ESTIMATED ECONOMIC COST OF AQUATIC NUISANCE SPECIES PROLIFERATION TO NORTH DAKOTA WATER INFRASTRUCTURE AND INDUSTRY


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INTRODUCTION

The North Dakota state legislature has prioritized the development of water infrastructure for individuals, municipalities, and industry. The North Dakota Department of Water Resources (DWR) has invested $1.4 billion in water supply and $765 million in flood protection infrastructure over the period from 2011-2021. Local water infrastructure investments are funded in partnership through grants provided by the State Water Commission (SWC) through the DWR cost-share program. As oil development has grown in the state, the funding of these projects has increased through a fixed apportionment of the state's oil extraction tax dedicated to water development and operations. These revenues are held in the North Dakota Resources Trust Fund (RTF). RTF funds are appropriated by the legislature each biennium to spending categories (buckets) which include Rural Water Supply, Water Supply, Capital Assets, Flood Protection, General Water, and Discretionary. The "buckets" are the primary financial source for the state's cost-share program. These DWR resources are then distributed for the development of regional, rural, and municipal water systems, flood prevention, and other general water management infrastructure by the DWR.

Aquatic nuisance species (ANS), specifically a bivalve commonly referred to as the zebra mussel, was first detected in the Red River watershed in 2010 as veligers (larval offspring), and then as adults in 2015. New infestations have since been detected in previously uninfested waters. Zebra mussels were detected in Lake Ashtabula and Lake Elsie in the Red River watershed in 2019 and 2021, respectively, and the James River watershed (a sub-watershed of the Missouri River basin) had detections in Lake Lamour and Twin Lake in 2020 and 2021. To date, there are currently no confirmations, outside the James River watershed, of invasive bivalves in the Missouri River watershed of North Dakota.

Zebra mussels are one of the fastest spreading aquatic nuisance species globally. First discovered in the Great lakes in 1988, zebra mussels have been documented in hundreds of North American waters (Pimentel et al, 2005). It took 27 years for zebra mussels to expand from the Great Lakes to the Red River. Since the first adult zebra mussels were discovered in the Red River in 2015, the species has become established in four North Dakota lakes and two major rivers. After just a few years, mussel densities of more than 100,000 individuals per square meter can be found on hard substrate in infested lakes. (Higgins and Vander Zanden, 2010) Now that the zebra mussel invasion has crept into North Dakota, the risk of further expansion is at an all-time high. Waters with the greatest recreational, economic, and intrinsic value are the most susceptible to new introductions. These are many of the water resources where water infrastructure may be exposed to zebra mussel spread from surface attachment to boats and other equipment being moved between water bodies including veligers in residual water.

Many countries, let alone individual states, lack the economic capacity to effectively manage invasive species. Yet, the direct socioeconomic impact generally outweighs the expected costs of prevention. (Haubrock et al, 2021) A monetary quantification associated with invasive species infestation can provide insight and perspective to decision-makers, and thus inform resource allocation. Policy makers can then make better decisions if they are provided an estimate of potential costs or damages if ANS proliferation is not addressed. (Lovell, Stone, and Fernandez, 2006) If ANS infestation is deemed inevitable, then baseline estimates can serve as a benchmark for potential future budget constraints predicated on maintaining existing services impacted by zebra mussel proliferation.

Nelson (2019) developed quantifiable methods to address sector specific costs of zebra mussel infestation for the state of Montana. Those methods are applied directly in this exercise. Each category of costs is briefly addressed in this white paper; however, a more detailed description of the methods and referential material is available in Nelson (2019). Published economic costs of impacts of freshwater bivalves were applied to the estimation methodologies by type of cost, economic sector, and impacted regions. As part of this effort, the five major watershed regions in North Dakota were used for regionalization of impacts. The scale of the potential problem facing North Dakota is significant, “Cumulative total global costs of invasive macrofouling bivalves were for the US $63.6 billion (2017 USD) across all regions and socioeconomic sectors between 1980 and 2020. Costs were heavily biased taxonomically and spatially, dominated by two families, Dreissenidae and Cyrenidae (Corbiculidae), and largely constrained to North America.” (Nelson 2019)

