

Greater Chilkat Watershed

A living atlas

*Richard
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Discovery
Southeast*

DISCOVERY
SOUTHEAST

Greater Chilkat Watershed

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This TOC shows 3 heading levels. Let's call em: **1) Sections** (eg Fish), **2) Chapters** (eg Salmon) & **3) Subchapters** (eg Sockeye)

Cover: Topography from IFSAR elevation model, rendered oblique in ArcScene. • This image: Fire haze dims boreal tundra at Nánde Héeni Yei Kéich Yé, sits in water facing north (Three Guardsmen Pass).

Place names convention:

In my writing and cartography since publication of *Haa L'éelk'w Hás Aani Saax'ú: Our grandparents' names on the land* (Thornton & Martin eds 2012: abbreviated "T&M12"),

I've used Lingit place names whenever available, followed by translation *in italic*, and colonial name in parentheses. Example: Kadigooni X'áat', *island with spring water* (Spuhn Island). Euro-names are typically distracting preemptions. Where the Lingit went unrecorded I default to the colonial, often acknowledging its inadequacy with a parenthetical ("*noTN?*") Lingit names are listed in *Appendix 4*, and shown on maps throughout this Atlas.

At the northern tip of Southeast Alaska's inland waterway, 5 silt-laden trans-boundary rivers—fanned like fingers of a giant hand—converge into a fertile, glacier-fed 'palm': ' Jilk'áat, *cache* (Chilkat River valley; originally from the Eyak language). Near the estuary, the port of Deishú, *trail's end* (Haines) greets raincountry travelers bound for drier, boreal realms in Canada and interior Alaska. Here is one of the continent's great **ecotones**—a zone of transition, connectivity, genetic mixing, and commerce.

In early winter, 2019, a coalition of Deishú-based organizations invited me to compile a biogeographic and cultural atlas for this region. Five years later (2024) this is where it stands.



Introduction

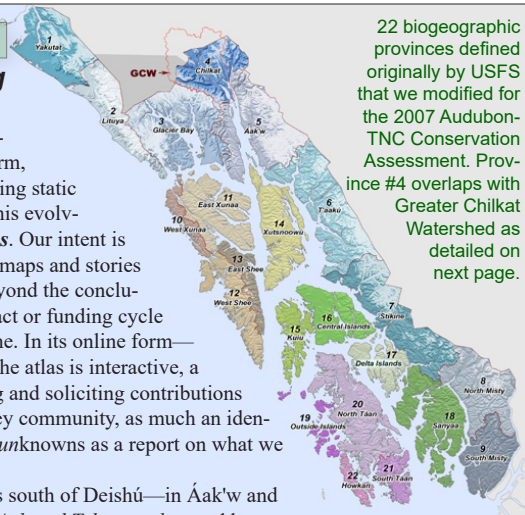
What's a 'living atlas?'

Because "atlas," especially in its printed form, might conjure something static or 'finished,' we call this evolving effort a *living atlas*. Our intent is that this collection of maps and stories continues to grow, beyond the conclusion of any one contract or funding cycle or (in my case) lifetime. In its online form—[JuneauNature>GCW](#)—the atlas is interactive, a means of coordinating and soliciting contributions from the Chilkat Valley community, as much an identification of gaps and *unknowns* as a report on what we do know. ¹

I, RC, live 80 miles south of Deishú—in Áak'w and T'aakú Aani, *land of Auk and Taku people*—and have never resided in the Greater Chilkat. I've devoted my career to study of Southeast Alaska, and love it all equally. Hopefully, then, I'm both unbiased (well, *sort of*) and rather uniquely qualified to pass this judgement: Jilkaat and Jilkaot Aani, *land of Chilkat & Chilkoot people*, has the most scenically stunning and ecologically diverse homeland of any of the 30-or-so human communities sprinkled throughout Alaska's Panhandle. ²

¹ ESRI—our host at ArcGIS Online, and providers for decades of GIS software used by Discovery Southeast—uses "living atlas" in a similar way. Although their scope is global and ours provincial, ESRI's *ArcGIS Living Atlas of the World* is similarly evolving, cloud-based, and beholden to the energy of its user community. <https://enterprise.arcgis.com/en/portal/latest/use/what-is-living-atlas.htm>

² As for scenic relief, viewsheds of Gustavus and Yakutat do boast taller mountains, but those 12-to-18K-footers are so distant they lack the 'punch' of, for example, Yéil Áx' Sh Wulgeiyi Yé,



22 biogeographic provinces defined originally by USFS that we modified for the 2007 Audubon-TNC Conservation Assessment. Province #4 overlaps with Greater Chilkat Watershed as detailed on next page.

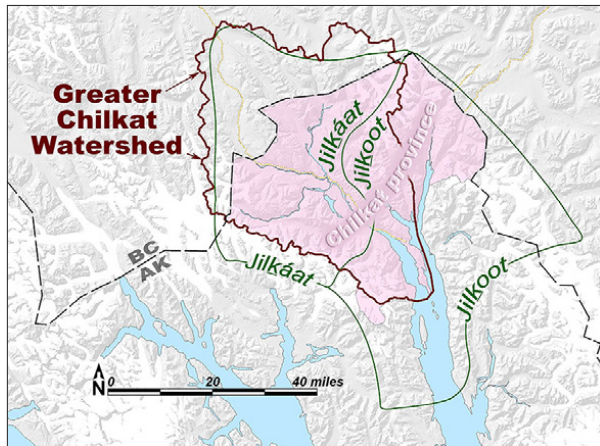
Defining home There are many ways to delineate landscape units according to ecological and social attributes, and I've participated in some of them. In 2005, as part of the steering committee for the Audubon-TNC conservation assessment for Southeast Alaska (Schoen & Dovichin, *eds*, 2007; Smith, *ed*, 2016), I helped TNC's Dave Albert expand the US Forest Service's 16 **biogeographic provinces**, which covered only lands within Tongass National Forest. We added 2 more—Glacier Bay and Chilkat-area—for lands outside the Tongass, then subdivided an oversized 400-mile-long mainland province into 5 units, yielding [22 biogeographic provinces from Yaakwdaát canoe rebounded \(Yakutat\) to Tàan Lunáa, sea lion promontory \(Cape Chacon\)](#).³

Those 22 island and mainland units were about the right size for a Southeast-wide assessment. Our Chilkat province—pink on map, right—was clipped to the Canadian border and included all watersheds exiting past the towns of Haines and Shgagwei, *windy white caps* (Skagway). It comes close to fitting the idea of "Greater Chilkat Watershed," as used by folks at Lynn Canal Conservation. The Takshanuk Watershed Council likewise defines their 'turf' as the Jilḱáat,

where raven swung (Mt Sinclair region) a 'mere' 6,330 feet tall but **10 times closer**. Glacier Bay and Yakutat have plant elevational keyed to great elevational range, but lacking in the huge precipitation gradient—and corresponding habitat array—of the Greater Chilkat rainshadow.

As for ecological diversity, there are several approaches to measurement. **Alpha, beta & gamma diversity** address species richness within and across communities, expanding to regional scale. **Structural diversity** addresses differences between, for example, an open woodland or closed forest. Although we lack numbers for both approaches, diversity is addressed conceptually in the [Section>Chapter titled Habitats>Measures of diversity](#).

3 Ecological Subsections are a finer-resolution multi-agency mapping effort defining 73 units in Southeast (Nowacki *et al* 2001). But those Subsections were defined more by geology and abiotic features than utility in conservation planning. In the Audubon-TNC assessment, we went with the older biogeographic provinces.



Alternative boundaries: Audubon-TNC's Chilkat biogeographic province in pink. Kwáan boundaries green-outlined. Alaska-British-Columbia border dashed. Greater Chilkat Watershed—outlined in red—intersects all and excludes portions of each.

of Jilḱáat, *cache* (Chilkat River) they hint at ancestral power-positioning relative to transboundary trading routes. Gustavus naturalist Greg Streveler—the broadest thinker I know in northern Lingít Aani—pointed out to me recently that Jilḱáat Aani is ecologically young: raw, burned, glacially and fluvially plowed, and rearranged. In contrast, Jilḱoot Aani—at least much of its coastal portion—is closer to the Lingít maritime norm, with actual old-growth forest, especially when moving southward down the great flord toward my home in Aak'w Aani.

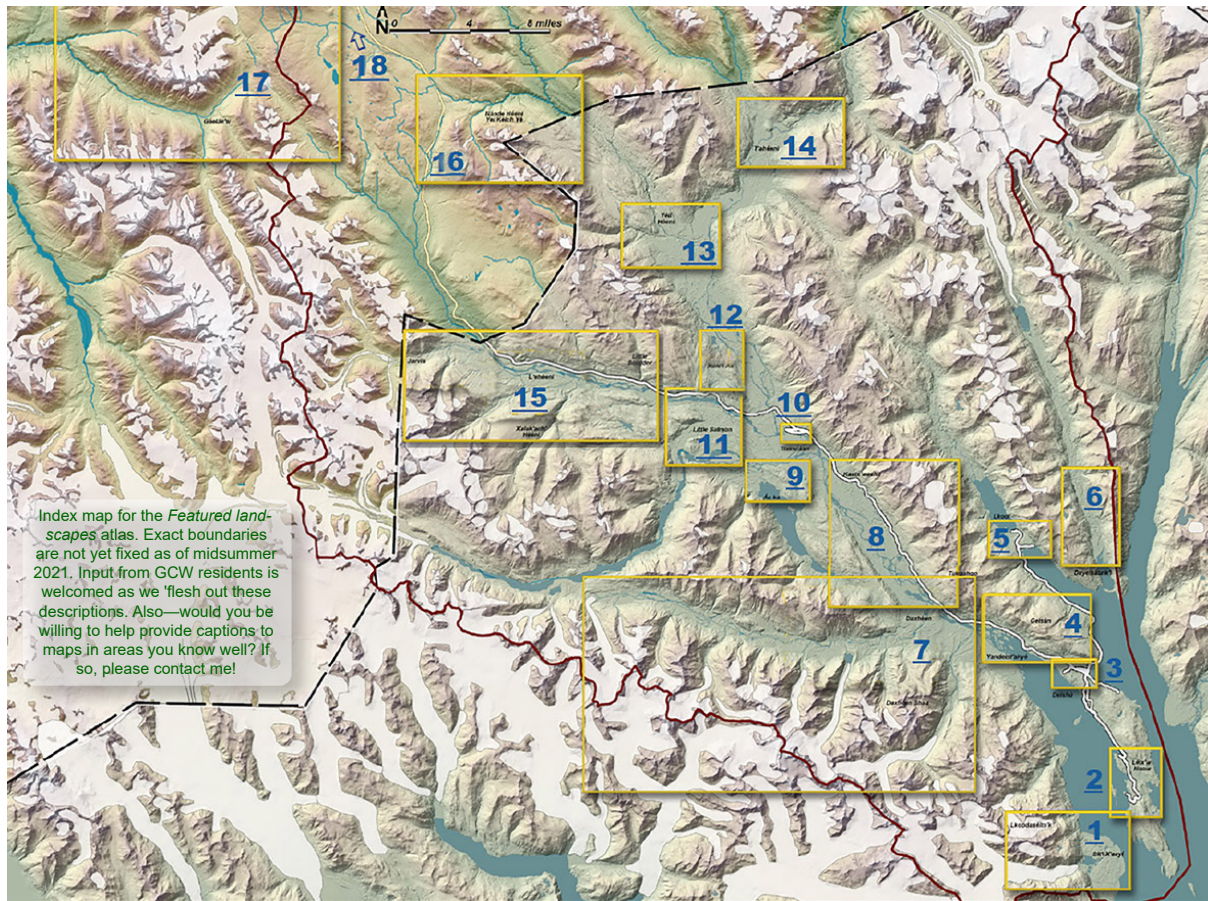
How do these profound ecological differences play out in stories and personalities of our northernmost kwáans and clans? These are not questions I can, or should, answer, but we can ask them of elders and culture bearers.

⁴ Kwáan, and Aani, are geographic concepts with no perfect one-word translation in English. Discussion is in [Culture>Deep history](#).

Lḱoot, *storehouse* (Chilkoot), and Dayeisáank'i Héen, *little cove river* (Ferebee) watersheds.

This atlas adheres to that definition—the customary 'use area' for residents of Deishú (Haines) and Tlak'áan, *eternal town* (Klukwan). Accordingly, we've removed the watersheds of Skagway and Dayéi, *to pack* (Dyea)—which lie beyond the LCC-TWC bailiwick. Most exciting to me, as a rather parochial Southeast cartographer with limited experience or resources outside Alaska, we're reaching northwest across the Canadian border to farthest limits of tributaries feeding Jilḱáat—**red-outlined** on this map. This adds 46% to the size of Greater Chilkat Watershed, and draws both moldy Alaskans and thirsty Canadians through permeable customs into 'exotic terrain.' Our binational GCW totals 1,889 square miles.

Of all borders and 'use-areas' depicted on this map, the Jilḱáat and Jilḱoot Kwáans, or Aani,⁴ are most venerable and ecologically attuned—**green outlines** on the map. Converging at the mouth



Featured landscapes

Scanning and assembling historical series from State Forest airplane missions, I find myself returning repeatedly to certain areas: Sít'i X'aayi, *glacier point* (Davidson); Tsirku fan, Little Salmon, Jarvis Glacier [*noTN?*], and many others. For any of these locations I can (and have!) quickly cobbled together many pages with these photo resources, other map layers, and—more gradually—stories&images solicited from residents and explorers. With Jessica and Eric I began to discuss ways to present 'sub-atlases' for such [Featured Chilkat Landscapes](#). There are 18 of these, as of summer 2021.

Since inclusion of these sub-site descriptions into the master GCW atlas would more than double its already large size, they're being organized as a separate pdf document, and as sub-pages of the Greater Chilkat page on *Juneau-Nature* on which to hang links and downloads—analogueous to the dozen watershed pages in our Áakw-&T'aaku section.

Understanding maps

Maps of many dates and scales and sources are presented in this *Atlas*. As a cartographer, it's tempting to expound at length in this *Intro* on their assembly, limits of credibility *etc.* But such an approach might off-put content-seekers uninterested in method. Those who *do* desire cartographic background ("metadata" in regrettably oversyllabed-&-soporific geo-speak) can geek out with me in [Appendix 2](#).

For now, I'll only point out that at broad scales, my maps are hillshade-based, with shadows generated from elevation models that know the height of terrain. At finer scales, ¹—scenes of, say, a few square miles or less—I typically switch to orthophotos (downward or 'nadir' aerials rectified to serve as maps). Only when zoomed in close do details of forest canopy or wetland vegetation make sense to human eyes. Farther out or *up*, mere 20/20 vision can't tell spruce from cottonwood, and ortho-detail fuzzes into meaningless white-noise. Most maps should feel uncluttered.

Appendices are the best home for stuff aficionados savor—while *Introductions* are better winnowed to what authors hope any reader might pause to ponder.

An introductory thought, to mull as you leap or tiptoe through this *Atlas*; Is there really any fundamental difference between what anyone

¹ Technical meanings of *small-* vs *large scale* are often 'flipped' by non-cartographers. In this *Atlas*, those expressions are replaced by *broad-scale* vs *fine-scale*, respectively. Explanation in [Appendix 2: Cartography](#).

would call a "map"—a Rand-McNally road map, say—and the cellphone picture you just snapped of your friends? Or (shudder) a selfie? Even that selfie is a map of your face. Why excommunicate these info-rich graphics from the realm of cartography? It can't just be a matter of scale. I think you'd agree that a map of mite-roads through a 2-inch-square liverwort jungle is still a map.

I also confronted this question when segregating out the Navy's 1926-&-29 oblique air photos, shot opportunistically over the sides of their biplane cockpits. In our companion *Featured landscapes* atlas, these are grouped with pedestrian historical photos taken pretty-much horizontally on the plain old ground.



Meanwhile, those same Navy pilots shot vertically-downward (nadir) images through a hatch in the fuselage belly that could be removed when airborne. *Those* images, stitched and georeferenced, *do* populate my GIS project for Greater Chilkat Watershed.

I guess one qualitative difference is that a map usually involves some degree of spatial referencing. It normally 'knows' where it is in the world, and can be compared, or overlaid, upon other views of that terrain. Until recently, almost all maps assumed a nadir perspective, if only because things get confused and hard to measure when you drift into oblique angles.

That's changing, however, as cartography matures. The new version of ArcMap—ArcGIS Pro—allows us to quickly set up a "*scene*"—as opposed to more traditional 2D "*map*" tabs—that



can be rotated and viewed from any perspective. It's similar to tilt-view in Google Earth, but way more sophisticated, allowing the intrepid 'mouse-pilot' to virtually fly, for example, not just over but inside a forest-canopy point cloud.

All this can remain 'under-the-hood' if you so desire. Our biogeographic atlas can be as flat and predictable as a paper road map—or as lush as a bear encounter, minus the smell, maybe. Either way, we want to hear from you; how can we sharpen this tool for your study and stewardship of Greater Chilkat Watershed?

Using this atlas

As reflected in our table of contents, the sequence of sections and chapters in this atlas follows a pretty standard approach to landscape description, working from the ground up. Beginning with bedrock foundations, then glacial and hydrologic histories and legacies, we move through biology (habitats, critters, etc) and conclude with cultural patterns. Landscape format best fits most maps and photos, and is also best for navigation on phones and tablets.

Hopefully, this atlas will be equally valuable as a quick 'lookup' reference—launching in Acrobat on your laptop—or as something to settle-in with for longer reading sessions. For the latter, my personal preference is to kick back with the pdf on tablet. As noted above, that's a particularly rich platform for high-res 3D viewing under a pocket stereoscope. Sure beats sitting at a keyboard for long passive stretches of reading.

But for jumping around in the document, zooming in on maps, or digitally annotating with 'yellow-stickies, no phone or tablet can keep up with a mouse-equipped computer running *Acrobat*. Here's some tools to load permanently to your header, which will much enhance your pdf-navigating. **From left to right:**

- 1) *Marquis zoom tool*. Draw a box to zoom precisely! Forget that time-sucking, trial-&-error "+" tool to get to the desired zoom level. 2) *Return-to-previous view*, invaluable reset from marquis-zooming, or recovering that place you abandoned in a 'by-the-way' detour, 48 pages back. ¹
- 3) *Contextual search tool*. If you type in "cottonwood," unlike simpler searches that just jump sequentially through every occurrence, you see a list of sentences in which *cottonwood* appears. Gets you to helpful info way faster. 4) *Yellow*

¹ There are many internal hyperlinks in this document, signaled by bluetext underline. They'll jump you across the document to related material or explanations. But when you're finished with that detour. . . . hmmm, . . . where'd you leave off? Just click the backward arrow icon, which you thoughtfully loaded to your Acrobat header.



highlighter, for marking text you'll return to. 5) *Yellow sticky-note*. For adding comments & questions.

Helping us build it The pdf and printed [?] versions of this atlas are just the tip of an online 'iceberg.' The real *living atlas* inhabits our websites — [LCC & JuneauNature](#)>[GCW](#)—and a collection of ArcGIS Online projects that allow you to explore the many data layers. This layered presentation gives you considerable freedom in both browsing and creating. You might choose, for example, to customize your own map for any portion of Greater Chilkat Watershed, with your choice of base (*raster*) imagery and *vector* overlays.²

Geopdfs At *JuneauNature* you can access a growing library of downloadable maps and orthophotos for Greater Chilkat Watershed. These are spatially-referenced pdfs for your device. Loaded to an app such as [Avenza](#) you can venture off-line into poor cell-coverage with just the GPS on your device, watching your position on the map, recording tracks & photopoints. Our map-library includes custom features such as stream, forest and bedrock types, not available on more generic navigation apps.

Geopdfs are linked-to from our companion atlas of *Featured landscapes*—signalled by this thumbtack icon—and described more thoroughly there in [Introduction](#)>[Geopdfs](#). The free version of Avenza only allows 3 geopdfs at once on your device, so just remember to clean out the folder and reload for each hike into a different area.



² Raster-vector distinction and other mapping esoterica are defined in [Appendix 2](#). As of midsummer, 2021, I haven't created ArcGIS Online map presentations, but still consider these the most flexible options for GCW cartography.

Setting, climate

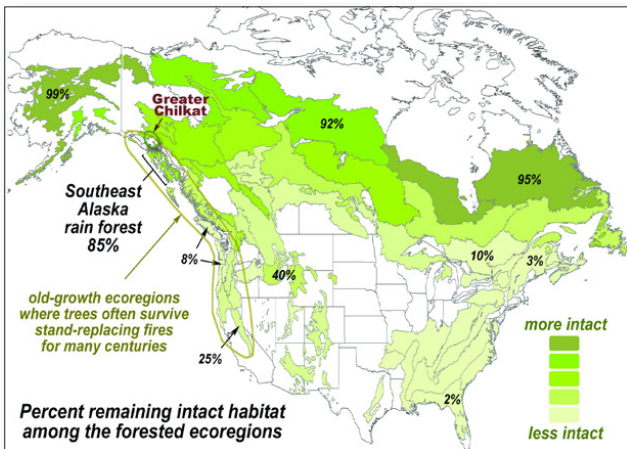
So far, 'setting' and 'climate'—still little more than placeholders—don't deserve [section](#) status in the atlas heirarchy, so I'm relegating to [chapter](#) under the [Introduction](#). See red-letter explanations of [Table of Contents levels](#).

Nested units Geographers dice the earth into progressively finer and finer nested units, each of which encompass lands with similar climate and vegetational communities. I've shown this heirarchical structure, and an example of each, in the box below.

Bioregions Here at the top of Lingit Aani (also referred to as Southeast Alaska, the Panhandle, Alexander Archipelago, Inside Passage, etc.), we

<i>nested units:</i>	<i>examples:</i>
bioregion	<i>Pacific temperate rain forest</i>
ecoregion	<i>northern Pacific coastal forests</i>
biogeographic province	<i>Chilkat province</i>
watershed	<i>Takhin River</i>

Ecoregions Within what's typically considered Southeast Alaska there are 2 *ecoregions* as defined by World Wildlife



Fund. WWF's *Northern Pacific coastal forests* ecoregion shoulders against their *Pacific coastal mountain tundra & icefields* ecoregion. Initially, working at archipelago scale for the Audubon-TNC conservation assessment, 2007-2010, I found these units rather nit-picky. On largest islands and in Sit' Eeti Geeyi, (Glacier Bay), they're broken out elevationally, producing fractured and farflung units, useless for, say, assessing wildlife carrying capacity within any meaningfully defined landscape.

But moving northward, I'll admit, it's intriguing to watch the gradual descent to sealevel of WWF's *Pacific coastal mountain*



tundra & icefields ecoregion, as we transition up L-word Canal ' into Jil̄koot & Jil̄k̄aat Aani. I kind of like thinking of this upper corner of the panhandle as affiliated at least as strongly with inland ecoregions as coastal ones. Maybe WWF was onto something when their cartographers drew these ecoregional boundaries. (But please, WWF, drop those silly summit units on Revilla and Shee (Baranof).

Biogeographic provinces are the next step down from ecoregions. Lingit Aani was originally subdivided into 16 of these. With Dave Albert, for the Audubon-TNC Southeast-wide

¹ I find it increasingly hard to acknowledge George Vancouver's birthplace every time I need to type the name of this largest of the world's glacial fiords (Lynn & Chatham together are 230 miles long). Why don't we have a Lingit name for this waterbody?! More thoughts in the intro to [Appendix 4](#)

conservation assessment (Schoen & Dovichin, eds. 2007), I made a few minor tweaks to these. We added 2 more—Glacier Bay & Chilkat—for lands outside the Tongass National Forest—then subdivided the continuous mainland province spanning Skagway to Dixon entrance into 5 units more comparable in size to the island provinces.

The first, spiral-bound edition of Schoen & Dovichin, eds, published in 2007 under the erudite title *A conservation assessment and resource synthesis for the coastal forests and mountains ecoregion in south-eastern Alaska and the Tongass National Forest*, was a door-stopper of more than 500 printed pages.² Printing costs limited that publication to just a select list of collaborators and decision-makers. Nearly a decade passed before Audubon Alaska reprinted it as a more affordable and reader-friendly 224-page large-format map collection called *Ecological atlas of Southeast Alaska*, Smith, ed, 2016.

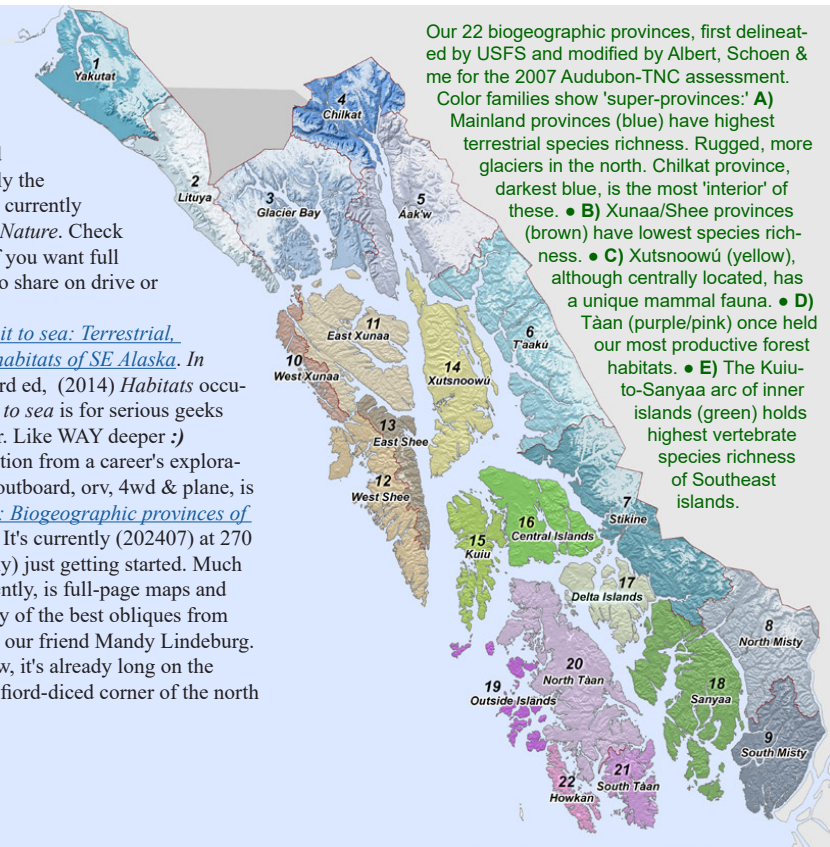
By the time of that revision I'd withdrawn from the collaborative, and their *Provinces* section was compressed from 75 down to 5 pages. Meanwhile, I was building out *JuneauNature*>PLACES to encompass what I've considered my geographic 'turf' since 1st edition of *Nature of SE Alaska* in 1992. Building on those exhaustive 2007 provinces descriptions, hand-written field notes, and scans of old 35mm slides taken on kayak trips and Landmarking expeditions throughout Lingit-&-K'áyk'aanii (land of Tlingit

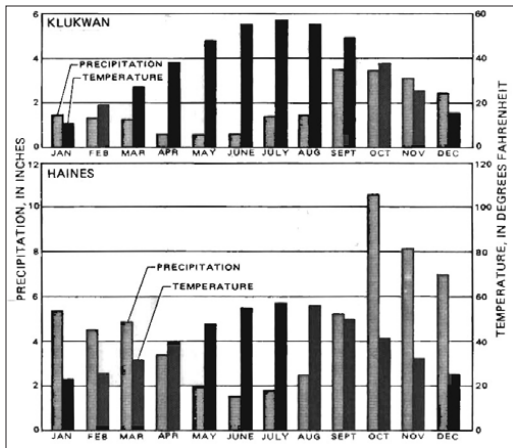
& Haida), I started cobbling together a pair of immense digital documents. Because they're both works in progress, and too big to upload, only the introductory pages are currently available from *JuneauNature*. Check those intros out, and if you want full draft pdfs, I'm happy to share on drive or sd card.

One is called [*Summit to sea: Terrestrial, coastal & freshwater habitats of SE Alaska*](#). In *Nature of Southeast*, 3rd ed, (2014) *Habitats* occupies 73 pages. *Summit to sea* is for serious geeks wanting to dive deeper. Like WAY deeper :)

My second compilation from a career's explorations by foot, paddle, outboard, orv, 4wd & plane, is called [*Heart and edge: Biogeographic provinces of Lingit-&-K'áyk'aanii*](#). It's currently (202407) at 270 pages, & I'm (hopefully) just getting started. Much of *provinces.pdf*, currently, is full-page maps and photos, including many of the best obliques from Alaska Shorezone and our friend Mandy Lindeburg. Short on prose, for now, it's already long on the visual splendor of our fiord-diced corner of the north Pacific coast.

² My section on the *Provinces* was 75 pages, and *Habitats* (terrestrial, coastal and freshwater) was another 100 pages.





Mean monthly temps F and precip, inches between 1927 and 1943. From Bugliosi, 1985.

Should create comparison from the last decade to check for changes. Good project for an LCC or TWC intern.

"Simultaneous temperatures differ by as much as 10° F between Haines and Klukwan, 20 miles from each other." Bugliosi (1985)

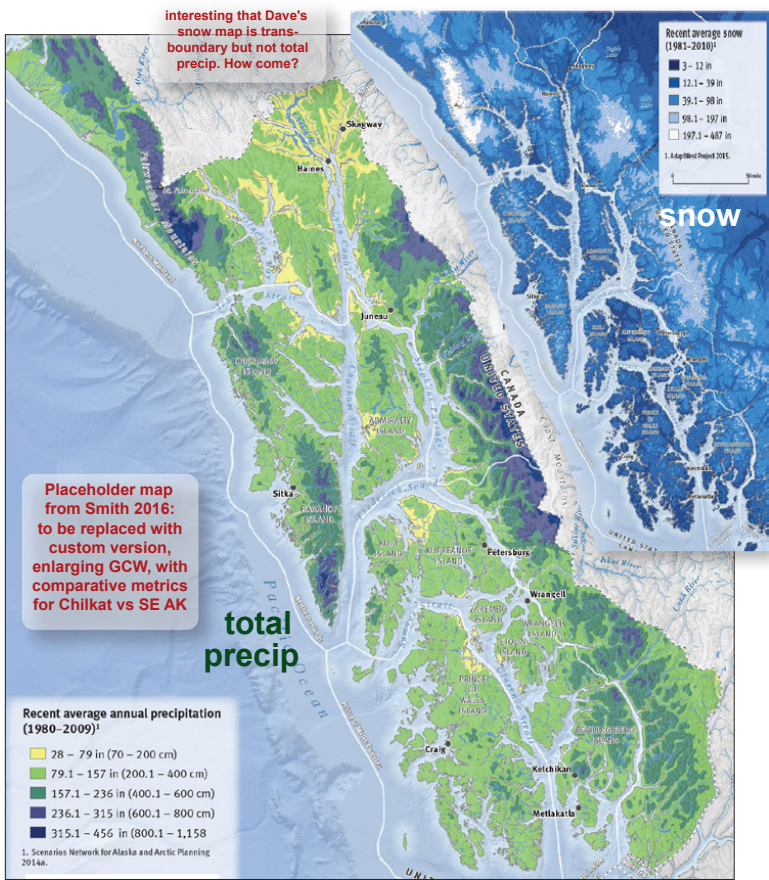
Climate placeholders

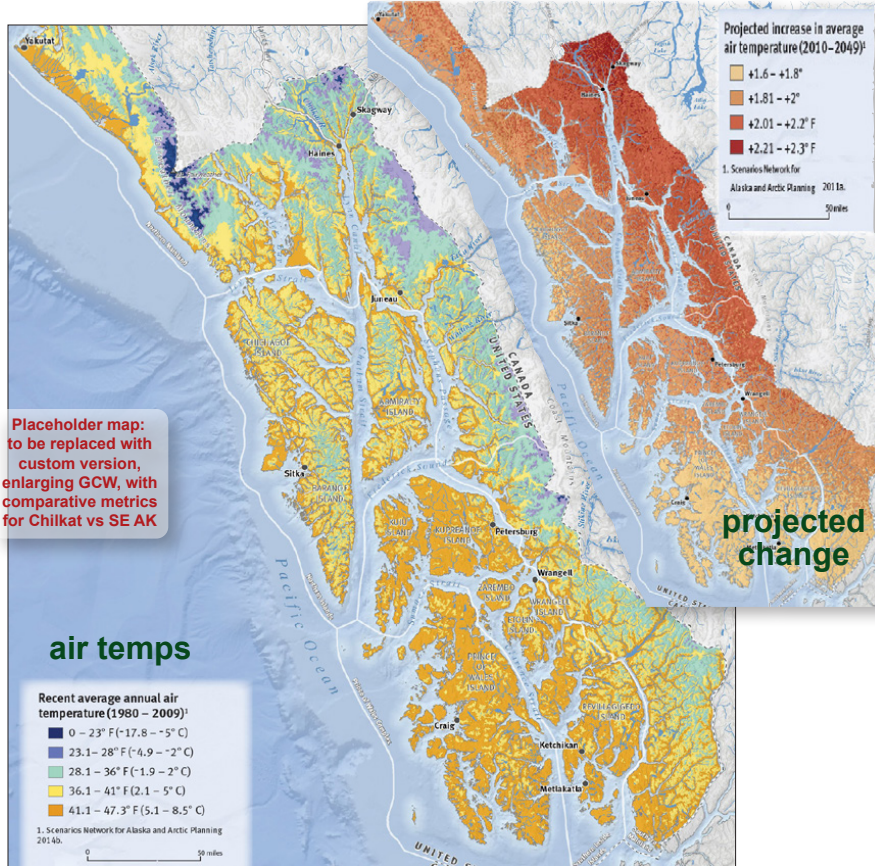
Natalie Dawson, former AK Audubon ED, now GCW resident, once said she could get me shapefiles for any of the maps in Smith *ed* (2016). Perhaps I've waited too long, but is that still true Natalie? Ideally, they'd be transboundary layers, not clipped to the AK-BC border like these. But I can probably do some creative merging with Canadian layers.

Jessica, Eric, Ben, Natalie, Kevin, Anthony:

Where are the data-recording stations in GCW? Just Klukwan vs Haines downtown? Have any private residences along Haines Highway voluntarily maintained stations for NOAA?

Would it be possible to create an impressionistic color-map of GCW showing wettest-grading-to-driest pockets? Aud-TNC's 5-color precip map only shows those 2 driest colors within GCW, and they simply split out unhelpfully along elevational thresholds. Even the crudest of guesses from longtime chilkaters would be more useful than that.



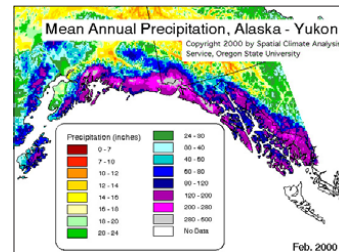


Is anyone at Audubon or perhaps TNC updating these? Colin Shanley recently (~2023) moved on to a private GIS consulting gig. So maybe in-house cartography at these organizations has waned or change focus?

Following a botanically-focused zoom session in early 2025, Nicholas Szatkowski sent us some resource connections:

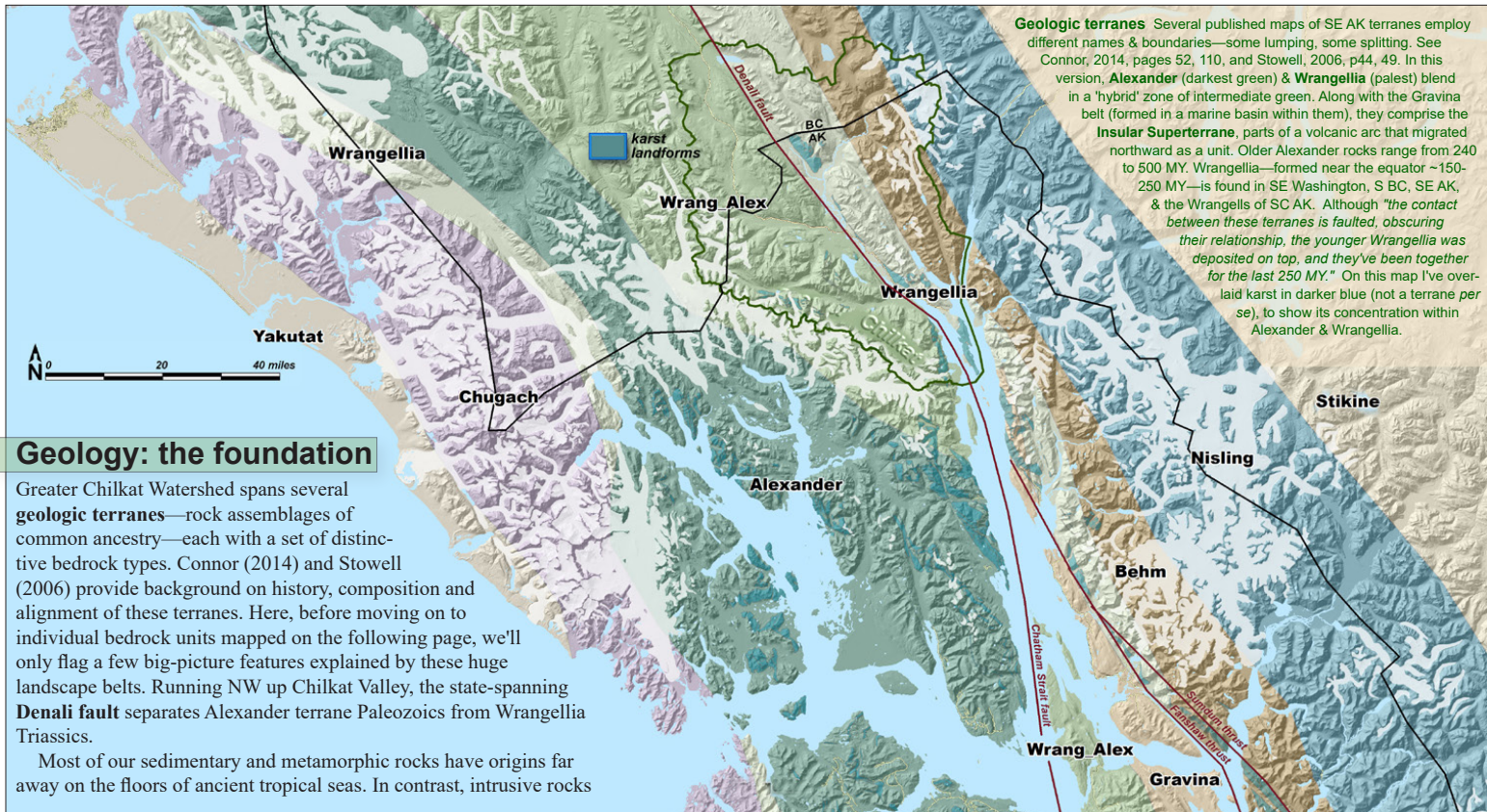
"Here are a couple links to some climate information that I find interesting. The first one has some maps that show well some of the differences in temperature and precipitation throughout Southeast AK. [2007 SEAN](#)

And here's a [PRISM map by OSU](#) of precipitation across the region. I like this map because of the colors, and because it includes both Alaska and Canada, without a break or cut-off at the artificial, international border. To me, these patters make more sense when we can see more of the landscape. By this map, much of the Chilkat valley would clock in at under 40 inches of annual precip (although it's around 55 inches in Haines, and even more near Mud Bay).



And here's a link to the Alaska Center for Conservation Science's report on "[Alaska Ecosystems of Conservation Concern: Biophysical Settings and Plant Associations](#)". The chapter on Lodgepole Pine/Cladina plant community is on page 275-278 (it's a pretty long report!). The rest of it is fairly interesting as well, although there is no mention of anywhere in the actual Chilkat watershed.

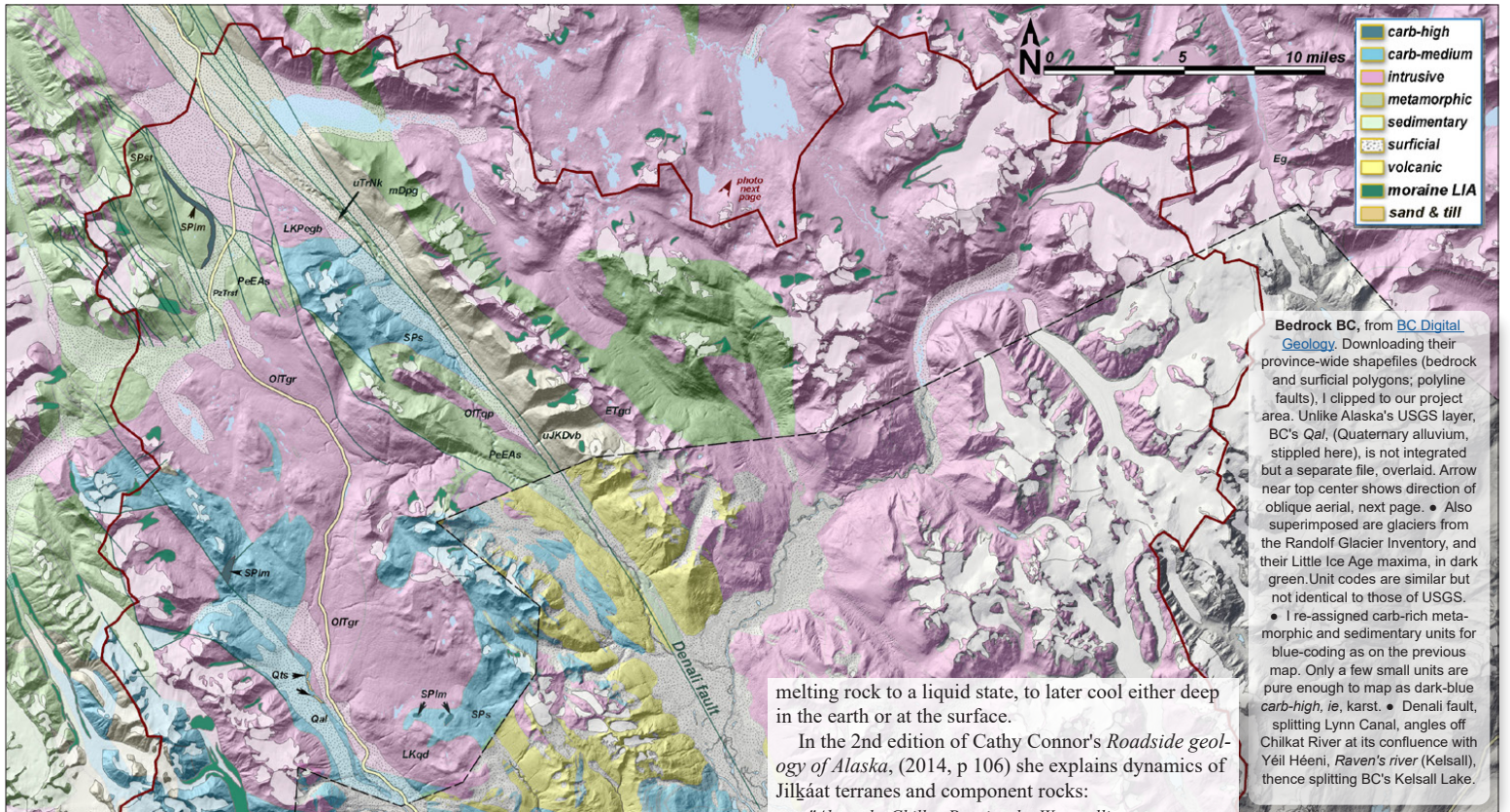
We're getting afield here from climate. But I've added that pine-cladina info below in [Habitats>Forest & scrub>Mixed deciduous: fire origin](#)



Geology: the foundation

Greater Chilkat Watershed spans several **geologic terranes**—rock assemblages of common ancestry—each with a set of distinctive bedrock types. Connor (2014) and Stowell (2006) provide background on history, composition and alignment of these terranes. Here, before moving on to individual bedrock units mapped on the following page, we'll only flag a few big-picture features explained by these huge landscape belts. Running NW up Chilkat Valley, the state-spanning **Denali fault** separates Alexander terrane Paleozoics from Wrangellia Triassics.

Most of our sedimentary and metamorphic rocks have origins far away on the floors of ancient tropical seas. In contrast, intrusive rocks





Kevin White

2020

greenstones of Triassic age, with interbedded volcanic sandstones, mudstones and cherts, outcrop on the eastern side of the Denali fault. Beautifully formed pillow basalts are located in Chilkat State Park. West of Chilkat Inlet, the Denali fault transects Alexander terrane carbonate and clastic rocks of Paleozoic age. Resistant Cretaceous diorite and gabbro form the Taksanuk Range, intruded into Wrangellia basalts ~83 million years ago."

Northeast over Duff & Goodwin Lakes (el. 3,786 ft). Granitic barrens just a few miles north of GCW boundary. Rarely is bedrock so thoroughly exposed; even ridgetop tundra closer to the coast typically has more vegetation.

The bi-national team of Sack, Karl, Steeves and Gemmell (2016) mapped this largest BC polygon as "*Eocene porphyritic granodiorite and migmatite, undivided: Coast plutonic complex; AK, BC, YT.*" Only 34 to 56 million years old, these monolithic intrusives from the age of mammals have largely resisted quarrying by glaciers, which lay shallower and less powerful here along the transition to the drier boreal. In the short alpine growing season, without a blanket of organics or even surficial deposits, this plateau was probably barren even during the Thermal Optimum.

On Goodwin massif in left distance, a swarm of alpine cirque glaciers each advanced and retreated about a mile in the Little Ice Age. They've been intensively studied by Menounos and colleagues.

[confirm date with kevin; not in his word doc, and exif fields are scrubbed]

Stowell (2006, p50) elaborates on stratigraphy within Wrangellia:

"The oldest Wrangellia rocks are late Paleozoic oceanic basalt, limestone and mudstone formed ~15° from the equator. They're overlain by Triassic basalt, metamorphosed into greenstone. [The terrane] probably originated as a thick volcanic section on the ocean floor or island arc."

Bedrock

Maps of bedrock units typically boast dozens of colors, overwhelming to the non-geologist. My bedrock map for Southeast Alaska has evolved over the past decade in an attempt to depict biologically relevant patterns, intelligible to naturalists and outdoorsfolk like me who might not know or care about the difference between phyllite and slate, but do maybe want to know which rocks host gold, or grow the largest trees. From discussion with Greg Streveler I settled on 8 categories. Most of these 'families,' are pretty self explanatory to anyone familiar the basic rock categories.

The pair that *aren't* standard in geo-cartography are the first two: **carb-high** and **carb-medium**. By this I mean that these units as described by Karl (2004) have a strong component of limey rocks, or carbonates. Such rock associations are commonly shown in shades of blue. By further sorting them into high and medium, I've broken out 2 groups of interest to landscape ecologists. *Carb-high* shows units encompassed within Jim Baichtal's separate **karst** layer. Here are the known and potential caves, as well as abundant solution features that only express in rocks with high % calcium carbonate. More thoughts on karst and its connection to our greatest forests follows at end of this *Bedrock* chapter.

Many other metamorphic, sedimentary and volcanic units, while lacking obvious solution features, do include enough carbonate rocks to influence productivity and even species composition of forests and wetlands. Some underlie our most coveted timberlands. These I pulled from their sed-meta-volcanic families into a rather mongrel family called *carb-medium*,

code	rocktypes	period
carb-high		
Pzm	folded marble	3 Paleozoic
PzZc	argillaceous marble	3 Paleozoic Precambrian
Mls	limestone phyllite	3b Mississippian
MDm	uncataloged	3b Mississippian
Dm	marble	3c Devonian
DSal	mudst grayw limestone	3c Devonian
DSld	limestone dolostone	3c Dev-Silurian
carb-medium		
Trha	argillite chert carb	2c Triassic
Trhl	limestone marble mudstone	2c Triassic
Pzca	metachert marble metatuff	3 Paleozoic
Pzcs	schists & semischists	3 Paleozoic
Pzlc	argillaceous chert marble	3 Paleozoic
PzZmv	greenstone schist marble	3 Paleozoic Precambrian
PzZq	siliceous&carbonaceous schist	3 Paleozoic Precambrian
Phl	siltstone limestone conglom	3a Permian
PMcc	carbonaceous slate phyllite	3a Permian Mississippian
MDcp	carbonaceous phyllite	3b Mississippian
Stl	limestone turbidites	3d Silurian

coded paler blue than the *carb-high* karstlands. ¹

¹ Almost all GCW logging mapped by ADOF falls on one of 3 bedrock 'families:' carb-high (karst), carb-medium, and Quaternary unconsolidated. Judging from neighboring units, these mostly overlie—sometimes thinly—the 2 carb-rich bedrock types, which, as 'parent material', substantially 'nutrify' the till and soil.

code	rocktypes	period
metamorphic		
TrPsa	phyllite semischist	2c Triassic Permian
Pzgs	schist semischist	3 Paleozoic
Dsc	siliceous phyllite slate	3c Devonian
sedimentary		
Tk	kootz formation sandst shale	1b Tertiary
Dsv	uncataloged	3c Devonian
volcanic		
Ti	gehrels volc unit	1b Tertiary
Trmv	mafic volcanic flows	2c Triassic
Trhf	felsici volcanic	2c Triassic
PzZsv	metaseds&volcanics	3 Paleozoic Precambrian
Psv	uncataloged	3a Permian
SOsv	metaseds&volcanics	3d Silurian Ordovician

Bedrock units of the Greater Chilkat Colors in these tables correspond to 'rock family' colors on preceding map, where units are labeled only with rock code. Capitalized letters are for time periods and epochs. My numbering system in the *period* column allows each rock family to be sorted by age.

One other rock family, important in the Greater Chilkat, deserves mention for its interest to biogeographers: the **ultramafics**. These are small, far-flung units that haven't received much attention in our region compared to karst. They're best known locally for deflecting compasses; magnetite is a common secondary mineral.

