plain Sight* wild card precursor is the slowing down of fluctuations in climate systems, which may indicate approaching tipping points that could lead to abrupt climate change.⁷⁸

Schwartz and Randall point out that identifying and monitoring *In Plain Sight* wild cards is not enough to motivate decision makers to act.⁷⁹ They argue that effective communication to make wild cards believable is perhaps the biggest challenge.⁸⁰ The vital task is to make them “sufficiently believable to spur one to act in advance and find ways to persuade others to act.”⁸¹ According to Wucker, framing *In Plain Sight* wild cards in an emotionally resonant way is a key to motivating decision makers to pay attention and act.⁸²

can be analyzed to develop strategies to promote desirable consequences and avoid undesirable ones. The Futures Wheel can help natural resource planners and decision makers anticipate unforeseen consequences of social-ecological change and become more proactive. *Id.*

72. See generally Bengston et al., *supra* note 27.

73. *Id.* at 4–5.

74. *Id.* at 7.

75. Ansoff, *supra* note 8, at 22, 31; see generally Mari Holopainen & Marja Toivonen, *Weak Signals: Ansoff Today*, 44 *FUTURES* 198 (2012).

76. Jeff Tollefson, *Why Deforestation and Extinctions Make Pandemics More Likely*, *NATURE* (Aug. 7, 2020), <https://perma.cc/4BYL-YT9N>.

77. Mrinalini Watsa & Wildlife Disease Surveillance Focus Group, *Rigorous Wildlife Disease Surveillance*, 369 *SCIENCE* 145, 145–147 (2020).

78. Vasilis Dakos et al., *Slowing Down as an Early Warning Signal for Abrupt Climate Change*, 105 *PROCEEDINGS NAT'L ACAD. SCI. U.S.* 14308, 14308 (2008). An example of slowing fluctuations that preceded abrupt climate change is the slowing of temperature fluctuations before the Bølling–Allerød interstadial, which was an abrupt warm and moist period that occurred during the final stages of the Last Glacial Period from 14,690 to 12,890 years before the present. *Id.* at 14309.

79. Schwartz & Randall, *supra* note 8, at 103.

80. *Id.*

81. *Id.* at 94.

82. WUCKER, *supra* note 44, at 238–239.

2. Strategies for *On the Horizon* Wild Cards

On the Horizon wild cards require a different set of strategies since these wild cards include surprising developments that experts often do not see coming and are not preceded by early warning signals. The difficulty in detecting this type of wild card in advance suggests the importance of methods that tap into imagination, creativity, and intuition.⁸³ Oliver Markley has long championed exploring possible futures with intuition and imagination, including guided cognitive imagery and “mental time travel.”⁸⁴ Markley observed that “the use of rational/analytic modes of thinking alone are inadequate for research on alternative futures involving deeply systemic transformation.”⁸⁵ Instead, he argues that “[i]ntuitive methods that draw on ‘hidden reserves’ of the mind are also needed.”⁸⁶

An example of an innovative approach to identifying and exploring *On the Horizon* wild cards is the writing competition held by the Committee for the Future of the Finnish Parliament.⁸⁷ The “Black Swans – What Will Change the World?” writing competition was open to the general public in Finland with the goal of seeking out creative ideas from diverse participants.⁸⁸ The competition explored surprises and discontinuities and promoted artistic and creative approaches in considering possible futures.⁸⁹ A panel of judges evaluated 132 short stories.⁹⁰ The top four stories received prizes and the top twenty stories were included in a book.⁹¹ The tone of the stories ranged from utopian to dystopian, and topics included wild cards related to future energy shortages, global justice, organized crime, Asia’s growing role in world politics, and many others.⁹²

Another approach used to identify potential *On the Horizon* wild cards includes scanning existing science fiction literature. For example, the European Commission’s iKNOW project explored the future of science, technology, and innovation policy in Europe by identifying a large number of wild cards through

83. An alternative approach to identifying *On the Horizon* wild cards affecting the future effects of climate change on biological systems was proposed by Srivastava et al. In this approach, the authors developed a framework to identify specific stress points where wild cards are likely to originate throughout the research process for studying the effects of climate change on biological systems. See generally Srivastava et al., *supra* note 7.

