Depiction and Description: Insights into Southern Alps Glaciers Conveyed by John Gully's Paintings and Julius Haast's Paper at the Royal Geographical Society

GEORGE HOOK AND ANDREW LORREY

Abstract
In 1863 Julius Haast sent a large map of New Zealand's Southern Alps, a manuscript and 12 watercolour paintings of glaciers by John Gully, based on Haast's field sketches, to the Royal Geographical Society in London. This article explores insights into the distinctive nature of glaciers and glaciation in the Southern Alps that the paintings, manuscript and map might have conveyed to a nineteenth-century scientific audience on the other side of the world, and what relevance the environmental information embedded in those artworks might have for twenty-first century glaciologists. The advantages and limitations of using such artworks to communicate scientific information about glaciers and glaciation are discussed.

Introduction

In June 1862, Julius Haast (1822–1887), the Canterbury Provincial Geologist, wrote to Joseph Hooker, Assistant Director of the Royal Botanic Gardens at Kew, informing him that "being now naturalized I think it my duty to offer my work to the scientific societies in England." Haast informed Hooker that as soon as his topographical map was finished, he would send the botanist "an account of the geological features of the Alps, on deposits of the glacial period, accompanied by maps, sections and sketches," requesting him to present the account to the Geological Society of London.[1] Although this anticipated initial foray into publishing in British scientific journals did not eventuate until 1865,[2] on 12 November 1863 Haast sent a copy of his large topographical map of the Southern Alps,[3] accompanied by extensive notes on the physical geography of that region and a set of 12 watercolour paintings (e.g. fig. 1), to the geologist Sir Roderick Murchison,[4] President of the Royal Geographical Society. Haast hoped that those landscape paintings would "best enable the members, to *gain an insight* into the wild mountain masses [of the Southern Alps], with their snowfields, glaciers and lakes [emphasis added]."[5]

This article traces the genesis and production of the watercolours, based on Haast's explorations in the Southern Alps, through to their presentation and reception at the Royal Geographical Society. Close inspection of each of the 11 landscape paintings that portray an identifiable glacier reveals insights that a nineteenth-century scientific audience might have gleaned into the distinctive nature of glaciers and glaciation in the Southern Alps. The relevance of the glaciological information embedded in those historical artworks for contemporary scientific research is also considered. The benefits and limitations of using landscape paintings, as compared to photographs, to corroborate and communicate glaciological insights are considered.

Journal of New Zealand Studies NS38 (2024), 66-91 https://doi.org/10.26686/jnzs.iNS38.9581

Figure 1. John Gully, *The West Coast of the Province of Canterbury. From the Northern Banks of the Grey*, 1862. Watercolour, 275 x 630 mm. Alexander Turnbull Library, Wellington, C-096-001. The painting is based on Haast's sketch *Ansicht der südlichen Alpen von dem nördlichen Ufer des Mawhera* [View of the Southern Alps from the northern bank of the Mawhera], *1 Juni 1860*, 1860. Ink and watercolour, 110 x 405 mm. Alexander Turnbull Library, C-097-051-1.

Haast's early exploration of the Southern Alps

After working with the German geologist Ferdinand Hochstetter on topographical and geological surveys of various regions of the North Island and then in the Province of Nelson, Haast was appointed Provincial Geologist of Canterbury in February 1861. On his first expedition in that role, he investigated the headwaters of the Rakaia and Ashburton rivers during March and April 1861. During the period February to May 1862 Haast conducted a topographical and geological survey of the headwaters of the Waitaki River, where he explored the Classen, Godley and Macaulay glaciers that fed Lake Tekapo, in addition to the Hooker, Mueller, Tasman and Murchison glaciers that fed Lake Pukaki. As Haast wished to show the provincial authorities and overseas scientific bodies the distinctive character of glaciers and glaciation in the Southern Alps, he made annotated field sketches (e.g. fig. 2) of different views using pencil, ink and a basic set of watercolours. Such sketches are categorised by art theorist Francis Pound as "topographical landscapes," as they purport to "accurately describe a given spot."[6]

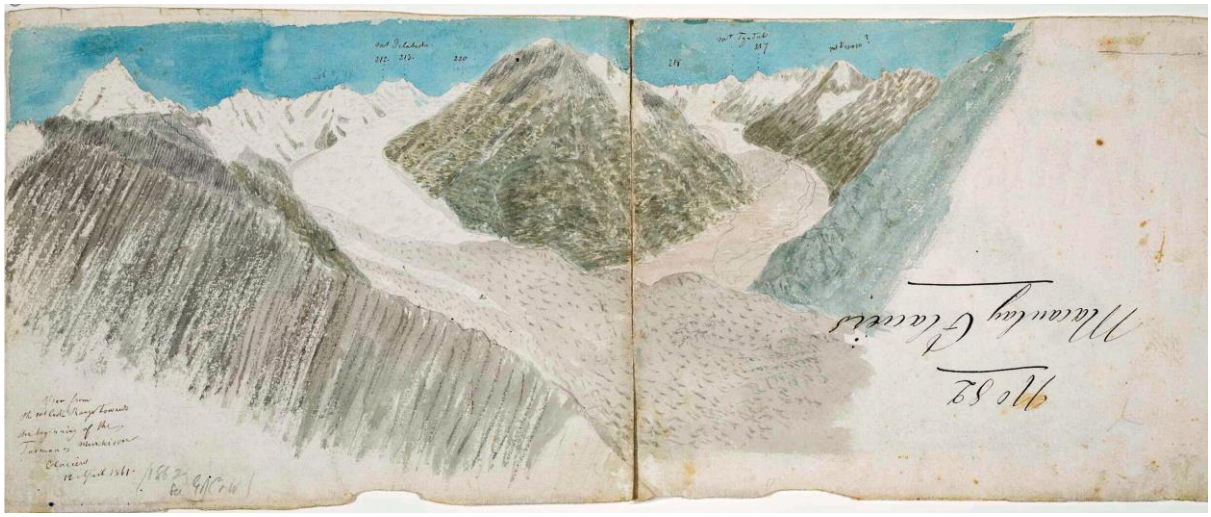

Figure 2. Julius Haast, *View from Mt Cook Range towards the beginnings of the Tasman & Murchison Glaciers, 12 April 1862*, 1862. Watercolour and ink, 170 x 430 mm. Alexander Turnbull Library, C-097-083.

In the middle of 1862, Haast commissioned John Gully (1819–1888), a landscape painter whom he had met while surveying in the Province of Nelson during 1859, to produce 12 large watercolour paintings, nearly all of which are based on field sketches that Haast executed during the Rangitata, Ashburton and Waitaki expeditions.[7] Haast intended to use the paintings to illustrate a scientific paper he was planning to submit to the Royal Geographical Society in London, but before doing so he exhibited them in his rooms in the Provincial Council Building in Christchurch.[8]

Gully was a largely self-taught artist, who primarily produced watercolour landscape paintings in the Romantic tradition,[9] which either idealised the beauty and orderliness of nature or expressed its sublime grandeur. According to Pound, Gully was often deprecated by art historians as being "the most reprehensibly 'picturesque' of painters, with a 'Turneresque' sublimity quite untrue to New Zealand."[10] Regardless, Gully's oeuvre is typically based on actual views of nature, either directly observed or as recorded by others in sketches or photographs. Haast's commission, however, proved a challenge for Gully as he had never seen any glaciers. The artist was completely reliant on the geologist's sketches and the written instructions provided.[11] As no letters from Haast to Gully have been located, and only later ones from Gully to Haast exist, we have no idea about the extent of the written descriptions that accompanied the sketches when they were posted to the artist in Nelson, but there is evidence in some of the works that Haast described additional details, which Gully included.[12]

While Gully was completing his commission, Haast updated his large four-miles-to-the-inch map of Canterbury, showing the results of his latest topographical survey of the Southern Alps. In 1863 he either made or commissioned a hand-coloured ink tracing of that map to accompany a paper he was writing. That manuscript included an introduction to the physical geography of the Southern Alps, followed by notes on the view in each of the 12 watercolours. Late in 1863, Haast's second wife Mary (née Dobson) informed her great aunt that she had made a "fair-copy" of a "very interesting article accompanying twelve pictures of Alpine scenery which [Julius] sent to the Royal Geographical Society, and giving an explanation of each painting."[13]

Towards the end of January 1864, Murchison received a package posted by Haast on 12 November, containing a "most interesting communication with the Map of the Province of Canterbury" and "beautiful & illustrative sketches." In his reply, Murchison assured Haast that "ample justice" would be done to his submission at the February meeting of the Royal Geographical Society.[14]

