Disappearing glaciers of the Oregon Cascades, USA

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Disappearing glaciers of the Oregon Cascades, USA

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The Oregon Cascades had 35 named glaciers on seven volcanos in the 1980s, with 34 of those glaciers remaining by 2000. Here we document the glaciers that fall into the Global Glacier Casualty List categories based on five years of field observations of these 34 glaciers. Five glaciers have disappeared, four have almost disappeared, and eight are critically endangered. Thus, half of the Oregon Cascade named glaciers have disappeared, almost disappeared, or reached critically endangered status in the 21st century. Between 1995 and 2024, six snow telemetry stations recorded May-October warming at ~0.8°C per decade with a 2020-24 mean temperature ~2.3°C warmer than the 1995-99 mean. In contrast, April snowpack showed statistically significant declines at only two of the six stations. Given the significant rise in melt-season temperature and limited evidence for a reduction in snow accumulation, we attribute ongoing glacier disappearance in the Oregon Cascades to the warming climate.

1. Introduction

Globally, glacier retreat has reached historically unprecedented rates (e.g., Zemp and others, 2015) in response to anthropogenic greenhouse gas emissions (Roe and others, 2021) that are predominately from the combustion of fossil fuels (Wolf and others, 2025). In western Canada and the United States, glaciers lost ~22.8% of their mass between 2000 and 2023 (The GlaMBIE Team, 2025). Such mass loss is resulting in glacier disappearance in the

United States' Pacific Northwest, including the state of Oregon (Fig. 1A) (e.g., Pelto, 2010; Fountain and others, 2023; Bakken-French and others, 2024; Pelto and Pelto, 2025).

