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Source: Ursus, 2020(31e17) : 1-16

Published By: International Association for Bear Research and Management

URL: https://doi.org/10.2192/URSUS-D-19-00005.2

Evidence for historical grizzly bear occurrence in the North Cascades, USA

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Abstract: The North Cascades ecosystem of north-central Washington State (USA) and southern British Columbia, Canada, has been identified as 1 of 6 recovery zones for grizzly bears (*Ursus arctos*) that were at one time distributed across a nearly continuous range of western North America. The current small number of grizzly bears, along with an apparent scarcity of historical observations, obfuscates the extent to which the mountain range and its surrounding lowlands previously supported grizzly bears. We reviewed and synthesized what is currently known about the historical distribution of grizzly bears in and around the North Cascades to better inform possible future restoration actions. Archeological, ethnographic, and incidental evidence confirm the prehistoric and historic presence of grizzly bears in the ecosystem and surrounding lowlands. Successful implementation of grizzly bear restoration and management in the North Cascades is dependent in part on the perception that they are an integral component of the ecosystem's historical benchmark. Education and outreach efforts that focus on the influence of human perceptions and correcting misinformation about the history of bears in the ecosystem and their interactions with humans may improve long-term restoration success in the North Cascades.

Key words: archaeological evidence, fur trade, grizzly bear, historical evidence, North Cascades ecosystem, population recovery, traditional ecological knowledge, *Ursus arctos*

DOI: 10.2192/URSUS-D-19-00005.2 ***Ursus 31:article e17 (2020)***

Grizzly bear (*Ursus arctos*) populations declined across North America over the past century as a result of extensive hunting, trapping, predator control, and habitat loss–fragmentation (USFWS 1993, 1997). By 1970, grizzly bears remained in an estimated 2% of their former range within the contiguous United States (USFWS 1993, Servheen et al. 1999). In 1975, the U.S. Fish and Wildlife Service responded by listing the species as federally threatened under the Endangered Species Act (USFWS 1993) and subsequently prepared a Grizzly Bear Recovery Plan in 1982, which was revised in 1993 (USFWS 1993). In order to manage remaining populations within the United States, 6 recovery zones were established in ecosystems where grizzly bears were, or had recently been, extant. Among those identified was the North Cascades Grizzly Bear Recovery Zone (USFWS 1993, Braaten et al. 2013).

The North Cascades mountain range spans the United States–Canada border in north-central Washington State, USA, and southern British Columbia (BC, Canada), and contains some of the most intact wildlands in the contiguous United States. Although the current population of grizzly bears in this ecosystem is unknown, there have been only 4 confirmed sightings in the past decade; therefore, the population is considered functionally extirpated (USNPS and USFWS 2017). The low density of grizzly bears in the ecosystem (Romain-Bondi et al. 2004), the species' slow reproductive rate (Nowak and Paradiso 1983, Schwartz et al. 2003), and isolation from other populations (Proctor et al. 2012, USNPS and USFWS 2017) make natural recovery unlikely.

In 2017, the National Park Service and U.S. Fish and Wildlife Service jointly released the Draft Grizzly Bear Restoration Plan–Environmental Impact Statement for the North Cascades Ecosystem (USNPS and USFWS 2017) and analyzed all comments submitted during the open review period that followed. Some comments expressed doubt that a viable grizzly bear population existed in the region prior to the onset of localized anthropogenic pressures and greater decline of the species across North America. Consequently, the broad purpose of this review is to synthesize and update disparate existing information on prehistoric (prior to 1800), historical (prior to

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1950), and recent grizzly bear presence in and around the North Cascades. In doing so, we hope to further inform discussions pertaining to grizzly bear management and restoration efforts.

Estimates of historical grizzly bear distribution and density in the North Cascades have remained uncertain and even puzzling, but biologists, historians, and park managers generally maintain that populations originally extended throughout the mountain range. Although the ability of grizzly bears to occupy a wide variety of habitats would have almost certainly resulted in a nearly continuous prehistoric range throughout North America (Rausch 1963, Guilday 1968, Leonard et al. 2000, Mattson and Merrill 2002), the infrequency of historical observations in Washington's coastal lowlands, Columbia Plateau, and Olympic Peninsula has led to the exclusion of these areas on some historical range maps (e.g., Seton 1926, Craighead and Mitchell 1982, Servheen 1990). Further, some skeptics posit that any historical population within the North Cascades did not exceed the scattered few bears that have been observed in recent years (Sullivan 1983).

The primary cause and timeline of the region's grizzly bear decline is not known, but local biologists have stated that the greatest impacts to grizzly bear populations probably occurred during the Northwest fur trade (1810–1872; Sperlin 1917) and continued with predator control and resource extraction (Sullivan 1983, Almack et al. 1993, Gaines et al. 2001). Other sources suggest that grizzly bears and other large animals were depleted before this period, as prehistoric human populations established dense and permanent settlements across the region's coastline and productive salmon (*Oncorhynchus* spp.) streams (Martin and Szuter 1999, Mattson and Merrill 2002, Laliberte and Ripple 2003). Developing a unified history of grizzly bear distribution and abundance in the region requires the consideration of a wide timeline and multiple areas of study, including archeology, ethnography, history, and contemporary scientific analyses.

Previous inquiries into the historical distribution of grizzly bears in the region have hinged upon Hudson's Bay Company (HBC) fur return records. This collection of pelt invoices from multiple fur-trading posts throughout the Pacific Northwest is the most robust systematic data set of wildlife presence prior to the 20th Century, yet it still leaves many questions unanswered. In 1983, Paul Sullivan (Washington Department of Game) produced a synoptic review of these records as evidence of a historical grizzly bear population in the North Cascades (Sullivan 1983). His evaluation included peak annual grizzly bear harvests from Fort Colville (spelled *Colvile* in historical records) and Fort Nez Percés (Walla Walla) in parts of the Columbia Drainage, Fort Thompson (also called Fort Kamloops) on the Thompson River, and Fort Nisqually in south Puget Sound. He maintained that it was unclear where the hides were collected; yet, subsequent publications have consistently cited these inconclusive results in statements regarding historical grizzly bear presence in the North Cascades. Sullivan's report also assimilated and verified the accuracy of other more recent sightings from personal interviews and written anecdotes by residents, explorers, and local tribal members. Later, as a part of their 5-year North Cascades grizzly bear ecosystem evaluation, Almack et al. (1993) continued compiling and ranking the reliability of grizzly bear observations made within the North Cascades.

In this review, we expand upon these previous studies to include a broader array of existing evidence from archeological, ethnographic, historical, and contemporary scientific sources relating to the prior distribution and abundance of grizzly bears within and surrounding the North Cascades. The breadth of information is intended to be an unbiased compilation of verifiable records, as well as evaluations made by experts in these respective fields.

