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Social-Ecological Resilience and Law in the Platte River Basin

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SOCIAL-ECOLOGICAL RESILIENCE AND LAW IN THE PLATTE RIVER BASIN

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ABSTRACT

Efficiency and resistance to rapid change are hallmarks of both the judicial and legislative branches of the United States government. These defining characteristics, while bringing stability and predictability, pose challenges when it comes to managing dynamic natural systems. As our understanding of ecosystems improves, we must devise ways to account for the nonlinearities and uncertainties rife in complex social-ecological systems. This paper takes an in-depth look at the Platte River basin over time to explore how the system's resilience—the capacity to absorb disturbance without losing defining structures and functions—responds to human driven change. Beginning with pre-European settlement, the paper explores how water laws, policies, and infrastructure influenced the region's ecology and society. While much of the post-European development in the Platte River basin came at a high ecological cost to the system, the recent tri-state and federal collaborative Platte River Recovery and Implementation Program is a first step towards flexible and adaptive management of the social-ecological system. Using the Platte River basin as an example, we make the case that inherent flexibility and adaptability are vital for the next iteration of natural resources management policies affecting stressed basins. We argue that this can be accomplished by nesting policy in a resilience framework, which we describe and attempt to operationalize for use across systems and at different levels of jurisdiction. As our current natural resources policies fail under the weight of looming global change, unprecedented demand for natural resources, and shifting land use, the need for a new generation of adaptive, flexible natural resources governance emerges. Here we offer a prescription for just that, rooted in the social, ecological and political realities of the Platte River basin.

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I. INTRODUCTION

In today's political climate of congressional gridlock and partisan conflict, resistance to rapid change characterizes the judicial and legislative branches of the United States government. Of the two branches, however, courts may have more capacity to be incrementally adaptive, sometimes despite public opinion to the contrary. Similarly, federal administrative agencies have some level of adaptive capacity through rulemaking, in adjudications including permit conditions, and by exercising administrative discretion within their legislative authority. Legislation from Congress, in contrast, is designed to be lasting, stable, and resistant to change, establishing order and bracing society against shocks and rapid changes. From this perspective, environmental statutes must be written to exist for operational perpetuity[1]. However, as our understanding of ecosystems has improved, it has become clear that the current judicial system and natural resources management policies lack the flexibility to address the nonlinearities and uncertainties that we now know to be common in ecosystems[2]. The efficacy of natural resources management legislation is thus limited by an older, more rigid interpretation of ecosystems that fails to address their dynamic nature.

Here we present the history, challenges, and opportunities of using law—particularly federal statutes—as tools in the management of the complex social-ecological system of the Platte River basin. We argue that by framing natural resources management laws within resilience theory[3] there is potential to introduce a new generation of natural resources management policy that better addresses the dynamic and somewhat uncertain nature of ecological systems.

II. PLATTE RIVER BASIN: ECOSYSTEM CHARACTERISTICS, RESILIENCE, HISTORY AND SERVICES

A. The Pre-European Platte River Ecosystem and Resilience Theory

1. The Physical System

The Platte River basin extends from Colorado and Wyoming, where snowpack melt runoff from the eastern side of the continental divide flows into the South and North Forks of the Platte River, to Nebraska, where the two forks join to form the main stem of the Platte, which is also supported by smaller tributaries and the Ogallala Aquifer[4]. The Platte River's South and North forks run 424 and 618 miles long respectively, combining for 310 miles in the main stem to deliver an

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1. *See* William Howard Taft, *The Boundaries between the Executive, the Legislative, and the Judicial Branches of the Government*, 25 THE YALE L. J. 599, 600–01 (1916) (providing a specific distinction among the branches of the US government and defining the legislative branch).

2. *See generally* STANFORD ENVTL. LAW SOC'Y, THE ENDANGERED SPECIES ACT (2001) (for an in depth explanation of how the most powerful environmental law in United States history, the Endangered Species Act, often fails to capture the true and complex nature of ecosystems in its aims to meet overly simple ecological targets).

3. Resilience is an emergent property of complex systems describing the capacity of that system to withstand disturbance without losing its defining structures and functions. This capacity largely includes the ability of the system to absorb disturbance through self-reorganization so that similar disturbances in the future are absorbed more effectively, i.e. with smaller reverberations throughout the system and less need for reorganization. If a system's resilience is unable to withstand the degree of disturbance, the system enters an alternative state with a new set of supporting and reinforcing processes and functions. Often, the alternative state is extremely stable, and reverting to the initial state requires significant intervention or may even be impossible. *See generally* CS Holling, *Resilience and Stability of Ecological Systems.* 4 ANNU REV. ECOLOGY & SYSTEMATICS 1 (1973). For an updated and in depth discussion on alternative states, disturbance and loss of resilience, *see* Marten Scheffer, Steve Carpenter, Jonathan A. Foley, Carl Folke & Brian Walker, *Catastrophic Shifts in Ecosystems*, 413 NATURE 591 (2001).

4. PLATTE RIVER EIS TEAM, CENTRAL PLATTE RIVER 1998 LAND COVER/USE MAPPING PROJECT, NEBRASKA 2-6 (2000), *available at* https://www.platteriverprogram.org/PubsAndData/ProgramLibrary/TC-R8%20Central%20Platte%201998%20Land%20Cover%20Mapping%20Project.pdf.

average flow of 7,052 cubic feet per second of water to the Missouri River and draining an area of some 90,000 square miles of land in Colorado, Nebraska and Wyoming[5].

Prior to European settlement, water from spring snowpack melt cascaded down the eastern side of the Continental Divide in the Rocky Mountains and into larger tributaries. These streams drain the Front Range of the Rocky Mountains of Wyoming and Colorado. East of the Rocky Mountains, water flowing into the North Fork, South Fork and then the main stem of the Platte River lose only an average seven feet of elevation per mile in the high plains and short, mid and tall-grass prairies, where the Platte is subsumed by the Missouri River.

During high springtime flows, during high springtime flows the river flooded a wide valley and then receded back to the riverbed, punctuated with occasional flood events throughout the year.[6] This major seasonal ebb and flow and the small elevation gradient across much of the Platte River's length controlled the pre-European settlement river's shape, flow and functioning, driving a "braided" stream dynamically connected with the land, characteristic of rivers of the Great Plains of the United States[7]. Periodic wetting and drying from the spring snowpack melt created a seasonally shifting range of moisture levels in sediments and soils, yielding a diverse mosaic of conditions for various ecological processes along the wetting and drying edges.[8]

These dynamic edges of the Platte River and adjacent land provided,[9] for example, key habitat for a range of wetland plants, fish and bird species.[10] Platte riverbanks likely remained largely unwooded before European settlement, save for willow, cottonwood and elm trees scattered along the riverbank and studding larger

5. TIM PALMER, AMERICA BY RIVERS 146 (1996); U.S. GEOLOGIC SURVEY, WATER RESOURCE DATA, NEBRASKA, WATER YEAR 2003 267 (2003), *available at* http://pubs.usgs.gov/wdr/wdr-ne-03-1/aar2003bookG.pdf; PLATTE RIVER EIS TEAM, *supra* note 4, at 2–6.

6. Ray Ring, *Saving the Platte*, 31 HIGH COUNTRY NEWS (Feb. 1, 1999), *available at* http://www.hcn.org/issues/147/4744.

7. The ecology of a river is driven by the nature of its dynamic flow. *See* N. LeRoy Poff et al., *The Natural Flow Regime: A Paradigm for River Conservation and Restoration*, 47 BIOSCIENCE 769, 770 (1997), *available at* http://www.tufts.edu/water/pdf/Natural%20Flow%20Regime.pdf. The magnitude, frequency, duration, timing and rate of change of flow events determine the water quality, food web dynamics, physical habitat and biotic interactions that form the riverine ecosystem. *Id.* at 770–72. This is foundational to stream ecology, and serves as a model to explain the historical Platte's physical, chemical and biological ecology as well as the multi-pronged impact of alterations of flow on the ecosystem. *See id.* at 774–77.

8. The zone of drying and wetting along the edge of a river is the site of a gradient of aeration. *See* Amy J. Burgin et al., *Beyond Carbon and Nitrogen: How the Microbial Energy Economy Couples Elemental Cycles in Diverse Ecosystems*, 9 FRONTIERS IN ECOLOGY & THE ENV'T 44, 47 (2011), *available at* http://www.esajournals.org/doi/pdf/10.1890/090227. The varying degree of oxygen availability in the sediment creates a range of conditions for a variety of essential processes that only occur given a unique level of oxygen availability. *Id.* The processes remove waste and provide important products for both the riverine and terrestrial ecosystem, making the linkage between the two essential for both. *See id.* For a further discussion regarding the historic physical Platte River, *see* T. R. Eschner et al., *Hydrologic and Morphologic Changes in Channels of the Platte River, Basin in Colorado, Wyoming, and Nebraska: A Historical Perspective*, *in* HYDROLOGIC AND GEOMORPHIC STUDIES OF THE PLATTE RIVER BASIN A1 (1983).

9. *See* Poff, *supra* note 7, at 777–79.

10. DAVID M. FREEMAN, IMPLEMENTING THE ENDANGERED SPECIES ACT ON THE PLATTE BASIN WATER COMMONS 14–26 (2010) [hereinafter FREEMAN].

islands.[11] The pre-European Platte River ecosystem was created under a unique set of conditions, and the suite of habitats it provided reflected this.[12]

2. Ecosystem Services

Ecosystem services determined the survival of Native American populations living in the Platte River Basin.[13] Along with water provisioning for cooking, hygiene and transportation, the river generated food and essential materials from the productive land-water interface, likely including rare but life-sustaining timber for Pawnee, Arapahoe, Cheyenne, Lakota, Omaha and Oto-Missouria tribes living in proximity.[14] While periodic floods, fires, droughts, and grazing inundations stymied forest growth in the Basin, it is not clear to what degree native human inhabitants controlled deforestation. Any trees left in the Platte River basin disappeared quickly with the establishment of white pioneers around 1845.[15]

B. Platte River Basin Following European Settlement

Before the European invasion Native American populations survived in a system characterized by periodic wildfires, floods, disease outbreaks, droughts, war and sparse resources for more than 10,000 years.[16] European settlers introduced

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11. *See* W. Carter Johnson & Susan E. Boettcher, *The Pre-settlement Platte: Wooded or Prairie River?*, 10 GREAT PLAINS RES.: A J. OF NAT. AND SOC. SCI. 39, 43 (2000), *available at* http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1484&context=greatplainsresearch [hereinafter Johnson]. The combination of low precipitation/dry conditions, periodic fires, nutrient limitation, and human deforestation limited forestation across the Great Plains. *See id.* at 61. While data suggests that the Platte River basin was never heavily forested, there exists little empirical data to support a completely deforested over moderately forested Platte River basin. *See id.* at 58–62.