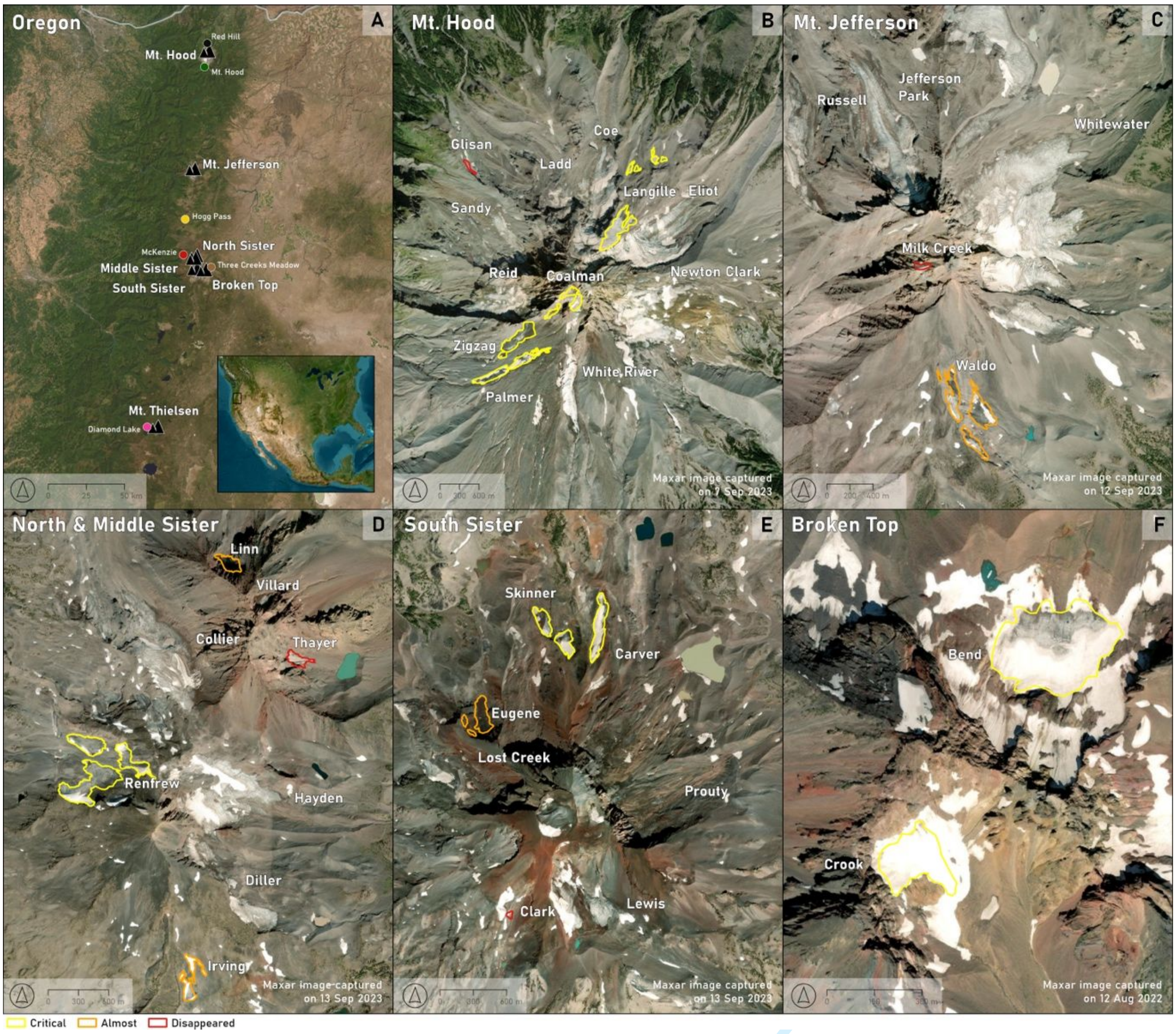

Figure 1. Location of Oregon glacierized volcanos (A) with inset showing location. Snow telemetry stations labeled with colors corresponding to Figure 4. Glaciers discussed in text for Mt. Hood (B), Mt. Jefferson (C), North and Middle Sisters (D), South Sister (E), and Broken Top (F). Orange outline critically endangered; yellow outline almost disappeared; red outline disappeared.

In the early 1980s, the Oregon Cascades had 35 named glaciers distributed across seven volcanos (Fig. 1A), with one glacier (Palmer Glacier; Fig. 1B) ceasing to flow on Mt. Hood by the 1990s (Fountain and others, 2023; Bakken-French and others, 2024). Fountain and others (2023) provided an updated inventory for the other 34 glaciers using remote sensing imagery from 2015, 2016, 2018, or 2020, but with no field observations to check imagery interpretation. As of 2015-20, six of the 34 glaciers that existed in 2000 were listed as no longer being glaciers (Table 1) (Fountain and other, 2023).

Volcano	Glacier	Latitude	Longitude	Year	Area (km^2)	2015-20 Status	No Crevasses	Concave	Broken up	No Accum.	2023 Area (km^2)	2023-24 Status
Mt. Hood	Glisan	45.387	-121.709	2015	0.082	Glacier	X	X	X	X	0.009	Disappeared
Mt. Hood	Coalman	45.371	-121.700	2016	0.099	Glacier		X			0.052	Critical
Mt. Hood	Zigzag	45.366	-121.708	2015	0.351	Glacier		X		X	0.239	Critical
Mt. Hood	Langille	45.382	-121.690	2016	0.316	Glacier		X			0.169	Critical
Mt. Jefferson	Milk Creek	44.674	-121.808	2020	0.016	Glacier	X	X		X	0.006	Disappeared
Mt. Jefferson	Waldo	44.662	-121.797	2020	0.123	Glacier	X	X		X	0.097	Almost
North Sister	Linn	44.173	-121.775	2018	0.040	Glacier	X	X		X	0.025	Almost
North Sister	Thayer	44.164	-121.766	2018	0.000	Gone	X	X	X	X	0.022	Disappeared
Middle Sister	Irving	44.137	-121.780	2018	0.068	Snowfield	X	X		X	0.033	Almost
Middle Sister	Renfrew	44.155	-121.792	2018	0.310	Glacier		X		X	0.215	Critical
South Sister	Clark	44.100	-121.776	2018	0.081	Snowfield	X	X	X	X	0.025	Disappeared
South Sister	Carver	44.112	-121.767	2018	0.131	Snowfield				X	0.067	Critical
South Sister	Skinner	44.109	-121.773	2018	0.100	Snowfield				X	0.050	Critical
South Sister	Eugene	44.110	-121.780	2018	0.048	Glacier	X	X		X	0.034	Almost
Broken Top	Crook	44.080	-121.700	2018	0.051	Glacier		X		X	0.033	Critical
Broken Top	Bend	44.086	-121.693	2018	0.219	Glacier		X		X	0.084	Critical
Mt. Thielsen	Lathrop	43.155	-122.066	2018	0.000	Gone	-	-	-	-	0.000	Disappeared

Table 1. Oregon Cascade named glaciers and their GGCL category. Data in columns Year, Area (km^2), and 2015-20 status from Fountain and others (2023).