Nelson (2019) also noted preventative and control measures ($1.7 billion) were shown to be a much lower cost alternative than post invasion resource losses ($30.3 billion). Socioeconomic costs were disproportionately due to bivalves (mussels), where the largest share of costs were incurred through public and private sector interventions including power generation, drinking water infrastructure, and irrigation system damage. Average annual cost was estimated to be approximately $1.6 billion per year.

This report is a North Dakota application of the methods used by Nelson (2019) in Montana for a novel cost quantification of impacts which highlight the economic justification for significant preventative management of zebra mussels. As noted by Nelson (2019), the above aggregate costs are severely underestimated because well-documented economic impacts are currently lacking for most invaded countries and for the majority of invasive bivalve species infestations. However, this analysis provides a starting point for quantification and better-informed management of North Dakota’s resources.

Keywords: Water Infrastructure, Invasive Species, Economic Impacts, Zebra Mussels


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METHODS

The state was divided into the five major watersheds: Missouri, Mouse, James, and Red Rivers, as well as Devil Lake. Estimates were also summed as a whole and split across the major economic applications of water use, specifically consumptive use in North Dakota. The economic use categories were organized under irrigation, public supply, thermoelectric power, mining, industrial, and hydropower. Non-consumptive uses related to recreation, tourism, property values, and tax revenue were not included in this exercise. Annual water use for each category were sourced from DWR-required water use report data. Economic damages to consumptive use were based on reported expenditures of facilities experiencing or exposed to dreissenid (zebra) mussels. Economic costs to each category were drawn from published or federal reported zebra mussel costs to maintain operations to each category or facility type. The application Nelson (2019) was then a simple scaler function of costs to categorical units consistent with the published cost data. Consumptive cost data were converted to volumetric units for consistent application. Please refer to Nelson (2019) for specific details to the modeling approach and derivation of parameters.

Two major assumptions were made in the application of this process: 1) Zebra mussel probability of colonization in 100% of all major water bodies across North Dakota with proliferation to maximum potential; and 2) Costs and damages will result from populations at infestation levels consistent with conditions in the Great Lakes.

RESULTS

The results have been updated to 2023 dollars with a lower and upper bound and are annual costs related to damages, mitigation, and operational impacts. The potential consumptive economic damage from zebra mussel colonization of North Dakota's waters ranges from $72.6 to $80.8 million per year. The Red River watershed is the most highly impacted watershed with damages from $37 to $38.4 million, followed by the Missouri River watershed at $24.4 to $30.7 million, and Devils Lake as the least impacted at $583,297 to $583,812 from an infrastructure perspective. (Table 1)

SUMMARY OF POTENTIAL DAMAGE COSTS

Stakeholder Group	North Dakota	
	Mitigation Costs - Annual	
	Lower Bound	Upper Bound
Irrigation	$274,461	$568,183
Public Supply	$16,968,640	$17,247,975
Thermoelectric Power	$4,018,392	$4,198,488
Mining	$3,158,397	$3,299,950
Industrial	$46,473,988	$48,556,856
Hydropower	$1,723,750	$6,923,750
Mitigation Cost Total	**$72,617,629**	**$80,795,202**

Stakeholder Group	Missouri River Basin	
	Mitigation Costs - Annual	
	Lower Bound	Upper Bound
Irrigation	$192,726	$398,977
Public Supply	$6,163,163	$6,313,193
Thermoelectric Power	$4,018,392	$4,198,488
Mining	$3,148,226	$3,289,323
Industrial	$9,162,762	$9,573,418
Hydropower	$1,723,750	$6,923,750
Mitigation Cost Total	**$24,409,019**	**$30,697,149**