12. *See id.*

13. *See generally* Robert Costanza et al., *The Value of the World's Ecosystem Services and Natural Capital*, 387 NATURE 253–58 (1997), *available at* http://www.esd.ornl.gov/benefits_conference/nature_paper.pdf. Ecosystem services are defined as the provisioning of ecosystem goods and processes essential to the survival and advancement of human societies. *See id.* at 253. While most ecosystem services rendered are not wholly commensurate with goods traded in the free market, the average annual contribution of ecosystem services (e.g., food production, water purification, soil carbon sequestration) to humans is estimated at roughly 18 trillion USD. *See id.* at 259. Replacing many ecosystem services through human industry is not only inefficient, but likely impossible. *Id.*

14. FREEMAN, *supra* note 10, at 12–23. Early European settlers recounted the reliance on woodland by the Pawnee: "We are, however, well assured that the [Pawnee] Indian horses, farther to the west, about the upper branches of the Platte, and Arkansa[s], subsist, and thrive, during the winter, with no other article of food than the bark and branches of the cotton wood." Johnson, *supra* note 11, at 54–55 (from Long Expedition, 1819-1820 on lower Platte River). From a European settler's journal: "In the summer the Dakotas follow the buffaloes in their range over the prairie, and in the winter fix their lodges in the clusters or fringes of wood along the banks of the lakes and streams." *Id.* at 55 (from Warren Expedition, 1855-1857).

15. There is some indication that extant trees present before 1840 and the establishment of White pioneers quickly disappeared, as observed in a personal correspondence from 1850: "The expense of establishing a new post 200 miles from any settlement which, under any circumstances, must have been great, has been enhanced here by the absence of every building material except a very scrubby inferior cottonwood . . . ." *Id.* at 56.

16. The first date of North America habitation is not fully understood and remains one of the enduring paleoanthropological debates. It is most likely that the first North American human habitation occurred sometime before 13,500 YA (years ago), with some sporadic evidence of earlier human populations.

novel disease, unprecedented deforestation, and intensive European agriculture,[17] altering the social-ecological system in much different ways than the Native American inhabitants.[18] While the pre-European system was presumably resilient to disturbances, it was unable to withstand this new suite of disturbances. The system clearly transformed to an alternative state with its own self-enforcing structures and functions, and native inhabitants and their way of life were resettled or eliminated from the landscape while European settlers proliferated.[19]

1. European Settlement and the Homestead Acts

Although European pioneer settlers quickly spread westward, establishing small settlements, farming, and clashing with Native populations, the federal government of the United States of America considered itself the sole proprietor of the western land.[20] The first sale of these so-called "public lands" occurred in 1796,[21] and for the next sixty years, the land prices that were set by the federal government were prohibitively high for poor white settlers, who chose instead to "squat" on the land. These European-descended settlers scratched out a living in defiance of Native American inhabitants and The Land Survey Ordinance of 1785,[22] which was enacted to generate federal income from the sale of "public" lands, even though no land was sold until 1796.[23] In fact, Congress repeatedly enacted failed legislation in 1785, 1796, 1800, 1804 and 1807 to demand that pioneer squatters vacate the land.[24]

In the Homestead Acts, the federal government reversed its stance on European settler land ownership while dealing the final blow to Native inhabitants of the West.[25] The Acts offered settlers of European descent and unenslaved African Americans 160-acre parcels of land at a trivial fee in exchange for five years of continuous inhabitance and development. The Kincaid Act amended the Act in Nebraska to allow for 640-acre parcels of land per homesteader, and much of the

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See Ted Goebel et al., *The Late Pleistocene Dispersal of Modern Humans in the Americas*, 318 SCIENCE 1497, 1500–01 (2008).

17. *See generally* ARMSTRONG STARKEY, EUROPEAN AND NATIVE AMERICAN WARFARE 1675–1815 (1998) (discussing the changes that European settlers brought to Native American societies).

18. While Native Americans are often portrayed as having lived passively on the land, they in fact shaped the landscape just as all other human inhabitants have impacted their natural environmental through some combination of animal husbandry, crop agriculture, and their indirect and direct impacts through activities such as: hunting, warfare, and deforestation to list a few. For further reading, *see generally* SHEPARD KRECH III, THE ECOLOGICAL INDIAN: MYTH AND HISTORY (1999) (discussing environmental impacts and difficulties that Native Americans have faced).

19. Richard H. Hart & James A. Hart, *Rangelands of the Great Plains Before European Settlement*, *in* RANGELANDS 19[1] 4–11 (1997); David Wishart, *The Dispossession of the Pawnee*, *in* ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS 69[3] 382–401 (1979).

20. JOHN OPIE, THE LAW OF THE LAND: TWO HUNDRED YEARS OF AMERICAN FARMLAND POLICY 26 (1987).

21. *Id.* at 34.

22. *Id.* at 4.

23. *See generally* THE PUBLIC LANDS: STUDIES IN THE HISTORY OF THE PUBLIC DOMAIN (Vernon Carstensen ed., Univ. of Wis. Press 1968).

24. *See* OPIE, *supra* note 20, at 49.

25. Homestead Act of 1862, Pub. L. No. 37-64, 12 Stat. 392 (repealed 1976).

land granted by the Homestead Act in Nebraska went to firms rather than to individuals.[26]

2. Water Law, Policies, and Infrastructure in Support of Economic Development

Colorado, Nebraska and Wyoming experienced especially large white settler population booms following the gold rushes in the 1840s and 1850s.[27] After the initial gold rush frenzy subsided, crop agriculture emerged as the foundation of the region's economy.[28] As populations grew, demand for agricultural products increased and the cultivation of arid land farther from the riverbed required increasingly intensive irrigation.[29] Although agriculture was not new to the settlers, the new system of water scarcity was: settlers migrated largely from the humid, eastern U.S. and had no experience with irrigation dependent agriculture.[30]

Most settlers' prior experience with water rights and sharing was based on a system of riparian law.[31] Under riparian law, water rights reside in owners of land adjacent to rivers, or lakes.[32] These landowners are expected to make reasonable use of water and share equally in reductions during rare times of scarcity.[33] While fitting for wet, humid conditions, the riparian law system was not well suited for the arid Platte River basin.[34]

One reason that riparian law was especially untenable in the Platte River basin arises from the fact that valuable non-water natural resources, such as mineral veins, were often far from sources of water.[35] The extraction and harvest of these non-water resources required that water be preferentially diverted to settlements. This placed priority on a first-come first ability to pay for water above proximity to water, violating the riparian doctrine.[36]

As the population of European settlers in the Platte River basin expanded, the riparian system was quickly replaced by the prior appropriation system.[37] Under the prior appropriation system, water is allocated based on the seniority of water rights rather than proximity to the river, and the burden of scarcity is not proportionally shared.[38] The shift in these early European Platte River basin societies away from

26. Kincaid Act, 33 Stat. 547 (previously codified at 43 U.S.C. §§ 222-224 (1970) (repealed 1976)); *See* OPIE, *supra* note 20, at 73–78.

27. *See* Gary J. Hobbs, Jr., *Colorado Water Law: An Historical Review*, 1 U. DENV. WATER L. REV. 1, 4 (1997).

28. DUANE A. SMITH, ROCKY MOUNTAIN WEST: COLORADO, WYOMING AND MONTANA 1859-1915 8–9 (1992).

29. *See* Hobbs, *supra* note 27, at 5.

30. *See* G. E. RADOSEVICH ET AL., EVOLUTION AND ADMINISTRATION OF COLORADO WATER LAW: 1876–1976 4 (1976).

31. CAROL M. ROSE, PROPERTY AND PERSUASION: ESSAYS ON THE HISTORY, THEORY, AND RHETORIC OF OWNERSHIP 186–87 (1994).

32. ROBERT W. ADLER ET AL., MODERN WATER LAW: PRIVATE PROPERTY, PUBLIC RIGHTS, AND ENVIRONMENTAL PROTECTIONS 23 (2013).

33. *Id*. at 46–61.

34. *Id*. at 87.

35. *See* GEORGE VRANESH, COLORADO WATER LAW 60–64 (1987).

36. ADLER ET AL., *supra* note 32, at 87–89.

37. *See id*. at 88–97.

38. *See id*.

riparian law was based not in experience with intensive irrigation or water scarcity, but on the economy and property rights associated with the resource that first attracted them to the area—gold.[39] In the gold rush era of the western United States, the foundational principle was first in time, first in right.[40] Claims to mines, water, and farm and ranch land under the Homestead Act were all allocated based on first in time, first in right.[41] Upon their admittance to the Union, all three of the Platte River basin states —Colorado, Nebraska and Wyoming—adopted prior appropriation as their water allocation systems in their state constitutions.[42]

As state prior appropriation systems matured to govern in-state appropriators, conflicts arose between states regarding shared rivers and lakes, requiring higher-level laws to govern interstate water sharing.[43] In the Platte River basin, compacts[44] and U.S. Supreme Court decrees currently comprise the large share of water allocation agreements.[45] One of the earliest compacts occurred between Nebraska and Colorado in 1923,[46] and represented a cooperative, non-litigious approach for settling water disputes.[47] The compact was ratified by Congress in 1926 and committed Colorado to deliver specific minimum amounts of water to Nebraska during the irrigation season.[48] In 1945, the U.S. Supreme Court ended a long-standing dispute over allocation of the North Platte between Nebraska and Wyoming by establishing a clear set of allocation rules.[49]

Although water infrastructure deeply impacted the native Platte River social-ecological system, it was essential to fulfilling Manifest Destiny's push to settle the West with European-descended ranchers and farmers.[50] To expedite the process of Western development and settlement, Congress enacted the Reclamation Act of 1902, which founded the Bureau of Reclamation and funded extensive dam and irrigation projects throughout the West,[51] including Nebraska, Colorado and Wyoming.[52] The primary goal of water laws and policies of the distant and near past was to encourage economic development by drawing water from the Platte River

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39. *See* FRANK J. TRELEASE, FEDERAL-STATE RELATIONS IN WATER LAW 21–23 (1971); ADLER ET AL., *supra* note 32, at 87–89. *See, e.g.*, Coffin v. Left Hand Ditch Co., 6 Colo. 443 (1882) (rejecting the argument that riparian law had ever been the rule in Colorado and adopting prior appropriation derived from miners' customs).

