Chapter 4: Bright Spots in Nature in the US

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Chapter Contents

Summary

Bright spots in nature are places and processes that are in better condition than expected given the negative impacts of human activities. Although the damage to nature is widespread, these bright spots are numerous and occur in many regions and habitats throughout the United States and its territories. Here, we define and describe bright spots in nature and document the social, ecological, and technological conditions that enable them. We also show how these examples of thriving nature benefit people—particularly when equity and inclusion are prioritized—and how these benefits can make bright spots even brighter and more durable. Understanding how bright spots emerge, elucidating the role of enabling conditions in sustaining them, and evaluating the diverse and critical benefits they confer for people and nonhuman species can reveal ways to replicate such successes. In this way, bright spots can serve as sources of inspiration, encouraging projects and processes that can lead to more brightness across Earth systems and across the country.

Background

Despite the increasing scale and scope of nature's decline due to human activities—including from climate change, habitat fragmentation, and pollution (1,2)—scientists, scholars, and writers have increasingly found exceptions to these disturbing general trends (3–5). These exceptions demonstrate both that human actions can result in positive outcomes for nature and that nature itself can be resilient. These exceptions are sometimes referred to as “bright spots” (6–14), which we use here as an umbrella term that covers a variety of descriptions of nature's ability to resist and recover from negative impacts (3,9,15–17). Here, we define bright spots in nature as species, communities, and ecosystems at all scales that are performing substantially better than expected given general environmental conditions and anthropogenic pressure (7,14). These bright spots include both the organisms themselves and the processes that govern their ecological structure and functioning across land, water, and air. Like nature itself, bright spots come in many forms, emerging from knowledge and practices accrued over thousands of years, alongside more recent efforts. While many bright spots in nature occur within less populated and less disturbed areas, they also exist in regions that are managed to sustain intensive extractive activities, as well as in urban systems that are densely populated. Bright spots range widely in their spatial scales, from micro-parks embedded within cityscapes to entire watersheds and adjacent seas.

Bright spots occur on a gradient ranging from the darkest of dark spots to the brightest of bright spots. The emerging literature on bright spots is largely qualitative, and there are no generalized quantitative thresholds for defining levels of brightness (or darkness) for all species, communities, or ecosystems. Consequently, what constitutes brightness for one situation may be different for another. Although quantitative metrics have been suggested for specific situations (6,7,12,14), brightness is variable, with no single threshold that can be applied universally across the circumstances considered in this review, which addresses an enormous diversity of ecological processes, enabling conditions, and ecosystems across land, water, and air.

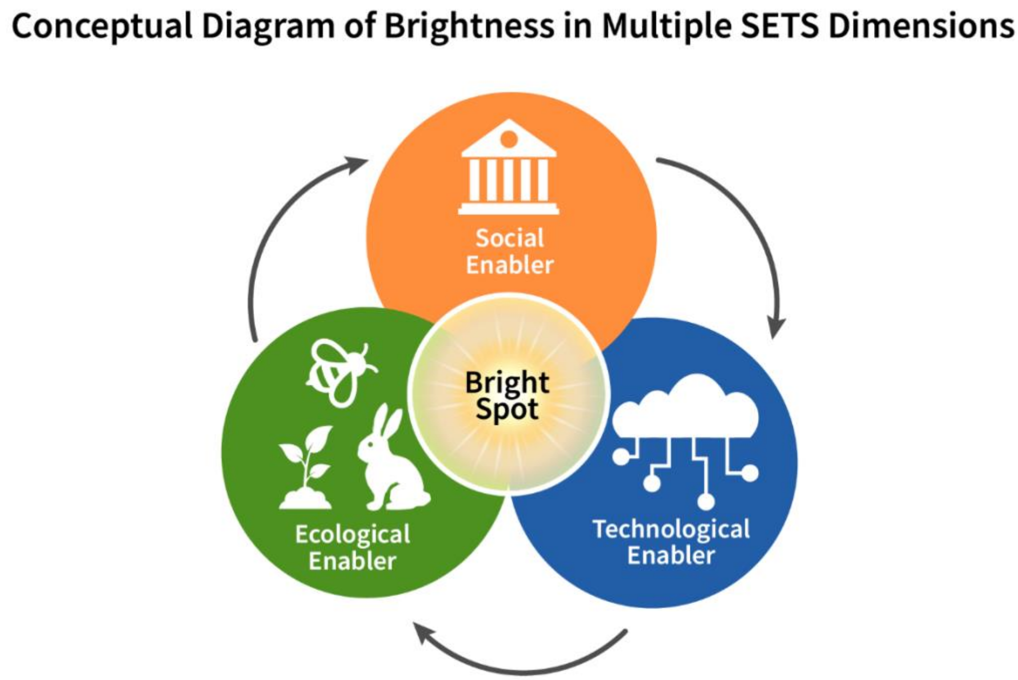
The study of bright spots can lead to improved strategies for conservation and for encouraging the use of environmental science in policy and practice (10). Bright spots are also levers of change because, by exceeding expectations, they become tangible goals for future actions (e.g., in agricultural landscapes (11)). Bright spots can also serve as "seeds of good anthropocenes" (9), demonstrating innovations in the present that could deliver positive outcomes for the future (13,16–18).

Assessment Process

In this chapter, we highlight a broad range of bright spots across diverse geographies, ecosystems, and social and cultural contexts, focusing on those places and processes where evidence demonstrates brightness in multiple dimensions over time. We also highlight emerging bright spots (or "seeds" (9)) with potential to grow, scale, and provide lessons for the future. Our aim is to embolden and guide communities and decision-makers across the US and its territories to strengthen, replicate, scale, and adapt existing successes, thereby working to improve the brightness of other places and processes now suffering from biodiversity loss and environmental degradation. Often the places in greatest need of such brightening also suffer from other aspects of social injustice. Thus, we focus on bright spot examples that balance the maintenance of biodiversity and ecosystem functioning with human needs (including climate adaptation and mitigation) in ways that are just and equitable in conferring social, economic, health, and cultural benefits.

Understanding what makes bright spots possible and what conditions and contexts enable brightness can help foster an evidence-based approach to creating, sustaining, and scaling them. Bright spots, like species, communities, and ecosystems in decline, occur within complex systems defined by multiple interwoven social, ecological, and technological dimensions (Figure 4.1). Bright spots emerge from the intersection of brightness in one or a number of different domains, including social (economic, policy, planning, and governance), ecological (climatic, biogeography, biogeochemical), and technological (technology, infrastructure, and digital). We assess bright spots in nature through a systems lens (19) to examine potential intersections and feedbacks among multiple social–ecological–technological system (SETS) dimensions (20–24).

Figure 4.1. Enablers of Brightness



Bright spots are brighter when they engage multiple social, ecological, and technological system dimensions.

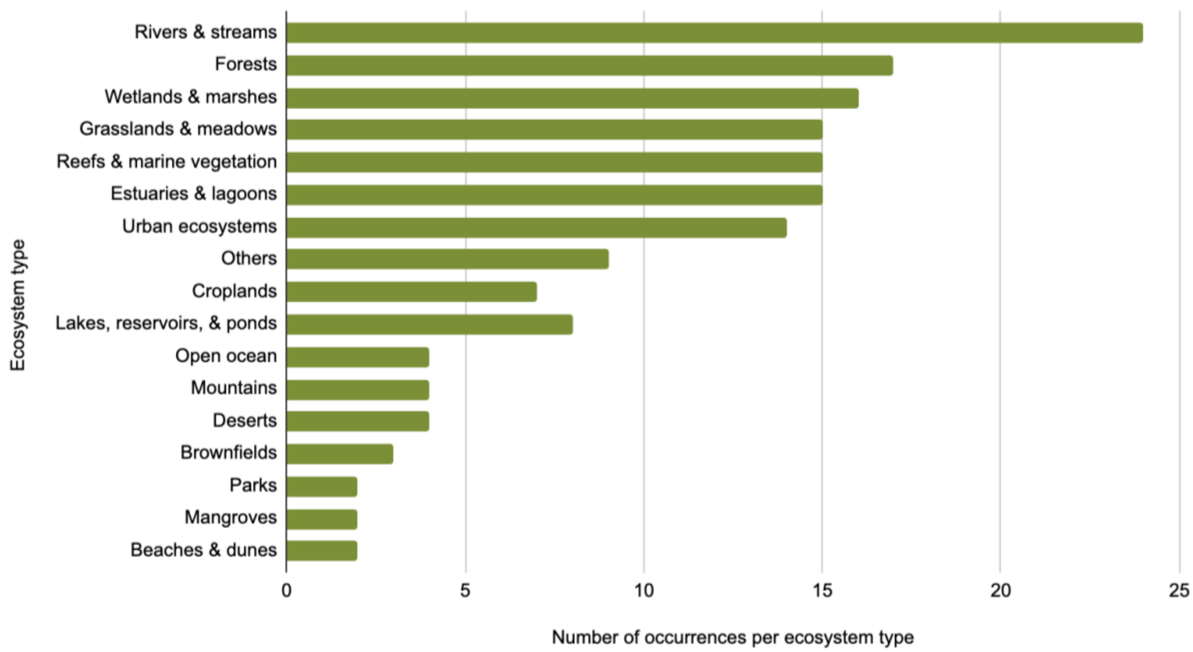
Bright spots emerge at the intersection of social, ecological, and technological dimensions within complex systems. This systems lens is useful for delineating the interacting processes and dynamics that enable bright spots. By assessing bright spots in nature in this way, we highlight the importance of all dimensions—and, importantly, their feedbacks on each other—that are needed to brighten spots that are currently dark. Figure original to The Nature Assessment.

