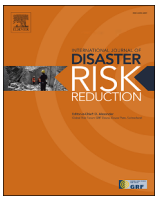
International Journal of Disaster Risk Reduction 113 (2024) 104827

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr



Multifaceted economic impacts of a 500-year flood on gateway communities of Yellowstone National Park

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ARTICLE INFO

Keywords:
Flood
Ecotourism
National park
Visitation
Small business
Tourism marketing

ABSTRACT

Disasters can have dramatic implications for gateway communities of National Parks, especially local economies that rely on park tourist visitation as their primary source of income. In June 2022, a 500-year flood event impacted Yellowstone National Park (YNP) and gateway businesses, both directly through infrastructure damages (property loss) and indirectly through park closures and post-disaster marketing. We used a combination of approaches to document and explore the relative importance of these diverse sources of economic impacts. First, structured surveys were used to evaluate economic impacts, from the perspective of individual business owners and community leaders in six gateway communities surrounding YNP. Average revenue loss was 48 % during peak tourist season across all communities but averaged 75 % for communities inaccessible to the park. Direct infrastructure damages to businesses were localized; however, even businesses sustaining property losses suggested more severe economic impacts were the result of loss of visitors from park closures and damaging media coverage. Using annual visitation and economic input-output model data, we developed a statistical model to estimate regional economic impacts from the flood. The model corroborated the results of our survey and suggested the flood led to a total loss of $156 million in visitor spending in gateway areas in 2022, exceeding economic losses from the COVID-19 pandemic in 2020. We present some guidelines for building economic resilience in gateway communities, including diversifying sources of income, building social capital, embracing tourist adaptations, and developing coordinated park-gateway-regional messaging and marketing to the media post-disasters.

1. Introduction

Globally, protected areas receive 8 billion visitors per year and generate US$850 billion (2014) in total economic expenditures and consumer surplus [1]. These economies are critical for local tourism-based communities dependent on protected area operations (e.g., Ref. [2]). Likewise, United States (U.S.) National Parks are vital to local economies, especially their proximate gateway communities. National Parks have been described as “economic engines for local communities”, supporting 252,000 jobs nationwide [3]. The National Park Service (NPS) manages 424 individual units covering over 340,000 km^2 in all 50 states and U.S. territories [4]. In 2022,

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https://doi.org/10.1016/j.ijdrr.2024.104827
Received 24 May 2024; Received in revised form 2 September 2024; Accepted 14 September 2024
Available online 19 September 2024
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the NPS estimated that almost 312 million people visited parks and spent $23.9 billion in gateway communities, leading to $50.3 billion in economic output to the national economy ([5]).

Given the critical co-dependency of local and regional communities on protected areas, disasters in parks can have dramatic implications for proximate economies. These highly localized, tourism-based economies can be "fragile" and risk-prone, due to their reliance on singular sources of income, making them vulnerable to changes in park operations [6,7]. Indeed, this was clearly demonstrated during the COVID-19 pandemic, where limited access to protected areas in South Africa led to 96 % losses in recreational visits and 90 % losses in tourism revenue [6]. Visitation to U.S. National Parks dropped 87 % during COVID-19 and created burdens for park management, including altered park operations, reduced staff, and decreased park revenues [8]. The global tourism industry experienced a loss of $4.7 trillion USD from global GDP and a loss of 174 million tourism jobs due to the pandemic [9].

Compared to other tourism-based economies, however, gateway communities may not respond predicably to disasters. Indeed, these areas may not experience diminished tourism because of complex interactions between park operations and tourist behavioral adaptations [10]. Depending on the significance of the hazard, studies have reported both measurable losses ([11]; [12]; [13]) as well as little-to-no effects [14–16] on visitation and economic impacts. For example, in some cases, wildfire occurrence led to reductions in visitation and measurable economic losses in gateway areas [11,13], whereas in other cases, park operations and tourist adaptations (i.e., driving further to open entrances) led to unnoticeable economic impacts [15,16]. Seemingly, the most critical factor influencing visitation and economic impacts is related to restricted park access, such as complete or partial park closures [8,17].

Aside from the potential impacts of reduced tourism, gateway communities, like other naturalized tourist destinations, are also exposed and vulnerable to hazards [18–20] and can experience a range of "traditional" economic losses (for a review, see Ref. [21]). Here, we define "traditional" impacts as generic categories of economic losses typified by any tourism destination experiencing a disaster, not just those proximate to National Parks. Traditional economic losses can occur through both direct and indirect pathways [22]. Direct losses include damages or destruction to infrastructure [23], labor shortages [24,25], or supply chain disruptions [26], whereas indirect losses can occur via diverse and systemic pathways, such as post-disaster marketing challenges and failures [18,20,27] or inadequate social capital and community inter-connectedness [28–30]. Chang et al. [31] report that small businesses oriented towards local customers, especially those within communities experiencing widespread impacts, tend to be the most vulnerable to economic impacts of disasters. These characteristics are epitomized by national park gateway communities, comprised of small businesses situated proximate to highly naturalized areas where human-built infrastructure, such as accommodation services, are highly exposed to extreme climate events ([18]; [32]). However, most studies of disasters within gateway regions, have focused almost exclusively on the influence of park-related visitation since this encapsulates the predominant source of tourism revenue [8,17], rather than the impact pathways more commonly documented in disaster-response literature [21,31].

As with most disasters, economic impacts are multifaceted [21] and depend on context [31]. This is especially true in the case of gateway communities where quantifying and characterizing the impacts of disasters on local economies, specifically elucidating the multifaceted impacts on small businesses, is critical to plan for future economic resilience and disaster preparedness [33]. Commonly documented hazards for U.S. National Parks, especially those in the Intermountain West, include wildfire [15,16], drought ([14]; [12]), and extreme heat ([12]; [34]). In recent years, riverine flooding impacts to visitation in U.S. National Parks are far less documented compared to wildfire events (but see Ref. [35]), although coastal flooding is a rising concern (e.g., Ref. [36]). Yellowstone National Park (YNP), in particular, has been no exception to disasters from wildfire [11] to climate extremes ([12]), the COVID pandemic [8], and most recently, a monumental flooding event that reshaped the northern portion of the park [37]. YNP sustains over four million visitors annually, generating 8736 jobs and $834 million of benefits to the surrounding region's economy [38]. During June 2022, a >500-year flood event [39,40] was spread across Southwest Montana and Northwest Wyoming, destroying or damaging buildings, roads, and utility services within YNP and gateway communities [41–44]. Although much of the physical impacts of flooding to gateway communities were ameliorated within a few weeks, entire sections of roads and bridges within YNP sustained heavy damages with some sections completely obliterated, cutting off access to the entire northern portion of the 890,000-ha park from the northern gateway villages [37,44,45]. YNP completely closed for over one week during the peak season, then partially opened allowing access from some gateways, but not others [44]. The locations and duration of park closures were expected to affect gateway communities disproportionately. Apart from park closures, businesses could have also experienced economic losses through physical damages to assets and workforce reductions [46].

The compounding stressors following the Yellowstone flood provides a unique case study to document the relative importance of the diverse direct and indirect economic impact pathways to small businesses in gateway communities following disasters. Herein, we used a multi-pronged approach to comprehensively document and explore the direct and indirect economic impacts, at the scale of both individual businesses and the entire gateway region. Specifically, we questioned the relative role of park operations and tourist adaptations versus the traditional disaster-impact pathways, including infrastructure damage, workforce loss, or marketing issues prevalent in other tourist destinations. Documenting the economic impacts of disasters are commonly achieved via surveys from the perspective of individual business owners [47,48]; however, community-level perspectives, especially from non-traditional sources, can also provide insightful information on recovery and social capital [49]. Hence, the first prong of our approach relied on a series of structured surveys, one set customized for individual business-owners and a second for community leaders, such as chamber of commerce executives or town mayors, to determine the leaders' awareness and accuracy of issues facing businesses, as a measure of social capital and connectivity. To understand longitudinal shifts in perspectives, we compared business surveys immediately following the flood to those almost three months following the event. However, surveys may fail to comprehensively capture the magnitude of economic losses, in which case economic models are used. In the second prong of our approach, we estimated system-wide economic impacts using statistical models linking national park visitation to regional visitor spending and economic output data. This approach

not only provided a regional estimate in economic losses due to diminished park visitation, but also a secondary validation of business revenue losses due to lower customers relative to other sources of economic losses (e.g. infrastructure damage).

2. Methods

2.1. Background

Yellowstone National Park (YNP) has five entrances, each associated with gateway communities (Fig. 1). On June 12, 2022, over two inches of rain fell within YNP and neighboring areas, escalating rates of snowmelt and leading to unprecedented flooding in rivers throughout the region, infrastructure damages, and losses to utility services. Landslides and rising flood waters led to the immediate closure of YNP and evacuation of more than 10,000 visitors. Due to proactive decisions by emergency responders, there were no mortalities from the flood within YNP and across the entire region. Although much of the impacts of flooding to roads in the communities outside YNP were ameliorated within a few weeks, large portions of the Northern Road and Northeastern Road entrances, along the Gardiner and Lamar Rivers within YNP, respectively, were completely severed, cutting off access of YNP from the northern gateway villages of Gardiner, Cooke City, and Red Lodge, Montana. The entire park closed on June 13, 2022, and remained closed until only the southern portion of YNP was opened under an alternative license plate system from the west, south, and eastern gates on June 22. The northern loop of the park was reopened on July 2; however, the northern and northeastern road entrances remained closed, continuing to disconnect northern gateway communities. To avoid extended closures and ameliorate economic impacts to the surrounding region, the National Park Service (NPS), with the aid of $50 million in emergency funds from the Federal Highway Administration, rapidly engaged on an ambitious road construction project to build a new Northern Road and repair the Northeastern Road [37]. The roads were finally opened in October and November 2022, which is typically the end of the primary tourist season for the YNP gateway communities. Even though YNP experienced closures from past climate-related disasters, 2022 was the first time that all five entrances to YNP were forced to close since a set of large fires in 1988 [50]. However, these past events do not share the modern context of visitation volumes, growth in gateway communities, and investments in infrastructure.