With 2020 as the most recent observation, which is for only one of the seven volcanos (Table 1), the Fountain and others (2023) inventory missed the effects of post-2020 warmth (Bakken-French and others, 2024). This period includes one of the most extreme heatwaves ever recorded on Earth in late June 2021 (Thompson and others, 2022) that impacted glaciers in the Pacific Northwest (Pelto and others, 2022). In Oregon, glaciers are also experiencing increased rock fall and debris cover, necessitating field observations to accurately map glacier extent and confirm glacier flow (Bakken-French and others, 2024). Furthermore, remote-sensing-alone investigations that use snow/ice area to delineate between flowing glaciers and a perennial snowfield can mischaracterize features whereas field verification can directly determine such characterizations (Pelto and Pelto, 2025). Here using field observations, we document the Oregon Cascade named glaciers that have reached one of the three vanishing glaciers classifications of the Global Glacier Casualty List (GGCL, 2025).

2. Methods

We used field observations from August-October from 2020 through 2024 for the 34 glaciers on the seven glacierized volcanos in the Oregon Cascades (Fig. 1) to place them in the three classifications of the GGCL: “critically endangered”, “almost disappeared” and “disappeared” (Fig. 2). Based on personal communications from the GGCL (D. Boyer, 16 March 2025), a “disappeared” glacier is between a stagnant ice mass and complete absence. An “almost disappeared” glacier is expected to reach disappeared status any year now. A “critically endangered” glacier is expected to reach disappeared status in the 2030s or later. We note that our study is not a full glacier inventory for these volcanos, nor do these classifications correspond with the methodology for glacier inventories (Müller and others, 1977). Rather, we classify Oregon Cascade named glaciers within these GGCL categories.

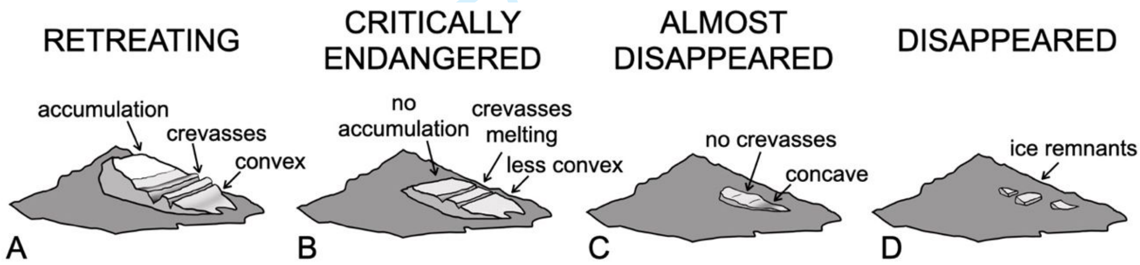

Figure 2. Graphic depicting glacier transition from a retreating (A) to critically endangered (B) to almost disappeared (C) to disappeared (D). Field-based characteristics noted.

Our criteria thus focused on determining if a glacier was still actively deforming and flowing under its own weight or had stagnated (Fig. 2). Evidence of flow were the presence of crevasses where we noted if the crevasses were being actively maintained open by flow (Fig. 2A, 3A) or were melting in on themselves, implying waning ice flow (Fig. 2B, 3B) (Leigh and others, 2019; Bakken-French and others, 2024; Pelto and Pelto, 2025). Termini were examined in the field. Termini were classified as either having a convex or concave topographic profile where the profile is defined as the cross-sectional view of elevation along the glacier flow line. A convex terminus was taken as indicating ice flow (Fig. 2A, 3A, 3C) while a concave terminus was used as evidence for the lack of ice flow (Fig. 2C, 3D)

(Leonard and Fountain, 2003; Lillquist and Walker, 2006; Leigh and others, 2019; Bakken-French and others, 2024). Each of these criteria was checked with high-resolution (0.3 m) Maxar (Vivid) imagery captured on 8 and 13 September 2023 (ESRI, 2024), which was used with field mapping and weekly Sentinal-2 satellite imagery to determine 2023 glacier extent (Paul and others, 2013; Bakken-French and others 2024). Lastly, accumulation area ratios consistently smaller than 0.3 are indicative of glaciers that are no longer viable in the current climate (Fig. 2B, 3B) (Pelto, 2010). We used Sentinal-2 satellite imagery provided in the application CalTopo (www.caltopo.com) with field verification to note whether a given glacier had any remaining prior-winter snow at the end of summer.

