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PERSPECTIVE

Can a large-landscape conservation vision contribute to achieving biodiversity targets?

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Abstract

Founded in 1993, the Yellowstone to Yukon (Y2Y) vision was one of the earliest large-landscape conservation visions. Despite growing recognition of large-landscape conservation strategies, there have been few tests to date of conservation gains achieved through such approaches. We tested for conservation gains in the Y2Y region of North America following initiation of the Y2Y conservation vision in 1993 using a counterfactual spatiotemporal comparison and tracking change in five different conservation metrics. First, we enumerated the area of land within Y2Y in designated protected areas. We then compared the rate of change of protected area growth before- and after-initiation of Y2Y in 1993 and to two adjacent counterfactual regions. Protected areas in the Y2Y grew by 7.8%, increasing by 107,289 km^2, exceeding the Aichi target of 17% of the area under protection by 2018. More importantly, the rate of protected area growth increased 90% following initiation of the Y2Y large-landscape conservation vision in 1993, whereas protected area growth declined in adjacent regions, or remained constant throughout North America. Sustained growth in protected areas and private land conservation was complemented by expansion of endangered grizzly bears in the U.S. portion of Y2Y, the greatest global expansion from zero to at least 117 wildlife road-crossing structures and growing mainstreaming coverage of the Y2Y vision. Our counterfactual comparison provides valuable evidence that large-landscape conservation strategies such as Y2Y can enhance protected area growth and other conservation metrics. We conclude that large-landscape conservation strategies may be a useful model for achieving global large-landscape conservation and biodiversity conservation targets.

KEYWORDS

Aichi targets, area-based conservation, biodiversity, conservation effectiveness, grizzly bear, large-landscape conservation, road ecology, Yellowstone to Yukon

1 | INTRODUCTION

Reconciling human activities and the conservation of biodiversity is one of humanity's most "wicked" problems (DeFries & Nagendra, 2017; IPBES, 2018). A growing number of global initiatives are striving to implement large-landscape conservation to conserve biodiversity (Hilty et al., 2020; Worboys, Francis, & Lockwood, 2010). Yet, a pressing question is whether such large-landscape conservation visions advance biodiversity conservation. This is critical to achieving the previous Aichi target's goals of protecting 17% of the earth by 2020 and enhanced future targets such as the recently adopted International Union Conservation Nature (IUCN) target of 30% by 2030 (Burkart, 2021; Coristine et al., 2018).

The articulation of the Yellowstone to Yukon (Y2Y) vision in 1993, an interconnected system of wildlands stretching from Yellowstone to Yukon, harmonizing the needs of people with nature, was among the earliest large-landscape conservation strategies (Chester, 2006). The Y2Y vision was inspired by the Wildlands Project and large carnivore conservation (Mann & Plummer, 1993). The Y2Y vision was motivated by the shrinking distribution of grizzly bears (*Ursus arctos*) and the journeys of gray wolves (*Canis lupus*), including an individual wolf in the Canadian Rockies that covered an area of 100,000 km^2 (Locke, 1994) (Figure S1, Supporting Information). This led to the creation of the Y2Y Conservation Initiative (Y2YCI), a collaborative non-governmental organization (NGO) with the goal of promoting large-landscape conservation in the Y2Y region (Chester, 2006; Worboys et al., 2010). The Y2Y vision is often promoted in conservation science globally (e.g., DeFries & Nagendra, 2017), yet its effectiveness has not been tested. Direct outcomes of any large-landscape conservation vision are difficult to measure, however. Our goal was to test whether the Y2Y vision contributed to five major conservation outcomes in the region.