On 8 February, Murchison read Haast's manuscript to the assembled members,[15] with Haast's large map hanging nearby and, presumably, each of Gully's watercolours displayed in turn. Murchison would have read Haast's words to his audience, that "the positions whence they were taken being marked in red on the accompanying map."[16] The author of a report on the meeting, published in the *Proceedings of the Royal Geographical Society*, commented on "singular glacial anomalies that present themselves on some of the glaciers" and "traces everywhere" that showed "many of these glaciers having at no remote period extended several hundred feet further than their present limits." Furthermore, the writer asserted there were "indications confirmatory of received theories of the mode of progression of glaciers," although these were not elaborated upon. In his introductory remarks, Murchison claimed the illustrations presented "a history of an intermediate link in the development of glacial action descending from ancient to modern periods."[17] In the Presidential Address he delivered on 23 May 1864, Murchison noted "features of glacial action, which [Haast] has thoroughly described in all its different phases, and illustrated by a series of very beautiful, coloured sketches upon a large scale." Those sketches would "enable the physical geographer to compare the results of Dr. Haast's observations with those which have been made amid the glaciers of the Alps and of the Himalaya Mountains."[18]

Before examining in detail what insights the paintings that Murchison displayed, and which were subsequently exhibited at the Royal Geographical Society, might have conveyed to the audience, the fate of Haast's manuscript and map, as well as Gully's paintings, ought to be noted. While Haast clearly desired his paper to be read to the "learned society," he would have realised that it could not be published verbatim unless the watercolours were reproduced as well. In any event, the journal's referee, Admiral Richard Collinson, heavily edited the paper into a form that was not reliant on viewing reproductions of the paintings. That version was eventually published in the *Journal of the Royal Geographical Society*,[19] as part of a trio of papers on explorations of the South Island, which included one by the Otago Provincial Geologist James Hector on an expedition to the West Coast and another by the District Surveyor of that province, James McKerrow, on the lakes of Otago and Southland.[20]

As each of the three manuscripts was reliant on a map supplied by the author, Collinson recommended that an extension of McKerrow's map "would suffice to explain Dr. Haast's notes and the extract from Dr. Hector's journal."[21] A relatively small, detailed map was prepared by the English cartographer Edward Weller and published as a foldout insert, titled *Map of the provinces of Canterbury and Otago to illustrate the papers of Mr. James McKerrow, Dr. J. Haast & Dr. Hector* (Alexander Turnbull Library, 9918218367502836), in the same edition of the journal. Haast's original map was listed under Accessions to the Map Room as *Province of Canterbury, showing the Glaciers and Alpine range*,[22] but it cannot now be located in the archives of the Royal Geographical Society.[23]

As for Gully's watercolours, in response to a request from Haast, Murchison sought to have the illustrations reproduced by Day & Son for the Royal Geographical Society as chromolithograph prints,[24] but the project foundered when that firm encountered financial difficulties in the mid-1860s. The paintings were then stored in the archives of the society until

1974, although there is evidence on the mounts of some works (e.g. fig. 1) indicating that they had travelled to France. Indeed, it has very recently been discovered that The Royal Geographical Society exhibited the artworks at the International Geographical Congress held in Paris in 1875.[25] In March 1974 the Royal Geographical Society offered the 12 watercolours to the Alexander Turnbull Library in Wellington for £5000, which it agreed to pay.[26] After 110 years the works were repatriated to New Zealand and a newspaper report declared it to be a "minor triumph" because of their "historical significance."[27]

Fidelity to nature of the paintings

Before identifying what glaciological insights nineteenth-century viewers might have gleaned from close observation of Gully's watercolours, the issue of the fidelity to nature of the artworks needs to be considered, as the value of the paintings for conveying scientific information is dependent on this. As noted earlier, Gully had never seen any glaciers and was, therefore, entirely reliant on the field sketches and the written instructions Haast provided, of which we have no direct record. Pound asserted that in those sketches Haast worked "within the genre of topography, and at that, topography in its most map-making and scientifically illustrative aspect."[28] After visiting many of the sites of Haast's sketches of glaciers during the twentieth century, alpine ecologist Colin Burrows concluded that he was "a careful accurate recorder of [glacial] scenes."[29] A recent publication confirmed the general fidelity to nature of Haast's sketches of glaciers and associated features, such as moraines (deposits of rocky debris) and roches moutonnées (glacially sculpted rocky mounds and hills), based on a study of Haast's later sketches of glaciological features in the headwaters of the Rakaia River.[30] This lends support to the assertion that the earlier sketches supplied to Gully by Haast were accurate delineations of the alpine scenes involved, a conclusion further corroborated by comparing the topography of each of those sketched views with digital elevation models generated at Haast's vantage point using Google Earth Pro and PeakFinder. The exception is Haast's sketch of Aoraki / Mt Cook and the Hooker Glacier. The difficulty encountered in determining a vantage point from which either application could digitally replicate the montane topography of Haast's sketch implies a significant degree of inaccuracy on Haast's part, although not of the glacier itself as an 1875 photograph by Alfred Burton taken from the same vantage point confirms.[31]

The fidelity of Gully's interpretations of Haast's sketches is a more complicated issue. Although Gully later acknowledged he sometimes took liberties with watercolours that Haast commissioned him to paint,[32] it is possible to identify in this set of works which features are faithful to nature and which are artistic "enhancements" by comparing each with the corresponding field sketch. Some features which Gully added to scenes were in response to written directions or possibly additional small drawings that Haast sent with the sketches.[33] In her analysis of members of pairs, art historian Janet Paul concluded they demonstrated "how closely Gully keeps to the essential structure of the prototypes even when he tames or enhances—with sunset glow, invented vegetation or foreground rocks, sweeping clouds or cold afternoon mist."[34] In contrast, Pound claimed the 12 works were "as 'picturesque' and 'Turneresque' as anything Gully did for gallery walls."[35] Regardless of such purported embellishments, in the paper Haast submitted to the Royal Geographical Society, he only noted where the artist misinterpreted his field sketches. These mostly related to perspectival changes that made glaciers, or the valleys formerly occupied by glaciers, appear much narrower than they are in reality. Overall, Haast was very complimentary about Gully's watercolours, declaring they were "carefully executed" and that Gully had "well and faithfully rendered what I sent him to copy." He did acknowledge, though, that Gully had difficulty portraying crevasses and seracs (pinnacles of ice), as Haast had been unable to provide "verbal explanation."[36]

Locations of the views in Gully's landscape paintings

In order to fully appreciate insights that viewers might have gleaned from studying each of Gully's landscapes, it is important to know the location of Haast's vantage point and the direction of his field of view. To facilitate such vantage point reconstructions, a section of Haast's 1870 *Map of the Southern Alps in the Province of Canterbury* (fig. 3), published by the Royal Geographical Society, is used in lieu of Haast's lost 1863 map,[37] with the views marked with arrows. The circle indicates Haast's approximate location when he made the sketch on which the painting numbered in the following section is based, and the arrow represents the principal sight line of the field of view. For each sketch, Haast's estimated vantage point and principal sight line was determined when the digital elevation model in PeakFinder or Google Earth Pro matched the general topography of the sketch,[38] using the technique developed by Hook.[39]