In 1989, mapping outflow of Chilkat Lake for NSRAA with hydrologist Dan Bishop, I remember his concern

Geologic calendar
1 Cenozoic
1a Quaternary
1a1 Holocene
1a2 Pliostocene
1b Tertiary
1b1 Pliocene
1b2 Miocene
1b3 Oligocene
1b4 Eocene
1b5 Paleocene
2 Mesozoic
2a Cretaceous
2b Jurassic
2c Triassic
3 Paleozoic
3a Permian
3b Mississippian
3c Devonian
3d Silurian
3e Ordovician
3f Cambrian
4 Precambrian

Left: numbering system for eras, periods and epochs. These have **Capital letters in the rock code.** Within each of my color-coded 'rock families,' I wanted to sort by age. In these tables I've therefore preceded each era, period or epoch with a numerical identifier—eg 1b1 Pliocene—to keep units ordered from young to old. In many cases geologists found rocks from a spectrum of ages, or else could not determine age except at the crudest level. JPzvs indicates rocks spanning Jurassic to Paleozoic ages. In these cases my number indicates the most recent in that span: 2b Jurassic.

about accurately closing a long compass-&-autolevel traverse through outwash and willow thicket, because a patch of ultramafics outcrops 4 miles NW on the side of T'ukyik, in the *cradleboard* (shoulder of Iron Mtn) above Tlákwaan, *eternal village* (Klukwan). In those pre-GPS days, a degree or two of deflection could make a big difference in base-station position. As it turned out, distance

'protected' us, and we re-occupied station #1 with only a few feet of error.

Today, surveyors triangulate from satellites, and

code	rocktypes	period
intrusives		
Tktf	foliated tonalite	1b Tertiary
Tktm	para- & orthogneiss migmatite	1b Tertiary
Togr	granite granodiorite	1b Tertiary
Toem	migmatite	1b Tertiary
Tag	quartz monzonite	1b Tertiary
Ten	norite gabbro	1b Tertiary
Todi	hornblende diorite	1b3 Tertiary Oligocene
Togd	granodiorite quartz diorite	1b3 Tertiary Oligocene
Tgdp	porphyritic granodiorite	1b4 Eocene
Tgdpm	migmatite	1b4 Eocene
TEt	tonalite granodiorite	1b4 Eocene
MzPzi	undifferentiated	2 Mesozoic Paleozoic
Kmz	quartz monzonite	2a Cretaceous
Kmg	migmatite	2a Cretaceous
Kg	granite granodiorite	2a Cretaceous
Kd	quartz diorite	2a Cretaceous
Kqd	quartz diorite	2a Cretaceous
Kgd	granite granodiorite	2a Cretaceous
Jqt	quartz diorite tonalite	2b Jurassic
Jag	alkalic granite syenite	2b Jurassic
Jgd	granodiorite	2b Jurassic
Tradi	foliated hornblende diorite	2c Triassic
SOmi	granite syenite gabbro	3d Silurian Ordovician

code	rocktypes	period
ultramafics		
Kum	pyroxenite hornblende	2a Cretaceous
surficial		
Qa	alluvium	1a Quaternary
Qnd	no data maybe	1a Quaternary
Qrg	receded glacier maybe	1a Quaternary
Qaf	alluvial fan	1a Quaternary
Qc	colluvium	1a Quaternary
Qls	landslide	1a Quaternary

botanical implications of heavy metals are perhaps more important than magnetic inconveniences. Following Gehrels *et al* (1992), I've given GCW's pockets of ultramafics a 'standout' dark purple coding in hopes of inspiring more scrutiny by plant people. The rare Kruckeberg's fern—a Southeast endemic—has been found on several of these units (Carstensen & Connor. 2013c. *Reading South-east Alaska's landscape*, p6). It was named for Art Kruckeberg, one of the few 'crossover' field workers equally competent on both sides of the biology—geology divide, whose book *Geology & plant life: the effects of landforms & rock types on plants* (Kruckeberg 2002) is my go-to source on these connections. Much of Art's book is devoted to serpentine barrens of the Pacific Northwest and California, where many endemic plant species have evolved tolerances to heavy metals such as nickle in shallow-soil ultramafic landforms. The only reason they're lacking here is that the 'mere' 10- or 20,000 years since glaciation have provided less time for genetic drift.

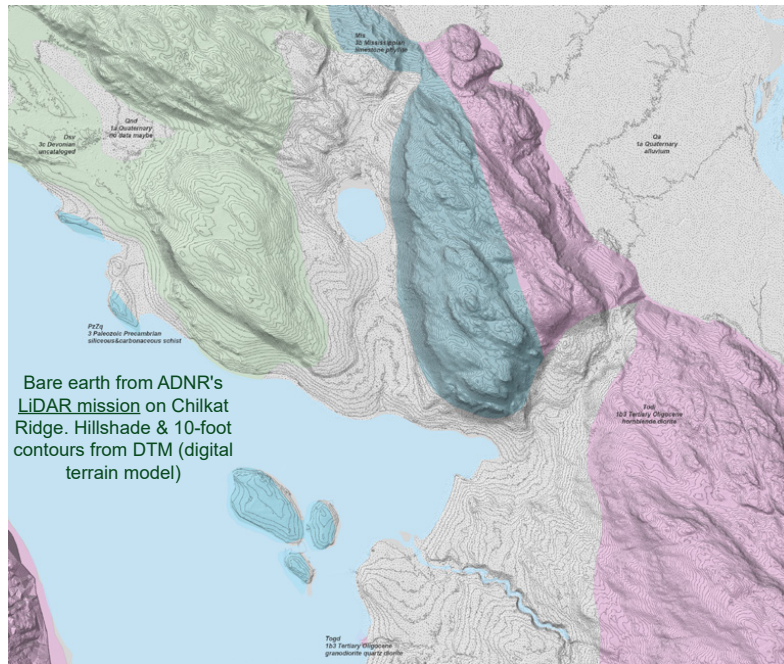
Bedrock type explains much about distribution and productivity of natural communities. Examples of plant community responses to differences in underlying bedrock are given in [Summit to sea](#) (Carstensen, 2018a). In general, granitic bedrock supports rather unproductive forest and wetland communities. Because they're most resistant to glacial erosion, granitics often maintain shear cliff faces, scenically spectacular but biologically impoverished. At low elevations, limestone and marble bedrock often undergird lie the opposite extreme. They once supported Alaska's legendary giant-tree forests of Sitka spruce. Almost all of these stands have been logged. Lingit Aani's karst map is a map of stumps, granted, but it also holds hope for the future. If we give karst habitats the stewardship they deserve, residents of Greater Chilkat could again see 200-foot shéiyi (sitka spruce) on marble-cored hills above Mosquito Lake and limey knobs of Little Salmon country. ²

Distillations from overview papers 2022: These can serve as placeholders until we come up with an integrated, lay-friendly summary of GCW bedrock geology. ● **202408:** I was hoping we could get Greg Streveler to write this. Professional geologists are generally not too good at translating their work for the jargon-averse public, and Greg several times partnered with them to create lay-descriptions. With his passing, and perhaps Cathy Connor's help, I may have to attempt this myself.

From Brew&Ford (1994)

"Rocks West of Coast Mountains Plutonic-Metamorphic Complex (CMPMC):

2 Ghost tree heights are speculative and bear further investigation. Here's my reasoning: **1)** karst supported *definitely* the fattest (cause stumps prove it) and *probably* the tallest spruce in Lingit Aani. **2)** tallest spruce on CBJ LiDAR (238 ft) is the equal of Tãan's tallest (235 ft, on Stoney Creek, POW). So there's no reason to expect strong decline in max height going northward from 55° to 60° latitude. **3)** initial scan of Baichtal karst layer and my carb-medium unit for GCW shows almost all logging has been on these bedrock types, or surficial deposits overlying them. **4)** Even though Jilkáat Aani is a raw, mostly youthful, glacier- and fire-restarted country, it doesn't take a karst spruce very long to reach 200 feet. **5)** There were probably plenty of 200-footers on the GCW timberlands in 1960. We should map a 'ghost forest,' as Matt Kirchoff and I did on Heceta in 1999. **6)** There may even be surviving karst giants in the GCW. First place I'd look is in the carb-hi *M/s* unit between Aa ka (Chilkat Lake) and the River. Hopefully the 2018 Chilkat Ridge LiDAR will show us some 'pumpkins,' when I figure out how to access the associated point cloud. *PS 2024: no progress on that. Should get those very large files from DGGs on external drive.*



To GCW residents: It'd be awesome if folks could seek out and photograph bedrock outcrops throughout the area mapped on [geopdf chilk-atgeo.pdf](#). Viewed in Avenza on your phone, you can navigate to USGS map units, lay down and save a track, and link your photos to this track as a point file. Together with the track, Avenza allows you to zip both into a kmz file that anyone can view in google earth. Send these kmz files to me, and I'll use em to fine-tune and illustrate a growing geologic *Story Map* for the Greater Chilkat.

SW of the Lutak Inlet-Chilkoot River fault are 2 fault blocks: 1 between Lutak Inlet-Chilkoot River fault and Chilkat River fault, and 1 SW of the latter. The former consists of Silurian or older pelitic, semipelitic, and carbonate sedimentary rocks and some intermediate-composition volcanic rocks (Rsv) intruded by biotite-hornblende granodiorite of the pluton centered at Mt. Emmerich (Tegd). We think its age is at least in part Eocene or younger. Any Cretaceous parts would probably belong to the Chilkat-Prince of Wales plutonic province.

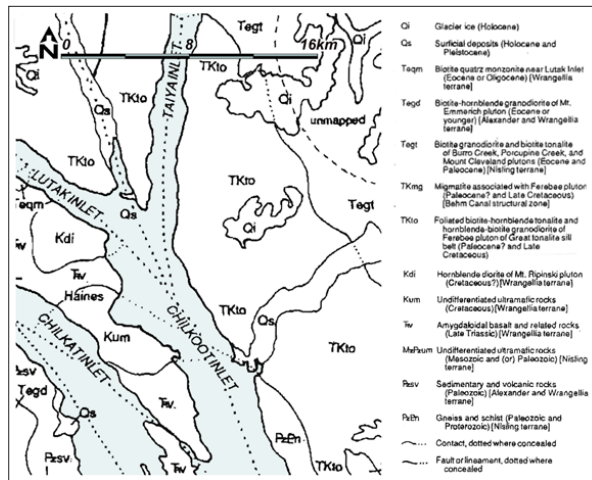
Chilkat River fault is the main local segment of the Denali fault system; others noted above are less important splays. The Denali system is right-lateral with ~150 km of displacement. A major unnamed splay cuts across the Chilkat Peninsula south of Haines and connects with Lutak Inlet-Chilkoot Inlet fault. That major splay cuts through the Upper Triassic amygdaloidal basalts (Trv) that make up most of the Chilkat Peninsula. The basalts are intruded by mid-Cretaceous ultramafic rocks of the pluton at Haines (Kum), by Cretaceous(?) hornblende diorite of the pluton at Mt. Ripinski (Kdi), and by a small plug of Eocene(?) leucocratic quartz monzonite (Teqm) on the southwest side of Lutak Inlet, with only minor separation on Lutak Inlet-Chilkoot Inlet fault and faults to NE.

Coast Mountains Plutonic-Metamorphic Complex (CMPMC) South of Skagway

CMPMC proper lies NE of Lutak Inlet-Chilkoot Inlet fault, described here from S to N along Taiya Inlet. Three major rock units expose between that fault and Skagway.

1) The first has pelitic schist, gneiss, and migmatite of Nisling(?) terrane on mainland shore SE of Haines (PzPn) & screens within Ferebee pluton of the Great tonalite sill belt.

2) The Ferebee pluton (TKto) is part of the Great tonalite sill belt, with foliated, medium-grained, locally linedated, color index about 12-25, hornblende-biotite granodiorite and sphene-biotite hornblende tonalite. There are large areas of metamorphic rocks and migmatite within the Ferebee, not mapped here. Ferebee pluton is in the central metamorphic



belt. K-Ar ages 59.9 Ma on hornblende and 43.3 Ma on biotite, reset, in part by younger plutons of the adjacent Skagway plutonic suite and locally in young shear zones.

3) Burro Creek pluton lies N of Ferebee pluton, also exposed in "Skagway plutons suite" (unit Tegt), with generally massive, but locally foliated, medium- to coarse-grained, color index about 15, biotite granodiorite and/or tonalite, and quartz monzonite. Euhedral biotite books as large as 6 mm occur locally.

From Bugliosi (1985):

Chilkat River basin is divided into two distinct geologic provinces by the Chilkat River fault. East of the fault and river, structural trends are predominantly NW. To the west, structural trends are complex and include west-trending faults and lineaments. Rocks east of Chilkat River are intrusives and metavolcanics from Cretaceous to early Tertiary, ~100 to 50 million years old. West of the river, the basin is underlain by lithologically

diverse, metamorphosed Paleozoic, Cretaceous, and Tertiary rocks, from 500 to 50 million years old.

[Slymaker ed \(2016 p 7\):](#)

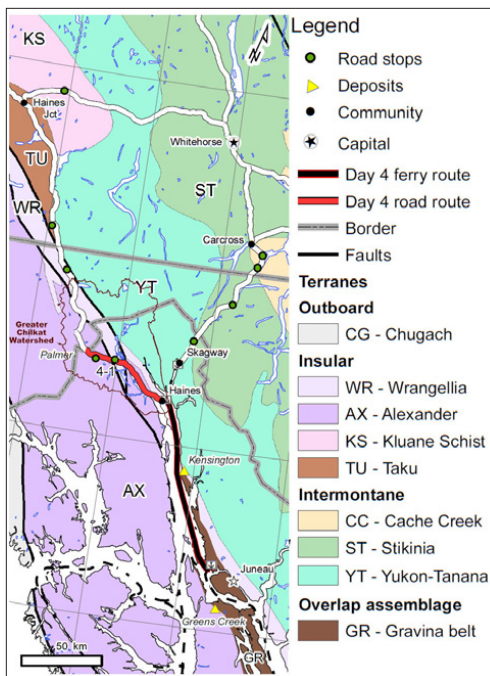
"Major lineaments of western Canada generally align NNW to SSE. Valley orientations define the conjugate failure planes for stresses from onshore movement of the Juan de Fuca plate. . . Three linear valleys >500 km long—the Rocky Mountain, Tintina and Shakwak trenches—formed due to underlying normal faults. They contain Cretaceous and Cenozoic sediments and glacialfluvial and glaciolacustrine deposits. The Shakwak Trench containing Klwane Lake follows Denali fault.

20220129 John Norton just linked me to an outstanding source on GCW geology, from the bi-national team of Sack, Karl, Steeves and Gemmill. In 2016 they led a 5-day field trip around the Skagway-Juneau-Haines loop, creating an illustrated 82-page guide to geology of the borderlands. Following are excerpts. In some cases I'm copying descriptions into relevant chapters of our separate document called *Featured landscapes*:

The city of Haines is built on Quaternary outwash and alluvial deposits. South of town on Chilkat Peninsula are coarse-grained biotite amphibolite with pegmatite dykes and pyroxenite that intrude Triassic mafic metavolcanic rocks assigned to Wrangellia. A concordant U-Pb zircon age of 107.5 Ma from pegmatite is similar to a K-Ar hornblende age of 111.7 Ma and a K-Ar biotite age of 110.7 Ma from pyroxenite.

The Klukwan ultramafic body 35 km north of town yielded hornblende K-Ar ages of 98.4 and 101.5 Ma from drill core, considered too young because of alteration. The ultramafics are intruded by plagioclase porphyritic quartz diorite with magmatic epidote and garnet, and yielded a U-Pb zircon lower intercept age of 83.5 ± 2.5 Ma providing minimum ages. Crustal thickening was accomplished by thrust burial. Ultramafic rocks and quartz diorites of this belt throughout southeast Alaska, including the Treadwell diorite, have whole-rock and mineral geochemistry supporting genesis in a volcanic arc.

As we drive northwestward from Haines, on our right is a prominent ridge of the Triassic mafic metavolcanic rocks intruded by the Klukwan ultramafic rocks, part of the Alaska-Urals mafic-ultramafic belt in southeast Alaska, and the 83.5 Ma quartz diorite on the north side of Haines Harbor. Chilkat River is underlain by the Denali fault. As we cross them, we cross from Wrangellia into the Alexander terrane (Fig. 4-1). Some of the oldest rocks in the Alexander terrane are exposed on the north side of the Klehini River, including the Neoproterozoic to Ordovician Four Winds Complex. These rocks are



metamorphosed to amphibolite facies, intruded by Silurian quartz diorite bodies, and structurally overlie Devonian to Triassic sedimentary and volcanic rocks. In contrast to the Triassic basalts of Wrangellia, these Triassic rocks have trace element signatures indicating arc and rifted arc affinities, and host a significant belt of VMS deposits, including the Palmer.

After we cross the Klehini River, we will drive by tilted

Driving route of Sack, Karl et al (2016) with GCW superimposed. By their convention, Greater Chilkat terranes include, from SW to NE: Alexander, Wrangellia, and Yukon-Tanana. My preceding [terrane map](#) gives "Behm" for the inboard YT terrane on this version

glacial outwash deposits and sheared fossiliferous Devonian and Mississippian limestones and shales that have kinematic indicators of recent dextral activity on a fault that the Klehini River follows. This road leads us to Porcupine, location of a gold placer mine and the Constantine camp. We'll walk up a short road east of Porcupine Creek and find corals, brachiopods and gastropods in bedded limestone of Middle Devonian age (Stop 4-1).

The Devonian limestone is gradationally overlain by black Mississippian limestone and chert, which is conformably overlain by the Porcupine Slate, upstream and west of the creek, with Early Permian brachiopods. It's a black, limonite-stained slate and phyllite, interlayered with dark gray siltstone turbidites, and subordinate greywacke, chert, limestone, conglomerate, and mafic volcanic rocks. The Porcupine Slate is identical to carbonaceous slate and phyllite of the Cannery Formation east of the Greens Creek mine. There, the Cannery slates also contain Permian brachiopods, but are otherwise compositionally indistinguishable from the mine argillite that contains Late Triassic Halobia. The Porcupine Slate west and south of Porcupine Creek is gradational to black carbonaceous slate of Triassic age associated with the Palmer deposit.

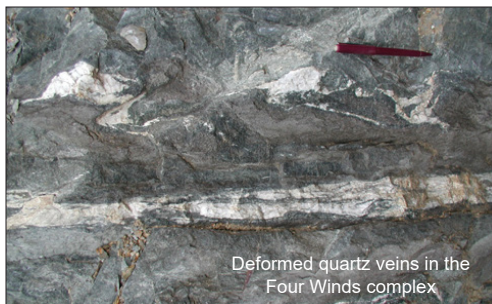
Day-5 drive description Stop 5-1 mile 27.2, Mosquito Lake Road, Four Winds metamorphic complex:

Geology between Haines and Haines Junction is complicated by a long history of contractional and translational faulting. NE of Haines, the Coast plutonic complex records Late Cretaceous to Paleogene metamorphism and synkinematic emplacement of a continental margin arc. In the late Early Cretaceous, subduction of oceanic crust beneath the

continental margin ceased as the various Insular terranes rafted into the subduction zone. The buoyant Insular terranes did not subduct but rather formed an orogenic welt. The Insular terranes, including the Wrangellia and Alexander terranes, consisted of an assortment of oceanic arcs overlying subduction complexes of their own, and as they amalgamated, a new arc formed on the western margin of the composite Insular terrane in the late Early Cretaceous. As the composite Insular terrane collided with Yukon-Tanana terrane at the margin of North America, significant crustal thickening along the collision zone formed a welt that was intruded by the eastward migrating arc magmatism on the composite Insular terrane. In the Early Tertiary the new arc on the Insular terrane migrated east of the collision zone, emplacing the Coast batholith into this pre-existing Mesozoic arc. In the Haines area, the Insular terrane that choked subduction beneath Yukon-Tanana terrane is Wrangellia. Very little of Wrangellia is preserved in this area because hundreds of km of dextral translation on the Denali fault, which underlies the Chilkat River, removed an unknown amount of Wrangellia and placed part of the Alexander terrane adjacent to the Chilkat basalts of Wrangellia. This part of the Alexander terrane, referred to as the Admiralty subterrane, consists of a long-lived oceanic arc, and can be tied stratigraphically to the rocks on Admiralty. This correlation is also supported by the distinctive belt of VMS mineralization unique to the Alexander terrane and absent from Wrangellia.

The Admiralty subterrane and the belt of VMS deposits extends from Alaska into British Columbia, to the Windy Craggy area, where carbonate platform deposits of the Saint Elias sequence that underlies Wrangellia are thrust over the island arc deposits of the Admiralty subterrane. As we head north on the highway through British Columbia, rocks of the Saint Elias sequence overlie rocks of the Admiralty subterrane on a structure that is obscured by Cretaceous and Tertiary intrusive rocks.

The Four Winds metamorphic complex is a tightly folded, multiply metamorphosed and deformed heterogeneous rock



Deformed quartz veins in the Four Winds complex

unit consisting of meter to 100-m scale alternations of biotite quartz schist, actinolite schist, biotite-hornblende semischist, graphitic schist, quartzite, felsic semischist, feldspathic quartz semischist, calc-schist, and marble. It is intruded by felsic dikes that yielded a U-Pb zircon age of 455 Ma and contained a xenocrystic zircon with a concordant age of 544 Ma indicating that 1) the protoliths are Ordovician or older, and 2) basement to these rocks likely does not range older than Neoproterozoic. These rocks are correlated with rocks in the Retreat Group on northern Admiralty and in the Wales Group on southern Prince of Wales Island.

The Four Winds Complex was intruded by numerous quartz diorite, now orthogneiss, bodies that yielded U-Pb ages of 420 to 442 Ma, including a body by Mosquito Lake with concordant U-Pb zircon age of 420.9 Ma. The Silurian orthogneiss and host rocks of the Four Winds Complex are ubiquitously cut by steep cataclastic shear zones up to 20 m in width that may be associated with the nearby Denali fault system.

At the intersection of Mosquito Lake Road and Haines Highway there is a large roadcut in amphibolite grade metamorphic rocks of the Four Winds Complex. The rocks are banded and folded chloritic semischists with subordinate

marble that appear to retain primary compositional layering, suggesting a volcanoclastic protolith. The fabric is northwest-striking with a very steep northeast dip. Fold axes plunge steeply northwest. Mafic dikes, almost sills, cut the fabric in the metamorphic rocks at a low angle. Similar mafic dikes constitute up to 20% of outcrops in the Four Winds Complex and in the structurally underlying phyllite and marble along the highway from here to the border with British Columbia. The maroon color in the outcrop here is derived from biotite and pyrite that postdate emplacement of the dikes. The dikes are slightly boudinaged and the boudin necks are subhorizontal, indicating down-dip extension. A large horizontal quartz vein cuts across one dike, also indicating down dip extension and contractional deformation. Quartz veins are folded and faulted, indicating additional subsequent deformation (Fig. 5-3). The rocks are cut by a number of north-striking, east-dipping faults, some of which are filled with gouge up to 3 cm in thickness.

White mica from numerous locations in structurally underlying, lower grade marble and phyllite along the highway yielded 40/39Ar plateau ages of 103 to 110 Ma. Similar marble and phyllite south of Klehini River are less recrystallized and lack white mica. The common syndeformational mafic sills and dikes along the Haines Highway intrude both the higher grade metamorphic rocks of Four Winds and the structurally underlying lower grade upper Paleozoic marble and phyllite, and are likely Middle Cretaceous, similar to the mica ages in the metamorphic rocks and to the plutons that intrude the Alexander terrane in this area.

These dikes and plutons were emplaced at shallower depths than most of the regional Middle Cretaceous magmatic belt in the Alexander terrane, but were emplaced during the same contractional event. In this area, white mica cooling ages in structurally lower rocks reflect exhumation following crustal thickening during the regional contractional event in the Middle Cretaceous.

Surficial geology

Atop the Greater Chilkat's bedrock foundation is a 'frosting' of loose, or *unconsolidated* material deposited and eroded by glaciers, rivers, mass wasting, and the sea. On **bedrock** maps, geologists tend to lump these surficial features into a single unit, often called *Qs*, for *Quaternary sediments*. **Surficial** geologists, in contrast, tend to map areas of exposed bedrock as simply *R*, for *Rock*,¹ instead directing their cartographic attention to varieties of that unconsolidated frosting.

First step in understanding our **spatial** array of surficial landform types is grappling with the basic **temporal** sequence outlined in this

1 Except for steepest surfaces, most bedrock throughout Southeast Alaska is covered to variable depths with ancient glacial till, left by the waning of Wisconsin-age glaciers. But these deposits are currently difficult to map, and there's little utility in doing so, unless it happens to explain visible landforms, vegetative patterns, or hydrology.

date	geologic age	event (BP: years before present; MBP: million BP)
2-3 MBP	Pleistocene	Series of ice ages gouge terrestrial fault basins into marine fiords, turning SE Alaska into a high-relief archipelago.
20,000 BP	climax, Wisconsin Glaciation	Peak of last great ice age. Greater Chilkat Watershed covered by ice one mile thick.
12-9000 BP	early Holocene	Ice retreats but land remains depressed 100s of feet. Today's Chilkat valley was submarine. First skinboat paddlers enter the archipelago.
6000 BP	Thermal optimum	Approximate end of ancient marine intrusion. Sea level comparable with today's but climate is warmer and drier.
3000 BP	Neoglacial	Cooler, wetter climate, episodic glacial advances.
1750 AD	climax, Little Ice Age	As glaciers crest and wane, trees sprout on end-moraines.
1800 AD		As ice thins, land begins to rise.

Reading the Great Ice Age

Above: Deishú, *trail's end* (Haines) lay buried under a mile-thick ice sheet at peak Wisconsin Glaciation about 20 millennia ago. Only highest peaks protruded. Icefree, they escaped glacial erosion that mellowed contours of lower topography. Climbers today encounter odd boulders perched on high ridge tops and ledges—*erratics*—stranded by a vanished ice sheet, once so thick and vast that nobody'd believe it; except maybe when flying over such white plateaus that still exist (!) below Kées' Kanadaa, *high tide all around* (Mt Fairweather)

Below: Peaks rise to north-facing cirques at nearly 6,000 feet, southwest across Jilkáat (Chilkat River) from Deishú. In lower left is a rolling, forested ridge about 2500 feet tall. If you drew a horizontal line about half-way through this scene, everything above would be jagged and angular, while the terrain below seems smoother. Close up, that rough/smooth contrast applies even on a micro-scale. Rock above the contact is pocked and eroded, with protruding crystals, while rock below feels almost polished in places.

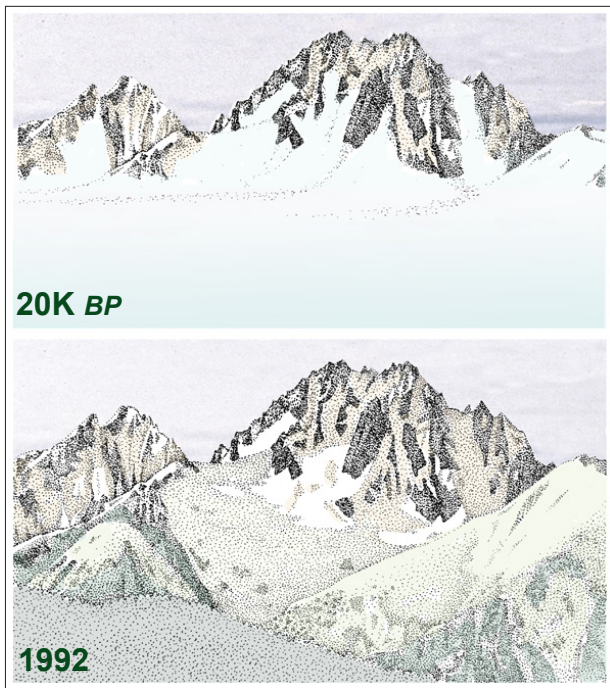


table. It's relevant not just to glacial and marine oscillations expressed over centuries and millennia, but to biotic and cultural histories and movements.²

My landforms key on next page divides surficial features into ancient (generally early Holocene) and

2 Here's an example of the importance of an introductory grounding in 'glacial literacy:' Contemporary interpretations of clan migration stories—journies spurred by advancing glaciers and changing sea levels (*ie*, "*flood stories*") conflate Great with Little Ice ages. This leads to double-order-of-magnitude errors in understanding of cultural tenure and story 'time-depth.'



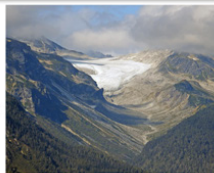
Greater Chilkat Watershed (GCW)
 Richard Carstensen • Discovery Southeast
 for LCC/TWC/CIV/CIA • 20221222

This map is a work-in-endless-progress, reflecting our 3-year effort to describe the bio-geo-cultural geography of a transboundary watershed. We define GCW (red outline) as all waters converging ultimately onto the estuary inside Deishú, *trail's-end* (Haines). The upper 46% of that watershed is today considered Canadian.

Placenames are from Thornton & Martin (2012) *Our grandparents names on the land*, with translation and colonial name on 2nd & 3rd lines. Hillshade base on US side is from 5-m-pixel IFSAR digital elevation model, and on BC side, a coarser one at 30-m-pixel, with 100-foot contours generated from these.

Glaciers are from the Randolph Glacier Inventory, in places adjusted to latest imagery from ArcGIS Online. On Canadian side, green-coded morainal deposits indicate expansion during the Little Ice Age, mid 1700s. I've extended this onto the Alaskan side, tracing ridges over the IFSAR terrain model.

Surficial landform units have been traced onto this hillshade without ground-truthing, so corrections from local knowledge are appreciated. Types shown only selectively are ancient glaciomarine (which probably exists far upvalley on moderate slopes below ~500 ft) and colluvium, so far only mapped where slide alder defines clearly active cones and aprons. I'll be fine-tuning these units with 1-m-pixel LIDAR, as more becomes available.



recent (Little Ice Age through present). As with biological endowments of the climate-straddling GCW, glacio-fluvial history is more complicated here than on either side of the bioregional divide.

Deep & shallow histories

My color key to this provisional map of surficial geology separates **ancient** from **recent** landform types. That larger category of recent types includes some landforms that have changed dramatically in lifetimes of older Chilkat

Greater Chilkat Watershed (GCW)

Richard Carstensen • Discovery Southeast
 for LCC/TWC/CIV/CIA • 20221222

Koren & Adrienne Bosworth asked for a hi-res, printer-ready GCW map, Christmas-2022 present to Adrienne's partner Jesse West. When Koren printed it, poster-sized, she had a second copy made, which we sent up to LCC-TWC offices.

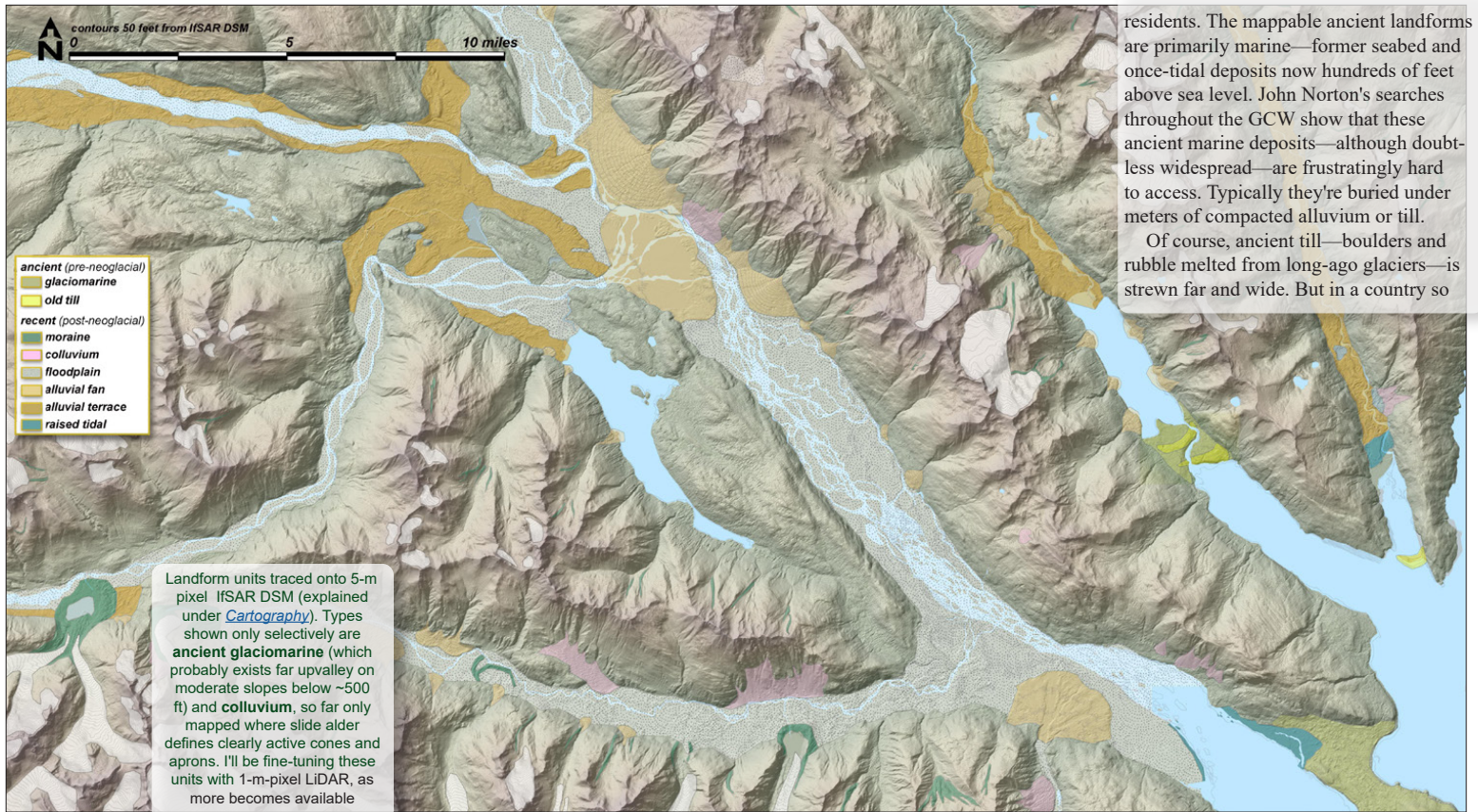
The map is a work-in-endless-progress, drawing from efforts since 2019 to describe the bio-geo-cultural geography of a transboundary watershed. We define GCW (red outline) as all waters converging ultimately onto the estuary inside Deishú, *trail's-end* (Haines). The upper 46% of that watershed is today considered Canadian.

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radically remodeled by powerful rivers and mass wasting, it's surprisingly difficult to identify discreet terrestrial landforms such as ~10KYBP end-moraines or drumlins, both ubiquitous in 'neoglacially tamer' landscapes such as my childhood home in upstate New York. Some lonely examples—old till [to]—on preceding 'surf-geo' map are curving Younger Dryas(?) moraines: **1)** the yellow-coded bay-mouth boulder-spit at Yoo Lihashgi X'aa, *point floating up-&-down* (Taiyasanka Spit) and **2)** another 'gateway berm' guarding the entry to Dakhéen, *inland river* (Takhin) valley.

On right, a map of ancient glacial extents (*ie* Great Ice Age & early Holocene) shows an untinted gray "driftless" area at top center, in country so dry that ice-cover never developed.³ From there to the sea, roughly 200 miles, all was buried under the Cordilleran icefield. You can visualize its gradual shrinkage through progressively paler shades of grey. At some point, the masses separated over North-Lynn [noTN?] at what I've labelled "*corridor*."

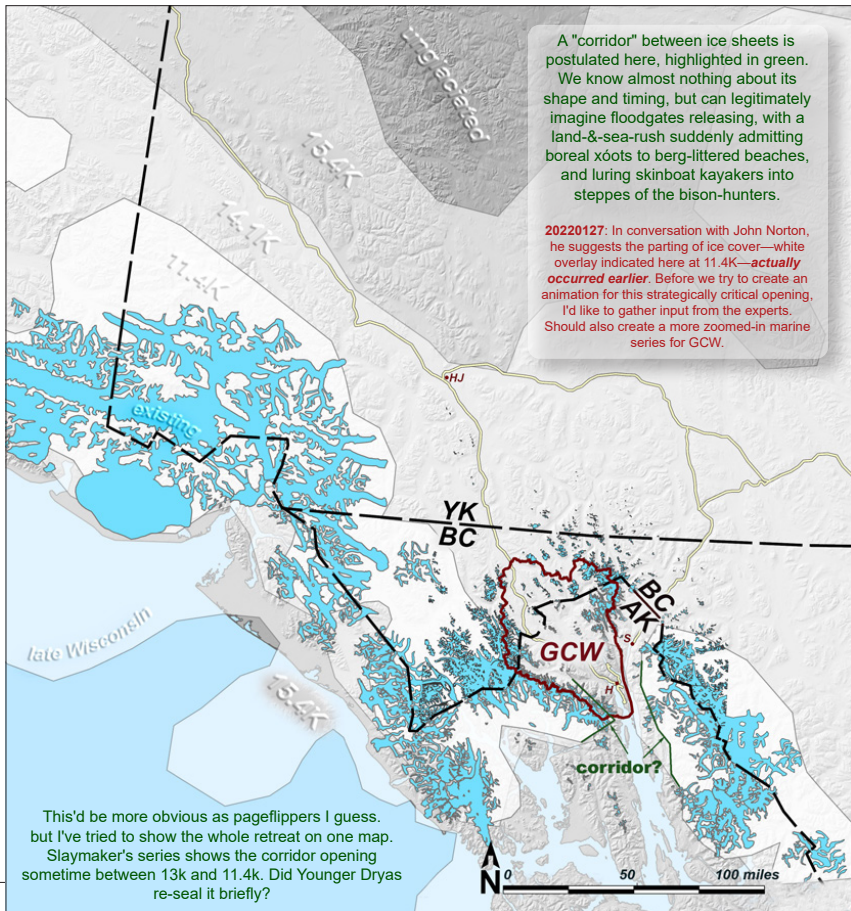
Post Little Ice Age recession

Hailing from Áak'w and T'aakú Aaní, where our largest valley glaciers emanate from a vast and vigorous transboundary icefield, I've generally been impressed by how *little* movement took place in GCW glacial tongues licking in and out during the recent Little Ice Age (LIA). Peaking in the mid-1700s, the LIA and its aftermath are best mapped and documented in Sit' Eeti Geeyi, *bay in place of the glacier* (Glacier Bay) and Áak'w K'wáan Sit'i, *Auk people's glacier* (Mendenhall). There, in the late 1940s, my mentor Donald Lawrence began studying primary succession across the chronosequence⁴ of terminal and recessional moraines.

³ The term "*driftless*" is most familiar in Wisconsin, where an anomalous region lacking glacial deposits is surrounded by lands buried in the advance named for that state. "Drift" was an early term for glacial till.

⁴ One approach to study of plant recolonization compares surfaces of increasing age—a chronosequence—assuming this spatial change correctly tracks the temporal change on any one of those sites.

Timing of Cordilleran glacial retreat, labeled in thousands of years BP: eg. 15.4K = 15,400 years before present. Dark blue is contemporary glacial extent traced from 2010 IFSAR & current orthophotography. Prior ice extents from Slaymaker *ed* (2016) and Kaufman & Manley (2004).



At my home-glacier, Áak'w K̄wáan Sit'i, Don's mapping in the 1950s was enabled by a textbook-clear nested rumpling of semi-circular ridges, stranded every decade or so by pauses in glacial retreat. Since the mid-1980s, Discovery Southeast has led students and teacher workshops into this foreland, fine-tuning our understanding of the 'great greening.' For any point along this sequence, thanks first to Don, and later to steady accumulation of aerial imagery, and GPSed positions, we can assign a surface age, accurate to at least 5 or 10 years.

In Greater Chilkat, the glacial foreland most resembling Lawrence's study sites to the south is, not surprisingly, the most coastal and 'well-watered.' At Sit'i X'aayí, *glacier point* (Glacier Pt) the retreating glacier named for Euro-cartographer George Davidson [noTN?] bulged from a narrow valley into Chilkat inlet, briefly assuming an expanded-toe conformation. In our companion volume *Featured landscapes*, a map-&-photo series details this very 'public' glacier's history. Drier, more 'conservative' rainshadowed termini with fewer aerial and Muir-sketch snapshots will be more challenging to chronicle.

Landforms

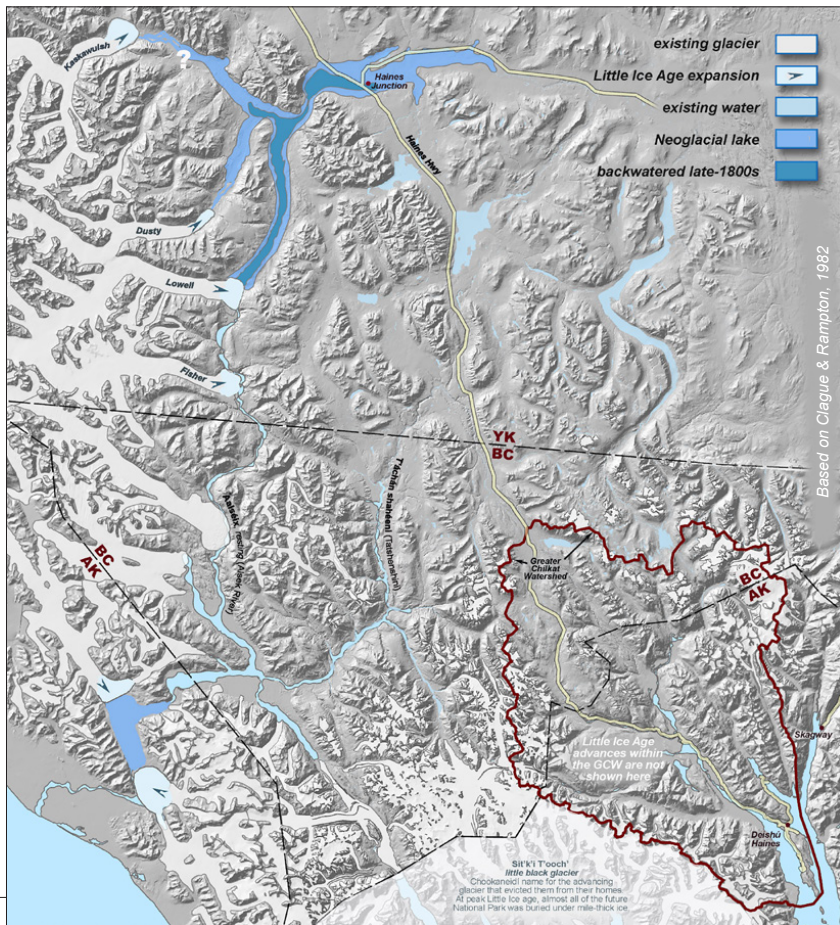
Within the Greater Chilkat, published surficial landform maps are only available for the immediate vicinity of Haines (Lemke & Yehle 1972) and for parts of the Porcupine mining district (Bundtzen, 1985, next page) ⁵ Beyond the limits of these small projects, I've applied basic mapping units used by RD Miller (1975) for Áak'w and T'aakú Aani to the south, tracing them over IFSAR bare earth. They have not been ground-truthed.

Glacial landforms

Glaciers leave behind a wide variety of landforms, both directly deposited by ice, and indirectly, by water and wind delivery described below. For our purposes in mapping, easiest and

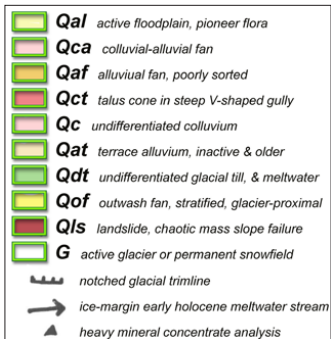
⁵ 2022: John Norton just sent me the Bundtzen map and I'm transferring those units into my surfgeo layer.

The Neoglacial and Little Ice Age Zooming in slightly from previous map, and sliding way forward in time, we see substantial glacial advances and vast, backwatered lakes, tinted in darker shades of blue. Reaching far outside the GCW, it shows important context. Chilkat country, mostly ice-free, remained a cultural and ecological corridor. Clague & Rampton (1981) mapped "maximum extent of Lake Alsek during last inundation of Dezadeash Valley in mid to late 1800s (darkest blue), and during early Neoglacial (intermediate blue). Lake extent in Kaskawulsh Valley is unknown because of extensive aggradation near toe of its glacier during the last several centuries."

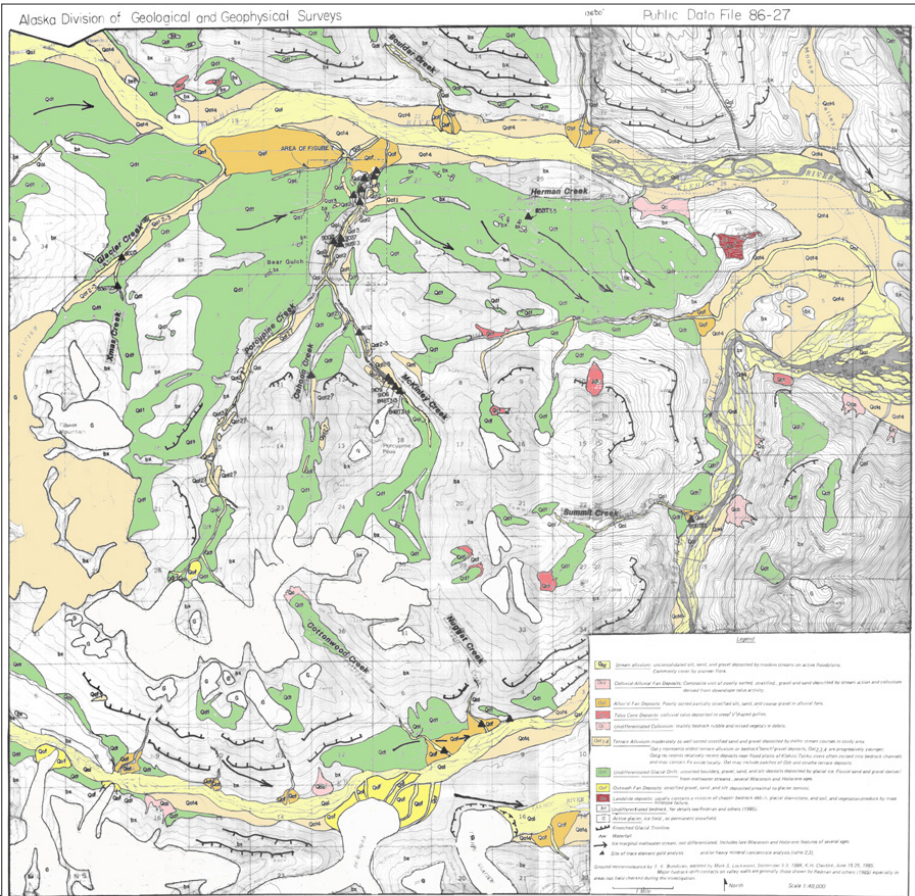


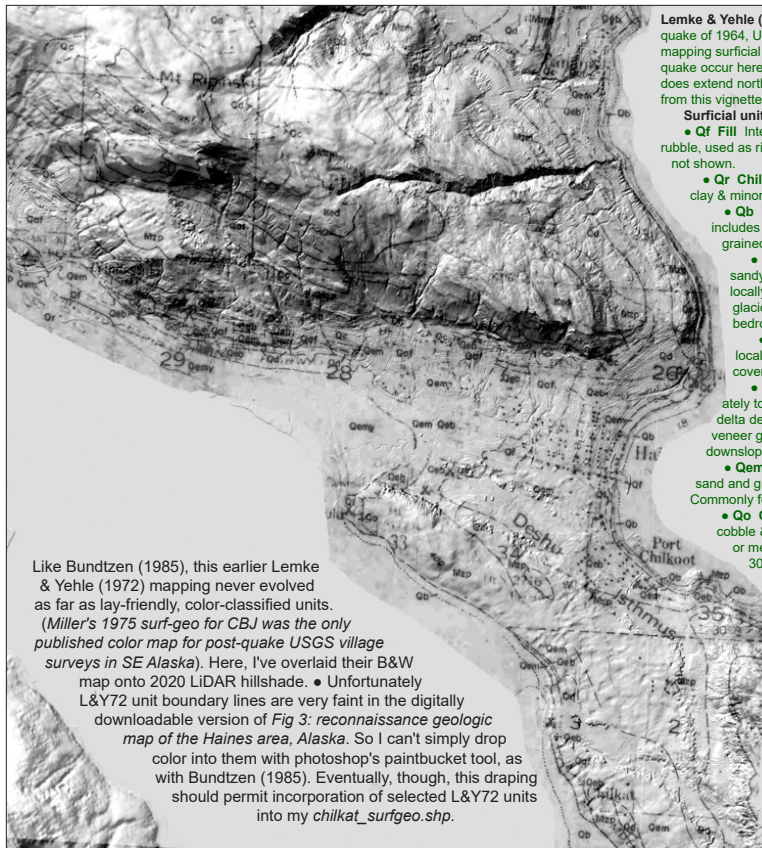
most significant to display at coarse and medium scales are moraines.

Glacial till is unsorted debris melted from the ice—in the GCW an almost ubiquitous substrate. Because larger glaciers moved through a variety of bedrock types, composition of till can be locally diverse. In addition to *lodgement till*, plastered down under the glacier's sole, looser deposits melt out along the glacier margins during recession. Concentric ridges formed at glacial maxima and during pauses in retreat are called *terminal* and *recessional moraines*, respectively. *Lateral moraines* form along valley walls, and create converging lines in little alpine cirques; they're the commonest green-coded *moraine* units on our surf-geo layer



Bundtzen surf-geo, 1985 The Porcupine District saw placer mining in alluvial landforms where gold washed downslope from bedrock sources and concentrated at base of sorted deposits. Sampling locations are shown as black triangles on this map—mostly in steep, V-notched tributaries to Klehini and Tsirku Rivers. To better understand and predict such occurrences, ADGGS's team of Bundtzen, Lockwood and Clautice produced this detailed, ground-truthed surficial geology for the GCW's most lucrative 183 square miles—10% of its overall 1,889 mi². • The better to visualize this geography on Bundtzen's B&W original, I dropped-in colors (above) mostly consistent with those of RD Miller (1975) for my home landscape in Aak'w Aani. Then, georeferencing this map, I've been tracing some of the units into *chilkat-surf-geo.shp*. More detail for each type is in Bundtzen's inset key. • Most widespread deposits here are the green-coded "undifferentiated" till & meltwater deposits on gentler hills. I haven't transferred these to *chilkat-surf-geo.shp*, partly because *Qdt* is a pretty speculative unit. And our above-described [bedrock layer from USGS](#) did incorporate Bundtzen's anomalously large till units; they're shown as *Qnd* stipple polygons south of Klehini. • Whatever Bundtzen's reason for mapping these massive till units, all proposed Baby Brown logging units [2022] fall within them, as well as most forest cut in the 1990s, after best alluvial fan and terrace stands (*Qaf*, *Qat*, respectively) had been taken.