2.2. Federal Reserve Bank of Minneapolis (FRB MN) survey

Directly following the flooding in June 2022, the Federal Reserve Bank of Minneapolis (FRB MN) conducted a survey of small businesses in Southwest Montana to assess the direct economic impact of the physical impacts, revenue losses, and community needs associated with flooding [46]. Through the FRB MN's Community Development and Engagement Program, supported by the U.S. Community Reinvestment Act, the survey was aimed at providing data analysis in support of labor and housing policy evaluations for impacted communities in their district. The survey was structured towards identifying the traditional economic impacts, particularly damages to property and assets, supply chain disruptions, staffing and labor shortages, and the financial status and outlook of each business. Similar to our approach, the FRB MN leveraged community partners (e.g. chamber of commerce, community foundations) to disseminate the survey and solicit responses. The survey provided a valuable template for drafting a subset of questions and to support a comparison of the longitudinal analysis of changes in small business perspectives over time following the flood. However, the FRB MN did not ascertain the importance of YNP park and its operations relative to the direct impacts of flooding on gateway businesses. Additionally, the FRB MN survey was focused solely on Southwest Montana, with respondents from at least seven counties, some of which were outside the gateway region, and did not consider gateway villages in Wyoming.

2.3. Direct and indirect economic impact survey

Our survey was aimed at assessing the direct impacts of the flooding in comparison to the indirect impacts, specifically YNP operations and closures, on the ecotourism business economy of six focal gateway communities, each situated outside of the park's five entrances: West Yellowstone, Montana (outside the west entrance), Jackson, Wyoming (south entrance), Cody, WY (east entrance), Cooke City, MT and Red Lodge, MT (Northeast entrance), and Gardiner, MT (North entrance) (Fig. 1a–Table 1). As our team navigated among these communities, other non-focal communities were also briefly visited including Bozeman, MT, Driggs, ID, and Victor ID (Fig. 1a). The businesses of these gateway communities are largely supported via ecotourism, which primarily includes lodging, restaurant/food, retail, and recreation; however, respondents representing other business sectors were included (Fig. 1b). Many businesses in the region are combinations of multiple economic sectors (e.g., lodging and restaurants).

All questions and optional response categories are provided in Tables S1–S2. Compatible questions between the FRB MN survey and our efforts are noted. Questions attempted to differentiate the direct effects of the flood from the indirect effects of park closures and operations. Like the FRB MN survey, we documented direct impacts by assessing the degree of direct physical impacts, such as losses in assets and supply chain issues from dysconnectivity of roads, as well as the perspectives of businesses as to their financial status and outlook. Additionally, we documented indirect impacts by evaluating the importance of YNP to each business, the peak timing of visitors and revenue to each community, and the magnitude and timing of revenue losses associated with both the flood and park closures.

Questions were issued via two web-based surveys, a business and community-level questionnaire, to assess and understand the nature of economic impacts on businesses and perspectives from community leaders, respectively. Community-level surveys were conducted to assess social capital, i.e. ascertain how well community leaders understood the nature and diversity of problems faced by businesses. Prior to issuing surveys, we contacted the chamber of commerce (COC) in each community to identify businesses, facilitate community participation, and serve as a centralized point of communication to businesses to circulate online surveys. The chamber representatives, along with community leaders they selected, were targeted as respondents for the community-level survey. We also inventoried all businesses using Google and Open-Street Maps.

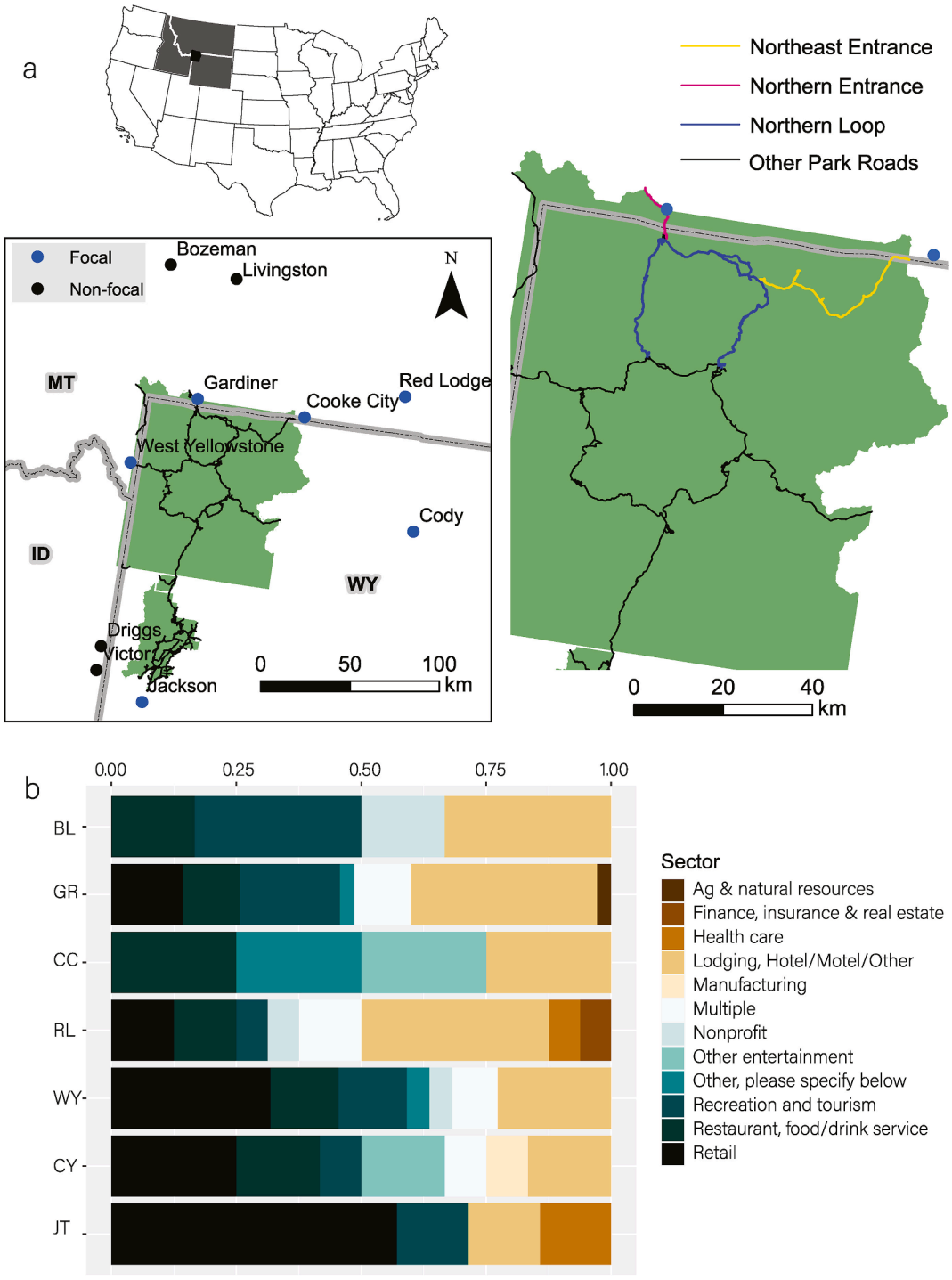

Fig. 1. a) Map of Yellowstone National Park Gateway region. Green area is boundary of Yellowstone National Park and surrounding focal and non-focal gateway communities. Major park roads are depicted at right. b) Stacked bar plot of economic sectors identified by business respondents in each community. Community codes are provided in Table 1. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Online surveys were first circulated via email to the respective chambers of commerce on September 4, 2022. During September 9–16, 2022, our team visited businesses in person and solicit responses to surveys. All gateway communities have a centralized downtown where businesses are aggregated. Each town was partitioned into sections, and a team member was assigned to a section. The team member asked for the manager, or if unavailable, spoke with the onsite representative to see whether they felt confident in responding to questions about the status of the business. Each survey required reading a preamble providing information about the sur-

Table 1
Distribution of regions (according to groups of zip codes) and business visited during the economic survey. Numbers of business respondents versus business contacted within each region are used to calculate response rate. Respondents to the community survey are also included.

State	Zip Group Region (Abbrev).	Zip Codes	Businesses contacted	Business respondents	Response Rate (%)	Community respondents
MT	Bozeman-Livingston (BL)	59034, 59047, 59718	5	4	80.0	1
WY	Cody (CY)	82414	49	8	16.3	13
MT	Cooke City (CC)	59020, 59081	16	3	18.8	0
MT	Gardiner (GR)	59027, 59030, 59065	38	29	76.3	1
WY, ID	Jackson-Teton (JT)	83001, 83002, 83420, 83422, 83455	75	6	8.00	4
MT	Red Lodge (RL)	59068	56	12	21.4	4
MT	West Yellowstone (WY)	59758	51	15	29.4	1
WY	Yellowstone National Park (YNP)	82190	1	1	100	1
MT	Other	59011, 59070	0	0	0	2

vey and contact information. Respondents were then asked if they would prefer to fill out the survey with the team member. If not, an information flier with access to the survey was left with the business representative. In cases where surveys were not filled out in-person, our team contacted businesses during the subsequent weeks via phone calls and email to re-solicit responses. Our survey response period closed on November 1, 2022.

Our survey and methodological approach were reviewed and approved by Baylor's Institutional Review Board (Project 1944825-1]. We conducted a comparison of the FRB MN results with our study to understand commonalities in responses across the broader Yellowstone region, but also assess how perspectives might have changed longitudinally over the tourist season. We also compared the results of the business and community-level surveys to determine the strength of association (or compatibility) between the two (Supporting Information). Finally, we amassed the open-ended responses to synthesize emergent factors that our survey was not necessarily structured to capture. We grouped these responses according to natural themes of response types.