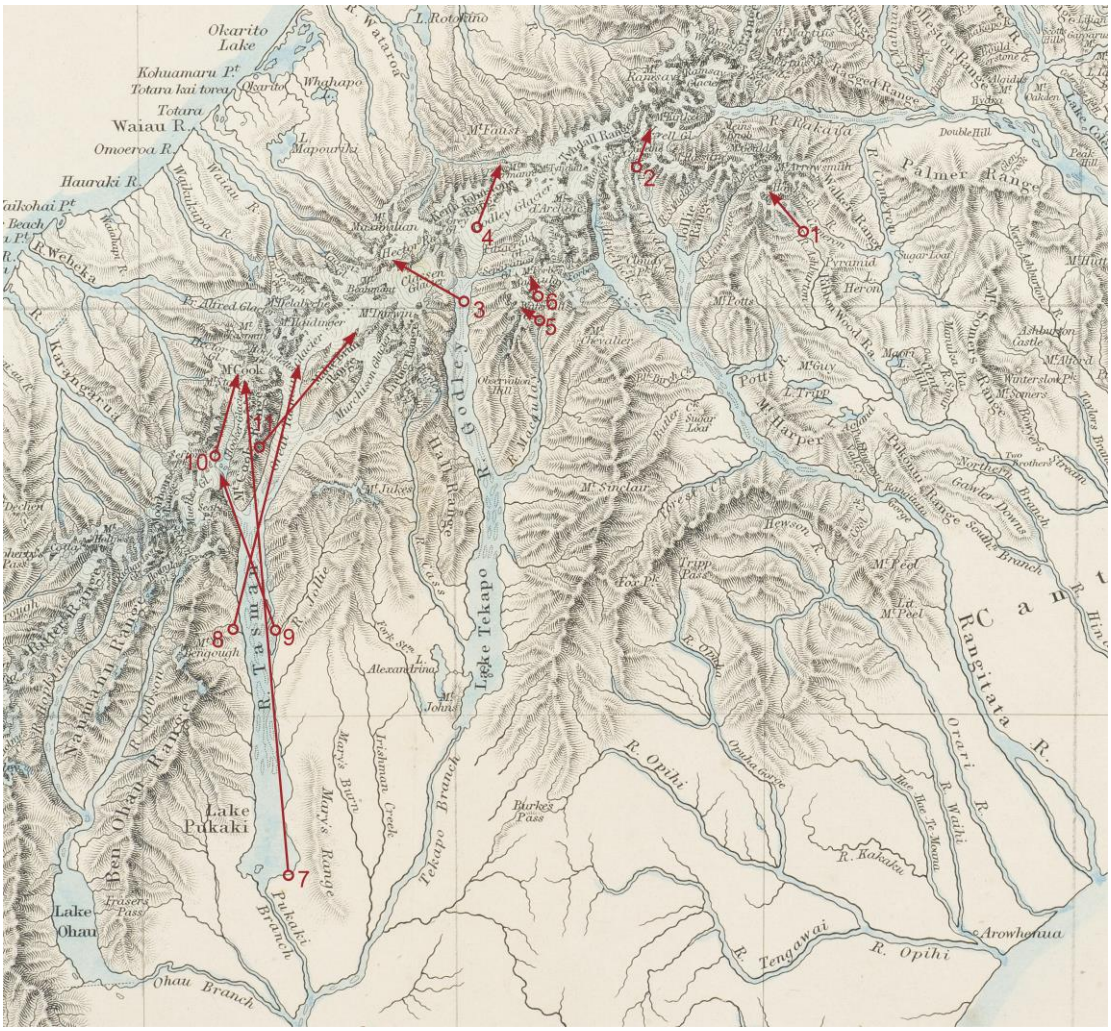

Figure 3: Edward Weller, *Map of the Southern Alps in the Province of Canterbury (New Zealand). Reduced from the large map by Julius Haast PhD, FRS*, [1870] (detail). Alexander Turnbull Library, 9917053113502836.

Possible glaciological insights conveyed to a nineteenth-century scientific audience

The following section identifies insights into the distinctive nature of glaciers and glaciation in the Southern Alps that members of the Royal Geographical Society might have gleaned from observing Gully's landscape paintings, bearing in mind that Haast's large map would have been to the forefront and Murchison would have read out Haast's explanation of each painting.

It should be noted that Haast had glued each watercolour onto an annotated mount identifying many of the peaks and glaciers, which would have assisted Murchison in his presentation. In the following analysis, the mounts of the paintings have been cropped in the figures. The mounted watercolours, and the field sketches on which they are based, can be studied in detail by clicking on the Alexander Turnbull Library reference codes or entering them into the search engine (https://natlib.govt.nz/search) of the National Library of New Zealand, selecting the appropriate image, clicking on "See original record" near the bottom of the window, then "Access digital content" on the next screen. The topographical location of Haast's vantage points can be seen by clicking on the geographical co-ordinates or entering them into the search field (https://www.topomap.co.nz) of the website *NZ Topo Map*. An oblique, three-dimensional digital elevation model of the vista in each painting can be viewed by copying and pasting the coordinates into the search box of Google Earth Pro, and then dragging the orange Street View icon onto the yellow coordinates pin. The field of view of the painting may need to be rotated into line.

1. Ashburton Glacier

Figure 4. John Gully, *The Ashburton Glacier, main source of the river Ashburton (4823 feet)*, 1862. Watercolour, 290 x 545 mm. Alexander Turnbull Library, C-096-002.

Gully's painting of the Ashburton Glacier (fig. 4) is based on a field sketch (C-097-027) made by Haast from a vantage point (~43°25'41.3"S, 171°1'15.0"E) on a ridge above the southern side of the South Branch of the Ashburton River / Hakatere, looking northwest. The snout of the steeply sloping glacier is visible behind a rocky spur that protrudes into the valley. Murchison would have alerted his audience about the moraine that stretches across the valley further downstream, but which had been excised by the meltwater stream of the glacier. That stream forms the beginnings of a braided river so typical of Canterbury. Viewers might also have noticed that Gully clothed the moraine in vegetation, implying that it is a recessional moraine deposited when the glacier was more extensive shortly before it commenced its retreat.

2. Clyde Glacier

Figure 5. John Gully, *The Clyde Glacier, main source of the River Clyde (Rangitata) 3762 ft.*, 1862. Watercolour, 290 x 545 mm. Alexander Turnbull Library, C-096-003.

Gully's painting of this glacier, which Haast had named the Clyde (fig. 5),[40] is based on a field sketch, currently in two parts (C-097-029 and C-097-025), made by Haast from a vantage point (~43°21'26.5"S, 170°44'28.6"E) on a ridge west of where Agnes Stream merges with the Frances River, looking northeast. The painting exemplifies the massive extent of the rocky debris carapace that typically covers the surface of the lower end of most of the large glaciers on the eastern side of the Main Divide, giving them a dirty grey appearance. The debris originates from rock avalanches, screes and the grinding action of ice as it moves past and undermines valley walls.[41] The faulted and folded nature of the greywacke rock making up the bulk of the eastern mass of the Southern Alps is readily broken down by erosive forces, creating massive scree slopes that contribute much of surface debris blanketing many of the glaciers. The sides of the snout of the Clyde Glacier are enclosed by rocky ridges called lateral moraines, formed as deposited debris accumulates along the sides of the glacier. To the true left side of the snout, a terminal moraine can be seen. Through his use of colour tones Gully also shows the bedded structure of the ice forming the terminus, and the location of the subglacial channel that meltwater emerges from, which Haast called an "ice vault."

3. Classen and Godley glaciers

Figure 6. John Gully, *Sources of Godley River, Classen and Godley Glaciers, 3550 feet*, 1862. Watercolour, 265 x 574 mm. Alexander Turnbull Library, C-096-004.
The Classen is directly above the travellers and the Godley, to the upper left of the campsite.

Gully's painting of the Classen and Godley glaciers (fig. 6) that feed Lake Tekapo is based on a field sketch (C-097-061) that Haast made from a vantage point (~43°32'42.4"S, 170°30'6.9"E) on a river flat near the junction of Lucifer Stream and Godley River, looking northwest. Haast wanted Gully to show viewers how broad the glacial valley was, and how the meltwater formed braids flowing across the shingle outwash plain, although he thought the latter aspect was less successfully realised in the lower regions. The mostly debris-covered Classen and Godley glaciers can be seen descending from the two valleys in the right half of the work. Although difficult to make out, the lateral moraines of each of these glaciers are nearly touching. Haast's field sketch shows that the old terminal moraines of Classen "were overgrown with a luxurious vegetation" and, as that vegetation was "half enveloped by the blocks of rocks thrown down upon them," he believed the glaciers were advancing and would soon unite.[42] Pound claimed Gully added the "irregular, light-catching rocks" in the foreground for picturesque effect, not realising the rocks are meant to be erratics, deposited by the glacier when it was much larger.[43]

4. Godley Glacier

Figure 7. John Gully, *On the Great Godley Glacier*, 1862. Watercolour, 310 x 615 mm, Alexander Turnbull Library, C-096-005.

Gully's painting of the upper regions of the Godley Glacier (fig. 7) is based on a field sketch (C-097-060) made by Haast from a vantage point (~43°28'15.1"S, 170°30'27.15"E) on the medial moraine of the glacier, but which he called the "central moraine," looking north-northeast. That moraine is now isolated between two recently formed proglacial lakes, which developed by the damming of meltwater by recessional moraines left by the retreating Godley Glacier and the tributary Grey and Maud glaciers. The artist's portrayal of the Godley Glacier shows the upper part of a contiguous ice mass that is largely free of supraglacial debris, except for a medial moraine formed when two tributary glaciers merged higher up on the right. The sharp, angular blocks of rock of the medial moraine, which were deposited on the surface of the glacier, either by rock avalanches, scree falls or by the grinding of rock walls by the glacier, are being transported "downstream" by the ice. Gully uses the diminutive size of the figures in the foreground to indicate the vast width of the glacier. The explorers were roped together because the surface of the glacier was broken up by deep crevasses.[44] Haast would have instructed Gully to illustrate this method of safely traversing the glacier as no explorers were included in his sketch.

5. Two Waterfall Glacier

Figure 8. John Gully, *Two Waterfall Glacier, Valley of the River Macaulay, 4080 feet*, 1862. Watercolour, 593 x 470 mm. Alexander Turnbull Library, C-096-006.