40. *See* ADLER ET AL., *supra* note 32, at 139–48.

41. *See generally* Homestead Act, ch. 75, 12 Stat. 392 (1862).

42. *See* COLO. CONST. art. XVI, § 6; NEB. CONST. art. XV, § 6; WYO. CONST. art. VIII, § 3. The Colorado constitution explicitly defined prior appropriation as the means by which water would be governed. Article XVI, section 6 states, "The right to divert the unappropriated waters of any natural stream to beneficial uses shall never be denied." COLO. CONST. art. XVI, § 6.

43. *See* ADLER ET AL., *supra* note 32, at 452–501.

44. *See, e.g.*, South Platte River Compact, ch. 46, 44 Stat. 195 (1926).

45. *See, e.g.*, Nebraska v. Wyoming, 325 U.S. 589, 646–57 (1945) (equitably apportioning the North Platte River among Nebraska, Wyoming, and Colorado).

46. South Platte River Compact, ch. 46, 44 Stat. 195 (1926).

47. *See* Report of Delph E. Carpenter, Comm'r for Colo., to William E. Sweet, Governor of Colo. 21 (Jan. 7 1925), *available at* http://digitool.library.colostate.edu/R/?func=dbin-jump-full&object_id=98161.

48. *See* South Platte River Compact, ch. 46, 44 Stat. at 197–98 (1926).

49. *See Nebraska*, 325 U.S. at 646–57.

50. *See id.* at 655.

51. Reclamation Act of 1902, ch. 1093, 32 Stat. 388 (1902) (codified at 43 U.S.C. §§ 372–498).

52. U.S. Bureau of Reclamation, *Projects and Facilities Database*, USBR.GOV, http://www.usbr.gov/projects/ (last updated Sept. 9, 2014).

and its tributaries and devoting it to "beneficial" use.[53] For European settlers, beneficial use meant irrigation and industry.[54] As the Bureau of Reclamation notes, "[a]bout 335,000 acres of sagebrush and rangeland have been transformed into productive farmland."[55] Farmers in the Platte River basin states currently raise water intensive dry beans, sugar beets, corn, and alfalfa in the basin—crops that require steep irrigation in the arid climate.[56]

3. Impact of Water Appropriation and Reclamation on Ecosystem Services

In the early years of European settlement, water from the Platte River would have appeared limitless to the settlers.[57] However, as industry and human settlements proliferated within the basin, the need to protect against droughts in this arid ecosystem emerged.[58] Currently, fifteen major reservoirs or dams and roughly 200 smaller diversion or storage schemes that store an average of more than 7.1 million acre-feet alter the Platte River.[59]

From an ecological standpoint, dams and diversions are important because they decrease overall flow and diminish flow variability and high flow events. High flow events are ecologically critical, establishing key habitat by transporting and depositing sediment, scouring vegetation from sandbars and banks, breaking up and mobilizing logjams, and transporting water and materials across the flood plain and downstream.[60] These processes are essential for maintaining a functional braided river ecosystem with dynamic morphology, wetlands and sandbar islands.[61] Dams and diversions may also serve to isolate aquatic populations, inhibiting genetic diversity in smaller, isolated populations,[62] potentially rendering them more vulnerable to stochastic disturbance events.[63]

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53. *See* Hobbs, *supra* note 27, at 7–15.

54. *See id.*; ADLER ET AL., *supra* note 32, at 121–28.

55. U.S. Bureau of Reclamation, *North Platte Project*, USBR.GOV, http://www.usbr.gov/projects/Project.jsp?proj_Name=North+Platte+Project (last visited Nov. 18, 2014).

56. *Id.*

57. *See* FREEMAN, *supra* note 10.

58. *See id.*

59. One acre-foot is the amount of water required to cover one acre of surface area to the depth of one foot, and serves as the standard unit of volume used in the United States to describe volume units of large scale water resources. *See generally* Leo Eisel & J. David Aiken, PLATTE RIVER BASIN STUDY: REPORT TO THE WESTERN WATER POLICY REVIEW ADVISORY COMMISSION, U.S. DEPT. OF COMM. (1997) *available at* http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1034&context=ageconfacpub; *Full Committee Oversight Field Hearing at Grand Island, Nebraska on: Endangered Species Act: The Platte River Cooperative Agreement and Critical Habitats Before the H. Comm. on Resources*, 107th Cong. (2002) (statement of John W. Keys, III, Comm'r, Bureau of Reclamation U.S. Dept. of the Interior).

60. *See generally* Poff et al., *supra* note 7.

61. *See* H.B.N. Hynes, *Edgardo Baldi Memorial Lecture: The Stream and its Valley*, 19 VERH. INT. VEREIN. LIMNOL. 1–15 (1975).

62. Dams and reservoirs serve to physically impede migration and mixing of populations of aquatic organisms, isolating, populating, and impeding the flow of genes up and downstream. For more reading, *see* Jonathan P. Benstead et al., *Effects of Low-Head Dams and Water Abstraction on Migratory Tropical Stream Biota*, 9 ECOLOGICAL APPLICATIONS 656 (1999).

63. There is a growing body of work showing that response diversity, defined as the range and distribution of responses to a disturbance experienced in a system, contributes to larger scale resilience, or ability to absorb the disturbance. This response diversity likely contributes to the systems overall ability to reorganize in the face of disturbance to prevent future responses of the same magnitude. *See e.g.*, Thomas

The once wide, slow, braided, shallow, sediment-bearing stream studded with sandbars and fringed by wetlands is currently in an alternative stable state characterized by a narrow, deep, channelized stream with well-defined, static edges.[64] Since European settlement, wetlands and native grassland habitats adjacent to or within the river have declined more than 73% in area, and natural sandbars and meander loop wetlands have all but disappeared.[65] The new state of the Platte results in changes to less obvious, but important, ecological features such as nutrient cycling, temperature stratification, water velocity, and turbidity.[66] Without historic peak flows and flooding events, the Platte cannot return to a braided, snowpack melt-driven river system with dynamic land-river connectivity. As a result, the ecosystem services provided by the contemporary Platte River significantly diverge from those provided before European settlement (Figure 1a).

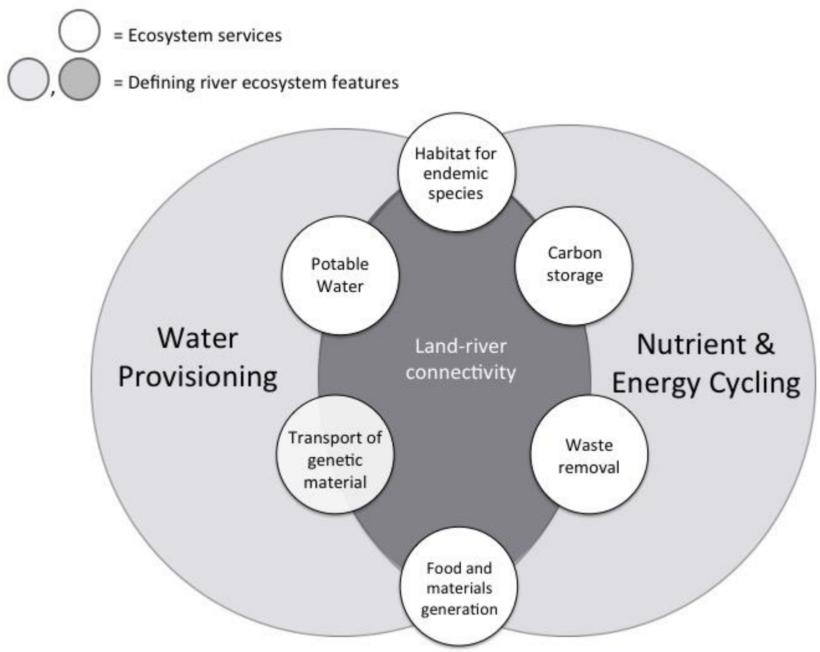


FIGURE 1A. Conceptualizations of ecosystem services generation from the Platte River.[67]

Emqvist et al., *Response Diversity, Ecosystem Change and Resilience*, 1 FRONTIERS ECOLOGY AND ENV'T 488 (2003).

64. M.P. Brooker, *The Ecology Effects of Channelization*, 151 GEOGRAPHICAL J. 63 (1995).

65. *See* BUREAU OF RECLAMATION & U.S. FISH AND WILDLIFE SERV., U.S. DEP'T OF INTERIOR, PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM: FINAL ENVIRONMENTAL IMPACT STATEMENT 31–32 (2006) [hereinafter PLATTE RIVER RECOVERY].

66. *See generally* Brooker, *supra* note 64.