2.4. Systemic impacts to local economies

To estimate the economic impacts of the 2022 flood to the entire gateway region, we developed two sequential statistical models, the first to predict annual recreational visitors over time and the second to predict annual economic activities, including visitor spending and total economic output, based on visitor counts. Visitor spending and total economic output was obtained from the National Park Service Visitor Spending Effects Report [51], specifically total annual estimates (2012–2022) associated with the YNP gateway region. Visitor spending includes the direct effects of park visitation, such as direct purchases from local gateway businesses, whereas economic output includes the additional indirect and induced effects of visitor spending on the gateway region [5]. Indirect effects include the purchase of supplies or inputs to the immediate businesses, whereas induced effects refer to the subsequent purchase of goods and services by employees of businesses or input suppliers [5]. Determining economic effects requires establishing a local gateway region, which are typically defined by NPS staff as the set of counties surrounding each park that include towns and cities visited by park visitors ([52]). In the absence of this information, gateways were considered, by default, all counties within a 100-km radius of the park. Visitor spending is estimated from park visitation counts partitioned into visitor spending profiles and lodging categories, both of which are estimated from visitor socioeconomic surveys ([53]; [52] [54]). Economic output, inclusive of secondary effects, relies on regional economic multipliers derived from IMPLAN Pro Version 3.0 software. IMPLAN is an input-output economic model that tracks all transactions between sectors and between industries and institutions based on general equilibrium models (https://implan.com/). Visitor spending effect model categories were first mapped to IMPLAN sectors, and then regional multipliers were obtained using county-level IMPLAN models for the gateway counties of interest [5]. An important note is there is considerable uncertainty in applying proportions of visitor spending profiles to visitor counts, as well as the estimates of regional economic multipliers.

Building the sequential models relied on gathering economic and visitation data from YNP as well as other neighboring parks or parks of comparable popularity (based on visitation statistics), including Grand Teton, Rocky Mountain, Glacier, Bryce Canyon, Zion, Grand Canyon, Yosemite, Acadia, and Great Smoky Mountain. As Grand Teton was proximate to YNP (south entrance), we considered Grand Teton to share similar, but less extreme impacts. Visitor count data were obtained from National Park Visitor Use Statistics [55] within the Integrated Resource Management Applications (IRMA) Portal. Visitor counts were modeled as a Poisson distribution in a generalized linear mixed model (GLMM), where time (Year) served as both a fixed effect and a random slope effect for each park (grouping variable). Certain years were classified as "disasters", specifically 2020 for all parks due to closures or partial entry systems during the peak of the Coronavirus Disease 2019 (COVID-19) restrictions, and in 2022 for Yellowstone and Grand Teton due to the June 2022 flooding. This categorical variable was also included as a fixed variable in the GLMM predicting visitor counts.

A GLMM was also used predict visitor spending and total economic output based primarily on visitor count. Given differences in local economies and sectors, we first normalized values ($\hat{x}$) for visitor spending and economic output from 0 to 1 for each park, using the following formula:

$$\hat{x}_{it} = \frac{x_{it} - \min\left(x_i\right)}{\max\left(x_i\right) - \min\ \left(x_i\right)}$$

Where.

x_{it} is the raw economic value for the *i*th National Park at time *t*. Minimum and maximum values are calculated across all time periods for National Park *i*. Normalized economic values, representing fractional values ranging from 0 to 1, were modeled as binomial distributions in a GLMM, where visitors were used as fixed variables and random slope variables according to National Park as a grouping variable (random effect). Because visitor counts were reduced from disaster years, there was no need to include a disaster variable. Proportions (e.g., 0.35) were translated into binomial trials as two sets of whole numbers, one representing the target values (e.g., 35) and the second vector representing alternative outcomes (e.g. 100–35 = 65). For every observation, these values were modeled jointly.

Both GLMMs were constructed and validated in R-4.4 using the glmmTMB library [56]. Prior to developing the models, we tested the data for potential temporal autocorrelation across variant time lags. No evidence of autocorrelative structure was found indicating no need to incorporate this structure in the models. The visitor and economic activity models were used sequentially to predict visitors and economic values, respectively, for Yellowstone and Grand Teton National Parks in 2020 and 2022 under normal operations, i.e., in the absence of COVID-19 restrictions and the flood-related closures, respectively. The predicted or expected values were then compared to observed visitation and observed economic values to estimate losses in visitation and revenues.

In order to associate economic losses with individual gateway communities surrounding Yellowstone, we examined traffic counts for each of the five entrances. Traffic counts, also obtained from the NPS [55], were used because these data explicitly report counts for each entrance, whereas visitor counts are only reported for the entire park. Visitor activity in Yellowstone appears to be synonymous with traffic counts, as annual traffic totals (1992–2022) explain 96.4 % of variation in annual visitor counts (Supporting Information, Fig. S1). Over the past thirty years, traffic counts have been increasing at all entrances, especially in the last five years, with notable increases at the West Entrance. We calculated the proportion of total traffic at each entrance for non-disaster years (2016–2019, 2021) to represent an expected distribution, and calculated the proportion of traffic at each entrance for the 2022 flood year. Predicted economic activity (visitor spending and economic output) for 2022 was multiplied by the average proportion of traffic at each entrance for non-disaster years. Observed economic activity (reported by NPS) for 2022 was multiplied by the proportion of traffic at each entrance for 2022. The difference between these values was used to estimate losses for each entrance and hence, groups of gateway communities. The values of economic loss for each entrance were then compared to revenue losses reported for business respondents in each gateway.

3. Results

3.1. Economic survey

A total of 291 businesses within the six gateway communities and surrounding areas were contacted by our team or a respective chamber of commerce person. During September 9–15, 2022, our team visited 267 of these businesses in person. We subsequently called all but 37 businesses who either had no phone number or the phone number provided did not work. An additional 24 businesses were not visited in person but were contacted by phone or the COC representative and responded to our survey. More businesses may have been contacted by the COC other than those recorded; however, we only have records of those businesses that completed the survey. Seventy-eight respondents completed the business survey, whereas 30 individuals completed the community-level survey. Across all respondents, 19 zip codes were represented, which were distilled into eight zip code groups for summarization (Table 1). Respondents to our business survey represented 15 of the zip codes, whereas nine zip codes were represented in our community survey. Business response rates were highly variable, ranging from 3.77 % in Jackson, WY to 75 % in Gardiner, MT (Table 1). Response rates were not indicative of effort, as Jackson had among the most businesses visited, yet lowest responses. Summaries of all responses for business and communities are provided in Figs. S2–S15.

Economic sectors listed as the primary importance to businesses included lodging, retail, restaurant and food industries, and recreation, although 35 % of respondents characterized their businesses under multiple economic sectors (Fig. 1b). Over 88 % of respondents surveyed considered their businesses to be located within a gateway community. Forty-one percent of respondents were in gateway communities that were also impacted by flooding, whereas only 8 % of respondents were impacted by the June 2022 flooding but not located in a gateway community (Fig. 2). Most respondents indicated that YNP was essential or very important to their business, and most indicated that closures to YNP, rather than infrastructure losses, had the most impacts to their businesses (Fig. 2).

Physical impacts of flooding were relatively rare for the businesses surveyed in our study. Across all categories, only a quarter of respondents had experienced some flooding physical impact, the majority of which were categorized as slight losses related to water, sewer, electric, or gas utility service outages (Fig. 3). Generally, only 10 % of respondents experienced flood-related impacts to their buildings, equipment, or property in our survey, whereas in the FRB MN survey, roughly 20 % of respondents indicated having impacts to those categories, partially an artifact of that study focusing primarily on Southwest Montana. Our survey found significant impacts to critical supply chains occurred directly after the flood but subsided considerably by the time of our survey (Fig. 4a). Prior to the flood, our survey documented moderate or significant supply chain issues in a small subset of businesses, whereas almost a third of businesses had issues in the FRB MN study (Fig. 4b). Verbal responses indicated these issues originated during the COVID-19 pandemic restrictions. Directly following the flood, 47 % of businesses in our study suggested significant supply chain problems, very similar to rates (48 %) reported in the FRB MN study (Fig. 4b). In the FRB MN study, businesses surveyed during June 2022 anticipated supply chain problems to continue in the foreseeable future; however, our survey during September 2022 indicated that supply chain problems, at least due to flooding, had mostly been resolved.

Most respondents reported only losses in revenue (Fig. 5a), with highest rates of loss reported in Gardiner and Cooke City (Fig. 5d). Loss of customers were cited as the primary reason behind revenue losses (Fig. 5b) with trip cancellations, lower numbers of visi-

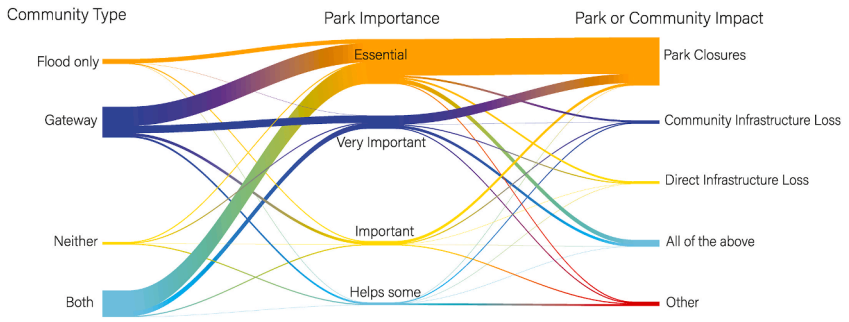

Fig. 2. River plot depicting the relative distribution of answers to business survey responses to three questions and the relations or connectivity in responses among questions. These included asking businesses to categorize their community type (left), the importance of Yellowstone National Park to their business (middle), and the largest source of impacts to their business revenue (right).