Stakeholder Group	Mouse River Basin	
	Mitigation Costs - Annual	
	Lower Bound	Upper Bound
Irrigation	$49,264	$101,986
Public Supply	$1,942,455	$1,942,464
Thermoelectric Power	$0	$0
Mining	$10,171	$10,627
Industrial	$6,531,315	$6,824,035
Hydropower	$0	$0
Mitigation Cost Total	**$8,533,206**	**$8,879,111**

Stakeholder Group	Devils Lake Basin	
	Mitigation Costs - Annual	
	Lower Bound	Upper Bound
Irrigation	$478	$989
Public Supply	$582,734	$582,734
Thermoelectric Power	$0	$0
Mining	$0	$0
Industrial	$85	$89
Hydropower	$0	$0
Mitigation Cost Total	**$583,297**	**$583,812**

Stakeholder Group	James River Basin	
	Mitigation Costs - Annual	
	Lower Bound	Upper Bound
Irrigation	$10,762	$22,279
Public Supply	$0	$0
Thermoelectric Power	$0	$0
Mining	$0	$0
Industrial	$2,095,233	$2,189,137
Hydropower	$0	$0
Mitigation Cost Total	**$2,105,995**	**$2,211,416**

Stakeholder Group	Red River Basin	
	Mitigation Costs - Annual	
	Lower Bound	Upper Bound
Irrigation	$21,231	$43,951
Public Supply	$8,280,288	$8,409,584
Thermoelectric Power	$0	$0
Mining	$0	$0
Industrial	$28,684,593	$29,970,177
Hydropower	$0	$0
Mitigation Cost Total	**$36,986,112**	**$38,423,712**

Table 1. Summary of Potential Damage Costs for Dreissenid Mussels by Basin

Irrigation impacts ranged from $274,461 to $568,183 for the state. The Missouri River watershed was the most potentially impacted at $192,726 to $398,977, followed by the Mouse River watershed at $49,264 to $101,986. (Table 2)

Public water supply system impacts added significantly to the statewide damages. Public water supply system impacts ranged from $17 to $17.2 million. The Red River watershed has the greatest potential impacts from $8.3 to $8.4 million, while the James River watershed had $0 impact due to the use of groundwater rather than surface water for raw water supply for treatment. (Table 3)

Thermoelectric production is a significant economic export for North Dakota. These facilities are solely located in the Missouri River watershed and the estimated damages from increased costs and mitigation are $4.0 to $4.2 million. (Table 4)

Mining industry costs are from $3.2 to $3.3 million. These operations are predominately in the Missouri River watershed. (Table 5)

Industrial facilities represent a significant portion of the overall state impacts, ranging from $46.5 to $48.6 million per year. The Red River watershed is the highest potentially impacted at $28.7 to $30 million, followed by the Missouri and Mouse River watersheds at $9.2 to $9.6 million and $6.5 to $6.8 million respectively. (Table 6)

Hydroelectric facilities are characterized by three specific cost/damage impacts. Mitigation of intake water using ultraviolet (UV) treatments, anti-fouling or fouling release coating, and reduced energy production impacts. The impact to hydroelectric power is from $1.7 to $6.9 million per year. (Tables 7 - 9)

DISCUSSION

The results of this exercise demonstrate the potential for significant impacts on discretionary funding for water projects statewide. Water supply projects may experience up to $17.2 million per year, which equates to $34.4 million per biennium. The DWR 2023-2025 biennium budget for water supply projects is about $640 million. The potential cost of a zebra mussel infestation equates to 5.3% of the current DWR budget. State and local budgets are intended to expand services and replace aging water infrastructure. ANS impacts would redirect both local and state resources to simply keep what is already built functioning during a statewide infestation. This highlights the potential scale of economic consequences an ANS such as the zebra mussel could have on budgets, priorities, and water resources and highlights the offsetting efficiency of preventive measures.

Non-consumptive and recreational damages may be even greater in both the Missouri River and Devils Lake watersheds. Recreational fishing and tourism are major inputs to the local economies for those regions. A review of the non-consumptive industries and property value impacts would provide a more comprehensive assessment of the potential economic impacts from an unconstrained zebra mussel infestation to North Dakota's surface water industries.