67. Figure 1a represents the pre-European settlement Platte River system and its associated ecosystem services. The grey spaces represent the defining ecosystem features of a river ecosystem: water provisioning, nutrient and energy cycling, and the space for water-land connectivity. This space of land-river connectivity represents dynamic zones of nutrient and energy cycling created by variable soil oxygen

The water demands of a post-European Manifest Destiny society and a free-flowing river are mutually exclusive, as they currently exist. To better understand tradeoffs associated with storage and diversion projects, it is beneficial to view the system not as an ecosystem versus society, but as one, complex social-ecological system grappling with the allocation of limited resources. While they come at the cost of many other ecosystem services, storage and diversion projects provide major value to society through year-round water provisioning for agricultural, municipal and industrial pursuits, decoupling (somewhat) water availability from drought, generating hydroelectricity, creating novel habitat and providing recreation.[68] However, if appropriation ever consistently exceeds supply, a continuously dry riverbed would move the social-ecological system into yet another alternative and more deeply undesirable state in which no riverine ecosystem services are provided.[69]

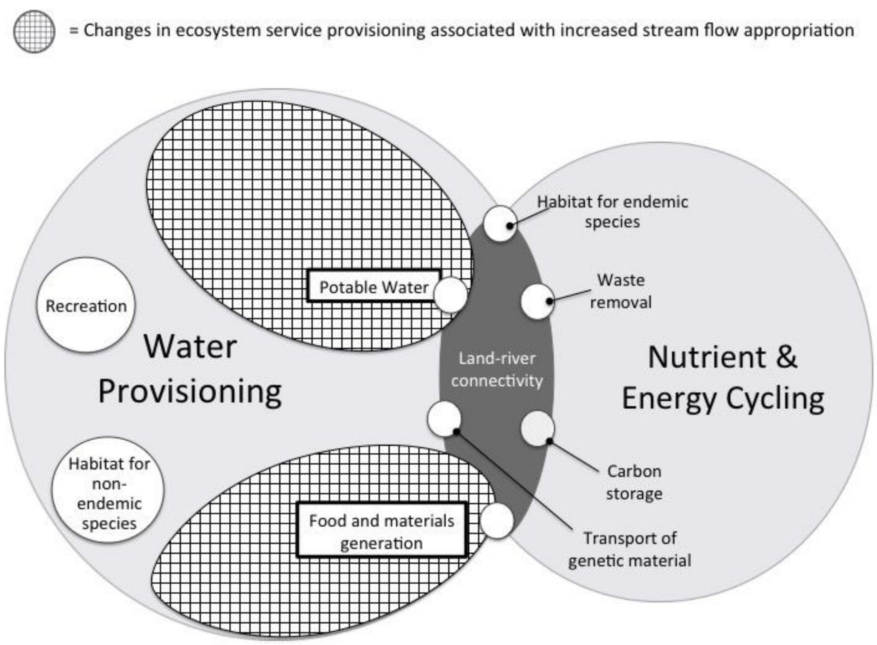


FIGURE 1B. Conceptualizations of ecosystem services generation from the Platte River.[70]

as flood and drought events pulsed the water across the floodplain and back to the riverbed, sandbar islands, and wet meadows/wetlands, and supported the provisioning of ecosystem services associated with braided plains streams. The major ecosystem services provided by the Platte are carbon storage, waste removal, food and material generation, gene flow for aquatic populations, increasing genetic diversity among, and potable water for drinking, washing and cooking, and key habitat for native species. In this conceptualization, ecosystem services are represented by the white spaces and patterned spaces.

68. *See* FREEMAN, *supra* note 10, at 47–54; PLATTE RIVER RECOVERY, *supra* note 65, at 24–26.

69. *See* Carl Folke ET AL., *Regime Shifts, Resilience, and Biodiversity in Ecosystem Management*, 35 ANN. REV. ECOLOGY EVOLUTION & SYSTEMATICS 557, 558–59 (2004).

70. Figure 1b shows how post-European settlement water provisioning is augmented through river damming and retention to meet new ecosystem service demands of food and materials production and

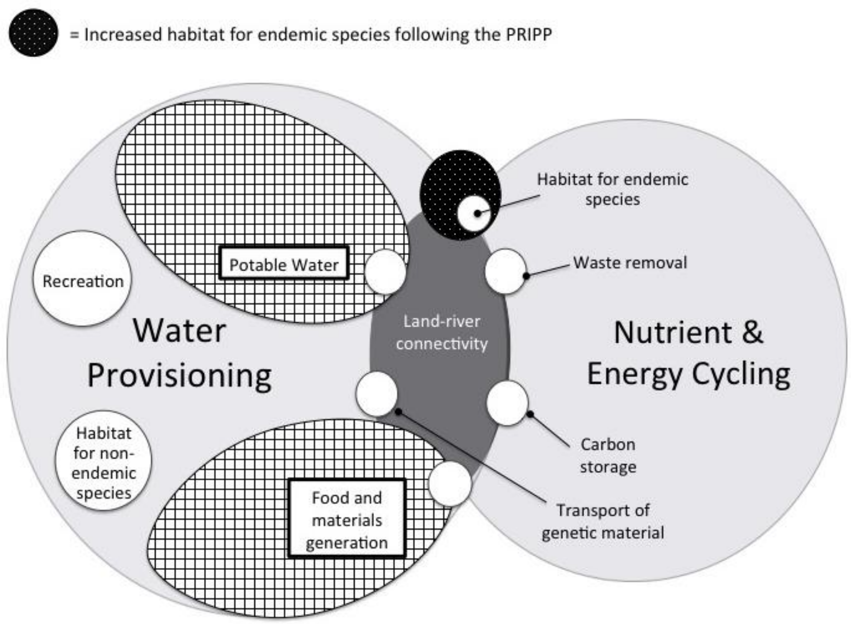


FIGURE 1C. Conceptualizations of ecosystem services generation from the Platte River.[71]

4. Resilience and Ecosystem Services

The continued generation of ecosystem services depends on a social-ecological system's resilience.[72] Resilience as used here is not the time required for a system to "bounce back" to equilibrium following a disturbance,[73] but rather an emergent system property that mediates the type and amount of disturbance a system can tolerate. When the set of disturbances experienced by a system exceeds its resilience, the system's defining processes and structures are lost and it moves to an alternative—and sometimes undesirable—state. Importantly, resilience is not normative, but rather a way to describe the system's capacity for tolerating disturbance

potable water. As a result of this appropriation, the land-river connectivity space is shrunken and some of the ecosystem services previously generated from the system are reduced. The ecosystem services augmented and/or created by this increase in water provisioning are represented by the black and white pinstripe space.

71. Figure 1c shows the ecosystem services generation and slight decrease in water provisioning and food and materials generation that resulted from implementation of the Platte River Recovery Program (PRRIP). PRRIP increased the habitat for endemic species ecosystem service through, for example, the direct creation of sandbar habitats, which is represented by the speckled white and black space.

72. Here we define fundamental ecosystem services as those essential to supporting ongoing human habitation, and supplemental ecosystem services as those that improve society and quality of life, but are not essential to survival. Further, the ecological resilience of complex-social ecological systems is the capacity to absorb disturbance without losing definitive structures and functions. *See* Folke, *supra* note 69, at 558. Resilient, complex systems are self-organizing and adaptive, meaning they have the capacity to adapt to disturbance so that the system increases its capacity to absorb future disturbance. *Id.*; *see generally* Holling, *supra* note 3, at 1–23.

73. That definition belongs to the term "engineering resilience." *See* Folke, *supra* note 69, at 558.

and the likelihood of retaining definitive structures and functions in the face of change (e.g., climate change or management intervention).

Conventional ecological thinking regarding the response of an ecosystem to disturbance is that, as long as conditions are reversed, the state can be commensurately reversed (Figures 2a and 2b).[74] This is an incomplete view of complex systems, however, because it assumes a linear response in a predictable system (Figure 2c),[75] which we now know to be untrue. The response of complex systems of people and nature are frequently non-linear and sometimes irreversible; as conditions shift, gradual observed changes belie the state's swift approach towards a threshold.[76] At this threshold of changing conditions (Figure 2c), the system enters an entirely different alternative state and enters a new basin of attraction, or a state in which the system tends to remain.[77]

This alternative state is defined by a suite of different self-perpetuating processes and functions that are often very resilient to even significant management intervention.[78] This sort of regime change is frequently unexpected and typically accompanied by steep losses in ecosystem services.[79] Because these services are often expensive or impossible to replace, and due to the unpredictability they create in social-ecological systems, alternative states are often undesirable.[80] These flips are also expensive because even if management intervention (represented by the vertical broken lines in Figure 1c) succeeds in restoring initial conditions, the system remains in the alternative stable state.[81]

74. *See* Scheffer et al., *supra* note 3, at 592.

75. *See id.*

76. *See generally id.* at 591–94.

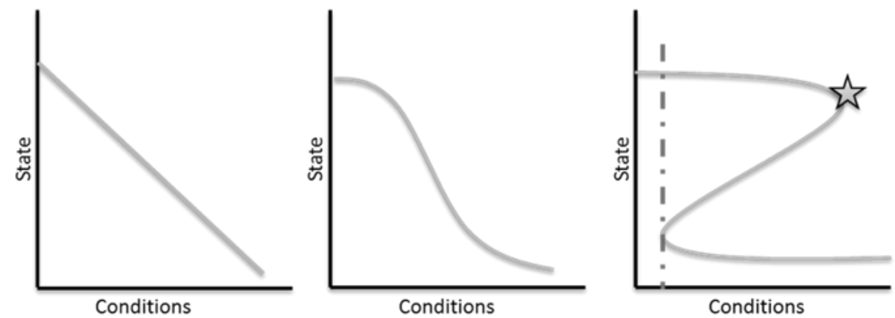
77. *See id.* at 591.

78. *See generally* BRIAN WALKER & DAVID SALT, RESILIENCE THINKING: SUSTAINING ECOSYSTEMS AND PEOPLE IN A CHANGING WORLD (2006); Carl Folke et al., *Resilience Thinking: Integrating Resilience, Adaptability and Transformability*, ECOLOGY & SOC'Y, Dec. 2010 at art. 26, http://www.ecologyandsociety.org/vol15/iss4/art20/.

79. *See* Scheffer et al., *supra* note 3, at 595.

80. *See id.*

81. *See id.* at 595–96.



a. b. c.