Demonstrating proof of the impacts of conservation is challenging, and yet of growing importance in our field (Andam, Ferraro, Pfaff, Sanchez-Azofeifa, & Robalino, 2008; Ferraro & Pattanayak, 2006). Ferraro and Pressey (2015) suggest the use of counterfactuals in both space (i.e., with and without conservation) and time (pre vs. post) to measure conservation effectiveness (Ferraro & Pressey, 2015; see also Schleicher et al., 2020; Wauchope et al., 2021). The difference between observed conditions and the counterfactual conditions (in both time and space) are one potential way of measuring the impacts of conservation (Andam et al., 2008; Ferraro & Pressey, 2015; Schleicher et al., 2020; Wauchope et al., 2021). For example, analysis of the benefits of ecotourism in Himalaya compared ecotourism zones to adjacent "control" areas over time to test efficacy of ecotourism for forest conservation (Brandt, Radeloff, Allendorf, Butsic, & Roopsind, 2019). Naidoo et al. (2019) evaluated conservation effectiveness of PAs across the globe in enhancing human well-being by comparing outcomes close and far from PAs. However, to our knowledge, few studies have employed such counterfactual approaches to evaluating effectiveness of large-landscape conservation strategies. It is also noteworthy that one of the founders of the field of evaluating conservation effectiveness, Ferraro, is a business professor. The field of marketing must also wrestle to determine its impact. How can you *prove* that an advertising campaign caused sales to increase? Similar to marketing, a second key step in evaluating the success of conservation is also the degree to which conservation practices are "mainstreamed" (i.e., branded) into much broader societal sectors than a single conservation NGO that can exert a much broader influence on governance and policy (Redford, Huntley, Roe, et al., 2015). We measured "mainstreaming" of the Y2Y vision across sectors to understand such mainstreaming in affecting large-landscape conservation.

We tested whether the Y2Y vision contributed to conservation outcomes in the Y2Y region since 1993 using a temporal and spatial counterfactual approach to evaluate conservation effectiveness (Ferraro & Pressey, 2015) by (1) comparing rates of protected area gains (a) across a 25-year time-series before- and after-initiation of the Y2Y vision and (b) across space to two regions without a large-landscape vision in North America; (2) evaluating changes in area of occupancy by an endangered flagship species, the grizzly bear, in association with these changes in the U.S. portion of the Y2Y region; (3) reviewing efforts to enhance private land conservation; (4) evaluating the growth of wildlife crossing structures in the Y2Y region; and (5) examining for mainstreaming evidence for adoption of the Y2Y vision in scientific, popular media, and other large-landscape conservation initiatives.

2 | PROTECTED AREA EXPANSION

Protected areas (PAs) are acknowledged as a cornerstone of biodiversity conservation and increasing the PA estate was an early goal of Y2Y (Locke, 1994). We first compared land area within designated protected areas in December 1993 to December 2018. Two sources of data were used for protected areas within the Y2Y region: (1) for Canada, the World Database on Protected Areas (WDPA, UNEP-WCMC 2019), using International Union for Conservation of Nature (IUCN) designations Ia (Strict Nature Reserve) inclusive through IV (PA with sustainable use of natural resources) and (2) equivalent

U.S. GAP Codes 1 and 2 (PAD-US Version 2.1; see Supporting Information). Using these data, PAs within the Y2Y region (Figure 1) increased by 80.5% from 133,135 to 240,425 km^2 in the 25 years following initiation of Y2Y. The proportion protected of the Y2Y region rose from 9.7% in 1993 to 17.6% in 2018 (Figure 1 and Table 1), exceeding the Aichi targets of 17% in 2012 with the addition of 4,989 km^2 Nááts'įhch'oh National Park Reserve.

Next, we tested whether trends in PA growth changed post Y2Y using a before- after-time-series comparative approach (e.g., Wauchope et al., 2021). We compared the cumulative area in the 25-years preceding Y2Y (1968–1993) with those post (1994–2018) using generalized linear models of cumulative protected area with the key hypothesis of Y2Y as a categorical interaction with time (see Supporting Information). The top statistical model of cumulative area strongly supported the hypothesis of greater protected area accumulation following initiation of Y2Y in 1993. Protected areas grew across the Y2Y region at an average of 2598 km^2/year since 1968 ($p < 2e\text{-}16$; see Supporting Information), but, following initiation of Y2Y, this increased by 2363.3 km^2 ($p < 2e\text{-}16$) such that after 1993, protected areas grew at an average of 4961.8 km^2/year. The number of PAs also grew; from 268 new PAs during 1968–1993 versus 417 PAs during 1993–2018. And the mean size of PAs significantly grew by 56% since 1993 (from 268 to 419 km^2, $\beta_{y2y} = 151$ km^2, $p = 0.0006$). Most growth (96.6%) of PAs in Y2Y occurred in Canada (Figure 1), especially British Columbia, Northwest Territories, and Yukon Territory. In the United States, new wilderness areas such as the Boulder White-Clouds and Rocky Mountain Front drove PA growth from 1993 to 2018 (Figure 1 and Table 1).