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FARMERS USING SPRINKLER IRRIGATION SYSTEMS

Lower Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	80,252	$3.42	$274,461
Missouri	56,353		$192,726
Mouse	14,405		$49,264
Devils Lake	140		$478
James	3,147		$10,762
Red	6,208		$21,231

Upper Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	80,252	$7.08	$568,183
Missouri	56,353		$398,977
Mouse	14,405		$101,986
Devils Lake	140		$989
James	3,147		$22,279
Red	6,208		$43,951

Table 2. Potential Annual Mitigation Costs to Farmers using Sprinkler Irrigation Systems | *Mgal - Million Gallons

WATER TREATMENT FACILITIES

Lower Bound Estimate					
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost of Chemicals (per Mgal)*	Number of Facility Intakes	Additional O&M** Plus Capital Costs ($190,549 + $3,696)	Annual Costs
	(a)	(b)	(c)	(d)	(a × b) + (c x d)
North Dakota	18,092	$14.57	86.00	194,245	$16,968,640
Missouri	9,717		31.00	194,245	$6,163,163
Mouse	1		10.00	194,245	$1,942,455
Devils Lake	0		3.00	194,245	$582,734
James	0			194,245	$0
Red	8,374		42.00	194,245	$8,280,288

Upper Bound Estimate					
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost of Chemicals (per Mgal)*	Number of Facility Intakes	Additional O&M** Plus Capital Costs ($190,549 + $3,696)	Annual Costs
	(a)	(b)	(c)	(d)	(a × b) + (c x d)
North Dakota	18,092	$30.01	86.00	194,245	$17,247,975
Missouri	9,717		31.00	194,245	$6,313,193
Mouse	1		10.00	194,245	$1,942,464
Devils Lake	0		3.00	194,245	$582,734
James	0		0.00	194,245	$0
Red	8,374		42.00	194,245	$8,409,584

Table 3. Potential Annual Mitigation Costs for Water Treatment Facilities (Public Supply) | *Mgal - Million Gallons, ** O&M - Operations & Maintenance

THERMOELECTRIC FACILITIES

Lower Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	11,256	$357	$4,018,392
Missouri	11,256		$4,018,392
Mouse	0		$0
Devils Lake	0		$0
James	0		$0
Red	0		$0

Upper Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	11,256	$373	$4,198,488
Missouri	11,256		$4,198,488
Mouse	0		$0
Devils Lake	0		$0
James	0		$0
Red	0		$0

Table 4. Potential Annual Mitigation Costs to Thermoelectric Facilities | *Mgal - Million Gallons

MINING OPERATIONS

Lower Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	8,847	$357	$3,158,397
Missouri	8,819		$3,148,226
Mouse	28		$10,171
Devils Lake	0		$0
James	0		$0
Red	0		$0

Upper Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	8,847	$373	$3,299,950
Missouri	8,819		$3,289,323
Mouse	28		$10,627
Devils Lake	0		$0
James	0		$0
Red	0		$0

Table 5. Potential Annual Mitigation Costs to Mining Operations | *Mgal - Million Gallons

INDUSTRIAL FACILITIES

Lower Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	130,179	$357	$46,473,988
Missouri	25,666		$9,162,762
Mouse	18,295		$6,531,315
Devils Lake	0.238		$85
James	5,869		$2,095,233
Red	80,349		$28,684,593

Upper Bound Estimate			
Stakeholder Group	Annual Withdrawals (Mgal)*	Average Cost (per Mgal) *	Potential Costs
	(a)	(b)	(a x b)
North Dakota	130,179	$373	$48,556,856
Missouri	25,666		$9,573,418
Mouse	18,295		$6,824,035
Devils Lake	0.238		$89
James	5,869		$2,189,137
Red	80,349		$29,970,177