84. See Oliver Markley, *Mental Time Travel: A Practical Business and Personal Research Tool for Looking Ahead*, 40 *FUTURES* 17, 17 (2007); Oliver W. Markley, *Visionary Futures: Guided Cognitive Imagery in Teaching and Learning About the Future*, 42 *AM. BEHAVIORAL SCI.* 522, 522–523 (1998). See generally Oliver Markley, *Introduction to the Symposium on Intuition in Futures Work*, 20 *J. FUTURES STUD.* 83 (2015).

85. Oliver Markley, *Manifesting Upside Recovery Instead of Downside Fear: Five Ways Megacrisis Anticipation Can Proactively Improve Futures Research and Social Policy*, 16 *J. FUTURES STUD.* 123, 130 (2011).

86. *Id.*

87. See generally *Entries from the Writing Contest of the Committee for the Future of the Parliament of Finland*, in *BLACK SWANS: WHAT WILL CHANGE THE WORLD NEXT?* (Ruth Urbom trans., 2013).

88. Toni Ahlqvist et al., *Chasing Black Swans Through Science Fiction: Surprising Future Events in the Stories of a Finnish Writing Competition*, 20 *J. FUTURES STUD.* 47, 47–48 (2015).

89. *Id.*

90. *Id.* at 53.

91. *Id.*

92. *Id.* at 53–54.

systematically scanning science fiction literature and then assessing those wild cards using an online expert system.⁹³ Science fiction prototyping is another method used to imagine alternative futures, and could be used to explore the potential consequences of *On the Horizon* wild cards once they have been identified.⁹⁴

The use of *serious games* is an approach that helps participants tap into right-brain holistic thinking, intuition, and creativity in exploring alternative futures⁹⁵ and could be used to explore *On the Horizon* wild cards. Gaming approaches, ranging from card decks and board games to a wide variety of online games, have been used in many fields in recent years, including environmental and conservation applications.⁹⁶ However, *serious games* have not been applied specifically to wild card identification and exploration, but a board game developed to explore forestry futures includes *disruption cards* that cause large-scale impacts.⁹⁷

Finally, scenario planning is another helpful method used to explore wild cards and other discontinuities. Many practitioners of scenario planning have called for expanding scenarios to consistently include wild cards.⁹⁸ Van Notten, Slegers, and Van Asselt examined 22 scenario studies and found that half of them examined gradual or abrupt discontinuities in a variety of ways.⁹⁹ Of the scenario studies that included discontinuities, all but one used intuitive scenario development processes involving participatory group sessions and qualitative information.¹⁰⁰ Those that excluded discontinuities used more formal scenario processes such as expert-based, quantitative data, and computer modeling processes.¹⁰¹ The European Union security program's FESTOS scenarios provides an example of wild card scenarios and the use of imagination in foresight processes.¹⁰²

93. Hauptman & Steinmüller, *supra* note 29.

94. See generally BRIAN DAVID JOHNSON, SCIENCE FICTION PROTOTYPING: DESIGNING THE FUTURE WITH SCIENCE FICTION (2011).

95. See generally I. Milojevic, *Introduction by the Special Editor to the Symposium on Gaming Futures*, 22 J. FUTURES STUD. 1 (2017).

96. See, e.g., Laura Bliss, *Game of Floods is Like Settlers of Catan, Only It's About Surviving Climate Change*, WIRED (Apr. 28, 2017, 10:00 AM), <https://perma.cc/2TWT-GQW6>; Leejiah J. Dorward et al., *Pokémon Go: Benefits, Costs, and Lessons for the Conservation Movement*, 10 CONSERVATION LETTERS 160 (2017); Robert Fletcher, *Gaming Conservation: Nature 2.0 Confronts Nature-deficit Disorder*, 79 GEOFORUM 153 (2017).