Lemke & Yehle (1972) In years following the great Anchorage earthquake of 1964, USGS geologists toured Lingit Aani's primary settlements, mapping surficial landforms with an eye to risk factors, should another quake occur here. The map for Deishu covered only 18 square miles, but does extend north about 4 miles past the ferry terminal into Lutak Inlet from this vignette.

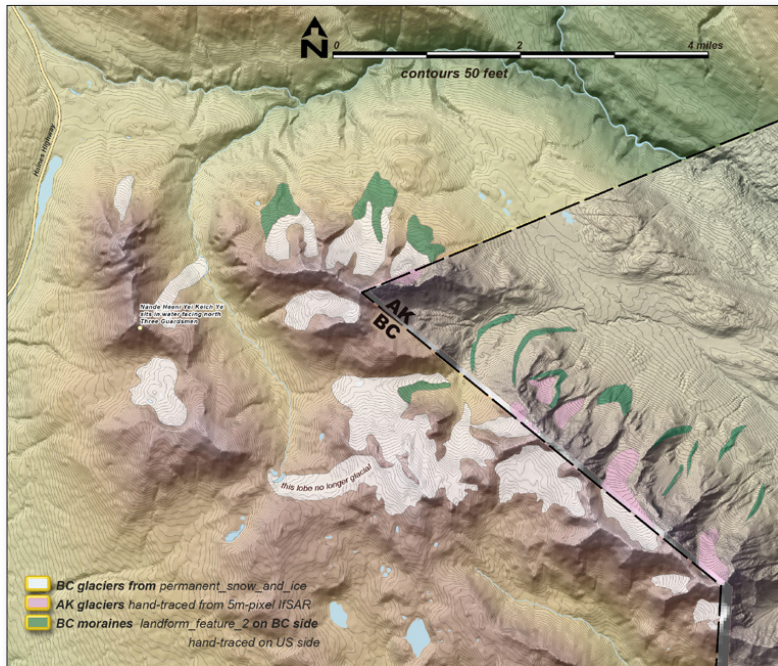
Surficial units:

- **Qf Fill** Intermixed gravel, sand, cobbles and boulders; includes rubble, used as riprap, and some refuse. Small areas, including road fill, not shown.
- **Qr Chilkat floodplain and delta.** Chiefly fine sand & silt; some clay & minor gravel. Mapped down to MLW, covered at higher tides
- **Qb Beach, modern** Gravel, sand, cobbles and boulders; includes small outcrops of bedrock and glaciomarine drift or fine-grained marine too small to map.
- **Qc Colluvium** Gravel, cobbles, sand or rubble in sandy to silty matrix, moved down by gravity. High % organics locally. Includes talus, landslide, downslope mixing of drift, glaciomarine, and elevated beach. Loose, unsorted, overlies bedrock at shallow depth.
- **Qa1 Alluvial fan** Gravel, sand, cobbles and boulders; locally sand and silt, poorly sorted and bedded. Merged or covering elevated beach, glaciomarine up to at least 300 feet
- **Qeb Elevated shore** Gravel, sand, cobbles, moderately to well sorted & stratified. Includes elevated shore and delta deposits to more than 5 ft thick. Thinner unmapped layers veneer gentle slopes to at least 300 feet. Often obscured by downslope gravity mixing.
- **Qem, Qemy Elevated marine** Silt and clay with variable sand and gravel; coarser near headlands and raised beaches. Commonly fossiliferous. *Qem* = older, *Qemy* = younger, near EHW.
- **Qo Outwash and ice-contact** Sandy gravel with varying cobble & silt. Moderately well sorted and stratified. Grades or merges with veneer of *Qeb* on gentle slopes to at least 300 feet.
- **Qd Drift, undifferentiated** Silty gravel and sand with variable clay and cobble. Mostly till and other diamictons; some fluvioglacial. Poorly sorted, unstratified and compact. Includes small alluvial fans, colluvium and elevated fine marine. Mantle of *Qeb* may veneer drift to at least 300 feet.

- Bedrock: igneous**
- **Kt Quartz diorite, tonalite** plagioclase, quartz, orthoclase
 - **Ked Diorite** light to medium-gray, coarse-grained
- Bedrock: metamorphic**
- **Mzm Metabasalt** dark-green, fine-grained metamorphosed volcanics, mostly hornblende and feldspar
 - **Mzp Pyroxenite** chiefly augite

Like Bundtzen (1985), this earlier Lemke & Yehle (1972) mapping never evolved as far as lay-friendly, color-classified units. (Miller's 1975 surf-geo for CBJ was the only published color map for post-quake USGS village surveys in SE Alaska). Here, I've overlaid their B&W map onto 2020 LiDAR hillshade. • Unfortunately L&Y72 unit boundary lines are very faint in the digitally downloadable version of Fig 3: reconnaissance geologic map of the Haines area, Alaska. So I can't simply drop color into them with photoshop's paintbucket tool, as with Bundtzen (1985). Eventually, though, this draping should permit incorporation of selected L&Y72 units into my *chilkat_surfgeo.shp*.

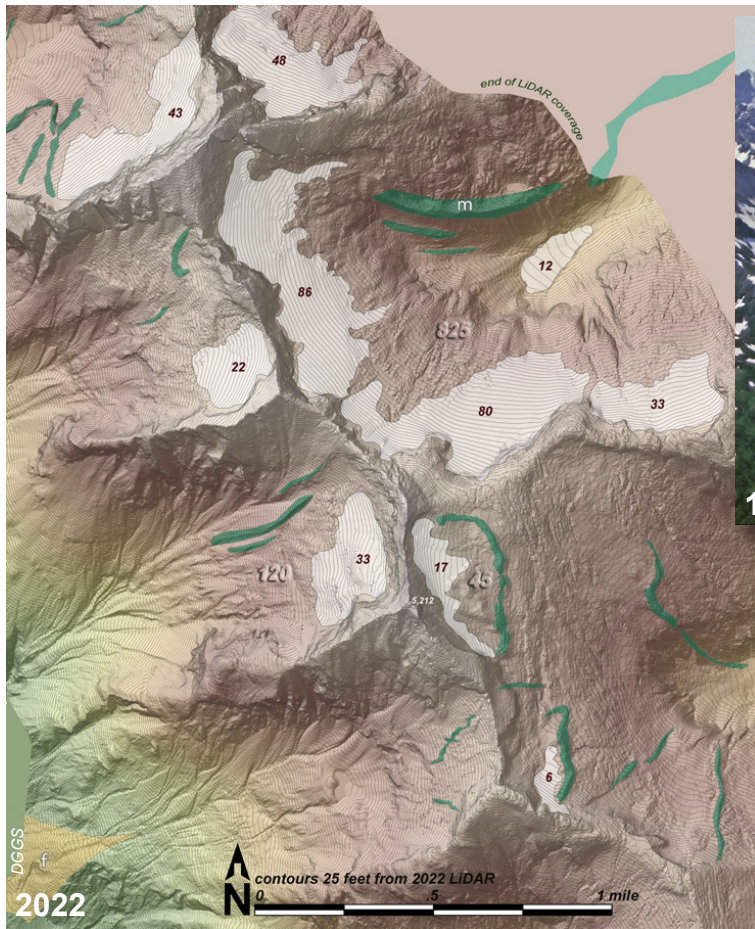
for Chilkat country. *Medial moraines* form where 2 glaciers converge, thence stretching downvalley as dark debris bands on the ice surface. Although obvious on active valley glaciers, like Tsirku terminus, next page, medials usually aren't mapped in *chilkat_surfgeo.shp* because they're less distinct than laterals after a glacier melts away and 'lets them down.'



Left: Glaciers & associated moraines from cross-border sources, east of highway near Nánde Héeni Yei Kéich Yé (3-guardsmen Mtn). While Canadian glacier polygons are more detailed, the Alaskan side has mid-resolution IfSAR terrain mode. (5-m vs 15-m-pixel) allowing my hand-traced improvements to AK-side polygons. ● **Above:** Ferry south from Deishú passes alpine barrens on eastern fiord walls that clearly display Little Ice Age necklace moraines—sometimes multi-stranded with terminals and recessions. Headwall here is Tertiary tonalite while foreground is much older paragneiss and marble. Tundra is fairly continuous outside terminal moraine #3, but little colonization so far on the inside recessions #2&1. Glacier came down from upper right.

include kames, eskers, drumlins and outwash as well as glacial till. But their mapped linear features that I've scrutinized are *generally* lateral and medial moraines. I've emulated their mapping style on the Alaska side, incorporating green-coded moraines as a landform type in the surficial geology layer.

Mapping moraines An exciting layer from Canadian sources is called *landform feature 2*. Within the GCW it shows 2 kinds of surficial deposits: sorted sands—limited to a few small patches along Haines Highway—and *Glacial Debris Undifferentiated*. Again, Canadian cartographers are being careful not to overstate accuracy of their landforms delineation. Ice margin deposits can



Angular horns of Cretaceous granodiorite in Chilkat Range 5 miles SW of Deishú stood free of ice in the Last Glacial Maximum. Little Ice Age cirque glaciers built necklake moraines that are still unvegetated on unstable slopes with short growing seasons. While these geologically brand-new moraines are easy to find along the ferry ride from Áak'w Tá (Auke Bay), most of the ancient, early Holocene moraines have long since been scrubbed from highlands. On gentler lowlands where some persist, few have been recognised beneath rainforest cover. (Barren talus cones on right also show retarded succession.)

Presumably, those 'necklaces' and converging 'V's' looping down from highcountry cirques mostly mark Little Ice Age maxima of slightly expanded mountain glaciers. But work by [Menounos and colleagues](#) in drier boreal mountains alerts us to the possibility of much older early Holocene glacial features, northward into rainshadowed alpine.

On left is the divider ridge between Shakuwúx'ku, *little wide-head* (Chilkoot Lake) and Dayeisaánk'i Héen, *Taiyasanka stream* (Ferebee River). On new (2022) LiDAR hillshades I can now trace LIA 'necklace moraines' far more delicately than from coarser IfSAR, illustrated on previous page. Green terminals give a sense for how much each small glacier expanded several centuries ago. I also combined the LiDAR with current late-summer imagery to retrace borders of extant glaciers in the [Randall Glacier Inventory](#). Recalculated areas are labeled in acres. For 3 of the basins I've also given a rough acreage for surface at peak LIA advance. In the north-facing bowl, 4 disjunct glaciers today totalling about 200 acres merged to cover about 825, more than a square mile. But

DRAFT

Dakhéen, inland river (Takhin River & glaciers)



They're best mapped from high-resolution bathymetry that's so far spotty in coverage for Lingít Aaní, and not available yet near the GCW.²

Partly our failure's been a matter of scale, awaiting high-res LiDAR for more confident mapping. Examples of recent moraines on the new 2022 LiDAR are on this and previous 2 pages, followed ancient moraines on the next.

glaciated during the LIA. These are discussed in the scoping&journal document for the UAS [Landforms class with Cathy Connor](#).

² Check out NOAA's [Bathymetric Data Viewer](#). Turn off all layers but BAG, and zoom to a place like Taalkú, *widemouth basket* (Thomas Bay).

it hasn't descended to Dayeisaank'i Héen for millennia.

Strangely, considering how earth-changing and ubiquitous the ice cover was throughout Lingít Aaní during the Great Ice Age, we have so far located few terrestrial examples of ancient morainal landforms in our conifer-cloaked mountains. Sure, the unpatterned ground moraine is smeared over nearly every surface sloping gently enough to retain it. But what about discreet recessional, or re-advance terminals?

For reasons I don't understand, we do have ancient *submarine* moraines, probably Younger Dryas in age.¹

¹ Our most famous submarine moraine, "The Bar" off the mouth of Sit' Eeti Geeyi, *bay in place of the glacier* (Glacier Bay) is actually only a Little Ice Age deposit. But I'm becoming aware of similar ones at bay-mouths all over the archipelago that were only lightly

Above: Another from Deishú-Aak'w ferry. NW-facing cirque glaciers expanded during the Little Ice Age, leaving a band of 'necklace' moraines through the center of this panorama. Portions were later erased by gravity processes. Most of this amphitheater falls within my blue-coded hi-carb belt of marble and paragneiss.. • **Right:** Goat relocation flights took Kevin White over glaciated landscapes few others ever see. This oblique looks ESE over terminus of Tsirku Glacier. Early seral vegetation on valley walls and thick medial moraines—dark green on my surfgoe layer—indicate rapid downwasting.

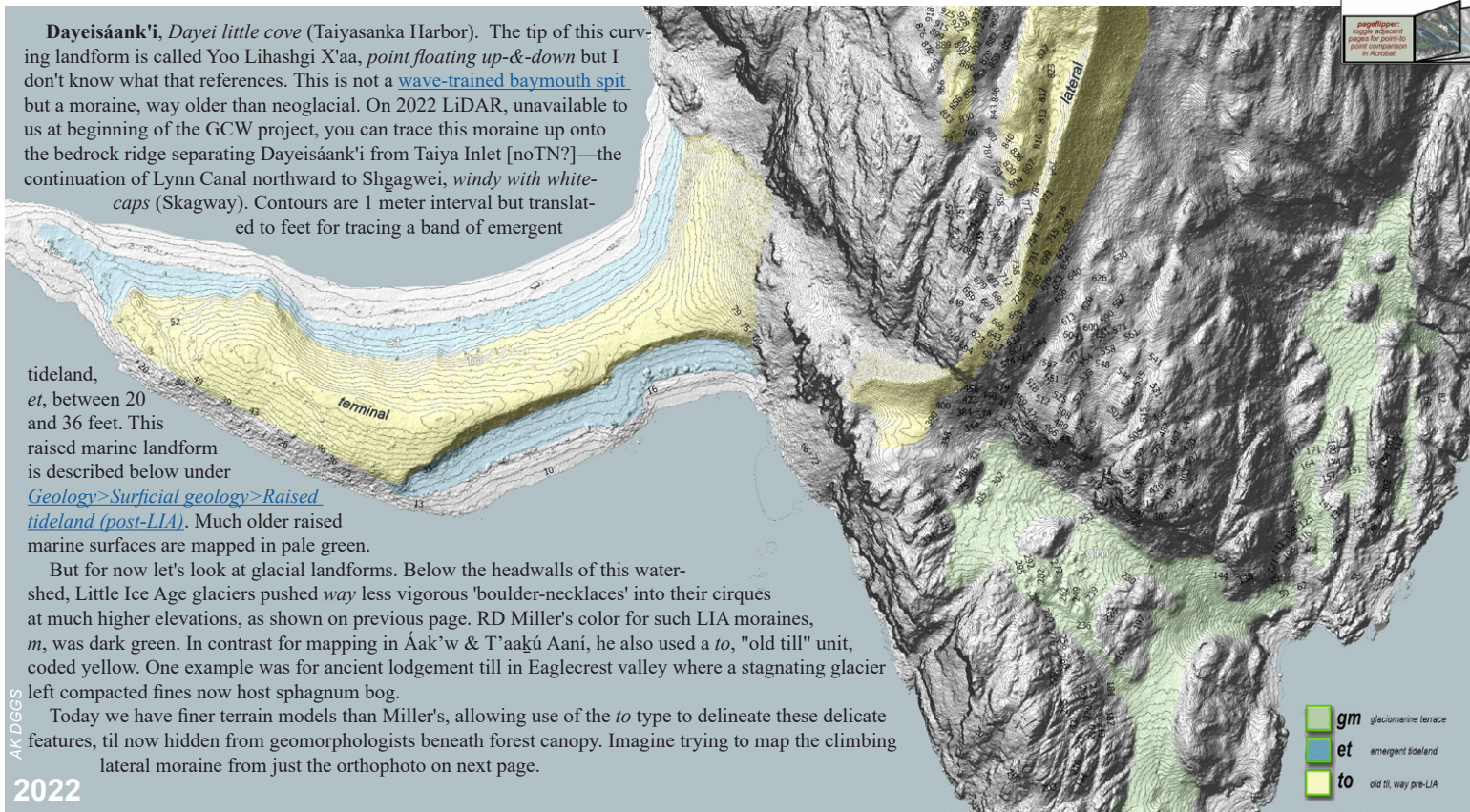
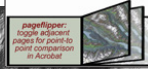


Dayeisaank'i, *Dayei little cove* (Taiyasanka Harbor). The tip of this curving landform is called Yoo Lihashgi X'aa, *point floating up-&-down* but I don't know what that references. This is not a [wave-trained baymouth spit](#) but a moraine, way older than neoglacial. On 2022 LiDAR, unavailable to us at beginning of the GCW project, you can trace this moraine up onto the bedrock ridge separating Dayeisaank'i from Taiya Inlet [noTN?]¹—the continuation of Lynn Canal northward to Shgagwei, *windy with white-caps* (Skagway). Contours are 1 meter interval but translated to feet for tracing a band of emergent

tideland, *et*, between 20 and 36 feet. This raised marine landform is described below under [Geology>Surficial geology>Raised tideland \(post-LIA\)](#). Much older raised marine surfaces are mapped in pale green.

But for now let's look at glacial landforms. Below the headwalls of this watershed, Little Ice Age glaciers pushed *way* less vigorous 'boulder-necklaces' into their cirques at much higher elevations, as shown on previous page. RD Miller's color for such LIA moraines, *m*, was dark green. In contrast for mapping in Áak'w & T'aakú Aani, he also used a *to*, "old till" unit, coded yellow. One example was for ancient lodgement till in Eaglecrest valley where a stagnating glacier left compacted fines now host sphagnum bog.

Today we have finer terrain models than Miller's, allowing use of the *to* type to delineate these delicate features, til now hidden from geomorphologists beneath forest canopy. Imagine trying to map the climbing lateral moraine from just the orthophoto on next page.



AK DGGS

2022

Glacial silt from Dayeisáank'i Héen, *Taiyasanka stream* (Ferebee River) tinted the water green in this 2014 ortho, before escaping to mix with clearer saltwater outside the ancient moraine.

Toggle back to compare forest textures to landform types. Near the label "lateral" there's a sharp change from coarse (W) to fine (E) in canopy color and texture. Eastside is probably young, even-aged windforest, with a more multi-aged and gappy stand, just over the moraine crest. It's probably not a coincidence that this ancient but fresh-looking 'termino-lateral' runs up the divider-ridge spine. Any such moraines on the steeper sidewalls ("recessional-laterals") were long ago rolled away in gravity events.

Dropping eastward, a very few large-crowned stands have developed on pockets of glaciomarine sediments; these would be fun to search for northernmost outliers of classic archipelago old growth. The rainforest's last hurrah.

Toggling also helps identify young spruce stands on raised former tideland coded blue. I can't quite decide on that super-tight green stuff on the southside. Babyspruce grading down to alder?



AOL 20230704

2014

Top, DigitalGlobe, Earthstar, Photogramics, CNES/Airbus DS, USDA FSA, USGS, AeroGRID, IGN,

Incision on alluvial fan at 19-mile undermines cottonwoods, showing ability of this species to add tiers of surface roots each time it's buried. These old trunks date back to a time when this portion of the fan was aggrading



1992

Alluvial landforms

Alluvium is material deposited by moving water. We present the basics in Carstensen & Connor (2013) p16-17. On LiDAR bare earth hillshades, the most obvious landforms created by streams and rivers are alluvial fans and alluvial floodplains.

Fans xxxx More on fans is in the following section on *Hydrology*.

As with distinctions in *Glacier* chapter, landform manifestation is treated here, whereas fluvial dynamics, biotic consequences, etc, are treated under *Hydrology*.

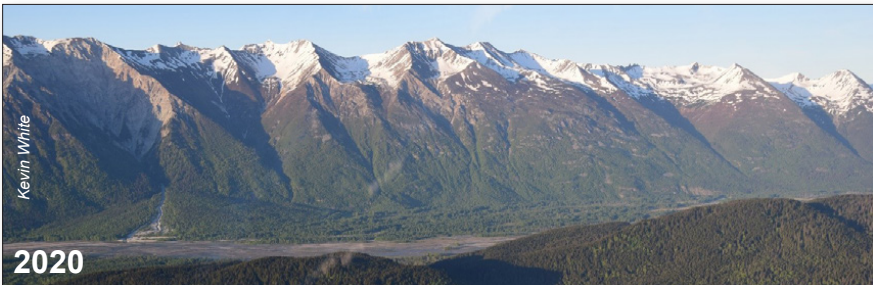
Floodplains xxxx

ibid

202408 Hopefully sometime this winter I can flesh out these 2 sections—and following one on colluvium—using the amazing new lidar from 2022.



Tatshenshini headwaters are incised into this plateau near the BC-YK border. Is it a remnant alluvial plain, as described in *Backward river*?



Colluvial landforms

Colluvium is material deposited by forces of gravity, moving particles from gravel to boulder-sized down steep slopes. ¹ Throughout the Greater Chilkat, it's important to hydrology, habitat arrays, wildlife (wintering goats, hibernating **bats**, soil-tilling **bears** . . .) and increasingly of concern in matters of human safety.

Cones & aprons More visibly than on alluvial fans, because of colluvium's higher relief, the classic depositional feature—where steep slopes deflect a valley bottom—is a smoothly

¹ Finer particles—sand, silt, clay—are typically transported by water, and of course it's impossible to completely isolate alluvial from colluvial processes on any particular landform. For example in a hard rain, wide chutes can become mobilized as slurry, racing catastrophically downslope. Is this an alluvial or colluvial event?

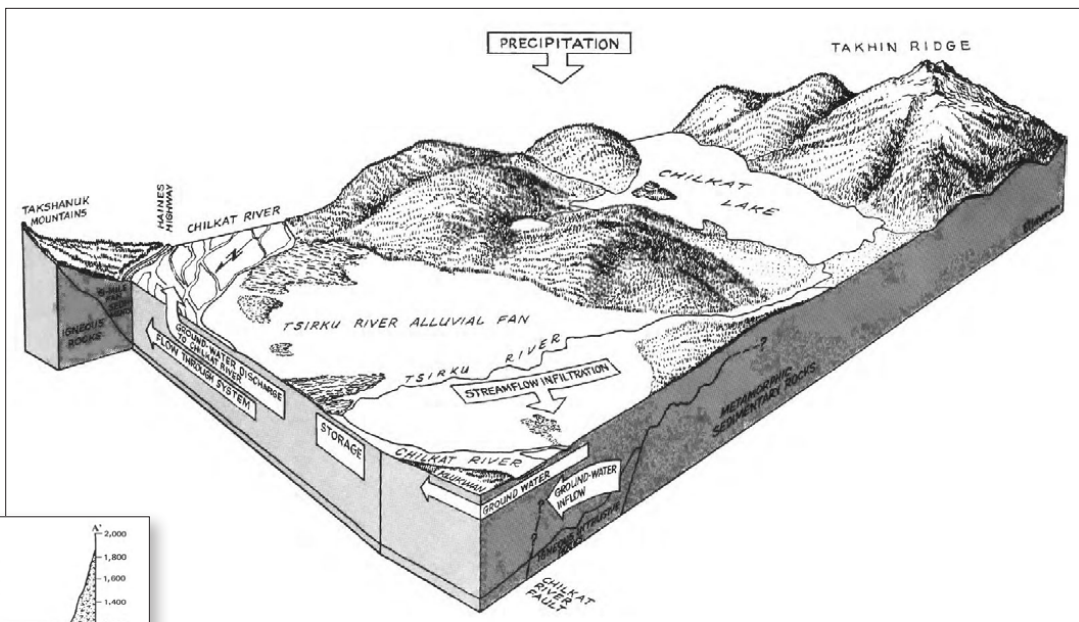
Above: East to Dakshaa, *inland* (Takshanuk Range) from flight over Aa ka, *on the lake* (Chilkat Lake). On left is 500-acre 19-mile slide, largest of an array of cone-shaped alluvial fans whose toes press Haines Highway against the river. Each is 'served' at its apex by huge steep amphitheatres, gouged over millennia by glaciation and subsequent colluvial/alluvial processes. ● **Right:** 19-mile fan and its mile-high colluvial contributing area, mapped on receipt of the 2014 SFM (structure from motion) elevation model. As explained in [Appendix 2>Cartography>SFM](#), this is a 'total-surface' model, unlike LiDAR's 'true' bare earth with vegetation removed. Thus the chaotic derivative 10-meter contours down on the brushy fan. Moving upward though, onto mostly bare terrain, SFM delivers beautiful, smooth contours, assisting in detection of high risk features such as incipient detachment-cracks. Zoomed in, we can generate contours down to 1 meter interval or finer. ● **PS 2024:** The 2022 LiDAR mission now gives true DTM for this and many other fans in the Takshanuks



curving cone. Where many cones butt up, side-to-side, we refer to the merged deposit as a colluvial apron.

Ed Bugliosi's 1982 report on Tsirku fan hydrology contrasts depositional patterns in that alluvial formation, and the abutting Klukwan fan, at least partially colluvial. Summarizing the following explanation for the Council Ground's critical discharge zones, he suggests that the more catastrophic fan formation on colluvium may characterize the entire east-side slopes composed of aprons and disjunct cones:

"Discharge zones at the toe of Tsirku fan may be [owed to] interlayering of sediments from Tsirku fan, Klukwan fan, and Chilkat River, which could cause local changes in hydraulic conductivity. Depositional modes may have ranged from catastrophic, colluvial/ fluvial deposition on Klukwan fan, to primarily fluvial on the Tsirku's. Klukwan fan appears to be built by a series of mud flows and slides with poorly sorted



sediments in a fine-grained matrix (H.J. Kaiser Co., written communication, 1983). This mode of deposition is dominant along flanks of eastern Chilkat Valley, where there is a series of steep colluvial/fluvial fans.

Historic landslides

Although snow avalanches and massive rock-&-mudslides are annual events throughout the GCW, they tend to get recorded only when damage is done to human life and property. ²

2 Can we describe the slide that wiped out Kaatx'waaltu, *rockslide village*. What others? Maybe Ben or John have thoughts on this. Even minor sluffs onto roads or properties remind us of ongoing relevance. **PS 20200523**. Just acquired the 2014 SFM hillshade and orthomosaic for Takshanuk ridge debris fans. **PPS 20240918**. And the 2022 LIDAR is even better.

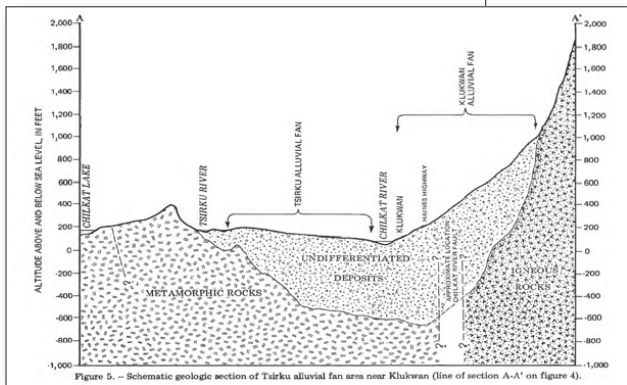
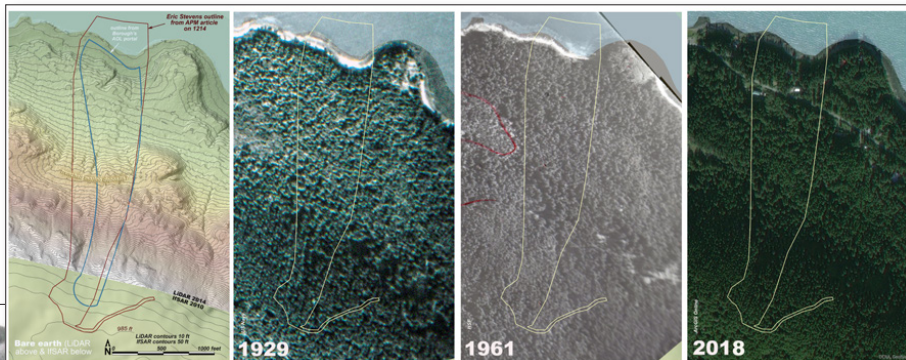


Figure 5. -- Schematic geologic section of Tsirku alluvial fan area near Klukwan (line of section A-A' on figure 4).

2020 landslides

On December 2nd, 2020, Haines received 6.62 inches of rain, (previous record 1.37 inches), lubricating a catastrophic slope failure that swept through Beach Road east of town, burying homes and killing 2 people. Search parties were unable to safely access the runout due to concerns about further slope failure.

For Jessica, shortly after the event, I prepared a 4-panel map, and sent copies



An Alaska Army UH-60 Black Hawk helicopter conducts search and rescue in Haines after a major landslide on Dec. 3, 2020. TESI PHOTO/THE ASSOCIATED PRESS

to my geo-mentors, Jim Baichtal and Greg Streveler, asking for their interpretations:

"Hi guys. I hope you're both well. I've been working with Lynn Canal Conservation and other groups up there (Chilkat & Chilkoot Kwáans, Takshanuk Watershed Council), on a biogeographic atlas of what we're calling Greater Chilkat Watershed, inclusive of Canadian tributaries. LCC asked what resources I might have for the recent destructive landslide near town.

I first made up the attached 4-panel map from LiDAR and historic aerials, with 2 conflicting outlines. In email correspondence, DOF forester Greg Palmieri says that neither is exactly right, but that the red line showing the headwall crack is pretty close. This extends off the LiDAR unfortunately, but IfSAR contours suggest about 985 feet.¹

Also attached is a photo, taken by Erik Stevens for an APM article. I added some annotations for your input. Do we have evidence for marine deposits that high in the Chilkat

¹ 2021, we now have rather erratic LiDAR extending higher, dated "2020" on the [DGGGS portal site](#).

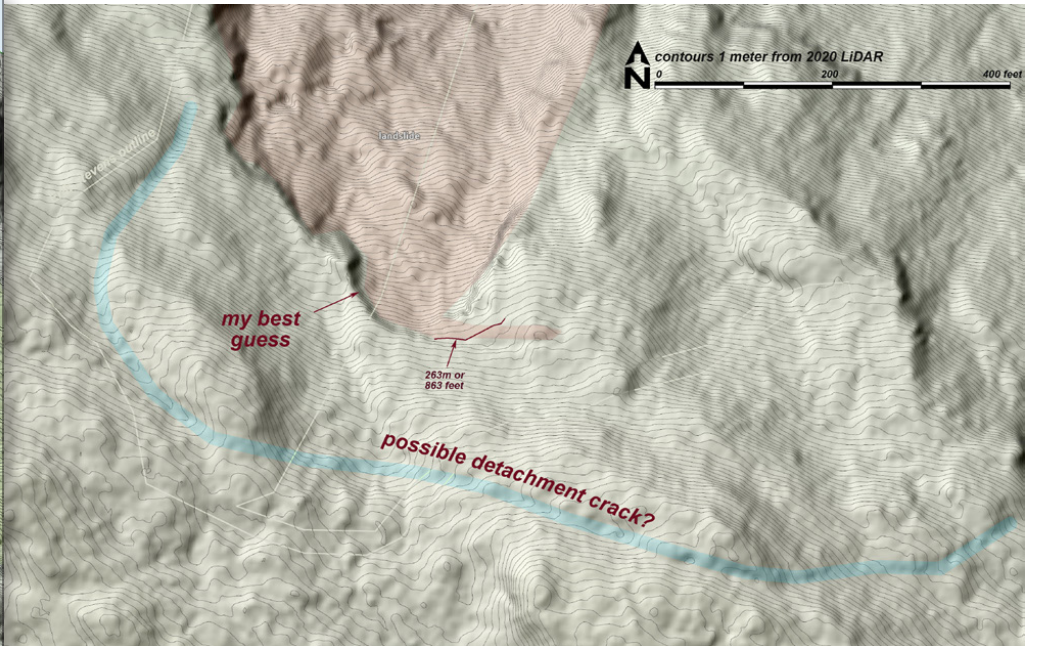
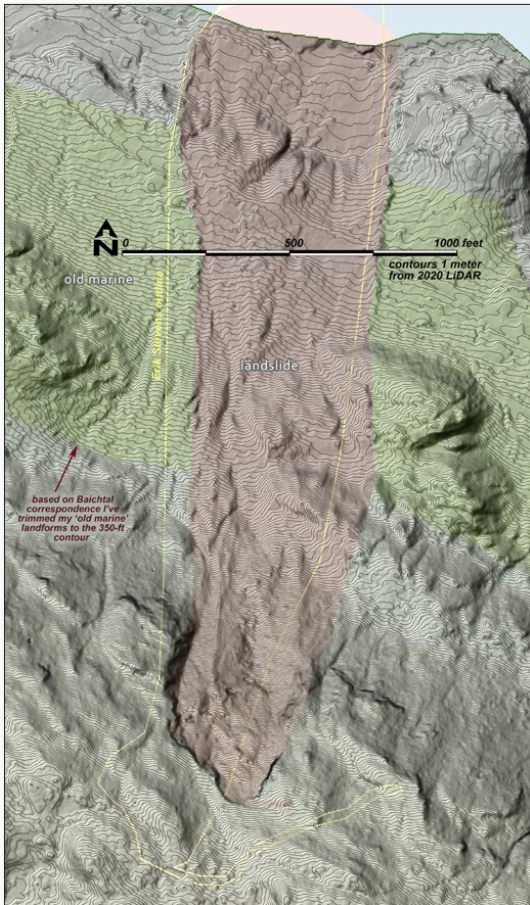
country? If not, what might account for the apparently sorted fines at the headwall?

USGS maps bedrock here as ultramafics (pyroxenite and hornblendite)—a fairly unusual type in SE AK. Has this base-rock proven unstable elsewhere in Southeast? I don't see it outcropping anywhere in the many oblique aerials posted online---albeit these are pretty low-res---so maybe bedrock type was fairly irrelevant, except in determining slope and roughness? Looking at vertical and oblique aerials,

*I'd never have predicted this would be the slope to give way.
Regards, RC*

Baichtal's reply was useful in regard to marine landforms, next section (and probably these are relevant to the 2020/2021 mudslide). But in terms of colluvial processes I'm no further along in understanding the driving forces behind this exasperatingly stochastic (!) calamity.

PS 2022: Eric mentioned a presentation suggesting, from post-slide analysis, that there was indeed a fracture zone that might have allowed prediction of instability. I haven't yet seen this dropbox-archived talk.



Post-landslide LiDAR, 2020 As described in [Appendix 2? Cartography > 2020 LiDAR](#), a new cover became available in 2021, dated 2020 on the state's GIS portal but with no MMDD to indicate whether it was in that last month, post mudslide. I suspect, however, that it was flown in response to the disaster. The DTM allows convincing contour generation at

least to 1-meter resolution. On left is my best take on extent of the slide in brick-red, with enlargement for the crest above. If correct, I'd revise my annotation of that crack on Stevens' oblique, previous page, from 985 down to 863 feet. This cover was not available (?) to Stevens when he drew that headwall crack (yellow). Should it actually follow my blue line?

Post Landforms class:

For the UAS 2022 fall semester, I co-taught a [class on landforms](#) with retired Geology Prof Cathy Connor for Environmental Science majors. For our most ambitious field trip, we ferried to Jil̄koot Aaní, where John Norton took us directly to the recent BRLS. Following pages are excerpted from my course scoping-doc-&-journal.

Jil̄koot example: Beach Road Our first stop after getting off the ferry on Friday, 20220916 was at the catastrophic [Beach Road Land Slide](#) (BRLS). It's been intensively studied by an interagency team including Jim Baichtal, co-author on a multidisciplinary summary published earlier this year.

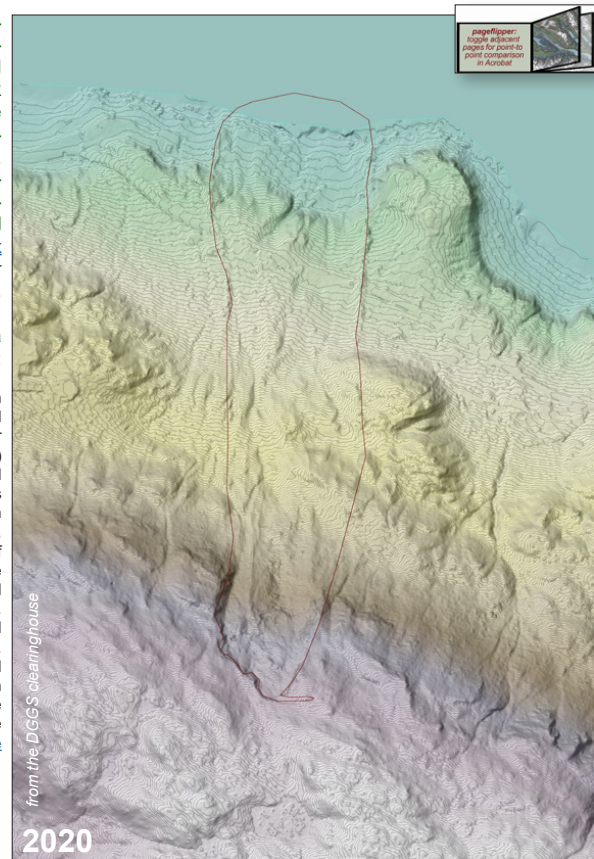
On December 2nd, 2020, Haines received 6.62 inches of rain, (previous record 1.37 inches), lubricating a catastrophic slope failure that swept through Beach Road east of town, burying homes and killing 2 people. It began as a debris avalanche, soon transitioning into a debris flow. Witnesses could hear it for 20 to 30 seconds. Search parties were unable to safely

First of 8 pageflippers showing topography and successional change at Beach Road Land Slide (BRLS). LiDAR was shot within days of the Dec_02 event in 2020, revealing a distinct crown at 863 feet, which I traced in red on this hillshade. A crack extended eastward from that headwall. And above *that*, on my [enlargement below](#), I've marked another possible stress fracture.

Here's from the metadata explaining this mission:

Abstract: The Alaska Division of Geological & Geophysical Surveys (DGGs) used aerial lidar to produce digital terrain (DTM) and surface models (DSM), and intensity image for Haines as part of emergency operations in response to the December 2, 2020, landslide that claimed the lives of two residents. Airborne data were collected December 8-12, 2020, and processed in Terrasolid and ArcGIS.

Ground control were collected December 15-16, by the DMLW. This data collection is released as a Raw Data File with an open end-user license. All files can be downloaded free of charge from the [DGGs website](#)



access the runoff due to concerns about further slope failure.

For Jessica and the *Atlas* team, shortly after the event, I prepared a 4-panel map, mostly from our growing collection of georeferenced historical air photos. A key question when trying to 'backtrack' events like these is whether vegetation suggests stability or prior disturbance, either widespread or small & patchy. Further clues to forest type and successional history can be deciphered by carefully matching forest type to underlying landforms.

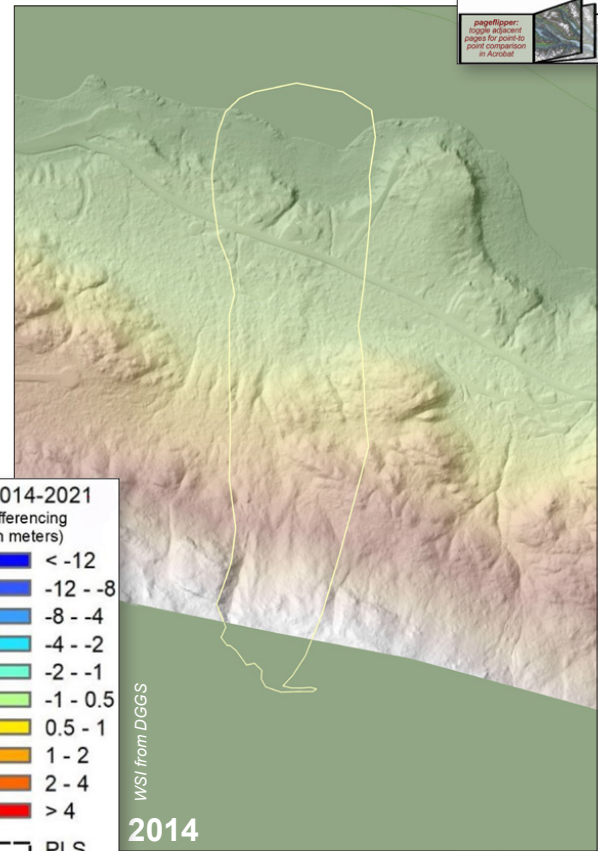
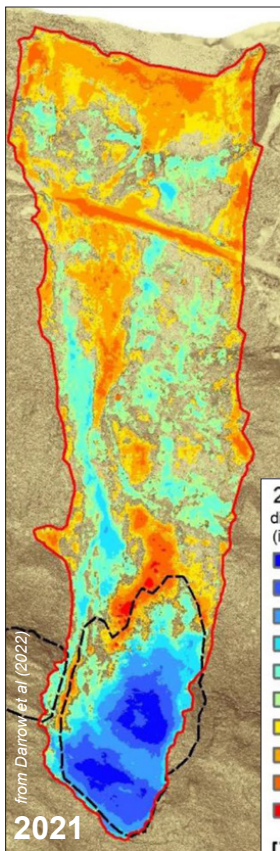
Although side-by-side historical panels are effective means of comparison, these pageflippers allow more careful point-to-point overlay. I'm doubling the 4x series to 8 precisely fitted panels in the following pages, adding a new post-BRLS orthophoto from AOL, and more products from the State's emergency mission, flown within a week of the landslide.

Following our geo-class

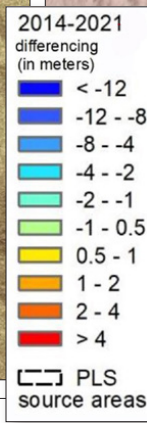
Far right: 2nd of 8 pageflippers. Toggle against previous post-slide hillshade, searching for changes in topography. • LiDAR shot in 2014 and downloadable from the DGGs portal unfortunately didn't extend south quite to where the crown detached. However, Darrow *et al* (2022) included maps from a 2014 Lidar DTM that continued to the hilltop. Apparently Watershed Sciences Inc. (WSI: since merged to form Quantum Spatial) was able to retrieve 'fringe' data that were clipped away to form this deliverable to the state clearinghouse?

Near right: ArcPro 'minus' tools subtract one terrain model (DTM) from another—in this case June, 2021¹ from 2014. Blue-to-red spectrum indicates more than 12 vertical meters of soil and rock were removed near the headwall (blue tones) while Beach Road was covered with more than 4 meters of debris. Darrow *et al*'s red outline is more accurate than my yellow border on the pageflippers; I've adjusted to their perimeter only for the last two maps in this series.

¹ I first suspected the team's post-slide LiDAR dated 2021 was in error; DGGs data were released 20210213 but LiDAR was actually acquired between December 8 & 12, 2020. Turned out, however that the authors contracted their own UAV survey the following June using "a Phoenix LiDAR Systems MiniRanger un-crewed laser scanner and high-res imagery from DJI Matrice 210 V2 RTK UAS. Leica GS18 (GNSS) receivers gave high-res georeferencing and post-processing, with lidar ground resolution of 0.1m & imagery resolution of 0.03m."



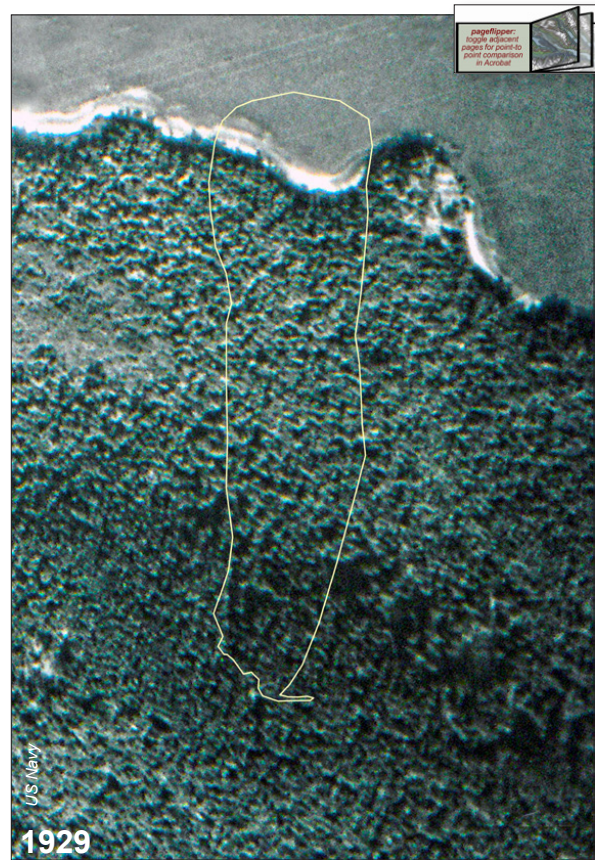
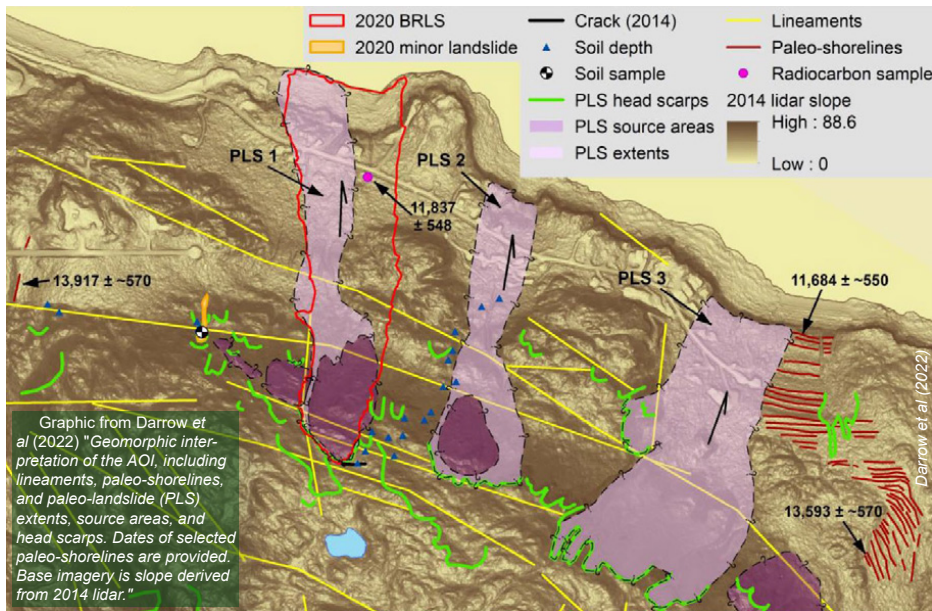
pageflipper: toggle adjacent pages for point-to-point comparison in Acrobat



trip, Geologist Jim Baichtal sent me a copy of Darrow *et al*, 2022, on which he was co-author. Jim's interest in the area—working with Norton—has been primarily the mapping of early-Holocene shorelines; the red lines on this map. More follows in the section on *Marine landforms*.

Right: 3rd of 8 pageflippers beginning a successional change series. A century ago, forest was already mature. See, however, comments below on even-aged stands in the runout portion.

Below: After the BRLS, scrutiny of 2014 & 2020 LiDAR revealed diagnostic signatures of what the Darrow team called "paleo landslides" (PLS)—both runout zones (pink) and steep starting zones above them (purple). Jim Baichtal & John Norton had already mapped ancient shoreline features. In addition to obvious wave-cut scarps, marine surfaces can be distinguished from till-&-bedrock outcroppings by their smooth texture.

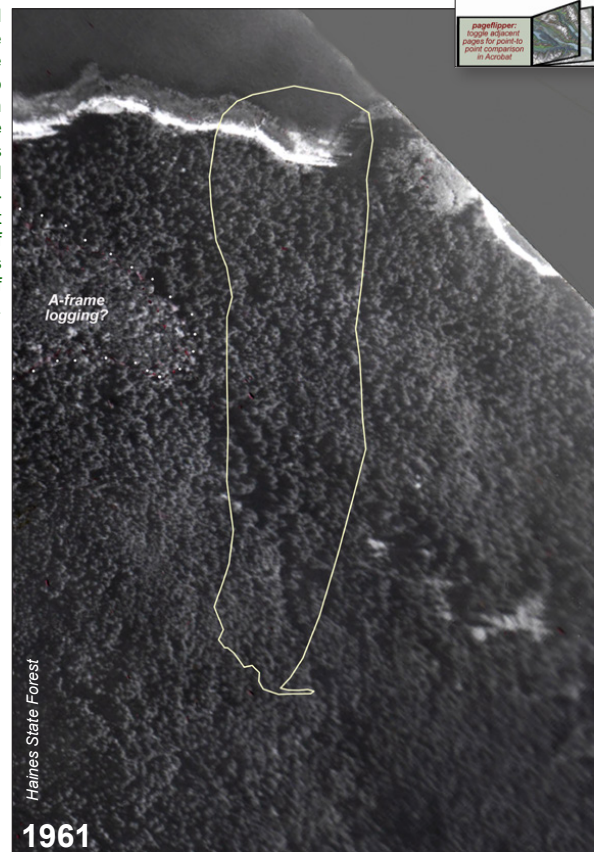


Avalanche forecaster Erik Stevens flew the head scarp immediately after the landslide and took the most revealing image we have, below. (20220920: *I'd hoped for some drone aerials on our Chilkat tour, but this site is in a no-fly zone due to proximity to the airport.*)

Forest at this headwall looks like small, fairly even-aged hemlock. Probably not old growth. Photo-resolution's not good enough in my copy to identify the smooth sediments in the head scarp. If it's marine, that's way above highest marine deposits so far documented by Norton & Baichtal in Greater Chilkat Watershed.



4th of 8 pageflippers. For 1961, my scanned imagery from the DOF collection in the Juneau office just barely reached the future landslide. I wish I'd scanned the next photo in this flightline, because it's low elevation and high-res, providing great stereo. The 1998 DOF collection probably also covers this slope, and could be scanned. (My crystal ball was out of commission in winter 2019-20 when copying these images) • On left I've outlined the only substantial patch of young growth. Off-photo, this stand narrows and drops to the beach—a pattern typical of coastal-access A-frame logging.