This systems framing approach underscores that single enabling approaches alone are less likely to be able to respond to the complexity and scale of interacting biodiversity, climate change, and social equity challenges. For example, although places, processes, and outcomes may be bright in an ecological dimension (such as through nature conservation that enhances biodiversity), brightness should grow and be better sustained if there is also brightness in the social dimension (such as through equitable and inclusive decision-making processes) and the technological dimension (such as incorporating monitoring technology or supporting infrastructure that can sustain and enhance biodiversity outcomes over time) (25).

The conclusions we draw are shaped by a systematic review of the peer-reviewed literature. We closely examined 730 papers that described successes in nature from an initial set of

8,965 papers returned from our search terms (see Figure 4.2, Figure 4S.1, and Supplementary Material 4S for detailed methods). Papers were manually coded to examine key case-study characteristics, outcomes, enablers, and challenges for nature bright spots in the US. We found that most documented examples focused on conservation and restoration, often at the single-species level, but the literature assessed missed some well-known cases that have been described and synthesized in governmental and nongovernmental reports and other gray literature (26). Thus, we also relied on expert knowledge to bring forward well-known cases and success stories drawn from established narratives, traditional and Indigenous knowledge sources, and published and gray literature to ensure we identified existing bright spots across a broad range of geographies and ecological systems.

Figure 4.2. Documentation of Bright Spots in Academic Literature



A systematic review of bright spots and analogous terms in the scientific literature reveals that bright spots exist in diverse ecosystems.

Analysis of 696 papers revealed 130 papers that explicitly describe bright spots (or use analogous terms, such as "success") in conservation, restoration, productive land- and seascapes, and urbanized contexts. These examples from the literature, combined with examples from gray literature and Indigenous knowledge, exemplify broad categories of human action and inherent natural processes that enhance and sustain nature and its benefits for people and the planet. Successes are documented in the literature across a wide range of ecosystems, with rivers and streams the most studied ecosystem type. Figure original to The Nature Assessment.

From this assessment of diverse literature and knowledge emerged three Key Messages regarding bright spots in nature across the US and its territories and the processes key to their success. For each Key Message, we highlight examples from an illustrative array of geographic, social, economic, political, and ecological contexts. Our assessment reveals well-documented examples of multiple benefits, including where species, communities, and ecosystems that have been revitalized through conservation and restoration are providing social and economic benefits for people, such as by mitigating climate change effects, restoring water and air quality, regenerating soils, supporting job creation, and cultivating rich and enduring relationships between people and places that elevate human well-being.

This chapter highlights the capacity for nature to thrive when given a chance, how the brightness of nature's bright spots can be intensified by human ingenuity and cooperation, and how understanding these bright spots promotes the ability to identify effective actions to address diverse environmental challenges. Understanding how these biodiverse and resilient natural systems emerged, along with the multiple benefits they provide to people, reveals viable pathways to scale and expand such solutions, creating a brighter future for all.

Key Message 4.1: Bright spots in nature exist throughout the US

Bright spots in nature exist across all major ecosystems and in most US states and territories, from micro-parks to entire watersheds and ocean areas (virtually certain). Bright spots occur in diverse places, from wildlands to areas supporting people through agriculture, forestry, and fisheries, as well as in urban and developed landscapes (virtually certain). Bright spots in nature create many benefits for people, illustrating how nature and humanity can thrive together (very well established).

State of Knowledge 4.1

Bright spots are found in wild lands and waters, as well as in systems that support agriculture, forestry, fisheries (Figure 4.3) (3–11,13,14,27–31), and densely populated areas. Numerous examples from terrestrial, aquatic, and marine systems document how degradation of species populations, habitats, and ecosystems by human actions (see Chs. 6, 7, 8, 9) can often be partially or fully reversed by strategic and appropriate interventions that leverage the inherent resilience of nature (7,32–40). Bright spots can emerge from species and habitat protections, active restoration, reductions in stressors, and infrastructure improvements (6,36,41,42). In both urban and rural nature, bright spots also contribute to a range of benefits to human communities, including physical and mental health (see Ch. 13: Health and Well-Being), food and water security (see Ch. 14: Risk and Security), resilience to natural hazards, and diverse economic benefits (see Ch. 12: Economy) (30,43–48). Together, these examples illustrate that diverse actors, policies, and processes are generating bright spots in nature across a range of scales, biomes, and social–cultural contexts, providing benefits for both nature and people. Highlights of these examples—organized within sections below focused on nature conservation and restoration, working land- and waterscapes, and urban regional systems—expand a database of successes useful for planning future nature-positive actions (9).

Figure 4.3. Bright Spots Across the US and Its Territories

Bright spots in nature can be found across the US and its territories.

(Figure is in development. Current version shows a map, but images and locations indicated do not necessarily correspond with actually identified bright spots.) Map shows locations of bright spots identified through a review of academic literature. Examples with photos are broadly representative of a range of bright spots in diverse geographies and social–ecological contexts. Photo Credits: Walter Martin/Unsplash (top left); Aaron Burden/Unsplash (top middle); Milos Prelevic/Unsplash (top right); Mathew Schwartz/Unsplash (center left); Dan Roizer/Unsplash (center right); Timothy K/Unsplash

(bottom left); Giorgia Dogliona/Unsplash (bottom center); Filipe Varela/Unsplash (bottom right). Figure original to The Nature Record.

Bright Spots in Nature Conservation and Restoration

Across a range of systems and regions, species and habitat protections are often successful in increasing species population sizes, biodiversity, and ecological and human resilience. Around the world, such actions have been highly effective in about two-thirds of well-studied cases on land and sea (31). In the US and its territories, species protections have often successfully recovered and stabilized populations formerly on the brink of extinction and returned ecological functions. Although not all efforts have been successful, such bright spots include bald eagles, Puerto Rican parrots, bison, ferrets, condors, gray wolves, prairie dogs, sea otters, lake sturgeon, Fender's blue butterfly, the American burying beetle, Hawai'i's Pele lobeliad plants, numerous shorebirds, northern elephant seals, and some whales, sharks, and sea turtles (39,40,49–56).

Beyond individual species, whole ecosystems have been successfully protected by place-based habitat conservation actions (6,32,39,57). For example, US national parks and many marine protected areas (MPAs) are established to minimize extractive uses such as logging, mining, or fishing, allowing natural processes to determine their states and trajectories (58). Such area-based protections, particularly when bans on extractive activities are well enforced, are important in sustaining sensitive habitats, biodiversity hotspots, and populations of formerly depleted species (in addition to supporting sustainable extractive activities elsewhere; see below). Passive reductions in human activities have sometimes produced similar results, such as regrowth of forests across the eastern US and Puerto Rico following abandonment of agricultural lands, partly restoring their biodiversity and services (59). Moreover, ecosystems that are not severely stressed by human activities often recover from natural disasters. When Mount St. Helens erupted in 1980, it created moonscape-like conditions apparently devoid of life. But within just a few decades, ecological succession had propelled this system to regain its pre-eruption magnificence while delivering recreational and economic value to the region (60). Similar but faster landscape-scale responses have occurred in tropical and subtropical regions of the US after extreme hurricanes (61,62). Together these examples highlight the inherent resilience of many ecological systems (34,38,63).

Recovery of species and habitats has also been achieved via policies, infrastructure investments, and best-management practices that reduce pollution (6,36,39,42,64), often simultaneously facilitating economic, health, and cultural benefits to people. Well-known examples include bans on organic pollutants (e.g., DDT, PCBs, and tributyltin) that aided recovery of iconic predatory birds, including the bald eagle and peregrine falcon (52,65). At the habitat and ecosystem scale, reductions in point-source and nonpoint-source pollution have improved water quality of the Delaware River, Piedras River (66), Tampa Bay (67), San Francisco Bay, and Chesapeake Bay (41), among others. Likewise, EPA's Air Quality program has driven reductions in ozone, nitrogen dioxide, sulfur dioxide, and inhalable particulate matter (PM_{10} and $PM_{2.5}$) concentrations, delivering direct and indirect benefits to nature and humans nationwide (68).

Another active intervention involves infrastructure improvements. For example, hydrologic flows and connectivity of waterways have been restored within watersheds nationwide via dam removal, culvert expansion, fish ladders, and other approaches that improve habitat and aquatic biodiversity (39,69–72). Similarly, wildlife corridors created with highway over- and underpasses, as well as urban greenways, can reduce mortality rates of numerous mammals and reptiles (73,74). Such infrastructure improvements can benefit entire ecosystems. Flows in Nevada's Truckee River were restored in the 1970s and 1980s to promote spawning habitat for an endemic fish, the cui-ui sucker (*Chasmistes cujus*). This increased the fish's population tenfold, stimulated regrowth of riparian woodland, and reestablished 10 of the 19 bird species extirpated or severely reduced at the site since the 19th century (39).