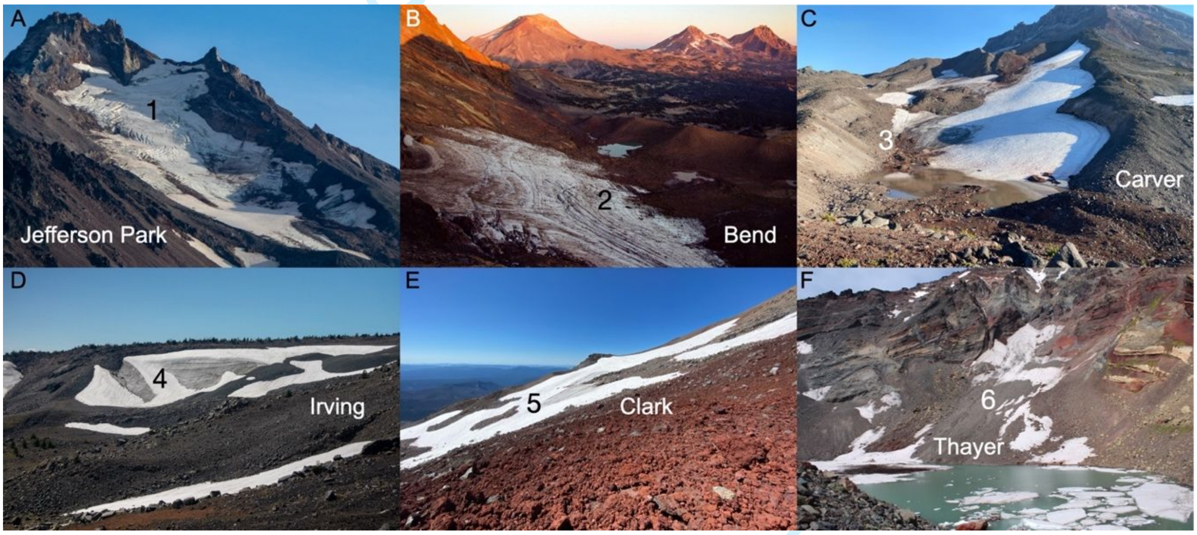

Figure 3. Example field observations used to place glaciers in GGCL categories. (A) Jefferson Park Glacier on Mt. Jefferson is an actively flowing glacier (1) that is retreating but not considered critically endangered. (B) Bend Glacier is critically endangered with crevasses melting in on themselves (2) and lacks an accumulation zone. (C) Carver Glacier is critically endangered with a convex terminus (3). (D) Irving Glacier has almost disappeared with a concave terminus and no crevasses (4). (E) Clark Glacier has disappeared and consists only of remnant patches of ice (5). (F) The basin that used to hold Thayer Glacier, which now has debris covering stagnant ice (6).

We placed a glacier in the disappeared status if its ice was completely gone or if it lacked evidence of flow (no crevasses and concave terminus), lacked an accumulation zone and the remaining ice was small, disconnected remnants to buried stagnant ice (Fig. 2D, 3E, 3F). An almost disappeared glacier lacked evidence of flow (no crevasses, concave terminus) and lacked an accumulation zone, but the remaining ice covered an area that still resembled its former flowing glacier area (Fig. 2C, 3D). A critically endangered glacier showed some evidence of flow with a convex terminus (Fig. 3C) or had crevasses, but the crevasses were melting in on themselves (Fig. 2B, 3B) and the glacier lacked an accumulation area (Fig. 2B), or the accumulation area ratio was consistently below 0.3.

There is thus a clear demarcation between a critically endangered glacier that still flows (Fig. 2B) and an almost disappeared glacier that does not flow (Fig. 2C). The next demarcation between almost disappeared (Fig. 2C) and disappeared (Fig. 2D) is more subjective and there can be overlap between these two categories. While both these categories are no longer flowing glaciers, an almost disappeared glacier is generally a larger, intact stagnant ice body relative to the remnant ice segments of a disappeared glacier.