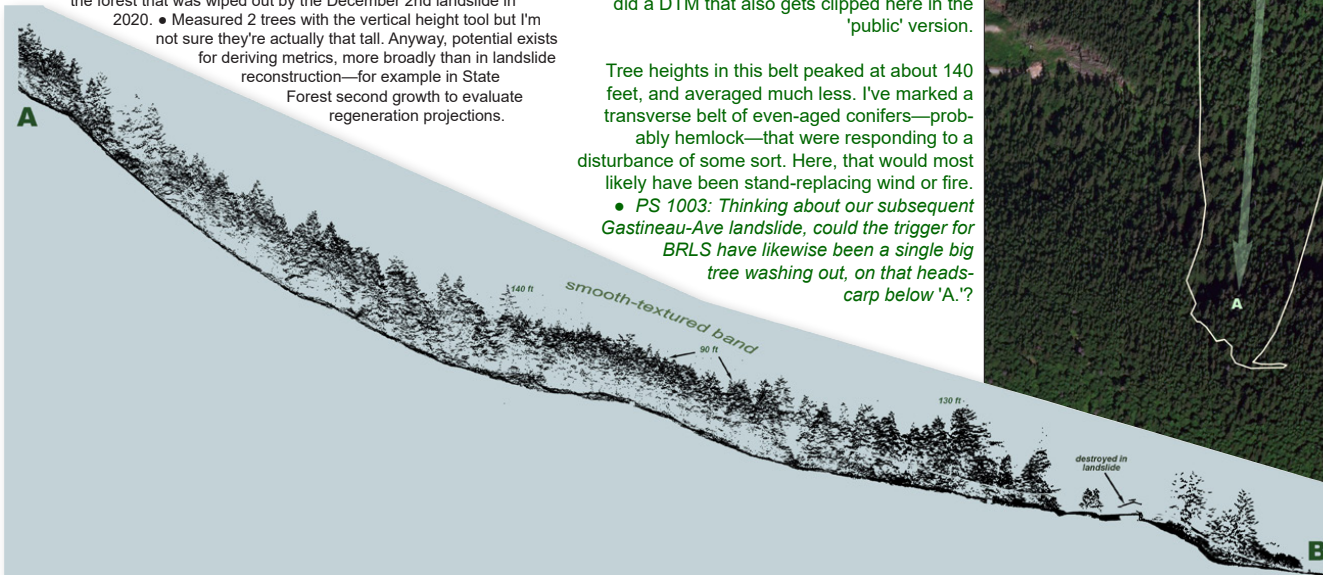


Darrow's team used change detection from DTMs to generate the previous colored map of erosion and deposition, and to put numbers on that transfer. They estimated:

"134,300 m³ of material loss in the landslide head region. [compared to] approximately 52,800 m³ of deposition throughout the landslide body including trees deposited along the flanks, with a total landslide volume of about 187,100 m³. Discrepancy between volume displaced and volume deposited indicates the majority of the landslide debris, roughly 81,500 m³, entered the inlet."

Just found some lidar pointcloud tiles from the 2014 mission that I downloaded but failed to convert from laz to las. Figured out how to do that, and was able to load them into *chilkat.aprx*. This profile runs through the forest that was wiped out by the December 2nd landslide in 2020.

- Measured 2 trees with the vertical height tool but I'm not sure they're actually that tall. Anyway, potential exists for deriving metrics, more broadly than in landslide reconstruction—for example in State Forest second growth to evaluate regeneration projections.



Right: 5th of 8 pageflippers. In 2018 imagery, a band of smooth textured forest extended cross-slope uphill. Then, where slope steepened, larger, gappier forest grew. Thanks to LiDAR, we have a detailed record of this forest's structure.

Below: LiDAR tiles from the 2014 mission allow us to visualize the 'ghost forest' wiped out by the December 2nd landslide. Transect A-B is a 55-footwide belt through 2 tiles of the point cloud. This profile doesn't quite extend to the head scarp, and our DGGs portal gives nothing higher. Perhaps, though, the data exist, as did a DTM that also gets clipped here in the 'public' version.

Tree heights in this belt peaked at about 140 feet, and averaged much less. I've marked a transverse belt of even-aged conifers—probably hemlock—that were responding to a disturbance of some sort. Here, that would most likely have been stand-replacing wind or fire.

- *PS 1003: Thinking about our subsequent Gastineau-Ave landslide, could the trigger for BRLS have likewise been a single big tree washing out, on that headscarp below 'A'?*

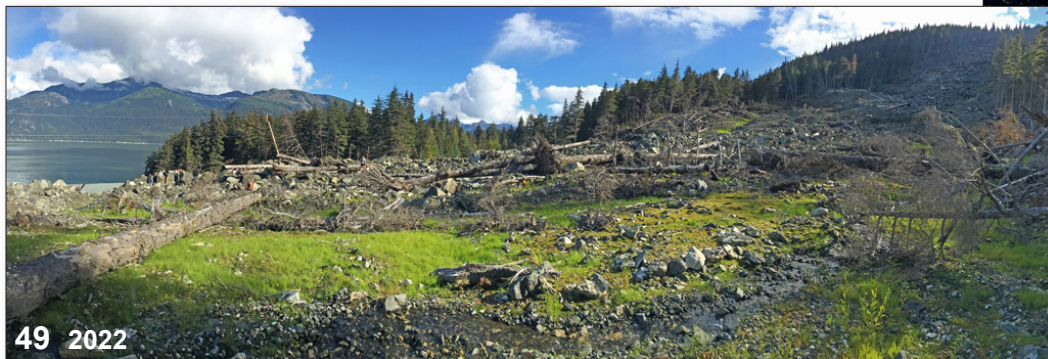


John holding forth in left distance, after advising students to fan out and experience the BRLS for ourselves. It's hard for many of us to properly acknowledge a tragedy until we're alone. For me, the fresh, bright green on these flush-seep fines was most poignant, like flowers on a grave. Panorama actually spans about 180 degrees, swung from ocean up to headscarp. My only decent pics of the BRLS were from the ferry. Once [on-site](#), sun was in exactly the wrong position for photography.

Cassie and others were intrigued by patterns of revegetation. Although I'm a decent regionally-grounded botanist, most green stuff here stumped me. It's as if natives were so shocked by the violence of this belch that they left the rubble to globetrotting, earthmover-riding invaders.

And many that may have been local were still in early cotyledon growth-stages that I'm not good at identifying. I experienced this also above my home in Áak'w Aanii, at mid-levels of Nettleslide, where a much smaller snow avalanche dumped fines over slopes around 500 feet above Service Road. Had to ask Koren Bosworth to scramble up there to help me [put names on them](#).

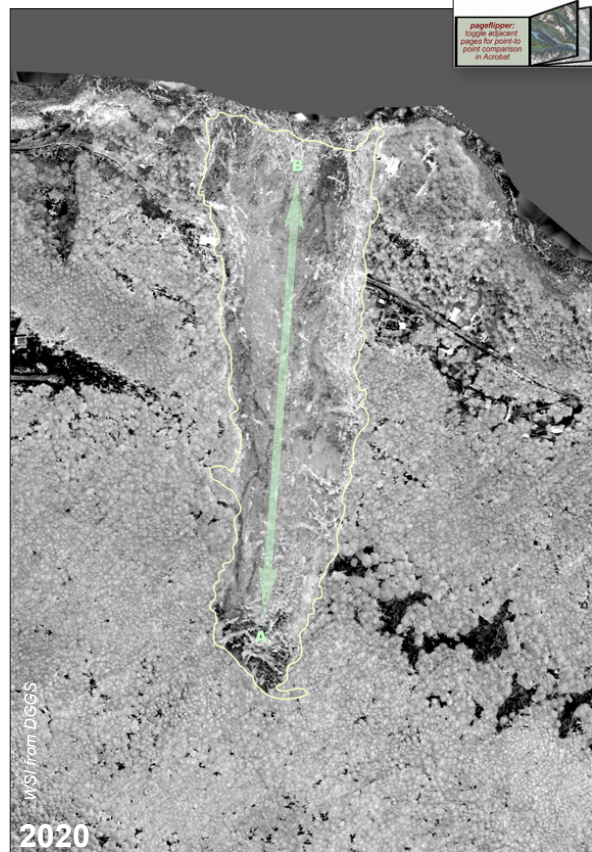
6th of 8 pageflippers. In summer 2020 there was almost nothing growing in the fresh scarp, at least not visible from this elevation. Arc from photo-point 49 shows span of iPhone sweep-pano, below.



Still requiring heavy retouching in Photoshop to bring up detail from the nearly backlit image, this telephoto from in-bound ferry at least shows fines in the headscarp, and still-unsettled debris-dams, poised to flush more soil downslope. Presumably in 'whimpers' not 'bangs'? Encompassing forest looks quite even-aged.

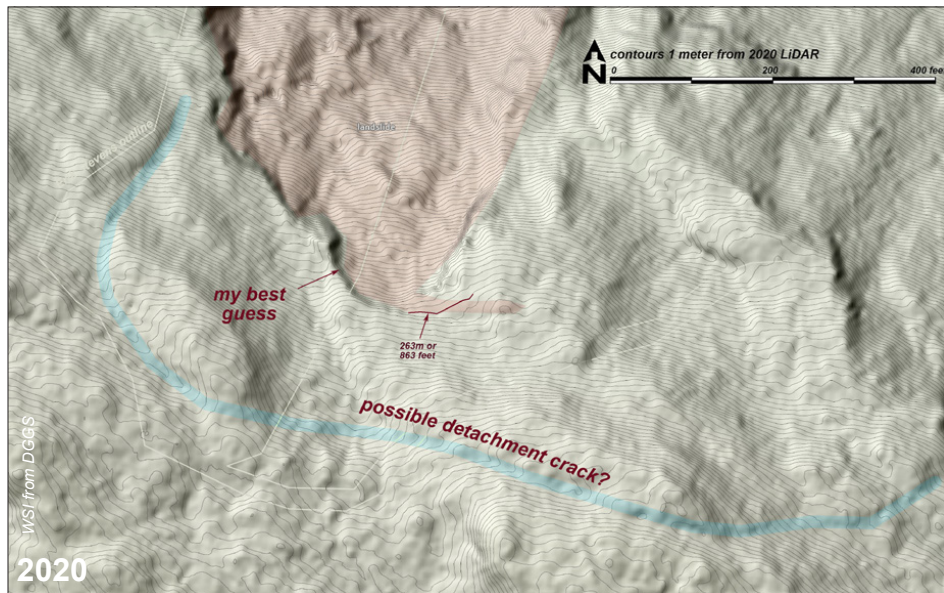


7th of 8 pageflippers. DGGS delivered an intensity image along with the DTM, DSM, and classified points (ie. the point cloud through which preceding profile was cut). Largest crowns and gappiest forest are on steepest slopes.

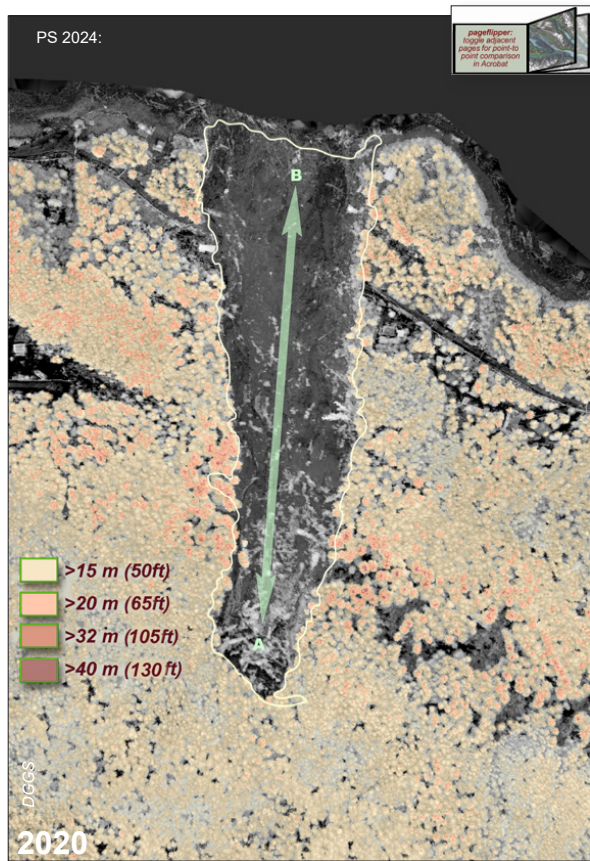


There's a little more detail on the BRLS in our *Part II* journal for 0916. But I've chosen to group these 8 Jilkoot pageflippers with preceding views of Áak'w downtown upfront in *Part I* > *Surf-geo*, because, collectively, they're my first close look at a landform I've long admired but never analysed in detail.

Below: Zooming in on the headscarp gives better views of one-meter contours. I've added a blue line over what could be yet another incipient detachment.

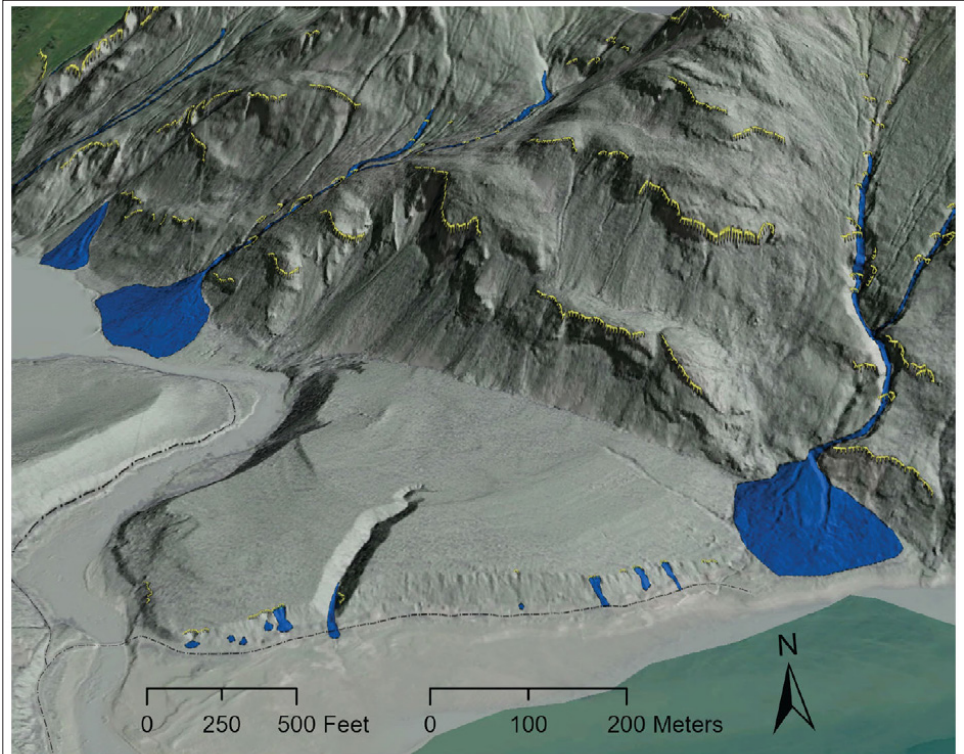
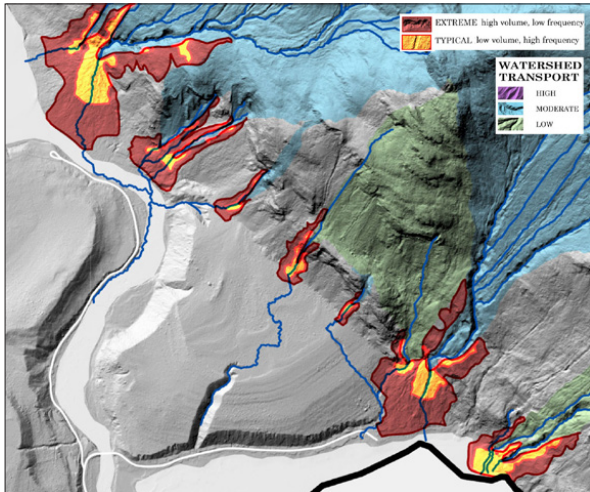


Last of 8 pageflippers. DGGS portal offers both DTM (bare earth, or ground), and DSM, (including vegetation surface). Subtracting DTM away from DSM gives canopy height. Tallest trees frame the upper (southern) end of the transect. By standards of my homeland in Áak'w and T'aaḱú Aaní, where some Nettleslide-framers reach 200 feet, these are not super-trees. But size is relative, and that gappy colluvial patch just east of BRLS headscarp with lots of brick-tinted crowns >140 feet is Jilkoot's answer to Áak'w's cliffhanging Landmark Trees.

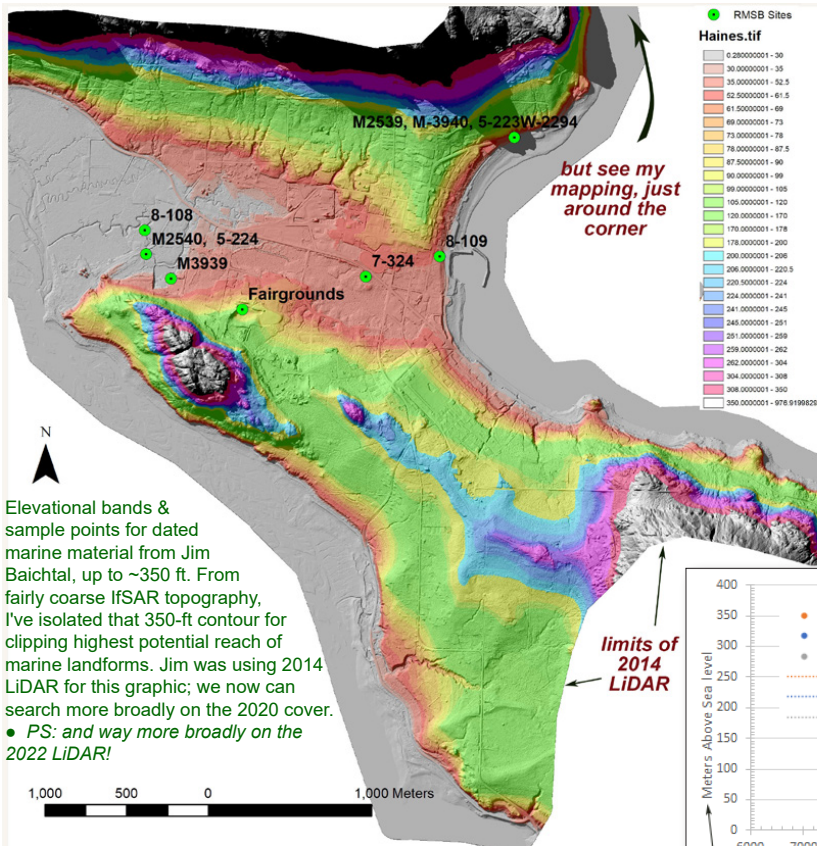


2024: I'll drop this here but much more remains to be said about the awesome 2022 Landslides LiDAR and subsequent analysis by Nicolazzo and Larsen. Tip-up oblique on right is the cover illustration for their hot-of-the-press summary of investigations, kicked off by the December 2020 BRLS.

That report is slim on illustrations, but accompanied by 3 high-res map pdfs. Below is an example from map 3 of 3, titled *Debris flow susceptibility*.



A partially transparent digital terrain model-derived hillshade raster over Esri's aerial image basemap, which shows a portion of the landslide inventory along Lutak Spur Road in Haines, Alaska.



Elevational bands & sample points for dated marine material from Jim Baichtal, up to ~350 ft. From fairly coarse IfSAR topography, I've isolated that 350-ft contour for clipping highest potential reach of marine landforms. Jim was using 2014 LiDAR for this graphic; we now can search more broadly on the 2020 cover.

● PS: and way more broadly on the 2022 LiDAR!

limits of 2014 LiDAR

Marine landforms

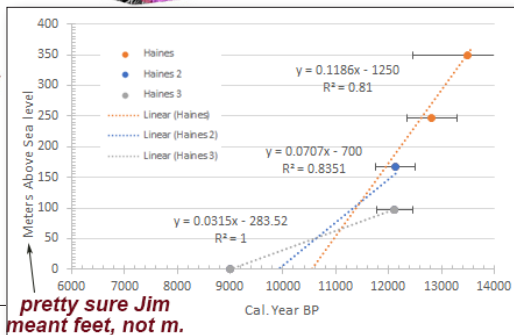
I've mapped ancient marine sediments and landforms throughout Aak'w & T'aaqú Aani, thanks to fairly universal LiDAR coverage to upper known limits of early Holocene marine intrusion. In the Greater Chilkat Watershed this is more difficult because of spottier LiDAR coverage. ¹ Can it be found in upper Chilkat Valley? Most is covered by valley wall colluvium but surely pockets persist. ²

On LiDAR bare earth, raised marine benches are pretty easy to spot, thanks to their smooth, gentle slope and texture, compared to rugged topography on till and outcropping bedrock. On the next page, I've excerpted the most exposed portion of GCW shoreline covered by LiDAR and mapped what looks like marine surfaces higher than reported from ground sampling by Baichtal and Norton. Jim's data suggest highstand of the sea at ~350 feet, and in the Norton sidebar [jilkaatsupplement.pdf], 250 feet is suggested.

Baichtal's reply to my preceding landslide query also addressed some marine-levation questions:

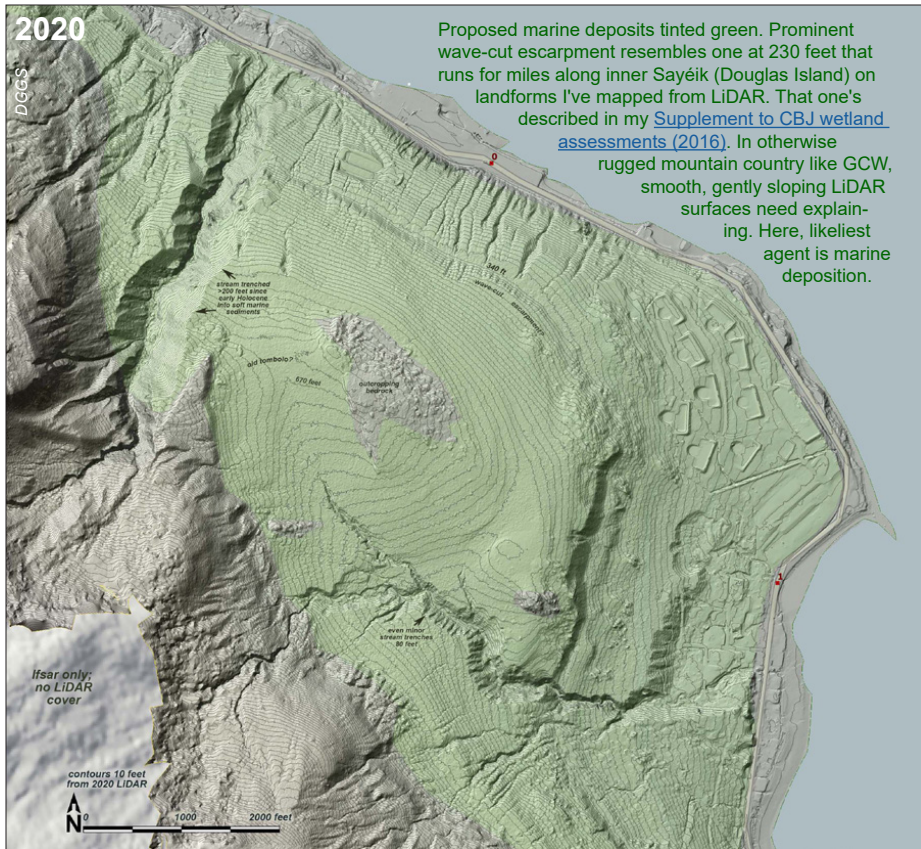
" Good to hear from you Richard. Happy New Year. Last week I was working with someone at Haines on just your question. (John Norton, I learned from CVN article) The LiDAR clearly shows multiple beach ridges up to ~350 feet ASL. In ArcGIS I measured & modeled their elevations. I took the dated material from Haines and estimated age of each of those terraces/strand lines. Linear trendlines (simple I know) suggest the uppermost shoreline might be as old as ~13,500 cal. BP.

Based on Baichtal's upper limit of 350 feet, I extracted that contour as reference line, and trimmed my 'old



1 PS 202407: Just became a lot easier, on receipt of the spectacular 2022 LiDAR. For now, I'll keep this record of our sleuthing in chronological order. and defer new-LiDAR notes to farther down in this section.

2 Quick search up valley on the 2022 DTM shows nearly complete erasure of any horizontal marine terraces by gravity processes, especially on Takshanuk side. At Moose Valley there are terraces far above current floodplain but they look fluvial & perhaps lacustrine, not marine.



Proposed marine deposits tinted green. Prominent wave-cut escarpment resembles one at 230 feet that runs for miles along inner Sayéik (Douglas Island) on landforms I've mapped from LiDAR. That one's described in my [Supplement to CBJ wetland assessments \(2016\)](#). In otherwise rugged mountain country like GCW, smooth, gently sloping LiDAR surfaces need explaining. Here, likeliest agent is marine deposition.

marine' polygons to fit. But on the newer 2020 LiDAR, which finally shows us substantial sections of GCW marine shoreline up to fairly high elevation, I think I'm seeing classic marine landforms. And some of them extend much higher than 350 feet.

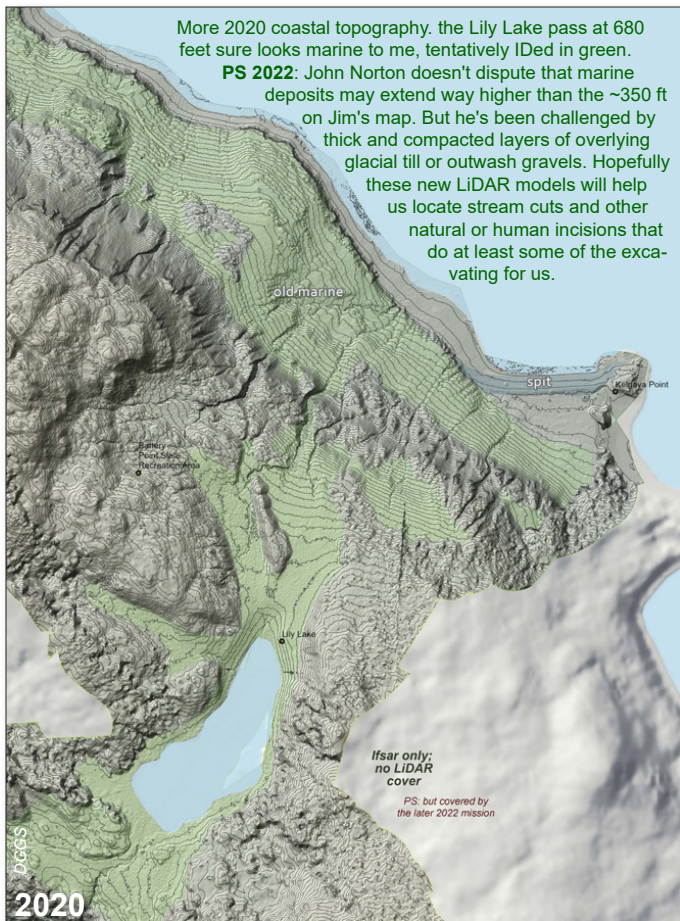
First, the most basic question. Depth of ice at peak Wisconsin glaciation was presumably as deep here as in Áak'w Aaní to the south. [Coulter et al's map of glaciation](#) (1960) shows a 5,000-foot ice surface running just inland behind both Déishu and Dzantik'i Héeni (H- & J-towns). Contact of rounded with angular topography is about a mile up, both places. In Áak'w Aaní Norton & Brock found marine shell nearly 700 feet above modern sea level. So, how closely does height of marine intrusion track with max ice thickness and associated depression, say, a millennium or two prior? Shouldn't the sea have reached as high up here?

Ideally we should create a provisional marine series for GCW similar to Streveler/Eichenlaub's series for The Bay. Panels for peak Wisconsin, peak marine intrusion, younger dryas re-advance, peak Little Ice Age, and today. Would be smartest to do this side-by-side with Greg, cause I'll be making abundant mistakes.

PS 202408. Damn! Waited too long. Without Greg, who's our best advisor in matters of bedrock and surficial geology?

More 2020 coastal topography. the Lily Lake pass at 680 feet sure looks marine to me, tentatively I ded in green.

PS 2022: John Norton doesn't dispute that marine deposits may extend way higher than the ~350 ft on Jim's map. But he's been challenged by thick and compacted layers of overlying glacial till or outwash gravels. Hopefully these new LiDAR models will help us locate stream cuts and other natural or human incisions that do at least some of the excavating for us.



20240905: I sent some of this section on marine landforms with the 2022 LiDAR to John Norton and he responded with ideas about the mysterious slumps circled on next page. Lily Lake comments are based on this map, which didn't yet cover the western, outlet side:

"Hi Richard, I spent a little time this morning looking at those circled areas on you LIDAR snapshot and would like to suggest a possible causative event for the large slump at Carr's Cove.

What I am suggesting is that Lily Lake appears to have had a larger impoundment in some previous time. That seems clear from what appears to be a sediment basin whose margin can be visualized in the LIDAR photo. [rc: i'm not clear on how John would map this impoundment]

It appears that there is more than one drainage from Lily Lake, an abandoned one that follows the current City Water Division access road, and the current preferred drainage that goes through the Rifle Range and joins Chilkat Inlet at the Bigsby residence. The current drainage is very evident and deeply incised. My thinking is that a former Lily Lake of greater extent may have breached the outflow channel during a heavy rain event, causing the release of the impounded upper lake waters. This release could have been partially routed along the alternate channel, allowing that flood event to saturate the Carr's Cove uplands and thereby causing the slump area that is so evident in the LIDAR data. Margaret Darrow referred to that area as a "slump" and discussed with me during our 2021 visit to that site that low angle slumps like that are not uncommon. At that time we had no ideas of the causative agent. So this is a hypothesis for your consideration.

In regards to the southern-most slumps I would suggest that consideration be given to the concept of an extraordinary rain event, similar to the one that caused the Beach Rd. slide in Haines in 2020. Once again, saturated ground that slumped during that event.

My considerations for the lowlands that connect Letnikof Cove to Mud Bay—I haven't a solid hypothesis to offer. That area is unusual in that it doesn't have the 6' of outwash gravel that I usually see, but instead the surface is marine clay. My home sits on that surface, and my well log is clear in that the surface covering is 6" or so of woody debris, underlain by 90' of clay before reaching bedrock. So the unusual lack of a surficial sandy cobble outwash layer in that zone requires a mechanism that would have removed that outwash layer. Hopefully your perceptive mind will supply me with an answer to that puzzle. Regards. John

I'll pick up this question of 'slumps' in Letnikof—Mud Bay pass, several pages down. One field task is to visit all 5 of the slumps mapped on next page with a shovel and see if John's '6-ft of outwash gravel' have been removed from all of them. What caused that layer, and why doesn't it blanket marine deposits, say, on the surfaces framing Séet ka, (Gastineau Channel)?

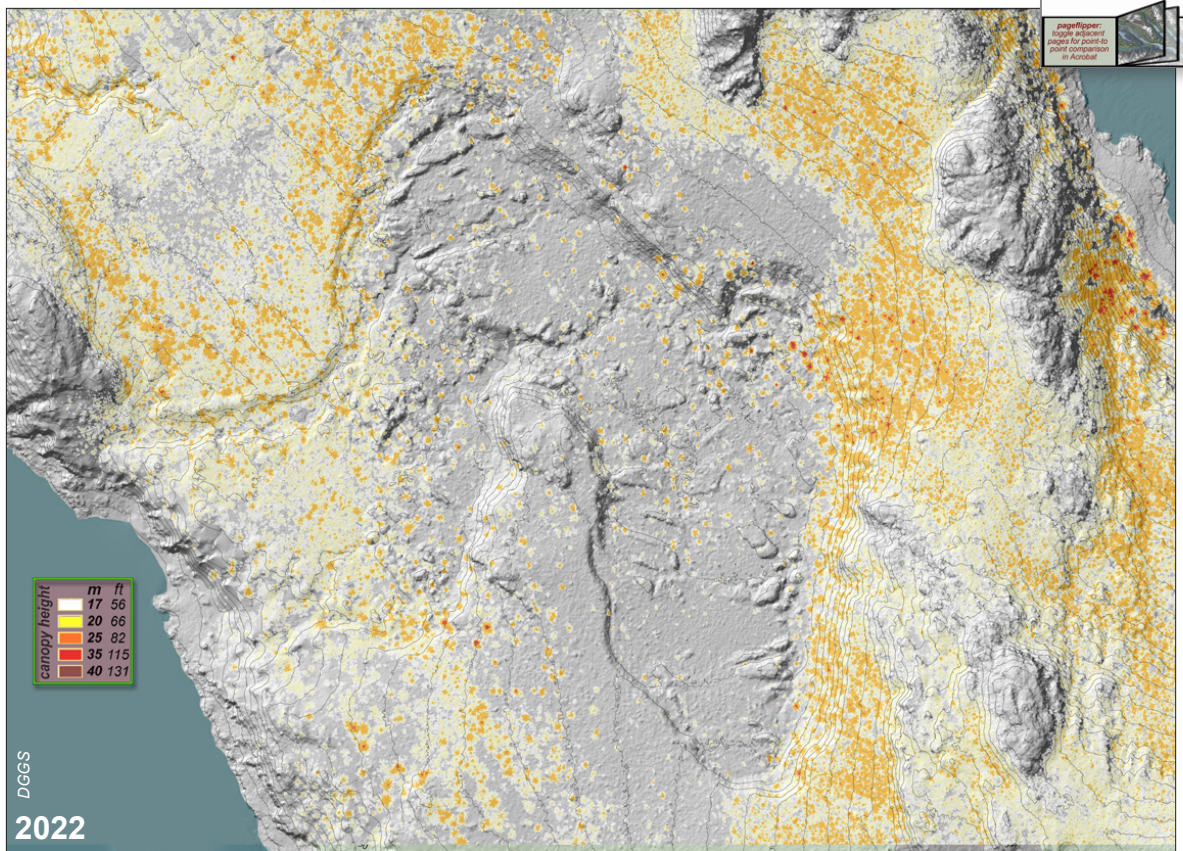
This photo alone would seem pretty boring and uniform, if we couldn't toggle back against LiDAR bare earth for underlying topography, and ahead for canopy height model (CHM), which shows surprising structural diversity not evident in a 2D aerial.

East side forests are even-aged and tight-crowned, maybe part of the 1915 burn. Most of the slump stands out as paler and coarser-textured.



Canopy height models are created by subtracting ground elevation (DTM) from highest-hit returns in the LiDAR. More on this follows in [Habitats>Forest>Canopy cartography](#).

I designed this particular classification so that a tree must be nearly 60 feet tall to even appear. Elsewhere we can see through the brush and short-trees (quite dense and obscuring on previous flipper) right down to bare earth.



Most dramatic and extensive of the mysterious 'slumps' are in the chaotically chewed-up 0.95-mi² lowland between Letnikof, Mud Bay, and Léix'w Noow, ochre fort (Paradise).

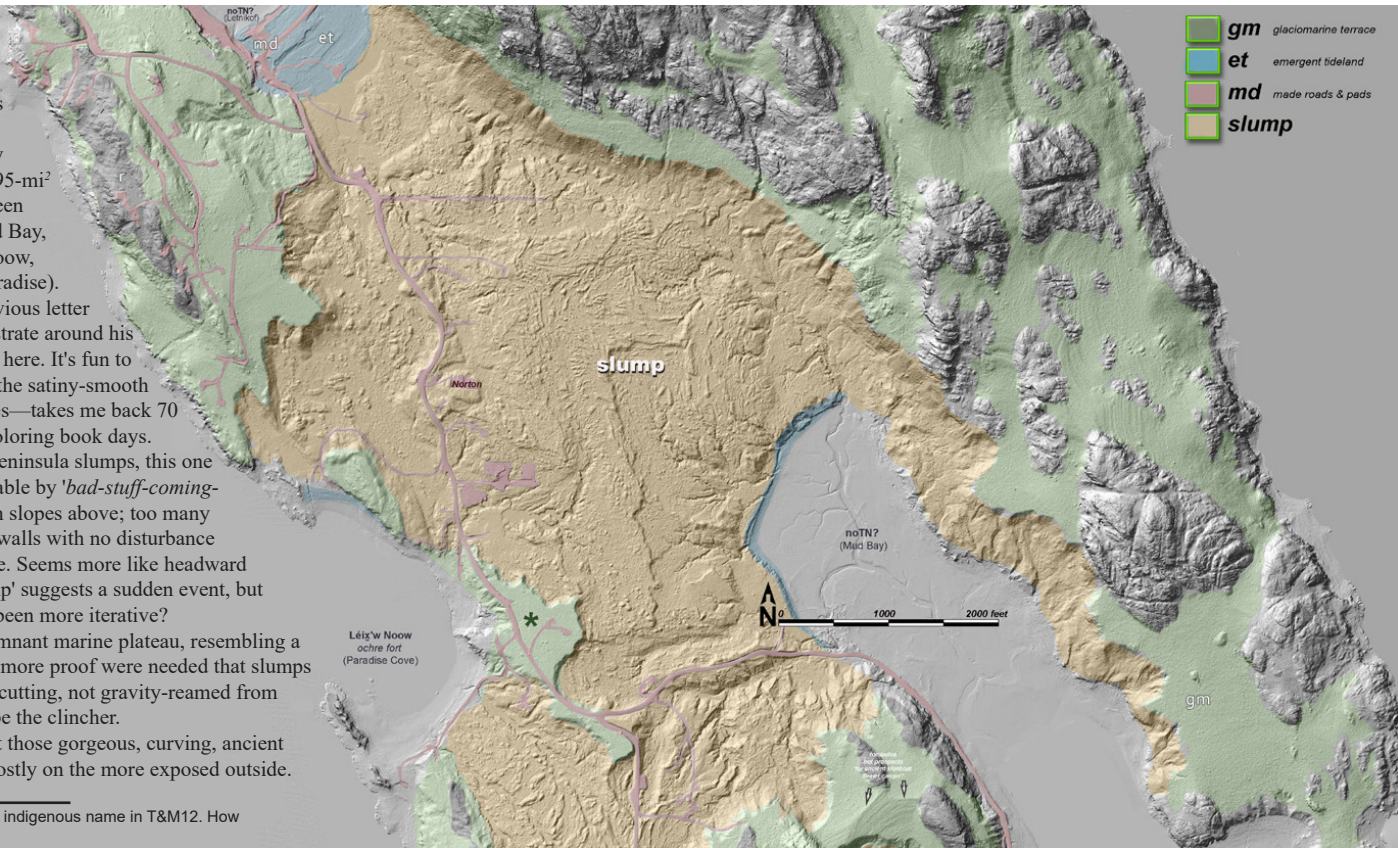
¹ Norton's previous letter describes substrate around his home, labeled here. It's fun to squiggle-tool the satiny-smooth marine terraces—takes me back 70 years to my coloring book days.

Of all the peninsula slumps, this one is least explicable by *'bad-stuff-coming-downhill'* from slopes above; too many different headwalls with no disturbance source upslope. Seems more like headward erosion. 'Slump' suggests a sudden event, but could it have been more iterative?

At * is a remnant marine plateau, resembling a Hopi mesa. If more proof were needed that slumps are headward cutting, not gravity-reamed from above, this'd be the clincher.

And look at those gorgeous, curving, ancient beachlines, mostly on the more exposed outside.

¹ Only 1 of 3 has indigenous name in T&M12. How come?



Raised tideland (post-LIA)

Placeholder for discussion of recent and ongoing landform generation as isostasy converts marine to terrestrial landforms.



2013

Connor, 2014, p 106):

The unnamed delta south of Davidson Glacier formed below sea level but is now entirely above water, indicating recent uplift (.85"/yr) along the west side of Chilkat Inlet.

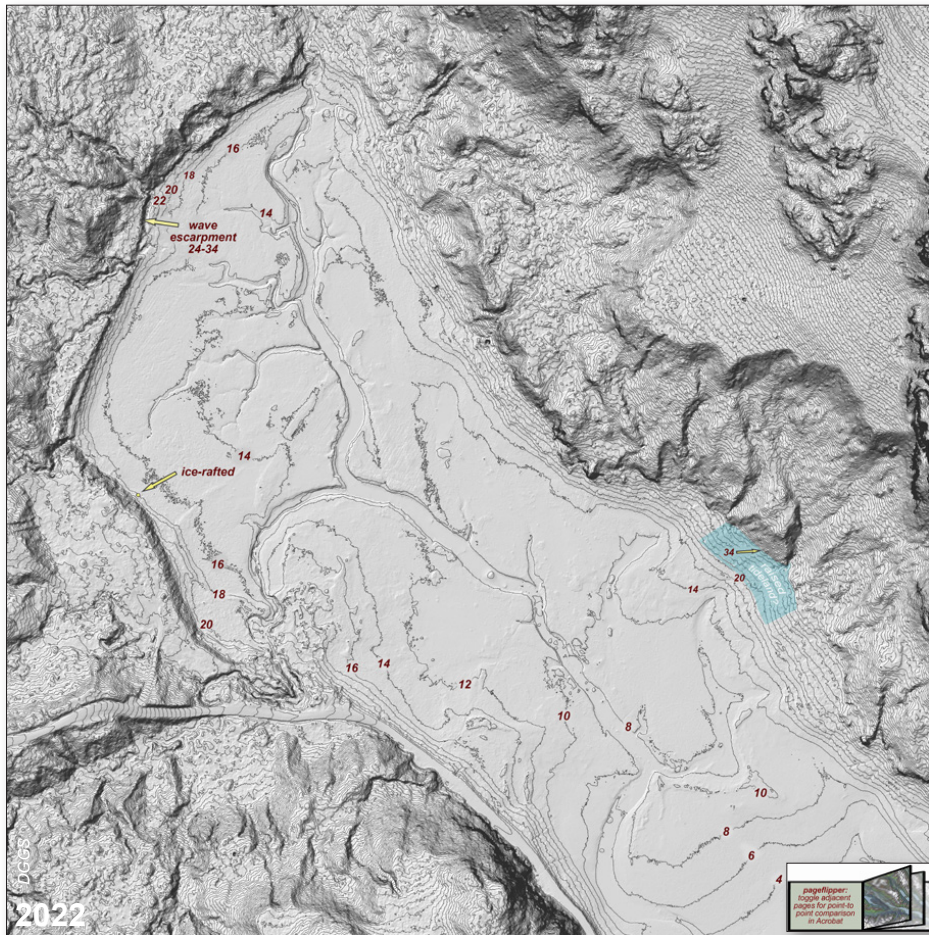
Granodiorite "**glacial erratic**" near modern Extreme High Water, Mud Bay [noTN?]. Local underlying bedrock is Triassic volcanics, and nearest upvalley source of this boulder is 7 miles northwest.

Concentrations of these boulders between current and early Holocene tidal elevations were mostly *not* released directly from ancient glaciers, as with most 'out-of-place' rocks ('erratics'). Rather, they were floated into position on gigantic icebergs, either dropped to the bottom from floating ice (one term for these is **dropstones**), or lowered, as grounded bergs slowly melted, roughly 9- to 14,000 years ago. The puzzling feature is their position atop geologically recent landforms. Here's how I interpreted them in my journal

for a [2013 visit with Southeast Alaska Land Trust](#), page 19:

"they probably were not let down directly from the surface or interior of a wasting, late-Wisconsin or Younger-Dryas glacier. Instead, they rest atop subsequent marine deposits from a period of higher sea level. So did they raft in on Little Ice Age bergs? That's dubious because we don't know of nearby tidewater advances, and also because a berg gigantic enough to float such erratics would have stranded long before drifting this far into Mud Bay.

That leaves me with the conclusion that—fresh and newly-perched as they seem—these rocks were dropped from city-block-sized bergs at close of the Younger Dryas, ~10,000 years ago, when Mud-Letnikof pass was under several hundred feet of water. That pass must have emerged soon afterward, or else the erratics would be buried under more Chilkat River sediment. Isostasy then delivered them from submarine into intertidal ranges over ensuing millennia."



Mud Bay flippers Two foot contours generated from 2022 LiDAR accentuate active tidal and raised former tidelands at Mud Bay [noTN?]. This is a pageflipper that can be toggled against the following 2023 orthophoto. Positions are marked for the ice-rafted (?) erratic boulder from previous page, and for a wave-carved escarpment at head of the bay.

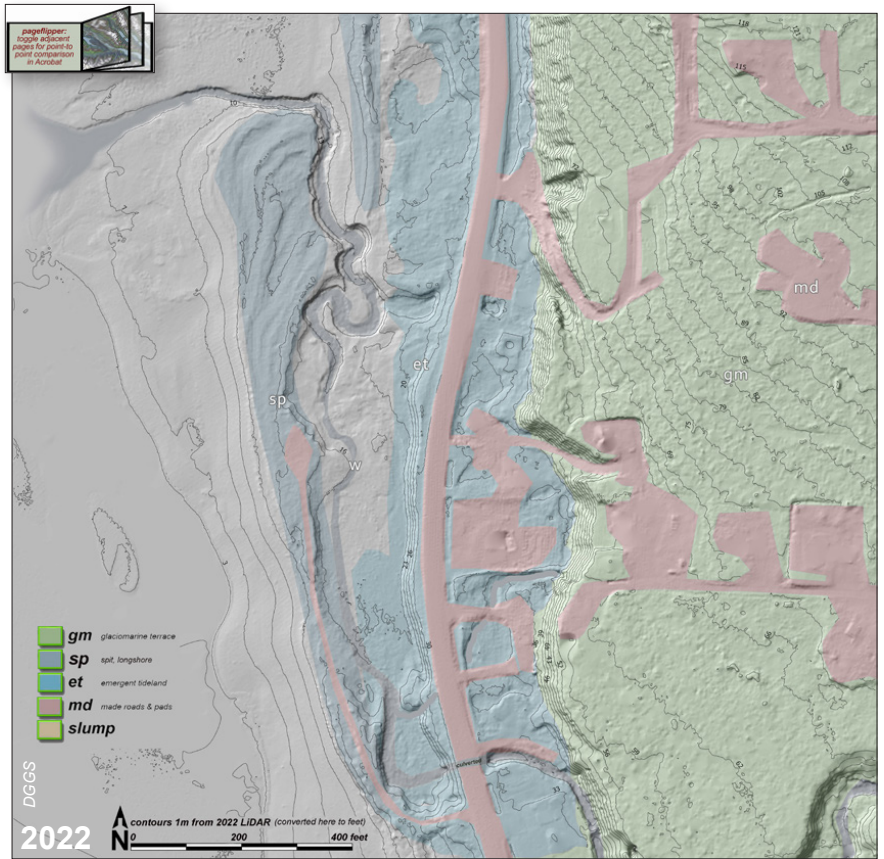
NOAA's list of 'official' High Tide Lines (HTL) has nothing for Haines but shows 22.0 feet for Skagway. That's only a bit higher than Juneau's, at 20.6 feet, so we can assume extreme tides for Jilkoot Aani are in the same ballpark. In LiDAR for Áak'w & T'aakú Aani we see consistent wavecut faces beginning at around 32 feet above current MLLW (zero in the tidebooks), suggesting about 11 feet of uplift beginning probably in the mid-1800s.

During our [Southeast Alaska Land Trust survey in 2013](#), I was puzzled by the abrupt bay-head escarpment beginning scarcely above current extreme high tide. In Áak'w & T'aakú Aani we often find young spruce forest growing between active HTL and about 32 feet, typically the base of an abrupt rise where waves eroded back the soil at maximum Little Ice Age marine intrusion. A better place to look for this in Mud Bay is on the eastern side, where a more moderately sloping bench is marked here in blue. The top of that sloping bench or terrace is at 34 feet, perhaps analogous to our more southerly escarpment system. With this new elevation model it should be possible to peruse the whole peninsula shoreline, and as far northeastward as Taiya Inlet approaching Shgagwei (Skagway) looking for landform clues to max-intrusion in the Greater Chilkat.

Here's Clay & Claire's neighborhood on the new 2022 LiDAR. By jumping around on the coast, I'm gradually getting a better idea of the extent of raised tideland on both sides of Chilkat Peninsula. In Áak'w & T'aakú Aani, a decade's use of LiDAR DTM from 2013 has left us pretty satisfied with highest LIA marine intrusion to the 32-foot contour above today's MLLW. Rebound there is about 0.5 inches per year. In Jilkoot Aani it's more like .8 or .9 inches per year, so I'd expect LIA high water several feet higher.

Base of the wave-cut face here is at about 36 feet. So let's make that our provisional LIA HTL. As for the bottom of our blue-coded belt of what RD Miller's map called emergent tidelands (*et*), I began at the 20 foot contour. In Áak'w & T'aakú Aani, it begins at almost 21 feet. ¹To my surprise, after creating this pageflipper pair, I found spruces growing below the first-draft blue zone. So it's been extended seaward to include all surfaces supporting conifers. That raises the question whether "zero feet" on this DTM is in fact true 0-ft, MLLW. Back on home turf, we're fairly comfortable with that assumption.

RD Miller's awesome 1975 surficial geology map for Áak'w Aani includes sparing use of an *sp* unit for a wave-built spit. They mostly extend obliquely from the shore, pushed by prevailing longshore currents. Interesting, here, that the spit, and little creek trapped behind it, are propagating northward, against direction of Chilkat River currents.



¹ There, Corps of Engineers defines HTL as 20.6 feet above MLLW.

Toggling against previous hillshade, I adjusted width of the blue emergent tidelands (*et*) belt downward, to include spruce parkland, obviously above HTL.



Couldn't help including this way more beautiful ortho from 12 years earlier, before Clay's house went up. (Not to say your house is ugly, Clay :) This is the quality all forest-habitat mappers aspire to.

Having spent much of the past year mapping tidal and near-tidal habitats at Taashuyee-Chookan.aani (the 6-mi² M-word wetlands), i'm intrigued by colors and textures on the little creek delta in upper left. What are those ameboid orange-brown blobs? *Fucus* beds? and why weren't they there a dozen years later?

And watch how fast the belts advanced seaward in the mere 12 years between 2011 and 2023. More change than we see in that interval at Taashuyee-Chookan.aani.