Table 6. Potential Annual Mitigation Costs to Industrial Facilities | *Mgal - Million Gallons

HYDROPOWER FACILITIES ADOPTING ULTRAVIOLET (UV) LIGHT SYSTEMS WITH DUPLEX STRAINERS

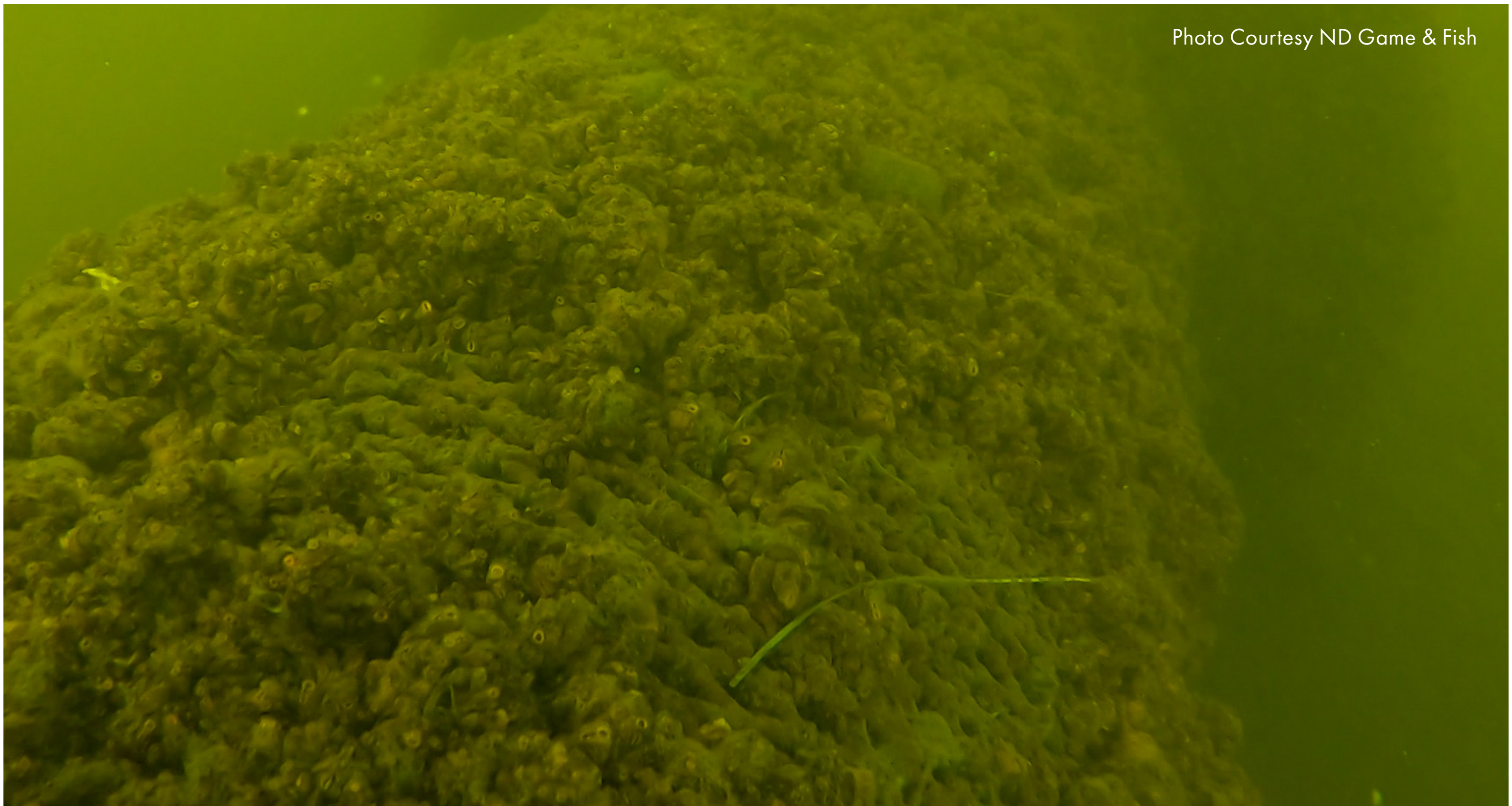
Stakeholder Group	Number of Generators	Annual Cost Per Generator	Costs for UV+ Duplex Strainers
	(a)	(b)	(a x b)
North Dakota	5	$61,428	$307,140
Missouri	5		$307,140
Mouse	0		$0
Devils Lake	0		$0
James	0		$0
Red	0		$0