We assessed the changing climate using May-October average temperature and April snowpack data recorded at six U.S. Department of Agriculture snow telemetry (SNOTEL) stations near the seven glacierized summits (Fig. 1A; Table 2) (USDA, 2025). May-October is the maximum length of the melt season in the Oregon Cascades (Bakken-French and others, 2024). 1 April usually represents peak snowpack depth expressed in snow-water equivalent (SWE) in the Pacific Northwest (Pelto, 2018). Temperature data were consistently recorded back through 1995. We thus analyze these data for the period 1995 through 2024.

Station	I.D. Number	Latitude	Longitude	Elevation (m)	°C dec^{-1}	r	ΔTemp	cm dec^{-1}	r
Red Hill	712	45.46	-121.70	1340	0.8	0.73	2.1	*-5*	*0.10**
Mt Hood Test Site	651	45.32	-121.72	1640	0.8	0.73	2.1	*-18*	*0.35**
Hogg Pass	526	44.42	-121.86	1460	0.8	0.75	2.2	-30	0.67
Mckenzie	619	44.21	-121.87	1450	0.7	0.77	1.8	*-14*	*0.32**
Three Creeks Meadow	815	44.14	-121.64	1730	1.2	0.87	3.2	-11	0.45
Diamond Lake	442	43.19	-122.14	1610	0.8	0.78	2.5	*-1*	*0.03**

Table 2. SNOTEL station location and trends for May-October temperature (°C per decade) and 1 April snowpack (cm per decade). Change in mean temperature from 1995-99 to 2020-24 indicated. Asterisk and italics indicate non-significant trends ($p>0.05$).

3. The Disappearing Glaciers

With Lathrop Glacier on its north face, Mt. Thielsen was the southernmost glacierized volcano in in the Oregon Cascades in the latter half the 20th century. Around the turn of the millennium, this small glacier was still present (Lafrenz, 2001) and a photo shared with us by M. Beagle (written communication 23 July 2021) indicated ice presence on 26 August 2012. Fountain and others (2023) listed Lathrop as gone as of an unknown date. Our visit in 2020 confirmed the complete disappearance of Lathrop Glacier.

Broken Top has two named glaciers: Bend and Crook (Fig. 1F). Fountain and others (2023) included these as glaciers in their inventory as of 2018. Our field observations place both glaciers as critically endangered because they consistently lack accumulation zones and have concave termini but do have crevasses that are melting in on themselves (Fig. 3B).

South Sister had seven named glaciers that were flowing as of 2000 (Ohlschlager, 2015), four of which we place in the GGCL categories: Clark, Carver, Skinner, and Eugene (Fig. 1E). Fountain and others (2023) listed Clark, Carver, and Skinner as snowfields in 2018 with Eugene being an active glacier. Whereas Clark has disappeared, with only small remnant of ice remaining as of 2020 (Fig. 3E), our field observations require revisions to the other three glacier statuses. In 2020, we found that Eugene lacked crevasses and had a concave terminus but still consisted of an intact ice body. As such, we place it in the almost disappeared category as it is not an actively flowing glacier. Conversely, both Carver and Skinner lack accumulation areas, but have convex termini (Fig. 3C) and crevasses that are melting in on themselves, implying potential ice flow. We list them as critically endangered.

Middle Sister had four named flowing glaciers in 2000 (Ohlschlager, 2015), of which two are in the GGCL categories: Irving and Renfrew (Fig. 1D). Whereas Fountain and others (2023) listed Irving as a snowfield in 2018, glacier ice still remains. We place Irving as almost disappeared because this ice area is continuous but has a concave terminus and lacks crevasses and an accumulation zone (Fig. 3D). Fountain and others (2023) found Renfrew to still be a glacier in 2018. Renfrew has crevasses that are melting in on themselves, but its terminus is concave, and it has no accumulation zone. We thus consider Renfrew to be critically endangered.

North Sister also had four named flowing glaciers in 2000 (Fig. 1D) (Ohlschlager, 2015). Fountain and others (2023) listed Thayer Glacier as completely gone but we have found remnant stagnant ice that underlies debris (Fig. 3F). In contrast, Fountain and others (2023) documented Linn as an active glacier in 2018. By 2020, the glacier lacked crevasses and an accumulation zone, and its terminus was concave. Linn still is a continuous ice body and so we list it as almost disappeared.