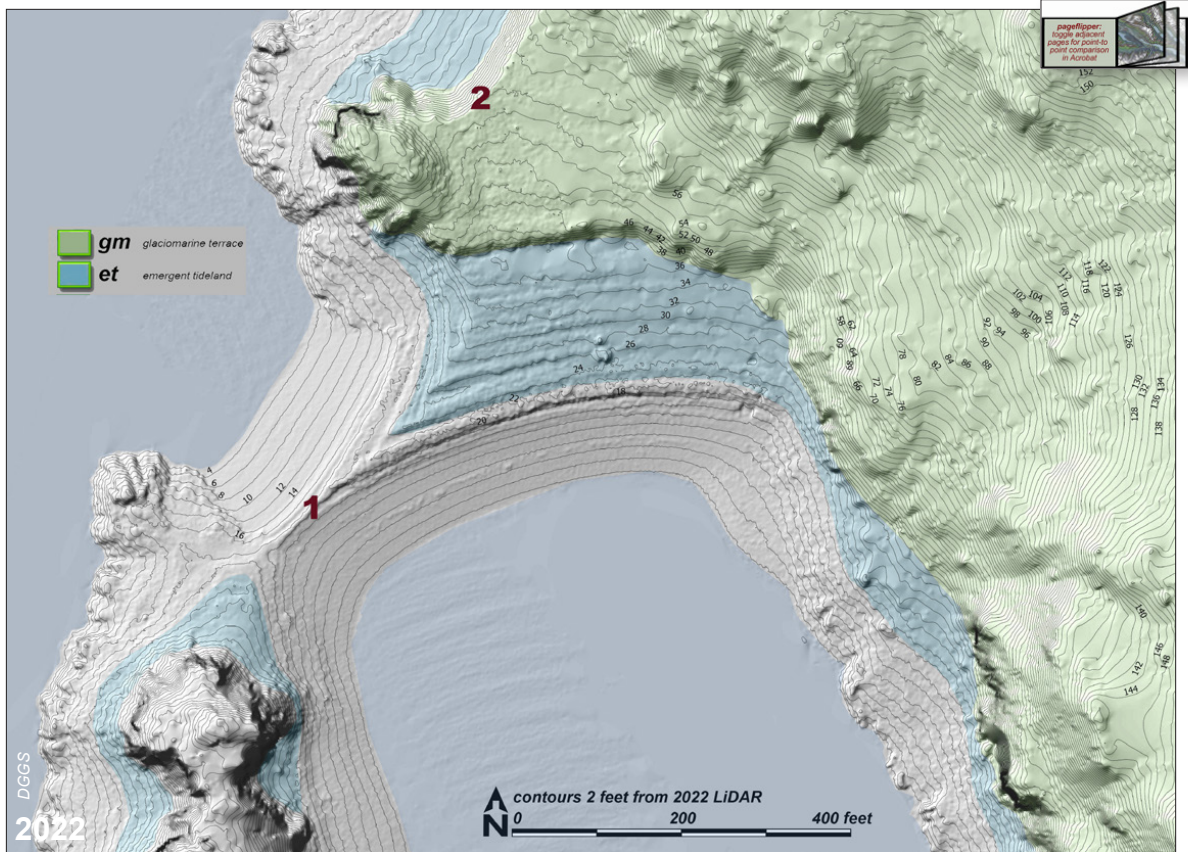
Yoo Lititgi X'aa, undulating point (Dalasuga Island) ¹ South from Mud Bay there are better shorelines to scrutinize for evidence of maximum LIA sealevel intrusion. This one has a lovely series of beachlines in the blue-coded emergent tidelands belt.

As at Clay's, to the north, we tentatively guessed the highest LIA HTL was around 36 feet above today's zero. Active HTL here judging from driftlogs is about 22 feet. ² In protected places a band of salt marsh extends well below HTL but on the exposed storm beaches, both sides of the tombolo, no vasculars can take hold. (that band of pastel green on the NW beach is too low for vasculars; probably algal mat)

1 is an active tombolo spit connecting the bottom-left island-that's-not-an-island at most tides. **2** is an analogous former tombolo spit from when tides reached to about 60 feet above today's MLLW. Once more smoothly sloping to NW as well, it was eaten back by waves into easily carvable sediments. But how long ago?

¹ There's more than one *undulating point* in Jilkoot Aaní. What does this reference, wave action? a mirage-type effect? Let's ask Marsha.

² Again, all this is on the unverified supposition that these lovely contours are not only relationally credible but anchored properly to official MLLW 'zero.'



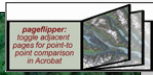
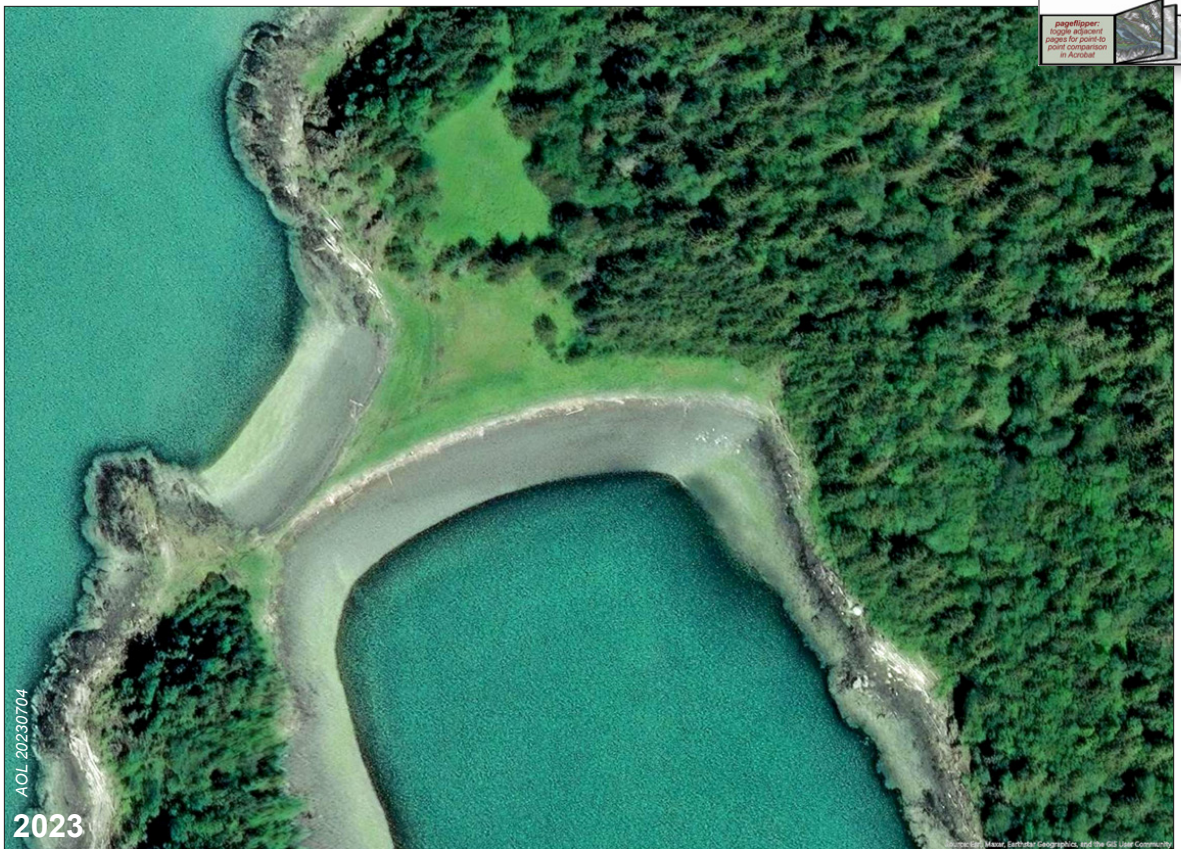
Ortho acquired on 20230704. In top center are 2 smooth-surfaced unforested slopes in slightly different green tones. Toggling back to the 2-footers and counting, these gently sloping 'meadow-treads' are separated by an 8-foot 'riser' (38-to-46 ft). My blue-toned *et*—emergent tide-land stops at base of this riser.

Okay, but then why should an ancient slope above it have no trees?

And for that matter, why is only the eastern half of the lower, *et*-zone forested?

I'm guessing the answer is meadow-capture, common on rich-soil cultural sites only a couple centuries old. There's a great example at the outlet of Ḻḵoot (Chilkoot Lake) that I've just mapped for the journal of our visit with Geo393 in September 2022. Canoeists and the skin-boat kayakers who preceded them favor tombolo camps offering lee-side landings regardless of wind direction. It's hard to imagine a more textbook site for small village or outpost.

If my mapping's correct, upper and lower 'treads' are part of the same 2-tier encampment but of very different geological ages. But could that be wrong? Should I have extended blue *et* to the top of the upper tread, at nearly 60 feet? So far, 60-feet looks anomalous, and I'll cap my provisional *et* at 36-38 ft.



2022

Aeolian (wind) landforms

In general, wind is not a big player in landform creation in Lingít Aani, not for lack of wind but rather abundance of vegetation and high soils moisture content. Unlike desert bioregions where unvegetated sediment is exposed to wind action, in most of our rainforest archipelago, bare



From ~9-mile, Haines Highway, looking southwest over Daxhéen, inland river (Takhin) delta. Strong wind raises alluvial silt, redepositing it as loess.

1992

surface is limited to a few coastal beaches and riverbars.¹

On transboundary rivers we find exceptions. Best known is at the mouth of Shtax'héen, *water biting itself* (Stikine River), where high-relief sand dunes frame portions of the river, and islands in the delta are capped by loess (airborne fines).

Loess, dunes As till describes the material from which moraines are constructed, so loess comprises dunes. Grain size of loess is small enough to launch particles into the air. It accounts for *all* of the Shtax'héen-mouth landforms on islands like Xakwnook', *little sandbar fort* (Rynda Island)—if only because larger sand grains sink beneath the tides. Over shorter distances, dunes include coarser sand, rolled into place.

John Norton's comments on this photo:

"The area around 9-10 Mile is a critical area for air masses to engage, and is know for high winds and dust plumes that occur when the river is somewhat lower, exposing large areas of fine sediment to wind currents. From the driveway at 9 Mile one can see what appear to be a series of dunes that have formed on the west side of the Chilkat R. Somewhere in my files I might have a picture that shows them. The dust clouds that form in that area can easily be seen from the airport, and often from as far away as Letnikof Cove cannery. They seem to form predominantly when North winds blow down valley towards town as it is the high pressure systems from the Interior that usually bring us our dry weather."

Before receiving this annotation to my 1992 photo, I'd inched over the zoomed-in riverbottom bare-earth layers delivered by 2011 and 2018 LiDAR

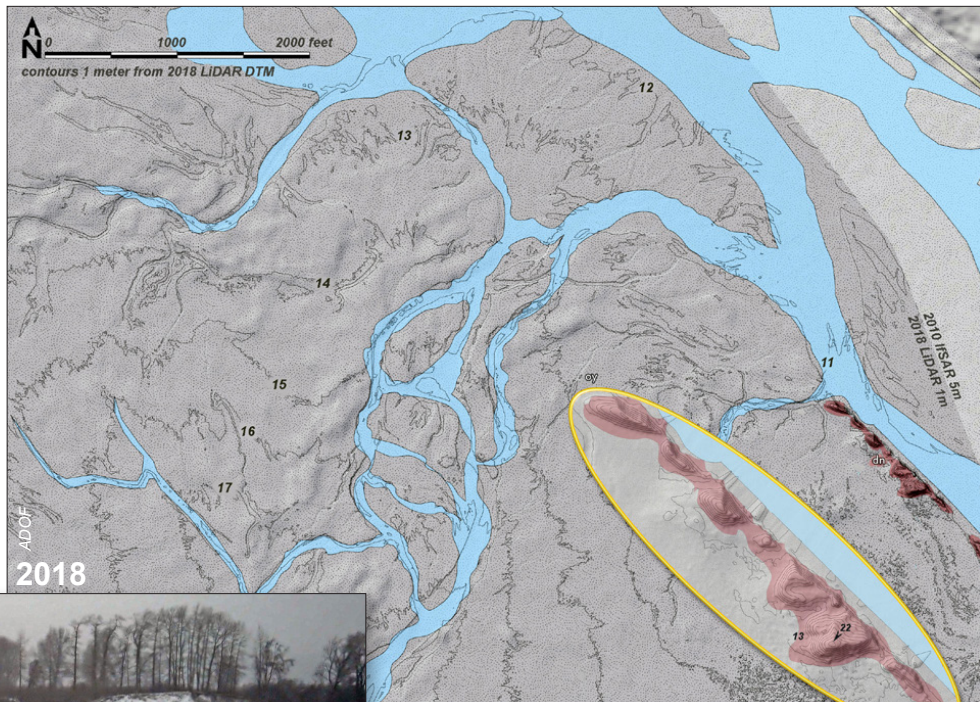
¹ Alpine barrens typically have less sediment and are steep, so gravity generally transports material before wind can play with it. Snow is of course another matter.

missions, scanning for possible dune formations, with no success. Seemed like I should be able to pick up ridges with, say, a meter or more of relief?

Fortunately, this Daxheen-Jilkaat confluence area was just barely covered in the 2018 mission.

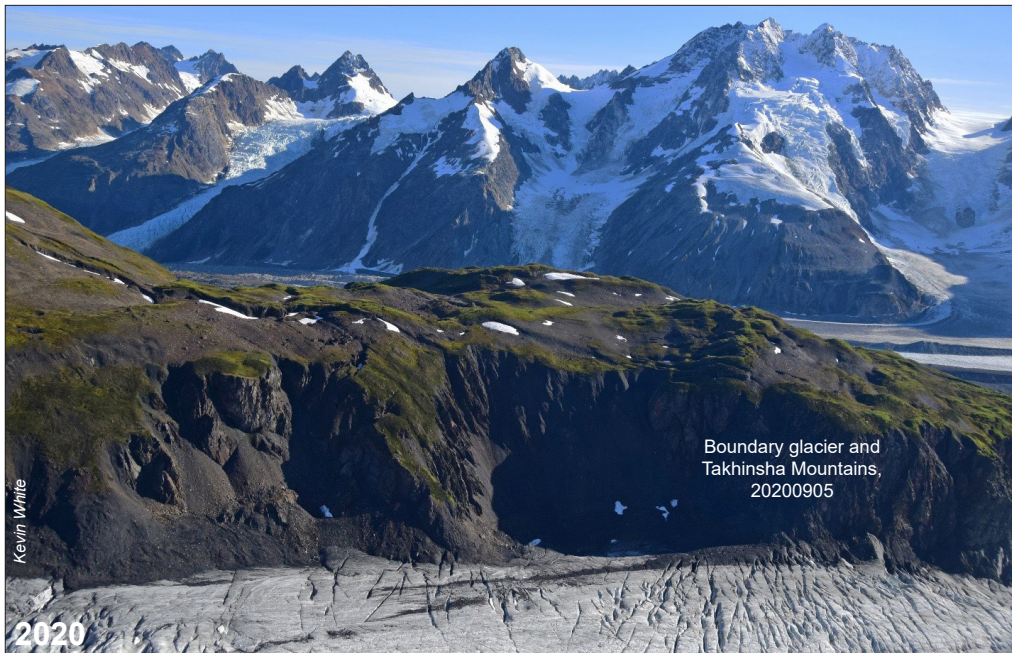
Dunes on bare earth Fortunately, the mostly east-side 2018 LiDAR mission reached across the river to capture a line of dunes, visible from 9-mile, Haines Highway. 22-13=9 meters, or 30 feet.

RC to JN: "After you explained the dunefield across from 9-mile, I dove back into the 2018 LiDAR, which luckily barely covers the Takhin-Chilkat confluence. I'd previously scanned the riverbottom lidar looking for dunes, with no success. Now that you've pointed me to some, I see my search image was off. They're quite tall (30 feet at Takhin!), but usually sliced by subsequent channel migrations until scarcely resembling desert sand dunes I've lidar-mapped in places like the albany pine barrens."



Left, from John Norton:

"Hi Richard, I was up Valley for a XC ski yesterday [20220225] and stopped at 9 Mile to take a few pictures of the dunes we discussed a couple of weeks ago. You can see the cutbanks with the snow cover, so that makes the shape of the elevated mounds fairly clear. Some day I'll have to put the canoe in the river and go over and take a close look at those. Cheers, John"



Glaciers

[Glacial history](#) and [glacial landforms](#) are briefly described above. But glaciers have such a special caché—both for residents immersed year-round in their power and bucket-listing pilgrims from warmer climes—that some elements of their story deserve their own section: elements we can't pigeon-hole into glacial timetables or landforms description.

How, for example, will glaciers respond to climate change? How strongly do they differ across GCW's temp-&-moisture gradient? What is their 'upriver' role in creation of habitat for fish, wildlife and humans? How have humans of different cultures named and responded to glaciers? And for our purposes in this atlas, how to best depict them on maps, given their historic fluctuations and snow-exaggerated margins?

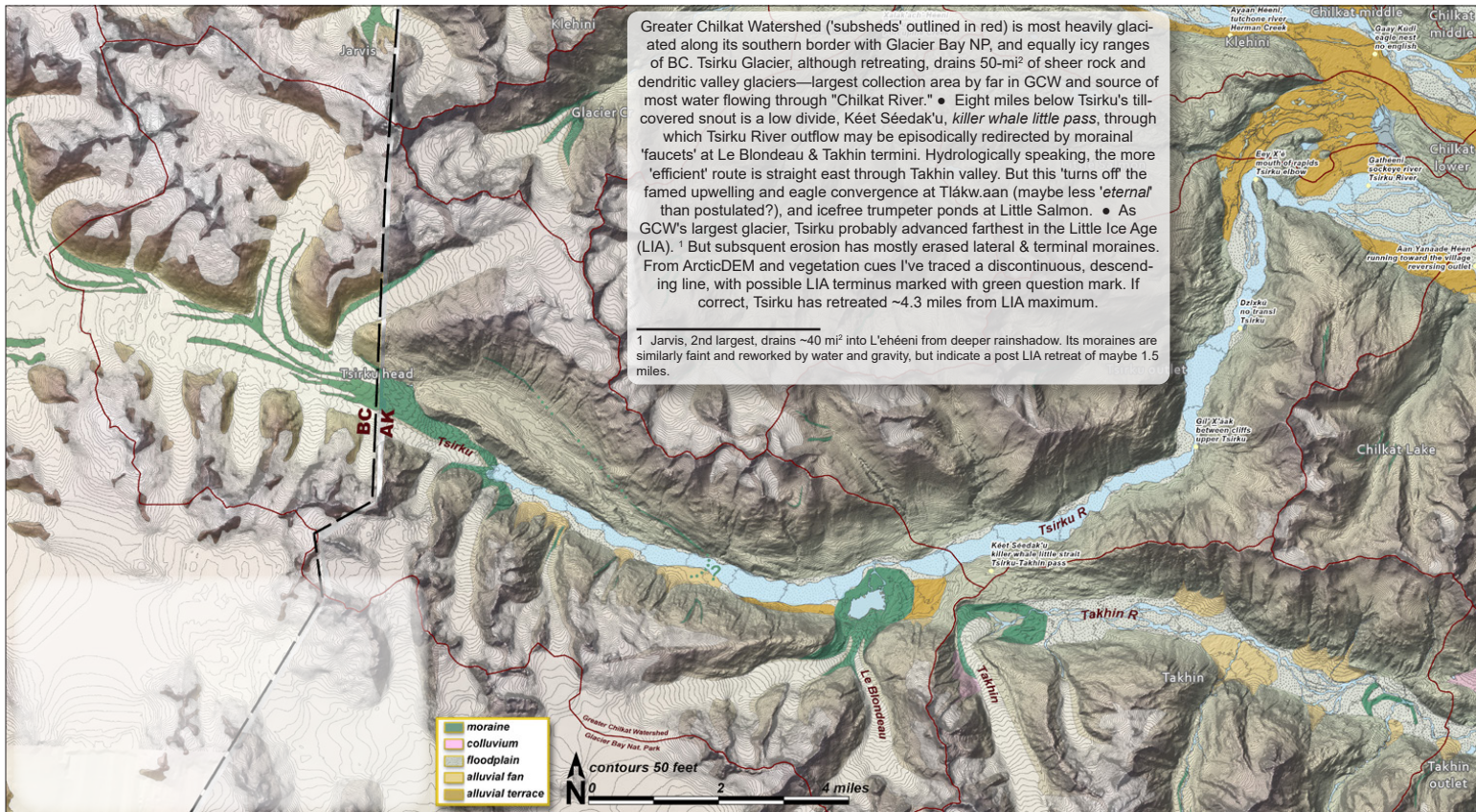
Mapping glaciers Glaciers are a moving target, presenting special challenges for cartographers. As of 2022, our most detailed *and* most globally comprehensive source for glacier mapping is the [Randolph Glacier Inventory \(RGI\)](#) – A Dataset of Global Glacier Outlines: Version 6.0. Background on the RGI, and my own, parallel, process for hand-tracing glaciers from IfSAR and other sources is in [Appendices>Cartography](#).

Naming glaciers Glaciers of Lingít Aaní are like waves in the sea—so many and so mobile that only the nearest, most threatening or most profitable have names on Federal or State-published maps.

For most glaciers that have names at all, we might appear to be stuck with IWGNs, because with a few exceptions such as Lkoodaséits'k, *giant's name* (Rainbow Glacier), even largest glaciers and icefields have only unimaginative, generic Lingít names. In T&M12, for example, the Brady and Grand Pacific are both simply Sit' Tlein, *big f-ing glacier*.

How come? As Julie Cruikshank makes clear in *Do glaciers listen?*, moving ice, like Xóots, was animate, sensate, only insulted by fools. Perhaps invoking Sit' Tlein, like calling Xóots by various 'avoidance names' 'Old step-widener', was a deference term, a declaration of respect?

For awhile, in my mapping, I was unoffended by commemorative names or IWGNs, especially where no prior Lingít name was known. But the longer I work with place-based, story-rich names, the more I feel that all intruders should be purged from our maps, and from our relationships to sacred places.





2013

The bergschrund is a defining crevasse—often snow-filled in winter—that forms where moving glacier ice separates from stagnant ice or **firn** upslope.

Hydrology

Expressions of water movement in alluvial landforms—both past and ongoing—are described above under *Geology*>*Surficial geology*>*Landforms*. Here, we turn to other attributes of moving water, beginning with a conceptual framework, then moving on to biological relations in forests and fish habitat.

More than perhaps any other biogeographic province in Lingít Aaní, ¹ the Chilkat is '*the land of rivers*.' Seven glacially-fed rivers drain highlands just across the Canadian border. From west to east, in English: Takhin, Tsirku, Klehini, Kelsall, Chilkat, Taiya and Skagway. Two other large rivers—the Chikoot and Ferebee—originate from glaciers and snowfields contained entirely within the province. Among the transboundary rivers, Yéil Héeni, *raven's river* (Kelsall) strikes deepest into the interior, thus has the strongest potential to serve as a wildlife corridor.

River names in Chilkat province have escaped the typical Euro renaming to a remarkable degree. Only on the Kelsall and Ferebee were Lingít names 'bumped' by IWGNs. Orth (1961) says the Kelsall was "*Jelchhini meaning 'crow river'*" according to the Krause brothers. That's way more



than we usually learn from the eurocentric *Dictionary of Alaska place names*, but unfortunately, it's also wrong—an error stemming from corvid-conflation. T&M12 explain that it's actually Yéil Héeni, *raven's river*. As for Ferebee, the real name is Dayeisáank'i Héeni, *little cove river*.

conceptual review, with maps & photos

Channel type xxxxx

conceptual review, with maps & photos

Aggradation and incision xxxxx

conceptual review, Little Ice Age legacies

Stream order xxxxx

¹ There are 22 of these, described in [JuneauNature>Places>SE AK biogeographic provinces](#).

review from Ben, Baichtal, Streveler of my surfgeo mapping;
active vs raised terrace. Am I missing places just above the floodplain
where succession has recently entered a new post-flooding paradigm?

2

Subsheds

Explain delineation process

XXXXX

Hyporheos: the invisible river

XXXXX

question of upwellings and ice-free areas.

Floodplains and forests

XXXXX

erosion-deposition here; forest structure below in [Habitats>Forest
&scrub>Cottonwood alluvial](#).



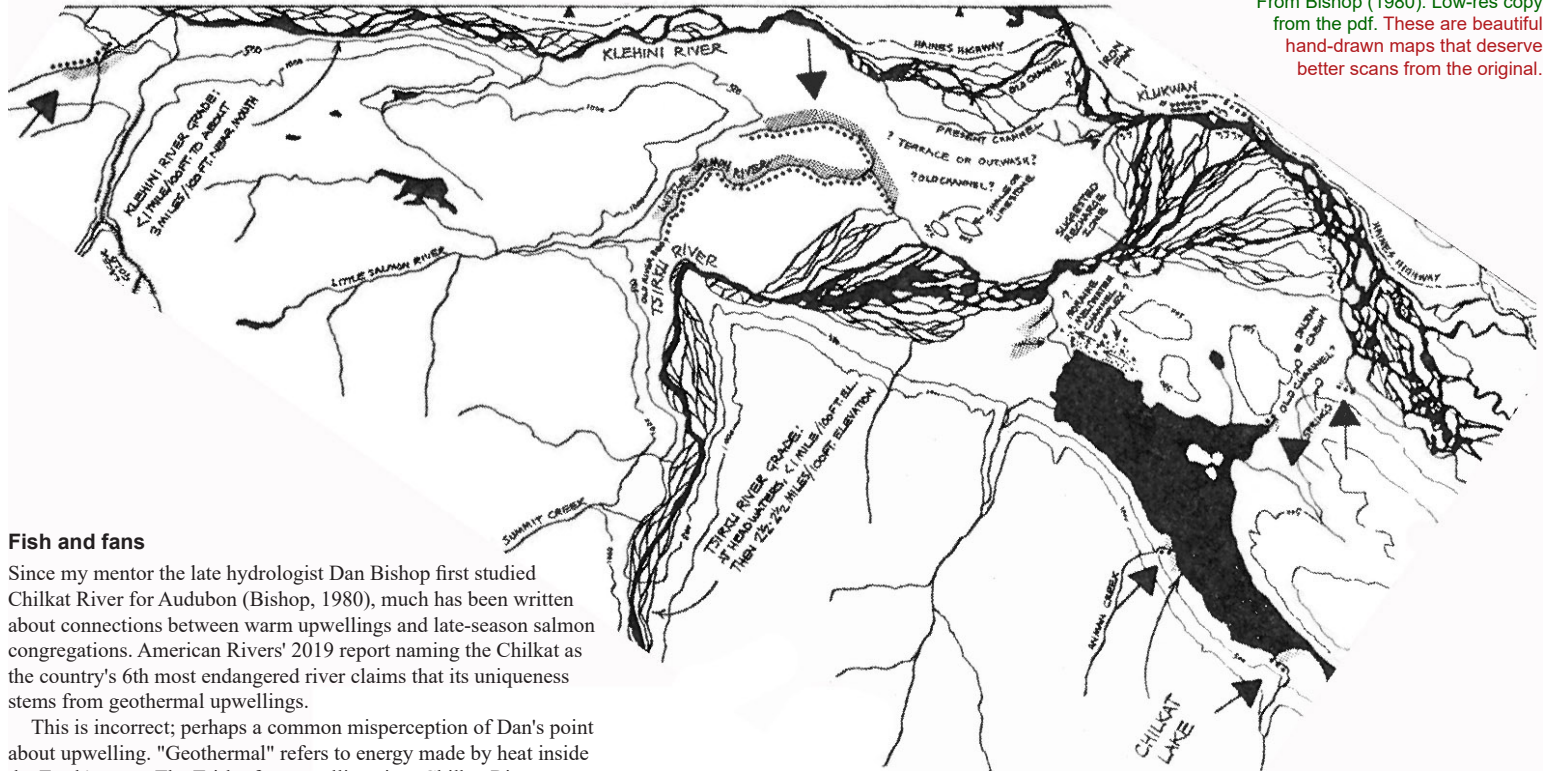
2 I continue to be puzzled by the question of changes to flow dynamics and
outwash volume during glacial advance, at maxima, and in recession. Hydrologists
tell me flow is greater *now* than at glacial maximum, because melting is greater.
But if this is true, why do pretty much all of the alluvial large-tree forests in northern
(most intensively glaciated) Lingit Aani appear to have been 'reset' at around peak
LIA?



Alaska Shorezone se05_ml_0536

2005

From Bishop (1980). Low-res copy from the pdf. These are beautiful hand-drawn maps that deserve better scans from the original.



Fish and fans

Since my mentor the late hydrologist Dan Bishop first studied Chilkat River for Audubon (Bishop, 1980), much has been written about connections between warm upwellings and late-season salmon congregations. American Rivers' 2019 report naming the Chilkat as the country's 6th most endangered river claims that its uniqueness stems from geothermal upwellings.

This is incorrect; perhaps a common misperception of Dan's point about upwelling. "Geothermal" refers to energy made by heat inside the Earth's crust. The Tsirku fan upwellings into Chilkat River are simply from storage in the hypercharged fan, of groundwater only slightly warmer than freezing.

Habitats

There are many ways of categorizing and naming habitats or vegetation communities. In this atlas, we've tried to choose types that are ecologically meaningful—explaining, for example, movements and distribution of certain wildlife species. Just as important, however, is that our categories be 'mappable.'

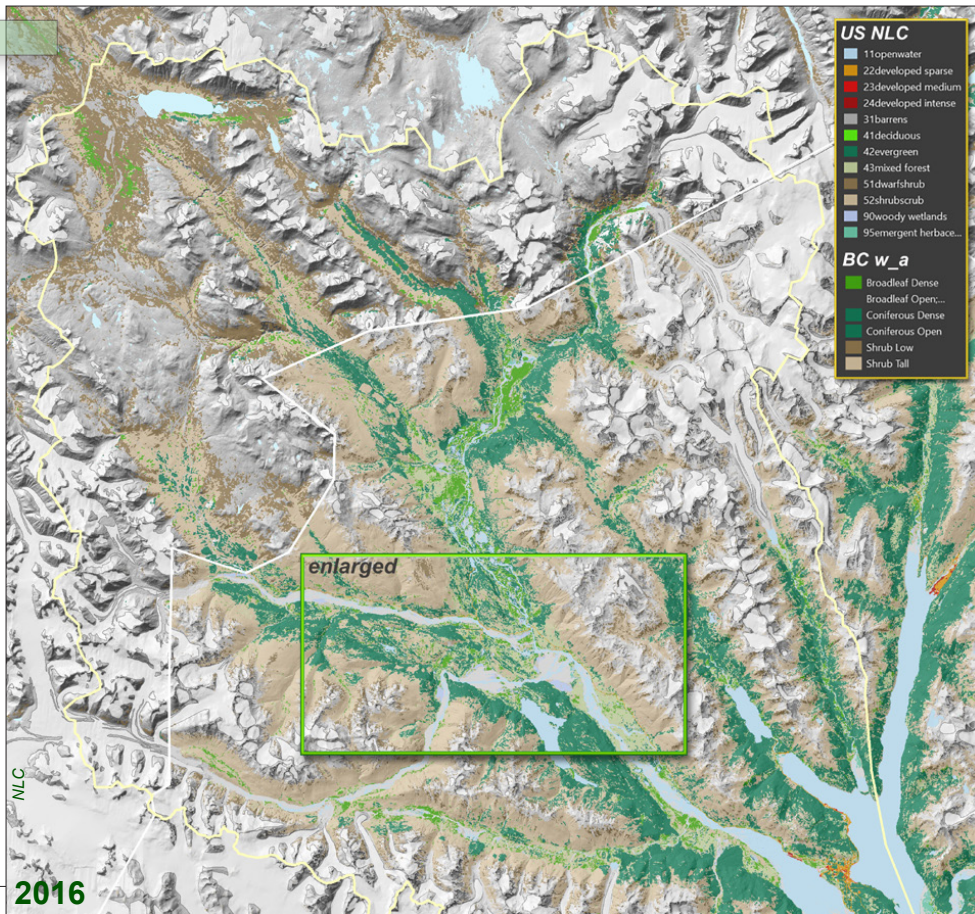
Mapping habitat: On the US side of the international border, our most 'standardized'¹ vegetation mapping for GCW is National Land Cover (NLC)—a rectified .tif with veg-types assigned to every 30-meter pixel. The current NLC for Alaska was created using change detection between 2011 and 2016 on Landsat imagery. Because veg-units are standardized across lower 48 & Alaska, locally meaningful types such as "hemlock old growth" are not broken out by NLC.

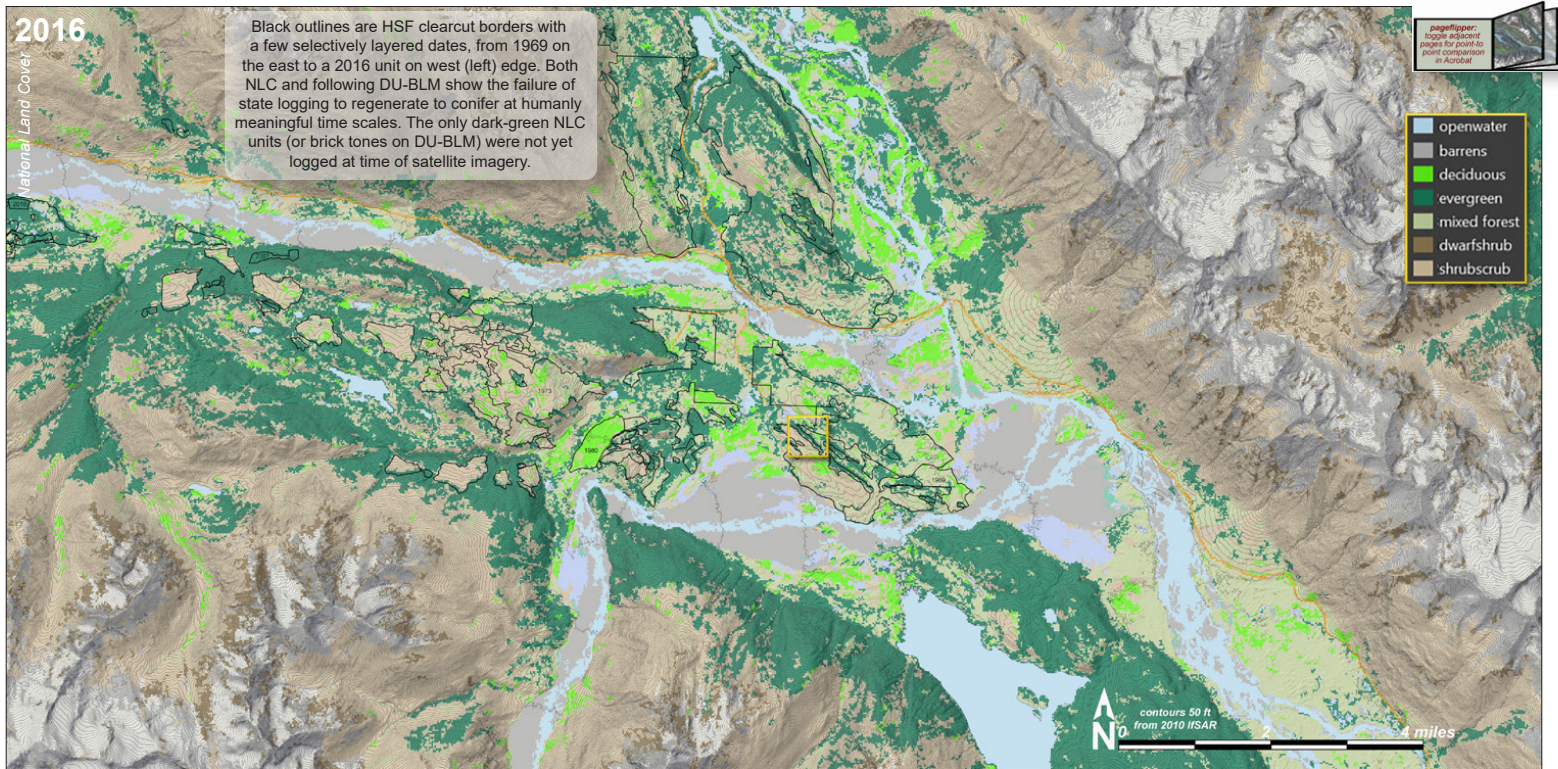
On the Canadian side of this white-line border, a cover titled *wooded_area_2* has classes somewhat analogous to our US NLC mapping. On right, I've tried to 'crosswalk' them by matching colors. In the green rectangle, next page, you'll detect 30m-pixel cells. But at full-GCW view, US-&-BC layers combined give a useful big-picture feel for veg-structure classes, and a bit of species info, albeit with many assumptions and caveats.

These vast, sat-photo-base landcovers involve almost no boots-on-the-ground, or even human interpretation, once a computer has been 'trained' to process the imagery.² For our purposes in detecting and displaying forest, woodland, shrub, tundra and wetland habitats unique to Chilkat country, we need to come down a bit from 30,000-foot level. Let's ease into that with this frame,

¹ ie, comparable to similar veg-mapping throughout the US, and with tweaking, BC

² In contrast, on the Tongass National Forest, veg-maps were traced unit-by-unit, by experienced photo-interpreters detecting differences on air photos, from 3D imagery under a stereoscope, with units down to ~city block size. But the GCW is beyond the bounds of the National Forest, and this type of non-automated mapping has never been done here. It would take a ton of time..

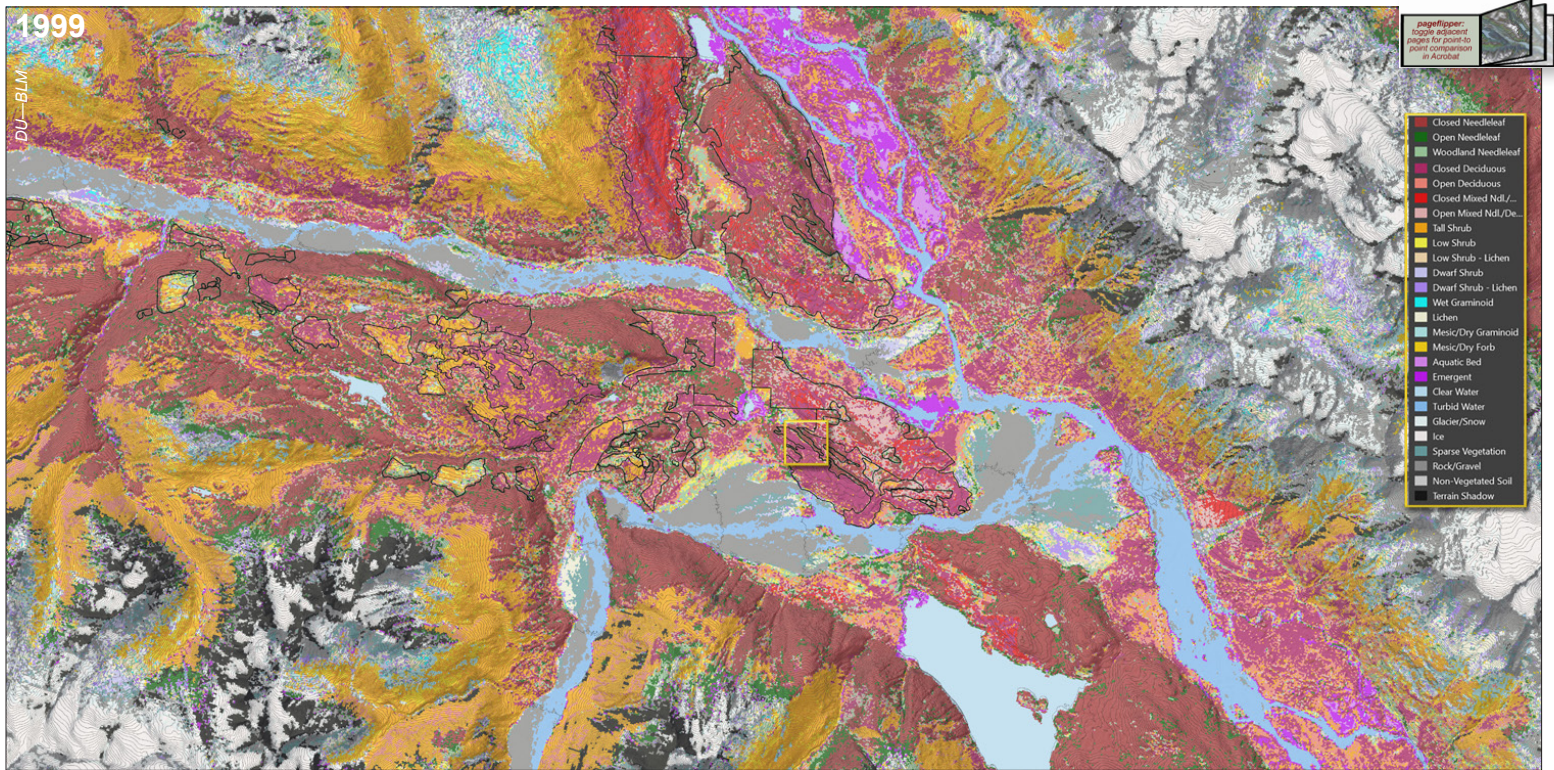




centered on Little Salmon country. NLC has only one option for displaying conifer forest, called "evergreen" and colored darkest green. We can ground-truth a sample

that Nicholas took us to in 2019. It's shown here in that yellow square. I'll defer that comparison to the [following section on hemlock old growth](#). But basically the news is

good; NLC picks up important differences at 30m scale. Meanwhile on this pageflipper pair, toggle back and forth between NLC and a more detailed, locally



customized Earth-cover from Ducks Unlimited and the BLM. Their 2002 report defines and explains these habitats, with helpful photos for some of them.

The kaleidoscope of 26 colorcodes makes me crazy. I find that my eye can only handle about 8 different colors, as in the preceding [bedrock geology map](#). The DU-BLM

team also made some embarrassing ID mistakes (aspen, subalpine fir, etc). But on the whole, I think this map is a great introduction to vegetation of the GCW. Its best

use is for much smaller areas, such as my following comparison in the hemlock old growth. Zoomed in closer in Arcmap, you'll reduce those 26 colors to a manageable half-dozen or so. Because it's a raster, we can't label pixels, but clicking on each 30m-pixel with the *identify* pointer, its *class_name* can be read from the popup: Tall Shrub, Closed Needleleaf, Open Deciduous etc.

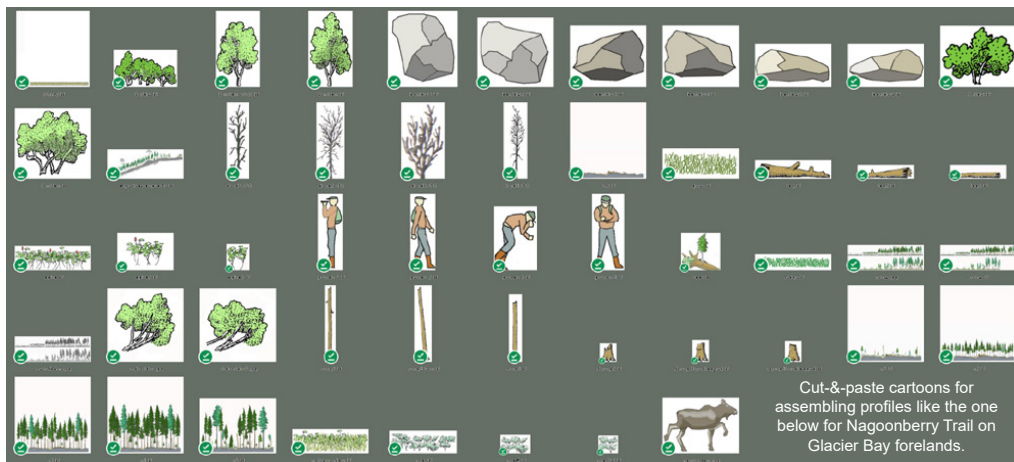
Measures of diversity

Diversity is what the *Atlas* project is trying to capture and convey to residents, visitors and decision-makers. Whether or not we consciously recognise it, floral and structural richness and variety is a huge part of what captures our attention in this glamorous transboundary watershed.

So we need to be clear what we mean by vegetation- or habitat diversity, and how that trickles down, to butterflies, mountain goats, toads, sockeye salmon, locations of mid-holocene cultural sites, and economic drivers for today's two-legged residents.

To be developed:

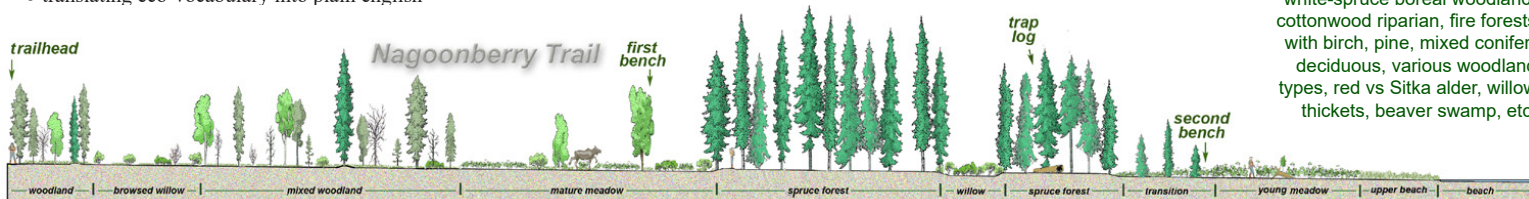
- alpha (within habitat) beta (between habitat) gamma (within region)
- species richness,
- translating eco-vocabulary into plain english



- structural diversity: forest vs woodland, etc
- floristics

Cut-&-paste cartoons for assembling profiles like the one below for Nagoonberry Trail on Glacier Bay forelands.

I need to create some new tree cartoons to add to the Caouette collection, for species and growth forms of the GCW. Then start generating block diagrams for types such as: OG hemlock, Sitka spruce riparian, white-spruce boreal woodland, cottonwood riparian, fire forests with birch, pine, mixed conifer-deciduous, various woodland types, red vs Sitka alder, willow thickets, beaver swamp, etc.



Late Quaternary vegetation history

Deep history of vegetation development through ~17,000 years since the LGI (last glacial incursion) is mostly reconstructed through peat and lakebed cores by palynologists. A thorough review for Southeast Alaska has been published by Ager (2019), who included results from a Cwynar (1990) study at Lily Lake on Chilkat Peninsula.

It's not my purpose here to summarize vegetation trends described in both professional papers and lay-friendly condensed versions such as *Nature of Southeast Alaska, 3rd edition*, page 75. Just a few notes are in order to introduce our *Habitats* section, as reminders of how dynamic this history has been, and how the Greater Chilkat Watershed fits into a larger picture of change in Lingit Aani.

Although subtle, gradually younger dates for earliest conifer arrivals can be seen on this map, moving northwest through the archipelago. Ager (2019) noted this in regard to spruce:

"[16.7K at Heceta] suggests possible refugia for spruce in the SW Archipelago or adjacent continental shelf. [Elsewhere] spruce first appears at onset of Holocen, 11.6–11.3K or soon thereafter. Spruce was somewhat later arriving at Pleasant Island and Lily Lake at 10.5K, suggesting a south to north migration from Mitkof Island of 240–300 km over a millennium."

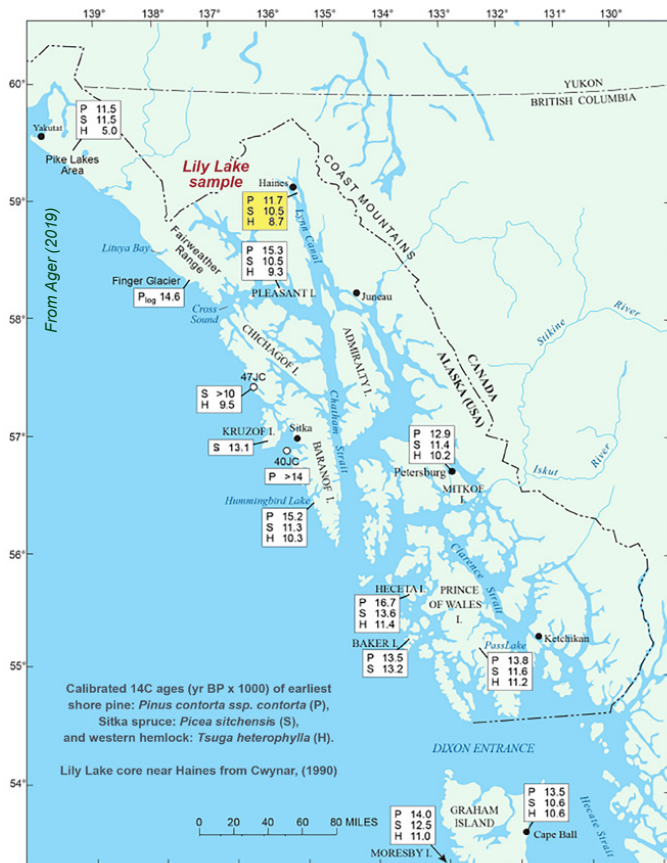
Here's the abstract from Cwynar (1990):

"Pollen and plant macrofossil analyses of a radiocarbon-dated core from Lily Lake . . . [show] a *Pinus contorta* woodland with abundance of herbs and ferns initially established after deglaciation 10,870 BP. By 10,330 BP, *Alnus viridis* was a significant component of pine woodland while herbs and other shrubs declined. At

9,480 BP, *Picea sitchensis* and *Populus* were locally present and *P. contorta* populations declined. *Tsuga heterophylla*, which dominates the modern vegetation, became locally established at 7,880 BP. The last major component, *Tsuga mertensiana*, joined the vegetation about 6,710 BP. The modern closed forest, dominated by *T. heterophylla* and *P. sitchensis*, became established about 2,870 BP. Arrival times for dominant species are compatible with dates from other studies that suggest a northward migration along the coast."

That conclusion from Cwynar (1990) has held up well in light of Ager's summary. And although most of these peat-core-based dates seem ancient, perhaps suggesting a relatively 'fixed' forest type and structure since the early Holocene, note that the Lily Lake cores show the hemlock-spruce "modern closed forest" has only been the 'norm' on Chilkat Peninsula for about 3,000 years.

1 Cwynar (1990) was published before C_{14} calibration curves "pushed" these dates earlier. Thus, Ager (2019) transposed 9.5K to 10.5K.