Table 7. Potential Annual Mitigation Costs for Hydropower Facilities Adopting UV Light Systems with Duplex Strainers

HYDROPOWER FACILITIES APPLYING FOUL-RELEASE COATING

Stakeholder Group	Number of Generators	Annual Cost Per Generator	Cost for Trash Rack Foul-Release Coating
	(a)	(b)	(a x b)
North Dakota	5	$23,322	$116,610
Missouri	5		$116,610
Mouse	0		$0
Devils Lake	0		$0
James	0		$0
Red	0		$0

Table 8. Potential Annual Mitigation Costs for Hydropower Facilities Applying FoulRelease Coating



HYDROPOWER FACILITIES FROM ADDITIONAL GENERATOR DOWNTIME

Lower Bound Estimate - 2% Reduction in Generation

Stakeholder Group	2019 Net Electric Generation	Reduction in Energy Generation (MWh)*	Market Price (MWh)	Lost Revenue	Cost for UV** + Duplex Strainers	Costs for Trash Rack Foul-Release Coating	Hydro Direct Impact
		(a)	(b)	(a x b)	(c)	(d)	(a x b) + c + d
North Dakota	2.6	52,000		$1,300,000	$307,140	$116,610	$1,723,750
Missouri	2.6	52,000		$1,300,000	$307,140	$116,610	$1,723,750
Mouse		0	$25	$0	$0	$0	$0
Devils Lake		0		$0	$0	$0	$0
James		0		$0	$0	$0	$0
Red		0		$0	$0	$0	$0

Upper Bound Estimate - 2% Reduction in Generation

Stakeholder Group	2019 Net Electric Generation	Reduction in Energy Generation (MWH)*	Market Price (MWh)	Lost Revenue	Cost for UV** + Duplex Strainers	Costs for Trash Rack Foul-Release Coating	Hydro Direct Impact
		(a)	(b)	(a x b)	(c)	(d)	(a x b) + c + d
North Dakota	2.6	260,000		$6,500,000	$307,140	$116,610	$6,923,750
Missouri	2.6	260,000		$6,500,000	$307,140	$116,610	$6,923,750
Mouse	0	0	$25	$0	$0	$0	$0
Devils Lake	0	0		$0	$0	$0	$0
James	0	0		$0	$0	$0	$0
Red	0	0		$0	$0	$0	$0

Table 9. Potential Annual Mitigation Costs for Hydropower Facilities from Additional Generator Downtime
*MWH - Megawhatt Hour, **UV - Ultraviolet

REFERENCES

Pimentel, D., Zuniga, R., and Morrison, D. (2005). Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics, 52(3 SPEC. ISS.), 273-288.

Higgins, S. N. and Vander Zaden, M. (2010) What a difference a species makes: a meta-analysis of dreissenid mussel impacts on freshwater ecosystems. Ecological Monographs, 80(2),179-196.

Haubrock, P.J., Cuthberg, R., Ricciardi, A., Diagne, C., and Courchamp, F., 2021, Massive economic costs of invasive bivalves in freshwater ecosystems. Research Square – Creative Commons.

Lovell, S.J., Stone, S., and Fernandez, I. (2006). The economic impacts of aquatic invasive species: A review of the literature. Agricultural and Resource Economics Review. 35(1), 195-2008.

Nelson, N.M., 2019, Enumeration of potential economic costs of dreissenid mussels infestation in Montana. University of Montana

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