Mt. Jefferson had five glaciers with Fountain and others (2023) listing them all as active glaciers in 2020 (Fig. 1C). By 2023, we found that Milk Creek Glacier was almost entirely gone, or disappeared, with only a small, stagnant (~0.006 km^2) ice patch remaining. Fountain and others (2023) also listed Waldo Glacier as active in 2020. Subsequently, Waldo has lacked crevasses and an accumulation zone and has a concave terminus. We thus consider Waldo to be almost disappeared, because it is still a contiguous ice body.

For the 11 named glaciers on Mt. Hood that existed in 2000, we use our observations in Bakken-French and others (2024) to place four glaciers into the GGCL categories (Fig. 1B). Glisan Glacier had stagnated by 2020, and we categorize it as disappeared because the glacier has broken up into a discontinuous ice body. Coalman, Zigzag, and Langille glaciers are all still flowing. However, all three have crevasses that are melting in on themselves and have concave termini. Zigzag lacks an accumulation zone, whereas Coalman and Langille have small (<0.3) accumulation zones. These three glaciers lost 40-48% of their area between 2015-16 and 2023. As such, we consider these three glaciers to be critically endangered.

4. Discussion and Conclusion

Based on our field observations, we place 17 of the 34 named glaciers that existed in the Oregon Cascades at some GGCL status (Table 1). This means that half of the Oregon Cascade named glaciers that existed in 2000 have now either disappeared (~14.7%), will disappear in the coming few years (~11.8%), or will disappear in the 2030s (~23.5%). Importantly, nine named glaciers in the Oregon Cascades have ceased to flow since 2000.

The five disappeared glaciers have remnant ice bodies that range in area from 0.000 km^2 to 0.025 km^2, which are distributed across five volcanos from Mt. Thielsen in the south to Mt. Hood in the north (Table 1). The four almost disappeared glaciers have stagnant ice areas between 0.025 km^2 to 0.097 km^2, underlining their greater area relative to disappeared glaciers, despite both categories lacking evidence of ice flow. These four almost disappeared glaciers are restricted to one on each of the Three Sisters volcanos and on Mt. Jefferson. The eight critically endangered glaciers have areas of 0.033 km^2 to 0.239 km^2, which overlaps with almost disappeared glaciers, showing how glacier area alone is not sufficient to distinguish between a flowing glacier and an ice mass that used to flow (Pelto and Pelto, 2025). These eight critically endangered glaciers are distributed across the Oregon Cascade glacierized volcanos, spanning from Broken Top to Mt. Hood, but with North Sister lacking a glacier in this GGCL category.

Using the six nearby SNOTEL sites (Fig. 1A), we find that May-October average temperatures were significantly ($p<0.05$) warming at ~0.7-1.2°C (average = ~0.8°C) per decade from 1995 through 2024 (Fig. 4A; Table 2). The 2020-24 May-October means were ~1.8-3.2°C (average = ~2.3°C) significantly ($p<0.05$) warmer than the 1995-99 means (Table 2). Conversely, only two of the six SNOTEL sites have significant ($p<0.05$) trends for 1 April snowpack from 1995 through 2024 with loss rates of about -11 cm SWE per decade (Three Creeks Meadow) and about -30 cm SWE per decade (Hogg Pass) (Fig. 4B; Table 2).