Finally, bright spots in restoration of degraded habitats can also be achieved by active planting of the foundation species that create habitat for others (6,36,42,69) or the removal of damaging nonnative species. Examples include the reestablishment of more than 3,600 hectares of seagrass meadows and associated wildlife in Virginia's coastal lagoons (57), restoration of more than 1,110 acres of oyster reef in Maryland's Chesapeake watershed (35,75), and recovery of more than 4.2 million acres of longleaf pine ecosystems (Box 4.1). Across drylands in the US West, restoration of the biological crusts crucial to the health of vulnerable soils is also surging, supported by cyanobacteria cultivation and soil inoculation techniques (76,77). Likewise, partnerships across the US, Mexico, and Canada are restoring grasslands to sustain bird biodiversity across millions of acres (78). Biocontrol programs, such as removing rats from small islands, are facilitating the recovery of seabirds and other species (79,80). Similarly, the release of multiple herbivorous insect biocontrol agents, coupled with decades of herbicide and fire control treatments, has resulted in significant reductions in *Melaleuca* in the Big Cypress National Preserve (81). Interdependencies among species in nature mean that actions designed to protect a specific endangered species often increase the health and functioning of entire ecosystems, as noted above.

Box 4.1. Bright Spots in America's Coastal Wetlands

Coastal wetlands, including mangrove forests, salt marshes, and seagrass meadows, occupy sedimentary shores along coastlines. They are hot spots of biological productivity supporting valuable fisheries (82,83), wildlife habitat, and the scrubbing of land-based nutrient pollution and human pathogens from runoff (Figure 4.4) (84). Coastal wetlands sequester disproportionate quantities of human-produced carbon from the atmosphere because of their high productivity and the slow decomposition of organic matter in their oxygen-poor soils (85), including in urban areas such as San Juan Bay, Puerto Rico (86,87).

Figure 4.4. Restoring Coastal Wetlands

Protection and restoration of coastal wetlands offers a cost-effective shield against erosion and storm damage.

Eckerd College students volunteer to restore native vegetation at Robinson Preserve, in Tampa Bay, Florida. Restoration in coastal wetlands can enable bright spots that support fisheries and wildlife habitat and provide important ecological functioning such as absorbing nutrient pollution run-off from nearby land uses. Photo credit: Joe Whalen, Eckerd College Service Learning Project.

Coastal wetlands also protect human communities against coastal erosion and storms. Analysis of 34 major US hurricanes found that coastal wetlands provided more than $23 billion per year in storm protection across the US (45), including $625 million in avoidance of direct flood effects related to Hurricane Sandy in 2012 (88) (see Ch. 14: Risk and Security). In the developing world, villages protected from the open ocean by mangrove forests experienced many fewer human deaths from a super cyclone than areas where mangroves had been cut down (89). Finally, maintenance of natural wetlands is less expensive than building and maintaining seawalls (43), highlighting the importance of wetland protection.

Unfortunately, wetlands are also hotspots of degradation and loss through coastal development and are vulnerable to sea level rise and nutrient pollution (90,91). But concerted efforts have begun to turn the tide. Scientific advances have improved restoration of seagrasses, mangroves, salt marshes, and oyster reefs, sometimes across thousands of hectares, with the habitats often persisting for years or even decades (6,35,36,75). Successful restoration has been scaled up considerably in the Gulf of Mexico with financing from a settlement after the BP Deepwater Horizon oil spill in 2010 (92). Scaling and sustaining these bright spots requires coordination and collaborative governance (69). Examples include the Chesapeake Bay Program, the South Atlantic Salt Marsh Initiative, and the Wetland Recovery Project Science Advisory Panel in California, which all convene state and federal agencies with academic and nongovernmental organization (NGO) partners across multi-jurisdictional regions to coordinate coastal wetland management. In the Chesapeake Bay, wetlands have shown improvements in recent years as a result of this coordination (41). Human actions can complement natural resilience. For example, the mangroves of Puerto Rico lost cover during periods of agricultural development, but they quickly recovered when agricultural activity was abandoned at these sites and responded positively to laws protecting them (93).

[END BOX 4.1 HERE]

Bright Spots in Working Land- and Waterscapes: Agriculture, Forestry, and Fisheries

Well-informed management of agriculture, forestry, and fisheries sustains productive harvests while also maintaining their biodiversity and resilience, creating bright spots with potential application elsewhere (11,29,94–96). For example, substantial evidence supports the effectiveness of intercropping, no-till planting, cover-cropping, and polyculture to sustain soil health and fertility, conserve water, and support pollinators (97,98). Polyculture—planting multiple crops together—has been central to Indigenous agriculture in the Americas for centuries (99,100), and its benefits are increasingly recognized by modern western societies (94). Compared to monocultures, polyculture and rotating crops across years improves soil condition, crop resistance to parasites and pathogens, and, in some cases, crop yield (101,102). Similarly, global evidence from agroforestry—a type of polyculture that intersperses crops with trees or shrubs—shows that compared to monocultures, this approach can increase land-use efficiency, soil conservation, resilience, yield, and yield stability of the target crop (103,104). These approaches often incur higher direct costs and use more land than monocultures; such challenges may be partly defrayed by public good benefits, although these are less easily quantified.

In US ocean waters (see Ch. 6: Marine Ecosystems), 50 harvested fish stocks have been successfully rebuilt after historical overfishing since 2000 as a result of management actions taken under the Magnusson–Stevens Fishery Conservation and Management Act (28), although many other stocks remain overfished. The recovery began in the 1990s and was accelerated in several regions by the 2010 catch-share policy that allocates shares of a fishery’s total allowed catch to individual fishers. This practice aligns conservation goals with economic incentives of individual fishers, who are rewarded for practices that conserve fish populations (105,106). Marine protected areas (MPAs) provide another bright spot in US waters. These areas restrict fishing and other extractive uses to preserve biodiversity and nature. MPAs have been highly effective in restoring abundance and diversity of marine life in situations where they are large, fully protected, and enforced (107), and the well-being of associated human communities is also greater under these conditions (108). Working closely with local communities is key to successful management of MPAs, a model example being the biocultural approach to the world's largest MPA, Papahanaumokuakea, in the Hawaiian Islands (109,110). Perhaps surprisingly, such protections can increase, rather than decrease, fishery catch in the region surrounding the MPAs due to population growth and emigration of fishes from the MPAs into fishing zones (known as spillover) (111). This phenomenon was evident for tuna catch around Papahanaumokuakea (112), as well as in the Southern California lobster fishery, where MPAs reduced the area open to fishing by 35% but led to a 225% increase in catch after six years (113).

In forestry, bright spots are similarly emerging from adoption of polyculture and other new approaches to management. Similar to results from agriculture, forest plantations with multiple tree species produced taller and broader trees that yielded 25% more above-ground biomass per hectare, on average, compared with single-species plantations (114). More diverse tree stands also support more animal biodiversity, are more resistant to insect pests, store more carbon, and are often more resilient to disturbance (96,115–117). A major threat to both managed forests and human communities in recent years has been increasing wildfire frequency and intensity. Prescribed burns turn fire from a stressor to an aid by making forests more resilient to catastrophic fires (see Box 4.2) and also provide compelling evidence of how collaboration among communities and multiple levels of government is essential in achieving good outcomes for both nature and people (see KM 4.3) (118).

Box 4.2. Cultural Burns and Fire Stewardship

Indigenous peoples of North America have practiced "cultural burning" for thousands of years in nearly every ecosystem (Figure 4.5) (119–121). The Indigenous knowledge and practices of these peoples relied on fire as a natural, rejuvenating disturbance to enhance biodiversity by creating patchy, mosaic habitats (121). Cultural burning, also known as "good fire" and "fire as medicine," reframes and recontextualizes fire as a resource management strategy and tool with numerous benefits to land and people (118). Good fire is characterized as slow, low intensity, more patchy, and cool, whereas bad fire is fast, hot, and burns thoroughly both horizontally and vertically up into a forest canopy. Cultural burning benefits the land by replenishing the soil with bioavailable nutrients via the ash. It also eliminates dead and diseased trees, dry shrubs, and other vegetation, reducing fuel load and thereby reducing the risk of catastrophic wildfire (122–124). Cultural burning also reduces pest populations, enhances plant diversity, and creates space for wildlife browsing and movement (122,124). Culturally, good fire helps shape and modify plant parts used for traditional purposes, such as basketry and musical instruments. Community cultural burns are also an important way for people to reconnect with fire as a sacred element to be respected rather than feared or demonized. In this way, cultural burning helps maintain Indigenous knowledge, worldviews, and values and creates opportunities for community connections and the transmission of Indigenous knowledge to younger generations and a wider community.

Figure 4.5. Cultural Burns and Fire Stewardship

Fire stewardship amplifies natural ecosystem resilience while reducing the risk of catastrophic wildfires.

Staff members from the Cultural Conservancy burn invasive grasses at their Heron shadow land project in Northern California in preparation for ecological restoration and Indigenous farming. Indigenous peoples of North America have practiced "cultural burning" for thousands of years in nearly every ecosystem, using fire as a natural, rejuvenating disturbance to enhance biodiversity. Photo Credit: Melissa K. Nelson, courtesy of the Cultural Conservancy.