Second, we used a spatial counterfactual approach to compare growth in PAs over the same time period in the Y2Y

FIGURE 1 Maps showing growth of protected areas (light green) in 1993 and 2018 (dark green) in the Yellowstone to Yukon (Y2Y) region

TABLE 1 Area of land within IUCN protected area categories I–IV (Ia, Ib, II, III, and IV), and corresponding US GAP status codes, in the Yellowstone to Yukon region in 1993 and 2018

Protected lands in the Y2Y region	US GAP status codes	Area in 1993 (km^2)	Area in 2018 (km^2)	Change (km^2)	Change (%)
IUCN category Ia[a]	1	949	6,582	5,633	86
IUCN category Ib[b]	1	56,299	84,143	27,845	33
IUCN category II[c]	1	75,592	146,321	70,729	48
IUCN category III[d]	2	163.5	214.5	51	24
IUCN category IV[e]	N/A	132.6	3,164	3,032	96
Total area protected		133,136	240,425	107,290	45
Proportion of Y2Y region protected		9.70%	17.55%	7.85%	

Note: The Y2Y region encompasses 1,369,947 km^2.
[a]British Columbia, NWT, and Yukon Ecological Reserves.
[b]U.S. Wilderness; Alberta Ecological Reserves, Wilderness Areas, and Wilderness Parks; and Yukon Wilderness Preserves.
[c]U.S. National Parks and National Monuments; Canadian National Parks and National Park Reserves; Alberta and British Columbia Provincial Parks; and Yukon Natural Environment Parks and Territorial Parks.
[d]U.S. National Wildlife Refuges.
[e]Canadian wildlife management areas, Indigenous habitat protection areas, and so on.

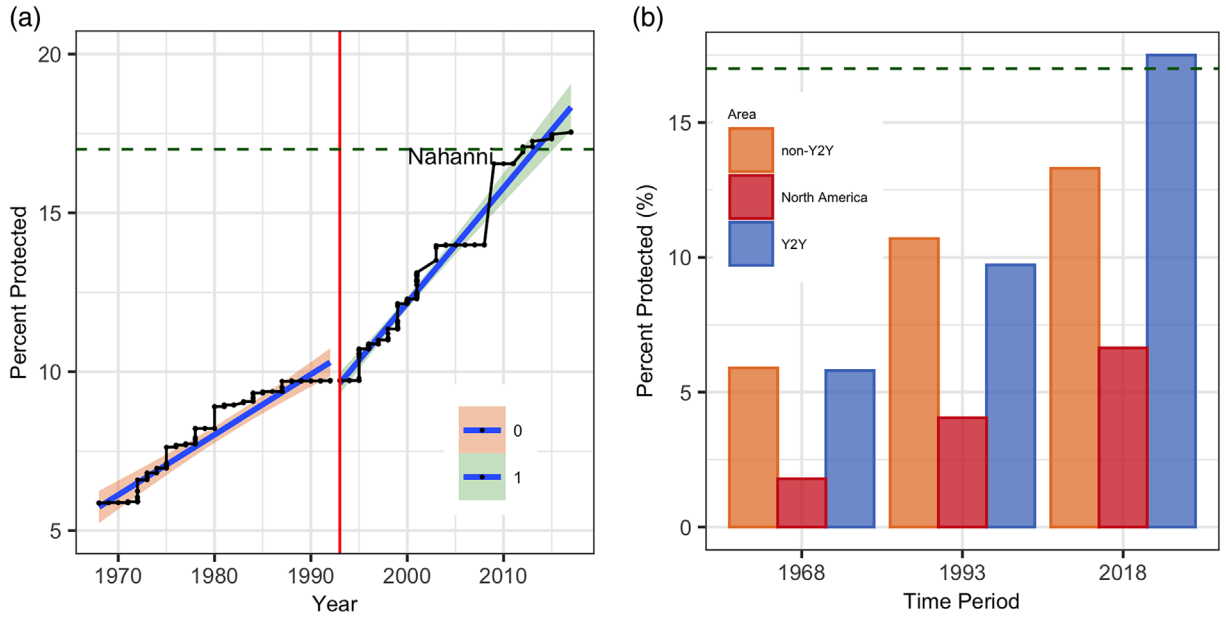

FIGURE 2 Trends in the (a) cumulative growth of protected areas (expressed as a percentage of the Y2Y region) in the Yellowstone to Yukon (Y2Y) region pre- and post-1993, when the Y2Y Conservation Initiative was founded, compared to (b) the Y2Y region (blue), the non-Y2Y portion of overlapping states, provinces and territories (red), and in North America (green) in 1968, 1993, and 2018. The rate of change of protected area growth in the Y2Y region increased after 1993

region to the non-Y2Y areas of the states, provinces, and territories with which Y2Y overlapped, but which lacked a large-landscape conservation vision. From 1993 to 2018 there was an increase of 127,093 km^2 in PAs in the 4,853,179km^2 region, a proportional increase of 2% growth from 10.7 to 13.3% (Figure 2b). This suggests it was not necessarily the concomitant opportunity to conserve large areas present in mountainous regions alone (which were prevalent in both the Y2Y and adjacent overlapping region) driving the higher rates in the Y2Y region.