FIGURES 2A–C. When the conditions of a social ecological system change, the system responds.[82]

Clearly, increasing the resilience or decreasing disturbance to a desirable system state is preferable to attempting to manage an undesirable alternative state that may be highly resilient to human intervention. The Platte River social-ecological system currently occupies a state that is alternative to that of pre-European settlement, with its own self-reinforcing and defining processes. Water provisioning is somewhat resilient to natural fluctuations in precipitation,[83] as storage and diversion plans largely decouple water availability from drought (though the system is very vulnerable to megadroughts, which may increase in frequency and duration with climate change).[84] However, many desirable riverine ecosystem services rely on flood pulses and peak flows, such as habitat for native species, carbon storage, and nutrient cycling, and these are much less resilient in this new system state.

III. POLICY UNDER UNCERTAINTY: USING LAW TO MANAGE SYSTEM RESILIENCE

In many ways the current state of the Platte River social-ecological system is not desirable, but a reversal in conditions to pre-European settlement Platte River state is practically impossible. Beyond the significant cultural, technological, political, social and economic intervention required to revert the system, the pre-European system supported very small human populations more immediately vulnerable to starvation, freezing to death, and conflicts regarding sparse resources.[85] In order to shift away from the current, over-appropriated state of the river, there are two options: (1) if the current state is not resilient, transforming the system to an alternative state characterized by a high output of ecosystem services or (2) if

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82. Figure 2a and b represent the conventional acceptance that ecosystems respond in a predictable manner to changing conditions. Figure 2c reflects a more realistic understanding that the state of a complex system responds to changing conditions in an unpredictable manner. Once changing conditions push the state across some critical threshold (represented by the star) and into an alternative state, restoration to initial conditions (broken gray line) does not restore the state of the system.

83. *See generally* FREEMAN, *supra* note 10.

84. *See generally* Dennis Ojima et al., *Potential Climate Change Impacts on Water Resources in the Great Plains*, 35 J. AM. WATER RESOURCE ASS'N 1443 (1999).

85. *See generally* Hart & Hart, *supra* note 19; Wishart, *supra* note 19.

the current state is resilient, altering it where possible to emphasize resilient fundamental ecosystem service output. In order for either of these options to actualize and improve the social-ecological system, smarter natural resources management policy is needed that bolsters the resilience of targeted ecosystem services.

A. The Endangered Species Act (ESA)

The federal Endangered Species Act (ESA),[86] as reformulated in 1973, provided a clear and robust mandate to "halt and reverse the trend toward species extinction, whatever the cost."[87] As such, the ESA marked a strong departure from earlier conservation policy of the 20th century that subordinated environmental needs to economic growth.[88]

Under the ESA, once a species is listed for protection,[89] Section 7 requires all federal agencies to "insure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat."[90] One of the greatest operational challenges of the ESA is enforcing and defining the concept of "jeopardy." Under the U.S. Fish & Wildlife Service and National Marine Fisheries Service's joint regulations, to "*[j]eopardize the continued existence of* means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species."[91] Thus, the process of determining "jeopardy" is open to subtlety and subjectivity, inviting criticism once a determination is or is not made. In addition, the listing of species triggers a response on the part of the U.S. Fish & Wildlife Service (USFWS) and the National Marine Fisheries Service to actually recover the species to the point where the Act's protections are no longer required.[92] Both the jeopardy consultation requirements and the species recovery obligations can effectively change the dominant policies in social-ecological systems.

In the Platte River basin in Nebraska, four species have been listed for protection under the ESA: the whooping crane, piping plover, interior least tern, and pallid sturgeon.[93]As explained in more detail below, the USFWS along with Nebraska, Colorado, Wyoming and the U.S. Bureau of Reclamation are currently pursuing the first thirteen-year phase of a recovery program for these species, which began in 2006.[94] The plan notably recognizes the continuing human use of the river system, listing as benefits: (1) More effective endangered species habitat improvements based on basin-wide strategies, as opposed to piecemeal attempts at species habitat

86. 16 U.S.C. §§ 1531–44 (2014).
87. Tennessee Valley Auth. v. Hill, 437 U.S. 153, 184 (1978).
88. FREEMAN, *supra* note 10, at 30.
89. 16 U.S.C. § 1533 (2014).
90. 16 U.S.C. § 1536(a)(2) (2014).
91. 50 C.F.R. § 402.02 (2014) (emphasis added).
92. 16 U.S.C. § 1533 (2014).
93. *Platte River Recovery Program*, UNITED STATES FISH & WILDLIFE SERVICE, http://www.fws.gov/mountain-prairie/wtr/PlatteRiver.htm (last visited Dec. 3, 2014) [hereinafter *USFW PRRP 2012*].
94. *Id.*

improvement; (2) Permanent restoration and protection of 29,000 acres of habitat; (3) Simplifications of the ESA review process for individual water-related actions throughout the basin; (4) Development of legal and institutional protections to help ensure that existing flows and any new water deliveries by a program will reach the critical habitat areas; (5) Implementation of an adaptive management strategy to test and evaluate the effectiveness of Program activities, including changes to river flows and the consequent effects on fish and wildlife habitat along the Platte River; and (6) Comprehensive basin-wide analysis of opportunities for water conservation and enhanced water supply.[95]

The ESA Section 7 jeopardy consultation process requires the consideration of alternative actions. If, for instance, the USFWS concludes that a proposed project will jeopardize the continued existence of a listed species, Section 7 requires that it identify in its resulting Biological Opinion "reasonable and prudent alternatives" (RPAs) to offset or reduce the threat to endangered species.[96] If the RPAs are deemed sufficient to eliminate the jeopardy concern, the project can move forward—but generally only in compliance with the RPAs. Moreover, the consultation and RPAs set a precedent for similar projects to move more easily through the regulatory system.

B. Responding to Social Disturbances: The Platte River Recovery and Implementation Program (PRRIP)

1. Triggering Negotiations

Efforts by the three Platte River basin states—Colorado, Nebraska and Wyoming —to address the degradation of the river in order to recover endangered and threatened species have been ongoing since 1997.[97] The impetus of this effort was the 1994 relicensing of Lake McConaughy's Kingsley Dam.[98] This was the first relicensing of a hydroelectric dam in the basin since the 1978 declaration of endangered species by the USFWS.[99] Prior to the dam's relicensing, the endangered species listing had stopped, deferred, or substantially modified all new proposed water projects in the basin,[100] but this was the first time an existing project was threat-

95. *Id*.

96. 16 U.S.C. § 1536 (2014).

97. David M. Freeman, *Negotiating for Endangered and Threatened Species Habitat in the Platte River Basin*, *in* LARGE-SCALE ECOSYSTEM RESTORATION: FIVE CASE STUDIES FROM THE UNITED STATES 59, 67 (Mary Doyle & Cynthia A. Drew eds., 2008) [hereinafter FREEMAN II].

98. *Id.* at 66.

99. Freeman describes the application of the Endangered Species Act thusly,

> "When water users are dependent upon federal government projects or when nonfederal water facilities need federal approvals, water users who plan to undertake actions that are likely to jeopardize a listed species must find ways to achieve ESA compliance (usually, to find a "reasonable and prudent alternative" to the original proposed action that is not likely to jeopardize a listed species) in order to gain essential permit(s). Since the 1970s ESA has been an unwelcome guest at virtual lyevery Platte Basin water provider dinner party." FREEMAN II, *supra* note 97, at 64.

100. *See generally* J. David Aiken, *Balancing Endangered Species Protection and Irrigation Water Rights: The Platte River Cooperative Agreement*, 3 GREAT PLAINS NAT. RES. J. 119 (1999) (describing the Platte River Cooperative Agreement).

ened.[101] Nebraska negotiated an agreement with the Federal Energy Regulatory Commission to provide 100,000 acre-feet of water annually for species recovery, which allowed the dam to be relicensed.[102] However, Colorado and Wyoming state officials also recognized that they, too, would be facing similar issues in their states, and Nebraska acknowledged that recovery efforts depended not only on what occurred among water users in Nebraska but on also what occurred in the two upstream states.[103] In recognition of this, the three states entered into an agreement that has become known as PRRIP (Platte River Recovery and Implementation Program).

2. Specifics of the PRRIP: Water and Land

The primary objectives of the PRRIP are to: (1) increase flow; (2) restore habitat; and (3) implement adaptive management—an iterative management approach that emphasizes learning from doing while adjusting management approaches to incorporate new knowledge in the Platte River basin. The agreement satisfied the relicensing requirements for the Kingsley Dam, which continued its municipal, industrial and agricultural water provisioning to Colorado, Wyoming and Nebraska.[104]

The program is divided into phases of activities and projects directed at species recovery and guided by an adaptive management approach.[105] The first increment is intended to cover thirteen years, from 2007 through 2019, but the phases may be adjusted depending on the performance of earlier increments.[106] At that point, the performance of the program will be evaluated and additional and different activities may be agreed upon to further support species' protection and recovery.[107]

The agreement takes key steps in making more water available to the river, restoring and protecting critical habitat, and explicitly incorporating adaptive management into its governance structure.[108] For example, the first increment of the program consists of mitigating pre-1997 water uses by the three states, providing 130,000–150,000 acre-feet of water to the river at strategic points in space and time to best meet the needs of recovery efforts.[109] Through the Tamarack Recharge Pro-

101. *Id.*

102. EDELLA SCHLAGER, EMBRACING WATERSHED POLITICS 77 (Willaim Blomquits ed., 2008).

103. *See generally* Aiken, *supra* note 100; As Doyle and Drew explain,

> "The three affected states (Nebraska, Colorado, and Wyoming) and water providers along the river, under the leadership of USBR, facing serious curtailment of water operations by and endless consultation with the US Fish and Wildlife Service (USFWS) in its capacity as enforcer of the Endangered Species Act (ESA), agreed in 1994 to negotiate a basin wide agreement." FREEMAN II, *supra* note 97, at 55.

104. *USFW PRRP 2012*, *supra* note 93.

105. FREEMAN II, *supra* note 97, at 78.

106. *Id.* at 85.