97. David N. Bengston et al., *A "Serious Game" to Explore Alternative Forestry Futures*, 120 J. FORESTRY 222, 222 (2022).

98. See, e.g., DAVID J. STALEY, HISTORY AND FUTURE: USING HISTORICAL THINKING TO IMAGINE THE FUTURE (2007); Toth, *supra* note 39; Paul Goodwin & George Wright, *The Limits of Forecasting Methods in Anticipating Rare Events*, 77 TECH. FORECASTING AND SOC. CHANGE 355 (2010); Hauptman & Steinmüller, *supra* note 29.

99. van Notten et al., *supra* note 9, at 182–183.

100. *Id.*

101. *Id.*

102. Hauptman & Steinmüller, *supra* note 29, at 63–66. The FESTOS scenarios focused on emerging technologies that could be put to surprising malicious uses. Selected technologies were assessed by experts in terms of the likelihood and severity of potential threats they could pose. Workshops with security and technology experts identified details about the technologies that were used to create compelling narrative scenarios. *Id.*

3. *Strategies for Over the Horizon Wild Cards*

Because they defy advanced detection, creating systems with high general resilience may be the only viable strategy for dealing with true *Over the Horizon* wild cards. General resilience is the capacity of social-ecological systems to absorb unanticipated and unforeseeable impacts of disturbance,¹⁰³ including disruption from wild card events. Scheffer et al. reviewed catastrophic and unpredictable change in which ecosystems abruptly shift to a new state.¹⁰⁴ They concluded that “building and maintaining resilience of desired ecosystem states is likely to be the most pragmatic and effective way to manage ecosystems in the face of increasing environmental change.”¹⁰⁵

Walker and Salt identified nine characteristics associated with a high level of general resilience in social-ecological systems. These characteristics include: (1) diversity, (2) ecological variability, (3) modularity, (4) acknowledging slow variables associated with thresholds, (5) tight feedbacks that allow detection of thresholds in advance, (6) a high level of social capital, (7) innovation to increase adaptive capacity, (8) redundancies in governance structures, and (9) including unpriced ecosystem services in decision making.¹⁰⁶ Of these nine factors, three were identified as key:

- **Diversity:** Maintaining or building diversity of species, ideas, and institutions. More diversity means greater flexibility and capacity to respond to wild cards;¹⁰⁷
- **Modularity:** Creating modular structures in systems such that components are strongly connected internally but loosely linked to each other;¹⁰⁸ and
- **Tightness of feedbacks:** A system has tight feedbacks when a disturbance in one part of the system is felt quickly and can be responded to in a timely manner in other parts.¹⁰⁹

The European Commission’s *2020 Strategic Foresight Report* proposed *resilience dashboards* which could be an effective strategy to strengthening resilience and monitoring *Over the Horizon* wild cards.¹¹⁰ The proposed dashboards would monitor resilience in four broad domains: (1) social and economic, (2) geopolitical, (3) environmental, and (4) digital. Each of these domains would include a range of indicators to assess multiple dimensions of resilience and their interlinkages. Combining strategic foresight methods, such as horizon scanning and scenario planning, could help identify emerging issues and challenges and ensure that new, forward-looking indicators of resilience capacities and vulnerabilities are

103. BRIAN WALKER & DAVID SALT, *RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD* 121 (2006).

104. Marten Scheffer et al., *Catastrophic Shifts in Ecosystems*, 413 *NATURE* 591, 596 (2001).

105. *Id.*

106. WALKER & SALT, *supra* note 103, at 145–148.

107. *Id.* at 121.

108. *Id.* Modularity in systems “allows individual modules to keep functioning when loosely linked modules fail, and the system as a whole has a chance to self-organize and therefore a greater capacity to absorb shocks” *Id.* at 121.