In a third spatiotemporal counterfactual comparison, we compared rates of change of IUCN I–IV Protected Areas in North America (Figure 2b). PA growth was similar between the 25 years pre- and post-Y2Y, ~2.5% in each period, in contrast to the increasing trend in the Y2Y region (Figure 2b). Recent studies using a broader

definition of PAs (e.g., including United States Forest Service, USFS lands) show a ~45% decline in PA expansion in North America since 2000, opposing trends within the Y2Y region (Brooks, Akakaya, Burgess, et al., 2016; IPBES, 2018) (Figure 2b). Our counterfactuals suggest Y2Y initiation was correlated with accelerated PA growth only in the Y2Y region (Figure 2). By 2018, the Y2Y region had protected at least 17.6% of the terrestrial area, exceeding the Aichi target. Trends since 2018 suggest continued growth in PAs in the Y2Y region, with signed commitments to create three new PAs; the Peel Watershed in the Yukon (55,850 km^2), and two Indigenous-led Protected Areas in British Columbia, Qat'Muk (~2,111 km^2), and an Endangered caribou (*Rangifer tarandus*) Protected area (~9,173 km^2). With completion of these three new PAs, the proportion of the Y2Y region protected would exceed 22%.

We next highlight several case studies of PA expansion to illustrate Y2Y's contribution to PA growth. First, the 64,000 km^2 Muskwa-Kechika Management Area (MKMA) in northern British Columbia created in 1997 (Figure 1). The MKMA was negotiated through a multi-stakeholder group appointed by the BC government (Sawchuck, 2009), two members of which had previously co-founded Y2Y in 1993. The large-landscape vision of Y2Y was explicitly integrated into the MKMA policy (Sawchuck, 2009). Y2Y also had a direct influence on the creation of four provincial parks in Alberta, Bow Valley (32.87 km^2), Spray Valley (254 km^2), Castle (25.5 km^2), and adjoining Castle Wildland (79.6 km^2).

The next most significant gain was the expansion of Nahanni National Park Reserve in Canada's Northwest Territories from 4,766 km^2 (founded in 1972) to 30,050 km^2 in 2009. The expansion encompasses the range of ~500 grizzly bears, two caribou populations, and significant biodiversity and cultural values (Weaver, 2009). A major narrative of the broad public campaign was Nahanni lay at the intersection of the Y2Y region and Canada's boreal forest (Nelson, 2017). Canadian Parks and Wilderness Society (CPAWS) commissioned Y2Y co-founder Locke on the campaign, who helped negotiate the bill's passage through Parliament (Nelson, 2017). Certainly, the Nahanni expansion would not have occurred without leadership of the Dehcho First Nation, the Federal governments, WCS, CPAWS, and many other conservation partners. The Y2Y vision also helped inspire the creation of the adjoining 4,898 km^2 Nááts'įhch'oh National Park Reserve (National Geographic, 2016).

3 | PRIVATE LANDS CONSERVATION

These gains in protected areas in the Canadian portion of the Y2Y region (where the bulk of lands are public) have been mirrored by gains in private land conservation, which are especially important in the U.S. portion of the Y2Y region. Quantifying rates of change in private land conservation easements is a huge challenge over the geographic scope of Y2Y, however (see Williamson et al., 2021 that demonstrate the challenges in just a small U.S. portion of the Y2Y region). Instead, we illustrate this with two case studies focused on restoring grizzly bear connectivity.