Due to the accelerating effects of climate change disruptions, and increasing risks of destructive fires, the US Forest Service, the Department of the Interior, and other federal and state agencies have begun to adopt policies and practices such as cultural burning to respect the long-term, place-based sustainable practices of Native Americans and to mitigate the effects of fire on people and places (125,126).

[END BOX 4.2 HERE]

Bright Spots in Urban Regional Systems

More than 80% of US residents (and over half the global human population) now live in cities (127). Rewilding these urban spaces showcases the potential for cities to support biodiversity (128). Cities are also adopting constructed wetlands and other green infrastructure, which manage stormwater and wastewater more effectively than conventional infrastructure while providing habitats for wildlife, improving water quality, reducing erosion, and providing recreation opportunities (129–131), as in New York City's Bluebelt Program (132). Green roofs are transforming many urban rooftops into lush, insulated spaces that reduce heat islands and manage rainwater runoff. For example, Chicago's green roof project has led to more than 500 vegetated roofs, 13 rooftop farms, and 5.5 million square feet of green roof coverage. Los Angeles (City Plants) and New York (MillionTreesNYC) have campaigns to add a million trees to their cities to improve air quality, reduce urban heat, and enhance community well-being (133,134). In San Juan, Puerto Rico, there is a roughly 8°F differential between urban and forest cover, with lower temperatures associated with vegetation cover (135). Living shorelines composed of plants, oyster reefs, and other natural features are now widely used along developed waterfronts to reduce erosion and storm surge while promoting biodiversity, carbon storage, and recreational activities (136–138).

The bright spots in agriculture, fisheries, and forestry discussed above are prime examples of bright spots that provide clear benefits for people because they demonstrate good outcomes for nature in systems managed for human use and benefits. A thriving natural world is recognized as one of seven vital conditions necessary for people to reach their full potential by the Federal Plan for Equitable Long-Term Recovery and Resilience (139). Many policies designed to protect public health, including the Clean Air and Clean Water Acts, have also benefitted wildlife (140,141), in some cases translating into economic benefits from recovered nature (142). Nature contact, greenspace, and parks are also associated with a range of physical and mental health benefits across the human lifespan (see Ch. 13: Health and Well-Being), including for members of disadvantaged communities (143), as well as with spiritual connection, community identity, and cultural keystones that enhance well-being and social cohesion (see Ch. 11: Culture).

Description of Evidence Base

Based on abundant and diverse evidence, it is *virtually certain* that bright spots benefitting both nature and people exist across all major ecosystems, throughout many regions, and at multiple spatial scales within the US and its territories (3–11,13,14,27–31). These bright spots arise from active restoration of species (6,31,35,36,39,40,49–57,69,75–80), place-based protections (6,32,39,57), pollution reduction (6,36,39,42,52,64–68), infrastructure improvements (36,69–72), and in some cases passive reductions in human activities (59–62). It is *very well established* that such bright spots occur not only in wildlands but also in systems managed for agriculture (11,94,97–104), forestry (114,118,144), and fisheries

(28,29,105–113), as well as in urban areas (129–132,136–138) and that these bright spots can emerge both from the inherent resilience of nature and from human interventions (7,32–40). It is also *very well established* that bright spots in nature can deliver benefits for people, including economic opportunities, public health, and better satisfaction with management (118,140,141,143).

Key Message 4.2: Enabling conditions facilitate bright spots

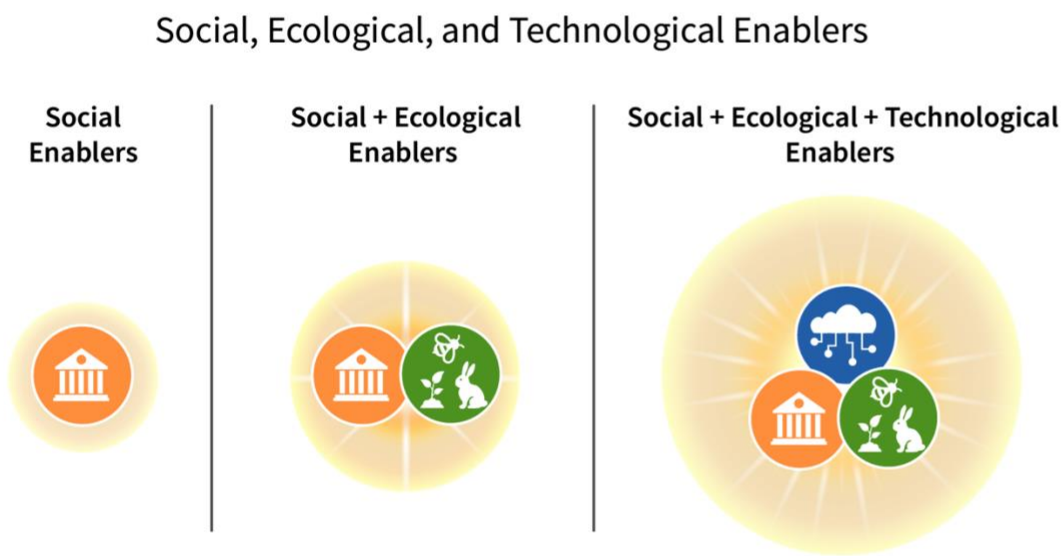
Bright spots in nature are created and sustained by a range of social, ecological, and technological factors—or enabling conditions—that interact with each other and vary in their relative influence (virtually certain). Understanding how these enabling conditions interact can help create bright spots and improve the benefits to humans and nature that result from them (virtually certain). Synergies among multiple enabling conditions are critical to establishing and sustaining bright spots in the face of environmental and global change (very well established).

State of Knowledge 4.2

A broad and deep evidence base shows that bright spots are enabled by the interactions of certain processes and conditions within social, ecological, and technological systems (SETS) (7,28,48,49). We identified these SETS enablers for the creation, management, or scaling of bright spots by identifying how biophysical factors (e.g., habitat structure, species reproductive capacity) interact with governance arrangements and technological tools to produce sustained success. The types and combinations of, as well as the feedbacks between, these enablers vary considerably. Moreover, we documented a wide range of examples where natural resource managers and practitioners have leveraged partnerships and other enablers to help establish and/or sustain bright spots (145–148). However, further monitoring and assessment would be helpful because the mechanisms giving rise to successes were not always explicitly measured or analyzed in the literature. Likewise, there are relatively few studies focused on sustaining, versus establishing, bright spots, making it unclear how the relative importance of different enabling conditions may vary as bright spots mature. While the evidence documenting how combinations of enablers create and scale bright spots is strong (29), the breadth of this evidence remains limited because many studies focus on single or primary enablers.

Below we summarize the enabling conditions that support the establishment, scaling, and sustainability of bright spots, organized by social, ecological, and technological dimensions. We highlight how combinations of multiple enabling conditions often support bright spots (Figure 4.6) (9,25), as reflected in the cases assessed in this chapter (Figure 4.7).

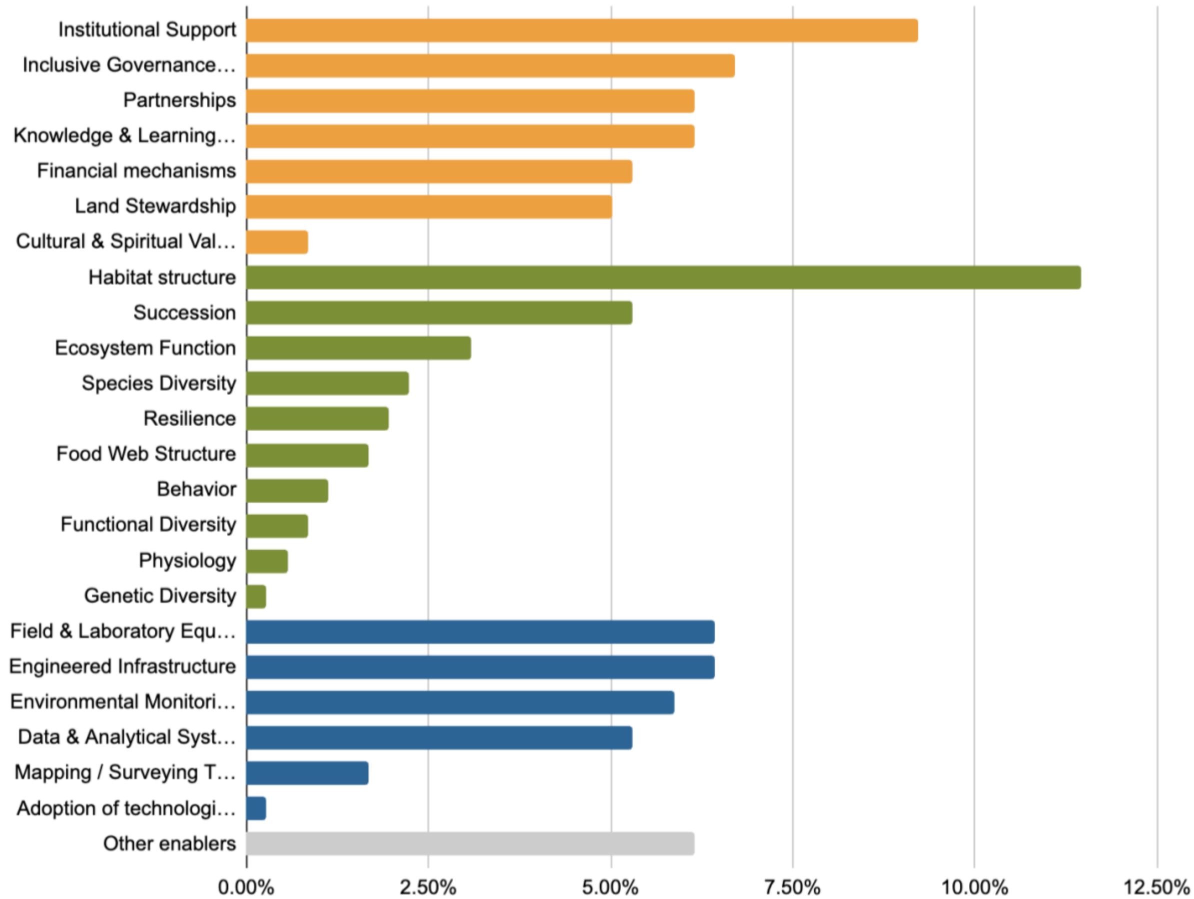
Figure 4.6. Social, Ecological, and Technological Enablers of Bright Spots



Brightness can increase as more social, ecological, and technological system dimensions are involved as enabling factors.