Gully's painting of the Two Waterfall Glacier (fig. 8), which descends from a ridge of the Sibbald Range west of the Macaulay River, is based on a field sketch (C-097-065) that Haast made from a vantage point (~43°32'22.2"S, 170°36'48.0"E) near the banks of the Macaulay River, looking northwest. Haast included this watercolour with his submission because of the dramatic view of meltwater from a glacier on Mt Forbes forming two magnificent waterfalls. As the glacier is located on a shelf high above the valley of the Macaulay River (which flows from right to left behind the viewer),[45] it is known as a hanging glacier. Not all hanging glaciers have a waterfall; some have an icefall instead. Gully laterally compressed and vertically stretched the field of view in Haast's sketch to emphasise the great height of the waterfalls, which Haast estimated to be about 800 feet (240 metres). Staffage has also been added to indicate scale, but forsaking accuracy for the sublime, Gully made the figures too small relative to the actual heights of the waterfalls.

6. Macaulay Glacier

Figure 9. John Gully, *Macaulay Glacier, 4375 feet*, 1862. Watercolour, 285 x 460 mm. Alexander Turnbull Library, C-096-007.

Gully's painting of the Macaulay Glacier (fig. 9), which is now known as the Murphy, is based on a field sketch (C-097-083-1) that Haast made from a vantage point (~43°32'2.1"S, 170°37'33.2"E) just north of where the flow of the Macaulay River changes from south-southeast to south-southwest, looking north-northwest. The watercolour clearly illustrates the névé (accumulation zone of the glacier), where snow is compacted into glacial ice before beginning its descent into the valley. After that the glacier passes between two rocky promontories and viewers of the painting could see that it fans out with crevasses radiating from a common centre. Atypically, this glacier is largely free from rocky debris as its truncated form has not ground past many rocky slopes or screes. Meltwater flowing out of the slightly bluish ice cave can be seen dividing into braids further downstream. Tiny figures near the stream give an indication of the scale of this glacier.

7. Lake Pukaki

Figure 10. John Gully, *Lake Pukaki 1746 feet*, 1862. Watercolour, 395 x 695 mm. Alexander Turnbull Library, C-096-008.

Gully's painting of Lake Pukaki (fig. 10) is based on a field sketch (C-097-128) that Haast made from a vantage point (~44°10'18.0"S, 170°12'40.3"E) looking north-northwest on a terminal moraine deposited by the ancient Tasman Glacier when it occupied the lake basin. Haast wanted Gully to show the great width of the glacial valley that Lake Pukaki occupied, as well as the gently sloping terraces cut high into the ranges on either side of the lake, both of which evidenced the existence of a massive ancient glacier. For whatever reason, Gully failed to render the latter aspect of Haast's field sketch. Gully did, however, effectively portray the nature of the recessional moraine in the foreground, left behind when the massive glacier commenced a major retreat. Murchison would have been delighted to inform his audience that this lake, at least, was created by the damming action of an ancient encircling terminal moraine.[46] Quoting Haast's words, he would have told his audience that "Nowhere, so far as my knowledge extends, are the proofs so convincing that it has, like similar lakes in other alpine regions, been formed by the retreat of an enormous glacier."[47]

8. Tasman Glacier

Figure 11. John Gully, *The great Tasman Glacier, from the west bank of the River Tasman, 2774 feet*, 1862. Watercolour, 272 x 620 mm. Alexander Turnbull Library, C-096-009.

Gully's painting of the terminus of the Tasman Glacier (fig. 11) is based on a field sketch (C-097-061-1) that Haast made from a vantage point (~43°50'32.4"S, 170°5'46.7"E) on Round Hill on the western side the Tasman River, looking north-northeast. However, Gully places the viewer on what appears to be an older lateral moraine, with its large angular blocks of rock, on the eastern side. The debris-covered snout of the massive Tasman Glacier can be seen in the centre of the painting, with only a small section of the frontal wall of ice visible. Just above the rocky cover of the main glacier, the white tributary Hochstetter Glacier can be seen flowing down from the range in front of Aoraki / Mt Cook. In this painting Gully effectively illustrated the meandering river flowing from the glacier in multiple channels across the outwash plain.

9. Mueller Glacier

Figure 12: John Gully, *View of Mt Cook and the Moorhouse Range from the valley of the River Tasman*, 1862. Watercolour, 438 x 615 mm, Alexander Turnbull Library, C-096-010.

Gully's painting of a distant view of the Mueller Glacier (fig. 12) is based on a field sketch (C-097-066) made by Haast from a vantage point (~43°50'23.0"S, 170°10'07.0"E) on a slope of The Big Hill near Mt Cook Station, looking north-northwest. An observant viewer attending Murchison's presentation might have noticed the snout of the Mueller Glacier, with its central streak of white ice, protruding into the valley. Haast's sketch also showed "old glacial terraces" cutting across the slopes of the dark midground peaks in front of Aoraki / Mt Cook,[48] further evidence of the massive size of the ancient Tasman Glacier, but they are more difficult to distinguish in Gully's rendition of the scene.

10. Hooker Glacier

Figure 13. John Gully, *Mt Cook with the Hooker Glacier, from the Mueller Glacier*, 1862. Watercolour, 610 x 450 mm. Alexander Turnbull Library, C-096-011.

Gully's painting of a view of Aoraki / Mt Cook (fig. 13) is based on a field sketch (C-097-064) made by Haast from a vantage point (~43°42'48.9"S, 170°5'34.6"E) near the eastern end of the high lateral moraine on the southern side of the Mueller Glacier, looking north-northeast. Glaciologically informed members of Royal Geographical Society might have appreciated that the moraine in the foreground would have been deposited only recently because the sharp angular blocks lacked lichens. Gully's rendition of the perimeter of the lower end of the Hooker Glacier may be problematic as it appears to be spiky ice, but it could represent a blanket of seasonal snow which fell on the lateral moraines while the explorers experienced bad weather for eight days.[49] Nevertheless, the rocky debris that covered most of the tongue of the Hooker Glacier is discernible, even though Haast noted in his manuscript that Gully had not rendered the crevasses he had requested.

11. Tasman and Murchison glaciers

Figure 14. John Gully, *The Tasman and Murchison Glaciers, from the Mt Cook Range*, 1862. Watercolour, 431 x 610 mm, Alexander Turnbull Library, C-096-012.
The Tasman flows from top left to bottom right, the Murchison from top right.

Gully's painting of the Tasman and Murchison glaciers (fig. 14) is based on a field sketch (fig. 2) that Haast made from a vantage point (~43°40'18.4"S, 170°9'10.9"E) atop the main ridge of the Mt Cook Range just south of Mt Mabel,[50] looking northeast. Viewers might have noticed that the ice of the upper part of the Tasman Glacier is free of moraine as it sweeps around the northwestern side of the Malte Brun Range in the centre of the picture, but a medial moraine on the true right side of that glacier eventually merges with another one to completely cover the lower part of Tasman glacier in rocky debris. Doubtless Murchison would have pointed out that the glacier named in his honour, which sweeps around the eastern side of the Malte Brun Range, also has a moraine-covered snout, which terminates some distance away from the edge of the Tasman Glacier. Haast also noted large hollows in the debris-covered terminus of the Tasman Glacier, which, "filled by pools of water of a deep blue colour . . . betray in their perpendicular walls the existence of ice,"[51] but they are difficult to make out in Gully's painting.

Summary of insights

As Murchison finished reading Haast's commentary on Gully's watercolours and pointing out their locations on the large map, attentive members of the Royal Geographical Society in London, particularly those who had visited the European Alps, and the "glacialists" who studied them, might have gleaned insights into the Southern Alps, such as that:

- the lower regions of most glaciers are covered with an extraordinary amount of rocky debris, much more so than in the European Alps, which must be due to the nature of the rock they grind past;
- the glaciers are very wide, more so than those in the European Alps, which must have something to do with the geological forces that formed the ranges and valleys between them;
- some glaciers are advancing, given that vegetation on older terminal moraines is now being smothered by rocky debris falling off the snouts of those glaciers;
- the glaciers had been very much larger in the recent and distant past;
- the alpine lakes resulted from damming of meltwater by recessional moraines, deposited by ancient glaciers before they began their major retreat;
- given the distance from the névés of glaciers to the recessional moraines of ancient forms of those glaciers, they must have been much longer than those existing in the European Alps;
- those very long ancient glaciers occupied parallel linear valleys, which the glaciers of the European Alps do not;
- the glaciers must release huge amounts of outwash gravel given the massive extent of the braided river flats.

Of course, some of those insights would only have been acquired through a closer inspection of the artworks and map, which could be viewed later as part of the ongoing exhibition in the society's rooms.