109. *Id.*

110. *See generally* EUROPEAN COMMISSION, *2020 STRATEGIC FORESIGHT REPORT: CHARTING THE COURSE TOWARDS A MORE RESILIENT EUROPE* (2020).

developed and used.¹¹¹ The proposed timeframe for the resilience dashboards is medium to long-term to provide “the best conditions for foresight-informed policies to mitigate vulnerabilities and strengthen capacities.”¹¹²

In addition to strengthening general resilience, several other strategies have been proposed for uncovering and assessing *Over the Horizon* wild cards. For example, complexity science uses a tool called agent-based modeling (ABM) to identify and explore emergent phenomena in the context of business, social science, epidemiology, military, law enforcement, and other fields.¹¹³ Ilmola and Rovenskaya used ABM to simulate what could happen to a system subjected to extreme “shock scenarios.”¹¹⁴ This approach yielded some surprising outcomes, such as a total collapse of regional economies in one case.¹¹⁵ Importantly, the authors point out the limitations of this approach for exploring unknown unknowns—i.e., *Over the Horizon* wild cards.¹¹⁶ Specifically, the emergent behavior of the system is path dependent and is based on available data and rules of behavior.¹¹⁷ Therefore, ABM may be best used to explore surprising emergent behavior and implications of *In Plain Sight* and *On The Horizon* wild cards.

Lempert, Popper, and Bankes proposed another alternative strategy for dealing with unforeseeable wild cards. Specifically, Lempert et al. used computer-assisted reasoning and simulation modeling to generate large groups of plausible scenarios for the case of planning for long-term global sustainability.¹¹⁸ They concluded that this type of “robust adaptive planning” can help analysts avoid making implicit assumptions that eliminate or reduce consideration of potentially important types of available information, and “may offer greater insight into the vulnerabilities inherent in several types of surprises and enhance decision makers’ ability to construct strategies that will mitigate or minimize the effects of surprise.”¹¹⁹

CONCLUSION

Wild cards—and the disruptive changes they bring—are a major challenge to the business-as-usual future planners and policymakers typically plan for. Most planning and policy making in natural resources avoids consideration of wild cards because thinking the unthinkable or the implausible is too *far out*. As a result, the possibility of future wild card events is often discounted or excluded entirely. Experts who warn of impending wild cards—like global pandemics or abrupt climate

111. *Id.* at 35. *Horizon Scanning* is first defined *supra* note 67.

112. *Id.* at 38.

113. See generally Eric Bonabeau, *Predicting the Unpredictable*, 80 HARV. BUS. REV. 109 (2002).

114. See generally Ilmola & Rovenskaya, *supra* note 10. An agent-based model uses an algorithmic or mechanistic approach to simulate the actions and interactions of “autonomous agents” (individuals or organizations) to understand the behavior of a system and what governs its outcomes.

115. *Id.* at 93. In their model, a surprising collapse of regional economies was caused by a shift from manufacturing-based economies to service-based economies.

116. *Id.*

117. *Id.*

118. Lempert et al., *supra* note 47.

119. *Id.* at 420.

change—are often ignored and viewed as panicking about highly improbable events.¹²⁰

However, wild cards occur more frequently than people think. Coates defined history as “the study of the effects of improbable events that nevertheless occurred.”¹²¹ Even a cursory study of history reveals the frequency of improbable and disruptive social, technological, economic, environmental, and political events that shaped the world, such as those listed in Table 1. High impact surprises will also shape the future. The COVID-19 pandemic wild card has illustrated the importance of identifying and preparing for low probability, high impact events.

In the long run, the future of natural resource management and planning will be shaped to some extent by wild card events. The examples given in Table 2 suggest that a wide range of future wild cards are possible. These and other wild cards—such as the rise of antibiotic-resistant superbugs, asteroid impacts, biological weapons, advanced nanotechnology¹²²—would be highly disruptive for natural resources and every other domain. The farther we peer into the future, the greater the number of potential known, unknown, and unknowable wild cards and the greater the probability that some will occur.¹²³ Based on various risk assessments, a recent Deutsche Bank report estimated a 33% chance that at least one of the four “massive tail risks” they examined will occur over the next decade.¹²⁴ The report also indicated a 56% chance of at least one of these *In Plain Sight* wild cards happening over the next two decades.¹²⁵ Of course, such assessments are unable to capture the risk of *On the Horizon* and *Over the Horizon* wild cards.