Bright spots exist across multiple contexts and may be enabled by social, ecological, or technological dimensions. Bright spots in nature can be even brighter when multiple dimensions are engaged. Figure original to The Nature Record.

Figure 4.7. Relative Contributions of Social, Ecological, and Technological Enablers of Bright Spots



Key enabling conditions for bright spots include institutional support, habitat structure, and effective technologies.

A review of the academic literature identified 131 peer-reviewed articles of bright spots in nature with enabling factors (358 enablers coded), which have been classified as social (orange), ecological (green), or technological (blue). Bright spots are enabled by single or multiple enabling factors, which in this figure are grouped broadly into social, ecological, and technological dimensions. Manual coding of papers found a range of conditions that enable bright spots to be created and sustained. Habitat structure was the most common enabling condition, alongside strong institutional support, inclusive practices, and enabling technologies. This indicates that documented successes are driven by a mix of social–ecological–technological system configurations. Figure original to The Nature Record.

Social Enablers

Partnerships

Multisector partnerships are often foundational for effective conservation, provisioning systems, and ecological restoration. Such partnerships can help to ensure accountability, transparency, and efficacy in decision-making (149) and implementation (149). They also allow for expertise, infrastructure, and relationships to be leveraged across organizations , (150).

Strong examples showcasing the potential benefits of partnerships include community-based wildfire planning in Arizona's Sitgreaves National Forest (118), collaborative stream restoration in the Clark Fork River Superfund project in Western Montana (151), and the formation in 1997 of a strategic multi-organizational partnership to establish the New York City Watershed Protection Program, which has since coordinated $2.5 billion in funding to protect water in reservoirs and the resilience of the drinking water supply in the state (152). Likewise, a diverse array of community-based stewardship groups and collaborative partnership arrangements are now supporting the creation of bright spots in urban areas, involving parks, trees, community gardens, and waterways (153). For example, a community governance bright spot in Puerto Rico addressed multiple environmental and health hazards, a lack of proper infrastructure, and informal housing with inadequate safety standards (154). These conditions led to strengthened community organization, broader involvement in planning, and transformative managed retreat from these hazards, resulting in adaptation to sea level rise, restoration of mangroves, and improved public health—all accomplished in a manner that was more equitable than is typical of such processes (155). This process, led by the community-founded Corporación del Proyecto ENLACE del Caño Martín Peña, achieved success in multiple areas including economic, social, cultural, political, and mental and physical well-being (154–156).

While partnerships often play a powerful role, bright spots can also emerge where individual landowners, organizations, or cultural groups steward natural resources effectively on their own.

Policy and Regulatory Frameworks

Robust policy frameworks are often vital to incentivizing, regulating, and evaluating the success of nature management efforts. Despite a multitude of challenges in implementation, several federal laws have helped enhance the condition of nature and specific species in the US, including the Clean Air Act (1963) and its amendments (157,158), Endangered Species Act (1973) (159), Marine Mammal Protection Act (1972), Magnuson–Stevens Fishery Conservation and Management Act (2007), National Environmental Policy Act (1970) (160), and Clean Water Act (1972) (161). At the state level, policies such as the Marine Life Protection Act in California, the Alaska National Interest Lands Conservation Act, and New York's Climate Leadership and Community Protection Act have also been credited with gains in nature protection, habitat conservation, endangered species protections, and climate change action (29,162–165). As natural areas often do not fall neatly within political boundaries, several iconic transboundary programs have also supported protection of widespread habitats, such as the Conservation Reserve Program coordinated through the US Department of Agriculture's Lesser Prairie-Chicken Initiative, which has helped increase the population of many grassland bird species (78).

Funding and Resources

Pervasive structural deficits in funding hamper efforts to initiate bright spots in nature protection and conservation, as well as to sustain them over time (166). However, a mosaic of financial penalties from environmental noncompliance, creative financing strategies, and major investments from government, industry, global financial markets, and philanthropy are serving as key activators for bright spots. The $20.8 billion legal settlement from damages inflicted by the Deepwater Horizon oil spill has supported a constellation of water quality and ecological restoration efforts at a regional scale that are beginning to show notable environmental benefits (92). Similarly, funds generated through recreational fishing and hunting licenses, and federal excise taxes on sales of hunting and fishing gear designated by the Dingell–Johnson and Pittman–Robertson Wildlife Restoration Acts, are helping sustain lake sturgeon, striped bass, bluegill, bald eagles, waterfowl, and wild turkeys nationwide (167,168). Conservation NGOs, from large organizations like The Nature Conservancy to smaller organizations including Ducks Unlimited and many land trusts, are strategically connecting private landowners and agricultural entities through Farm Bill programs to conserve and restore habitats on private lands at impressively large scales (169,170). High demand for grants through a number of Farm Bill programs indicate that additional funding is needed to meet needs nationally. Regional funding efforts include recent state-level bonds to allow public borrowing for strategic programs. Examples include New York State's $4.2 billion effort in 2022 to protect water quality, adapt to climate change, and create green jobs, as well as California's Proposition 4 (2024), which authorized a $10 billion general obligation bond for resource protection and climate change mitigation activities (171,172). Such investments are driving successful management programs for conservation, restoration, and provisioning systems.

Community and Governance

Some bright spots are also enabled by aspects of community and governance, including strong multi-stakeholder and multi-scalar (e.g., local, Tribal, state, regional, and national scales) governance structures that incentivize conservation, human well-being, and economic security (173). For example, the innovative co-management structure involving five Tribal Nations and the Federal Government for the Bears Ears National Monument in Utah (174) places traditional and Indigenous Knowledge and Tribal governance as central elements in decision-making. The final plan, which was cocreated through a multiyear planning effort, supports recreation, grazing, and Tribal co-stewardship, allowing for the balanced use and management of a culturally significant landscape. Such relationships significantly influence the success of conservation efforts (175). In other words, the socioeconomic context helps create the circumstances in which bright spots can develop and be sustained.

Ecological Enablers

Time and Ecological Succession

Most ecological systems are inherently resilient in the face of moderate levels and frequencies of stressors (32,37,38). But resilience depends on resource availability and the reproductive rates of dominant organisms. For example, land- or seascapes with abundant water and nutrients and mild climate tend to recover biomass and diversity faster after disturbance than those in cold, arid, or otherwise marginal environments (176). Importantly, perceptions about recovery also depend on these factors as they influence timescales of recovery (or lack of recovery) in the ecosystem of interest. For example, the recovery of an old-growth forest ecosystem following severe hurricane disturbance or clear-cutting will take significantly longer than the recovery of herbaceous vegetation or of a river following dam removal (32) (although some forests can reach maturity in relatively short time periods, as happened in the northeastern US (177) and Puerto Rico (59) after clear-cutting). Deep-sea ecosystems, with cold temperatures and little food, recover very slowly if at all from fishing (178). Thus, documented bright spots may be biased toward ecosystems with relatively short turnover times (32).

Habitat Structure

Bright spots of rapid recovery following a disturbance can depend on reestablishing focal species that provide the early successional foundation of the ecological community, thus setting the stage for other species to recover (70,179). Important habitat structure can be formed by native or nonnative species, as in Puerto Rico where nonnative tree species successfully colonized degraded sites, accelerating nutrient cycles and creating forest canopy under which other native species could then develop (180). Many restoration practitioners focus on establishing foundation species via seed or larvae cultivation as a means to jump-start ecosystem functions and facilitate food web development, such as in seagrass, oyster, coral, and salt marsh restoration (6,42,181). Recent studies reveal that planting foundation species together with their mutualist partners or in configurations that catalyze positive feedbacks among members of the same species can dramatically increase the successful reestablishment of habitat structure and associated food webs (148,181).

Biological Diversity and Food Web Structure

Measures of biological diversity tend to be positively correlated with the resilience of ecosystem processes because multiple species can provide a wide range of ecological traits that provide functional redundancy in the face of disturbance (182). Highly diverse systems often support large, complex food webs that enhance flows of nutrients and energy (183). Bright spots are thus likely to be sustained by high levels of biological diversity (47,94,184,185) and complex food webs. Restoration of natural habitat structure and processes can also be catalyzed by reintroduction of keystone species, such as sea otters, gray wolves, and beavers (186,187). For example, sea otter recovery in Monterey Bay, California, was essential to controlling populations of sea urchins that allowed degraded kelp beds to recover, restoring their value as aquatic nurseries (188,189).