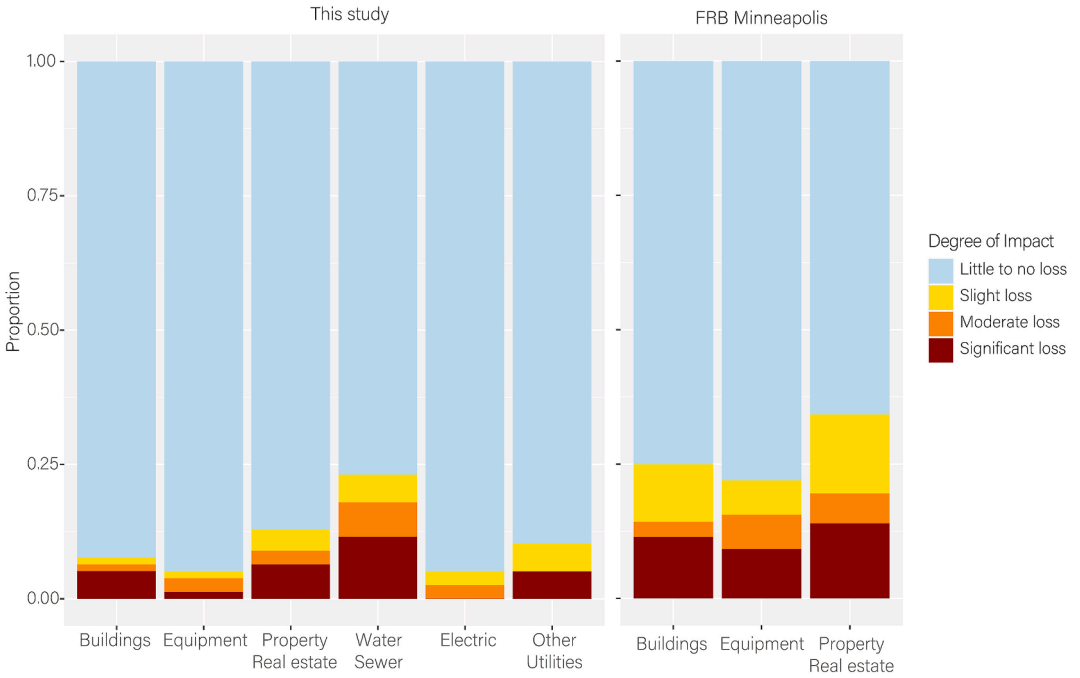

Fig. 3. Proportion of business respondents reporting infrastructure damages and losses or utility losses from the June 2022 flood relative to the significance of damages or losses. Left panel are responses from our study, whereas the right panel includes responses from the Federal Reserve Bank of Minneapolis (FRB MN).

tors generally, and less advanced bookings all cited as the predominant factors related to lower visitation (Fig. 5c). Reasons behind revenue losses and the presumed reason for lower customers were generally similar among communities (Fig. 5e–f).

Most businesses in the YNP gateway region experience high volumes of customers throughout the entire tourist season (May–September), with a slight peak in July (Fig. 6a). Impacts to revenue from the flooding and park closures were also distributed across the entire 2022 season, with noticeably more impacts occurring primarily in June 2022 but also July 2022 (Fig. 6b). In our survey, roughly 40 % of respondents reported 50 % or greater declines in revenue for June, July, and August compared to revenue levels in 2021 (Fig. 6c). The FRB MN survey similarly asked respondents to report their losses for the month of June 2022 but to project their estimated losses for July and August. Reported declines for June and projected declines for the remainder of the summer were similar to our survey in terms of general losses (Fig. 6d). On average, respondents reported 50 % losses in revenue across all months (Fig. 6f). Gardiner and Cooke City reported the most extreme losses in revenue, averaging 75 % losses for the summer months, followed by Red Lodge and West Yellowstone, averaging 44 % and 40 % losses, respectively (Fig. 6e). Cody and Jackson-Teton, WY reported 21 % and 4 % revenue losses, respectively (Fig. 6e).

Responses were mixed regarding which of the YNP operations had the largest influence on businesses (Fig. 7). Timelines of operation are noted in Fig. 7a. The largest percentage of respondents reported that closure of the North and Northeast Entrances (July 2 to October 5) had the most significant impacts on businesses, whereas equal numbers of respondents indicated that any closure or the complete closure (June 13–22) had the most significant impacts (Fig. 7b). The influence of YNP operations among communities was mostly related to the location of each community relative to entrances and closures. For instance, Gardiner, Cooke City, and Red Lodge are positioned outside of the North and Northeast Entrances; hence, the closure of these roads was reported as the most signifi-

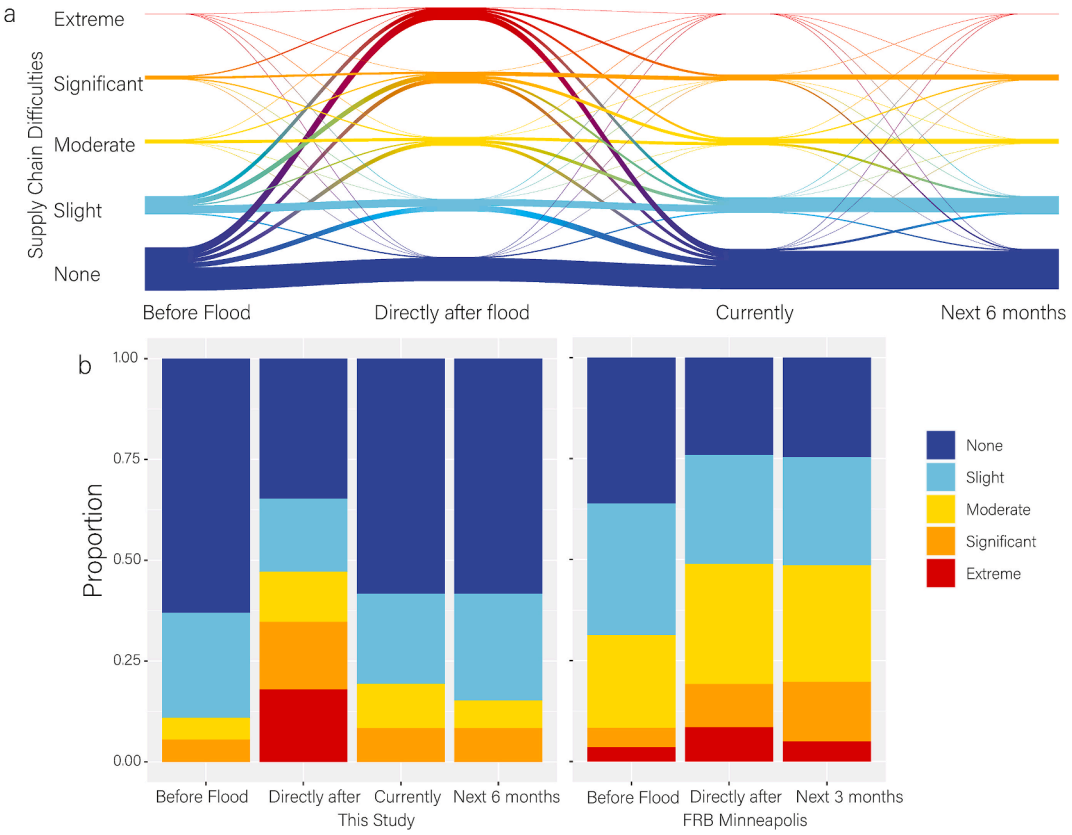

Fig. 4. Significance of impairments to supply chains supporting businesses in the gateway region relative to before or after flood occurrence. (a) River plot depicting associations among responses related to time period and degree of difficulty. (b) Proportion of business respondents with supply chain difficulties relative to the degree of difficulty and time period surrounding the flood.

cant impact to businesses in these communities (Fig. 7c). In contrast, West Yellowstone and Cody were more impacted by the complete closure of the park from June 13–22 (Fig. 7c), whereas after June 22, the West and East Entrances were opened for the remainder of the season.

Most respondents reported the financial status of their businesses as strong or good and stable, which was typically associated with positive financial outlooks, although this varied (Fig. 8a). A third of respondents indicated their financial status as poor or declining, and this corresponded to a range of financial outlooks for the future (Fig. 8a). Cooke City, by far, had the highest proportion of respondents with poor financial status and likely to go out of business, followed by Gardiner (Fig. 8b–c).

Generally, community surveys showed agreement with business responses; however, this varied by community and survey question (Fig. 2–9, 9–15). Community survey responses for Gardiner and Red Lodge tended to accurately reflect trends in business responses. Community responses for all communities seem to fail to capture the timing of economic impacts experienced by businesses (Fig. 9). Bozeman-Livingston community responses were generally poorly reflective of business responses in that area. Jackson-Teton community responses did not seem to agree with business responses related to revenues and financial status of businesses (Fig. 9).

Based on open responses, we identified five major themes that were repeated among survey respondents: media and marketing, financial assistance, communication issues, tourist adaptations, and park operations (Appendix Table 1). We selected a subset of the most representative quotes from respondents as indicative of each theme.

3.2. Systemic impacts to local and regional economies

Apart from disaster years, visitor counts to national parks have increased over time, which has led to increased visitor spending (Fig. 10a) and increased economic output. All parks displayed a peak in visitation in 2021, a response to the widespread lockdown procedures from COVID-19 in the year prior. Patterns in visitor spending in Yellowstone and Grand Teton mimicked the general patterns of other national parks, including ubiquitous decreases in economic values in 2020 due to COVID-19 restrictions (Fig. 10a). In contrast, Yellowstone and Grand Teton showed major declines in visitor spending in 2022 relative to other parks.