Flora on the edge

Nicholas Szatkowski

Here's a beginning list of some of the dry-associated plants in the Chilkat Valley. It falls short of detailing the range of species in the whole valley, but is a start toward describing special plant communities of the dry zone, from approximately 8-mile to 20-mile on the SW face of the Takshanuk Mountains.

Continentially-associated plants/communities in GCW dry sites:

Plants of driest, S-facing sites, on well-drained, rocky soils. Communities with pine-parkland, abundant ground lichens (*Cladonia spp.* and others), and a mix of:

- *Phacelia serica* (silky phacelia). I've seen only on warm, dry rocky sites next to Haines Highway from 10-mile to 14-mile. Chilkat specimens apparently disjunct from other occurrences by 500 km or more.
- *Apocynum androsaemifolium* (spreading dogbane). On dry, semi-open, S-facing slopes of Takshanuk Mountains; possibly elsewhere.
- *Sedum divergens* (spreading stonecrop). I've seen only on warm, dry, piney, SW- or S-facing slopes along the lower Takshanuk Mountains from 10-mile to 20-mile
- *Saxifraga tricuspidata* (prickly, or three-toothed saxifrage). Spread throughout the valley on semi-open, S-facing slopes. Prominent in the driest areas, but also more widespread, from Chilkat Inlet to cliffs at Chilkat Canyon (upstream of Tahini confluence).
- *Pinus contorta latifolia* (interior, or rocky mountain lodgepole pine). Distinct from shore pines (*P. c. contorta*) in morphology and cone orientation. Mainly on sunny, S-facing slopes. Abundant on slopes of Takshanuk

from 8-mile to 16-mile, and on Turtle Rock near Tahini confluence. Also scattered on favorable S-facing slopes from Lynn Canal to Chilkat Canyon, Little Boulder Creek, and Devil's Elbow.

- *Juniperus communis* (common juniper). Relatively widespread, on dry sites.
- *Collinsia parviflora* (small-flowered blue-eyed Mary). On warm sites from 10-mile to 16-mile. May be more widespread, but small and inconspicuous, especially after spring bloom. Chilkat is near NW range limit, although Bruce Bennet has collected it near Carcross and Tagish Lake.
- *Symphoricarpus albus* (snowberry). On dry slopes. Abundant around Klukwan.¹ May not occur anywhere else in Alaska. Known to some people in Klukwan as "owl berry".
- *Arctostaphylos uva-ursi*. (kinnickinnick, or common bearberry). Dry sites from sea-level to alpine.
- *Ribes triste* (northern red currant). I have one photo from approximately 1000' elev. at 20-mile. Seems not to occur elsewhere in SEAK, but grows in interior and S central AK, and is circumboreal.
- *Populus tremuloides* (quaking aspen). I have only seen one occurrence, on S-facing slope of Takshanuks at 20-mile (I have photos), with at least one large clonal patch with hundreds to thousands of stems, and other multi-aged trees and saplings. E-Flora BC lists 2 collections from other parts of valley (13-mile and "woods SW Mosquito Lake"), but I have never located aspens in these areas.

¹ RC: Could it have been a precontact transplant?

Alpine:

- *Arctostaphylos rubra* / *Arctous rubra* (red-fruit bearberry). Alpine, throughout Chilkat watershed. Distributed across arctic and boreal North America. Evidently also collected in alpine on karst on NE Chichagof and Mt. Calder on POW. (E-Flora BC)
- *Arctostaphylos alpina* / *Arctous alpinus* (alpine bearberry). Apparently collected near Tina Creek along Canadian portion of Haines Highway, in pass area between Klehini River and Stonehouse Creek (E-flora BC). I know of no other observations within Alaskan portion of Chilkat. Distributed across arctic and boreal N America, including Mt. Katahdin, Maine.
- *Zygadenus elegans* / *Anticlea elegant* (mountain death-camas). Alpine / subalpine. On Sunshine Knob, Flower Mountain, Takhin Ridge, and Chilkat Pass area. Possibly other inland alpine areas. Apparently collected by Mary Stensvold 1 km N of Endicott River (E-flora BC).²
- *Cassiope tetragona* (four-angled cassiope). Alpine throughout Northern Lynn Canal, but apparently not elsewhere in Southeast Alaska. Circumpolar.
- *Phyllodoce empetriformis* (red mountain-heath, or pink mountain-heather). Alpine, on Flower Mountain, and other interior mountains in Chilkat, and at Chilkoot and White passes. Rare in Southeast Alaska (doesn't occur in other parts of Alaska); Western cordilleran distribution. One of the 2 species of conservation concern collected by ANHP during a vascular plant survey of Klondike Gold Rush Nat'l Park.
- *Diapensia lapponica* (diapensia). Alpine.

² efloraBC has nothing even close for ZYEL. For ANEL,

Apparently absent from the rest of SEAK. Circumpolar.

- *Ledum decumbens* (narrow-leaved Labrador tea).

The "regular" Labrador tea (*L. groenlandicum*) occurs throughout the area in low-elevation muskegs. I believe the narrow-leaved species is particular to alpine wet spots. Chilkat alpine areas, but I think not in the rest of SEAK.

- *Dryas drummondii* and *dryas octopetala* (Drummond mountain-avens and white mountain-avens). I am not good at distinguishing between these 2 species, but literature and E-flora BC indicate that they both occur in inland, alpine areas of the Chilkat watershed.

- *Abies lasiocarpa* (subalpine fir). I have photos of the one occurrence of this species in the Chilkat that I have seen or ever heard of. It is an isolated (clonal?) stand at about 3,300' elevation, surrounded by shrub-tundra on a broad, open, N-facing slope upstream (to the East) of Kelsall Lake. Of course, this species is widespread around White Pass.³

Widespread continental associates:

- *Geocaulon lividum* (northern commandra).
- *Chimaphila umbellata* (pipsissewa). In temperate forests across N America and Eurasia. Not in wetter parts of outer coast. Alaska occurrence only in Northern SEAK; this population may be disjunct from closest range in central BC.
- *Viburnum edule* (hibbush cranberry). Extremely widespread in central and upper valley, in forests and

open areas. Best berry production in sunny areas, where berries are heavily fed on by brown bears.

- *Rosa acicularis* (prickly rose). These roses in the Chilkat, at least in certain parts of the valley, often grow to prodigious size (3m or more).

- *Betula papyrifera* (paper birch)
- *Polemonium pulcherrimum* (pretty Jacob's ladder)
- *Linnaea borealis* (twinflower)
- *Acer glabrum* (rocky mountain maple). Favored moose browse.

- *Dryas integrifolia* (entire-leaved mountain-avens). Abundant and widespread on well-drained, boreal-influenced, glacial river floodplains, such as Klehini and Tsirku Flats, where it can form an extensive, single-species, ground-covering mat. These areas, covered with *Dryas integrifolia*, patches of soapberry, groves of diminutive poplars, and supporting willow ptarmigan and snowshoes hares, have a distinctively boreal character, and strongly reminiscent of river flats in the Yukon. (with the 2 alpine *Dryas* species, it appears that the Chilkat Valley supports 3 species in this genus).

- *Shepherdia canadensis* (soapberry or soopallalie). Common on dry, well-drained sites throughout central and upper Chilkat Valley. Widespread on boreally-influenced, glacial river floodplains, such as Klehini and Tsirku Flats. Important food plant in traditional Tlingit culture.

- *Artemisia tilesii* (wormwood or mugwort). On dry, well-drained, gravelly soils throughout valley. A good native pioneer species. Known as wormwood in Klukwan, but I haven't heard of any traditional medicinal use locally.

Norton-notes

John Norton

John has assembled a bibliography of resources for plant mapping and habitat descriptions for the GCW.

20250126 GCW Atlas meeting: Plant Inventory as part of Environmental Resource

"Pojar and Mackinnon (1994) have suggested that the head of Lynn Canal is the greatest center for plant diversity in Alaska." Carlson et al 2004 pg 9.

Land Cover Classification styles: splitters & lumpers L. Vierek 1992: Land Cover Classification Bible

Paustian et al 1994 KGLO Ecological Inventory Land Cover Classifications Plant Associations Species List with common names Species Abbreviations Soils at sample sites Macroinvertebrate sampling and list Elaine Gabrielson 1993

M. Shephard 1995 Yakutat Forelands Glacial terrain / Geomorphology system Community Types system Detailed discussion of associations, defining characteristics of sites. Shoreline tidal Flats class Floodplain class

Martin, J. et al. 1995 Tongass Forest Chatham Area Plant Associations Teaches basic plant ecology while discussing plant assoc. Based on observed plant communities Forest Series focus only, no Shoreline Soils included Indicator species Table 2 used to define plant community designations Species list, abbreviation codes, common names Plant compass aspect Appendix Table 2

Parker, C. 2001 Haines Vascular Plant Inventory 22 sites around Chilkat Watershed, 2 sites Skagway, 1 Katzehin R. 416 plant species (not exhaustive) list with locations Plants of special note Takhin Ridge carbonates and plant diversity Digital database of study available

Smith, W. et al, 2001 Bird, Mammal, Vegetation Community Survey Tongass USFS Useful for list of birds, mammals common and species names

³ BLM 2002 Earthcover report says subalpine fir is "infrequently associated with the spruce trees at lower elevations, [but] more commonly found in stunted, bushlike krumholtz form at higher elevations."

BLM/Ducks Unlimited 2002 Haines Earth Cover Study Spectral analysis satellite imagery Landstat Thematic Mapper (TM) Helicopter verification for majority of the sites 175 sites 86% verification of class assigned by software Classification Decision Tree Appendix G Field Forms for Haines Photos for Earth Cover classes Digital database of study available

Carlson, M. et al 2004 KLG0 Vascular Plant Inventory 175 individual taxa, 55 new species added to Park list 330 verified species User guide for digital database access Page 57 Pink Mountain Heather example of value of this document

Carlson, M. et al 2004 Glacier Bay Vascular Plant Inventory 300 taxa identified and listed Site descriptions with photos very helpful, some correspond to Haines Organized around site selection for diversity of samples User guide for digital database access Arcview GIS ESRI.com

Boggs, K. et al Glacier Bay Landcover and Plant Associations Landcover Classification system may be very useful for Haines Landcover map via Landstat and helicopter verification Plant associations descriptions add detail and definition to Land classes. 70 ground plots 10m x 10m for plant associations verification All data available via Glacier Bay Field data viewer (NPS) Site pictures very helpful

Boggs, K. et al. 2010 Gl. Bay Chronosequence Deglaciation Alpine, sub-alpine plant communities Interesting in view of glacial and snowfield melting in Haines

Flagstad, L., Boucher, T. 2015 KLG0 Landcover classes and Plant Associations Key to designation land cover class, especially shrub class Very useful descriptions and photos Full species list, common names, abbr. symbols

Flagstad, L., Boucher, T. 2017 KLG0 Vegetation change 1948, 1979, 2003-5nPhoto interpretation and ground study documents veg. area

Where to go from here:

What will a useful to people *ie* how can this information be applied

1. Informational materials: brochures, flip packs, signage
2. Locations for educational settings: Haines Huts, Dog Beach, Deishu boardwalks, etc.
3. Scientific research, improving data set for Haines
How to integrate the studies and data sets in the above documents into the GCW Atlas.

Forest & scrub

xxxx

- forest versus woodland
- 'marrying' the US National Land Cover to Canadian mapping units
- disease&damage layer
- Streveler's observation about old forest restricted to coastal areas outside the rainshadow. Basically Jiḻkoot vs Jiḻkaat Aani.

201907 mtg notes: ¹ Some notes from LCC members on habitats and succession:

- Ben: 7 mile saddle, pine, birch, large spruce, some mention of fir on peninsula?
- Eric: we need a map of remaining old-growth forest, 26 mile has some. There are few developed trails, so it is difficult to access old growth for people to see it and care about it. What sort of old growth corridor remains?
- Nicholas can show us old growth near the Little Salmon. (*PS, RC: my notes for 0708 describe an almost pure hemlock OG forest. Does any of the mixed cottonwood-spruce type qualify as old growth?*)
- Maps of forest structure, successional condition
- Mario: Basin around Kelsall lake: white spruce, lodgepole pine, subalpine fir, mtn hemlock, very diverse.
- Don Hotch: Seaweed. Sea asparagus doesn't grow any more, used to be subsistence picking, mushrooms, moss (?)
- R: St James Bay has glasswort. anything N of there?

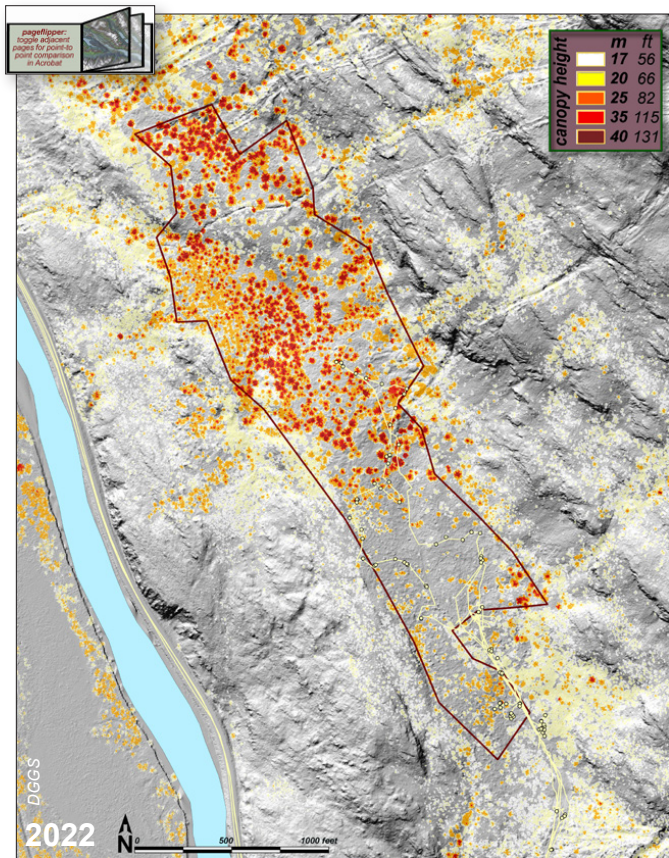
¹ On our preliminary meeting with LCC/Takshanuk, 20190706. Cathy Pohl kept notes that can be read in their entirety on pages 6-8 of journal for that visit

Canopy cartography

LiDAR is a game-changer for folks engaged in forest ecology and timber issues. Examples in this atlas have so far emphasized 'last hit' laser-pulse returns that show us 'bare-earth' land-forms, achieved by stripping away returns from vegetation. Foresters, in contrast, want the whole point cloud, which gives us extraordinary three-dimensional 'pointillist' images of trees, shrubs, and stand structure.

In addition to those fine-scale profiles, or even video stand orbits, we can create a canopy height model or CHM. By subtracting DTM (T for terrain or ground level) from DSM (S for surface of highest leaves and branches), we can generate these height models. With my new lightning-laptop I've just (post-Origin-crash, late summer, 2024) churned one out for the entire coverage of the awesome 2022 DGGS LiDAR.

On right is the how canopy looks on 13-mile bench, where LCC/Takshanuk teams have been surveying one of the State's proposed timber targets. It's a pageflipper; toggle against following page for an orthophoto version, and a spectacular nadir drone view from Derek.







From LCC/TWC surveys at 13-mile





2019

Hemlock old growth

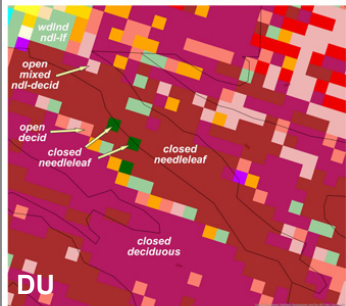
We don't have a good understanding of either the historical (pre-logging) or current extent of old-growth forest in Greater Chilkat Watershed. Palmieri, ADOF (2015), page 11 states:

According to our recent inventory most of the trees in the valley are around 200 years old.

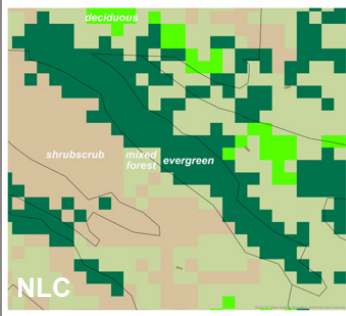
This matches my impression of the forest Nicholas Szatkowski showed us in July, 2019.



In the introduction to this *Habitat* section I compared 2 vegetation structure covers, National Land Cover (NLC) and a more detailed EarthCover from Ducks Unlimited. Our visit to a rare, barely-old-growth hemlock stand in July, 2019 with Jessica's family provides an opportunity to test whether these layers can separate conifer from deciduous forest types. On right is a view of the stand from my drone flight over Little Salmon marshes. The asterisk marks about where I took the photo on previous page. Likewise, on left, top panel, a white asterisk marks the photo.



The clearcutting layer for Haines State Forest is shown in white boundaries on the top panel, and black for the lower two. Forest NE from the conifer strip was removed in 1969, and to the SW in 1974. We can safely assume that everything cut was larger and more valuable than these remnant hemlocks. Perhaps more spruce? ¹ What is now a rare forest type was a common and majestic habitat prior to the State's assault on GCW conifers.

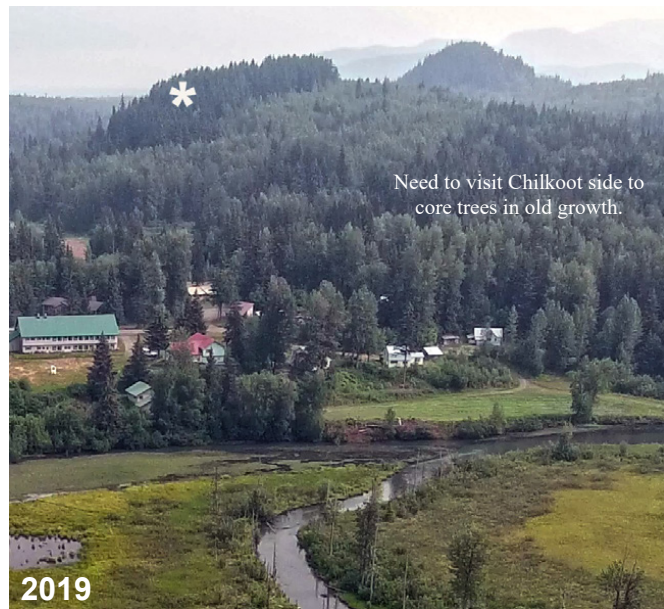


Loggers on Alaska's federal southern timberlands refer to these leave strips as the "*monk's fringe*." I don't know why this narrow band was allowed to remain on State Forest, but in some areas a few conifers were retained along ridgetops on the supposition that they'd reseed the clearcuts below for the benefit of future, hungrier loggers.

Obviously, it didn't work in this case. Half a century later the scrubby crowns on either side remain a sea of deciduous young growth.

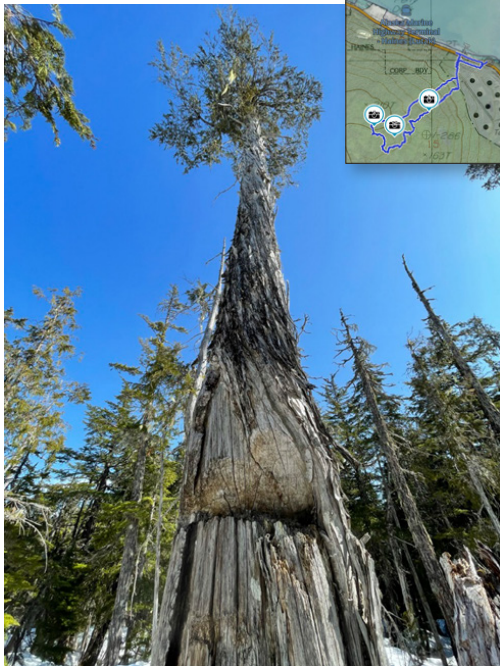
National Land Cover—the bottom left panel—did a good job mapping the monk's fringe. When I first exported this pair, I thought the DU/BLM cover missed it. But

¹ If stumps remain, 55 years later, close examination might reveal ratio spruce to hemlock. I doubt rings are still countable.



that's only because their color choice was so screwy. Note the almost identical colors for closed deciduous (dark pink) and closed needleleaf (red). And if you're one of the high % of colorblind males, don't even try :)

I look forward to digesting DU/BLM's habitat distinctions. Right now (early 2025), the simple 4 colors of the NLC are a lot easier to understand.



Yellow-cedar old growth

Eric Holle to Herb Hammond: I hope you are well. I went out with a friend yesterday to what I believe is the second most northerly stand of yellow cedars in Alaska. It's a bit outside of the Chilkat Valley just three or four miles north of

As a matter of interest, we have an ecological reserve of yellow cedar at high elevation in the Slocan Valley. Yellow cedar does not occur in the interior of BC, except in this one location. This stand may represent a remnant of a glacial refugium.

Seems like the presence of yellow cedar near the Chilkat is another example of the ecotones that occur at a variety of spatial scales in this landscape.

Haines along the road to the ferry terminal. Of particular interest to us was the ax cut in one of the larger trees. Largest diameter we found was about 22 inches and the tallest between 80 and 100 ft. The microclimate in that area produces a lot of snowfall. In open areas we measured snow depths from 120 to 160 cm. So maybe not directly relevant to our project but thought you would find the photos of interest.

HH to EH: Thanks for sending along these photos of yellow cedar. The words "tough trees" comes to mind for me when looking at the photos. Clearly these trees have and continue to survive in stressful climatic and site conditions.

Was it possible to estimate age from the ax cut? When I zoom in on the images of the ax cut, it looks like there are parts of the cut where growth rings are still visible. It would be interesting to count rings for a distance where they are visible and extrapolate that to a complete radius. I would guess that growth did not vary much over time for these trees, if the site conditions are as harsh as they appear that they might be from the photos.

Post-logging young growth

According to ADOF (2015) p11:

" DOF replants our clearcut harvest areas with Sitka spruce seedlings grown with spruce seed from the local areas. While this suggests regenerating units may become pure spruce it is not the case. Hemlock is shade tolerant and there is considerable hemlock ' understory in primarily hemlock stands west of Porcupine Creek. Seedlings remaining post-logging quickly release. Both spruce and hemlock re-generate well after clearcutting especially if mineral soil is exposed. Since adjacent stands are primarily hemlock there will be plenty of seed and regen. Our precommercial thinning favors the most dominant species. The spruce beetle infestation from 1989 to 2005 is a good indicator why we do not want monocultures of just one species.

And from ADOF (2018) Baby Brown Sale. p33:

" stands identified for harvest in this sale are composed primarily of Western Hemlock. The DOF anticipates natural regeneration composition to return similarly in Western Hemlock. The natural state of the stand is close to a monoculture. The DOF believes natural regeneration of that species will not adversely impact ecological forest stand dynamics. Per the requirement of the FRPA, the DOF will examine harvest areas to determine if natural regeneration is occurring successfully over the next 5 years. If DOF determines the stand does not meet minimum stocking levels required by the FRPA, we'll likely plant seedlings to meet those requirements. Planting of such stands with Sitka Spruce seedlings is typical in the area to provide a more diverse composition while meeting regeneration goals. Sitka Spruce has been used in this capacity by DOF in the past with good results.

¹ Meaning unclear. Perhaps that DOF tries to emulate pre-cutting spruce:hemlock ratio in thinning prescriptions?



Mixed deciduous: fire origin

To Southeast Alaskan outdoorsfolk or naturalists accustomed to spongy moss understories and moldy hemlock old growth, the forests of Jilkaat Aani can feel like a different bioregion. In fact, they *are*. Only a few miles upriver from the harbor at Deishú (Haines), precipitation drops by xxx (do we have good data from comparative rain gauges, in town and out-the-road?)

Journal excerpt from our [Repeat photography](#) visit (Carstensen & Hocker, 2005b)

"1915 fire Here are 2 views taken shortly after the great Haines fire of 1915. We didn't have time to retake them, and in fact they would be quite challenging. It's possible that the photographer of the upper view (g04052) had to climb a tree



even to get the original shot; we can find no rock outcroppings in stereophotography of this uniformly forested, ~1000-foot knob. Old-growth trees lacking low branches are difficult to climb, and it's hard to predict from the forest floor which tree top will give you an unobstructed view of your target. You often have to climb a succession of trees before finally locating one with a clear view.

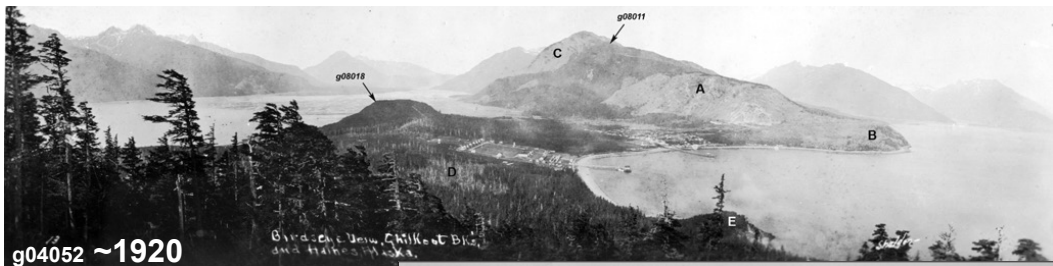
The photographer of shot g08018 was aided by the great fire, which temporarily unveiled the striking view southward over Chilkat Inlet. Today, this view has again disappeared behind trees.

On each photograph we've shown the positions of other photopoints in our collection. Using all of the photographs together, along with the landscape-replication capabilities of ArcScene and Google Earth, it would be possible to produce a fairly accurate map of the total extent of the 1915 fire.

The most obvious scar in the upper photo is at **A**, already discussed in our photopair from Eagle's Nest Hotel (see also vegetation notes from Ripinsky trail climb). This huge patch extends all the way out to Pt Nukdik at **B**. It's possible the fire also burned parts of the very steep south face of Mt Ripinsky at **C**. However these cliffs remain barren today and may never have had thick enough forest to catch fire. An isolated small burn south of Fort Seward shows at **D**.

In contrast, notice the lack of burn evidence at **E**. In the 1943 view from g04047, we noted that the area had pale second-growth forest but that the boundaries suggested logging rather than fire. The upper shot clearly shows that at least it wasn't part of the 1915 fire.

In g04049, taken from the 280-foot hill southwest of Fort Seward, almost the entire foreground has burned. Exceptions are patches at **A** and **B**; these can be seen from a higher perspective in g04046. Point **C** shows that the fire continued all the way to the southernmost 1450-foot knob on Chilkat Peninsula.



Across the inlet at **D** there is a puzzlingly low forest limit. Forest is still restricted to fairly low elevations here today, so its upper limits may be controlled by perennial slides rather than fire. These narrow belts of toe-slope conifers are characteristic of much of the steep-walled Chilkat River complex.

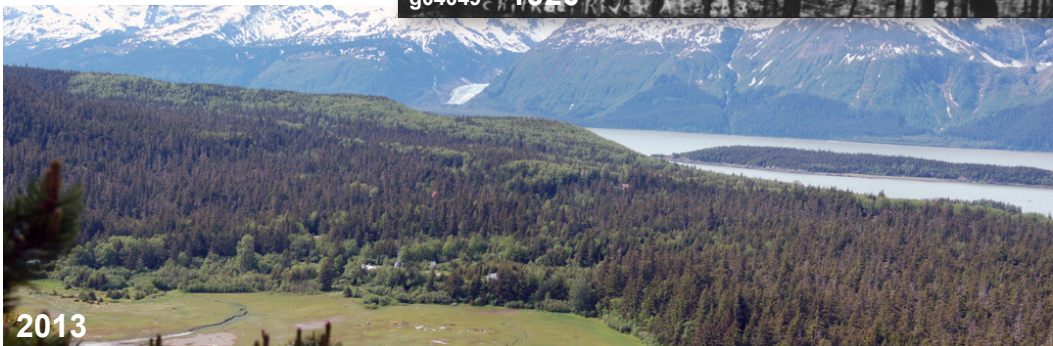
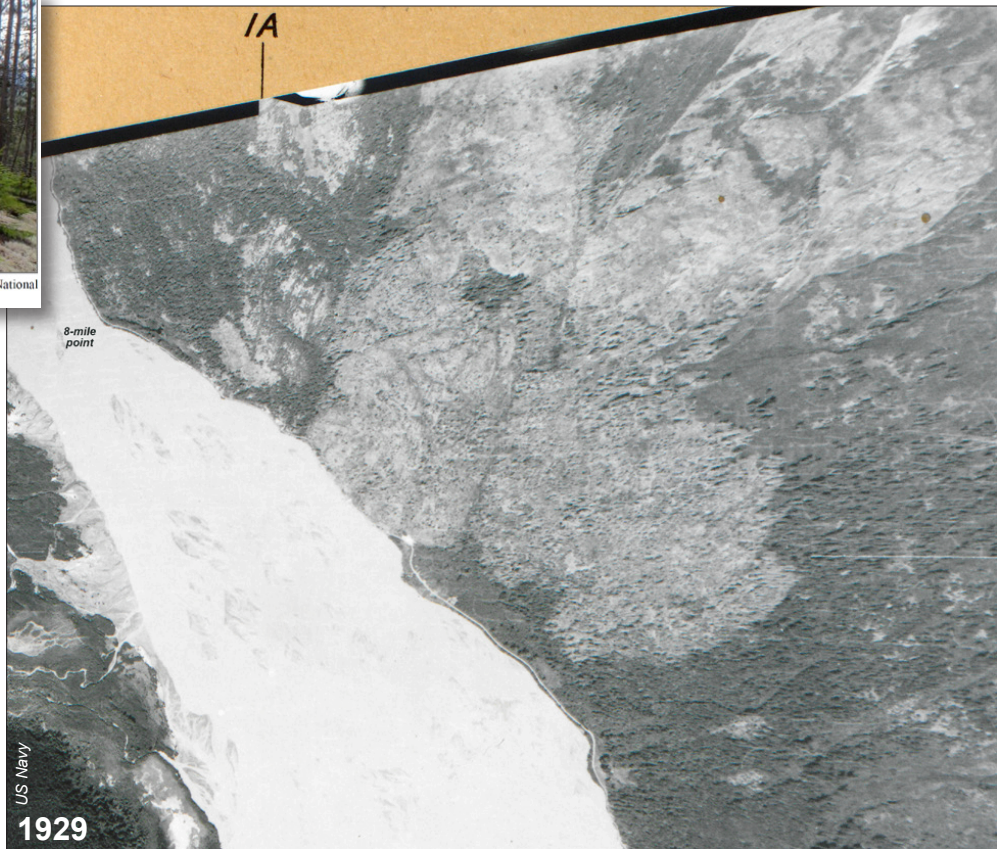




Figure 133. The *Pinus contorta* var. *latifolia*/*Cladina* species Plant Association in Klondike Gold Rush National Historical Park, Alaska (photo by L. Flagstad).

Nicholas S directed us to the lovely Boggs *et al* (2019) descriptions of conservation-concern habitats, which includes a locally common but regionally rare *Pinus contorta* var. *latifolia*/*Cladina* spp Plant Association. Their type locality is in Ferebee but it's widespread on dry granitic slopes above Haines Highway.

Judging from historical photography, fires seem to have been commoner in early days of Euro settlement on the Chilkat and Skagway surroundings. In 2005, Kathy Hocker and I, coming from wetter rainforests to the south, were intrigued by this and devoted the lions share of our photo retakes effort to deciphering fire history. Here, at the palpable transition from coastal to interior microclimate, around 8-mile on today's highway, a crispedged fire scar of about xx acres seems to have burned right down to the early coastal road.



Mature cottonwood forms
a tall-tree woodland on
the alluvial plain of Little
Salmon River



Cottonwood: alluvial

XXXX
XXXX



Kevin White

Chilkat River and the Takhinsha Range, 9/29/20

1990



2019

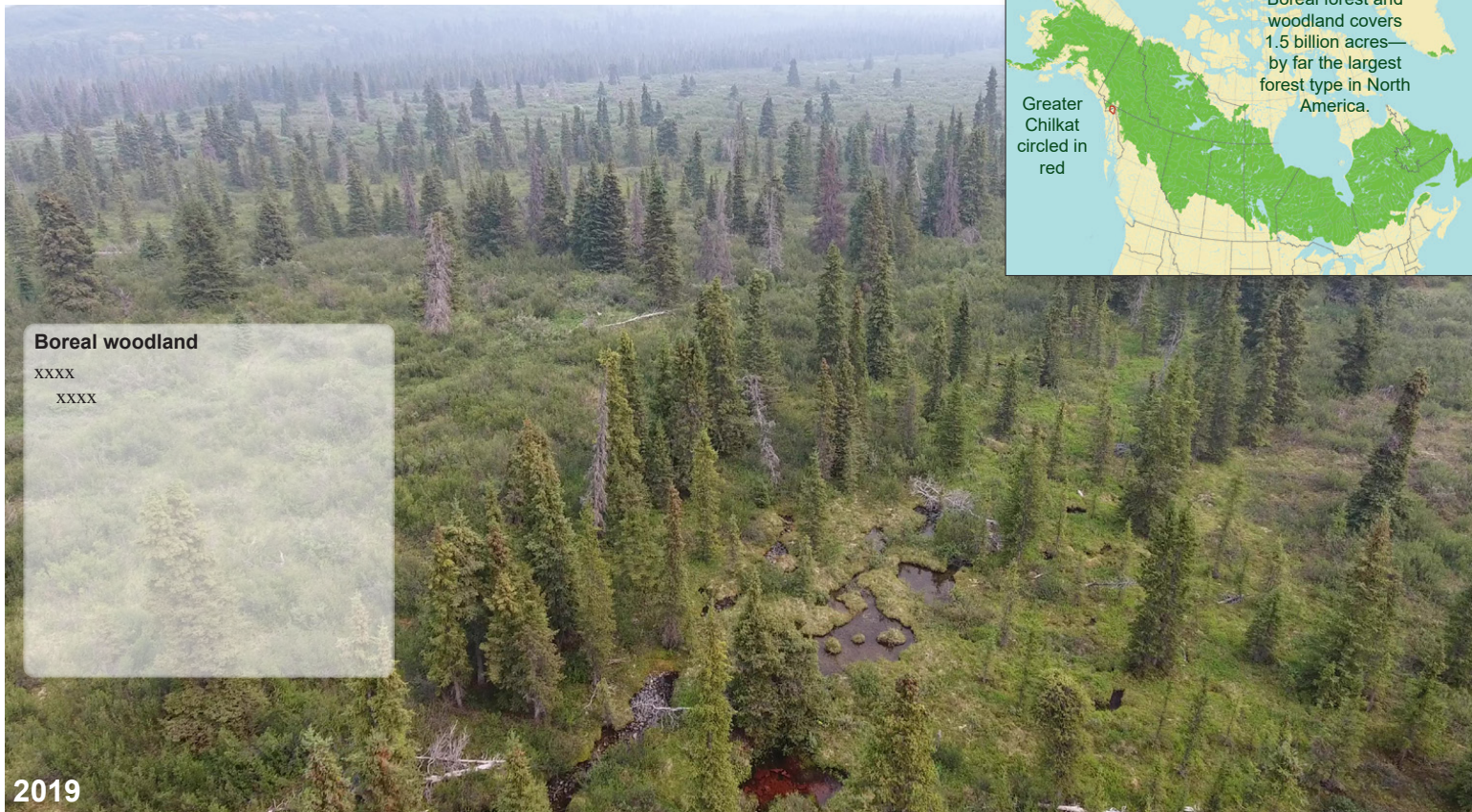
Left: Hydrologist Dan Bishop bushwacking through tall-shrub willow thicket below Yandeist'akyé, *faraway stuff drifts ashore* (Yindastuki) during our studies on airport expansion, 30 years ago. Stem on right was ridden down and snapped by **moose** seeking uppermost twigs. Moose can have a profound influence on shrubland succession. • **Above:** Bull **moose**, just up and right from center, moves into tall-shrub willow cover on the headwaters of Stonehouse Creek [noTN?]. ¹ Until my irritating 'bee-swarm' camera went over 4 minutes earlier, he'd been siphoning succulent aquatics off the bottom of that pond. Well above conifer forest limit, rolling highlands near Nánde Héeni Yei Kéich Yé, *sits in water facing north* (Three Guardsmen) don't offer many places for animals this big to hide.

Shrublands

The National Land Cover maps 2 categories of shrublands: dwarfshrub and shrubscrub. In Canada, they also distinguish shrub-low from shrub-tall. Whether or not height thresholds and photo-search algorithms are identical [??? [check on this](#)], we can 'crosswalk' these trans-boundary classifications to map shrublands throughout

XXXX

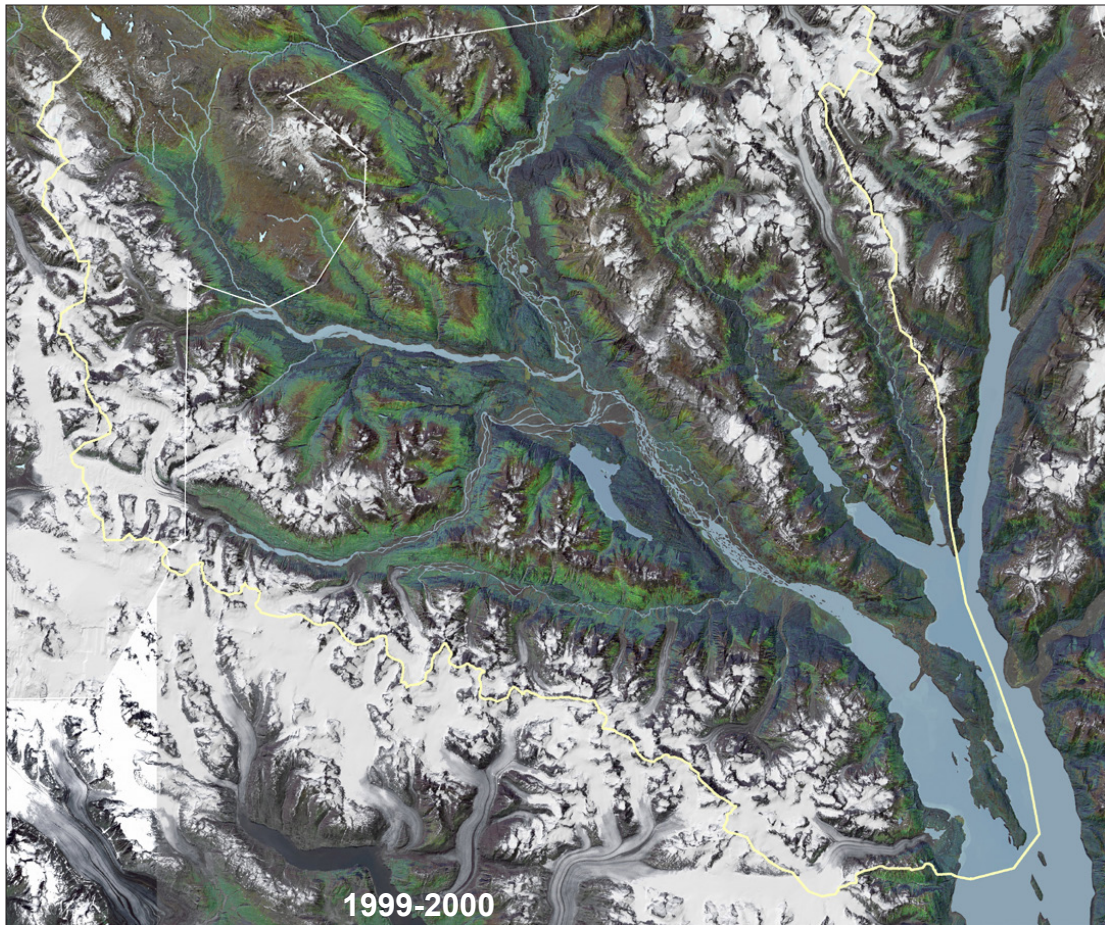
¹ At least Stonehouse is not an IWGN. It's named for the Stone House boulder monument erected in 1838 by the Tlingit guides of Lindeman (Henry, 2017, page 46). As for Three Guardsmen Mountain, Pass, Lake, etc, this is over the border, so not explained in Orth (1967). A BC website— <http://apps.gov.bc.ca/pub/bcgnews/names/15822.html> —says the cluster of 3 summits was named after the explorer Glave in 1924) * *Name changed to Three Guardsmen Mountain 1 September 1957 on 114P/9, being the local name for this group of three peaks. [the highest (northernmost) of the three peaks retained the name Glave Peak " (my italics) Sounds like the BC Geographical Names Office has a somewhat more respectful naming protocol than our US Bureau on Geographic Names. But was that "local name" Lingit, Tutchone or European? In the BC database, the original Stone House has collapsed to "Stonehouse," and no background story is given. • PS 2022: John Norton say's he's searched with friends for Stone House monument, unsuccessfully.*



Boreal woodland

XXXX
XXXX

2019



Four-band panchromatic satellite image at 30m pixel, mosaicked from 1999 and 2000 imagery, with colors adjusted to best elucidate key forest and scrub habitats.

Can I get a more up-to-date landsat from Whitney at NPS, with identical color-band settings, that also reaches farther north, to the top of the GCW?



Wetlands

XXXXXXXX

review of NWI (National Wetlands Inventory)

Palustrine emergent (PEM)

XXXXXXXX

true bogs only on Chilkat Peninsula?

2019

Scrub shrub (PSS)

xxxxxxx

eg, willow wetlands.

whatever the canadian equivalent of PSS is, should be lots up in the alpine dwarf birch & soapberry elevations. But are they actually wetlands?

Is PFO a meaningful unit here? In 'typical' SE AK, I think of this as sparse, small-tree hemlock or cedar old growth on shallow peat more aptly called woodland than forest. If it exists, it'd probably have to be on the Chilkat Peninsula, and I don't see anything obvious on the orthos



Beaver workings

XXXXXXX
XXXXXX.

2019



Tidal marsh and uplift meadows

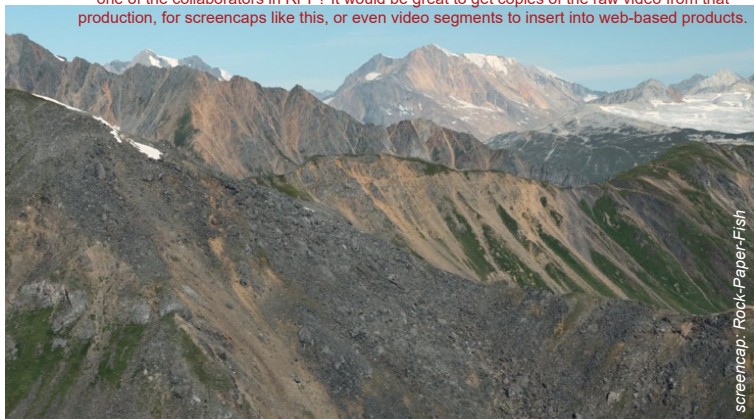
XXXXXXX
XXXXXX.

Alaska Shorezone sec05_ml_0828

Mud Bay [noTN?] on Chilkat Peninsula. Ref to Sealtrust journal

2005

I think it was Mario who mentioned this was acquired from a drone-flight? Maybe by Colin or one of the collaborators in RPF? It would be great to get copies of the raw video from that production, for screencaps like this, or even video segments to insert into web-based products.



NW from Palmer holdings to Little Jarvis glacier in right distance.

Highlands

Getting up into high country should be a priority for my next visit. Except for the 3-guardsmen area I have zero experience at elevation in the Greater Chilkat. Tons of interesting questions about these habitats:

- How variable is alpine/subalpine between the 'typical' coast and drier canadian-style interior?

- xxx
- xxx

xxx

"Traditionally, they say the mountaintops were like our fenceposts here"

Jones Hotch, Klukwan, *Rock paper fish*, (2018)

Subalpine meadow



xxx

xxx

Alpine tundra

xxx

xxx

notes on a climb to alpine from the Tat are in my journal for 19930724. permafrost question. Has anyone mapped its extent on AK side of border? See note, next page.

will add section on the Flower Mountain study by cathy and colleagues.



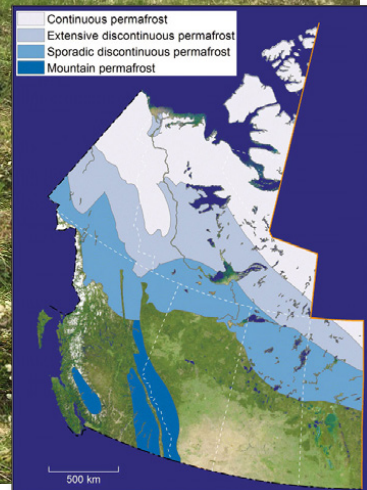
Assigination Pass in winter. Takshanuk Ridge to left, upper Chilkoot River on right foreground, Assigination Creek flowing north to the Chilkat River in the distance. 2/5/21

Hole in the wall ridge, Takhinsha Range, 9/5/20





Tussock tundra. Ref to Chilkat journal & permafrost questions. On p6 of journal, is ref to increased sliding across highway due to permafrost melting on ridges.



Invasive flora

AK Epic, Koren's 202007 surveys

Marine environment

Phytoplankton

We have a pdf from LCC members Cadie Buckley & Arjun Raman titled *Phytoplankton: the intersection of light and water*. Their websites are phytofarming.org and unfundedscience.com. I'm struggling with how to fit this 3-page paper into the GCW Atlas, as it seems (to me at least?) to shed no light on matters of biogeography.

However, these folks have PhDs and a way bigger vocabulary than me. Arjun could no doubt explain the errors in my thinking.

Til then, I'm inclined to draw the GCW content line—elevationally speaking—somewhere around Mean High Water. That would exclude all but the highest, transitional elements of our marine environment, including whales, phytoplankton, etc, while leaving open the incorporation of salt marsh vascular plants, such as culturally important beach greens, etc, and species accessible to terrestrial herbivores.

I will, however, keep this draft page as a placeholder, flagging it for discussion with the Atlas 'kitchen-cabinet,' and carving space in the table-of-contents, should anyone want to expand the Atlas seaward.

Fish & wildlife

This begins the *Species* section of our *Atlas*. It will have to be quite selective. After the 'no-brainers'—**eagle, swan, goat, brown bear, sockeye, eulachon**—picking and choosing among the next tier down: keystone species (**beaver**), charismatic (**lynx**) 'umbrella species,' plants and critters symbolic of certain defining attributes such as connectivity or genetic uniqueness.

But after these nominations and selections, how do we deal with the 'leftovers?' Do we present species lists? References to treatment elsewhere? On a brainstorming call with Jessica and Eric, the obvious 2 candidates were sockeye and eulachon. They 'check all the boxes:' iconic 'chilkaters'; deep cultural connections, visually stunning. In the next tier down, it becomes harder to rank one above the other.

Salmon

XXXXX

aside from sockeye and hooligan, what other species deserve 'feature' status in this atlas? King, maybe, because they're mostly absent from the island provinces. Chum, because of their connection to the eagle convergence?

How would a ranking look if you prioritized \$ to the Haines/Klukwan economy? Then, how would that differ for sheer biomass? Genetic distinctiveness? Conservation urgency?

Sockeye

XXXXX

King

XXXXX

Coho

XXXXX

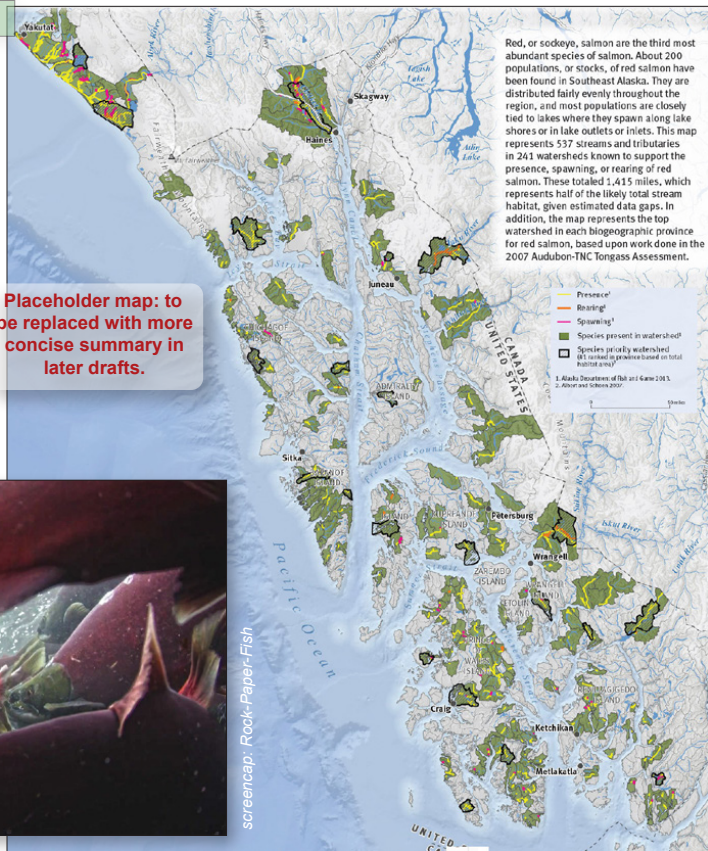
Chum

XXXXX



screenshot: Rock/Paper/Fish

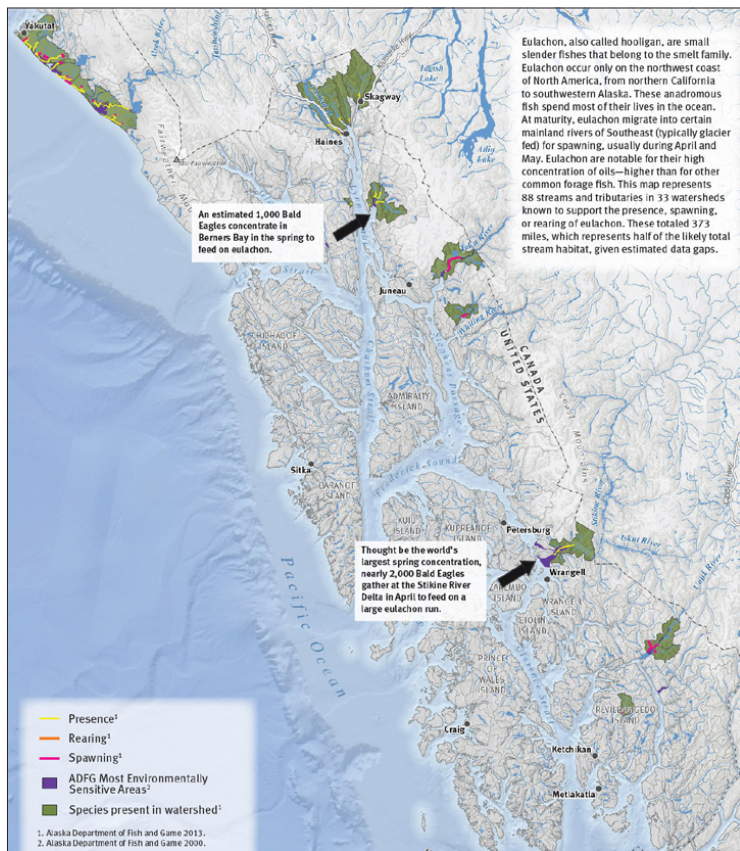
Placeholder map: to be replaced with more concise summary in later drafts.