Study area

The North Cascades Ecosystem Grizzly Bear Recovery Zone (US) and the North Cascades Grizzly Bear Population Unit (GBPU; Canada) spans north-central Washington State and south-central British Columbia, respectively (Fig. 1). In this report, we refer to this collective transboundary area as the North Cascades ecosystem. The U.S. portion of the ecosystem is roughly 2.5 million ha, of which 97% are public lands and 3% are privately owned (USFWS 1997). The majority of the public land is managed by the U.S. Forest Service (75.1%) and the North Cascades National Park Service Complex (NPS Complex; 10.9%), which includes approximately 1.2 million ha of designated federal wilderness. The remainder of public lands are governed by various state, other federal, and municipal and county units.

The adjoining North Cascades GBPU in British Columbia spans >971,000 ha, including >161,880 ha of protected lands (Gyug et al. 2004). The Fraser River defines much of the GBPU's western border. The river, 2 national railroads, and the TransCanada Highway are considered major barriers to natural movements of grizzly bears (North Cascades Grizzly Bear Recovery Team 2004). The eastern boundary extends eastward to the Similkameen River and terminates to the north at the confluence of the Fraser and Thompson rivers.

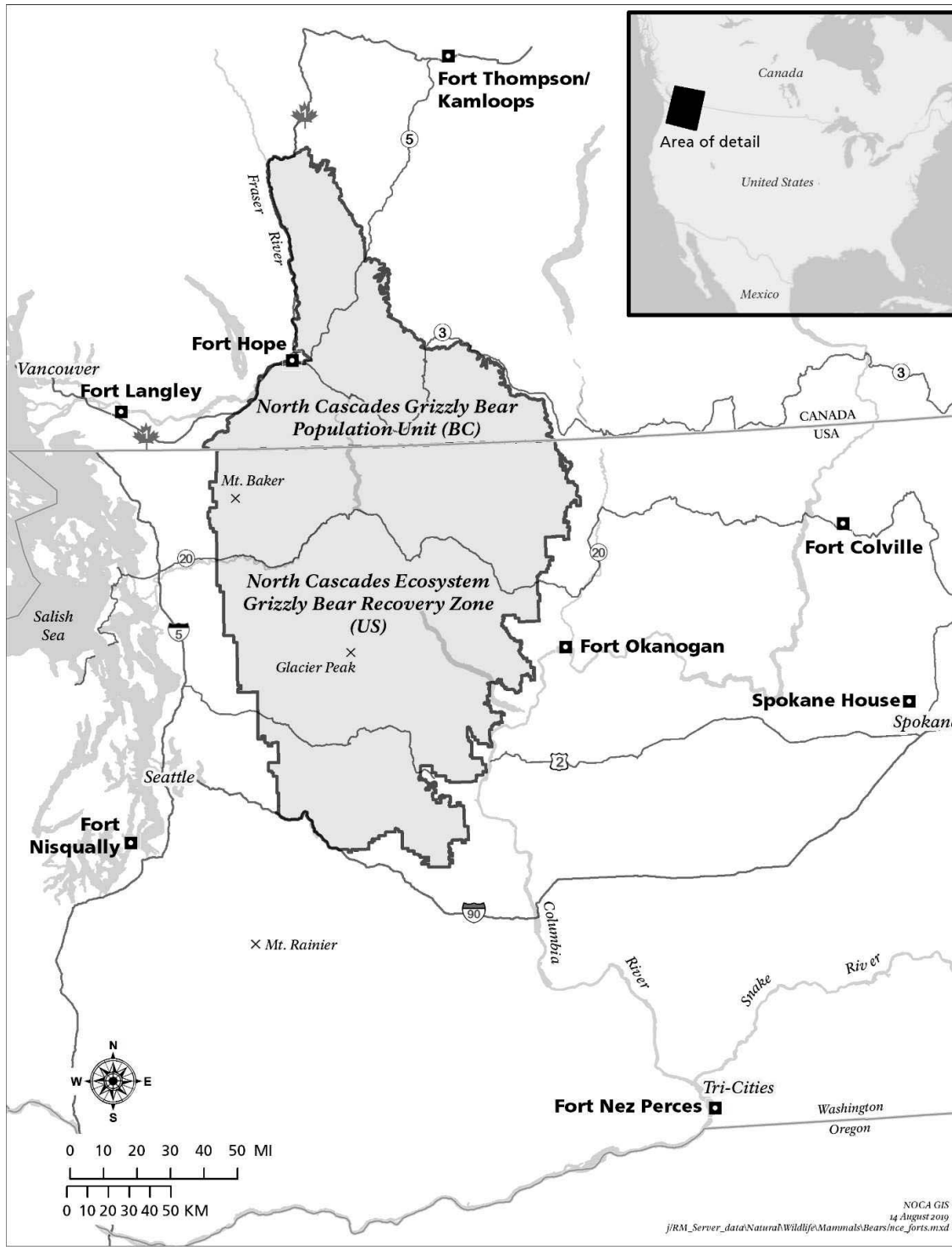

Fig. 1. Locations of Hudson's Bay Company trading posts analyzed in this report relative to the North Cascades ecosystem. The ecosystem is administrated as a Grizzly Bear Recovery Zone in Washington State (USA), and as a Grizzly Bear Population Unit in British Columbia (Canada).

The landscape and climate of the North Cascades ecosystem is diverse. Snow melt and glacial run-off from the mountains feed the Skagit, Nooksack, Snohomish, Stillaguamish, and Skykomish rivers west of the crest; and their eastern slopes drain several tributaries of the Columbia River, including the Methow, Stehekin (Lake Chelan), Entiat, Wenatchee, and Cle Elum rivers. The extensive lowland and subalpine forests of the western slope of the range are heavily influenced by a maritime climate. Crossing the crest of the North Cascades, the alpine meadows quickly transition to dry forests and dry lowland valleys on the eastern slope. Elevation ranges from 25 m in the Puget Trough to peaks exceeding 3,200 m at Mt. Baker and Glacier Peak. The ecosystem is predominantly roadless; however, several major east–west highways intersect and surround the landscape (Fig. 1).

Methods

Review of archeological and ethnographic literature

We conducted a literature search for evidence of grizzly bear presence in and around the North Cascades ecosystem prior to the onset of Euro-American settlement (ca. 1804). We expanded the geographic scope of our search beyond the bounds of the ecosystem to the entirety of Washington State and southern BC in order to gain a broader context for the prehistoric–historic status of grizzly bears in the region. Target literature primarily included summaries of archeological findings, original ethnographic documents, ethnographic studies, and contemporary meta-analyses of archeological findings. We also visited the Stó:lô Nation archives in Chilliwack, BC, to review a report on their traditional ecological knowledge of grizzly bears within the Stó:lô territory (Roburn 2001). Without dates of the actual observations, most ethnological accounts represent traditional knowledge that survived the initial introduction of smallpox to the Coast and Plateau Salish in the late 1700s and the subsequent collapse of an estimated 90% of their population (Boyd 1999).