The relevance of Gully's glacier paintings for contemporary glaciologists

Photographs of glaciers in alpine and polar regions provide a strong line of evidence that documents the impact of both long-term climate change and short-term climate variability on the frozen water part of Planet Earth known as the cryosphere. For New Zealand, early photographs are scant compared to contemporary photographic documentation,[52] which has been nearly continuous for a subset of Southern Alps index glaciers since the late 1970s.[53] Historical paintings have the potential to provide a surrogate for photographic visual resources, but their qualitative value is retained only if they maintain strong fidelity to portraying the physical environment in an accurate way.

With Gully's paintings of glaciers based on Haast's 1861–62 topographical sketches, multiple examples emerge where high degrees of accuracy are apparent across specific parts of the landscape adjacent to glaciers and glacierised areas. This assessment is permitted through comparisons of the paintings with modern cartography and Google Earth Pro imagery (fig. 15).

In most of Gully's paintings described above, the margins of glaciers are clearly depicted, which allows estimates of ice spatial coverage to be established. This element is important for glaciology as it facilitates evaluations of past overall ice geometry, which can then be converted to a quantitative equilibrium line altitude estimate (the line which demarcates where there is no net loss or gain of ice occurring). Equilibrium line altitudes are important in glaciology for the determination of mass balance, which describes the net difference between the accumulation of ice by the glacier and its ablation (loss).

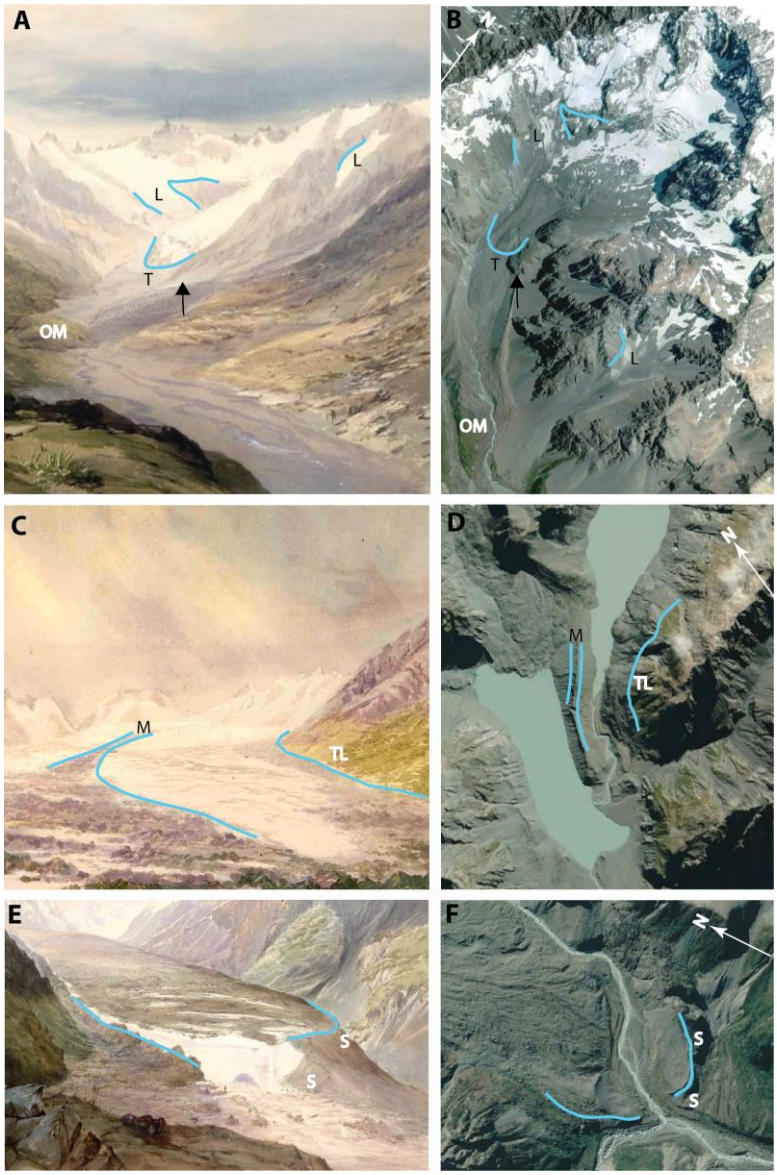

Figure 15. John Gully's paintings (left column) and contemporary satellite views using Google Earth Pro imagery (right column) highlighting key landscape features that suggest at least a partially accurate portrayal of the environment. Blue lines mark edges of ice seen in paintings on the left, and those edges are marked in their relative position within the contemporary landscape on the right. **A & B**: The cropped portion of *The Ashburton Glacier, main source of the river Ashburton (4823 feet)* shows an example of a lateral valley (labelled 'L') containing clean ice that was much more extensive than in the modern view; T = terminal end moraine; OM = older moraine; black arrow = bedrock spur sticking into valley. **C & D**: The cropped portion of *Sources of Godley River, Classen and Godley Glaciers, 3550 feet* shows a medial moraine (M) touching ice that fills the valley extending to the right, where it passes a line of rocky debris directly below a vegetated slope at the location where a trim line (TL) can be found today. The contemporary landscape is deglaciated at that location, with two proglacial lakes in view. **E & F**: The cropped portion of *The Clyde Glacier, main source of the River Clyde (Rangitata) 3762 ft* shows a rocky ridge of sediment in the foreground to the left of an ice meltwater tunnel and a sediment rampart (S) directly abutting buried glacier ice.

Journal of New Zealand Studies NS38 (2024), 66-91 https://doi.org/10.26686/jnzs.iNS38.9581

In almost all cases, where the higher reaches of glaciated alpine catchments have been painted, the extent of snow and ice coverage appears much more extensive than at present. This also includes mountains and lateral valleys that constitute the backdrop for the main subject matter. Key aspects of this type of depiction include: less segmentation of the névé (Tasman, fig. 14); more extensive contiguous snow and ice within high, steep-sided basins near mountain tops known as cirques (Ashburton, fig. 4; Classen, fig. 6; Godley, fig. 7; Macaulay, fig. 9; see fig. 15 A & B for comparison between Gully's images and the present); and significantly advanced ice positions near lateral valley mouths where there is currently no ice (Two Waterfall Valley, Macaulay catchment). In addition, there is much less exposed rock and bare ground in places that ice no longer covers (Ashburton, fig. 4; Macaulay, fig. 9; Clyde, fig. 5; see fig. 15 A & B, C & D, E & F for comparisons between Gully's images and the present). Furthermore, there are lateral portions of valley glaciers that touch bounding moraines, and views where ice nearly meets trim lines along the sides of a valley (see example C & D in fig. 15) which are juxtaposed with higher exposed rock, debris and vegetation (Godley, fig. 7; Clyde, fig. 5; Tasman, fig. 14). All these aspects are useful for implicating a more extensive past spatial footprint of snow and ice, and they have utility for facilitating geomorphological studies that are focused on the relatively recent extent of past ice changes.

A challenging aspect for reconstructing past ice geometry (and therefore ice volume) relates to ice thickness: how far above or below demarcating lateral moraines did ice reach in the past? In that light, there are several elements in the paintings that can contribute toward estimates of ice thickness in retrospective glaciological studies which rely on landscape evidence. Nunataks (rocky prominences projecting above the surface of a glacier) are shown in the Macaulay painting (fig. 9) and also within side valleys that are lateral to the main trunk of the Classen Glacier (fig. 6). These features act like vertical dipsticks as a proxy for ice thickness, and they could have value for approximating glacier depth profiles. Relic medial moraines that appear barely exposed with a rocky crest poking above ice in Gully's paintings (Godley, fig. 7) also give a perspective about the degree to which some valleys were filled with ice for locations where they now lie exposed on both sides, or where ice was laterally contiguous (Two Waterfalls, fig. 8).

Gully's depiction of long valley glaciers includes vistas that capture vast exposures of ice with a debris cover in the lower half of the glacier. The main difference of these historical views from the contemporary perspective, where much of the trunk portions of New Zealand's longest and largest glaciers are not only diminished in thickness but are largely debris covered well up valley of the terminus (e.g. La Perouse glaciers), is that more clean ice is apparent in closer proximity to the terminus (at lower elevation, Tasman, fig. 11, Classen, fig. 6). Some glaciers also have the appearance of a high or even rounded terminal face (Ashburton, fig. 4; Godley, fig. 7). On a qualitative note, the presence of more clean ice and/or less supraglacial debris from ablation suggests thicker and healthier glaciers, because less ablation till would have accumulated as a cover over the ice. This perspective is also reinforced in the depiction of Tasman Glacier (fig. 11), where thicker ice can be seen merging above the Hochstetter ice flow. Thicker ice is inferred because microdebris trains that readily characterise the ablation zone today are not seen penetrating up as high in the paintings.