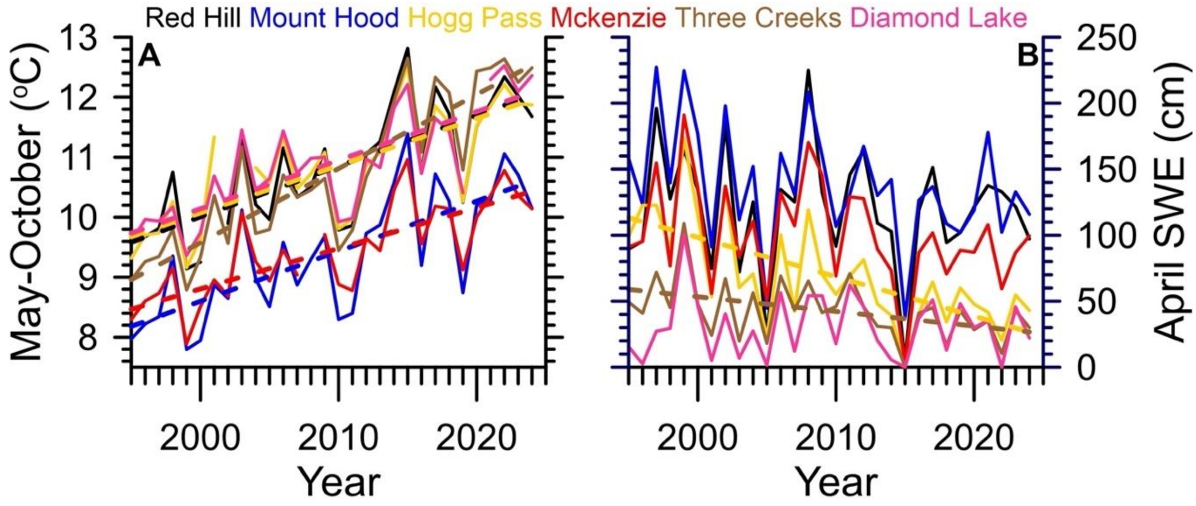

Figure 4. May-October temperature (A) and 1 April snowpack in cm snow water equivalent (SWE) (B) from six SNOTEL stations (Fig. 1A, Table 2). Dashed lines are significant ($p<0.05$) trends.

Given the statistically significant and consistent trends in May-October temperature, we attribute the glacier retreat in the Oregon Cascades to increasing temperature that has moved half of their named glaciers into a GGCL category and caused nine glaciers to stagnate. This temperature-control on glacier retreat is similar to what Bakken-French and others (2024) found for overall glacier recession on Mt. Hood since 1900 and what Roe and others (2021) demonstrated for glacier recession in general. We conclude that glacier retreat and disappearance will continue in the Oregon Cascades until this warming trend is reversed.

Acknowledgements

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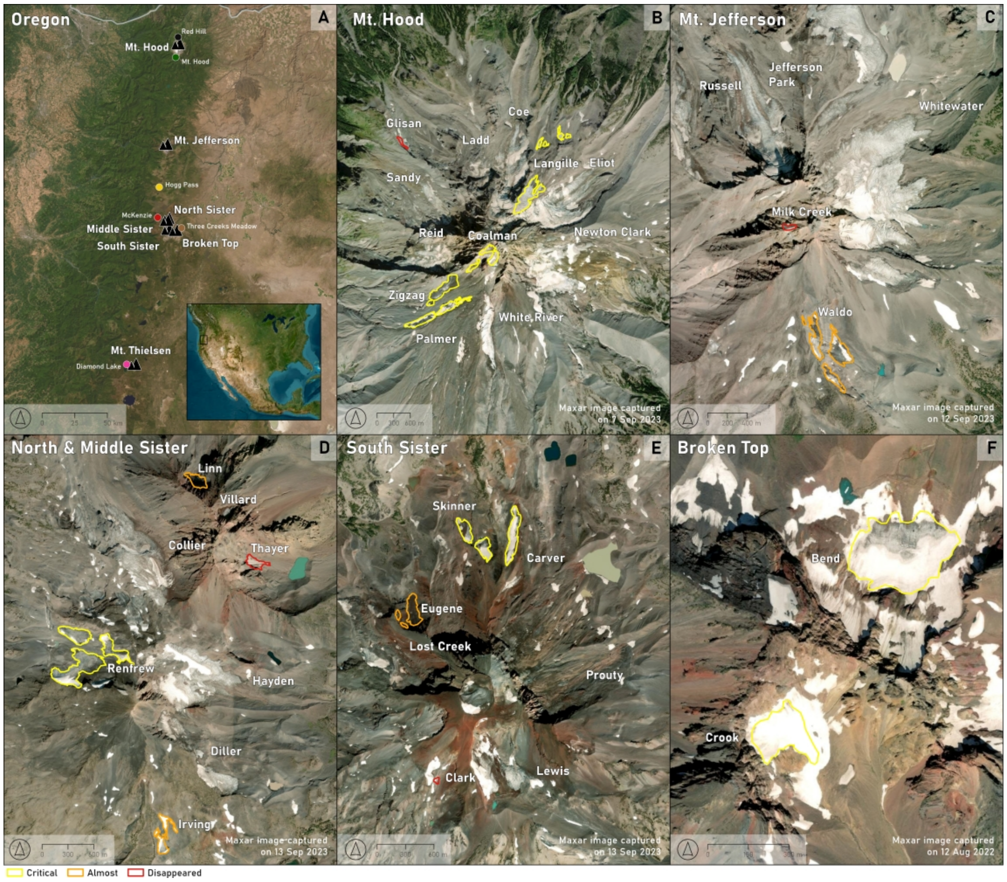