Including wild card assessment in natural resource planning and management would require investment in strategic foresight capacity and expertise, like that found in many innovative and forward-looking organizations. But there would be numerous benefits from anticipating, exploring, and preparing for wild cards. For example, significant costs can be avoided if organizations make preemptive decisions that increase their resilience to disruption.¹²⁶ Another benefit includes reducing the reaction time in crisis management situations if organizations have planned for possible wild card events.¹²⁷ Exploring the implications of negative wild cards can reveal their positive higher-order consequences and opportunities.¹²⁸

120. See, e.g., Stephen T. Green & Lorenzo Cladi, *Cassandra’s Curse and Covid-19: Why Do Governments Listen to Businesses Over Doctors?*, 369 *BRITISH MED. J.* 1852 (2020); Laurie Garrett, *The World Knows an Apocalyptic Pandemic Is Coming—But Nobody Is Interested in Doing Anything About It*, *FOREIGN POL’Y* (Sept. 20, 2019, 12:48 PM), <https://perma.cc/83BE-FPUJ>; Timothy M. Lenton et al., *Climate Tipping Points—Too Risky to Bet Against*, 575 *NATURE* 592 (2019).

121. V. T. Coates, *Lessons Learned from Futures Research*, in *WHAT I HAVE LEARNED: THINKING ABOUT THE FUTURE THEN AND NOW* 140 (Michael Marien & Lane Jennings eds., 1987).

122. *GLOBAL CATASTROPHIC RISKS* (Nick Bostrom & Milan Ćirković eds., 2008).

123. Hauptman & Steinmüller, *supra* note 29.

124. Steve Goldstein, *There’s a One-in-Three Chance of a ‘Massive’ Disaster that Could be Worse than COVID-19, Says Deutsche Bank*, *MARKETWATCH* (June 17, 2020, 8:44 AM), <https://perma.cc/X43W-YJ77>.

125. *Id.*

126. PETERSEN & STEINMÜLLER, *supra* note 19.

127. Mendonça et al., *supra* note 26.

128. Walsh et al., *supra* note 26; see also Bengston et al., *supra* note 27.

The frequency of disruptive, discontinuous change, and its power to shape the future, suggest the importance of thinking broadly about wild cards to minimize the risk and consequences of being unprepared. Natural resource planning, management, and policy that implicitly assumes a business-as-usual future, dominated by a continuation of current trends, narrows the scope of possible futures that are considered. This, in turn, leaves society vulnerable to being blindsided by wild cards or missing significant opportunities they may offer. Incorporating wild card thinking into natural resource decision-making broadens the scope of possible futures and helps us navigate fundamental uncertainties.

Table 1. Examples of Past Wild Card Events.

Wild Card	Primary Domain of Origin	Date	Reference
Pearl Harbor attack	Military	1941	Ben-Zvi (1976)
East Asian financial crisis	Economic	1997–98	Hale (2007)
Publication of <i>Silent Spring</i> , environmental movement	Social	1962	Lytle (2007)
Collapse of the Soviet Union	Political	1989–91	Berkowitz (2007)
Racial justice movement	Social	2020	Lowery (2020)
Pandemic influenza	Health	1918–20	Crosby (2003)
Launch of Sputnik	Technological	1957	Dickson (2019)
Carrington event geomagnetic storm	Space	1859	Ritter et al. (2020)