The first case involves private land conservation along the Elk River in British Columbia, negotiated between Y2Y and the private forestry company Tembec and then passed to the Nature Conservancy of Canada (NCC; Konstant, Hannah, & Locke, 2005). Y2Y raised >$4 million of the $5.3 million-dollar project cost. Over the next 10 years, Y2Y worked in cooperation with the Transborder Grizzly Bear Project (Proctor, Kasworm, Annis, et al., 2018), NCC, and the Nature Trust of BC to make additional strategic private land purchases for grizzly bear connectivity along Highway 3 in British Columbia (Locke & Francis, 2012). On the U.S. side of the border at the Yaak-Kootenai River confluence in Montana along Highway 2, Y2Y, and Vital Ground Foundation engaged in similar private land conservation (Locke & Francis, 2012). Y2Y also worked with the Trust for Public Land to frame the rationale for $11 million that secured easements on 11,331 ha of Stimson Lumber lands around the Yaak River confluence (Locke & Francis, 2012; Reece, 2012). The Y2Y vision also helped inspired the Montana Legacy project which focused on restoring connectivity between the Northern Continental Divide Ecosystem and the Selway-Bitterroot, among other goals (J. Williams, The Nature Conservancy (TNC), personal communication). This involved the purchase by TNC and Trust for Public Land of 130,000 ha of Plum Creek Timber lands, at $490 million, perhaps the largest private land conservation transaction in U.S. history (Wikipedia, 2019). These case studies demonstrate significant private land conservation in support of the Y2Y large-landscape conservation vision.

4 | GRIZZLY BEAR RANGE EXPANSION AND LAND CONSERVATION

Next, we examined correlations between land conservation in the U.S. and the range of Y2Y's flagship species, the grizzly bear. Grizzly bears are known for their wide-ranging behavior and vulnerability to conflict with humans (Lamb, Ford, McLellan, et al., 2020). Recent analysis (Steenweg, 2016) has borne out early conservation theory that grizzly bear conservation would have umbrella benefits for biodiversity (Noss, Quigley,

Hornocker, Merrill, & Paquet, 1996). When the Y2Y vision was articulated, in the United States, grizzlies numbered less than 400 in the three recovery zones of NCDE, the Greater Yellowstone Ecosystem (GYE), and the Cabinet-Yaak Ecosystem (CYE) and were listed as threatened under the U.S. Endangered Species Act. In June 2018, grizzly bears in all three ecosystems numbered at least 1,700 in large part due to coordinated recovery-driven management and monitoring by many agencies, and the GYE population was proposed for delisting, though a court case reversed the decision (Crow Indian Tribe (Plaintiffs) vs. US et al., 2018), in part, because of concerns over connectivity between recovery zones (USFWS, 2009).

We examined changes in land protection categories within the ranges of all three grizzly populations between three periods for each population: from 1980 to 1989 (1990s), 1990 to 2000 (2000s), and 2000 to 2014 (2010s: see Supporting Information). Occupied grizzly bear range in the United States more than doubled between 1990 and 2014, from 53,130 to 119,515 km^2 (Figure 3). As grizzlies expanded, the proportion of their range occurring on PAs declined from 70 to 45%, whereas the proportion of unprotected lands occupied by bears increased from 5 to 41% (Table S3). Thus, while protected areas still form the core of grizzly range (Figure 3 and Table 1), unprotected public and private lands are increasingly essential (Proctor et al., 2018). This highlights the important role of PAs in anchoring the past expansion, but also the key role of enhanced bear–human conflict reduction on private lands, work furthered by many Y2Y partners (see below definition; Lamb et al., 2020) and fostering increased connectivity between recovery units in the future (Crow Indian Tribe et al. (Plaintiffs) vs. US et al., 2018). Reducing human–wildlife on private lands and enhancing connectivity are core tenants of the Y2Y vision and indeed, large-landscape conservation (e.g., Hilty et al., 2020).

5 | WILDLIFE ROAD CROSSINGS

A major challenge to increased connectivity between PAs is the network of road, rail, and energy infrastructure that fragments the Y2Y region. Collisions between vehicles and wildlife are a major source of wildlife mortality and population fragmentation (Beckman, Clevenger, Huisjer, & Hilty, 2010). We collected information about wildlife overpasses, underpasses, and exclusionary fencing associated with highways in the Y2Y region (Table 2). The Y2Y vision helped inspire the construction of the first highway crossing mitigation for large carnivores on the Trans-Canada Highway in Banff National Park (Beckman et al., 2010; Worboys et al., 2010). In the United States, the Confederated Salish and Kootenai tribes sought Banff-like crossing structures when Highway 93 was upgraded through their reservation in Montana, which are now the most extensive system of highway crossing structures in the United States (Huijser et al., 2016).