All models converged and displayed relatively high performance when all parks were included (Supporting Information, Tables S3–S5). Validation plots indicated performance was robust when considering all parks (Supporting Information, Figs. S16, S17, S19); however, when only considering Yellowstone and Grand Teton National Parks, the visitor spending and economic output model performances were significantly improved (Figs. S18 and S20). For the visitor count model, time had a significant positive effect on visi-

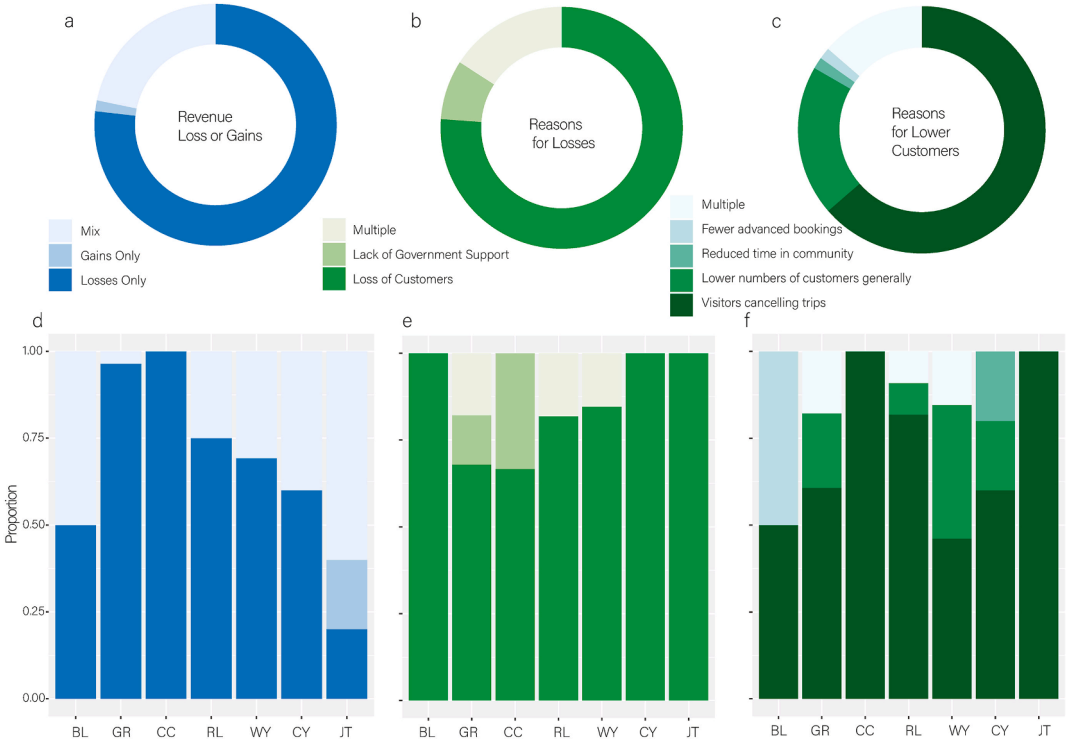

Fig. 5. Characterization of impacts to business revenues based on the proportion of respondents across all communities reporting (a) revenue losses or gains, (b) reasons behind revenue losses, and (c) reasons for lower customers. (d) Responses are also broken out by community.

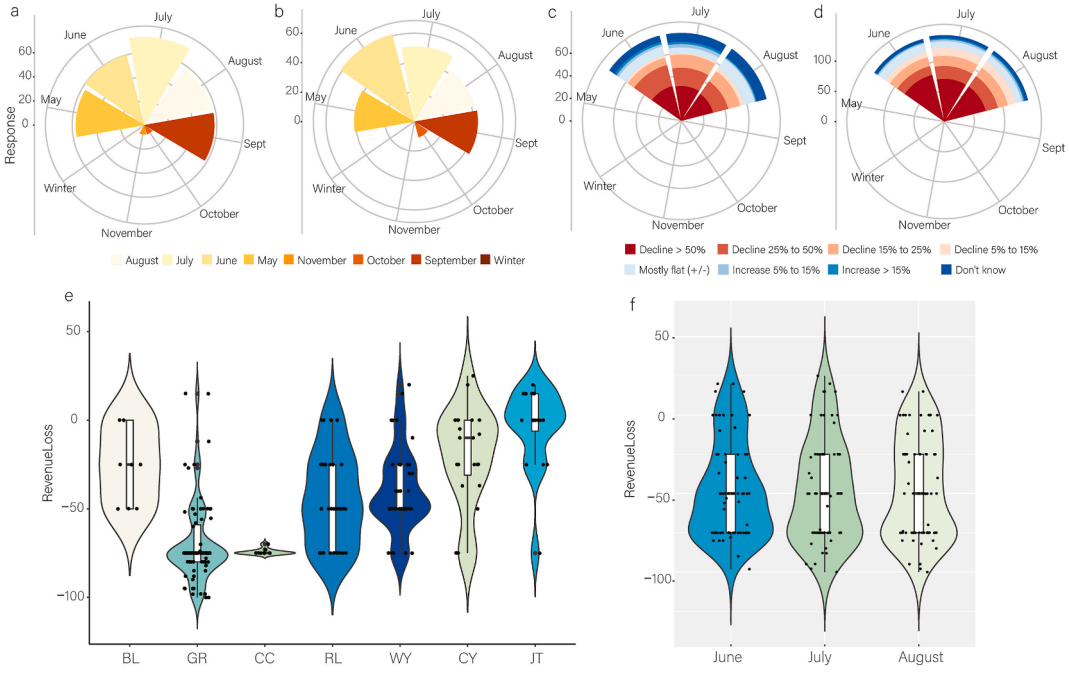

Fig. 6. Timing and degree of impacts to revenue from flooding and park closures. Business respondents indicated the (a) time of year they experienced highest numbers of customers and (b) the time of year (month) they experienced the most impacts to sales and revenues. The timing, direction, and magnitude of impacts to sales and revenues were explored in (c) our study and (d) the Federal Reserve Bank of Minneapolis survey. Violin plots depicting the distribution of revenue impacts presented (e) among communities for all months, and (f) among months for all communities for our study. "Jittering" of points is used to highlight distribution of observations.

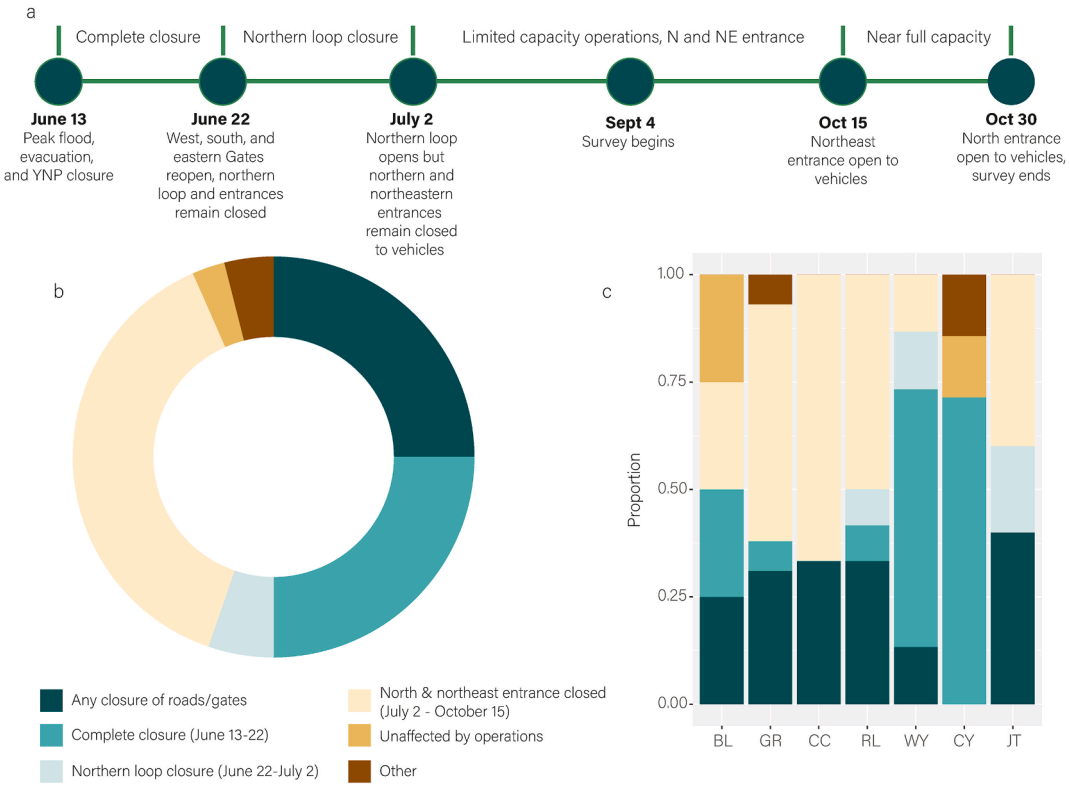

Fig. 7. Effects of Yellowstone National Park operations on business revenue and sales. (a) Timeline of park operations following the June 2022 flood. Proportion of business respondents indicating which operation had the most significant effect on business sales or revenue is summarized for (b) all respondents, and (c) among communities.

tor frequency, whereas disasters had significant negative effects. For both the visitor spending and economic output models, the number of visitors had significantly positive effects.

Based on our models, we estimate the 2022 flood led to 1.5 million less visitors in Yellowstone and 1.3 million less visitors in Grand Teton (Fig. 10b). Losses in visitors from the 2022 flood were larger than those estimated for COVID-19 in 2020. We estimate COVID-19 led to 731,000 less visitors in Yellowstone and 477,000 less visitors in Grand Teton than expected (Fig. 10b). Likewise, we estimate the June 2022 flood caused $156 million in losses to visitor spending in communities outside Yellowstone and $158 million in losses to Grand Teton; these numbers both exceed estimates of losses from COVID ($134 million and $121 million, respectively) (Fig. 10c). Economic output losses from the flood mirrored visitor spending and totaled $193 million from Yellowstone and $214 million from Grand Teton (Fig. 10c).

When distributed across the gate entrances, the 2022 flood had the most significant negative impacts on the economies of the Northeast (−82 %) and North (−53 %) gated entrances, followed by the East and South areas (Fig. 10d). Of note, is that the impacts on the Northeast ($33 million) are reported as percentages of expected revenues (baseline), and hence impacts of the June 2022 are considered the most severe for the Northeastern communities, even though the total gross losses for the North gate were more than twice this value (-$75 million). All entrances displayed declines in traffic volume relative to the previous 5-year average (2016–2019, 2021) except the West entrance, which showed a 47,000 vehicle increase in traffic (Supporting Information). Based on this outcome, we estimate that the West entrance could have had a very modest increase in visitor spending and economic output when compared to the 5-year baseline traffic expectations for 2022. However, all entrances, including the West gate, showed dramatically lower numbers of vehicles in 2022 than in 2021. Had we used 2021 as a baseline, however, the relative percentages of impacts to each gateway community would have still mirrored the analysis reported herein. For instance, based on 2021 traffic volumes, the Northeast gate had 83.5 % lower traffic in 2022 (109,000 less vehicles) and the North gate had 61 % lower traffic in 2022 (305,301 less vehicles), whereas the West gate had 15 % lower traffic (123,000 less vehicles). As an additional validation measure, the visitor spending model, when proportionalized to each gate entrance, mirrored the revenue losses reported by survey respondents for each corresponding gateway community, except West Yellowstone (Fig. S21).