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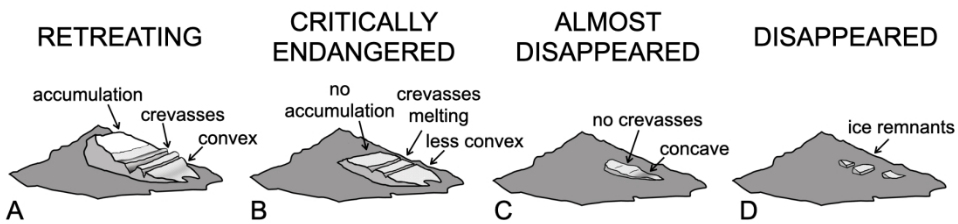

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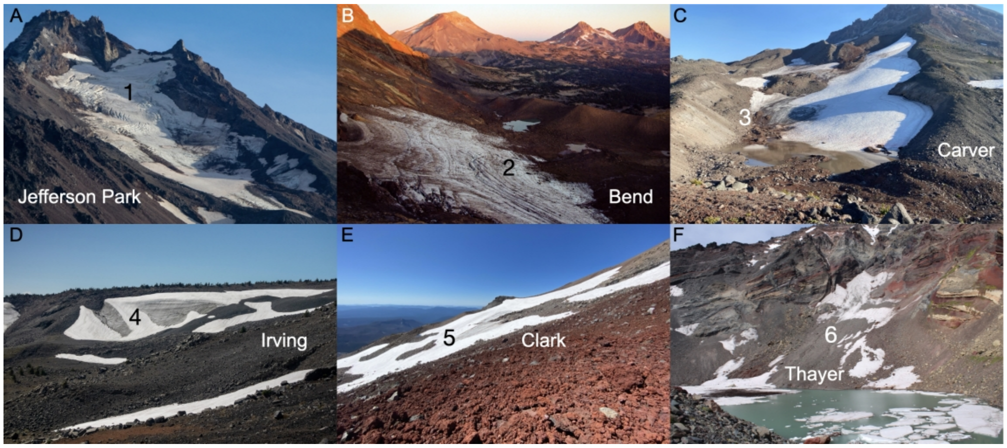

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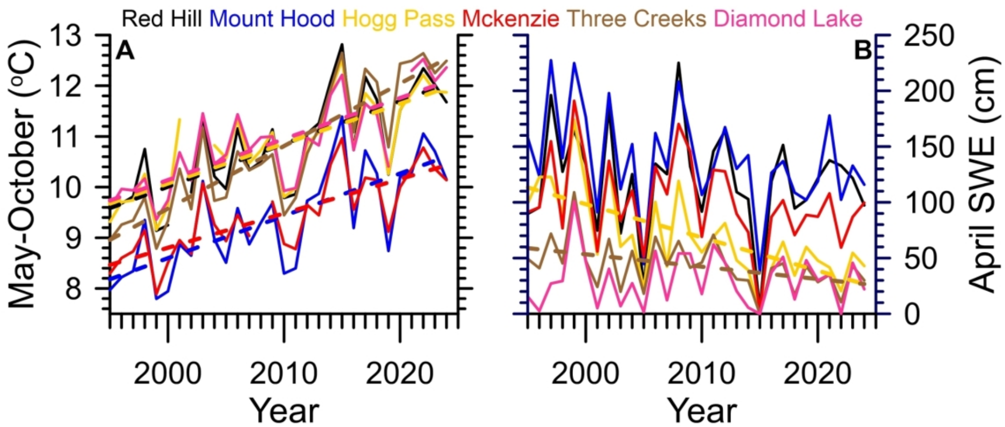

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