While other examples of wildlife crossing structures exist worldwide, the Y2Y region now boasts the world's most extensive system of highway-crossing structures designed for wildlife connectivity (Table 2). There are at least 107 wildlife crossing structures facilitating connectivity across 169 km of highway in the Y2Y region (Table 2). The most iconic are the fencing, six overpasses, and 38 underpasses for wildlife along an 80 km stretch of the Trans-Canada Highway through Banff National Park, which represent the highest density of crossing structures in the globe (Beckman et al., 2010). Monitoring for >15 years demonstrated the effectiveness of these structures for enabling wildlife movement including grizzlies (Sawaya, Kalinowski, & Clevenger, 2013) and reducing wildlife-vehicle collisions by more than 90% (Beckman et al., 2010). In 2020, announcements were made by provincial governments for two more wildlife crossing structures in connectivity pinch-points in Alberta's Bow Valley and BC's Elk valley, continuing the growth of wildlife road crossings in the Y2Y region. The Y2Y region has become a global model for green infrastructure to reduce fragmentation and foster connectivity.

6 | MAINSTREAMING

Establishing whether the Y2Y vision had any contribution to these conservation trends is challenging. Mainstreaming conservation science can be defined as the process of integrating conservation science into broad sectoral institutions relevant to conservation governance (Redford et al., 2015). We evaluated mainstreaming evidence of the Y2Y vision since 1993 across (a) scientific citations, (b) uptake into social and popular media, (c) growth of collaborating organizations in the vision, and (d) influence on philanthropic funding for conservation being directed toward large-landscape conservation in the Y2Y region.

The first metric we assessed was the growth of the Y2Y vision in the scientific literature by updating a previous literature review (Chester, 2006; see Supporting Information for details). We found 275 records, 67 books, 44 Book chapters, 32 Reports, 26 Y2YCI Reports, 98 Scientific Journals, and 8 graduate theses, evidence of growing scientific influence of Y2Y (Figure S2). The recent IUCN connectivity guidelines were co-authored by Y2Y staff scientists and featured Y2Y as an example of