Relative timings of landform deposition may also be gleaned from Gully's paintings in multiple ways with reference to 1861–62. There is a temporal frame of reference for older and younger moraines of the Holocene Epoch that commenced about 11,700 years ago, which is depicted by showing older stable, vegetated glacial landforms in the foreground and more recent landforms behind and upslope of those features (Ashburton, fig. 4). Coeval glacial landforms

are also indicated by ice in direct, simultaneous contact with multiple features, as with the Godley Glacier (fig. 7) showing lateral ice coverage linking moraines along the true left side wall with a medial moraine separating it from another glacier. The scene with the Clyde Glacier (fig. 5) illustrates a rocky recessional moraine in the left foreground. Part of the true left terminus has a sediment rampart that is the beginning of a kame, an ice-contact depositional landform (such as a fan or a composite landform combining a recessional moraine with outwash). These ice-contact features can be located in Google Earth imagery and they help to establish that the glacier terminus was just beginning to pull away from this location in 1861. Rocky ridges that extend in an arc, as illustrated in the Lake Pukaki vista (fig. 10), mimic the sequences of moraines ringing the lake foreshore that are located farther downstream. The full view of these rocky landforms is hidden by water, but their presence would stimulate a perspective about a longer and more complex history of ice activity in the catchment.

Insights into the dynamics of ice retreat and readvance may also be gleaned from Gully's paintings. For example, the Ashburton view (fig. 4) shows a fresh terminal ice face located upstream of where the current low-profile debris-covered carapace exists for this glacier as it flows through the proglacial landscape (including a relic braid plain). The Macaulay painting (fig. 9) shows no kame where the ice tunnel is painted, suggesting that the 1862 view may have captured a late advance of ice or the onset of retreat at that site. The Tasman glacier painting (fig. 11) is only partly similar to the current landscape where a late Holocene moraine is preserved. However, darker paint shades near the terminus imply the existence of a thick moraine sequence and a meltwater cavity, though the latter does not align to the present location of the Tasman River outlet.[54] This reinforces the view that the terminus of Tasman was dynamic until the early 1970s when the Tasman Lake formed. In addition, the prominent lateral moraine side lobes of the Tasman Glacier that seal off the Murchison Valley are not emphasised in the painting. This suggests these moraines were still being formed and distorted from the merged flow of Tasman and Hochstetter glaciers propagating downstream.

Irregular glacial surfaces with hollows in some of Gully's paintings are examples of thermokast (an erosional process associated with the melting of massive ice). This is depicted by ponds within the debris carapace zone located near terminal moraine sequences (Mueller Glacier, fig. 12; Tasman Glacier, fig. 11), which implies downwasting for some glaciers was already underway in the early 1860s. Similarly, proglacial lakes, formed during the retreat of melting glaciers, are also relevant for gaining some knowledge about landscape change from the paintings. In multiple views, there are no proglacial lakes, or there are lakes that are much smaller than those that have developed in recent times (notably the Classen, Godley, Tasman, Mueller, Hooker and Murchison lakes).

In broad terms, Gully's paintings contain enough visual information to locate them within the extensive nexus of contemporary cartographic and photographic records. This presents us with an opportunity to evaluate whether or not the paintings have scientific value, which, as we have seen, they do appear to have in multifaceted ways. That said, the works are not perfectly accurate. In some of the peripheries of the alpine environments that Gully illustrated, features are consistent with what is typically found in alpine settings, such as aretes (ridges), but they do not always match what would be expected at a given location (note the western [left] margin of the *Ashburton* view [fig. 4]). There is vertical exaggeration in some paintings, such as *Two Waterfalls* (fig. 8) and *Hooker* (fig. 13), and possibly the addition of textural elements in some works. This suggests minor portions of the perspectives shown in Gully's paintings were likely embellished using artistic licence. Nevertheless, the commonalities between many of the works examined here indicate that Gully's contributions have value as environmental history records,

as well as application and utility for supporting glacier reconstructions at the pre-industrial/post-industrial transition (mid-to-late 1800s).

Limitations and advantages of landscape painting for conveying glaciological information

As a well-informed lover of the visual arts, Haast might have been aware of the rise of *plein air* painting, associated with the British Pre-Raphaelites and, by the late 1860s, the French Impressionists.[55] If he had been asked whether it might be possible to paint the glaciers of the Southern Alps in situ, most likely he would have replied that it would be nigh on impossible, particularly given the challenges he had experienced completing field sketches. Paul described those sketches as "small, quick works, colour records of the fall of a glacier, the disposition of moraines, the profile of a peak." She was struck by Haast's "accurate eye and the speed of his work." That speed was essential, as conditions could rapidly change and become appalling. Haast executed the panoramic sketch (fig. 2), on which Gully's painting of the Tasman and Murchison glaciers (fig. 14) is based, "with a hand trembling from the cold," while experiencing gale-force winds that would have blown even the most robust easel away.[56]

While studio-based painting of glaciers was the only realistic possibility, the ability of such works to effectively communicate the glaciological insights that Haast wished to convey was dependent on the services of a highly skilled landscape painter who could appropriately interpret field sketches. The relatively modest widths (~60 cm) of Gully's landscape format paintings meant that the panoramic views captured in many of Haast's field sketches could not be effectively reproduced without the glaciers becoming quite small, and features such as seracs and crevasses becoming indistinct. Moreover, the watercolour medium used by Gully meant that it was not possible to show the fine detail of glaciological features in the foreground, which might have been possible if he had used oils. However, the obvious advantage of using landscape painting as the medium to communicate scientific information was the potential of colour to illustrate the different features of the ice making up the glacier, such as the seracs, crevasses and bedding. Using a variety of techniques, a skilled landscape painter like Gully could create the spatial depth needed to illustrate relative distances and sizes of massive features, and by increasing tonal contrasts emphasise key glaciological features. The size of those features could also be exaggerated, although that would be at the cost of accuracy, which is important to contemporary glaciologists interested in establishing the extent and mass of the glaciers in the mid-nineteenth century. Regardless of Haast's concern to accurately convey glaciological insights, commissioned landscapes completed in the Romantic tradition had the added benefit of enabling him to communicate the sublime beauty and drama of the Southern Alps, for which, as his writings reveal, he had a great passion. Writing about his exploration of the Godley Glacier, Haast asserted that: "It is impossible to convey in words a description of the sublime panorama around us, where everything is on a gigantic scale."[57]

Haast's subsequent efforts to visually communicate glaciological insights

Given that Haast was undoubtedly aware of the limitations of using the services of an artist who had yet to see a glacier, in 1865 he sought to persuade Gully to accompany him on an expedition to explore the headwaters of the Rakaia River in the following year. Gully replied "I am greatly obliged by your very kind offer, but I am sorry to say I cannot accept the offer much as I should like it. . . . I am very vexed, but I will not give up the idea of doing those Glaciers some day."[58] Haast wanted to include images of the Rakaia River, Lake Coleridge and the Lyell and Ramsay glaciers in his report to the provincial government so, as an amateur "geologist-artist," he resorted to producing watercolour landscape paintings based on ten of his field sketches.[59] These were then reproduced as two-colour chromolithographs in the back of the report.[60] In this way Haast was able to produce reasonably convincing pictorial images of

the views.[61] Understandably, "enhancements" typical of nineteenth-century landscape painting, such as the introduction of a visually engaging foreground, the elevation of peaks and the creation of spatial depth through increased tonal contrasts, are apparent in these works. The fidelity of Haast's landscape paintings to nature has previously been assessed by Hook, who concluded that despite the use of artistic licence in some works, the overall extent and details of the glaciers and other significant geomorphological features (with the exception of the exaggerated shape of some glacially sculpted sugarloaf-shaped roches moutonnées) were accurately rendered.[62]

Haast, however, was aware of the limits of his artistic abilities as well as the limitations of art for accurately conveying glaciological detail, so in 1869 he invited the adventurous alpine photographer Edward Sealy to join him on his last major expedition into the Southern Alps in order to photograph the magnificent glaciers of the Aoraki / Mt Cook district.[63] Sealy had previously photographed glaciers in the headwaters of the Ashburton and Rangitata rivers as well as in the Mt Cook district, although he found that dry-plate photography did not produce the quality of images he hoped for. For this expedition, Sealy brought a heavy full-plate camera and resorted to using the much more challenging wet plate technique.[64] He had to carry about 60 pounds of photographic equipment onto the Tasman moraines and even further up the glacier to "the snowfields at the foot of Hochstetter Dome" (~43°31'4.4"S, 170°19'46.0"E).[65] A light-proof "tent" for preparing and processing the glass plate negatives in situ was required as well.[66] Sealy was able to take stunning, highly detailed images of glaciers for Haast (fig. 16), which the geologist used to illustrate displays in the newly opened Canterbury Museum in October 1870, as well as in later national and international exhibitions. Sealy's *Head of the great Tasman Glacier* image was also reproduced using the photolithographic technique in Haast's 1879 magnum opus *Geology of the Provinces of Canterbury and Westland*, along with other photographs by Sealy and images taken by Thomas Pringle and Alfred Burton.[67]