4. Discussion

We used a combination of methods to transect and explore the relative roles of direct and indirect economic impacts of a flood on gateway communities of YNP. The results suggest that gateway communities experienced significant economic impacts from the flood, predominantly the result of park closures and diminished visitor volumes, rather than property loss, workforce reduction, or

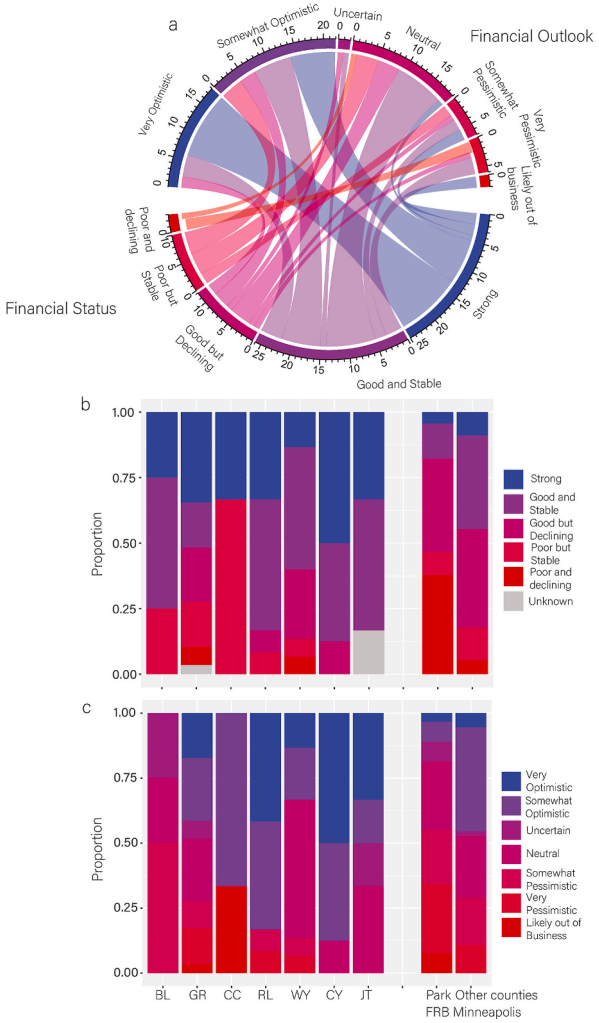

Fig. 8. Financial outlook among gateway businesses, based on (a) circos plot comparing associations among current financial status (at the time of the survey) and financial outlook. Proportion of business respondents in different communities reporting different (b) financial status, and (c) financial outlooks. Results from the Federal Reserve Bank (FRB) of Minneapolis survey are provided for Park County, MT and other counties.

supply chain issues. As other studies have shown [57], even temporary park closures can lead to significant reductions in tourists and economic losses in gateway communities. We found these effects persisted and were not mitigated through shifts in tourist behaviors, i.e. social disruptions [10]. Similar levels of economic impacts of park closures to gateway communities were clearly documented during the COVID-19 pandemic, for not only U.S. National Parks [8,17] but also other international communities surrounding protected areas supporting tourism [6,7,58,59].

4.1. Economic losses in gateway communities following disasters

Multiple previous studies have pointed to the dependence of gateway economic vitality on visitor volumes to National Parks during or following climate-related hazards [8,11,13,17,35]; however, many of these previous studies did not consider other potentially confounding factors that could further dampen revenues to tourism industries in gateway areas. Despite the extensive nature of regional flooding, physical impacts were isolated among businesses and public infrastructure. Even with areas that received widespread physical impacts, such as Red Lodge, where 40 % of respondents indicated damages and 70 % indicating loss in utilities, business owners responded that losses in customers posed more significant impacts to revenue. The regional economic model also corroborated the results of our survey. The model suggested a 30 % decline in visitor spending, slightly lower than the average revenue losses reported among business respondents (48 %). Estimated losses in visitor spending, when proportionalized across gated park entrances, closely mirrored the revenue losses reported in surveys for corresponding gateway communities (except West Yellowstone), further suggesting that the primary source of economic loss was dampened visitation.

Our regional economic model estimated over $150 million USD in losses to visitor spending in YNP gateway communities from diminished visitation during 2022 – this estimate exceeds the estimated losses from COVID in 2020 by $20 million. This estimate also dwarfs the predicted $7.9 million in annual regional economic losses to the YNP gateway region due to dampened visitation from re-

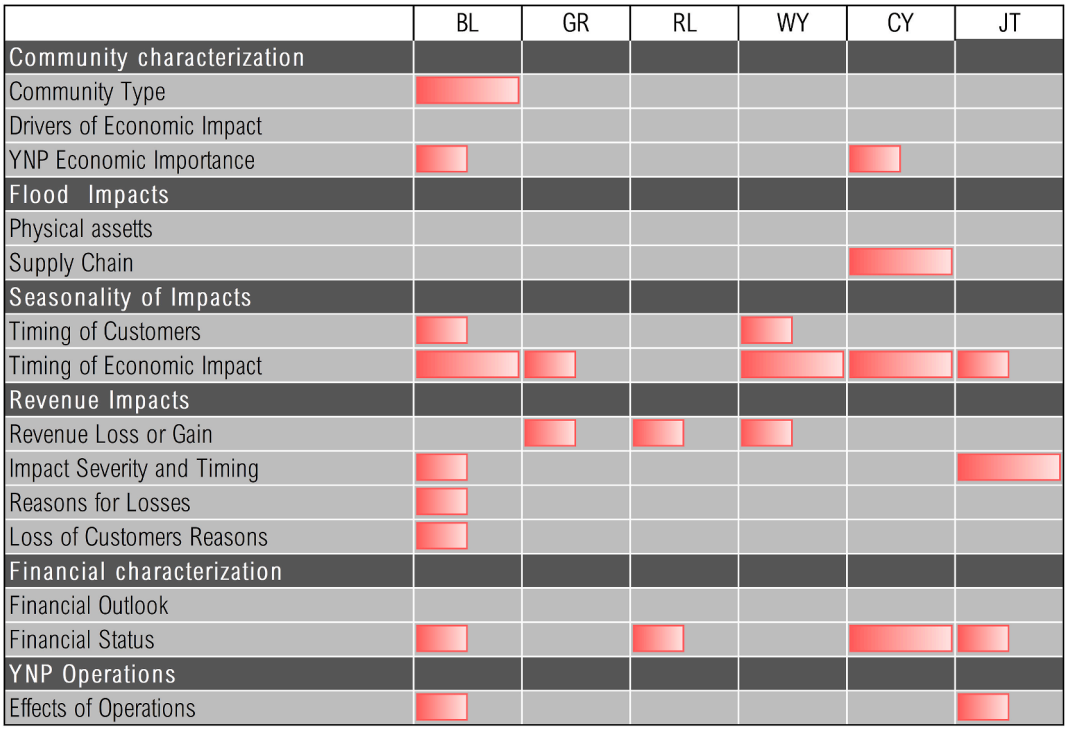

Fig. 9. General agreement between community responses and business responses across each gateway community. Full red bars indicate little or no agreement, partial red bars indicate some agreement, and no red bar indicates general agreement between the community and business responses. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

cent wildfires [11]. A similar study estimated $2.7-$4.7 million in losses to the regional economy for all of Utah's National Parks due to visitation losses from wildfire [13]. Jedd et al. [12] found that visitor responses to extreme dry conditions were inconsistent among parks and years, ranging anywhere from $9 million to $90 million in losses to regional spending around individual parks, particularly Rocky Mountain, Grand Teton, and YNP. In all these situations, National Parks were operating under full or near-full capacity; hence, any shifts in visitation were based on visitor preferences. In the case of the June 2022 flooding, YNP was fully closed and then operated at partial capacity for the remainder of the primary tourist season. The severity of these impacts should be expected given that 90 % of gateway respondents consider YNP very important, if not essential, to their livelihood.

Although the June 2022 flood was unprecedented for YNP, the hydrometeorological and socioeconomic context of the event was not unprecedented in the broader Rocky Mountain region. A near identical flood disaster occurred in Yosemite National Park in 1997 when an atypical, warm torrential rain escalated melting following historical snowfall [60]. The resulting flood was the largest in 40-years and immersed the Yosemite Valley, causing significant infrastructure damage and eliciting $258 million in total flood recovery funding [60]. Yosemite was fully closed for a month, then partially opened, leading to an estimated loss of almost 800,000 visitors across 1997 and 1998 and $46.5 million in cumulative losses to personal income (2023 USD) in the gateway region [35]. Based on other IMPLAN assessments, total visitor spending is typically 2 to 2.3 times that of labor income [51], which although not identical to personal income, suggests that the total losses in visitor spending were approximately $90 to $110 million, comparable with economic losses reported in our study.

4.2. Post-disaster media and marketing

Managing negative perceptions of risk and disaster is a major challenge for tourism [18,20,27]. Media attention to disasters can create elevated perceptions of risk to disasters [61]; hence, post-disaster marketing is key for economic recovery [62]. Media sensationalism created a negative perspective of New Orleans following Hurricane Katrina leading to multiple years of devastation to that area's travel and tourism industry but has since been mitigated using strategic 'destination image management' [63]. Likewise, following the Indian Ocean tsunami, the media created misconceptions about the severity of damage in the Maldives, grouping it with far more extreme cases ([64]).