Grizzly bears and the region's fur trade

We searched multiple archival sources within the US and Canada and targeted records of grizzly bear furs collected from fur trading posts that were geographically and historically relevant to the North Cascades. We sought out any other original manuscripts (e.g., trappers' journals, interview transcripts) containing information necessary to interpret patterns in fur return data, namely harvest areas and distribution patterns for each trading post. We also sought any records spanning the evolution of the fur trade in the general North Cascades area. This encompassed the operations of the Pacific Fur Company, the North West Company, and the HBC, from David Thompson's first exploration of the Columbia Plateau in 1807 to the functional end of the Pacific Northwest fur trade in the 1870s.

We received copies of all available fur return records from the HBC's Columbia and New Caledonia trading districts from the HBC Archives in Winnipeg, Manitoba (accessed 19 Apr 2017), which contain the majority of existing historical documents from the fur trade era. The Columbia District (west of the Rocky Mountains and south of the Thompson River) and New Caledonia (present-day British Columbia north of the Thompson River) records summarized for this report were recorded at Fort Vancouver, located at the mouth of the Columbia River. As the headquarters and the central distribution center for the West, records for all animal resources that were collected throughout the Columbia District and New Caledonia were transposed into one record book, "Fort Vancouver. Fur Trade Returns, Columbia District and New Caledonia, 1825–1857." (Hudson's Bay Company Archives [no date], accessed 19 Apr 2017).

Incidental observations in the North Cascades

In addition to analyzing fur return records from trading posts around the ecosystem, we compiled all known reliable historical and recent accounts of grizzly bears. We chose to synthesize the following information from the original records, if available: the year and geographic location of observations, their type (e.g., track, sighting), and level of reliability (described below). If only a general location description (e.g., Windy Pass) or approximate set of coordinates (i.e., township and range) were provided, we assigned Universal Transverse Mercator coordinates (North American Datum of 1983) in order to provide a map of the results. Data excluded from original reports are names and addresses of observers and descriptions of the animal and encounter. We provide the source of each observation so that readers may further investigate these details.

We derived data for this analysis from the NPS Complex's wildlife observations database, 2 previously published reports of grizzly bear accounts in the North Cascades (Sullivan 1983, Almack et al. 1993), data from the Interagency Grizzly Bear Committee (IGBC), and various other written accounts (e.g., Dow 1964, Beckey 2003), as well as compilations of sightings collected from local newspapers and ethnological descriptions. After we compiled data, we identified and deleted duplicate

Fig. 2. Grizzly bear (*Ursus arctos*) photographed near the East gate of Manning Park, British Columbia, Canada, in 2015. The key morphological traits required for positive identification (long front claws, prominent shoulder hump, and a dished face) are clearly displayed. Photo by J. Ashley-Pryce.

observations by cross-checking dates, locations, and source names. If all observation parameters (date, location, observer name, observation type) between multiple observations matched, we deemed it as the same observation. Historical and recent observations compiled by Bjorklund (1980) were later integrated and confirmed by Sullivan (1983); therefore, we directly cite the latter.

Sullivan (1983) and Almack et al. (1993) used a class scale (1 to 4) to rate the reliability of observations according to methods approved by the North Cascades Grizzly Bear Working Group and the IGBC (Almack 1986, 1990). Class 1 observations were confirmed as a positive identification by a biologist using a photograph or video, track, hair, carcass, dig, or food cache. Class 2 observations were characterized as "high reliability" if ≥ 2 of the following defining characteristics were confirmed: shoulder hump, concave facial profile (i.e., "dished face"), long front claws (Fig. 2), and scat if it was associated with a sighting or tracks. Tracks can provide some of the most definitive distinguishing features between American black bears (*U. americanus*) and grizzly bears (Herrero 1985). We chose to include Class 1 and 2 observations, but not Class 3 (low reliability) and 4 (not a grizzly bear) observations.

Results

Review of archeological and ethnographic literature

Grizzly bear fossils dated from between 12,000 and 850 bp (before present) have been recovered throughout much of Washington State, including the eastern slopes of the Cascades. Five Holocene archeological sites along the Columbia, Okanogan, and Snake rivers of central and eastern Washington contained grizzly bear remains that were possibly linked to human hunting and cultural use (Lyman 1986). One of these sites was a 1,000-year-old Salish house on the eastern boundary of the North Cascades ecosystem at the mouth of the Wenatchee River. Another notable finding occurred on the west coast of Whidbey Island in northern Puget Sound from the Late-Pleistocene epoch, dated to 9,000 years bp (Mustoe and Carlstad 1995). Grizzly bear remains have been recovered at fewer Holocene archeological sites than American black bear remains, suggesting that grizzly bears were either less abundant during that period or were not hunted as often by humans (Lyman 1986). Archeological evidence indicates that both American black and grizzly bears were more abundant prior to 1850 in the warm and dry Columbia Basin, where many have considered them to be largely absent (Lyman 2011).

Ethnological records of grizzly bears from the Upper Skagit, Sauk–Suiattle, Thompson, Stó:lô (Chilliwack), Chelan, and Methow peoples demonstrate varying degrees of significance within their traditional subsistence practices, cultures, and territories (Table 1). The consistency of the reports suggests that grizzly bears were widely integrated in the cultural and hunting traditions of Salish groups inhabiting the North Cascades and other regions of Washington and Southern BC (Smith 1988). It is difficult to infer even relative differences between the abundance of grizzly bears among different Salish territories, but coarse distribution within territories is specified in some ethnographic records. Sauk–Suiattle, Chelan, and Stó:lô informants noted that grizzly bears were "numerous," "fairly common," and "particular frequenters" in higher elevations of their respective drainages (Table 1). The Upper Skagit people also hunted them at higher elevations, and, although the Thompson sources do not specify where grizzly bears occurred, the hunting grounds were said to occur in the "tall mountains" (Table 1). An Upper Skagit member stated that the range of grizzly bears "did not extend much, if at all" west of the present-day North Cascades National Park boundary (Smith 1988).

Other ethnographic accounts are somewhat contradictory, but give the impression that grizzly bears were relatively scarce on west slope and lowland floodplain forests. The Swinomish people of the lower Skagit River valley and surrounding coastline are reported to have utilized grizzly bear hides and skulls in rituals, but active hunting

Table 1. Summary of historical grizzly bear (*Ursus arctos*) accounts by Salish people living in and around the North Cascades ecosystem, north-central Washington State (USA) and southern British Columbia (Canada), 1900–2001. NCNP = North Cascades National Park; R = River; U = upper; L = lower; NF = North Fork; Ck = Creek; BC = British Columbia.