107. SCHLAGER, *supra* note 102, at 78.

108. FREEMAN II, *supra* note 97, at 71–72.

109. *Id.*

ject, located near the Nebraska border, Colorado captures surplus water and places it in ponds at varying distances from the river.[110] The water percolates underground and returns to the river at the times most needed for species recovery activities.[111] Wyoming meets its commitment of 34,000 acre-feet by expanding storage at the Pathfinder Dam, located on the North Platte River approximately 111 miles from the Nebraska border.[112] Finally, Nebraska meets its commitment by devoting 10% of the water captured in Lake McConaughy during the winter storage season (November through April) to the program.[113]

In addition, the states agreed to replace all new depletions of water from 1997 forward, with each state tailoring a depletion plan that simultaneously meets its own needs and the requirements of the agreement.[114] Every year Wyoming measures and compares current water use against the thresholds,[115] and if water use exceeds the thresholds, the state covers the excess depletion by releasing water previously stored in reservoirs back to the river.[116] Nebraska has developed a depletions plan that centers on conjunctive management—diverting water into irrigation canals during the non-irrigation season that seeps underground and returns to the river, along with reservoir releases.[117] Nebraska also agreed to cover depletions of wells installed between 1997 and 2005; after 2005 well owners and/or the state, depending on the mechanism of depletion, cover depletions.[118] Like Nebraska, Colorado relies on conjunctive water management to cover post-1997 depletions.[119] As stated in its depletions plan:

> Colorado will, in each Reporting Period, undertake such re-regulation projects within Colorado as are necessary to shift water flows at a point upstream from the Colorado-Nebraska state line and downstream from the last diversion in Colorado, from periods of net accretion to periods of net depletion. After diversion, this water recharges the alluvial aquifer of the South Platte River.[120]

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110. *Id.*

111. *Id.*

112. Robert Autobee & Bureau of Reclamation, *North Platte Project*, 3 (1996), *available at* http://www.usbr.gov/projects/ImageServer?imgName=Doc_1305124785545.pdf; *See generally* Neb. Dept. of Natural Res., *Platte River Recovery Implementation Program*, (2006), *available at* http://dnr.ne.gov/Media/iwm/PDF/PRRIP_Document_2006.pdf (discussing the final Platte River implementation program) [hereinafter PRRIP].

113. FREEMAN II, *supra* note 97, at 71–72.

114. *See generally* PRRIP, *supra* note 112.

115. *Id.*

116. FREEMAN, *supra* note 10, at 84; *Platte River Recovery Implementation Program*, WYOMING STATE ENGINEER'S OFFICE, http://seo.wyo.gov/interstate-streams/know-your-basin/platte-river-basin (last visited Nov. 11, 2014).

117. As explained in the Nebraska depletions plan, "Nebraska's Cooperative Hydrology Study models and other tools will be used by the state and the NRDs to determine the amount, timing and location of depletions to state-protected flows and target flows and also to evaluate the effectiveness of proposed offset projects. In all cases, the offset objective will be to replace the water depleted in the amounts needed and at the times and locations needed to prevent harm to the water uses and/or the target flows for which such flow protection is required. All offset measures shall be constructed and operated or implemented so that they do not cause additional shortages to either target flows or state-protected flows." PRRIP, *supra* note 112, at 3.

118. FREEMAN, *supra* note 10, at 84.

119. PRRIP, *supra* note 112, at 4–5.

120. *Id.*

In addition to covering new and existing water diversions, the states have acquired more than 10,000 acres of riparian habitat in the central Platte River basin between Lexington and Chapman, Nebraska, for various conservation projects using a willing buyer/willing seller model.[121] The land itself is managed according to a good neighbor policy, which includes removing weeds, maintaining fencing, and paying taxes.[122] Each parcel of land is managed according to a plan designed to protect and rehabilitate it for species recovery purposes,[123] and the land is the location of a series of active efforts to encourage species recovery based on adaptive management practices.[124]

3. Specifics of the Agreement: Adaptive Management (AM)

Adaptive Management is a critical component of PRRIP.[125] Adaptive management (AM) treats interventions as experiments, using results to revise subsequent activities in order to meet goals more effectively and efficiently.[126] The Platte River recovery plan contains three primary AM goals: "1) improve production of least tern and piping plover from the central Platte River; 2) improve survival of whooping cranes during migration, and 3) avoid adverse impacts from Program actions on pallid sturgeon populations."[127] These goals guide the development of a series of AM hypotheses directed at system processes, such as the role of sediment in channel morphology, as well as each of the endangered and threatened species, e.g. terns and plovers prefer riverine habitats for nesting.[128] The adaptive management plan rests on an integrated monitoring and research plan designed to determine the biological response of target species and habitats to interventions and provide pertinent knowledge to decision makers to improve states' compliance and management activities.[129]

4. Governance and the PRRIP

The Platte River recovery program is guided, monitored, and governed by a committee consisting of a representative from Colorado, Nebraska, Wyoming, the U.S. Bureau of Reclamation, the USFWS, water users, and environmental interest

121. *Id.* at 4.
122. *Platte River Recovery Implementation Program: Bi-Annual Report 2009 & 2010*, PLATTERIVERPROGRAM.ORG, *available at* https://www.platteriverprogram.org/PubsAndData/ProgramLibrary/PRRIP%20BiAnnual%20Report%202009-2010.pdf (last visited Dec. 24, 2014). As explained in PRRIP, *supra* note 112, at 8, "When land is acquired by the Program and held by the Land Interest Holding Entity or the acquired land is owned by another tax-exempt entity, the Program shall pay or provide for the payment of real property taxes or an equivalent amount. Such taxes or equivalent amount shall be determined each year using the assessments and levies in effect at the time such taxes are due or would be due if the property were owned by a tax paying entity."
123. PRRIP, *supra* note 112, at 1–2.
124. *Id.* at 4.
125. FREEMAN, *supra* note 10, at 86; PRRIP, *supra* note 112, at 6.
126. PRRIP, *supra* note 112, at 6.
127. *Id.* at 1.
128. *Id.* at 1, 13–14.
129. *Id.* at 27.

groups.[130] The committee meets regularly to review the program performance and state compliance.[131] The committee is assisted in its efforts by an executive director who oversees day-to-day operations, an environmental account manager employed by the USFWS who oversees releases of water from reservoirs, and advisory committees devoted to the water, land, and adaptive management plans and programs, and an independent scientific advisory committee.[132]

The performance of the PRRIP relies largely on the actions of the signatory states.[133] In turn, each state's ability to meet its commitments depends on the state's own water laws and policies and the extent to which the state's water administrators have the authority to implement the required activities.[134] Water law in Wyoming, Colorado and, most recently, Nebraska, acknowledges the hydrologic connection between groundwater and surface waters and give water officials the authority to regulate wells in ways that minimize their impact on surface water flows.[135]

In Nebraska, prior to 2004, groundwater and surface water were managed separately, by natural resources districts (NRDs) and the Nebraska Department of Natural Resources (NDNR), respectively.[136] The 1976 Groundwater Management and Protection Act granted NRDs the authority to develop groundwater management plans, subject to the approval of NDNR.[137] Most districts developed groundwater quality plans, but only a single district chose to actively regulate groundwater pumping as well.[138] The NDNR could not compel districts to adopt groundwater management plans that strictly regulated pumping or that took into account surface water impacts of pumping.[139]

As a consequence of Nebraska's legal and administrative separation of groundwater and surface water management,[140] the NDNR was not required to consider stream flow needs in issuing permits,[141] and managers did not have policy tools to bridge the two water sources and manage them in an integrated fashion.[142] Thus, between 1997 and 2004, Nebraska representatives negotiating the PRRIP

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130. *Id.* at 1–2.

131. SCHLAGER, *supra* note 102, at 83–85; *See generally Platte River Recovery Implementation Program 2010 Budget and Work Plan*, PLATTERIVERPROGRAM.ORG, https://www.platteriverprogram.org/PubsAndData/ProgramLibrary/Forms/AllPublicDocs.aspx (last visited Nov. 18, 2014).

132. PRRIP, *supra* note 112, at 5–6, 9.

133. SCHLAGER , *supra* note 102, at 80.

134. *Id.* at 80–81.

135. Justice Gregory J. Hobbs, *Colorado Water Law: An Historical Overview*, 1 U. DENV. WATER L. REV. 1, 21 (1997); Gary Bryner & Elizabeth Parcel, *Groundwater Law Sourcebook of the Western United States*, NATURAL RESOURCES LAW CENTER 64 (2003), *available at* http://cacoastkeeper.org/document/groundwater-law-sourcebook-of-the-western-united-states.pdf.

136. J. David Aiken, *Hydrologically-Connected Ground Water, Section 858, and the Spear T Ranch Decision*, 84 NEB. L. REV. 962, 977 (2006).

137. *Id.*; Kirk Stephenson, *Groundwater Management in Nebraska: Governing the Commons through Local Resource Districts*, 36 NAT. RESOURCES J. 761, 764 (1996).

138. Aiken, *supra* note 136, at 978.

139. Stephenson, *supra* note 137, at 761–62.

140. *See* Mary Kelly, *Nebraska's Evolving Water Law: Overview of Challenges & Opportunities*, PLATTE INSTITUTE FOR ECONOMIC RESEARCH (2010), *available at* http://www.platteinstitute.org/Library/docLib/20100927_Kelly_Paper_-_FINAL.pdf.

141. *Id.* at 17.

142. SCHLAGER , *supra* note 102, at 80.

could not credibly commit to directing the water provided by the states upstream of to the central Platte River basin, nor did they have legal and administrative tools in place to implement a realistic depletions plan.

This changed in 2004 when the Nebraska legislature adopted LB 962, which gave the NDNR the authority to declare river basins as over- or fully-appropriated.[143] Such a designation triggers integrated water management, obliging NRDs and NDNR to develop integrated management plans that recognize the hydrologic connection between surface and groundwater. Furthermore, the bill declared the Platte River basin over-appropriated and imposed a moratorium on new wells and new surface water diversions.[144] By the time the PRRIP was adopted, Nebraska's NRDs and the NDNR had an integrated water management plan in place for the Platte River basin.[145] Thus, Nebraska could commit to its partners that it was capable of protecting program water supplies and implementing an effective depletions plan.