Technology Enablers

Engineered Solutions

Engineering can turn the tables to create bright spots in places where it previously caused challenges (190,191). These include innovative applications of wastewater and stormwater treatment systems to address older infrastructure that did not allow for infiltration, environmental remediation to address pollution challenges, fish passages installed to bypass infrastructure and restore fish migration, and irrigation technologies that can reduce water demand. For example, road crossings coupled with fencing can support both wildlife passage across roads and improved motorist safety, reducing wildlife mortality by up to 80% (192). Such cases helped justify the construction of the largest crossing built to date to support mountain lion conservation in California's Santa Monica Mountains (193). The contributions of technology as enablers of bright spots are sometimes hidden from public view but can be revealed after extreme disturbances dismantle such technology. This was the case when Hurricane Maria caused failures in wastewater treatment plants in San Juan, rapidly reducing water quality, safety, and the ecological condition of the estuary (66).

Environmental Monitoring Systems

Rapid innovations related to in situ field sensors, environmental DNA (eDNA), remote sensing, and companion technologies (e.g., edge computing—real time data synthesis and integration near the location of data collection—5G, and satellite network access), and battery storage have facilitated more strategic prioritization of natural resource management interventions and evaluations of their efficacy. Such improvements in adaptive design and management (194) are supporting a range of bright spots, such as the use of a compilation of geospatial planning tools to support the design of California's coastal marine protected area network (29), the use of genetic information to design translocation strategies for the endangered Stephens' kangaroo rat (51), and the use of eDNA to rapidly detect and mitigate impacts of introduced and nonnative species (195). Additionally, wildlife cameras and sound recorders have been helpful in monitoring and restoring wildlife habitats and corridors (196). Rapid innovation in artificial intelligence to process and analyze monitoring data and optimize sensor design and deployments has improved a range of applications in conserving species, communities, and land- and seascapes (197).

Restoration and Production Technology

As the demand for large-scale restoration and more sustainably managed provisioning systems has risen, there has been a surge of investment in new technologies to rapidly improve the cultivation of nature. These include increasingly expansive nursery and planting programs for genetically targeted coral species (198), alley-cropping techniques for combined tree and row crop production, and silvopasture designs—integrating trees into livestock operations—that are achieving equal or greater success than conventional restoration or production techniques (199).

Description of Evidence Base

A systematic review of literature indicates that it is *virtually certain* that bright spots are enabled by a large variety of conditions spanning social, ecological, and technological dimensions (Figure 4.7), which vary considerably in type and interactions with other enabling conditions. Studies within our evidence base routinely stressed the importance of understanding social, ecological and technological conditions that affect bright spot creation or maintenance (29,42,200), making it *virtually certain* that deepening knowledge of the relationships between bright spots and their enabling conditions can support creating bright spots and enhancing the benefits they confer to humans and nature. Finally, in the many locations where global and/or environmental change present significant challenges to nature, multiple social, ecological, and technological factors were commonly identified as enabling conditions for bright spots (201,202), but the interactions and feedbacks between them were not consistently articulated. Thus, it is *well established* that establishing and sustaining bright spots in the face of global and environmental changes depends on synergies among multiple enabling conditions.

Key Message 4.3: Equity enables and sustains bright spots

Bright spots emerge and endure when equity and inclusion are centered in decision-making regarding conservation, restoration, and design management (very well established). Bright spots are enabled by inclusive, equitable, multi-actor processes, especially those that draw on Indigenous, local, and contextual knowledge and practices (very well established). When equity is placed at the center of decision-making, bright spots can repair past harms through equitable distribution of ecological, economic, social, and cultural benefits, contributing to positive, enduring outcomes for society and future generations (well established).

State of Knowledge 4.3

A growing body of evidence has demonstrated how equity and inclusion are both enabling conditions for and defining features of bright spots. Studies of urban greening, Indigenous and local knowledge, and community-driven adaptation consistently find that initiatives that center equity—in the fair distribution of benefits and burdens, recognition of marginalized voices and knowledge systems, and meaningful participation in decision-making—achieve more resilient and widely shared outcomes (203–205). Similarly, case studies of urban greening (Box 4.3), community-led climate adaptation, and Tribal stewardship and co-management of lands and resources consistently demonstrate that outcomes are more durable, just, and widely shared when decision-making elevates Indigenous, local, and contextual knowledge (206–210). Examples of success span participatory tropical forest preservation (211), marine conservation (212), protection of Indigenous biocultural landscapes (213,214), and urban habitat restoration (215,216). Inclusion of Indigenous communities has produced particularly robust and lasting partnerships (217).

Efforts that are rooted in inclusive multi-actor processes are the most enduring and impactful (204,205). For example, research–practice collaborations like Louisville's Green Heart project are embedding health science into forestry interventions to document links between greening and community well-being, highlighting how disadvantaged communities have experienced inequitable access to both green spaces and healthcare services (218). Co-production processes—such as participatory design of green infrastructure, collaborative watershed management, and recognition of cultural and spiritual relationships to land—result in projects that are better maintained, more ecologically effective, and more socially legitimate over time (219,220). On the other hand, when equity and inclusion are absent, projects often falter: benefits are captured by wealthier groups, trust between communities and institutions erodes, and ecological gains are less durable (221,222). Conversely, when residents and rightsholders are positioned as co-leaders, their place-based knowledge and long-term commitments enhance knowledge exchange, allow interventions to be tailored to local needs, and ensure accountability in implementation (223).

In practice, across diverse US contexts, bright spots are enabled and maintained when equity is ensured through fair distribution of benefits and responsibilities and when inclusion is practiced as respect for diverse ways of engaging with nature. This may involve reparative actions, such as land return and active community management, or stewardship approaches, such as the "honorable harvest," a common Indigenous practice that focuses on restraint, permission, sharing, and protecting the health of a resource to ensure its capacity to thrive (224). Since residents and rights-holders are often the most direct users and stewards of a resource, their leadership and participation in management efforts are important ways to enhance knowledge exchange, design more locally appropriate solutions, and ensure greater accountability and success (225,226). An ability to center equity also helps to amplify voices of diverse communities (227,228). Equity has been put into practice through reparative measures such as land return, legal recognition of Tribal sovereignty, and co-management arrangements that embed Indigenous authority in governance (223,229). These practices not only address historical harms but also strengthen long-term stewardship by aligning conservation and adaptation goals with community values.

However, there are still gaps in understanding how repair can be realized in practice across different contexts. There is also a lack of systematic and longitudinal evaluations to provide evidence on the role equity-centered approaches play across more diverse contexts (230–232). Additionally, there may be trade-offs between maximizing equity and conservation, depending on context and how social equity is defined (233).

Box 4.3 Emerging Equity-Focused Approaches in Urban and Community Forestry

Recent years have seen a proliferation of programs that explicitly seek to integrate equity into urban and community forestry (Figure 4.8). Municipal examples include urban forest management plans in Portland, Oregon, and Oakland, California, which emphasize addressing historical disparities in tree canopy. Civil society initiatives, such as the Groundwork USA Climate Safe Neighborhoods project (234), link community organizing with urban greening to redress legacies of disinvestment. Research–practice collaborations like Louisville's Green Heart project are embedding health science into forestry interventions to document links between greening and community well-being, highlighting how disadvantaged communities have experienced inequitable access to both green spaces and healthcare services. At the federal level, the USDA Forest Service Urban and Community Forestry Program (235) was included under the Justice40 initiative (236), directing $1.5 billion toward disadvantaged and overburdened communities. These examples illustrate a growing recognition of equity as a guiding principle for urban forest investments.

Figure 4.8. Urban and Community Forestry in the US

Multiple programs across the US explicitly seek to integrate equity into urban and community forestry.

Three people explore the Bethel Community Forest in Bethel, Maine. Photo credit: Jerry Monkman, courtesy of Trust for Public Land.

In the field of urban and community forestry—which includes the planting, maintenance, and care of trees in urban and urbanizing areas—research has demonstrated that the current spatial distribution of tree canopy is inequitable, with patterns strongly linked to historical practices of redlining and disinvestment in Black and Brown communities (237,238). Studies have also developed assessment tools, such as Urban Tree Canopy metrics and Tree Equity Scores, to identify and monitor inequities (239). While systematic evidence of their long-term outcomes is still limited, these programs represent promising directions that may one day provide more robust evidence of equity-centered bright spots (240,241).

[END BOX 4.3 HERE]

Indigenous Leadership and Land Stewardship

Efforts to address environmental injustices have demonstrated that acknowledging and rectifying historical harms can create transformative outcomes for both people and ecosystems—especially in ways that address past harms through restorative justice where the aim is to create or rebuild the conditions of trust and accountability between actors (240,242). As historical drivers of environmental inequity and injustice continue to constrain the voices and opportunities of under-resourced frontline communities, efforts to empower and support communities can be powerful tools to render bright spots in nature conservation even more bright.