From the early 1870s onwards, photographs rather than watercolours or chromo-lithographs became the preferred medium to illustrate glaciological features of the Southern Alps. Geologist D.R. Gregg concluded that such use of the camera in fieldwork "to a large extent destroyed [the need for] the geologist-artist.[68] According to the independent scholar Kathleen Davidson, such photographs might be considered to provide "more naturalistic or objective images" of natural phenomenon when compared to the interpretations of landscape artists,[69] but the absence of colour is an obvious limitation when it comes to portraying subtle differences of natural phenomena. Moreover, photographers also make subjective decisions about what to include or exclude in the field of view, which affect what insights viewers might gain. Sealy's inclusion of the centrally placed seated figure, Thomas Stafford,[70] atop a medial moraine of the Tasman Glacier may have evoked sublime feelings about the insignificance of humans amidst the grandeur of nature famously seen in the paintings of Caspar David Friedrich, but that would have distracted from what the photographer intended to communicate to the viewer about the nature and significance of the rocky debris on the surface of the glacier. On such expeditions Haast "devoted repeatedly many hours to a thorough search of the moraines," as "no locality offers a better insight into the character of the mountain chains" because of the rocks brought down from mountain tops. For two whole days in 1869 Haast "examined carefully the whole breadth of the [surface of the] Tasman and Mueller Glaciers."[71] Doubtless he would have been seated as Stafford was for much of that time, as "an attack of rheumatism" prevented him from ascending further up the Tasman Glacier to where the photograph was taken.[72]

Figure 16. Edward Sealy, *Head of the great Tasman Glacier, with Hochstetter Dome and Mount Darwin in Mt Cook District, March 1869*, 1869. Mounted photographic print, 183 x 236 mm, Hochstetter Collection Basel.[73] The photograph was taken from a vantage point located at ~43°32'08"S, 170°16'50"E, looking northeast.

Conclusion

The efficacy of Gully's watercolours in conveying accurate insights into the distinctive nature of glaciers and glaciation in the Southern Alps of New Zealand to a nineteenth-century scientific audience can be judged by responses to Haast's submission. The member of the Royal Geographical Society who wrote up the report on the February meeting clearly gained an insight into the distinctive nature of those glaciers when he noted "the singular glacial anomalies that present themselves on some of the glaciers." Furthermore, he correctly concluded that "traces everywhere [showed] many of these glaciers having at no remote period extended several hundred feet further than their present limits," evidence of which is apparent in several paintings. In his introductory remarks, Murchison appropriately asserted that the illustrations presented "a history of an intermediate link in the development of glacial action descending from ancient to modern periods."[74] This would have related to the artworks that illustrate the distinctive connection between the origin of Lake Pukaki and the retreated Tasman Glacier.

The utility of Gully's watercolours for contemporary scientific research is evidenced by their being valued and referenced by glaciologists as accurate environmental history records of the state of major glaciers on the eastern side in the Southern Alps in the early 1860s. Furthermore, those works support the development of glacier reconstruction models at the pre-

industrial/post-industrial transition of the mid-to-late 1800s,[75] a critical junction in the recent history of the cryosphere. Glaciers respond dynamically to climate change. Comparing contemporary aerial and satellite imagery with historical paintings and early photographs provides a measure of how rapidly and extensively different glaciers react, which helps assess the likely impact of further climatic warming on the fate of the glaciers of the Southern Alps over relevant timescales.

Acknowledgements:
The authors would like to thank: Sascha Nolden, independent researcher, for providing transcriptions of letters written by Haast and Murchison, identifying the exhibition in France and checking the manuscript; the late Oliver Stead, Curator Alexander Turnbull Library, for arranging a viewing of the twelve Gully paintings; Claire Viskovic, Senior Digitisation Specialist, Alexander Turnbull Library, for organising the photographing of the Gully paintings; Alicia Tolley, Imaging Technician, Alexander Turnbull Library, for photographing the Gully paintings; Alice English, Collection Technician Registration, Canterbury Museum, for photographing Sealy's glass plate negative; Daniel Smith, Collections Manager, Akaroa Museum, for processing the image of the glass plate negative; Quinn Jacobson, photographer and author, for confirming the photographic process; and Joy Wheeler, Librarian Royal Geographical Society, for providing access to Haast's manuscript. Andrew Lorrey was supported by the NIWA Strategic Science Investment Fund project "Alpine Climate" contract CAOA2401.

---

[1] Sascha Nolden, Esme Mildenhall and Simon Nathan, *The Correspondence of Julius Haast and Joseph Dalton Hooker, 1861–1886* (Wellington: Geoscience Society of New Zealand, 2013), 22. Haast became a British citizen in February 1861.
[2] See Julius Haast, "Notes to a Sketch-Map of the Province of Canterbury, New Zealand, Showing the Glaciation During the Pleistocene and Recent Periods as Far as Explored," *Quarterly Journal of the Geological Society of London* 21, nos. 1–2 (1865): 87–96.
[3] On 11 June 1863, Haast informed Hooker that he was sending Murchison a large map with a set of watercolour drawings by the next mail (Nolden, Mildenhall and Nathan, *Correspondence Haast-Hooker*, 42–43).
[4] Ibid., 57.
[5] Julius Haast, "Notes Accompanying a Map of the Province of Canterbury" (Royal Geographical Society Manuscript Archive, 1862), 1.
[6] Francis Pound, *Frames on the Land: Early Landscape Painting in New Zealand* (Auckland: Collins, 1983), 13.
[7] The exception is a view of the Southern Alps from the West Coast (fig. 1), which Haast had sketched while working for the Provincial Government of Nelson in 1860.
[8] At some point Haast commissioned Gully to produce a second set of watercolours based on those field drawings. These he kept for his own personal pleasure (Heinrich Haast, *The Life and Times of Julius von Haast: Explorer, Geologist, Museum Builder*, (Wellington: H.F. von Haast, 1948), 842–43).
[9] John Sidney Gully, *New Zealand's Romantic Landscape: Paintings by John Gully* (Wellington: Millwood Press, 1984), 24–25.
[10] Pound, *Frames on the Land*, 15.
[11] There is no record of Haast having travelled to Nelson nor of Gully to Christchurch in 1862 (Gully, *Romantic Landscape*, 26).
[12] The correctly located campsite in fig. 6 and the historically accurate roping together of the explorers in fig. 7 are not recorded in either of Haast's field sketches. Such non-fanciful additions by Gully must have been made on the basis of written instructions from Haast.