5. PRRIP Conclusion

The three Platte River basin states have committed to providing resources, namely water and revenues, to restore some of the river's natural flow regime in order to recover and protect endangered species.[146] The PRRIP was one of the first collaborative approaches leading to an agreement that was not brokered by the courts. The contemporary, PRRIP-era state of the Platte River social-ecological system, through increased land-river connectivity and direct creation of habitat, provides more ecosystem services (Figure 2c) and represents a more desirable system state than that of post-European settlement, pre-PRRIP.[147]

C. Promoting Resilience Through Policy: Obstacles And Opportunities

A major obstacle to writing natural resources management laws rooted in resilience theory is the current lack of a standard method for measuring resilience.[148] Some system components can be estimated with a specified level of uncertainty using sophisticated models, but many remain difficult to predict with any meaningful level of certainty.[149] Unfortunately, a system's thresholds and resilience are most accurately calculated after a flip. In other words, only after an irreversible system change are we consistently able to identify the areas of vulnerability and non-linear responses of system components. This uncertainty must be addressed in order for resilience theory to guide policy in any meaningful way.

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143. Kelly, *supra* note 140, at 21.

144. *Id.*

145. SCHLAGER , *supra* note 102, at 80–84.

146. Poff et al., *supra* note 7; PRRIP, *supra* note 112.

147. Kristine T. Nemec et al., *Assessing Resilience in Stressed Watersheds*, ECOLOGY & SOC'Y, 2014, at art. 34, *available at* http://www.ecologyandsociety.org/vol19/iss1/art34/ [hereinafter Nemec et al.].

148. While many frameworks have been proposed to systematically evaluate resilience, few have proven applicable to a broad range of systems.

149. Carl Walters et al., *Ecosystem Modeling for Evaluation of Adaptive Management Policies in the Grand Canyon*, ECOLOGY & SOC'Y, 2000, at art. 11, *available at* http://www.ecologyandsociety.org/vol4/iss2/art1/.

The first step in addressing this system uncertainty is to ensure that relevant statutes recognize non-stationarity in ecosystems and the potential for ecosystem transformation, regardless of whether that transformation is ultimately deemed desirable or undesirable.[150] This does not mean that all environmental laws need to function in the same way; for example, there are good reasons to ensure that pollution control laws remain stringent and relatively inflexible.[151] However, natural resources management laws will need to increasingly adhere to norms of principled flexibility, with increased emphasis on monitoring, study, management nimbleness, and regulatory triage.[152]

D. Panarchy Theory and Law

Natural resources legislation of the past fifty years characterized ecosystems as hierarchical, stable systems that could be managed effectively via top-down approaches with command and control.[153] Importantly however, we now understand that natural systems do not always behave in a predictable manner, especially in response to top-down controls.[154] In place of the idea of ecosystems as hierarchical, stable and predictable, we now understand ecosystems to be dynamic, panarchical and somewhat unpredictable.[155] Thus, in order for the next generation of natural resources policy to effectively regulate ecological systems, policy must become "cross-scale, interdisciplinary, and dynamic."[156] This includes letting go of the idea that ecosystems are successional and can be controlled from the top-down. Complex systems are seldom, if ever, arranged in strict hierarchies that respond in any meaningful way to a top-down control,[157] and system controls may occur at many levels, as explained in Panarchy Theory.[158]

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150. *See* Robin Kundis Craig, *"Stationarity Is Dead"—Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9, 31–40 (2010) (discussing current norms of preservation and restoration and the need to move to a resilience framework).

151. *Id*. at 43–53.

152. *Id.* at 40–43, 63–70; Regulatory triage is described by RK Craig as the application of medical triage assessment to water systems. A triage assessment recognizes which systems are beyond intervention and should be ignored, and which are worth the cost of intervention and restoration. *See* Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 3, 920–21 (2008).

153. Craig, *supra* note 191, at 31–35; C. S. Holling & Gary K. Meffe, *Command and Control and the Pathology of Natural Resource Management*, 10 CONSERVATION BIOLOGY 2, 328–30 (1996), *available at*
http://www.ecology.ethz.ch/education/Ecosystem_Files/Holling_and_Meffe__1996__Pathology_of_Natural_Resource_Management.pdf.

154. Simon A. Levin, *Ecosystems and the Biosphere as Complex Adaptive Systems*, 1 ECOSYSTEMS 431, 431 (1998), *available at* http://www.esf.edu/cue/documents/Levin_Ecosys-Biosphere-ComplexAdaptSys_1998.pdf.

155. *Id.*

156. J.B. Ruhl, *Panarchy and the Law*, ECOLOGY & SOC'Y, 2012, at art. 31, *available at* http://www.ecologyandsociety.org/vol17/iss3/art31/.

157. Levin, *supra* note 197, at 431–32.

158. Adapted from CS Holling, LH Gunderson, and D Ludwig, editors. *Panarchy: Understanding Transformations In Human And Natural Systems*. Island Press, Washington, D.C., USA. (2002).

Panarchy Theory captures nested cycles of growth, destruction and renewal in complex systems (Figure 3).[159] As the system reorganizes (α) following release (Ω), species begin to exploit and accumulate (r) newly available resources.[160] When resources available for exploitation diminish, a specific set of interactions among species emerges.[161] With time, these interactions deepen and increase connectivity in the system. The system eventually becomes reliant on this connectivity, and species that benefit least from their interactions are outcompeted by specialists (K stage).[162] In the K stage, the system is at its most rigid and most vulnerable to disturbance.[163]

While the stages of succession line up well with this description, the adaptive cycle shows that release following the climax state—an element that is missing from the successional understanding of ecology—is essential for social-ecological resilience. For example, fire suppression in grassland systems, such as the Great Plains, artificially locks the system into the K stage.[164] This extension heavily selects for specialist grasses that grow in dense monoculture stands at the expense of other grasses and flowering plants.[165] As this K stage persists, the system becomes increasingly rigid and vulnerable to disturbance. A smaller range of responses to disturbance due to the loss of biodiversity combined with a strong preference for minimal disturbance by the dominant species lead to a system with very little resilience to disturbance. As a result, when a disturbance such as fire, drought or flood, does occur to disrupt the plant community, the loss of organization and capital is significantly greater. The biodiversity losses during the extended K stage mean that less system memory is transferred to the next iteration of the adaptive cycle and the system may never fully recover some of its important components, such as flowering plant species whose seeds do not persist long in the soil and are important to pollinating insects. The loss of these plant species reverberate throughout the system if they are important to, for example, different insect and bird species that colonize the system post-collapse.

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159. C. S. Holling & Lance H. Gunderson, *Resilience and Adaptive Cycles, in* PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS 25, 32–47 (Lance H. Gunderson & C. S. Holling eds., 2002).

160. *Id.*

161. *Id.*

162. *Id.*

163. *Id.* at 43–47.

164. Steve Archer et al., *Mechanisms of Shrubland Expansion: Land use, Climate or CO2?*, 29 CLIMATIC CHANGE 91, 92–96 (1995), *available at* http://ag.arizona.edu/research/archer/reprints/Archer%20et%20al.%201995%20Mechanisms%20Shrubland%20Expansion.pdf; O. W. Van Auken, *Shrub Invasions of North American Semiarid Grasslands*, 31 ANN. REV. ECOLOGY SYS. 197, 198 (2000), *available at* http://www.annualreviews.org/doi/pdf/10.1146/annurev.ecolsys.31.1.197.

165. *See* WALKER, *supra* note 77, at 76–90.

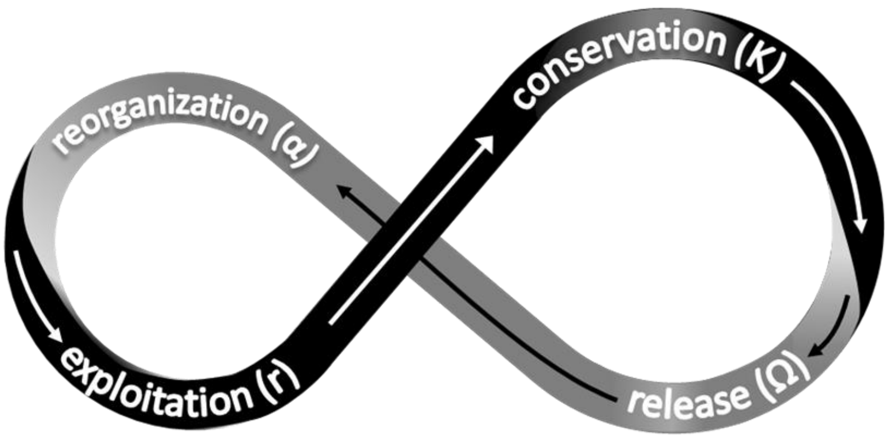

FIGURE 3. The adaptive cycle from the Theory of Panarchy, showing how complex social-ecological systems conserve capital, experience a disturbance that releases materials back to the system, which reorganizes around and then exploits these resources until the conservation stage is once more reached.

While Panarchy Theory is fundamental for understanding and recognizing the uncertainty inherent to complex social-ecological systems, a method for operationalizing resilience will serve to reduce this uncertainty. Realistically, both an acknowledgement and a reduction in system uncertainty are required if resilience theory is to shape future policy.

E. Reducing Uncertainty by Operationalizing Resilience Assessments

Although there exist few attempts to operationalize resilience, concepts from the *Assessing Resilience in Social-Ecological Systems: A Workbook for Scientists*[166] and Nemec et al. provide preliminary approaches.[167]

The Resilience Alliance is a multinational, interdisciplinary network of researchers committed to studying the resilience of complex social-ecological systems.[168] Their guide, *Assessing Resilience in Social-Ecological Systems: A Workbook for Scientists* is available through their website and provides a guide for policy makers, managers, researchers and all other stakeholders to better achieve management and policy goals through the lens of resilience theory.[169]

166. Resilience Alliance. 2010. Assessing resilience in social-ecological systems: workbook for practitioners. Version 2.0. [online] URL: http://www.resalliance.org/index.php/resilience_assessment

167. RESILIENCE ALLIANCE, ASSESSING RESILIENCE IN SOCIAL-ECOLOGICAL SYSTEMS: A WORKBOOK FOR SCIENTISTS (2007), *available at* http://www.resalliance.org/index.php/resilience_assessment [hereinafter ASSESSING RESILIENCE]; Nemec et al., *supra* note 147.