First Nation tribe	Territory	Relationship to grizzly bear	Presence in landscape	Sources
Upper Skagit	Middle Skagit R. drainage to Newhalem, excluding Sauk drainage to the south	Hunted at higher elevations (Ross Lake area); furnished robes, wool and necklaces; guardian–hunter spirit form	Limited to higher elevations; "did not extend much if at all" west of NCNP boundary	Collins 1974, Smith 1988
Sauk–Suiattle	Sauk drainage and surrounding highlands, including Glacier Peak	Hunted by Sauk Indian tribe leader (born around 1800)	"Numerous" on ridges surrounding White, Indian passes, White Chuck meadows and the Suiattle R. high country	Bedal Fish and Bedal 2000
Nlaka'pamux (Thompson)	U. Thompson band: L. Thompson R., L Nicola R.; L. Thompson band: Fraser Canyon, across the Cascade crest to Similkameen drainage	Hunted (secondary importance); hunter and shaman spirit forms; various meanings in dreams and mythological history	Not specified, but hunting grounds included "tall mountains," Fraser Valley and adjacent higher areas	Teit 1900, Ruby and Brown 1988, Smith 1988
Stó:lô (Chilliwack)	Mouth and L. Fraser Valley to Chilliwack R., extending south to NF Nooksack R. and east to Chilliwack Lake.	Hunted (secondary importance to American black bear, difficult to secure); guardian spirit form	Seen at fishing sites and berry patches; more frequently seen on east side of territory; were "particular frequenters of the high country"	Duff 1952, Smith 1988, Roburn 2001
Chelan	Entire Chelan–Stehekin R. drainage into areas east of Columbia R	Hunted; dangerous spirit form	Present from upper Stehekin Valley to south end of Lake Chelan; "fairly common" in mountains surrounding the lake	Ray 1942, Dalquest 1948; Durham 1972, Smith 1988
Okanogan	Extends from Mica Ck, B.C. to below the Chelan R., Columbia R. confluence	Name of a chief: "Walking Grizzly Bear"	Not specified	Ruby and Brown 1988
Methow	Methow R. basin	Hunted; religious and ceremonial roles	Not specified	Ruby and Brown 1988

was not confirmed (Almack et al. 1993). Naturalists Suckley and Cooper (1860) stated that grizzly bears were not known to occur near the Northwest coast, although they observed that the Chinook people of the lower Columbia River had seen them in their territory and had a separate name for them (*esiamb*), differentiating them from American black bears (Gibbs 1863). There is no evidence of extensive direct killing of grizzly bears by indigenous people, but ethnographic records leave little doubt that they were hunted and occasionally killed in defense of life or food (Smith 1988, Bedal Fish and Bedal 2000, Sappington and Schuknecht-McDaniel 2001, McLaren et al. 2005).

Grizzly bears and the region's fur trade

The most substantive findings from our archive search consist of the HBC fur return records that were previously reported by Sullivan (1983) and Almack et al. (1993), along with some additional anecdotal records in trapper journals. The HBC trading-post clerks kept systematic records of the numbers of each species harvested each year (Tables S1–S5); however, there were no associated descriptions of harvest events, such as specific locations of kills and work effort. The fur return records transcribed at Fort Vancouver show that the HBC harvested 3,188 grizzly bear pelts from 5 trading posts bordering the North Cascades ecosystem between years 1826 and

Table 2. Number of grizzly bear (*Ursus arctos*) furs harvested from selected Hudson's Bay Company trading posts surrounding the North Cascades ecosystem, north-central Washington State (USA) and southern British Columbia (Canada), 1826–1857. Source: Hudson's Bay Company Archives, Winnipeg, Manitoba.

	Trading post				
Year	Colville	Langley	Nez Percés	Nisqually	Thompson
1826	0	0	0	0	0
1827	9	0	0	0	0
1828	6	0	0	0	2
1829	18	0	0	0	10
1830	68	0	1	0	3
1831	49	0	7	0	12
1832	33	0	7	0	3
1833	36	0	19	0	8
1834	10	1	12	0	8
1835	33	0	9	0	7
1836	29	0	3	0	15
1837	25	0	3	0	2
1838	61	0	3	0	4
1839	66	1	4	0	5
1840	27	1	0	0	7
1841	45	3	2	1	2
1842	85	2	5	0	3
1843	107	0	21	0	3
1844	185	4	22	0	7
1845	203	2	33	0	6
1846	244	3	27	0	4
1847	160	2	3	0	5
1848	369	1	2	0	3
1849	227	1	2	0	11
1850	245	1	0	1	11
1851	188	2	0	0	6
1852	195	2	1	0	7
1853	0	2	0	0	9
1854	0	14	0	0	11
1855	0	13	0	0	7
1856	0	9	0	0	2
1857	0	30	0	0	0
Totals	2,723	94	186	2	183
Grand total	3,188				

1857. Records from Fort Colville accounted for 85.4% of harvest efforts during this time period, followed by Fort Nez Percés (5.8%), Fort Thompson (5.7%), Fort Langley (2.9%), and Fort Nisqually (0.1%; Table 2).

The total number of grizzly bear pelts recorded at Fort Colville during its operation (n = 2,723; 1827–1852) far outnumbers that of other forts surrounding the North Cascades ecosystem. However, the effort or interest in collecting pelts from bears and other large animals did not seem to begin until 1840, after which returns increased dramatically to their peak in 1848 (n = 369; Table 2, Fig. 3). Thirty-four grizzly bear pelts were collectively contributed to Fort Colville's inventory from Fort Okanogan and Spokane House between 1827 and 1829 (Work 1830:5). In addition, records show that the Kettle Falls tribe traded grizzly bear furs at Fort Colville in 1827 (n = 4) and 1828 (n = 1; Work 1830:7). These accounts present strong evidence that north-central Washington, specifically the Okanogan region, harbored at least a small population of grizzly bears (Suckley and Cooper 1860, Thompson 1970).