Eulachon

XXXXX

XXXXXX

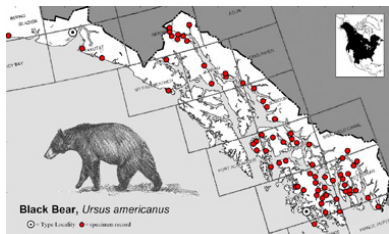


Mammals

Diversity In fall, 1993, Greg Streveler and I gave a class for Haines teachers on natural history—part of a series for communities of northern and central Lingít Aaní. Other schools were at Petersburg, Sitka, Angoon and Hoonah, thus the other 6 columns in the table on right that Greg prepared for each region. Clearly, highest species richness was in the last, Haines column.

S'EEK: black bear

Below is a suggested format for species descriptions, borrowed in part from the Southeast Alaska Conservation Assessment (Schoen & Dovichin, 2007). Not all categories need be included for every species, if there's nothing interesting to say about, for example, genetics. This is just a template that might expedite use of the atlas as a reference or look-up document. I don't propose that *Mammals* be a comprehensive Chapter with many species Subchapters; rather that we select a handful of iconic species, focusing especially on those for whom range maps or seasonal



distribution maps are possible.

Distribution First a generic overview from published sources, followed by whatever we can say about distribution within the project area

Archipelago In this case, a range map from MacDonald & Cook (2007), which also includes a thumbnail of continental distribution. This broader-scale view is essential to understanding the ecological role and conservation issues for common and rare species in Jilkáat Aaní.

Greater Chilkat Not sure if we can create actual polygon range maps for many species at this scale. They'd have to be 'fuzzy-boundary' units, or 'heat maps' showing density gradients, and we don't have the data. (goats, maybe, are one exception?) But we can certainly give verbal descriptions of spatial patterns from knowledgeable biologists and residents.

Land Mammals of Northern Southeast Alaska

SPECIES	Stikine	Mitkof	Baranof	Chichagof	Admiralty	Glac. Bay	Haines
Insectivores							
masked shrew	X	X	X	X	X	X	X
dusky shrew	X	X	X	?	X	X	X
water shrew	-	-	-	-	-	X	X
Bats							
little brown bat	?	X	X	?	X	X	?
long-legged bat	-	-	-	-	X	-	-
Rabbits							
pika	-	-	-	-	-	-	X
snowshoe hare	-	-	-	-	-	?	X
Rodents							
beaver	X	X	I	X	X	X	X
porcupine	-	X	-	X	X	-	-
hoary marmot	X	-	-	-	-	X	X
northern bog lemming	X	-	-	?	?	?	?
deer mouse	X	X	X	X	X	X	X
long-tailed vole	X	X	?	X	X	X	X
meadow vole	X	X	-	-	X	-	X
red-backed voles	X	-	-	?	-	X	X
tundra vole	-	-	X	X	-	X	X
muskrat	X	-	-	-	X	-	-
bushy-tailed woodrat	-	-	-	-	-	-	?
red squirrel	X	X	I	I	X	X	X
north. flying squirrel	?	X	-	-	-	X	X
meadow jumping mouse	-	-	-	-	-	-	X
western jumping mouse	X	-	-	-	-	-	-
Hoofed Animals							
black-tailed deer	X	X	X	X	X	X	-
moose	X	X	-	x	-	X	X
mountain goat	X	-	I	-	-	X	X
Carnivores							
brown bear	X	X	X	X	X	X	X
black bear	X	X	-	-	-	X	X
wolf	X	X	-	-	-	X	X
coyote	?	x	-	-	-	x	X
red fox	x	-	-	-	-	x	X
lynx	-	-	-	-	-	-	X
wolverine	X	X	-	-	-	X	X
river otter	X	X	X	X	X	X	X
marten	X	X	I	I	X	X	X
mink	X	X	X	X	X	X	X
ermine	?	X	X	X	X	X	X
least weasel	-	-	-	-	-	-	?
feral dog	-	-	I	I	I	-	-
Totals	27(4?)	21(0?)	16(1?)	18(4?)	18(1?)	30(3?)	34(4?)
Introduced	0	0	4	3	1	0	0

Key X = established in the wild
 x = rare
 - = not established in the wild
 I = introduced

Genetics Not sure if this is the best title. In Schoen & Dovichin (2007).it's called "*Taxonomic considerations*," but that's probably a bit jargony and formal for our audience. Especially since *ancestry.com* and *23&me*. Most folks are comfortable with "genetics" "Taxonomy" probably means nothing to the average reader (study of the IRS?). However, the later does include insights not only from molecular study and gene-sequencing, but also from more old-school approaches of skull morphology etc.

Habitat To the degree possible, this description makes use of categories and terminology in the preceding *Habitats* section.

xxxxxx
Conservation Trends, threats, opportunities

xxxxxx
References Only a handful of the most relevant publications to be listed here.



Kevin White

Tracks from a brown bear sow and cub scavenging of a mountain goat winter-kill, Little Boulder Creek, 4/14/2020

Xóots: brown bear
 xxxxxx



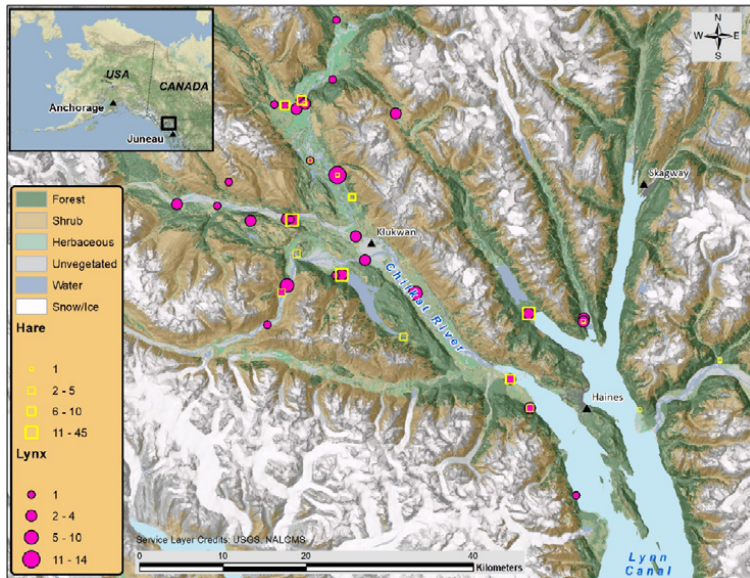
Medium-sized brown bear, Little Salmon River. Pencil is 6 inches.

2019



Kevin White

Brown bear after digging out and scavenging an avalanche killed mountain goat, Hiteshitak Mountain/Kelsall River, 5/27/20



Lynx and hare camera grid events, June 2018 to October, 2020. Anthony Crupi, unpublished data.

Gaak: Canada lynx

by Liz Hofer, 20210330

Biology/ecology Canada lynx (*Lynx canadensis*) or Gaak (local Tlingit name) is an icon of the vast interior boreal forest spreading across northern North America from western Alaska to Newfoundland. However, lynx are also year-round residents of coastal rainforests of Southeast Alaska including the Chilkat Valley. Much less is known about numbers of lynx on the coast and how they live compared to relatively

well-studied populations in the interior.

Canada lynx are medium-sized cats, weighing about 20-25 pounds, with distinctive ear tufts, facial ruffs, and short tails. They appear much larger than they are because of their long legs and thick coats of grey-brown to grey (rarely with a blueish tinge) fur. They have large feet which they use as snowshoes to keep them from sinking deeply in the powdery snow of the boreal forests they typically inhabit.

You can't talk about lynx without also considering snowshoe hares (*Lepus americanus*). Wherever lynx have been studied, their main prey species is the snowshoe hare and their geographical ranges overlap almost exactly. Snowshoe hares have been much studied and celebrated for their "10-year" cycles in abundance in the boreal forest, with peak numbers up to 100-times those at cyclical lows.

Numbers of lynx follow these cycles with a year lag, and lynx may be 15-20-times more abundant at cyclical peaks than at lows. Trappers are very familiar with these large fluctuations in density of animals. Population crashes in lynx are characterized by an almost complete reproductive failure, low survival of adults, and high rates of movements and emigration. When prey becomes scarce, normally sedentary adults will move hundreds of miles in search of better conditions. Recent research in northern Canada and Alaska have documented some epic journeys—the record is about 700 miles—over mountains, glaciers, and unfrozen lakes and rivers by radio collared lynx.

When snowshoe hares are abundant, adult lynx typically establish home ranges of about 5-20 square miles—ranges of males are larger—from which they mostly exclude others of the same sex. There is some overlap though and there is intriguing evidence from snow-tracking and following radio-collared animals that adult lynx may sometimes travel with companions more than previously thought, especially when prey abundance is low. When conditions are good females give birth to relatively large litters of up to 8 kits (4-5 is average) and kits stay with their mother through most of their first year, hunting as a group during their first winter.

Habitat requirements Lynx utilize all forested habitats but are most attracted to denser cover where snowshoe hares are most abundant. They like hunting along the edges of shrub thickets along creeks and rivers. If they can help it, they avoid open habitats such as aspen forest, alpine, or frozen water bodies. Females seek out downed trees or dense shrubs for denning in May.

Snowshoe hares are the preferred prey of lynx in all seasons, although they utilize a wider variety of prey during the summer when they have more options. During periods of prey scarcity, lynx in the interior devote more effort to hunting alternative prey, especially red squirrels; other prey species include voles, grouse, flying squirrels, ground squirrels, muskrats, porcupines, weasels, foxes, waterfowl, and songbirds. Lynx may also kill larger prey such as caribou or thinhorn sheep, but these are nowhere staples.

Lynx typically hunt by slowly stalking through promising cover and capturing prey by bounding after them in short chases. Family groups often fan out and hunt as a unit. When numbers of hares are low, lynx switch more to hunting from ambush beds that they set up near hare runs or red squirrel middens. Lynx prefer freshly-killed prey but will sometimes cache prey remains if satiated and return to them later, and will also scavenge on found carcasses during periods of prey shortage (a recent observation near Skagway shows a lynx scavenging on the carcass of a young mountain goat that was killed when it fell off a cliff).

Past, present and future in Chilkat Valley Almost everything that scientists know about lynx comes from studies in the interior boreal forests. There have been no studies of lynx in coastal rainforests. Native people who have lived here for thousands of years and present-day trappers have a wealth of knowledge about local wildlife but little of that is documented in print. We have started to collect and record accounts by local Haines (and a few Yakutat and Cordova area) trappers who have worked over many years in their respective areas and know

first-hand the changes over time in lynx and snowshoe hare abundance. Historical and traditional knowledge from Tlingit elders will also soon be gathered and recorded.

It is generally thought that numbers of lynx and snowshoe hares are much lower on the coast than in the interior and that there aren't the strong cycles in abundance as seen in boreal forests. In adjacent areas of coastal British Columbia, records of lynx are rare and snowshoe hares are considered rare and spottily distributed. The accounts from trappers and biologists that we have from the Haines area and in coastal areas to the west (around Yakutat and the Copper River), and the limited data that exist from trapping records are also consistent with this view. While there is no direct monitoring of lynx numbers, the Alaska Department of Fish and Game does keep track of harvest by trappers. There is harvest of lynx in most years in the Haines area, but overall harvest in south-east Alaska is low. In 21 years from 2000 to 2020, only 90 trapped lynx were recorded, compared to many hundreds in good single years in the interior regions. In a 2019 survey, no trappers in Southeast Alaska rated lynx as one of the most important furbearers whereas statewide lynx were second in importance only to marten. Interestingly though, 61 of the 90 trapped lynx were harvested in 2018-2020, so these were banner years for lynx along the coast. There is no monitoring of snowshoe hare numbers or potential alternative prey small mammal populations in SE AK, so we can't relate the lynx numbers to prey abundance.

Trappers and biologists in Alaskan coastal areas have noted that numbers and lynx and snowshoe hares are generally scarce but that they see more lynx in years following the crashes of interior populations. These may



Adult lynx detected in bear camera trap grid. Anthony Crupi, unpublished data.

be dispersers from the north that are pushed by hunger to emigrate in search of better hunting opportunities. Several trappers reported seeing the most lynx they'd ever seen in 2019 and 2020—this is following 2 years of a cyclical decline in hare numbers in the interior. That pattern is also apparent in people throughout the valley talking about increased observations and photos of lynx over the past 2 years even in and near town. Lynx were widely distributed in the Chilkat Valley in 2018-2020 based on some of the few data that exist, from camera traps set out by the Alaska Department of Fish and Game to monitor bears that also picked up photos of lynx and hares (map above). A lynx was also recently picked up by a camera trap set out to monitor mountain goats near 7 Mile Haines Highway.

The status and abundance of lynx in the Haines area



are largely unknown but it is clear they are regularly present. The camera data, even though not targeting lynx or hares, will provide an index of change over time in the valley. The cameras will be in place until 2023. Besides being trapped, interactions with humans are quite few. Lynx sometimes prey on domestic animals and pets, particularly during population declines when food is short. Lynx are quite tolerant of human presence at most times compared to other carnivores, and they are very photogenic.

Many questions about lynx and snowshoe hares in the Chilkat Valley remain. Why do numbers of snowshoe hares remain so low in the coastal rainforests—is there inadequate food? Inadequate cover? (Local trappers have said that hares and lynx are most abundant in mixed forest areas with willow,

alder, and other brush on forest edges in the Haines area). Do numbers of hares cycle in abundance? Are most of the lynx seen and trapped recent immigrants that would have starved or is there a persistent local population? Why were so many seen in 2018–2021 compared to other years? What do the lynx that live here eat if there are few of their preferred prey? Do they prey on deer? Do the lynx have kits in the Haines area? How is lynx ecology in the Chilkat Valley affected by the presence of coyotes? A study of lynx in the area would be both challenging and fascinating and some work is now being contemplated which would compliment ongoing lynx research in the interior of Alaska and the Yukon. In the meantime, we can just enjoy the fact that these beautiful carnivores are a part of our native fauna.

Jánwu: mountain goat *Iconic relic of our ice age past*

Kevin White, 20210428 All photos and graphics by the author

Mountain goats (*Oreamnos americanus*) are an iconic species of coastal Alaskan mountain landscapes. Their long, white winter coats and the relative ease in which they persist in extreme ecological settings and severe winter conditions, reflect their ice age origins. Indeed, mountain goats today often remain linked to the last refuges of our glacially dominated past, as they inhabit rugged topography in high alpine valleys, knife-edged ridges and even nunataks. The species exhibits largely unique morphological adaptations such as broad shoulders, narrow bodies and suction cup-like hooves that foster a climbing ability unsurpassed among large-bodied, four-legged mammals. Galen Rowell, an accomplished world-class mountaineer and nature photographer, once revealed at the ability of a mountain goat to readily climb the exact 5.8 pitch that he and fellow hominid alpinists had only been able to previously scale with assistance of ropes and other rock climbing gear (Rowell 1995). While this and subsequent observations led to the casual conclusion that mountain goats, at times, may climb for the sheer joy of it, such capabilities also promote distinct survival advantages. Fast moving and clever carnivores such as wolves, brown and black bears present a formidable threat to mountain goats. Escape into clifty terrain is **Jánwu's forté**. If cornered, saber-like horns and cantankerous disposition are an effective last line of defense. **Kevin; okay to use the Lingít name occasionally? RC**

Strategies for extreme environments Life in the rocks can be challenging even in the best of times, as such habitats are limited in spatial distribution and vegetative productivity. Mountain goats are generalist herbivores, consuming a wide variety of plants, but versatility has costs. That is, ingestion of forages of lower nutritional quality combined with living in snow-dominated landscapes that increase energetic costs of travelling can limit growth and accumulation of fat stores—factors critical for overwinter survival and successful reproduction.

As a consequence, mountain goats have a late age of physical maturity and a conservative reproductive strategy in comparison to other local species such as moose or Sitka black-tailed deer. For example, mountain goats do not typically attain mature body size until 4 or 6 years of age, for females and males respectively. And females do



Takshanuk Ridge mountain goats taking in some spring sunshine in Chilkat Valley mid-elevation winter range. The photograph was taken from a remote camera.

not produce their first kid until age 4 or 5, rarely have twins (3% of the time) and often exhibit reproductive pauses to nutritionally **skip years to?** recover from high energetic costs of bearing young and lactation (Festa-Bianchet and Cote 2008).

These life-history characteristics result in low rates of lifetime reproductive success among individuals and populations. Mountain goats typically exhibit low **population compounded?** growth rates (1-3%, on average), as compared to other species (Figure 1). Consequently, they are particularly sensitive to natural and anthropogenic perturbations of their environment. Carefully designed conservation strategies are important for

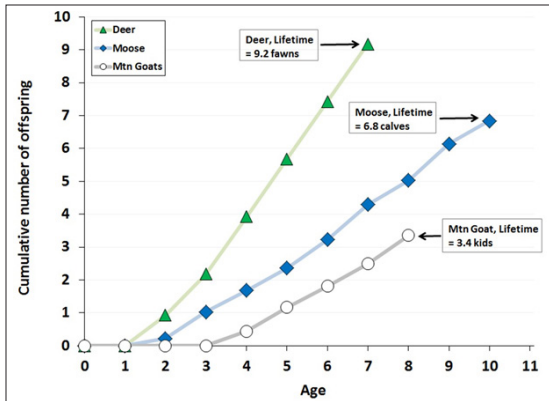
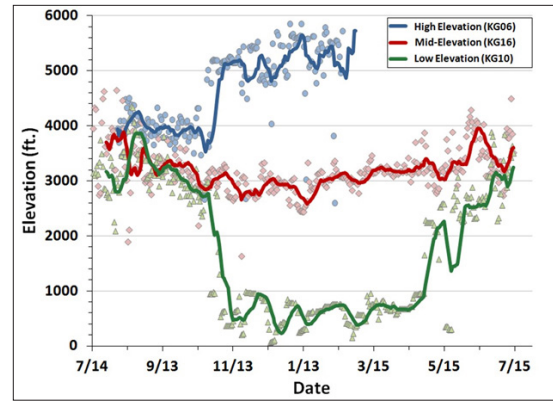


Figure 1. Lifetime reproductive success of mountain goats in relation to other coastal Alaska ungulate species (deer data from S. Gilbert no citation; unpublished?).

Figure 2. Example of elevational wintering strategies used by 3 different GPS radio-collared mountain goats in the Haines area. Wintering elevation generally follow a coast to interior gradient, with coastal animals wintering a lower elevation (KG10—Taiyasanka Harbor area), whereas animals in the upper Chilkat Valley tending to winter at high elevation (KG06—Goat Hollow).

Kevin: this coastal-vs-interior distinction is the info most relevant to our *Atlas*, so I've inserted some language below to develop and emphasize that. Let me know if these changes are okay. RC



ensuring viability of local populations (Northern Wild Sheep and Goat Council 2020).

Mountain goats are shaped by their extreme environments. A “*bearded, climbing beast the color of winter*” was the apt description forwarded by celebrated mountain goat biologist and writer Douglas Chadwick (1983). Indeed, Jánwu’s mountain landscapes are largely snow covered for 8-9 months of the year—longer than the other 3 seasons combined. Yet, unlike the similarly-minded adventure skier who searches the globe for endless winter, mountain goats strategically utilize relatively small localized home ranges that simply shift altitudinally depending on seasonal conditions.

Coastal versus interior populations During true winter months, mountain goats seek out micro-sites with shallower snow and more forage than surrounding areas. Populations of Greater Chilkat Watershed nearest to the coast (warmer, moister microclimates) tend to find these conditions in lower elevation forested sites. Southerly aspects close to steep escape terrain are also favored. This wintering strategy typifies that of most herds throughout the maritime mountains of mainland Southeast Alaska and Shee, (Baranof Island). But not all of GCW has a warm-moist climate, and Jánwu’s wintering behavior adjusts accordingly.

Moving upvalley, to more interior-climate locales such as Kellsall River, wintering mountain goats may select high, wind-blown alpine ridges. (Figure 2; White and Gregovich 2018). High, dry, wind-cleared tundra is actually more typical of *Oreamnos*’ winter habitat selection over the majority of its North American range; descent to low cliffs in coastal Lingit Aani is the anomaly in this broader context. (cite some of the key interior studies?).

However, there is no clean or “fixed” boundary between warm-moist and cold-dry in the GCW. Due to variable and sometimes extreme winter weather in this bioregion-straddling watershed, heavy deep or dense? snow can create surprising conditions (*Snowpit* sidebar, next page) and lead to severe challenges for mountain goats, sometimes reducing over-winter survival (White *et al.* 2011). *

Avalanches During spring and summer, recently avalanched slide zones and margins of snowfields promote emergence of highly nutritious sedges and forbs, critical forage for mountain goats (Fox 1991). During such periods mountain goats appear to be in search of everlasting spring—following ‘green waves’ of newly sprouted vegetation upslope and alongside shrinking snowbeds.

However, avalanches—in addition to over-winter malnutrition and predation—also kill mountain goats. As the backcountry skier can attest, avalanches can be a wicked problem and are an ever-present risk in steep snow-covered mountain topography (Absolon 2021). Mountain goats' incredible capability and confidence negotiating high-risk avalanche terrain **belies the is-undetermined-by-inherent** difficulty of risk assessment. **Bone piles in runout zones suggest that trial-and-error is a suboptimal learning tool.** In the Greater Chilkat, avalanches account for 43% of all mountain goat mortalities—a significant fraction considering the already thin margin of existence in mountain environments.

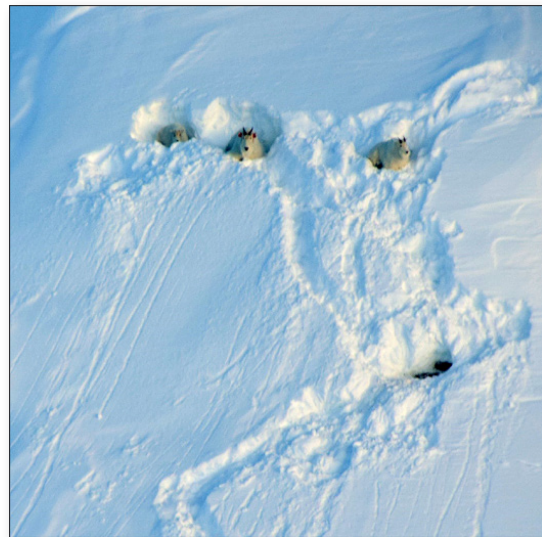
So avalanches are both givers and takers of life. In



late spring, in many parts of Chilkat Valley, mountain goats—along with herbivorous brown and black bears—are readily seen foraging on fresh greens in avalanche chutes. Even during mid-winter, glide avalanches—which slide deep slabs of snow off alpine mountainsides down to the ground surface—can expose a bounty of readily accessible and nutritionally rich vegetation amidst otherwise foodless snowscapes.

One such observation occurred in the upper Summit Creek basin in February 2021. It involved a mixed group of 9 mountain goats intensively targeting a nutritional hot spot laid bare by a recent glide avalanche (*Crown foragers* sidebar). The extent to which glide avalanches provide biologically meaningful foraging opportunities is unclear. A local avalanche expert suggested that glide avalanches tend to consistently occur in certain locations—perhaps enabling mountain goats to integrate such knowledge into their optimal foraging calculus over time. Whether the life-giving nutritional

Mountain goat tracks in the mid-winter alpine snowscape near Four Winds Mountain. Small wind scoured outcrops provide sparse patches of desiccated forage in the hungry landscape.



Snowpit beds Photo from aerial survey, 20211220, near Porcupine Peak. Just prior to survey the Chilkat country experienced a 200-yr storm with ~10 inches rain and up to 45 knot winds at sea level over 48 hours, with substantial snow at higher elevations (96 inches at 2600 ft over 6 days). This radio-collared male and nanny/kid pair, well above treeline (~3000 ft), excavated small shelters into the snow pack. This removed them from exposure to high winds, aiding thermoregulation during extreme conditions. Given that avalanches are an important source of mortality in this area, the next step is for them to learn how to assess avalanche conditions in the nice snow pits they dug!

benefits of avalanches compensate for mortality seems unlikely, yet it's compelling to consider the complex and nuanced way in which mountain goats are affected by and adapt to avalanches in their precipitous home.

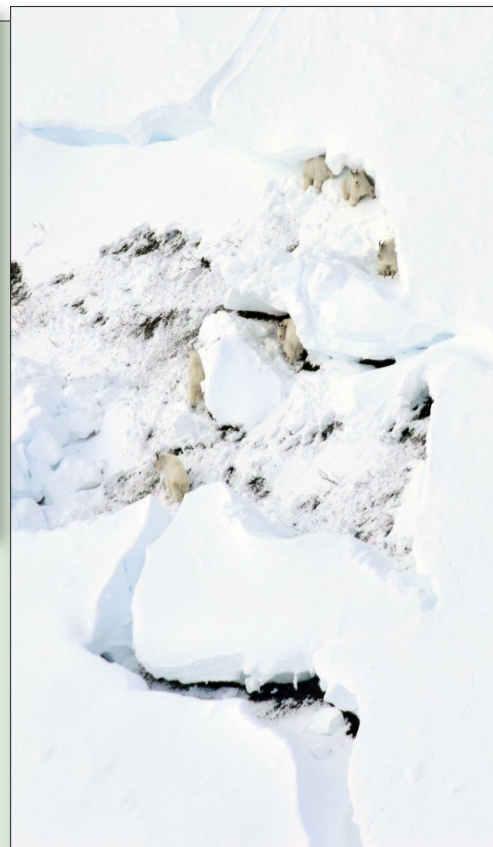
Genetics, traditional uses, conservation Mountain goats of Greater Chilkat Watershed are believed to have emanated from nearby northern refugia during the last glacial maximum. The area is recognized as a hot spot of genetic diversity within the species' western North American distribution (Shafer *et al.* 2011). * Jánwu conservation in GCW has justifiably taken on special significance.

The relationship between mountain goats and humans is long and has given rise to deep, cultural connections among the Tlingit inhabitants of the area. Indeed, mountain goats have long been considered an iconic part of the ecological fabric of the region. Jánwu is not only a key subsistence food but also a source for creation of Ravenstail and Chilkat robes, spoons and rattles made from wool, horns and hooves.

Contemporary hunters continue to harvest mountain goats for subsistence and also sport purposes. Because of inherent low population growth rates, mountain goat harvest must be carefully implemented using scientific data and analyses to ensure sustainability. Even still, natural and anthropogenic forces can impact local mountain goat populations and need to be carefully considered in the decision-making matrix. For example, commercial and recreational activities (*i.e.* mining, timber



Crown foragers During a mountain goat telemetry flight, 20210206, in Summit Creek drainage, we observed a large glide avalanche on a south-facing slope at ~3000 ft elevation. The crown of the avalanche was about 6-8 feet deep and went all the way down to alpine vegetation. The slide zone had since been dusted with snow and revealed extensive mtn goat tracks and evidence of feeding on the newly exposed vegetation. We tracked a radio-collared adult male mountain goat into the slide zone and observed 2 adults and a kid feeding, then moving up to the crown line. Nearby, we observed another 6 adults (including the radio-collared male) bedded in and amongst a complex of stress fractures above the crown line—a pretty remarkable juxtaposition. Given the extensive deep snow in the immediate



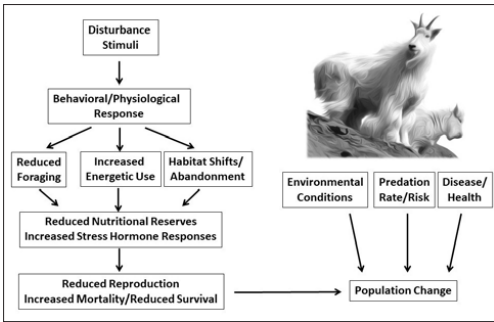


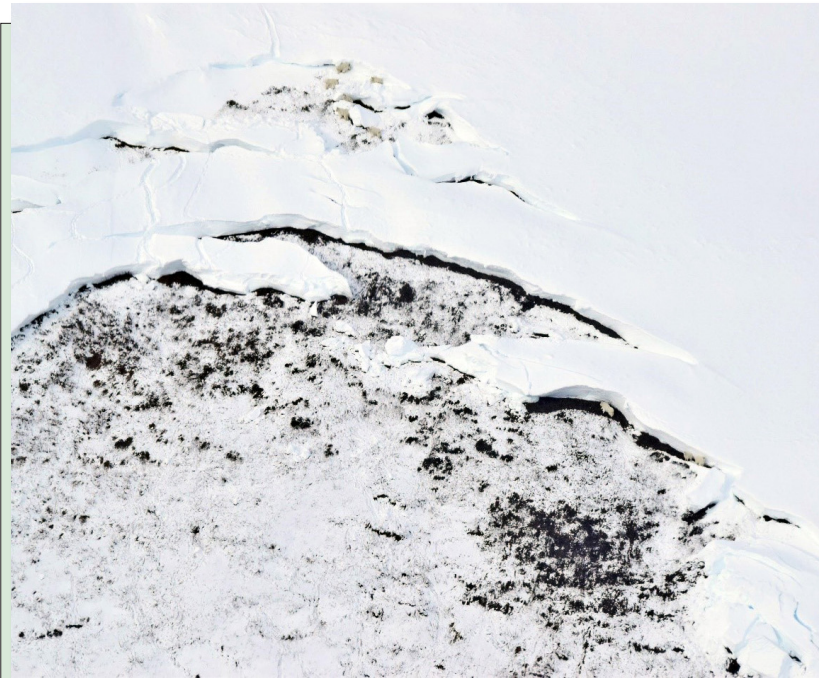
Figure 5: Disturbance effects on mountain goats, in context of other drivers of population demography (adapted from Frid and Dill 2002 no citation, Wilson 2011 no citation). Expected impacts of disturbance can be exacerbated, or buffered, depending on demographic conditions, environmental conditions, predation, and disease.

harvest, hydroelectric development, helicopter tourism) have been documented to directly and indirectly affect mountain goats by altering foraging behavior and movement patterns resulting in displacement and, in some instances, demographic declines (Figure 5; Northern Wild Sheep and Goat Council 2020). While habituation may occur in some species, evidence from long-term study indicates mountain

Differential effects of snow on locomotion of adult female vs kid mountain goats, Takshanuk Ridge, 12/19/20



Adult female (KG84) with kid, 11 Mile Goat Cliffs, 12/19/20



surroundings, it was striking to observe how the mountain goats readily utilized the fairly extensive new foraging patch amidst the dramatic setting—as if they were a bunch of football revelers crowding around the chip bowl on Super Bowl Sunday. In the Haines area, avalanches are significant source of

winter mortality (40% of all deaths). Yet, it was interesting to consider how they may yield surprising benefits at times, and occasionally yield a nice nutritional surplus during the otherwise energetically hard times of winter.

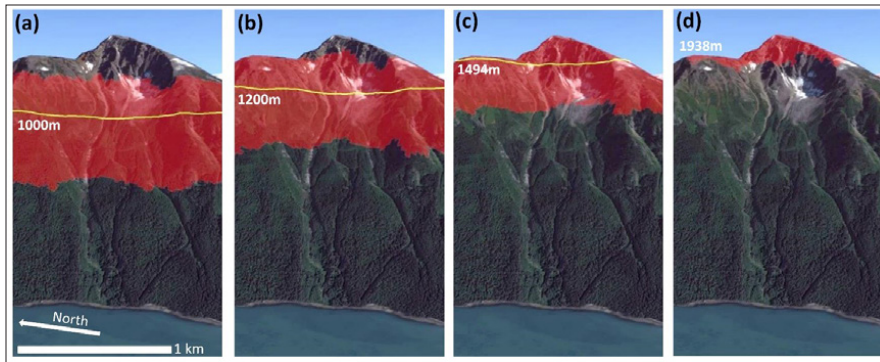


Figure 6: Resource selection function modeling output describing predicted changes in mountain goat summer habitat distribution for 4 global circulation model (GCM) climate change scenarios: **A)** current distribution (2005–2015 baseline conditions), **B)** Year 2085, GCM-GISS-RCP4.5 (“best case scenario”), **C)** Year 2085, GCM-MRI-RCP8.5/GCM-GFDL-RCP4.5 midpoint (“intermediate scenario”), and **D)** Year 2085, GCM-CCS-RCP-8.5 (“worst case scenario”). Based on White *et al.* (2018).

goats do not readily habituate to disturbance (Côté *et al.* 2013). Overall, such impacts are considered to be additive to other natural factors thus highlighting the conservation attention such issues require to ensure population sustainability. Climate change may also have important effects on mountain goat populations over the long-term. Conical shape of mountains results in shrinkage of alpine habitats as treeline advances up hillsides (Figure 6; White *et al.* 2018). And, even though winter snowfall is expected to decline such benefits may not offset projected increases in summer temperature, which can alter availability of highly nutritious emergent forages and also induce thermal stress—an issue for cold adapted species such as mountain goats.

The relationship between mountain goats and humans is widely celebrated and for some has deep cultural significance. It must be carefully navigated

to ensure viability over the long term—a process that benefits greatly from engaged local communities and strategic, science-based planning endeavors.

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A few more are needed, as noted above in red. Would also be nice to have a 1 or 2-sentence bio, relating to your goat research background



Moose—brown bear standoff in a lower Chilkat River cottonwood gallery forest-meadow complex. Photo was taken just before the moose chased the bear for about ½ mile, after it had been eating its newborn calf.

Dzísk'w: moose

XXXXX

Range-margin ungulates

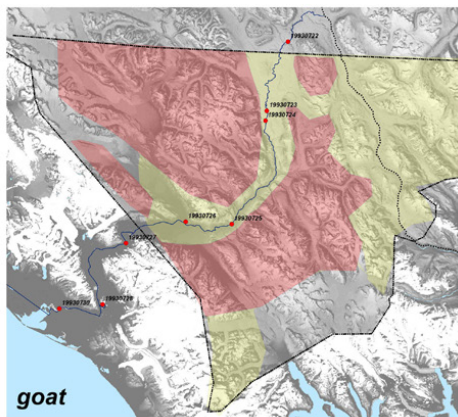
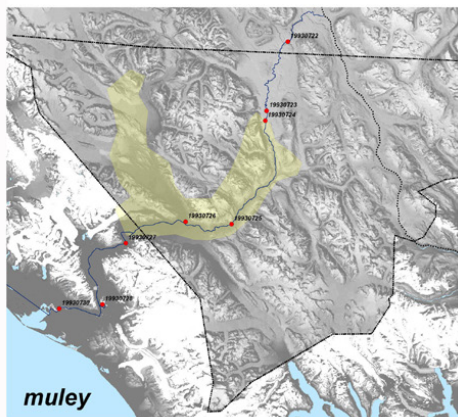
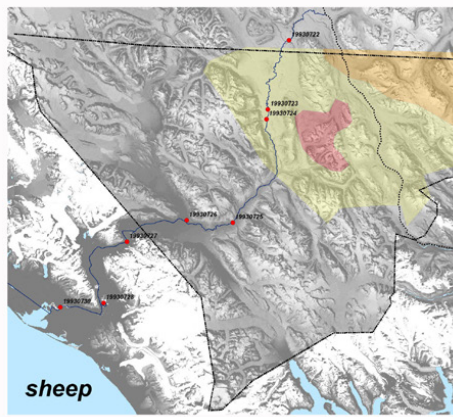
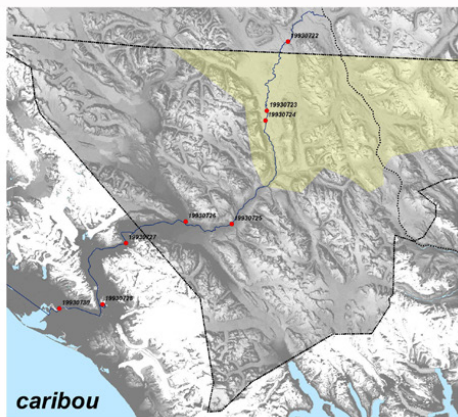
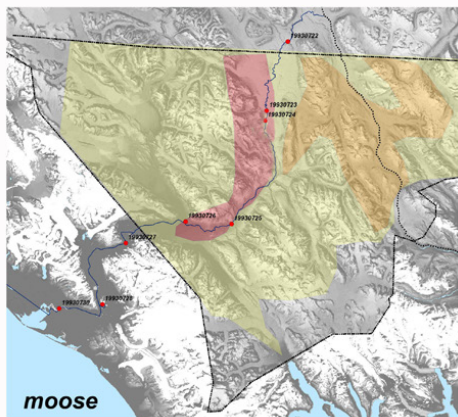
Three species are at the edge of their range in the Greater Chilkat, and pose fascinating questions about colonization,

- **Dall sheep** rumored but poorly documented in the pass
- **caribou** XXXXX
- **black-tailed deer** XXXXX

Wide-range predators

Some of these might get bumped up to feature status but that has more to do with collaborator interest/expertise than any prioritization on my part:

- **wolf** XXXX
- **coyote** XXXX
- **fox** XXXX
- **wolverine** recreational trapping, indication of trapping pressure being high now.



abundant Ungulate ranges from Shackleton Hooved mammals of British Columbia 1999.

moderate

few

Placeholder ungulate ranges from a Tat-Alsek journal, to be replaced with maps extending farther east in later drafts.

Small-&-midsize mammals

- beaver

201907 mtg notes: ' Surprisingly scarce. Maybe not recovered from suppression in early Euro times? Can someone help me assemble an abundance map? Eric says during ADF&G work 1991-2001 he noticed lots of summer homes for beavers along banks of Chilkat above Kelsall confluence.

Ben: in 90s, beaver coming back, cyclical,

Eric agrees they're coming back. Glacial rebound is affecting things, succession, beaver not always where you think they would be. Why? trapping? Can someone at F&G give us an overview of trapping?

- **bats** ask Karen for a section? long straight valley serves as corridor?

ID manual: small mammals of BC

David Nagorsen, 2002. Royal BC Museum
Selected species with range maps for 'Haines triangle'

Soricidae: shrews

Sorex cinereus common shrew

S. monticolus dusky shrew

S. palustris water shrew

S. tundrensis tundra shrew (Kelsall Lake)

Vespertilionidae: bats

Myotis lucifugus little brown bat

Lasionycteris noctivagans. silver-haired bat

Lagomorpha: pikas & hares

Ochotona collaris collared pika

Lepus americanus snowshoe hare

Sciuridae: squirrels

Glaucomys sabrinus northern flying squirrel

Marmota flaviventris hoary marmot

M. monax woodchuck

Spermophilus parryii arctic ground squirrel

Tamias minimus least chipmunk

Tamiasciurus hudsonicus red squirrel

Castoridae: beavers

Castor canadensis beaver

Arvicolinae: voles & lemmings

Clethrionomys rutilus northern red-backed vole

Lemmus trimucronatus brown lemming

Microtus longicaudus long-tailed vole

M. oeconomus tundra vole

M. pennsylvanicus meadow vole

Ondatra zibethicus muskrat

Phenacomys intermedius heather vole

Synaptomys borealis northern bog lemming

Sigmodontinae: New World rats & mics

Neotoma cinerea bushy-tailed woodrat

Peromyscus keeni Keen's mouse

Dipodidae: jumping mice

Zapus hudsonius meadow jumping mouse

Z. princeps western jumping mouse

Erethizontidae: New World porcupines

Erethizon dorsatum porcupine

1 On our preliminary meeting with LCC/Takshanuk, 20190706, Cathy Pohl kept notes that can be read in their entirety on pages 6-8 of journal for that visit

Birds

The 'corridor effect' and bioregion-straddling qualities of Greater Chilkat Watershed are strongly expressed in bird species distributions and migratory phenologies. Data sources and data gaps for GCW birds are a 'goodnews—badnews' story. On the plus side, growing popularity and cloud-sourcing of birding-as-hobby over the past few decades has made bird cartography perhaps the most outstanding beneficiary of citizen science for any taxon worldwide. Explosion of *eBird* records and sophistication of geographic display make this birder-&-ornithologist partnership a model for data-seekers in every other ecological discipline. On the minus side, as noted in West (2008: sidebar, right), the GCW has not attracted many aggressive 'listers.' Reasons for that are complex. ¹

Anyone—avid birder or avian agnostic—who is interested in citizen science and online interactive geographic databases should spend some time exploring *eBird*—a

1 Birding can become a rather odd game, as anyone who has kept a lifelist soon notices. In its extreme form it focuses the birder on new species called "*life birds*," instilling neglect of and even boredom with common species. In ecology, one could make the opposite case—that common, tropically influential birds teach more about one's home than rare, once-a-year or edge-of-range species. For our purposes in understanding avian diversity and geography of the bioregion-spanning Greater Chilkat, both common and rare species are instructive.

For cartographers relying on citizen-science data, the rarity bias can make it hard to evaluate ranges and abundance of common species. Resident birders may not record species they see every day, and traveling birders typically target regions and habitats promising life birds or 'trip birds' (first of that species for a given trip), leaving broad data gaps in more 'generic' landscapes.

There's no question that the most skilled and experienced North American birders—those who, for example, identify unseen warblers from chip notes or a 2-second glimpse of its flight pattern—contribute more to avian databases than we mere mortals. Unfortunately, Southeast Alaska offers few species that a good birder from—say—Washington or Oregon hasn't already '*bagged*.' So the birding elite typically overfly Southeast to destinations such as Attu. There, species who might be "*junk birds*" to a Siberian lister are must-see strays and accidentals for the aficionado building a North American life list. This is partly why Weston's guide deems the GCW "*not well explored*."

But there are encouraging trends. First, birding is not solely the domain of rarity seekers. Many of us happily study and even record robins and mallards, never tiring of their adaptable behaviors and interesting distributions. Secondly, *eBird* encourages participants to submit "*Complete*" lists, which include number of observers, time spent, distance traveled, and a count for every species identified. The sample record from Brad Benter, right, shows how this captures information not only for abundant robins and tree swallows, but an edge-of-range nighthawk pair over Little Salmon marsh, along with confirming photo and notes on possible breeding.

Alaska eBird
CHECKLIST S24199238
Wed 8 Jul 2015 10:00 PM
Haines-Chilkat Lake Rd Haines County, Alaska, United States
Brad Benter
Traveling Complete 1 hr, 30 min 5 mi
10 Species observed
1 Common Nighthawk
2 Arctic Tern
1 Red-tailed Hawk
1 Belted Kingfisher
1 Tree Swallow
2 American Robin
1 Song Sparrow
2 Orange-crowned Warbler
1 Common Yellowthroat
1 Yellow-rumped Warbler

**Placeholder sidebar:
to be removed or
replaced with more
concise summary in
later drafts.**

A birder's guide to Alaska

Paraphrased & quoted from George West's 2008 guide:

"Haines is not well explored by birders, and much remains to be learned about the area's birdlife. . . . [Chilkoot Lake outlet in Lutak Inlet] is perhaps the richest birding location in the Haines area."

- **yellow-billed loon & California gulls** regular in fall. (However, for those accustomed to the coastal birds of Southeast Alaska, the following notes on the birds of Haines Summit are probably more interesting. West may call Lutak "richest" just because of the overlap of land and seabirds.)
- In addition to the usual old-growth breeding birds (**Townsend's warbler, pacific-slope flycatcher, sooty grouse**) Chilkat State Park has **warbling vireo, MacGillivray's warbler & western tanager**.
- In addition to eagles, the Chilkat Bald Eagle Preserve is great for gulls:

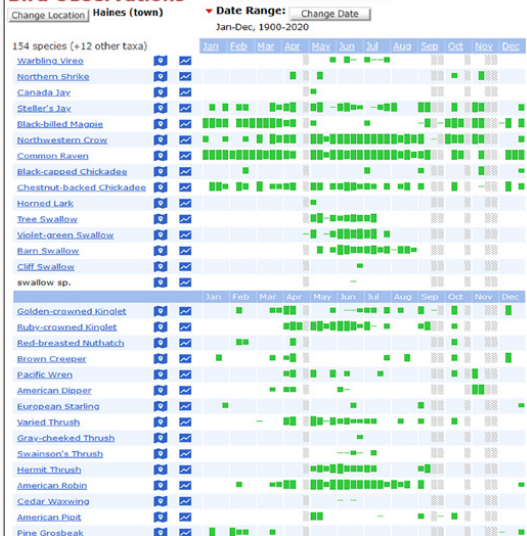
"Among the common *mew* and *glaucous-wings*, watch for less-common species such as *ringbilled*, *California*, *herring*, *Thayer's*, *glaucous* & *ivory gull*."

- and songbirds in mixed deciduous woodlands:
"Hammond's flycatcher, warbling vireo, Macgillivray's warbler & western tanager."
● On Mount Ripinski:
"*golden eagle, sooty grouse, white-tailed ptarmigan, Townsend's solitaire, MacGillivray's warbler, horned lark & gray-crowned rosy finch*. Possibles include *dusky flycatcher* & *mountain chickadee*."
● Little Salmon River marsh good for rarities. Aside from songbirds mentioned above, also:

"American bittern, hooded merganser, Vaux's swift, common nighthawk"

- Mosquito Lake State Recreation site:
"*Trumpeter swans nest on the lake, and pied-billed grebe & hooded merganser have been seen*."
● Haines Summit, British Columbia:
"*Exceptional birding destination with many noteworthy species: goshawk, golden eagle, gyrfalcon, all 3 ptarmigan, boreal owl, wandering tattler, arctic tern, northern hawk owl, 3-toed woodpecker, northern shrike, gray-cheeked thrush, tree sparrow, golden-crowned sparrow, brewer's (timberline) sparrow, Smith's longspur, snow bunting & hepburn's race of gray-crowned rosy finch*."
● Mosquito Flats surrounding Kelsall Lake is a popular birding area.

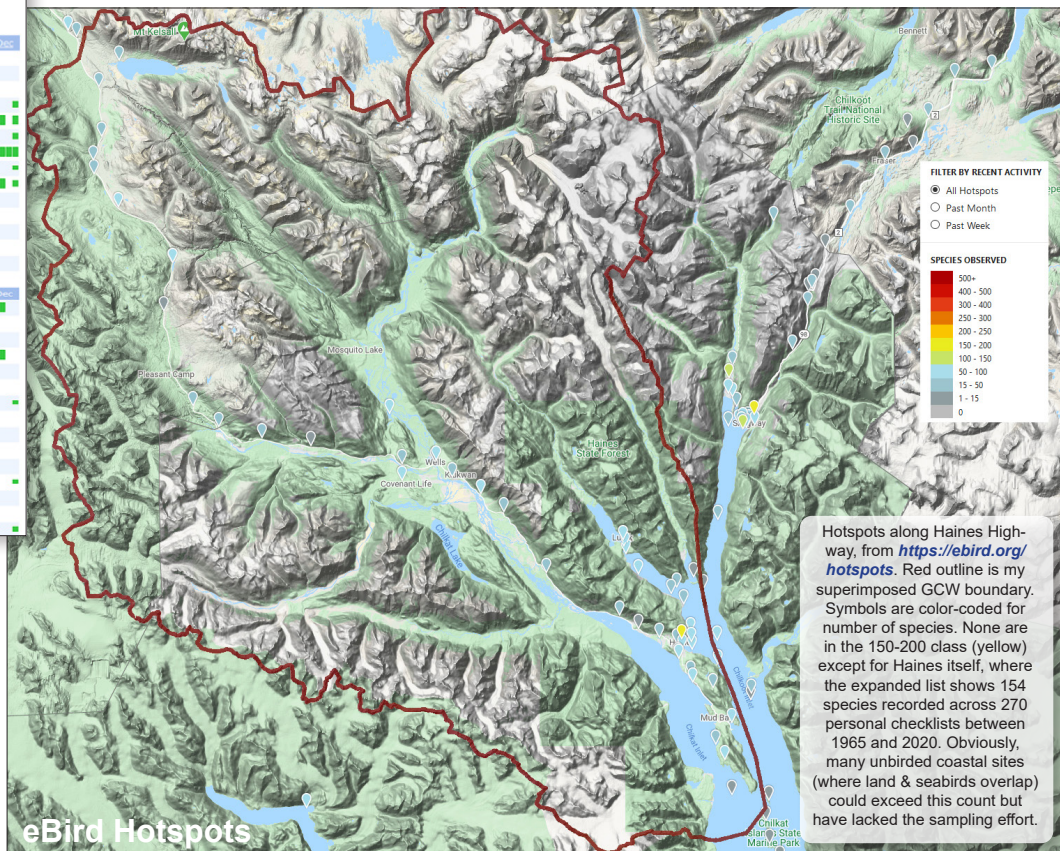
Bird Observations



Sample rows from an auto-generated weekly abundance chart for the downtown-Haines hotspot, marked in yellow (>150 species) on the map, right.

network managed by Cornell Lab of Ornithology. Perhaps because I'm not (currently) an active birder or data-uploader, every time I visit I'm amazed at how rapidly this portal is expanding—not only in depth of information but ways in which data can be displayed or analyzed. Some of them are suggested in these screenshots from eBird.org.