Due to the history of European colonialism, many Indigenous, traditional, and local knowledge systems and associated stewardship practices—rooted in diverse ecosystems and cultural lifeways and languages—have been silenced, oppressed, and erased (229,243). Indigenous and local knowledge systems contain vast amounts of critical environmental information that can be respectfully engaged and ethically utilized to complement the tools and strategies of western science, a process often called “two-eyed seeing” or “co-producing knowledge” (244–246). This strategy of inclusion is codified in the United Nations Declaration on the Rights of Indigenous Peoples.

Across all federal agencies, from the Department of Agriculture to the Department of Interior, there has been a concerted effort to respectfully include the Indigenous knowledge systems of American Indians, Alaska Natives, and Native Hawaiian communities in land-use decisions, as well as to provide training and resources for federal employees to improve collaborations with Indigenous peoples (247). This bright spot of historical and epistemic justice to honor and respect Indigenous people’s knowledge has led to additional, inclusive co-benefits such as an increase in Indigenous fire stewardship to help prevent destructive wildfires (see Box 4.2). However, the continuation of such federal policies is unclear.

The growth of the Native land trust movement in the US is an important example of an effort to equitably include multiple knowledge systems and epistemic justice for Indigenous peoples in the protection and conservation of lands, waters, and resources (248). For example, in early 2025, the Yurok Tribe, in partnership with Western Rivers Conservancy, completed California's largest "land back" conservation deal (249). This effort transferred 47,097 acres of ancestral lands along the Klamath River to create the Blue Creek Salmon Sanctuary and Community Forest, protecting critical habitat for endangered salmon and other species. The project, costing more than $70 million, demonstrates how conservation organizations, state agencies, and Indigenous nations can work together to restore lands previously managed by commercial timber companies for nearly a century. In other cases, through using the private conservation strategy of land trusts, Native American and Indigenous communities are partnering with agencies and private philanthropy to purchase back and restore farmland, sacred sites, forests, and other lands and waters for Indigenous land stewardship (248). Many old ranches, farms, and homesteads are being donated back to or sold to Tribes and Indigenous communities at a reduced rate as acts of historical and environmental justice.

Nature-Based Education

Nature-based education is a growing bright spot that connects children and youth with the natural world through outdoor learning, play, and stewardship. Programs include outdoor preschools, where children spend most of the day outside regardless of weather; nature-based curricula and green schoolyards in K–12 schools (see Box 4.4); and summer camps that incorporate ecological literacy and hands-on science. Evidence from environmental education research shows that nature contact in early childhood improves motor skills, fosters creativity, reduces stress, and supports socio-emotional development (250,251). Longer-term studies find that environmental education increases pro-environmental attitudes and behaviors, enhances academic performance in science and math, and can narrow achievement gaps for underrepresented students (252). The Billion Oyster Project is an example of an oyster reef restoration that endeavors to improve ecological functioning, support biodiversity, and improve water quality while also providing education and nature connection by working with more than 100 schools in the region (253).

Box 4.4. Green Community Schoolyards

Green schoolyards exemplify how nature-based solutions can address inequities while delivering tangible benefits for people and the planet (Figure 4.9). Across the US, schools are transforming paved, heat-trapping schoolyards into green spaces through participatory design that centers students, families, and local communities (Figure 4.10). Increasing evidence shows that green schoolyards increase physical activity, support social-emotional and academic outcomes, and build stronger community cohesion, particularly in neighborhoods historically lacking access to quality green space (254,255). By prioritizing schools in underserved areas, these initiatives help redress disparities in access to nature, making them a powerful example of a bright spot.

Figure 4.9. Greening a Community Schoolyard in New York City

Community schoolyards that are transformed through green infrastructure showcase bright spots with multiple social and ecological outcomes.

*(**left**) Before renovation, the schoolyard at PS19 Asher Levy School in New York City was characterized by extensive asphalt with minimal vegetation, shade, or opportunities for nature-based play and learning. (**right**) Following a community-informed redesign led by the Trust for Public Land, the schoolyard was transformed into a multifunctional space with trees, a garden area with an outdoor classroom, a turf field, a painted track, play equipment, a basketball court, and a green-roof gazebo. Designed as a green infrastructure playground, it will capture hundreds of thousands of gallons of stormwater each year. Photo credit: courtesy of Trust for Public Land.*

Figure 4.10. Community Schoolyard at Centennial Academy in Atlanta, Georgia

Community schoolyards that are transformed through green infrastructure showcase bright spots with multiple social and ecological benefits.

Centennial Academy's renovated schoolyard in Atlanta features a pollinator garden, a rain garden, and channels to collect runoff, providing educational opportunities. Students pictured are engaging in close observation of nature in their schoolyard. Photo credit: Leah Overstreet, courtesy of Trust for Public Land.

The benefits of green schoolyards extend well beyond school boundaries, yielding measurable gains for human health and climate adaptation. By replacing asphalt with trees, native vegetation, and permeable surfaces, they create pockets of urban biodiversity, provide habitat for pollinators and birds, reduce the urban heat-island effect, and often create edible schoolyards by planting vegetables and fruit trees to increase availability of local, healthy food (44,256–258). Many schoolyards integrate green infrastructure, such as bioswales, rain gardens, and cisterns, which improve stormwater management and reduce localized flooding. These living landscapes double as outdoor classrooms, where students gain hands-on experience with sustainability practices and ecological systems, building knowledge and capacity for future resilience. When these spaces are designed with community input, they can help ensure that the resulting spaces reflect neighborhood priorities and foster a sense of shared stewardship.

Collectively, public school districts are one of the largest landowners across the US, controlling about 2 million acres that are used by almost 50 million children daily. Of the 90,000 public schoolyards in the US, only a small proportion are rich in green space and stay open to the neighborhood outside of school hours. Several national organizations and initiatives are working to change this, including the Children & Nature Network, Green Schoolyards America, and the Trust for Public Land (TPL). TPL has created 305 community schoolyards across the US, and there are almost 100 more in progress (259). This movement has also been supported by legislative action such as Colorado's HB25-1061, which established the Community Schoolyards Grant Program, providing up to $150,000 for planning and design and up to $850,000 for capital construction of community schoolyards (260).

[END BOX 4.4 HERE]

Equitable access to nature-based education, particularly through schools, can ensure that all children benefit from these experiences (261). Many states have passed legislation in recent years aimed at increasing outdoor and environmental learning opportunities for children, often including equity and access provisions. For example, a New Jersey bill introduced in 2024–2025 would direct the commissioner of education to develop guidelines for outdoor education opportunities in public school curriculum (262), and a Washington State bill (263) funded the Outdoor Learning Grants Program from 2023 to 2025 to develop and support outdoor educational experiences for students in all geographic regions, with high levels of accessibility for students with disabilities. Public investment and licensing programs, such as Washington State's 2021 decision to formally license outdoor preschools (264), are creating pathways for more children to participate in nature-based education. These programs also provide workforce opportunities for educators skilled in outdoor learning and create community hubs that connect families to nature. By prioritizing equity in design and access, nature-based education not only supports child development but can also cultivate the next generation of environmental stewards (252).

Description of Evidence Base

The evidence base draws on a largely consistent body of interdisciplinary evidence, including peer-reviewed empirical studies, systematic reviews, case studies, Indigenous and local knowledge scholarship, policy analyses, and program evaluations across conservation, restoration, urban greening, and nature-based education contexts in the US. Evidence that bright spots emerge and endure when equity and inclusion are centered in decision-making, and that inclusive, multi-actor processes elevating Indigenous, local, and contextual knowledge enhance durability and legitimacy, is *very well established*, supported by strong agreement across diverse settings and scales (175,244,265,266).

Evidence that equity-centered approaches can repair past harms and generate more equitable distributions of ecological, economic, social, and cultural benefits is *well established* (240,242). However, conservation planning research shows that integrating equity alongside ecological and economic objectives involves inherent trade-offs that vary by context and definition, underscoring the need for clearer equity metrics and systematic long-term evaluations (29,233). Key uncertainties remain regarding scalability, durability over time, and the institutional conditions required to sustain equitable power-sharing, particularly with Indigenous and frontline communities, highlighting important research needs as efforts move from isolated bright spots toward broader, more just transformations.

Environmental Justice and Equity Highlights

Bright Spots for All

Research shows that bright spots in nature conservation and protection depend on inclusive governance that involves multiple stakeholders and acknowledges how power structures shape government–community relationships and access to unpolluted nature. This reflects core environmental justice principles: Fair outcomes require meaningful community participation, knowledge co-production, and explicit attention to who controls environmental decisions.

However, substantial obstacles persist. Communities with limited resources or capacity often cannot participate in or benefit from nature conservation initiatives (267). Questions also remain about whether funding reaches the communities most in need, revealing ongoing challenges in distributing conservation benefits equitably across different social and economic groups (268).

Several research priorities could advance more equitable nature conservation approaches. These include long-term studies that track outcomes over time, comparative analyses of equity-centered versus traditional habitat restoration and conservation methods, improved processes and models for ethically combining Indigenous, local, and scientific knowledge in decision-making, and standardized tools for measuring how environmental benefits are distributed across different communities, species, and geographies. More equitable nature conservation will be achieved by understanding the importance of sovereign Tribes as rights-holders due to their unique federal status and respecting and including their Indigenous Knowledge in long-term environmental decision-making.