The role of the media in diminished visitor volumes to YNP is likely significant. The June 2022 flood elicited sensationalism from national and international media outlets, such as alarmist narratives suggesting similar apocalyptic events should be expected in the future [42,43]. Written responses and personal discussion with respondents anecdotally suggested that the media portrayal of the flooding situation was very harmful to visitation (Appendix Table 1). The media attention, however, was not completely unwarranted. The flood situation was critical for communities like Gardiner, which was completely isolated due to road closures. The town was without clean water from water line breaks [45], and officials were considering evacuations [44]. Visuals of the YNP road

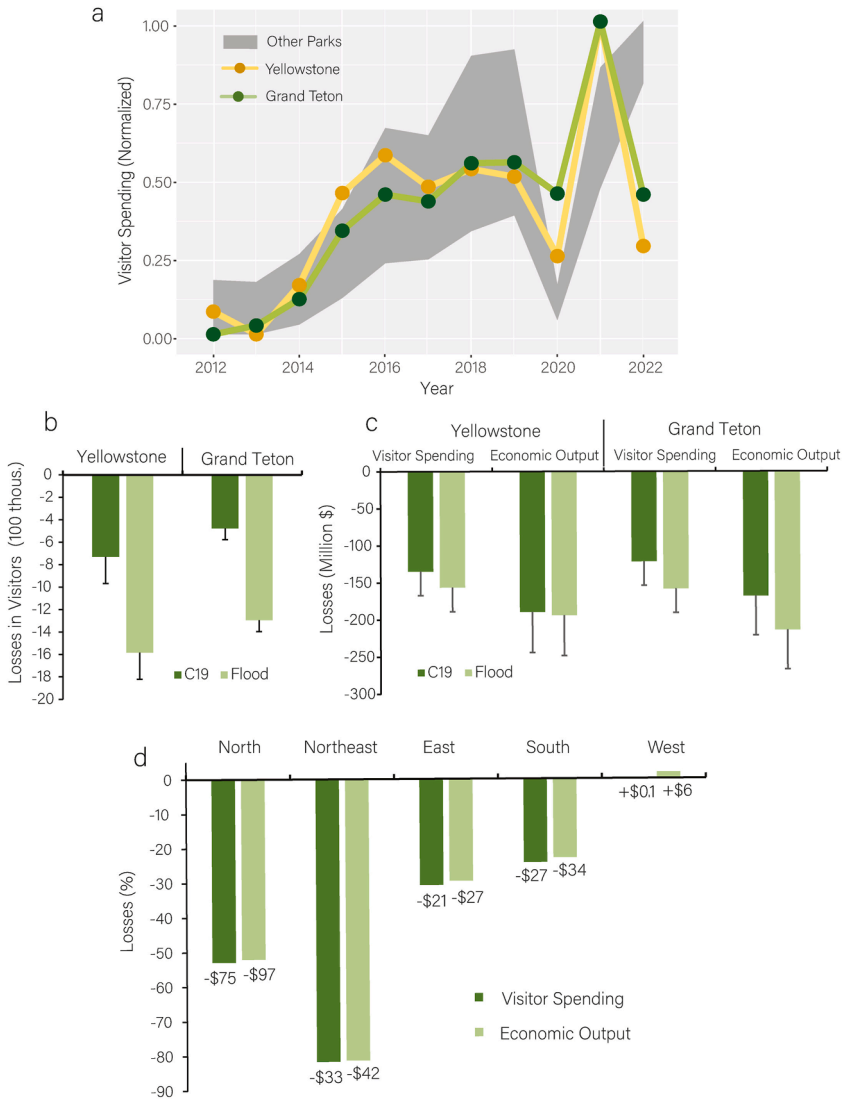

Fig. 10. Regional economic impacts of the June 2022 flood and park closures. (a) Normalized visitor spending in Yellowstone and Grand Teton National Parks relative to 8 other U.S. National Parks. Grey region represents 95th percent confidence interval. Modeled estimates of losses in (b) visitors and (c) visitor spending and economic output to Yellowstone and Grand Teton National Parks due to COVID-19 (C19) and the June 2022 flood (Flood). (d) Percent losses in visitor spending and economic output from the June 2022 flood are broken down by gate entrance.

washouts [65] and a single house collapsing into the Yellowstone River were repeatedly circulated on mainstream outlets even after the flood had receded [66,67]. Repairs, clean-up, and rehabilitation were rapid, and within a week, Gardiner was open for business [44] but was virtually empty of tourists [68]. Visitors immediately began canceling or rerouting reservations upon seeing the news and hearing of the park closures [44]. Originally, the National Park Service communicated that road reconstructions would take several years to complete [41] – this occurred prior to developing formal plans for rebuilding the northern roads.

Following the 2004 Tsunami, Carlsen and Hughes [64] suggested several post-disaster marketing mitigation strategies, including developing a broader communication strategy for consistent messaging, first using the media to correct those misconceptions and second, halting cancellations through tourism agencies. Broad post-disaster communication strategies should be pro-active, consolidated, follow a common agenda, set out the facts, shift to promotion of new or niche markets, and emphasize the positive ([64]). Consolidated communication is challenged in gateway communities as national parks operate independently and have very different objectives than for-profit tourism enterprises. In some cases, park management objectives may deprioritize gateway community members' values and fail to consider broader economic sustainability in future planning [69,70]. Under normal circumstances, YNP communications are coordinated with outside parties (*personal communication,* Christina White, National Park Service); however, immediately following the flood, YNP communications were understandably disorganized, as staff were still assessing damages. Within a week following evaluations, NPS began clearly and routinely communicating park conditions, recovery operations, and expected reopening dates throughout the remainder of the tourist season [71]. National and international media attention, however, remained

gravitated towards damages rather than the rapid road to recovery [44]. Furthermore, respondents suggested that social capital was limiting, and in some situations, most of the small gateway community leadership were unable to provide a consolidated communication strategy to mitigate customer losses (Appendix Table 1).

4.3. Tourist adaptations in gateways

Tourist adaptations, also termed 'social disruptions', can play major roles in exacerbating or mitigating potential economic impacts of disasters, particularly in national parks [10]. In these cases, disasters or hazards do not lead to predicable responses in visitor volumes, depending on tourist behavioral changes and perceptions of risk. For instance, during the early stages of the COVID pandemic, tourists flocked to national parks in the US, Finland, and Germany for safe spacing and outdoor recreation [72,73]. Once authorities banned or limited visitation, tourist numbers plummeted, but peaked again after parks were re-opened [10,59]. Extremely dry years in the western US negatively affected visitation and economies surrounding U.S. National Parks in the Rocky Mountains ([12]), whereas climate projections and empirical models of visitation for Waterton National Park in Canada suggested increases in future visitor volumes [14]. Brown and Jenkins [16] reported shifts in visitor behaviors rather than gross losses in visitation following road closures from the 2013 Rim Fire surrounding Yosemite National Park. Most displaced visitors entered from other entrance stations, which increased traffic in gateways but did not necessarily lead to increased spending in those areas. This suggests that visitors maintained their lodging in gateway areas despite those areas precluding immediate access to the park.

Most respondents in our study indicated that YNP park closures, even temporary, had significant impacts on losses in visitors and customers, primarily from trip cancellations and less advanced bookings. Within three weeks of the flood event, 93 % of YNP was accessible to visitors through three entrances [44], yet we estimated visitation was 38 % lower than expected levels. The inaccessible areas, although a small fraction of the entire park, are popular destinations in YNP, including the Lamar Valley, a well-known area for siting wolf packs [74]. The reintroduction of the wolves in YNP was estimated to increase visitation by almost 5 %, leading to an additional $54.2 million (2023 USD) in visitor spending [74]. Even with most of the park open, lack of access to popular areas in the park could have been sufficient to thwart visitation and induce cancellations.

Likewise, Gabe [57] showed that a 16-day shutdown of the U.S. Federal Government during October 2013 led to a 76 % reduction in visitation to Acadia National Park and 13 % reduction in tourism sales in Bar Harbor, Maine. The study further estimated that 17 % of the potential visitors had cancelled their trips based on the shutdown. Although Brown and Jenkins [16] found that closures in Yosemite were mitigated via alternative entrances, YNP is three times larger and closure of one entrance could require significant travel, even several hours to access another entrance. Hence, for practical reasons, many visitors canceled reservations completely or shifted reservations to areas where they could access the park (Appendix Table 1). Consistent with the Brown and Jenkins study, however, we found traffic increases through the West Entrance did not necessarily lead to increased spending in West Yellowstone where respondents reported 40 % losses in revenues (suggesting that displacement did not lead to increased spending). In the case of Gardiner and Cooke City, park access was critical for attracting visitors, and businesses in these gateways, on average, experienced 75 % losses in revenue.

4.4. Study Limitations

Our analysis was based on a relatively small number (n = 108) of survey respondents from a limited population of potential respondents. Our business survey's response rate was 27 %, which is comparable to response rates (21 %–25 %) documented elsewhere for small businesses, a notoriously unresponsive survey group ([75,76]). Low survey response rates were likely due to combinations of factors, including the response group, current economic conditions, the level of tourist activity, and the community culture in each town. For example, the Jackson-Teton region had the most businesses visited yet had among the lowest response rates. During surveys, most businesses in Jackson were extremely busy, and managers were too occupied to engage with our team. In contrast, business owners in Gardiner were highly engaged in the survey and its intended results, but they also had time to engage because of few customers. By the time of our survey, many businesses were also experiencing "survey fatigue", as multiple surveys had been previously deployed in the region. In contrast to our survey, the FRB MN survey was conducted in late June, immediately following the flood event, but for a broader area. The FRB MN successfully solicited 148 responses from businesses, 112 of which were from counties overlapping our survey, and undoubtedly sharing similar respondents. Apart from minor differences, our survey results are consistent with responses in the FRB MN survey.