References: Abraham Ben-Zvi, *Hindsight and Foresight: A Conceptual Framework for the Analysis of Surprise Attacks*, 28 *WORLD POL.* 381, 389–390 (1976); Bruce Berkowitz, *U.S. Intelligence Estimates of Soviet Collapse: Reality and Perception*, in *BLINDSIDE: HOW TO ANTICIPATE FORCING EVENTS AND WILD CARDS IN GLOBAL POLITICS* 29–41 (Francis Fukuyama ed., 2007); A. W. CROSBY, *AMERICA’S FORGOTTEN PANDEMIC: THE INFLUENZA OF 1918* (2nd ed., 2003); PAUL DICKSON, *SPUTNIK: THE SHOCK OF THE CENTURY* (2019); David Hale, *Econoshocks: The East Asian Crisis Case*, in *BLINDSIDE: HOW TO ANTICIPATE FORCING EVENTS AND WILD CARDS IN GLOBAL POLITICS* 42–53 (Francis Fukuyama ed., 2007); Wesley Lowery, *Why Minneapolis was the Breaking Point*, *ATLANTIC* (June 10, 2020), <https://perma.cc/J9GD-U7D9>; MARK H. LYTLE, *THE GENTLE SUBVERSIVE: RACHEL CARSON, SILENT SPRING, AND THE RISE OF THE ENVIRONMENTAL MOVEMENT* (2007); S. Ritter et al., *International Legal and Ethical Issues of a Future Carrington*.

Event: Existing Frameworks, Shortcomings, and Recommendations, 8 NEW SPACE 23 (2020).

Table 2. Examples of Possible Future Wild Card Events.

Wild Card	Primary Domain of Origin	Reference
Supervolcano eruption at Yellowstone	Environment	Knott et al. (2020)
Radical extension of the human lifespan	Medical	Kovic, Rauchfleisch, and Caspar (2018)
Artificial general intelligence	Technology	Baum (2017)
Solar-geomagnetic superstorm	Space	Ritter et al. (2020)
Abrupt climate change	Environment	Lenton et al. (2019)
Pathogens from melting permafrost	Environment	Miner, Edwards, Miller (2020)
World war, Thucydides's Trap	Geopolitical	Allison (2017)

References: GRAHAM T. ALLISON, DESTINED FOR WAR: CAN AMERICA AND CHINA ESCAPE THUCYDIDES'S TRAP? (2017); Seth Baum, *A Survey of Artificial General Intelligence Projects for Ethics, Risk, and Policy* (Glob. Catastrophic Risk Inst., Working Paper 17-1, 2017); Thomas R. Knott et al., *Discovery of Two New Super-Eruptions from the Yellowstone Hotspot Track (USA): Is the Yellowstone Hotspot Waning?*, 48 GEOLOGY 934 (2020); MARKO KOVIC ET AL., KILLING DEATH: SOME IMPLICATIONS OF EXTENDING HUMAN LIFESPAN INDEFINITELY (Zurich Inst. Pub. Affairs Rsch., Discussion Paper Series, 2018); Timothy M. Lenton et al., *Climate Tipping Points—Too Risky to Bet Against*, 575 NATURE 592 (2019); Kimberley. R. Miner et al., *Deep Frozen Arctic Microbes are Waking Up*, SCIENTIFIC AMERICAN (Nov. 20, 2020), <https://perma.cc/7FXW-BAF9>; S. Ritter et al., *International Legal and Ethical Issues of a Future Carrington Event: Existing Frameworks, Shortcomings, and Recommendations*, 8 NEW SPACE 23 (2020).

Table 3. Three Types of Wild Cards and Strategies for Addressing Them.

Type of Wild Card	Characteristics	Broad Strategies	Examples of Strategies
In Plain Sight	<p>High likelihood of advanced detection by subject matter experts.</p> <p>Early warning signals. Timing unpredictable.</p>	<p>Systems to identify, assess, and monitor potential wild cards.</p> <p>Utilize expert opinion.</p>	<ul style="list-style-type: none"> • Horizon scanning. • Interviews, brainstorming with experts. • Wild card clearinghouse. • Effective communication.
On the Horizon	<p>Low likelihood of advanced detection.</p> <p>Early warning signals very difficult to discern.</p>	<p>Use of imagination, creativity, intuition to identify potential wild cards.</p>	<ul style="list-style-type: none"> • Wild card writing competition. • Scanning science fiction. • Serious games.
Over the Horizon	<p>Defy advanced detection.</p> <p>No early warning signals.</p>	<p>Build resilience into social-ecological systems.</p>	<ul style="list-style-type: none"> • Maintain or build diversity, modular structures, tight feedbacks • Resilience dashboard