Return records from Fort Nez Percés show a fairly consistent harvest of grizzly bear furs from 1830 to 1852, although 33 were harvested during its peak year (1845; Table 2, Fig. 3). Fort Thompson trapping operations produced 183 grizzly bear furs from 1828 to 1856 (Table 2, Fig. 3). A relatively small number of furs were taken each year during this time, and peaked at 15 grizzly bears in 1836. Ninety-four grizzly bear pelts were recorded at Fort Langley between 1834 and 1857. The annual

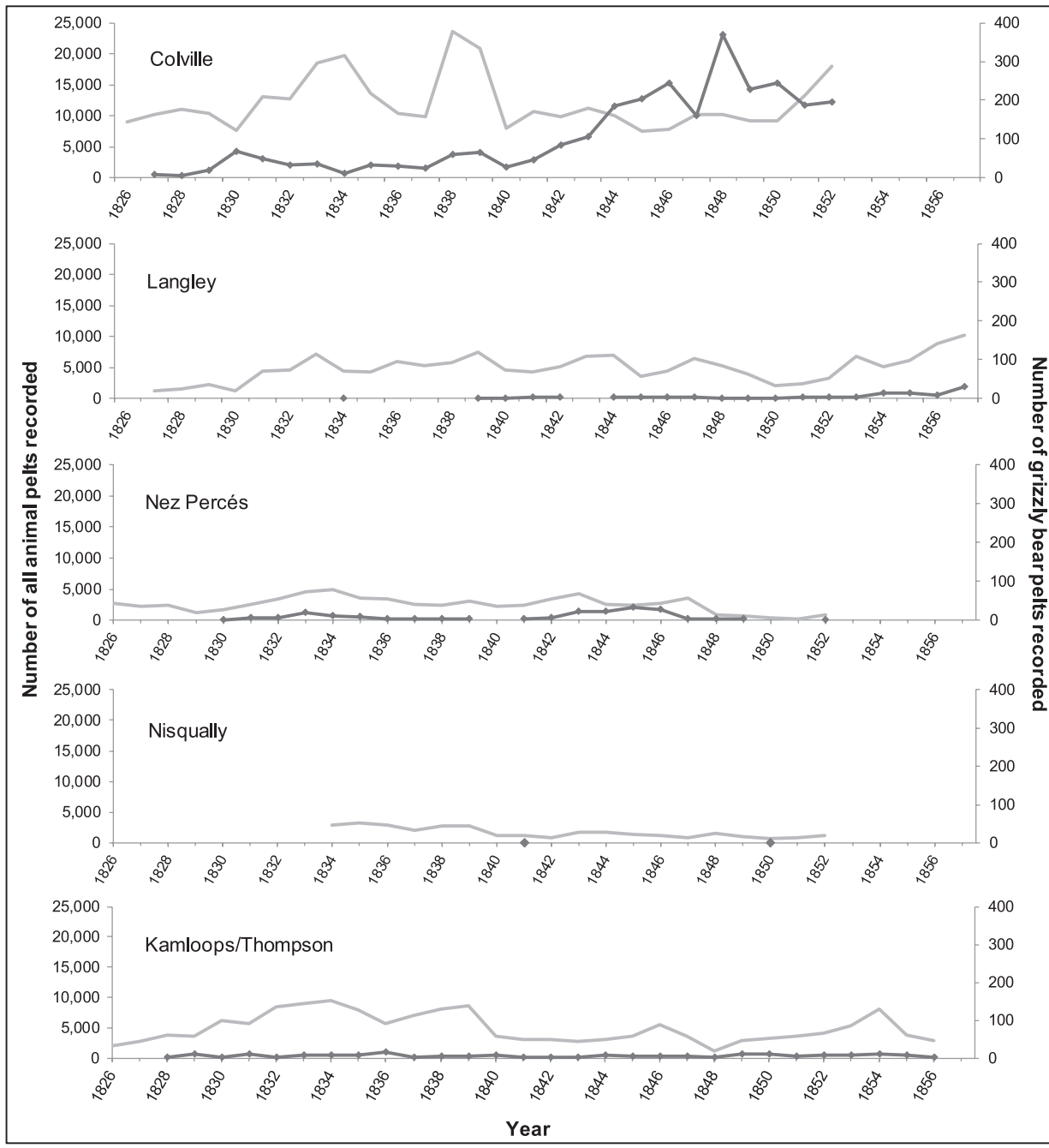

Fig. 3. Inter-annual trends of grizzly bear (*Ursus arctos;* black points, line) and total animal (gray line) fur harvests from Hudson's Bay Company trading posts surrounding the North Cascades ecosystem, north-central Washington State (USA) and southern British Columbia (Canada), 1826–1857. Left-hand vertical axis: yearly total of all animal furs; right-hand vertical axis: yearly total of all grizzly bear furs.

returns of grizzlies remained at ≤4 until the last few years of its fur trade, when 30 were collected in 1857 (Table 2, Fig. 3). Grizzly bear pelts were especially scarce in Fort Nisqually records. Only 2 pelts were harvested during the entirety of the post's operations from 1834 to 1852.

There is no substantive evidence for large-scale trapping operations by the HBC throughout the core of the mountain range (Thompson 1970). The only posts within the boundaries of the ecosystem, Forts Hope and Yale on the lower Fraser River, did not produce detailed fur return records because they did not contribute significantly to the region's industry. Rather, they functioned primarily as staging and supply posts between interior overland brigades and boats operating downstream (Watson 2010). The only documented exploration by a Euro-American was Alexander Ross' sole expedition over the orographic crest in 1811 (Thompson 1970). Although it appears that the core of the mountain range was left largely untouched by the Euro-Americans during this early period, it is generally assumed that resident indigenous people hunted animals within their territories and traded the pelts at nearby posts, such as Forts Okanogan and Langley (Sage 1934, Luxenburg 1986).

Incidental observations in the North Cascades

We compiled 178 geo-referenced (Class 1 and 2) observations of grizzly bears or their signs within the ecosystem between 1859 and 2015. There were ≥2 documented mortalities for which there are no geo-referenced data (1920 "Entiat River" [Dow 1964]; and the Stehekin–Lake Chelan area, approx. 1920; Fig. 4). Of all observations, 23.0% ($n = 41$) were previously designated as "confirmed" Class 1 observations (Table S6) and 78.1% ($n = 139$) were "high reliability" Class 2 (Table S7). Locations of grizzly bear sightings and other signs are widely dispersed throughout the North Cascades ecosystem, but encounters were slightly concentrated east of the Cascade crest (Fig. 4) as previously reported by Agee et al. (1989). The number of both Class 1 and Class 2 observations peaked in the 1980s and remained elevated in the following decade (Fig. 5). The number of Class 1 observations before 1980 remained relatively constant over time, whereas Class 2 observations showed a general increase up to that point.

The majority of observations (88.2%, $n = 157$) were visual sightings (Table 3), and 17 of these were associated with tracks, remains, visual media, scat, DNA, or a combination thereof. Tracks were the next most common grizzly bear sign encountered by observers (14.0%, $n = 25$; Table 3). Sixteen sets of tracks were the sole sign at the time of observation, and the remaining 9 instances were accompanied by other signs. Five observations consisted of remains (2 skulls, 3 hides), 4 of which were positively identified by a biologist (Class 1; Tables S6–S7).

Table 3. Number of each grizzly bear (*Ursus arctos*) observation type recorded between 1859 and 2015 in the North Cascades Ecosystem, north-central Washington State (USA) and southern British Columbia (Canada). More than one observation type may be included in a single account.

Observation type	Class 1[a]	Class 2[b]	Total
Sightings	31	126	157
Tracks	9	16	25
Photo or video	6	0	6
Remains	4	1	5
Digs	1	2	3
DNA	2	0	2
Food cache	1	0	1
Scat	1	0	1

[a]Class 1: observations confirmed as a positive identification by a biologist using a photograph or video, track, hair, carcass, dig, or food cache.