Emerging Issues

Bright spots in nature have only recently emerged as a field of scholarship. Efforts to document and evaluate bright spots are advancing but nascent within a globally still maturing field. This is reflected in our search of peer-reviewed literature, which failed to identify numerous bright spots known to our author group. This highlights the need for a more comprehensive search, review, and quantitative meta-analysis of the conditions enabling bright spots. The Seeds of Good Anthropocenes initiative has documented more than 500 examples of “seeds” globally that are bright spots with potential to grow, spread, or inspire positive change (9,16,18). Celebrating existing bright spots, sharing their success stories, and characterizing the effective enabling conditions can also showcase how to leverage those conditions to create and sustain bright spots and deliver benefits to additional communities. New investments in the following research areas could help inform the most effective pathways to scale bright spots in places that are now dark.

Extending and expanding bright spots requires better understanding and ideally prediction of how nature responds to disturbances in complex, interacting social–ecological–technological systems, including in the urban systems where most of the country's and the world's population lives. For example, resilience theory demonstrates the need for a diversity of components and approaches to create the enabling conditions for brightness (269,270), yet the relative importance of any SETS enabler in a specific place or context is not yet well understood. Understanding bright spots in order to encourage their spread thus requires a holistic, long-term research approach, with several specific emphases.

Bright spots depend on the inherent resilience of nature but also are often critically enabled by a combination of regulatory processes, community-driven initiatives, multisector collaboration, and innovative finance and governance. Ecosystem recovery after disturbance often takes decades, whereas most research is based on short-term studies and/or biased toward rapidly changing indicators and relatively simple model systems. Further challenging understanding of bright spots is the reality that the inherent complexity of ecosystems is layered over a changing climate, which is shifting distributions of species and habitats (see Ch. 10: Climate Change). As a result, it is difficult to judge whether recovery of disturbed systems is durable and what it looks like, since "recovered" systems will likely differ from their previous states. Long-term research is needed to capture these complex dynamics and to better elucidate causes of change.

Similar challenges and opportunities apply for understanding the social dimensions of bright spots. For example, systematic, longitudinal studies would help researchers understand the factors enabling successful equity-centered efforts and their durability. Comparisons between equity-centered and traditional conservation approaches would also help clarify this understanding. Standardized frameworks that quantify distribution of environmental benefits and burdens across communities and species—similar to but broader than existing Tree Equity Scores (239)—would sharpen equity-centered research approaches. Also highly useful would be research into effective methods for ethically combining Indigenous, local, and scientific knowledge systems for decision-making (271–274). The concept of equity is also expanding, with work advancing on how to evaluate equity and justice for nonhuman species, and to recognize rivers, mountains, and diverse ecosystems as deserving of the rights of personhood and environmental justice (275). More scientific focus on the costs and benefits to people of interventions that influence nature (see other Chapters in this volume) would inform more effective ways to achieve additional bright spots.

Much of the existing research on bright spots has been international in scope (7,9,11), with two important implications. First, testing the international lessons in US contexts could offer promising opportunities. Second, nature does not recognize political boundaries, and cross-border cooperation is often necessary for effective conservation and management, particularly as the changing climate is shifting distributions of species and habitats. The high seas, in particular, are outside national jurisdictions entirely, and effective management is likely to benefit from international agreements, for example, the

Biodiversity Beyond National Jurisdictions agreement and the Commission for the Conservation of Antarctic Marine Living Resources (276–278). Since many marine species and processes move in and out of exclusive economic zone boundaries, such management in the open ocean has implications for what happens within US borders.

Highlighting the wide range of bright spots in nature is vital to assessing nature in the US and its territories, not only because of their intrinsic and instrumental value but also as sources of inspiration for policy, planning, and management that help nature and people thrive in all areas of the country. In a complex, constantly changing world facing planetary-scale challenges to biodiversity, climate, and societies, bright spots are a critical source of inspiration to recognize the positive seeds that are already effective in the present and can grow into a hopeful future. Better understanding the causes and conditions that enable bright spots to grow, replicate, and scale would help support the transformation of dark spots into bright spots. This assessment points toward opportunities to advance these goals.

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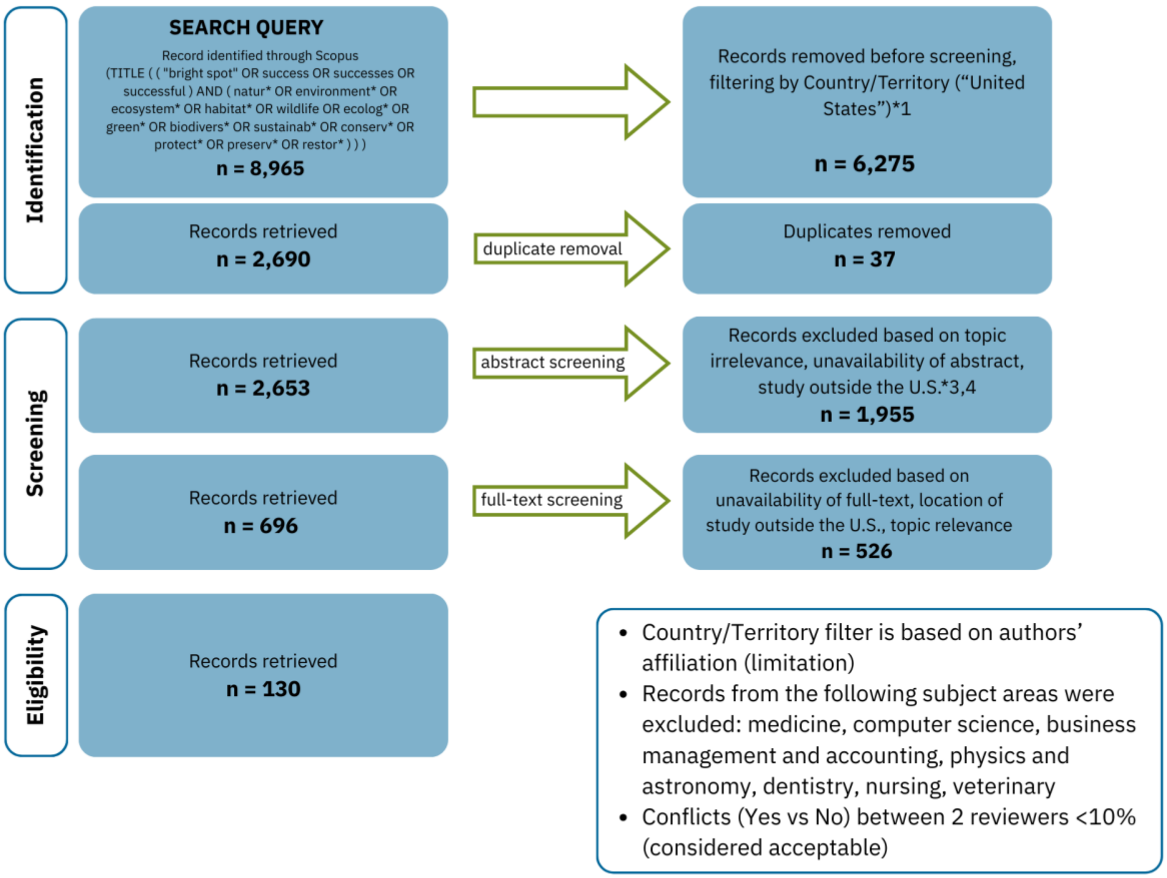
Supplementary Material 4S

Section 4S.1. Bright Spots Literature Review Methods

Figure 4S.1. Diagram of the Literature Review Process



A systematic literature review from an initial search return of 8,965 academic papers results in 130 papers that describe bright spots and related successes.

This PRISMA diagram (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) describes the literature review process, including search terms and papers retrieved, excluded, and ultimately included in the manual coding of 130 papers. Coding methods and results are described below. Figure original to The Nature Record.

We conducted a systematic literature review to identify and characterize evidence of bright spots in nature in the US and their potential enablers. Literature search was carried out in SCOPUS with search strings targeting article titles. Search query was as follows:

("bright spots" OR success OR successes OR successful) AND (natur* OR environment* OR ecosystem* OR habitat* OR wildlife OR ecolog* OR green* OR biodivers* OR sustainab* OR conserve* OR protect* OR preserv* OR restor*)

The following steps were undertaken to narrow down results from an initial return of 8,965 papers (Figure 4S.1):

- Geographic restriction: Results were restricted to articles with at least one author affiliated with an institution in the US. Search conducted on January 13, 2025, returned 2,690 articles.
- Sensitivity analysis: Analysis of this article subset found that 64% of the 50 most-cited articles and 62% of the 50 most recent articles were directly relevant to our research objectives and were considered to have satisfactory levels of relevance for the literature review (see Jenkins, 2004).
- Screening and selection: All results were initially screened using Rayyan, a web-based platform for systematic review management. The author team applied predefined inclusion/exclusion criteria to determine final eligibility. Articles were included if they reported empirical cases, theoretical frameworks, or reviews that directly addressed bright spots or analogous concepts of ecological–social success. Exclusion criteria eliminated articles that used search terms in unrelated contexts (e.g., business, medicine).
- The final sample of 730 articles was coded by the review team. Coding focused on capturing case study information (location, impact scale, evaluation timescale) and the social, ecological, and technological characteristics of bright spots, including enablers, outcomes/benefits, and challenges.