168. *About*, RESILIENCE ALLIANCE, http://www.resalliance.org/index.php/about_ra (last visited Dec. 5, 2014).

169. ASSESSING RESILIENCE, *supra* note 167.

Practitioners initiate their assessment in the order presented in the *Assessing Resilience in Social-Ecological Systems: A Workbook for Scientists*, but are not required to complete a section before moving on, and are encouraged to "move back and forth" among sections. In fact, continuous adjustment of this synthesis occurs as past steps are revisited, learning grows, and uncertainty in the synthesis is reduced. Policy rooted in system resilience will be better suited to address the complex, non-linear, and panarchical nature of complex social-ecological systems.[170]

The second set of concepts for operationalizing resilience comes from Nemec et al.[171] There is significant overlap of concepts between *Assessing Resilience in Social-Ecological Systems: A Workbook for Scientists* and Nemec et al., but the latter resource goes about their assessment in a much different manner, using nine properties proposed by Walker and Salt that "a resilient world would value" to assign resilience scores to the Platte River basin.[172]

Nemec et al. use these nine properties to describe changes in resilience of the Platte River basin social-ecological system during the 20th century. They assigned the system a score of 1-5 for each resilience property, defining what constituted each score to achieve replicability through time and across systems. Once scores for individual properties were assigned, they were averaged to create a mean resilience score of the system in spider web diagrams to illustrate changes in the social-ecological resilience of the Platte River basin in response to water diversion projects. The resilience property values assigned to each stage of the system were determined by the individual expert authors (eight in total) so, while this approach

170. Ahjond S. Garmestani & Melinda Harm Benson, *A Framework for Resilience-based Governance of Social-Ecological Systems*, ECOLOGY & SOC'Y, 2013, at art. 9, *available at* http://www.ecologyandsociety.org/vol18/iss1/art9/ [hereinafter Garmestani & Benson]; Ahjond S. Garmestani et al., *Can Law Foster Social-Ecological Resilience?*, ECOLOGY & SOC'Y, 2013, at art. 37, *available at* http://www.ecologyandsociety.org/vol18/iss2/art37/ [hereinafter GARMESTANI II].

171. Nemec et al., *supra* note 147.

172. WALKER & SALT, *supra* note 77; *See generally* Nemec et al., *supra* note 147. The nine properties used are as follows: (1) *Diversity*, of genetics, species, biomes, response to disturbance, land and resource use in order to maintain a high level of insurance against any one event inciting a major losses resulting from homogeneity of response to disturbance; (2) *Ecological variability*, such as periodic flooding, fluctuations in population size and wildfire events, all of which (a) reduce the risk of an unprecedented extreme event and (b) drive flexible systems with the capacity to learn from and adapt to change; (3) *Modularity*, meaning that system components are not overly connected with other system components. Overconnected systems are less able to absorb disturbance, because shocks are rapidly transferred throughout the system, reverberating and amplifying the disturbance; (4) *Acknowledging slow variables*, which moves management and policy focus towards those slow-changing variables that largely move a system towards release and reorganization (desired change) –or past a critical threshold and into an alternative stable state (undesirable change); (5) *Tight feedbacks*, so that existing relationships more easily reveal where thresholds lay before they are crossed. But relationships must not be overly tight, or the system risks a loss in modularity; a fine balance exists here; (6) *Social capital*, whereby "trust, strong networks, and leadership" create the capacity of society to take collective action to strengthen the social-ecological system against disturbances; (7) *Innovation*, because "learning, experimentation, locally developed rules and embracing change" allows society to create effective plans in the face of unwanted disturbance; (8) *Overlap in governance*, meaning there are multiple institutions with redundant functions so that overall institutional response to disturbance is diverse and flexible; and (9) *Ecosystem services*, whose value would be accounted for in development proposals in a resilient world. Hierarchical governance structures lacking redundancy gain efficiency but have low capacity to absorb major disturbance compared to systems with high overlap in governance. *Id.*

yields less than ideal data (votes from a larger, more diverse group of stakeholders including experts from a multitude of disciplines and policy makers would likely make for a more complete and realistic assessment of system resilience), it serves as an nascent attempt to operationalize a critical system property often noted but infrequently measured.

IV. CONCLUSION AND SYNTHESIS

A. Building a Governance System that Values Resilience

By rooting natural resources management policy in resilience theory, a new generation of policy would: (1) tailor policy by identifying the particular aspect of a system that should be bolstered by resilience along with a specific approach that would best meet this objective; (2)address modularity (i.e. tightness and importance of feedbacks among system components) in order to establish a set of probable policy outcomes to avoid surprises; (3) increase social capital through an increased focus on citizen participation and awareness of natural resources management and policy, which is largely absent from the command-and-control approach currently in place; (4) encourage innovation and experimentation so that uncertainty is reduced and policy is rooted in smart science to continuously improve our understanding of complex social-ecological systems; and (5) take advantage of changing socio-economics and demographics in the basin to make smart long-term plans—specifically regions of declining population growth serving as ecosystem services mitigation banks paid for by growing metropolitan centers in the same basin.

Reframing policy from a resilience perspective will mark an improvement in how we manage natural resources; however, institutional change is also required to make many meaningful changes. Cumming et al. propose that scale misalignments between law and ecosystem processes may be corrected by institutional changes throughout the governance hierarchy,[173] and Garmestani and Benson argue that incorporating multi-scale feedbacks could reconcile scalar mismatches.[174] This can be described overall as incorporating greater "reflexivity" in the legal system.[175] A reflexive system establishes "procedural and organizational norms but [does] not determine the final outcome" and must be flexible in order to transform as learning emerges.[176]

B. Climate Change and Unknown Futures: The Growing Urgency for Policy Transformation

The need for a new generation of laws that incorporate flexibility and adaptive governance principles is especially urgent in the face of climate change, which

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173. Graeme S. Cumming et al., *Scale Mismatches in Social-Ecological Systems, Causes, Consequences, and Solutions,* ECOLOGY & SOC'Y, 2006, at art. 14, *available at* http://www.ecologyandsociety.org/vol11/iss1/art14/.

174. Garmestani & Benson, *supra* note 170.

175. Graeme S Cumming, *Scale Mismatch and Reflexive Law*, ECOLOGY & SOC'Y, 2013, at art. 15, *available at* http://www.ecologyandsociety.org/vol18/iss1/art15/.

176. *Id.*

may cause rapid, unexpected social and ecological changes in the Platte River basin.

Temperatures across the Great Plains have been rising in recent years, and are projected to continue to increase in the coming decades.[177] For example, average annual temperatures in the Great Plains were 0.8°C higher in 2000 than for the 1960-1979 reference period and are expected to be 1.4-7.2°C higher than this reference period by 2100.[178]

Because the majority of surface water in the Platte River basin originates from winter snowpack, increasing temperatures that affect snowpack can have widespread impacts on water resources in the basin.[179] High springtime temperatures have already resulted in consistently earlier snowmelt in much of the Western United States.[180] Even earlier spring snowmelt is projected in the future, which may increase the lengths of summer droughts, affecting ecosystem services such as water supply, wildfire management, and wildlife habitat.[181] Future changes in the flow regime that are mediated by climate change can also affect current legal allocations within the Platte River basin, since the amount of water allocated to different states is based on river levels from the mid-to-late 1900s, whereas river flows may be drastically different in a future with higher temperatures and longer droughts.[182]

Although there is broad consensus that temperatures will increase across the Platte River basin in coming decades, with potentially widespread societal and ecological changes, there is greater uncertainty about the magnitude or the rate of the temperature increase, the extent to which precipitation will change, and the climatic thresholds at which the Platte River basin will shift into a different, undesired state.[183] New, flexible policies that acknowledge the potential for uncertainty and rapid, non-linear changes are needed if society is to adapt to future climate change and improve the resilience of the Platte River basin social-ecological system.

C. Synthesis

The American system of law, while excellent in many areas, is largely too rigid to accommodate current understanding on the dynamics of social-ecological systems. Since our natural resources laws are based on outdated conceptions of nature, they are suboptimal, as they currently exist.[184] Thus, there are significant barriers built into natural resources laws that hamper our capacity to manage for resilience.

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177. GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES 9–11 (Thomas R. Karl et al. eds., 2009), *available at* http://downloads.globalchange.gov/usimpacts/pdfs/climate-impacts-report.pdf.

178. *Id.* at 123.

179. Jacqueline J. Shinker et al., *Climatic Shifts in the Availability of Contested Waters: A Long-Term Perspective from the Headwaters of the North Platte River* 100 ANNALS ASSOC. OF AMERICAN GEOGRAPHERS 3 (2010).

180. Iris T. Stewart et al., *Changes in Snowmelt Runoff Timing in Western North America Under A 'Business as Usual' Climate Change Scenario*, 62 Climate Change 217, 217–18 (2004).

181. *Id.* at 230.

182. *See, e.g.*, Shinker et al., *supra* note 179, at 6–12.

183. *See* Ojima et al., *Potential Climate Change Impacts on Water Resources in the Great Plains*, 35 J. OF THE AM. WATER RESOURCES ASS'N 1443 (1999); Chaffin et al., *A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions*, ECOLOGY & SOC'Y, 2014, at art. 56, *available at* http://www.ecologyandsociety.org/vol19/iss3/art56/.

184. GARMESTANI II, *supra* note 170.

However, there are aspects of existing law that are underutilized and may be harnessed to provide improved environmental management.[185] In addition to identifying aspects of existing law that can be used to manage for resilience, some combination of reforming existing laws and creating new ones is likely necessary.

As the history of the Platte River transitions from prior appropriation, water diversion, channelization and water compacts (focused on economic development) to adaptive management for endangered species, habitat creation, natural flow variability and increased land-river connectivity, there is hope for the river, as collaborative approaches, and smarter management, better science and a new era of natural resources management laws offer the potential of a brighter future for the Platte River basin.

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185. Robin Kundis Craig & J.B. Ruhl, *Designing Administrative Law for Adaptive Management*, 67 VAND. L. REV. 1, 60–62 (2014).