[b]Class 2: observations characterized as "high reliability" if ≥2 of the following defining characteristics were confirmed: shoulder hump, concave facial profile (i.e., "dished face"), long front claws (Fig. 2), and scat if it was associated with a sighting or tracks.

Twenty separate observations noted a group of ≥2 bears together. Half of these cases involved a female accompanied by 1–3 offspring, but only 1 of these observations was designated as Class 1 (1991, Moore Point, WNF; Table S6). That subadult was also the only individual, of 21 offspring, that was confirmed as a grizzly. The remaining 10 multiple-bear observations involved groups of adult or unaged grizzly bears of roughly the same size, but it is impossible to say whether these groups consisted of a female with offspring, siblings, or a mated pair. Only 2 of these 10 observations were rated as Class 1 (Table S6).

In addition to the records compiled by Sullivan (1983) and Almack et al. (1993), Gyug (1998) compiled sightings for the North Cascades GBPU in British Columbia. Details of individual records were not available, and therefore some of the records may be the same observations as those compiled in this report. Between 1993 and 1997, Gyug reported 2 Class 1 observations and 36 Class 2 observations. Using these data, he estimated the minimum population in the GBPU to be 17 bears, with a density of 1 bear/150 km^2. Most sightings occurred in subalpine habitat, where bears were observed foraging for berries. Sightings were concentrated in 4 areas:

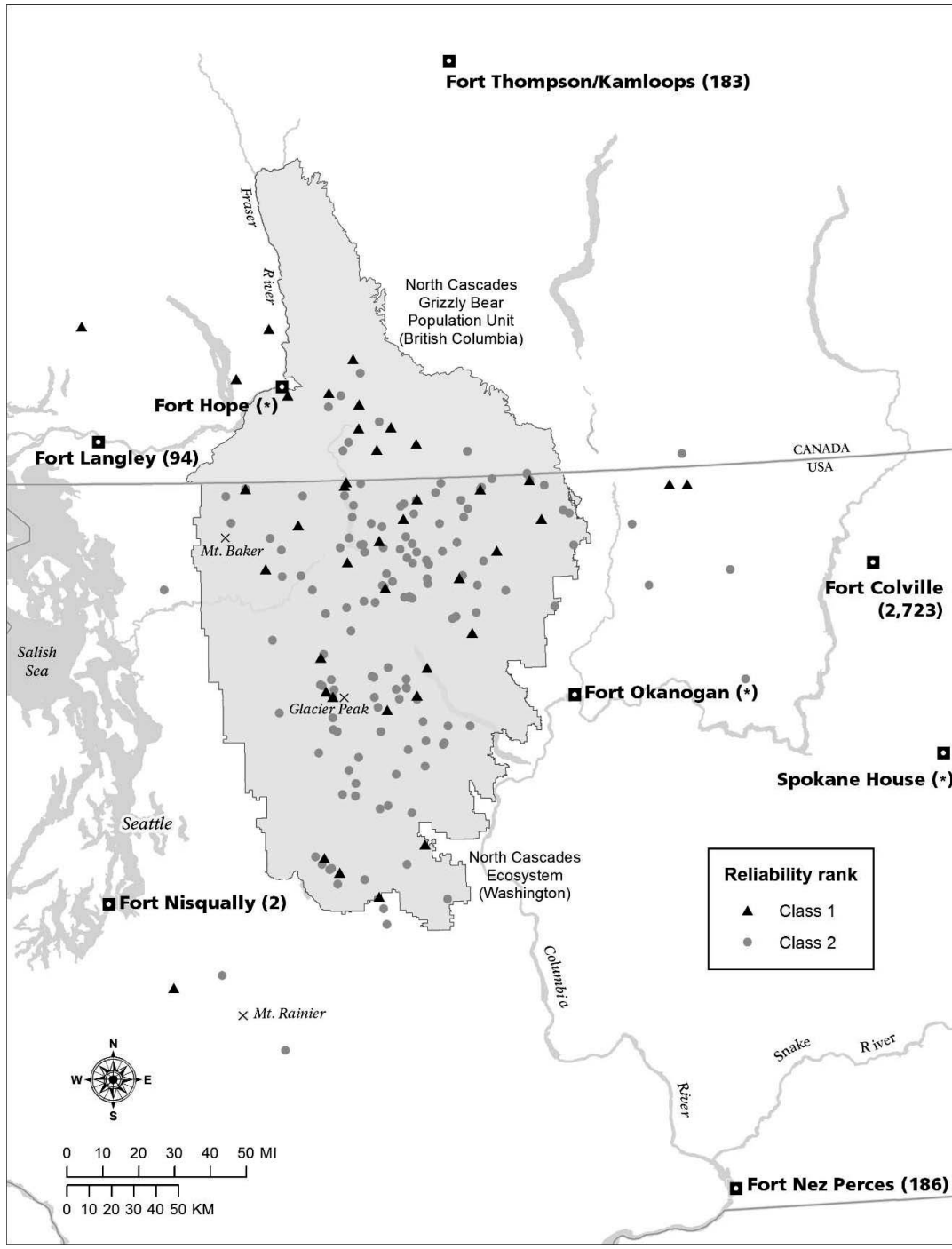

Fig. 4. Locations of Class 1 (black triangles) and Class 2 (gray circles) grizzly bear (*Ursus arctos*) observations within and around the North Cascades ecosystem, north-central Washington State (USA) and southern British Columbia (Canada), 1859–2015. The sum total of grizzly bear pelts reported to Hudson's Bay Company's (HBC) Fort Vancouver by each trading post across all years of operation is shown in parentheses. (*) Fur returns processed by these trading posts were not reported to HBC's Fort Vancouver.