4.5. Building future economic resilience in gateway communities

Because of the interdependencies between U.S. National Parks and gateway communities, coordinated planning of broader sustainability pathways is required to preserve both natural ecosystems and economies that depend upon them [7]. Based on the YNP experience, we assembled several considerations for building future economic resilience in gateway communities (Table 2) – these themes should be generalizable and extendable to other contexts. Preparedness starts with individual and community planning, but also requires devoting local financial resources and capital, perhaps through taxes [77]. Unfortunately, the Yellowstone flood was a perfect storm of compounding issues. For western communities anticipating another summer of drought and elevated wildlife risk, the flood came as a surprise - even though 90 % of disasters in the US are flood-related [78]. Indeed, increased flooding magnitude and shifts in the timing of peak runoff were predicted as a part of a regional climate assessment, suggesting the need for additional resiliency measures and infrastructure preparation [79]. Although alternative transportation routes were evaluated to minimize exposure to active landslide areas [80], the National Park Service, still financially recovering from the pandemic, had delayed some of the planned infrastructure rehabilitation resilience measures prior to the flood [37]. Restoring park access quickly, identifying alternative routes, and maximizing the resilience of transportation corridors to hazards are priorities for future economic resilience.

Table 2
General recommendations by theme for building economic resilience in gateway communities of national parks.

Theme	Recommendations	References
Preparedness	Prioritize and apply for federal-to-local infrastructure resilience investments (e.g., U.S. Department of Transportation). Develop individual and community-level preparedness action plans and finance institutional and infrastructural mechanisms for resilience. Diversify supply chain sources. Prioritize alternative transportation corridors that connect gateways.	[19,31,77]
Economic Diversification	Diversify local economies by expanding into new domestic and international niche markets. Promote more local (domestic) tourism. Enhance visibility of non-park related outdoor recreation opportunities. Invest in affordable housing. Avoid 'disaster capitalism' through local (non-corporate) assistance.	[6,7,81]
Media and Post-disaster Marketing	Develop coordinated, consolidated, and broad communication and marketing strategies that highlight unique attractions within gateway and avoid misconceptions during disaster. Identify trusted, centralized points of contact. Be proactive and ensure communications are coordinated with park management.	[18; 20,64]
Social Capital and Communication	Build tighter social capital and stronger communication networks for community support, centralized information sources, common understanding of assistance programs, and coordinated messaging to the media. Extend chamber membership to assist with social benefits.	[28–30]
Enabling tourist adaptation	Improve the services available in gateways to provide alternative recreation opportunities. Enhance marketing and guidance measures to enable tourism awareness and adaptation. Increasing flexibility to accommodate alternative forms and timing of tourism.	[10]
Financial assistance	Identify a broad suite of federal-to-local assistance mechanisms. Identify smaller, faster, less restrictive (gap) funding to avoid limitations, e.g. compounding debt and saturation of opportunities.	[31,82,83]

To add insult to injury, many businesses were ineligible for re-applying for grants or loans because they had already saturated the same financial assistance programs from COVID-related losses only two years earlier (see responses, Appendix Table 1). In these cases, identifying smaller and less restrictive sources of gap funding can help carry businesses along until revenue streams increase [31,82]. Communities with large social capital are likely to be more resilient to disasters [31]. For instance, business recovery from disasters tends to be more rapid for chamber of commerce members than non-members [30]. The social benefits of chamber services are many and include coordinated advocacy for policies, participation in town planning, as well as training, workforce development programs, and access to marketing resources [28]. Stronger social capital can also assist in coordinated and accurate messaging to the media, especially during and immediately following disasters ([64]). Furthermore, resilient social capital is also required to maintain small community identity and avoid the risk of corporate predation during economically vulnerable periods, e.g. “Disaster Capitalism” [81].

Going forward, building economic resilience in gateway communities requires diversifying singular sources of income [6,7], perhaps by marketing the wealth of recreation potential in other protected areas neighboring the park (Table 2). For instance, Montana has over 20 million acres of U.S. National Forest lands, roughly 10 times the size of YNP [84]. These other public lands border all gateway areas in the region. Following COVID-19's economic impact on tourism in Ghana, Soliku et al. [7] suggested promoting more domestic (local) tourism in addition to international sources. Gateway communities could be proactive in establishing new niche markets to attract local customers and prioritize development of affordable housing to support a viable workforce, a critical need mentioned in multiple community planning reports [85]; [86]. Furthermore, new economic benefits can arise by increasing gateway community flexibility to embrace and adapt to alternatives in tourist behaviors, perhaps social disruptions, such as increasing visitation in the traditional non-peak season during atypical climate extremes [87], rapid shifts in the volume of visitation from social changes, such as pandemics [88], or seeking opportunities afforded by alternative transit and entry systems to mitigate over-crowding in parks ([89]; [90]).

5. Conclusions

The 2022 Yellowstone flood provides numerous lessons in managing and mitigating the impacts of disasters to local economies. Indeed, the experience induced adaptations of NPS management, the most immediate being reconstruction and relocation of road, lodging, and water infrastructure [37,71]. Although the compounded nature of the flood hazard itself was not unprecedented for other National Parks in the Rocky Mountain region, the unique infrastructural and socioeconomic context of YNP and gateway communities created additional stressors, exposing these areas to unforeseen vulnerabilities. By far, most of the significant and long-lasting impacts to infrastructures occurred within YNP, not in gateway communities. Roads in the northern portion of the park transected floodplains and steep landslide-prone valleys, leaving the infrastructures vulnerable to climate and geological hazards. Nonetheless, the indirect impact pathways, specifically closure of the park and isolation of gateways from park access, resulted in the most severe economic impacts. The frequency and temporally compounding nature of disasters is also an important consideration. Due to COVID-19 economic losses only two years prior, grant and loan opportunities for small businesses were largely saturated. Furthermore, shortly following the flood, lines of communication were stressed due to uncertainties in park conditions, leaving a temporary void that was filled by media sensationalism. Rapid and coordinated short-term post-disaster communication was needed to mitigate the impacts to the tourism industry.

Complex and compounding events are likely to continue to increase in the future and exacerbate the impacts of existing stressors on vulnerable systems [91]. The flood warrants an introspective evaluation into future resilience planning and disaster preparedness, not only for YNP but also coordinated activities with gateway communities. The difficulty of managing disaster risk in national parks and their gateway communities is that infrastructure in these areas are designed to provide an intimate experience of humans with

nature, and as such, are exposed to hazards. Understanding the multi-faceted nature of hazards and identifying mechanisms for building economic resilience of these unique socioeconomic systems area areas of much needed research.

CRediT authorship contribution statement

Ryan A. McManamay: Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Jillian Sturtevant:** Investigation, Formal analysis, Data curation. **Jordan Jatko:** Investigation, Formal analysis. **Terese Petcoff:** Writing – review & editing, Resources. **Benjamin Ryan:** Writing – review & editing, Investigation. **Jean L. Dixon:** Writing – review & editing, Resources, Funding acquisition. **Ryan R. Morrison:** Writing – review & editing, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Funding for this study was provided by The National Science Foundation, Humans, Disasters, and the Built Environment (HDBE) PD 19–1638. CMMI Research and Development Award ID 2241213. We thank Ron Wirtz (Federal Reserve Bank of Minneapolis) for access to his survey results. We also thank three anonymous reviewers whose comments improved previous versions of this manuscript.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2024.104827.

Appendix Table 1
Common emergent themes among open responses from surveys.

Media and Marketing
The media immediately made it sound as though the closure would last all summer, leading to many cancellations. This occurred before anyone knew really how long it may take to repair.
85-90 % cancellations from closures to YP & negative media reports
Negative National Media Reports … Reporters would not even take positive guest interviews when they asked nor my positive interviews when I asked … must get best ratings from negative reporting.
When media is more positive, the road to Mammoth is open to public and gaining public confidence … next year should get back to normal … just have to make it through this year!
Poorly written press releases and response to Yellowstone closure by media outlets scared people away
The Park staff did an amazing job of reopening most of the Park in a safe and timely manner. The media did a poor job of celebrating their efforts and accomplishments. Social media still has factions that believe Yellowstone is mostly closed and resides mostly in Montana.
The fact people saw the flooding on natl news and cancelled their reservations
Financial Assistance and Disaster Recovery
We're still waiting on a disaster relief loan. All savings are gone. Credit cards and credit lines maxed. Hopefully we can hold out through February.
I'm frustrated I didn't get any support because it's the first year of my new business. I keep filling out surveys and applying but there is no help for me.
We have had an 80 % decrease in income for the year. But next year hopefully we will be back to business as usual. We still have a eidl SBA loan from Covid.
Having to take out a huge SBA loan to recoup hundreds of thousands of dollars in tour refunds leaves us unable to make any financial gains in the foreseeable future
Need Federal/State grant funding assistance for loss of revenue to compensate for summer of 2022.
Most business did not qualify for much help through FEMA. What help we did get was only in the beginning. The last part of the summer was painfully slower than even after the flood. No help on the horizon to keep business sustained.
Communication Issues
Communication wasn't good, found out about forced shutdown on facebook, no direct communication from health department. Serious issues with communication
Communication still an issue, didn't know that free water was being brought in
Tourist Adaptations
The flooding impacted us for a month or so with some cancellations, but we also experienced an increase in visitation with folks re-routing to Grand Teton NP and surrounding areas
Guests are going directly to Cody since that is the only Gateway to Yellowstone at this time for this area
Evacuation of the park led to our community becoming primary site for RV relocation.
Park Operations
The north entrance road not being completed. Construction is not working holidays, weekends, and night shifts.
Visitors canceling and no new bookings due to the North Entrance road is closed.
The closure of the North Entrance Road into Yellowstone completely gutted our local economy economically. We are a ghost town. We elected to stay open (at a loss) and had to lay off more than half our staff after the flood. The economic impact of this will be felt for years to come
When Yellowstone closes, the number of the customers are greatly reduced and sales are lower.

(*continued on next page*)

Appendix Table 1 (*continued*)

Closure of the Park caused complete loss of reservations. No one wanted to reserve in fear they would not be able to enter.
All of the reservations are canceled, and people stopped coming to Yellowstone National Park because they shut down the park due to the flooding. Then they tried to do the license plate admission and that drastically continued to decrease the amount of people that were willing to take a chance that they could come and get into the park. The whole summer was affected.
Loss of income due to lack of access to the park by tourists.
As a community we sustained very little physical damage. It was primarily economic damage due to a substantial loss in tourism.

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