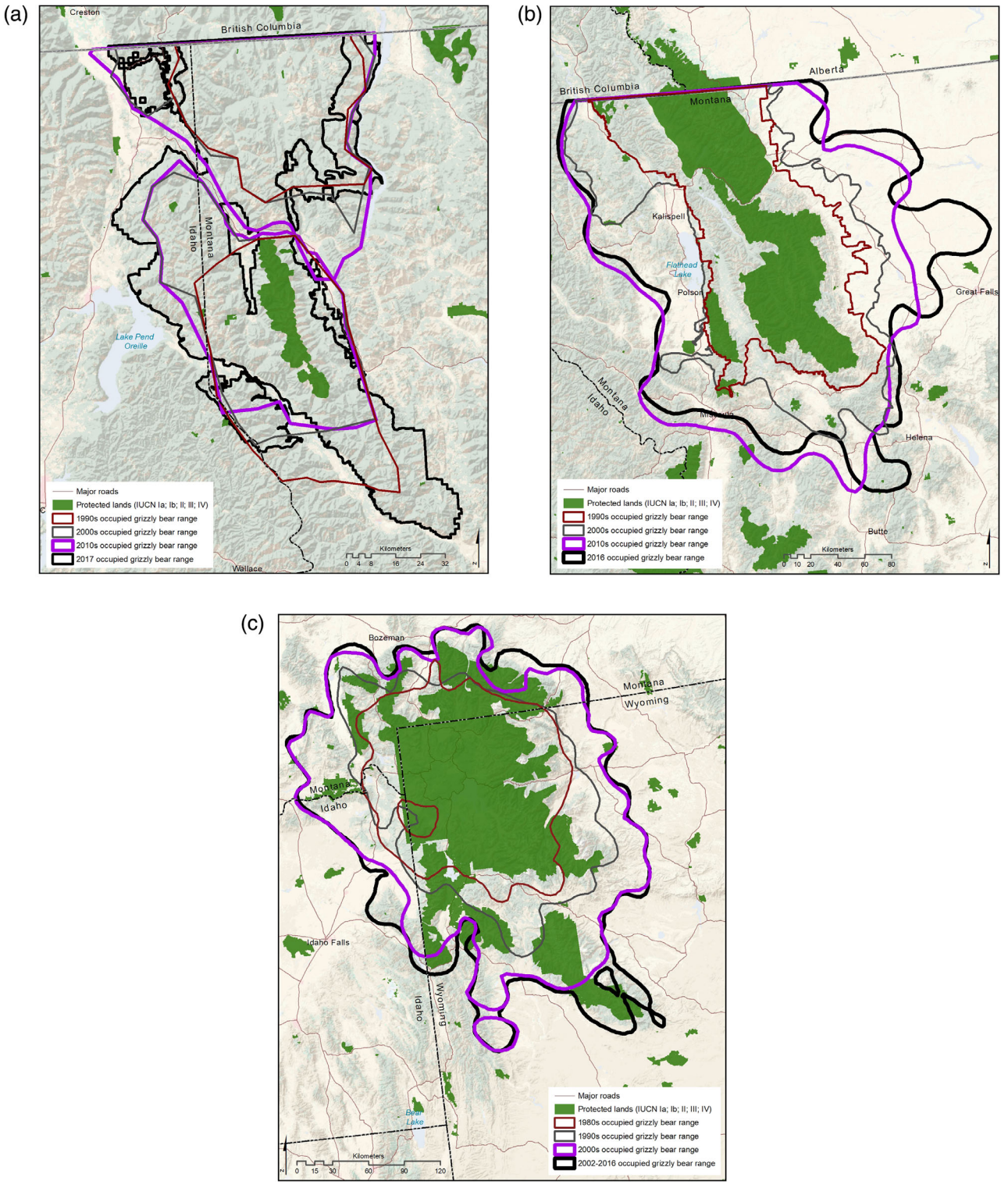

FIGURE 3 Change in the distribution of grizzly bears (*Ursus arctos*) in the Cabinet Yaak Ecosystem (2a), Northern Continental Divide (2b), and Greater Yellowstone (2c) from the 1900s (purple outline) through the 2000s (brown outline) to 2014 (black outline)

large-landscape conservation (Hilty et al., 2020). We did not exhaustively review popular media. However, five examples of high-profile mainstreaming in popular media are illustrated in Figure 4, including TV shows Grey's Anatomy and the West Wing, and the PBS NOVA program Wild Ways: Corridors of Life.

TABLE 2 Existing wildlife road-crossing projects in the Y2Y region (note this is a list of only the known major road mitigation projects in the region; there are many other smaller projects consisting of fencing and/or culverts and/or signage)

Location	Length of fencing mitigation (km)	# of overpasses	# of underpasses
Trans-Canada Highway, Banff National Park, AB (*25*)	82	6	38
Trans-Canada Highway east of Canmore, AB (*40*)	3	0	1
Highway 93, Kootenay National Park, BC (*41*)	15	0	9
Highway 3, southern Alberta (*42*)	1.5	0	1
U.S. Highway 93, MT (*43*)	14	1	41
U.S. Highway 200, MT	12	0	2
I-90 at Bozeman Pass, MT (*44*)	2	0	1
U.S. Highway 191 near Pinedale, WY (*45*)	49	2	6
Waterton Lakes National Park (salamander crossings)	0.8	0	4
Yoho National Park	3.4	1	4
Total	183	10	107

Note: There were zero wildlife crossing projects in the region in 1993.

Next, we report on the number of partner organizations collaborating with Y2Y since its inception in 1993 as another measure of documenting mainstreaming. Since 1993, the Y2Y organization has collaborated with more than 450 partners (see Table S4), emphasizing the critical collaborative nature of large-landscape conservation (Guerrero, McAllister, & Wilson, 2015). Partner organizations are defined as organizations who either received financial support from Y2Y, contracted with Y2Y to implement conservation actions, participated in a collaborative conservation plan or project, or supported the Y2Y vision and identified themselves publicly as a Y2Y partner. Furthermore, the Y2Y vision inspired philanthropic resources and programs in foundations that may not have otherwise been available after 1993. Since 1993, this resulted in the infusion of at least $47 million in additional funding to support conservation actions within the Y2Y region.

A concrete example of the conservation impact of such funding is the highway crossing structures in Banff National Park. Parks Canada funded their construction, and initial monitoring but then curtailed subsequent funding for long-term monitoring (Beckman et al., 2010). Woodcock, Wilburforce, and Kendall Foundations all continued funding these studies based on their importance to large-landscape conservation. The results of such long-term monitoring have clearly demonstrated their effectiveness and have informed highway crossing structure actions across the globe (Beckman et al., 2010). This illustrates large-landscape conservation is most effective when both bottom-up and top-down policy support exists (Chester, 2015; DeFries & Nagendra, 2017), and that mainstreaming the Y2Y vision has helped support large-landscape conservation through Y2Y and beyond.