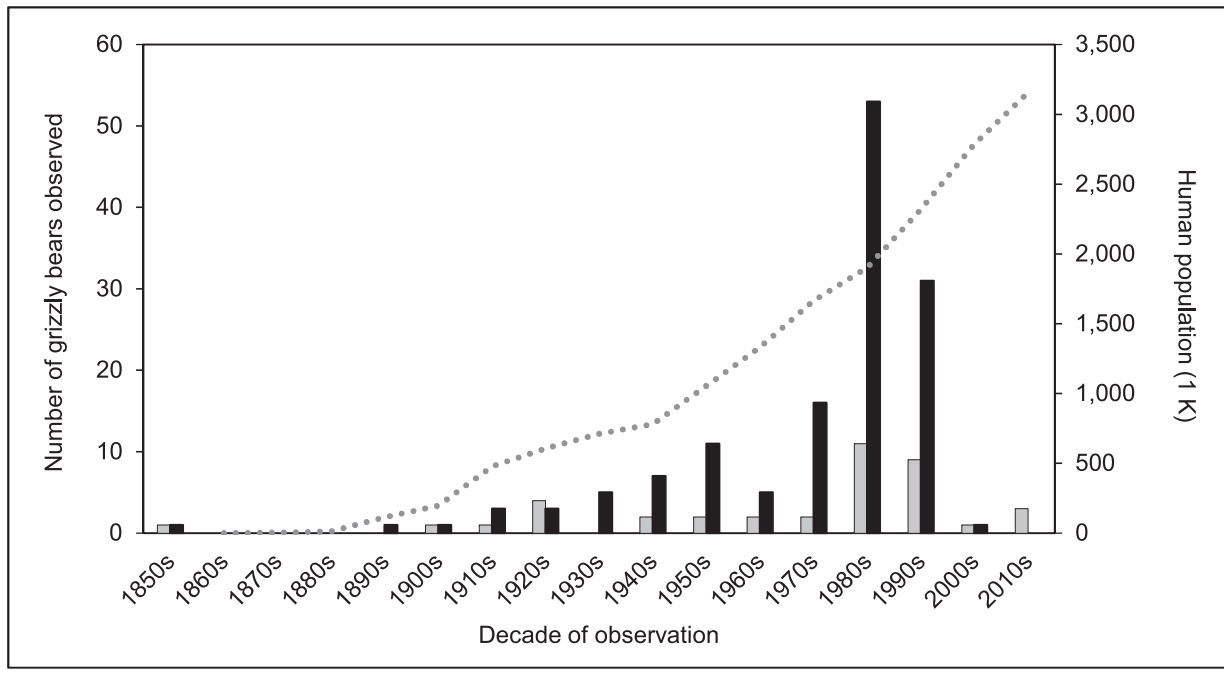

Fig. 5. Number of Class 1 (gray bars) and Class 2 (black bars) grizzly bear (*Ursus arctos*) observations across decades (1850s to 2010s) in the North Cascades ecosystem, north-central Washington State (USA) and southern British Columbia (Canada). The human population in United States counties encompassing the North Cascades ecosystem (Chelan, Douglas, Kittitas, King, Okanogan, Snohomish, Skagit, and Whatcom) is provided (gray dotted line) for greater context (U.S. Census Bureau).

Stoyoma Mountain, Central Core (Coquihalla Mountain), Ashnola, and Skagit–Chilliwack.

Discussion

Multiple lines of evidence confirm the prehistoric–historic presence of grizzly bears in and around the North Cascades ecosystem. Several patterns emerge from across sources to suggest (1) that relative abundance in recent memory was greater in high-elevation habitat and across the eastern slopes of the ecosystem, and (2) that human activities within the past 200 years severely reduced population levels.

Ethnographic literature from the Upper Skagit, Sauk–Suiattle, Thompson, Stó:lô, and Chelan tribes agree that grizzly bears were historically more common in higher elevation habitat within their respective territories (Smith 1988, Bedal Fish and Bedal 2000). Given the variable environmental conditions and food sources within the historical range of grizzly bears (Servheen 1990, Mattson and Merrill 2002), it is likely that they occurred across a wide range of elevations throughout prehistoric Washington State (Lyman 1986, 2011), including the subalpine (Apps et al. 2004). It appears that the core and subalpine regions of the mountain range were less influenced by the Euro-American fur trade and indigenous human settlements (Thompson 1970, Luxenberg 1986). If pelt harvesting occurred at higher elevations, it was likely at a reduced rate compared with the valleys in and around the ecosystem (Chittenden 1935), allowing a relic grizzly bear population to persist (Lyman 2011).

Historical and recent incidental sightings indicate that grizzly abundance may have been greater on the east side of the Cascade crest. The analyses by Agee et al. (1989) revealed that grizzly bear sightings in the North Cascades were disproportionately concentrated in open-canopy habitat that included subalpine meadow, montane shrub, and whitebark pine (*Pinus albicaulis*)–larch (*Larix* spp.) cover types, where many preferred plant foods are abundant (e.g., *Vaccinium,* graminoids, forbs, and bulbs; Gaines et al. 1994, Ransom et al. 2018). The spatial patterns of these observations may not be truly reflective of grizzly bear distribution and density, because the rate of sightings would probably be higher in open-canopy

habitats, which are more widespread along and east of the crest (Agee et al. 1989, Almack et al. 1993). Apparent distribution is also influenced by the geographic coverage of research by Almack et al. (1993) and Sullivan (1983). For instance, Sullivan stated that his research in the Nooksack Valley north of Mount Baker, the Skykomish Valley west of Stevens Pass, and British Columbia was less represented than other areas in the North Cascades.

The vast majority of grizzly bear pelts recorded by the HBC were processed by trading posts outside the ecosystem's eastern and northern borders (Forts Colvile, Nez Percés, and Thompson), compared with the numbers from coastal trading posts west of its border (Forts Langley and Nisqually), thus broadly aligning with the distribution of ethnographic and incidental sightings. A leading HBC trader noted in a report that the exact extent of trading within the Colville District was difficult to determine (Work 1830); similarly, we were unable to find any accounts from trappers' journals that specified regional harvest locations. Fort Colville has been cited as the center of operations for a large trapping network that included the Okanogan, Pend Oreille, Kootenai, and Flathead regions (Bancroft 1890), whereas the Fort Nez Percés location was essential for staging the "Snake Party" expeditions that explored much of the land west of the Rockies, from the Flathead region to the mouth of the Columbia (Hussey 1975, Watson 2010). The Upper Skagit, Swinomish, and other tribes regularly traveled up to Fort Langley to trade (Sage 1934). It is therefore possible that some of the few grizzly bear pelts recorded at this post had origins on the western slopes of the North Cascades. If the pelts traded at Nisqually were obtained in the mountain range, it was likely closer to Mount Rainier, the origin of the Nisqually River. Collectively, ethnological (Upper Skagit; Smith 1988) and historical (e.g., Suckley and Cooper 1860) accounts describing the scarcity of grizzly bears on the west side support the notion that the fur return numbers may be reflective of true distribution on a coarse scale.

Recent scientific findings indicate that grizzly bears were initially extirpated in lowland areas, where permanent human establishments and activity have historically been greatest (e.g., Mace and Waller 1996, Mattson and Merrill 2002, Apps et al. 2004, Lyman 2011). This dynamic may have already been in place when Lewis and Clark's party arrived on the lower Columbia in 1805, given their observations of the relatively dense Coast and Plateau Salish population, as well as the absence of big game species (Moulton 1986–1996, Laliberte and Ripple 2003, Ubelaker et al. 2006). The concept of regional game overkill by indigenous people is not widely supported by paleoecologists (Butler and Campbell 2004, Campbell and Butler 2010, Jones 2013), but human–grizzly resource niche overlap (e.g., salmon, berry, and ungulate consumption; use of open habitat) was probably significant enough to reduce the bears' density in the lowlands (Mattson and Merrill 2002, Schullery 2002, Laliberte and Ripple 2003), while allowing the persistence of populations in less accessible mountainous terrain (Lyman 2011). In the North Cascades, the Upper Stó:lô and Lower Thompson peoples gathered by the thousands along the banks of the Chilliwack and Fraser rivers to dip-net returning Chinook (*Oncorhynchus tshawytscha*) and sockeye salmon (*O. nerka;* Smith 1988), likely increasing confrontations and displacing bears from such high-value feeding spots (Mattson and Merrill 2002).