[13] Letter from Mary Haast to Mary Barker, 12 December 1863 (Haast, *Life and Times*, 325). It is not known whether as a newly married nineteen-year-old Mary had the confidence to also edit Haast's text, as the original version has not been located.
[14] Letter from Roderick Murchison to Julius Haast, 25 January 1864, Alexander Turnbull Library, MS-Papers-0037-122-09, transcribed by Sascha Nolden.
[15] Haast, "Notes Accompanying a Map of the Province of Canterbury." A scan of Haast's manuscript can be accessed on the Wiley Digital Archives of the Royal Geographical Society website.
[16] Ibid., 20.
[17] "Sixth Meeting, 8th February, 1864," *Proceedings of the Royal Geographical Society* 8, no. 3 (1863–1864): 55–57.
[18] Joseph Hooker was one of the members who had observed the Himalayan glaciers.
[19] Haast, "Notes on the Mountains and Glaciers of the Canterbury Province, New Zealand," *Journal of the Royal Geographical Society of London* 34 (1864): 87–96.
[20] See James McKerrow, "Reconnaissance Survey of the Lake Districts of Otago and Southland, New Zealand," *The Journal of the Royal Geographical Society of London* 34 (1864): 56–82; James Hector, "Expedition to the West Coast of Otago, New Zealand; with an Account of the Discovery of a Low Pass from Martin's Bay to Lake Wakatipu," *Journal of the Royal Geographical Society* 34 (1864): 96–111.
[21] Referee's report by R. Collinson attached to Haast's manuscript (see endnote 5).
[22] "Sixth Meeting, 8th February, 1864," 55.
[23] Hector's map has been located in the Royal Geographical Society's digital archives, but not McKerrow's.
[24] Murchison's letters to Haast: 10 August 1864, MS-Papers-0037-122-1, and 25 January 1865, MS-Papers-0037-122-14, Alexander Turnbull Library, both transcribed by Sascha Nolden.
[25] Adhesive labels with "Nouvelle Zélande" written on them. *Congres International des Sciences Géographiques, 2e Session, Paris 1875, Exposition, Catalogue Général des Products Exposés, 4e éd. Revue et Augmentée* (Paris: Typograhie Lahure, 1875), 91.
[26] File 3/1/1/4 March 1974, Alexander Turnbull Library.
[27] "Art and science matched," *The Press*, 16 July 1975.
[28] Pound, *Frames on the Land*, 52.
[29] Colin Burrows, *Julius Haast in the Southern Alps* (Christchurch: Canterbury University Press, 2005), 173.
[30] George Hook, "How True to Nature Are Julius Haast's Field Sketches and Paintings of Glaciers in the Southern Alps of New Zealand?" *Canterbury Museum Bulletin* 11 (2022): 61–96.
[31] Burton Brothers, *Mount Cook, (13,200 ft) from the Hooker Glacier*, 1875, albumen silver print, 138 x 200 mm, Museum of New Zealand Te Papa Tongarewa, O.007006. Burrows also questioned the topographical accuracy of Haast's sketch (Burrows, *Julius Haast*, 55), but suggested that Haast was in a hurry when he made that sketch.
[32] Excerpt from John Gully's letter to Julius Haast, 2 June 1863, quoted in Gully, *Romantic Landscape*, 26.
[33] These would have included: the giant Spaniard speargrass (*Aciphylla scott-thomsonii*) in the foreground of fig. 4; the sharp-edged angular rocks in the fore- or midground of figs. 5, 8, 9, 10 and 13; the location of the campsite in fig. 6; and the roped together explorers in fig. 7.
[34] Janet Paul, "Twelve Water Colours of Glaciers in the Province of Canterbury, Julius Haast and John Gully: Collaborators," *Turnbull Library Record* 7 (1974): 9.
[35] Pound, *Frames on the Land*, 15.
[36] Julius Haast, "Notes Accompanying a Map of the Province of Canterbury," Royal Geographical Society manuscript archives, 1863, 1, 26, 30, 32, 33.
[37] The 1864 Royal Geographical Society map was not used due to its smaller size and because Mount Cook is incorrectly located at the foot rather than the head of the Tasman Glacier.
[38] The use of PeakFinder has the added benefit of identifying peaks in the view.
[39] George Hook, "True to Nature? Fidelity and Transformation in Eugene von Guérard's Antipodean Landscape Paintings" (PhD, Federation University, 2022), 161–63. The technique is described in more detail in Hook, "Julius Haast's Field Sketches," 69–71.

[40] The remnants of the retreated Clyde Glacier are now known as the Colin Campbell and Frances glaciers.
[41] Known as supraglacial till, this unsorted rocky debris is transported "downstream" by the moving body of ice, and can progressively build up as a debris carapace draped over flowing ice.
[42] Haast, "Notes Accompanying a Map of the Province of Canterbury," 24–25.
[43] Pound, *Frames on the Land*, 52.
[44] In his 1879 book, Haast described how the glacier "began to be so much crevassed that it became dangerous to advance without the necessary protection, we therefore attached ourselves to a rope brought for the purpose and advanced in a line, of which I as usual took the lead. I had now to cut steps with an ice axe up and down the crevasses, gradually getting broader and deeper, which made our advance very slow work" (Julius Haast, *Geology of the Provinces of Canterbury and Westland: A Report Comprising the Results of Official Explorations* (Christchurch: Provincial Government of the Province of Canterbury, 1879), 23).
[45] Burrows, *Julius Haast*, 75.
[46] For further information on the debate involved, see George Hook, "Julius Haast and the Discovery of the Origin of Alpine Lakes," *Annals of Science* (2024), https://doi.org/10.1080/00033790.2024.2304332.
[47] Haast, "Notes Accompanying a Map of the Province of Canterbury," 28.
[48] Ibid., 32.
[49] Haast, *Geology of Canterbury and Westland*, 33.
[50] Burrows, *Julius Haast*, 55.
[51] Haast, "Notes Accompanying a Map of the Province of Canterbury," 34.
[52] Edward Sealy began photographing glaciers in the late 1860s, Thomas Pringle in the early 1870s and Alfred Burton in the mid-1870s.
[53] See Trevor Chinn, "Glacier Fluctuations in the Southern Alps of New Zealand Determined from Snowline Elevations," *Arctic and Alpine Research* 27, no. 2 (1995): 187–98; "Distribution of the Glacial Water Resources of New Zealand," *Journal of Hydrology (New Zealand)* 40, no. 2 (2001): 139–87; Andrew M. Lorrey et al., "Southern Alps Equilibrium Line Altitudes: Four Decades of Observations Show Coherent Glacier–Climate Responses and a Rising Snowline Trend," *Journal of Glaciology* 68, no. 272 (2022): 1127–40.
[54] When Haast revisited the Tasman Glacier in 1869, he noted that the glacier now had two meltwater cavities.
[55] Haast organised an exhibition of art in the Canterbury Museum in 1870 and gave lectures on the history of art (Haast, *Life and Times*, 1948, 599–601, 836–37, 851).
[56] Haast, *Geology of Canterbury and Westland*, 34. Arthur Dobson, the surveying assistant on Haast's expedition, had much trouble keeping the stand of his instrument steady in gale force winds.
[57] Ibid., 24.
[58] Gully letter to Haast, 23 January 1866, Alexander Turnbull Library MS-Papers-0037-068-33.
[59] Term used in D. R. Gregg, "Early New Zealand Geologists as Artists," *Geological Society of New Zealand Newsletter* 16 (1964): 27.
[60] Julius Haast, *Report on the Headwaters of the River Rakaia* (Christchurch: Provincial Government of the Province of Canterbury, 1866).
[61] Four of Haast's Rakaia watercolours were included in a touring exhibition of early watercolours curated by the Auckland City Art Gallery in 1964 (*Geological Society of New Zealand Newsletter*, no. 16, July 1964, 27).
[62] Hook, "Julius Haast's Field Sketches," 91–92.
[63] Sealy was the first person to take photographs from on top of glaciers in the Southern Hemisphere, but there is no mention of his pioneering glacial photography in John Hannavy, ed. *Encyclopedia of Nineteenth-Century Photography* (New York: Routledge, 2008).
[64] M.J. Dixon, "The Attempts on Aorangi from the Eastern Side: An Historical Resumé," *The New Zealand Alpine Journal* II, no. 7 (1895): 5; also *Poverty Bay Herald*, 23 May, 1936, 5.
[65] Edward Sealy, "The Early Explorations of Sir Julius von Haast, K.C.M.G., F.R.S., Etc, the First Explorer of the Southern Alps," *New Zealand Alpine Journal* 1 (1894): 20–21, 55.

[66] "Obituary: Mr E.P. Sealy," *Timaru Herald,* 3 November 1903, 2. Most likely the "tent" was tied around his waist. Quinn Jacobson, an expert on nineteenth-century wet plate photography techniques, confirmed that the plate glass negative of fig. 16 was taken using the wet plate technique. Email to George Hook, 28 February 2024.
[67] Haast, *Geology of Canterbury and Westland,* views (a) to (e). See also Sascha Nolden, "Sir Julius von Haast's 'Geology of Canterbury and Westland,'" *GSNZ Journal of the Historical Studies Group* 64 (2020): 44, 46–48.
[68] Gregg, "Geologists as Artists," 27.
[69] Kathleen Davidson, "Photography and the Triumph of Science in European Vision and the South Pacific," in *The Legacies of Bernard Smith: Essays on Australian Art, History and Cultural Politics*, ed. Jaynie Anderson, Christopher R. Marshall and Andrew Yip (Sydney: Power Publications, 2016), 103.
[70] Sealy, "Early Explorations," 20.
[71] Julius Haast, "Notes on the Geology of the Central Portion of the Southern Alps, Including Mount Cook," (Wellington: Geological Survey of New Zealand 1870–1871), 24.
[72] Sealy, "Early Explorations," 20.
[73] Sascha Nolden and Sandy Nolden, *Hochstetter Collection Basel: Part 2: New Zealand Photographs and Prints* (Auckland: Mente Corde Manu, 2012): 166 [HCB 2.16.12].
[74] "Sixth Meeting, 8th February, 1864," 55–57.
[75] Andrew Lorrey, et al., "The Little Ice Age Climate of New Zealand Reconstructed from Southern Alps Cirque Glaciers: A Synoptic Type Approach," *Climate Dynamics* 42 (2014): 3039–3060; Aaron E. Putnam, et al., "Regional Climate Control of Glaciers in New Zealand and Europe During the Pre-industrial Holocene," *Nature Geoscience* 5 (2012): 627–630; Jonathon L. Carrivick, et al., "Ice Thickness and Volume Changes Across the Southern Alps, New Zealand, From the Little Ice Age to Present," *Scientific Reports* 10, no. 13392 (2020), https://doi.org/10.1038/s41598-020-70276-8.