7 | OTHER LARGE-LANDSCAPE INITIATIVES

To propose a large-landscape conservation vision such as Y2Y was largely experimental in 1993. Y2Y itself was at least partially inspired by an even earlier large-landscape initiative, the Paseo de Panthera, now the Mesoamerican biological corridor. Yet there have been few assessments of their efficacy. Y2Y has since become a global model for broadening conservation from protected areas to landscape-level conservation (Nature (editorial), 2011) and has inspired other similar large-landscape conservation initiatives. Two Countries One Forest and Algonquin to Adirondacks in eastern North America, the Great Eastern Ranges in Australia, and Baja to Bering are a few examples of other large-scale initiatives that attribute their inspiration, at least in part, to Y2Y (Worboys et al., 2010).

8 | DISCUSSION

Our counterfactual analysis and recent global syntheses (Hilty et al., 2020) provide good evidence that large-landscape conservation can help enhance area-based biodiversity targets. Despite the significant growth in protected areas to >17% of the Y2Y region, the globe's highest numbers of wildlife crossing structures (117 and growing), and the expansion of endangered U.S. grizzly bear populations, there remains much conservation to be done in the Y2Y region. Recent studies emphasize the need for greater area-based biodiversity conservation targets post-Aichi such as the 30% by 2030 initiative recently adopted by the IUCN (Burkart, 2021). Despite range

FIGURE 4 Successful conservation often requires conservation science to be effectively "mainstreamed" into public consciousness as part of the policy process. Examples of successful mainstreaming of the Yellowstone to Yukon large-landscape vision into popular media including (a) the successful PBS-NOVA Wild Ways documentary, (b) being featured in a poster in the TV series Grey's anatomy, (c) the Yellowstone to Yukon art celebration at the Jackson Hole Wildlife Art Museum featured in Images West, (d) a special issue of National Geographic Destinations dedicated to the Y2Y region, and (e) a recent issue and article in Canadian Geographic Parks issue focusing on Yellowstone to Yukon

expansion, the GYE's grizzlies are still isolated from protected areas further north, and the Cabinet-Yaak subpopulation has not expanded into the unoccupied Selway-Bitterroot recovery unit as required under the USFWS recovery plan. In Canada, Mountain caribou populations are declining due to unsustainable oil and gas development and/or forestry outside of protected areas (Ray et al., 2015). Further understanding of private land conservation success and challenges in the southern portion of Y2Y is critical given the pressures on private

land development. Despite these exceptions, the Y2Y region remains among the last bastions of large mammal diversity in North America (Laliberte & Ripple, 2004), and large-landscape scale conservation represents among our best strategies for its future.

Attributing cause and effect in any conservation strategy, however, is challenging (Ferraro & Pattanayak, 2006; Wauchope et al., 2021). Our spatiotemporal counterfactual time-series and spatial approach illustrates that since the inception of the Y2Y vision in 1993, protected areas and other conservation measures have increased significantly and efforts to increase safe wildlife movements across highways now lead the globe. Our counterfactual framing highlights the accelerated conservation gains made in the Y2Y region (Figure 2b) despite constant or stagnating growth of protected areas in adjacent regions of North America (Brooks et al., 2016; World Bank, 2017). Many of the advocates for these increased conservation actions have been among the >450 explicit conservation partners of Y2Y (Guerrero et al., 2015). And evidence of mainstreaming of the Y2Y vision in scientific and popular media supports the effect of Y2Y on conservation in the region and globally. This provides good evidence that the Y2Y vision contributed to enhanced growth in protected areas to >17% of the Y2Y region since 1993. Collectively, our results suggest large-landscape conservation strategies can promote growth of protected area networks globally and help achieve enhanced area-based conservation targets.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

W. Francis, H. Locke, J. Hilty, and M. Hebblewhite conceived of the ideas. W. Francis, G. Kehm, S. Williams, and M. Hebblewhite collated and analyzed data for this analysis. M. Hebblewhite, W. Francis, and J. Hilty lead manuscript writing, and all authors contributed to previous drafts of the analyses, presentation of results, and approved the final version for publication.

DATA AVAILABILITY STATEMENT

All data compiled here on protected areas are included as a Supporting Information file y2ydata.csv, and United States Government sources for data for grizzly bear range expansion are also provided in Supporting Information.

ETHICS STATEMENT

All ethical guidelines were followed in the conduct of this research; as no new data were collected, and we used only existing datasets, no research permits, animal care review, etc. were required.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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