Regardless of the mechanisms and timeline for grizzly bear extirpations in the lowlands surrounding the North Cascades ecosystem, it is likely that the rapid changes in the region's human populations and resource degradation over the past 200 years, coupled with higher rates of direct killing that followed the initial appearance of armed Euro-American fur traders, far exceeded the cumulative effects of indigenous humans over thousands of years (Storer and Tevis 1955, Servheen et al. 1999, Mattson and Merrill 2002). The increasing trend of incidental Class 2 sightings over time (and certainly the spikes in all observations in the 1980s and 1990s; Fig. 5) runs counter to the notion of gradual extirpation, but suggests a reporting bias rather than an actual population trend. Sullivan (1983) and Almack et al. (1993) do not provide specific explanations for this pattern, but their disproportionately large effort to actively document these accounts in interviews during this time should be a strong consideration when interpreting these data. Indeed, only 5 of 35 observations in the 1990s were made after Almack et al. published their observation data in 1993 (Tables S6–S7). It is therefore likely that the sudden change in sampling method, effort, and/or some aspect of the verification process caused the spikes, rather than a true lack of bears at other times (Gaines et al. 2001). The same effect can also be applied to the period before the Sullivan and Almack et al. studies, which would likely be compounded by failing memories and fewer living observers for increasingly older accounts (Sullivan 1983, Almack et al. 1993, Gyug 1998). These temporal patterns underscore the importance of active, systematic documentation to the results presented here, and to the public's perception of scarcity throughout the state.

In many ways, the most valuable historical anecdotes are those from ethnographic records. Salish tribes have long occupied regions within and around the ecosystem

and have possessed an intimate knowledge of the landscape and its fauna; therefore, their accounts of grizzly bears should be given significant credibility. For example, anecdotes accurately described certain characteristic differences in the size, behavior, and habitat preference between American black and grizzly bears (Collins 1974, Ruby and Brown 1988, Smith 1988, Bedal Fish and Bedal 2000). In contrast, record keeping by trappers and HBC clerks was generally poor and inconsistent (Nation-Knapper 2015, Tables S1–S5), suggesting that the numbers here represent only a snapshot of the actual harvest during the fur trade. For instance, Edward Huggins, the general manager at Fort Nisqually after 1850, recorded 250 grizzly bear pelts brought in from the 1855 trades at multiple forts east of the Cascades that were not included in the HBC's Fort Vancouver books (including Fort Colville, Okanogan, and Nez Percés; Farrar 1924). These supplemental data probably represent a larger body of information lost in the complex and unregulated web of trapping operations (Nation-Knapper 2015).

A number of other interacting and variable factors probably influenced actual and apparent harvests. For instance, it is possible that relatively few grizzly bear pelts were collected because they required considerable risk to acquire compared with beaver (*Castor canadensis*) and other small fur-bearers, and because the HBC generally did not encourage indigenous traders to hunt bears (Work 1830). Other sources of uncertainty include varying trade relationships among the Salish people and Europeans (Merk 1931), spatial extent and frequency of inter-tribal trading (Thomson and Ignace 2005), population dynamics and harvest rates of other furbearers, and seasonal timing of trapping efforts relative to bear activity. We conclude that the HBC records and other documents cited here show evidence of a general historical presence of grizzly bears within the North Cascades and surrounding areas.

The objective of this review was to synthesize existing information from several disparate fields of study concerning the historical presence of grizzly bears in the North Cascades region and to survey possible factors contributing to the observed dynamics. Although this review was not exhaustive, we note that there is a lack of historical demographic data for the region's grizzly bears. The scarcity of information is sufficiently explained by the rapid extermination that occurred over a relatively short time span (approx. 200 yr; Frank and Woodroffe 2001, Mattson and Merrill 2002) that mostly predates systematic wildlife record keeping. The mystery is compounded by the loss of records, the difficulty in confirming species identification from observation reports, and the remoteness and topographic complexity of the North Cascades.

Overall, it is likely that what was almost entirely anecdotal evidence was slowly lost with the passing of multiple generations of settlers and native peoples. The shortage of information has understandably led some to doubt that Washington State was ever home to viable grizzly bear populations; however, we suggest there is an intrinsic fallacy in the act of drawing conclusions based on scant or negative evidence (Fischer 1970). Specifically, the lack of information for any given time period does not equate to true scarcity of grizzly bears in the North Cascades. More research should be undertaken to supplement data gaps, especially during the post-Columbian historical period. A valuable and relatively accessible area of research is contained within the Pacific Northwest's ethnographic literature and collective traditional ecological knowledge (Huntington 2000).

Management implications

Of all prehistoric and historic factors that have contributed to the current state of grizzly bears in the Pacific Northwest, none is perhaps more influential than active persecution by a growing human population, and the many associated anthropological effects. Coupled with the slow reproductive rate of grizzly bears and the surrounding human-developed landscapes that isolate the North Cascades ecosystem from other occupied patches (Mowat et al. 2013), the population is at risk of extirpation (Lyons et al. 2018). Successful implementation of grizzly bear restoration and management in the North Cascades is dependent in part on the perception that they are an integral component of the ecosystem's historical conditions prior to European arrival. Discussions of restoration issues and the historical benchmark that is ultimately chosen is not solely reliant on scientific consensus; it also depends on social, political, and economic variables that together represent a mix of theory, opinion, and fact (Lyman 1996, Jones 2013). Active outreach highlighting historical misconceptions, empirical data, and the influence of human perception on management outcomes of large carnivores may improve long-term success of grizzly bear restoration in the North Cascades.

Acknowledgments

Many thanks to the Hudson's Bay Company Archives in Winnipeg, Manitoba, Canada, for providing copies of fur return records and other resources cited in this publication. We also wish to express sincere gratitude to the

Stó:lô Nation (Chilliwack, BC, Canada) for allowing us to review archived reports and collections of writings related to grizzly bear observations and stories. Thanks to P. Schullery for providing consultation, collaborative dialogue, and resources. Thanks also to the Interagency Grizzly Bear Committee North Cascades Ecosystem Subcommittee Technical Team members, L. Grace, and M. Huff for their review of the document.

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Received: February 15, 2019
Accepted: September 6, 2019
Associate Editor: F. T. van Manen