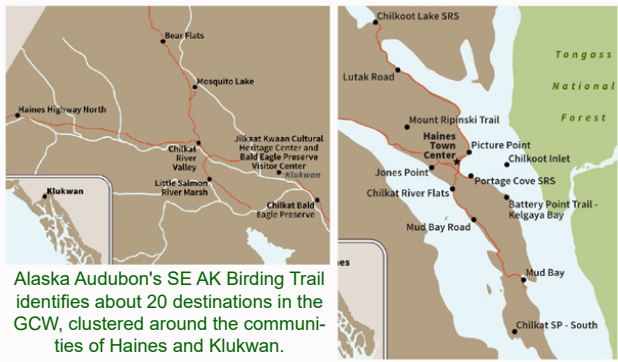
Alaska Audubon's *Southeast Alaska Birding Trail* is another good source for popular destinations within



Hotspots along Haines Highway, from <https://eBird.org/hotspots>. Red outline is my superimposed GCW boundary. Symbols are color-coded for number of species. None are in the 150-200 class (yellow) except for Haines itself, where the expanded list shows 154 species recorded across 270 personal checklists between 1965 and 2020. Obviously, many unbirded coastal sites (where land & seabirds overlap) could exceed this count but have lacked the sampling effort.

Image provided by eBird (www.ebird.org) & created 20200229

the Greater Chilkat Watershed. Because the Birding Trail is a community-centric program driven partly by tourism outreach, these destinations are not uniformly distributed throughout the GCW, but rather clustered around Haines and Klukwan as shown on their maps. <https://ak.audubon.org/southeast-alaska-birding-trail/klukwan>



Alaska Audubon's SE AK Birding Trail identifies about 20 destinations in the GCW, clustered around the communities of Haines and Klukwan.

Migration, corridors

Many breeding species of tundra and boreal woodland pass through Southeast Alaska in spring and fall, unable to find suitable summering or wintering habitat within our region. For brief periods in passage, species richness and total abundance can be many times greater than during those more settled periods in a bird's annual cycle.

In addition to seasonal concentrations, topographic funneling further 'shoehorns' birds into hotspots such as Haines Summit.

What have local birders and duck-hunters noticed about this funneling? I'd anticipate a rather obvious valley-bottom passage of waterfowl, for example. On the other hand, in Áak'w and T'aak'u Aani, we see a strong ridgetop movement of southbound raptors in fall, especially during clear northerlies.

Habitat specialists

Another feature of the GCW that concentrates 'birds of interest' is unique habitat, not widely distributed throughout the coastal rainforest bioregion. An example is Little Salmon River marsh, described thus on Audubon's Birding Trail site:

Little Salmon River Marsh features close juxtaposition of freshwater wetlands, conifer & deciduous forest, along with agricultural fields of Covenant Life, leading collectively to high species diversity. Birders should stay on



Rock ptarmigan, Peak 3920, Kevin White photo

Chilkot Lake Road while exploring near private residences. This area offers species normally more associated with interior habitats, such as Downy Woodpecker, and deciduous-loving species such as Common Yellowthroat, American Redstart, Hammond's Flycatcher and Warbling Vireo, all less common throughout most of Southeast Alaska.

'Border species'

Birds more typical of the boreal interior, uncommon elsewhere in Southeast Alaska

Birding from Haines

XXXXXX

Trumpeter swan

XXXXXX

aside from eagle and swan, what other species merit 'feature' status in this atlas? What conservation issues?

201907 mtg notes: ² Mostly comments from Mario:

Mario says gyrfalcon are regular in the pass. Written about, Beebe, tree nesting? (RC, in Beebe 1974?) Probably breeding but nests not found. Only place outside Arctic Circle. Ground squirrels probably main prey in summer.

Gyrs also overwinter, when they probably switch to ptarmigan.

Also golden eagles, snowy owls (nesting?) Mario also says that several migrants who typically breed much farther north are known to stop and breed here, far out of range. He speculates these are exhausted birds who stop at

² On our preliminary meeting with LCC/Takshanuk, 20190706, Cathy Pohl kept notes that can be read in their entirety on pages 6-8 of journal for that visit

the first place that fits their search image for breeding habitat. I can't remember his list . . . hudsonian godwit, what else? (Weedon, 1960 also had records)

Willow ptarmigan come down into the valley in winter. This is a low year for ptarmigan. (all spp or just for willows?) Get names of local birders from Jessica.

Mario: riparian habitat, olive-sided flycatcher (where was he talking about? mentioned their status as state species of concern).

Western screech owls Northernmost habitat for a number of species—sooty grouse, chickadees (some blackcaps here), QC goshawk is in the Bald Eagle Foundation. on display, moribund. Are QCs breeding?

They (who?) have been establishing the value of the valley as waterfowl migration corridor.

On Kelsall 'delta' Eric saw a dozen kestrels in one cottonwood snag one time. (thus, local breeding? I don't think they migrate together)

CP: recent info to add from Canada on birds.

Bald eagle

The Chilkat is best known for its post-breeding congregation of eagles on the Council Grounds. But nearly every *Featured landscape* in our companion atlas has well mapped and described nest trees.

Would be great if Steve Lewis, USFWS, could write us a chapter on GCW eagles, with not only info on the congregation, but also pointers on how to use the nest-tree database. This is a perfect application for *Survey123*, which, unlike my geopdf, could bring up the entire record in the field for any nest visited, integrated into the map.

But the geopdf will get you to any mapped nest, and it's easy to create an excel, loadable to phones, to examine F&W's notes for each numbered nest.

37-38 NEST TREE SPECIES 1 Alder 2 Birch 3 Cedar 4 Chestnut 5 Cottonwood 6 Cypress 7 Elm 8 Fir 9 Hemlock	1 Hickory 2 Locust 3 Maple 4 Oak 5 Palm 6 Pine 7 Spruce 8 Walnut 9 Other	39 LIVE TREE NEST 1 Normal Slender Top 2 Normal Bushy Top 3 Broken Top - Live 4 Dead Top - Unbroken 5 Dead Top - Broken 6 Deformed Top 7 Double Top 8 More Than Two Tops 9 Other	40 DEAD TREE NEST 1 First Year - Normal Top 2 First Year - Broken Top 3 Sound Snag - Normal Top 4 Sound Snag - Broken Top 5 Old Snag - Normal Top 6 Old Snag - Broken Top 7 Full Snag - Supported 8 Broken Snag - Supported 9 Other	41 GROUND NEST 1 Stick Nest On Cliff 2 Scrape On Cliff 3 Cavity In Cliff 4 Open Hillside 5 Gravel Lagoon - Saltchuck 6 Marsh/Tundra 7 Treeless Islet 8 Sea Stack 9 Other	42 NEST FRONTAGE 1 Open Sea 2 Narrow Saltwater Channel 3 Inland Sea or Broad Channel 4 Saltwater Bay 5 Brackish Lagoon - Saltchuck 6 River or Stream 7 Lake 8 Landscape In General 9 Other					
43 TIMBER TYPE 1 Heavy Old Growth 2 Light Old Growth 3 Second Growth 4 Selective Cutting 5 Tree Left in Logged Area 6 Tree In Logging Leave Strip 7 Scrub Timber 8 Sparse Timber 9 Blodoun Area	44 TIMBER DEPTH 1 Landscape Well Timbered 2 Timbered Peninsula 3 Meadows Within 200 Yards 4 Small Islet 5 Narrow Beach Fringe Only 6 Snowside Area 7 Nest Behind Clearcut 8 Nearly Clearcut 9 Seeding Strip Only	45 BIRDS IN NEST TERRITORY 1 None Observed 2 1 Adult On Nest 3 Pair On Nest 4 1 Adult In Nest Tree 5 Pair In Nest Tree 6 1 Adult Near Nest 7 Pair Near Nest 8 1 Adult Flying 9 Pair Flying	46 ACTIVITY AT THE NEST 1 Defending Nest Territory 2 Nest Under Construction 3 Adult with Food 4 Adult with Nest Material 5 Young Chirping 6 Whistling Adult 7 Adult Circling Nest Territory 8 Escorted Flight Behavior 9 Courtship or Mating Activity	47 NEST STATUS - SURVEY METHOD 1 Active - Boat 2 Inactive - Boat 3 Active - Helicopter 4 Inactive - Helicopter 5 Active - Plane 6 Inactive - Plane 7 Active - Foot 8 Inactive - Foot 9 Status Unknown	48 NEST CONDITION 1 Excellent - New Material Seen 2 Excellent - Old Material Only 3 Good - New Material Seen 4 Good - Old Material Only 5 Fair - New Material Seen 6 Fair - Old Material Only 7 Poor - Stable 8 Poor - Unstable 9 Remnants Only					
49 NEST HEIGHT, TREE OR CLIFF IN FT. 1 0-25 Feet 2 25-50 3 50-75 4 75-100 5 100-125 6 125-150 7 150-200 8 200-400 9 400 Feet and Over	50 NEST ABOVE GROUND IN FEET 1 0-25 Feet 2 25-50 3 50-75 4 75-100 5 100-125 6 125-150 7 150-175 8 175-200 9 200 Feet and Over	51 NEST TO WATERFRONT, YARDS 1 0-10 Yards 2 10-20 3 20-30 4 30-40 5 40-50 6 50-100 7 100-200 8 200-300 9 300 Yards and Over	52 TIDAL MARGIN, HIGH TO LOW 1 0-10 Yards 2 10-20 3 20-30 4 30-40 5 40-50 6 50-100 7 100-200 8 200-300 9 300 Yards and Over	53-54 NEST ABOVE SEA LEVEL 1 0-25 Feet 2 25-50 3 50-75 4 75-100 5 100-125 6 125-150 7 150-200 8 200-300 9 300-500	55 NEST MARKING AND ACCESS NEST TREE MARKED 1 Tree Easy To Climb 2 Tree Difficult To Climb 3 Tree Impossible To Climb 4 Tree Climability Unknown NEST UNMARKED 5 Inaccessible 6 Accessible by Foot 7 Cliff - Ropes Required - Easy 8 Cliff - Ropes Required - Hard 9 Access Unknown	56 RESURVEY - NEST NOT FOUND 1 Tree Definitely Destroyed 2 Nest Definitely Destroyed 3 Occasional Boat Survey 4 Moderate Boat Survey 5 Superficial Boat Survey 6 Intense Aerial Survey 7 Moderate Aerial Survey 8 Intense Foot Survey 9 Moderate Foot Survey	57 NEST DESTROYED 1 Nest Blown Out of Tree 2 Tree Blown Down 3 Road Building 4 Logging 5 Urban Development 6 Violation of Bald Eagle Act 7 Violation of Other Law 8 Predation 9 Disturbance	58 YOUNG IN THE NEST 1 Egg 2 Chicks 3 Eggs and Downies 4 Partly Feathered 5 Near Flapping 6 Flying Young	59 NUMBER - - - - -	60 TREE UNMARKED BY GCW SERIALS - - - - -

Chilkat River is most famous for its post-breeding congregation of thousands on the Council Grounds near Klukwan. But decades of research from generations of Fish & Wildlife Service (USFWS) biologists has been devoted to mapping and monitoring of eagle nests—a perfect fit for our *GCW Atlas* project. The rich database is rather impenetrable to the layperson without recourse to this listing of code numbers for each field in the shapefile's attribute table. For example, a "4" in field "45" means *adult seen delivering nest material*.

To create this layer, I downloaded the latest update, 202108, from [SE AK GIS library](#), and clipped to the GCW boundary, giving 1,130 records. Many are repeat observations, so our map shows only xxx actual nest trees. The 6- or 7-digit unique identifier number is in the *nestmap* field.



Before the crash. In 1989, researching hydrology of the Tsirku/Chilkat Lake/nexus for NSRAA (Northern Southeast Regional Aquaculture Association) with Dan and Gretchen Bishop, I photographed this mature male toad near Clear Creek weir. Until that year, toads were perhaps the most widespread and easily examined vertebrate in Southeast Alaska, and I had no idea this would be one of the last I'd see until beginning intensive surveys with Bob Armstrong and Mary Willson in 2003 (Carstensen, Armstrong & Willson. *Habitat use of amphibians in northern Southeast Alaska.*)

Amphibians

Only 2 amphibians are known within Greater Chilkat Watershed: *Anaxyrus boreas*, or western toad, and *Rana sylvatica*, the wood frog,

Western toad

Anaxyrus boreas in Chilkat Valley

Tim Shields

Biology/ecology

The insectivorous western toad (*Anaxyrus boreas*) is widespread in the Chilkat Valley, occurring from sea level to over 3,000 feet elevation. The species is notably terrestrial in its habit and can often be found far from open water, though it must return to open water to breed. Individuals have been found to wander widely. One radio-tagged male covered over a mile in a 10-day period.

Western toads are relatively long-lived for amphibians, known to have survived in the wild for up to 11 years. Females can lay up to 16,000 eggs in a season, but may not breed every year. Over a long life span a single female may lay 50,000 to 75,000 eggs. Their fecundity is necessary, given the very low odds of survival of any individual tadpole.

They are active from late April, when they gather for a week at breeding ponds, to early October. They spend cold months hibernating in burrows, attempting to find refuge below frost line.

Of note is the toxic nature of the skin secretions of the toad. The parotid glands of distressed toads can secrete large amounts of powerfully toxic whitish exudate whose active ingredient is termed “bufotin”. A predator attacking a toad is likely to get a mouthful of this fluid and to experience a very bad trip. The toad gets by with being relatively unathletic by virtue of this chemical warfare capacity. You are well advised to resist the temptation to kiss this amphibian.

Habitat requirements

Western toads prefer warm, shallow water for breeding, selecting habitats conducive to the survival and growth of their tadpoles. They will use shallow, temporary ponds, deep ponds with near-shore shallows, large lakes such as Chilkoot and Lily Lakes, and

even glacially formed kettles near Davidson Glacier. In late April or early May, large numbers of adults gather at breeding sites. Females lay eggs as males, clasping them about the mid-section, release sperm externally. The eggs hatch one to two weeks later and growth of the largely algae-eating tadpoles is dependent on water temperature and food availability. From 6-8 weeks later, they emerge on newly sprouted legs. Soon after that their skins harden and they hop off into nearby areas to feed, grow and find frost-free refuges for their first winter.

As they grow, the toads range widely and are independent of open water, able to occupy forest floor environments, as well as grassy and shrubby areas. Other than a week or two spent at breeding ponds in late April and early May they can be found in a wide variety of terrestrial habitats.

Iris Holmes conducted genetic sampling of tadpoles from different rearing ponds in 2008 and 2009. Her work showed that toads readily use newly-available habitats, while returning to some breeding areas year after year. The cohort of adult toads using any breeding site varies from year to year, as shown by the genetic differences between year-cohorts of tadpoles within a single pond. There is little genetic differentiation across space, probably because the toads are able to range so widely away from water. In particular, the Chilkat and Chilkoot valleys should be considered one single inter-breeding population, rather than distinct genetic units. However, more isolated populations, such as the toads at Glacier Point, have a unique genetic identity.

Past, present and future in Chilkat Valley

Prior to an evident population crash in the 1980's and 1990's this species was likely the most numerous terrestrial vertebrate in the area. As an insectivore with catholic tastes, it likely played an important role in regulating invertebrate populations. Anecdotal reports (*pers comm* Lani Hotch, Guy Hoffman, Norm Blank) indicate that they migrated and gathered in great numbers at breeding sites and communal wintering refuges.

Many oldtimer stories agree that their numbers dropped suddenly sometime around 1985. In 2007 and 2008, Iris Holmes sampled many adult toads in the Chilkat and Chilkoot Valleys and confirmed the presence of chytrid fungus, a worldwide killer of amphibians. It seems likely that chytridomycosis played a significant role in the sudden decline of the species. In recent years, Shields has noticed a significant increase in the numbers and geographical distribution of road-killed toads and has received numerous

reports of large numbers of young toads from throughout the area. 2019 saw a huge emergence of metamorph toadlets, on the order of hundreds of thousands, from Lily Lake, for example. It seems likely that the species is increasing in numbers in the area. Similar recoveries are known from other amphibian populations that have suffered crashes from chytridomycosis.

Given its generalist diet, its adaptability in terms of habitat, breeding and otherwise, and its distribution from sea level to over 3,000', the species is likely to do relatively well in the face of climate chaos. Amphibians are, however, very sensitive to water pollution, especially in the completely aquatic tadpole stage. Any threat to water quality, including airborne spread of toxic materials, will likely impact the western toad negatively.

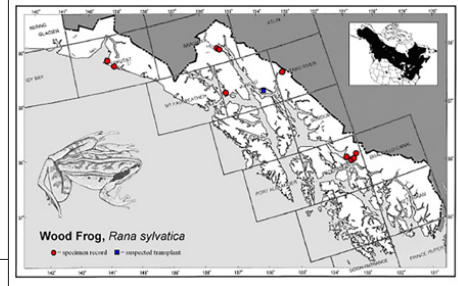
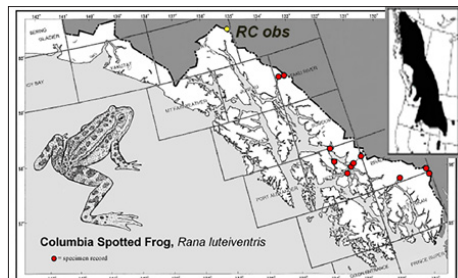
- Does Tim have maps? notes on trends for key breeding ponds?
- How bout pics? I've got tons of generic toadpics from down here but would be nice to have a few GCW spawning pond photos, etc.

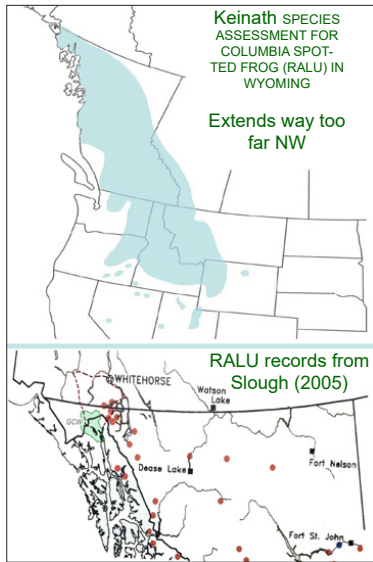
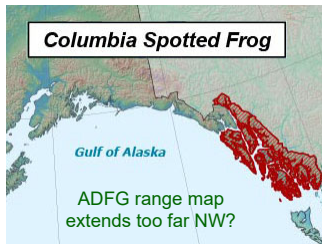
Frogs

Wood frog, *Rana sylvatica*, and spotted frog, *R. luteiventris*, are known and possible, respectively, in GCW. MacDonald and Cook (2007) list wood frog (RASY) specimens from 9- and 11-mile, Haines Highway. Eric Holle has seen them on the Tahini.

As for spotted frog (RALU),

MacD&C (2007) range maps at archipelago scale give only point locations for museum-held specimens. Insets show polygon distributions, but at resolution too coarse for our questions in the GCW.





McD&C show northernmost SE AK collection from Taku River. Since around 2003 we've been undergoing a well documented invasion of spotted—most likely introduced—in Áak'w Táak (Mendenhall Valley).¹ But Steve and Joe only accept specimens held by museums. Their inset map for overall range does show spotted continuing northward into Yukon, but like Keinath's map, its boundaries are impressionistic and probably much exaggerated at north-westernmost limits.

ADFG's species profile for

1 Only a specialist can tell RALU from red-legged frog, (*R. aurora*), invasive in SE AK and aggressively spreading over Chichagof Island. Because colonization of Áak'w Táak has been so rapid, we sent out specimens, and were relieved to confirm them as RALU. Although probably escaped pets or hobbyist snake-food, we'd like to think our spotted came from nearby 'native' populations on T'aakú (Taku River).

spotted frog has a [crude map](#) implying presence in the GCW, but state biologists have no conclusive records:

"They have also been reported but not confirmed in Haines area."

Several range maps online—possibly all morphs from one overly optimistic progenitor?—suggest spotted are possible in GCW. My guess, for reasons following, is that reports referenced in ADFG's

description were wood frog or western toad.² Closest I've seen spotted frogs to GCW was in 2004 at Áax'w Sáani Xoo, *among the little lakes* (Log Cabin), just over the border into British Columbia on White Pass highway. I've marked this location "RC obs" on MacD&C's range map,

2 Many born & raised southeasterners, never having lived in frog country, refer to our once ubiquitous western toad as "frog." Armstrong, Willson and I encountered this confusion routinely during intensive amphibian research, 2003-2006, when I fielded hundreds of calls and emails from observers throughout Lingít Aani, building a spatial database for toad, frog and newt distributions. This 'lumping' may also apply to clans who claim Frog as primary or secondary crest—Kiks.ádi, Kaach.ádi, Ishkeetaan, L'uknaḡ.ádi, Teeyhittaan, Teeyeneidí, T'akdeintaan, Gaanaxteidí and Gaanax.ádi—who now mostly live beyond the range of true frogs.

Worldwide, while frog symbolizes transformative, positive energy, few tribal people consider toad a totemic animal; it carries sinister karma (Hofrichter, ed 2000; p196). Most Tlingit clans entered Southeast Alaska down transboundary rivers, where wood and spotted frog were abundant, and may well have given rise to original clan and house crests. My sense is that on arrival in the mostly-frogless archipelago, Kiks.ádi and other frog-associated clans 'transposed' frog stories onto a convenient relative. Stories of "frogs" at Xixh'i Geeyí, *frog bay* (Silver Bay), for example, far from *Rana*, must actually reference toads, by then called Xixh'i, the ancient word for frog. In Jilkáat Aani, the frog/toad question becomes more complicated, because wood frog does occur here. But clan migration stories place origins to the south, and those journeys transited an archipelago where actual frogs are generally absent. So, for example, to which local flesh-&-blood amphibian do Jilkáat Kwáan Gaanaxteidí Xixh'i Hít (Frog House) attach the word xixh'i: *Anaxyrus boreas* or *Rana silvatica*?

Searching on "frog" in the digital version of X'unei, Lance Twitchell's *Tlingit dictionary* (2019) gives 29 hits, largely for crest associations of above-mentioned clans and their subsidiary houses. The word "toad" does not occur in this dictionary.

preceding page.

Most authoritative and locally-scaled range map for our purposes here at distal NW end of RALU world distribution is from Brian Slough, a Whitehorse herpetologist (Although he pronounces it rhyming with "ow", not "oo," it's a wonderful name for an amphibian biologist). Brian's invaluable 4-fold brochure on YK/BC amphibians—like MacD&C's—gives point locations, probably more scientific and less speculative than polygons. Northernmost points extend into Yukon, but not much farther west than my 2004 sightings at Áax'w Sáani Xoo. Closest are about 15 miles from Greater Chilkat Watershed, separated by icy elevations in headwaters of Dayeisáank'i Héen (Ferebee River).

Generations of fish-bios and sharp-eyed naturalists have walked the waterways of Jilkáat and Jilkoot Aani. Where spotted frog occurs it's hard to miss. Walking the bank, you alarm a slippery, toad-sized herp, who shoots out over the water, landing with resounding *plop*. Even RALU tadpoles are jumpy, fleeing from your shadow, unlike oblivious toad larvae. In spring mating season, spotted calls carry far beyond anemic chirps of western toad. When spotted get here, you'll probably know it. For now, let's call RALU 'pensing,' not present.

Culture

Deep history

Because the term "*prehistory*" may be taken to infer that written records are the only legitimate windows into our human past, some of us have begun to seek other, less-loaded terms. *Deep history's* a little better than "*prehistory*," because it carries no obvious bias against oral tradition. But left unsaid is the rather deflating converse, "*shallow history*." In Lingít Aaní that'd be the fleeting 278 years since a Russian vessel first capsized in our tiderips. More thoughts on tenure-titling follow in *Euro history*. Personally, I have no problem self-identifying as newcomer (in the case of Jilkáat Aaní, not even that; a mere tourist or passer-through). But I sense that the title 'newcomer' might not go over so well among "pioneering" Haines families.

That said, I'm growing increasingly skeptical of claims to many millennia of residence by Lingít spokesmen and women. Expressing these reservations is not a way to be popular in Lingít Aaní, but my first loyalty is to **wildness**, expressed in academia as the anti-domestic ' scientific method, a prescription for clan-free conduct in the never-concluded search for truth. Making something "true" just by saying it over and over is not acceptable—the tool of dictators and evangelists.

Post-glacial colonization of the Americas is a ~15,000-year story of migration and dispersal with no firmly demonstrated residencies longer than a millenium or two. ² If a convergence of evidence from multiple disciplines—genetic, linguistic, archeological—someday confirms Lingít

¹ "Domestic" is here intended to imply control. Of livestock genetics, potato cultivars, wives, minions, and in matters of mind, religious belief or political doctrine. Real scientists—a much smaller club than suggested by, say, membership in AAAS—develop a sense of humor, and a humble satisfaction in stumbling away from wrongness toward rightness.

As for clans, sorry, but they aint wild. The mitochondrial side of clans warms my heart; the Hatfield-&-McCoy side chills it. Both sides suppress my objectivity.

² Those exceptions are mostly in xeric, hard-to-inhabit ecoregions such as the Zuni homeland. They seem improbable in rich but glacially upheaved NW coast archipelagos. More thoughts on the geography of deep-tenure are in my narrated slideshow [Glacial & cultural history of northern Lingít Aaní](#) Drag to 22:20 on the slider—section titled *How long do we live here?*



cut&pasters:

to reviewers: *Appendix 4* lists names with proper spelling, *translation*, (& IWGNs) for those who wish to apply the 3-part *Placenames convention* described on page 2 of this document.

common letters&names for cut&paste:

á é í ó ú

ǰ Ǥ ǧ ǩ ǫ ǰ ǰ ǰ

Raven: Gaanax̄teidí Lukaax̄.ádi
Eagle: Daǵl'aweidí Kaagwaan-
taan Shangukeidí

Jil̄koot Jil̄káat ǰwáan Lingít
Aaní



David Hotch making cottonwood canoe in Klukwan, 1953-57.

residence in place since first human entry into Southeast Alaska, I'll concede my skepticism was unwarranted. But it's hard to understand how that meshes with each clan's migration story, most of whom seem to this student of glacial history to chronological Little Ice Age odysseys.

This is an atlas; not an attempt to summarize Tlingit culture or history. But there are many mappable elements of that story that claim a rightful place in this evolving compendium. So let's start with some basic definitions.

Tlingit Kwáans are somewhat analogous to "tribes" in the sense of being geographic units. But they differed from our standard concept of a Native American tribe or nation in having no political authority—at least in precontact times. That power resided in . . .

Clans, of which there were always several in each kwáan, a mix from both the Raven and Eagle sides. On the (**highly provisional!**) [Clans map](#), some of the important clans are (gulp) mapped.

Streveler has pointed out something I hadn't noticed: Intriguing that the Jil̄koot/Jil̄káat border pretty much coincides with the coastal vs interior forest types described in the *Habitats* section.

Tlákw.aan, eternal village (Klukwan)

historical photos. sidebars from elders and *a few* maps . . .

We now have a chapter for spatial description of Tlákw.aan in *Featured landscapes*. But due to the centrality of this community to our cultural and ecological understanding of GCW, I'm inclined to keep a section here as well. Probably this location's best for the human story, while the other document will treat matters of geography.

Clans and houses

I've roughed-out clans polygons (map, next page) simply as a starting point, to solicit comments and discussion. There are several published sources describing traditional clan territories in Jil̄káat and Jil̄koot Aaní, but none that I've seen show claimed lands as polygons in this manner—so I anticipate there will be differing opinions. In Goldschmidt & Haas (1996), chart 5, land claimed by the 5 principle clans is shown rather vaguely with a number, centered over villages, or forts, or fish camps to which ownership was attributed by an interviewed elder. Of course, any cultural map is just a snapshot in time. Lands could be ceded from one clan to another, and elders often stated that although one clan claimed a fish stream or berry patch, the entire community was welcome there. Furthermore, because marriage was always outside the clan, there were always inlaws living in every camp and village.

Why do we live here?

Factors in site selection, for the key active and historic sites. Since 2013, this oft-repeated question about people and place has declared an intention by Discovery Southeast to always press boldly deeper into [cultural biogeography](#).

Starting on homeground in Áak'w and T'aaḱú Aaní, in partnership with Goldbelt Heritage Foundation and Sealaska Heritage Institute, we've taken elements of this program to Sitka and Hoonah, and would be honored to cohost a session with Klukwan culture bearers for the GCW.

Roughing out this *Atlas* in the early 2020s, I pulled down a very nice deep history (not called that by its

authors of course) from the Haines Borough website. I'm glad I copied it rather than just linking, because clicking that link today (20250124) just brings up a blank white page. No '*page does not exist*' notice, or other redirection advice. Eerily symbolic, eh?

Of course, the incentive for removal might not have been 'whitewashing,' but the result kinda looks like it. The current *hainesalaska* site has a [sanitized history](#) from which you might conclude that it all began with the noble gold-seekers struggling over wilderness trails into Canada.

I imagine the new cultural center at Tlákw.aan has taken on spokespersonship for pre-euro history. And maybe they even asked for the *haines.gov* version below to be removed.

I like it a lot, though, and will keep it here unless requested otherwise. Strangely (or perhaps understandably?) no authors were credited.³ But they clearly knew their Tlingit history—probably *were* Tlingit, or at least adopted. I haven't edited in any way, and have resisted adding current orthography; Lingit names are otherwise pretty close to X̄'unei (Lance Twitchell's) spellings. My editorial additions are entirely segregated into footnotes.

From [hainesalaska.gov/tourism/history](#)

The Haines area was originally settled by Native Alaskans of the Tlingit culture who traveled along the Northwest Coast upwards behind the receding glaciers or came down the mountain valleys from the Interior. The area was valued for its mild climate and abundance of food. The original Native name for Haines was Deishu, meaning "end of the trail". With

³ Surely someone in our *Atlas* 'kitchen-cabinet' can explain the removal and name the author(s). Dan Henry? The Hotches?

an oral tradition, and no written history, details of Tlingit Native migrations are largely undocumented.⁴

Many Tlingits of the Chilkat Valley can trace their families back generations to residents of local villages. There are Tlingit sites in Southeast Alaska where fish traps and basketry date from 5,000 to 10,000 years ago.⁵ Local archeological evidence shows fish traps in the Chilkoot River 2,100 years ago and remnants of houses at the Chilkoot village site date to over 800 years ago. Oral history also reflects a long tradition of Tlingit habitation in the Chilkat valley.

The Chilkats were well known as the largest and most powerful of all the Tlingit tribes.⁶ They had exclusive control of many trade routes into the interior through which they maintained their position as middleman in the fur trade and amassed great wealth.

Historically, the Chilkat valley had many village sites

4 Interesting expression. Obviously each clan has an oral migration story. So, by "documentation" the authors probably mean that nobody's taken on the story from glaciological, ethnological or archeological perspectives?

5 Admirable and unfortunately increasingly unusual restraint in attribution of ownership. Today, both culture bearers and their "scientific" enablers would automatically say those fish traps and baskets were definitively Tlingit. Here, we're just informed that they exist on territory claimed most recently by the Tlingit.

6 This is a fair claim as of the 1830s when Russians established Redoubt St. Dionysus in Wrangell, home of Shtax'héen K'wáan. Shakes dynasty was positioned on a far larger, more easily traveled corridor into the vast boreal fur country than that of Jil'káat/Jil'koot Aaní. Kaachxana.áak'w, little lake accessible to people (Wrangell Harbor) was also closer to redcedar country, source of war canoes so essential to Tlingit power structure. Until Russian arrival, and the smallpox epidemic of 1835, Chilkat hit s'aatís (housemasters) were 'Avis' to the 'Hertz' of Shakes' vast armada.

But what Kaachxana.áak'w lacked and Tlákw.aan retained throughout the 1800s was distance from ship-mounted cannons, and to some degree, from plagues that swept the archipelago's seaside villages. Even in Muir's day, euros smiled respectfully when addressing Jil'koot or Jil'káat hit s'aatís

but only two are still occupied today. A village was located along the banks of the Chilkoot River and was occupied by three clans:

Lukaax.adi (raven/sockeye)
Kaagwaantaan (bear)
Shangukeidi (thunderbird)

There were 30 houses on the West bank of the Chilkoot in the 1860's, and more on the East bank. The site on the East bank was destroyed between 1881-1890 by a landslide and many lives were lost. It was called Akaxwoo.ee (earth/mud slide over it).⁷ More lives were lost to Western diseases so that by 1882 only 8 houses and 127 inhabitants were reported at the village site. By 1895, 4 named tribal houses and 9 smaller houses remained.

A road was constructed in the late 1950's directly through the village site to Chilkoot Lake and gradually over the years became a park way-side. Native use continues on a seasonal basis for subsistence food gathering and the Lukaaxadi have erected a cultural camp within the old village site. Additional village sites of the Lukaaxadi were Tan.aani on Lutak Inlet, Deishu at Haines, and on the Chilkat River, Yandeist'akye' at 4 mile, and Kaatxawultu' at 19 mile. Kaatxawultu' was destroyed by a landslide after 1895, and some of the villagers moved to Yandeist'akye'.

Located near the Haines airport, Yandeist'akye' was an important village site to the local Tlingit. In 1880, Yandeist'akye' had 16 houses and 171 people, but by 1900 only 7 houses remained. Both Tan.aani and Yandeist'akye' were decimated by disease so that by 1895 Tan.aani was deserted and the last residents of Yandeist'akye' died in the 1930's. Many residents who did not succumb to disease moved to Deishu, where their descendants still survive today.

Many areas in the valley have a long history of use by the Tlingit. Duk Point "Little Cottonwood Point" at 7 mile on the Chilkat and 4 mile point are important sites to fish

7 The 2024 report from [Nicolazzo & Larsen](#) maps out this tragic landslide.

for eulachon and Jones Point was important for early king salmon. South of Jones Point was a large Chilkat Village and a Cemetery before a cannery was built in the same area in 1882.

European explorers began arriving in the late 1700's. During the Vancouver expedition in July 1794, Lieutenant Joseph Whidbey led a small exploration party up the Lynn Canal (named after Vancouver's birthplace) to the shores of the Chilkat Inlet. It was during that visit that the Whidbey party greeted local Natives and first charted the local physical environment.

During the following decades, explorers and traders became more frequent visitors to the Upper Lynn Canal region. Most notably, Captain Richard Jeffrey Cleveland sailed to the end of Taiya Inlet in 1799 and John D'Wolfs trading excursion of 1805. The first white man to settle here was George Dickinson, who came as an agent for the Northwest Trading Company.

The location of Klukwan or "Eternal Village" more than 20 miles up-river, offered protection from the well-armed sailing vessels of the Russians, Americans, British, and others. The village had many large clan houses and a population of a few thousand, but by 1882, only 65 houses and about 600 people remained.

Chief Kohklux of Klukwan was known as the most powerful warrior and greatest diplomat on the Northwest Coast. By the mid 19th century, traders were attempting to access the interior to trade for valuable furs. Hudson Bay Company built Fort Selkirk on the Pelly River but Chilkat warriors led by Kohklux were responsible for its destruction on August 21, 1852. Historically many defensive forts were constructed by the Tlingit in the area; one on a point in Portage Cove, one on a hill at the mouth of the Chilkoot River, and on the Chilkat River: one at 7 mile, one at 9 mile, and one at 13 mile above the current road. The Russians built "Willow Fort" near Pyramid Harbor about 1838 while surveying the Chilkat River.

The Chilkats became aware of the transfer of Alaska from

Russia to the United States, when Kohklux was presented with a U.S. flag on October 17, 1867 by Capt. Howard on the ship Lincoln. Kohklux displayed the flag mounted on his canoe, one day before the US flag was raised at Sitka.

In 1869, William Henry Seward, his son Frederick and surveyor George Davidson visited Klukwan to view a total eclipse. While there, Seward became friends with Kohklux and was well respected as a man of peace as he negotiated a treaty between the Sitka Tlingits and the Chilkats. Seward realized the importance of the Chilkat Valley to the United States. Starting in 1903 the US Government began construction of Fort William H. Seward to help settle the boundary dispute between the United States and Canada.

In 1879 when John Muir and Presbyterian missionary, S. Hall Young visited Yandeist'akye', Kohklux wore a robe that was a gift from Seward and showed a tattoo of "Seward" on his arm. At this time, at the request of Chiefs Kohklux and Daanawaak, permission was given to the Presbyterians to build a mission school at Deishu to educate local Native children. The site chosen was on the narrow portage between the Chilkat River and Lynn Canal. By 1881, with the financial help from Sheldon Jackson, the mission was established. The town was named for Mrs. F. E. Haines, secretary of the Presbyterian National Committee of Home Missions, which raised funds for the new mission.

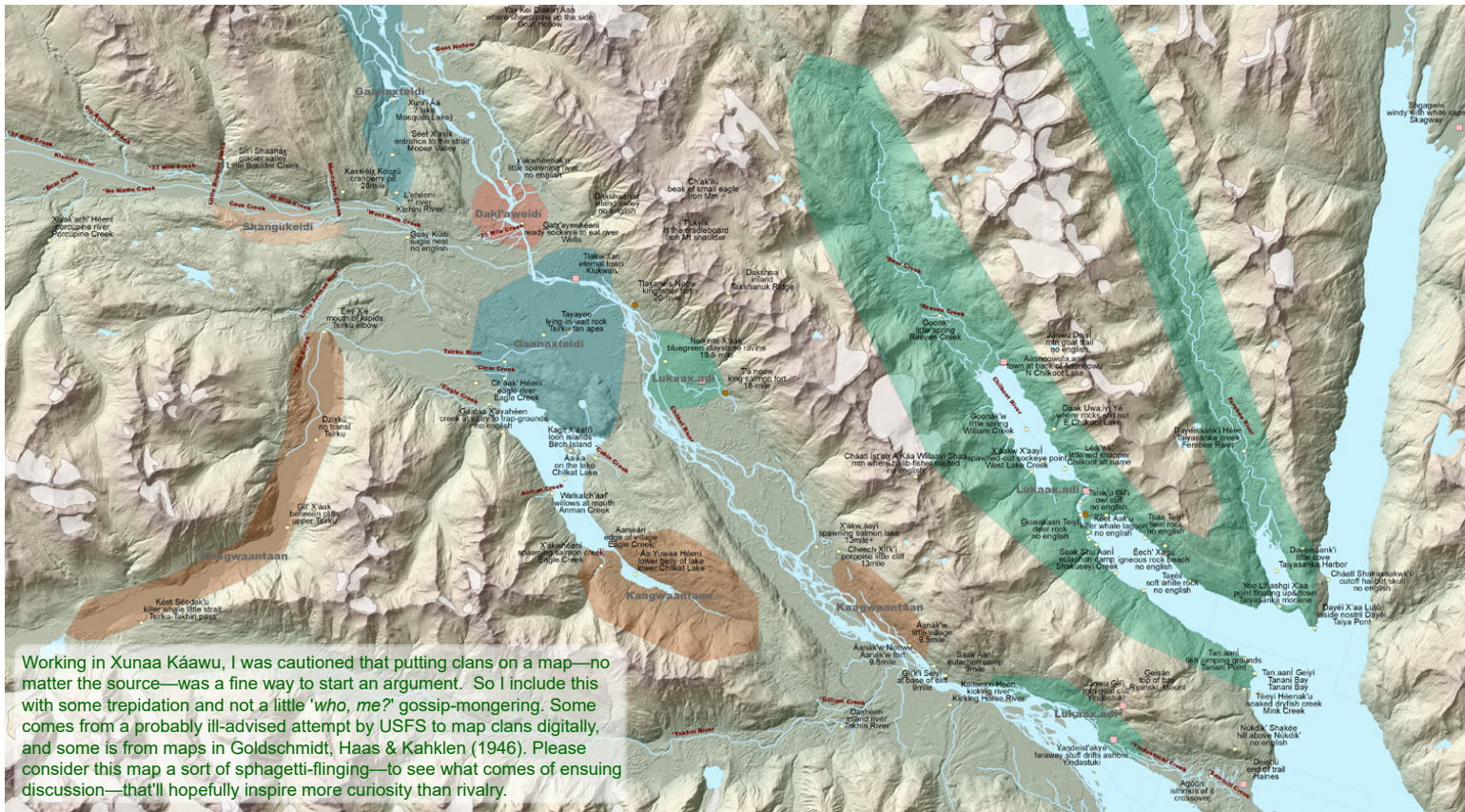
Leaving Sitka on May 20th, 1880, the "Edmund Bean Party" was the first group of miners allowed into the interior with permission of Chief Kohklux. As pressure was brought to bear on the Chilkat Tlingit to open trade access to the interior, their position as middleman in trade was threatened. Lunaat, 38 years old and the second chief at Yandeist'akye' was killed in Dyea in 1888 during a dispute over rights to pack on the trail. Kohklux died in 1889 at the age of 70 and Chief Daanawaak of Yandeist'akye' was very old by then. Many changes were coming fast.

During the 1890's their income derived from the "fur trade" was shrinking, as others began to haul freight over the passes. As the gold rush began, mounting pressures due

to economics and Native rights issues caused the government to exert more pressure on Native peoples through the courts. Often Tlingits lost their cabins, hunting, fishing and berry picking sites to encroachment by new "owners". As Native rights issues were developed, the ANB and ANS were formed to fight for the rights of Natives to vote and own land.

Many of the founders of the Haines ANB/ANS went on as leaders to influence the development of Native Rights issues statewide. Elizabeth Peratrovich was from the Lukaaxadi of Yandeist'akye'. Mildred Sparks and Victor Hotch of the Klukwan Gaanaxteidi', Austin Hammond of the Chilkoot Lukaaxadi and others were active on issues and received statewide recognition for their efforts and dedication.

Today Tlingits still maintain a strong cultural presence in the community and the Elders are influential in the region protecting Native rights and subsistence issues.



Working in Xunaa Káawu, I was cautioned that putting clans on a map—no matter the source—was a fine way to start an argument. So I include this with some trepidation and not a little 'who, me?' gossip-mongering. Some comes from a probably ill-advised attempt by USFS to map clans digitally, and some is from maps in Goldschmidt, Haas & Kahlen (1946). Please consider this map a sort of spaghetti-flinging—to see what comes of ensuing discussion—that'll hopefully inspire more curiosity than rivalry.

Jilkáat & Jilkoót clans & houses

From Hope (2003):

Jilkáat Raven

Gaanax̄teidí *Gáanax head, Stewart*

X'áakw Hit *freshwater-marked sockeye house*

Yaay Hit *whale house*

X'aak Hit *gully or ravine house*

Ʒutis' Hit *looking out house*

Xixch'í Hit *frog house*

Ishka Hit *salmon hole (in river) house*

Lukaax̄.ádi *Lukaax̄, Duncan Canal*

Naach'ooneidí ?

Noowshaka.aayí ?

Eagle

Kaagwaantaan *Burnt house*

Gooch Hit *wolf house*

Kéet Hit *killerwhale house*

Ligooshi Hit *killerwhale dorsal-fin house*

Dagisdinaa Dakséet, *Dangerous R?*

Xeitl Hit *thunderbird house*

Shis'gi Hit *sapling house*

Dak'l'aweidí *Inside Sand, Stikine*

Ch'eet Hit *murrelet house*

Teilu Hit *moth house*

Kéet Gooshi Hit *killerwhale dorsal house*

Kéet Ʒwáani Hit *killerwhale people house*

Kéet L'oot'í Hit *killerwhale tongue house*

Kéet Déx'í Hit *killerwhale backbone house*

Jilkoót

Raven

Lukaax̄.ádi *Lukaax̄, Duncan Canal*

Yéil Hit *raven house*

Yéil Kiji Hit *raven's wing house*

Shaa Hit *mountain house*

Kooshdaa Hit *land otter house*

Geisán Hit *Mt Ripinsky house*

Eagle

Shangukeidí *Shánkw, Klawock*

Kaawdliyaayi Hit *lowered from sun house*

Kaagwaantaan *Burnt house*

Xóots Hit *brown bear house*

Ch'áak' Hit *eagle house*

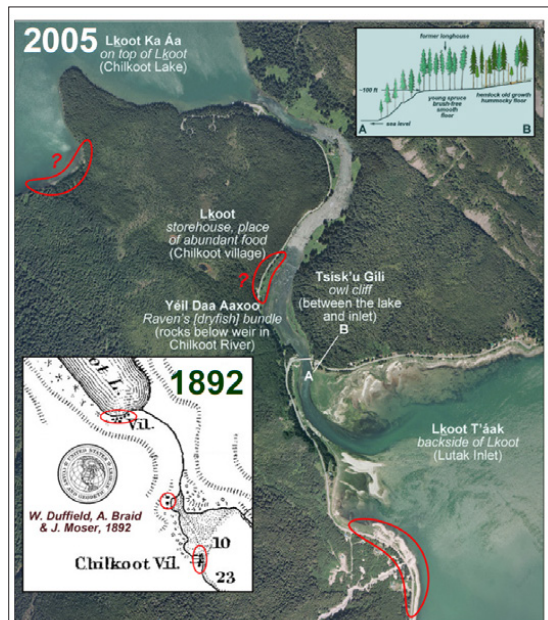
Kaagwaani Hit *burnt house*

Outlet of Lkoot Ka Áa, on top of Lkoot (Chilkoot Lake), on 2005 Census imagery. Land is rising at about an inch per year. Where exactly were the habitations indicated as numbered points in Thornton & Martin (2012)?

In 1992, on the bluff in transect A-B, Greg Strevler and I found the house-site below (faint pink outlines) about 100 feet above saltwater.

Before spruces grew up to obscure visibility, this bluff (owl cliff?) gave long views to the southeast into Lkoot T'áak (Lutak Inlet). This platform is too high for post-Little Ice Age uplift. But the gentle gradient suggests a marine landform of some kind.

More recently I found the 1892 chart by US Coast & Geodetic Survey that more explicitly shows villages ("Vil.") and unlabeled buildings (smokehouses?) on the west river bank. I climbed a tree for this perspective down onto an old house site. Superimposed pink rectangle shows foundation outline (transect A-B, above). This level terrace was in young-growth spruce. Trees have rooted on the raised lip surrounding the house site.



Euro-history ¹

If we accept "*deep history*" as logical title for pre-Euro stories in this *Atlas*, then by some lines of thinking this section should be titled "*shallow history*." But Alaskans, for an odd and embarrassing combination of reasons, are big into the "*I've-lived-here-longer-than-you*" competition. And since that can get touchy, it's probably best for our *Atlas* to stay neutral on the deep-vs-shallow dichotomy.

After all, who wants to draw the 'shallow-stick'? Seems to me that some non-Native, multi-generation families take overweening pride in depth of tenure, especially those descendants of pioneers and founding fathers who stood with rifles in doors of cabins and canneries built on middens of the marginalized. Teasing these patriarchs can be dangerous. Matriarchs too. Daughters of the American Revolution would be unamused by my pokes at latecomer-land-barrons.

But what might we 'non-Natives' call ourselves? I'm disinclined to define any culture by what it is not.

¹ Perhaps local Haines historians could be enlisted to write some of these sections? I've dropped-in some titles for obvious topics, largely centered around the markets that lured us here: **furs**, & the passes to Tutchone country, **fish** & the era of canneries; **timber**, & the chainsaw/Schnabel episode; **mining**, from Porcupine to Constantine; & a summary of the **conservation** community's origins and evolution in the GCW. As an outsider, I don't have much to offer to this effort except willingness to cut&paste the nuggets of local knowledge. To the extent & such history is '*atlasable*,' the obvious graphics are early maps & air-photos. ● **20200702** Yesterday I had a fun and educational catch-up call with Jessica, in which we touched on relations LCC and some of the conservative elements in Haines. I then listened to several interviews with Heather Lende on the launch of *Bears and Ballots*, in part about how divided the town can be. Makes it clear that as an outsider, I could so easily stick my foot in my mouth, at small cost to myself but considerable to my partners who live in Jilkkáat & Jilkkoot Aani, year-round. So, in cases where I do opine—such as captions to these historical maps—I suggest severe editing by Jessica, Eric, and other Deishú-wise messaging-police. I won't be offended—promise. Doesn't mean we totally trash inflammatory drafts. There can and should be an in-house version of this *Atlas* for LCC, and others (Takshanuk?) who could use em as reference as opposed to ammunition.



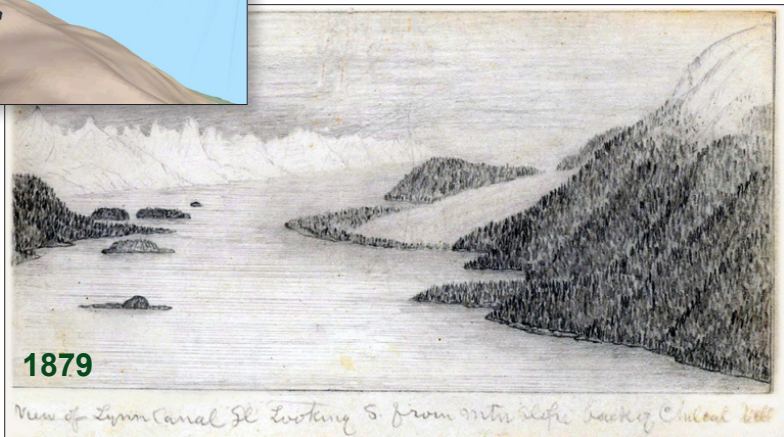
John Muir

As of early 2022, our national reimagining of "American" history is shifting so fast—to show how hip I am, I should say "pivoting," :)—that it's hard to know how we'll feel about any Important White Guy a decade or even 5 years from now. ¹

[Audubon](#) and [Sierra Club](#) are distancing

¹ 2025: I'm ashamed to say that 3 yrs ago I couldn't see the pendulum swinging back. Our commander has just ordered Denali changed back to McKinley. IWNs are on the ascendency. Of course, we greenies, former disciples of Muir and Audubon will persist in patriarch-bashing.

Sketch by John Muir of "Lynn Canal Gl. Looking S from Mtn slope back of Chilcat Vill." A USGS map from ~1894 locates "Chilcat Village" on the shore half mile NE of Laxách' (Pyramid Island). But my 'tip-up' simulation best fits a vantage near summit of Geisán (Mt Ripinski). Journal excerpts, following, elaborate on this ascent.



themselves from their namesakes and founders. Pedestals are crumbling. A trajectory can be traced across 2 fairly recent Muir partial-biographies by local authors—and my friends—Kim Heacox and Dan Henry.

- **2014 Heacox** *John Muir & the ice that started a fire: How a visionary & the glaciers of Alaska changed America.*
- John as pretty much a conservation saint.
- **2017 Henry** *Across the shaman's river: John Muir, the Tlingit stronghold, and the opening of the north.*
- John as flawed and bigoted, but moving toward wokeness by the clanhouse fires of Tlákw.aan.

Much as I admire the art and scholarship of these biographies, neither—wet as their

ink may be—would manage to duck editorial disapproval today. JM tossing off a one-liner about "wild children" sending missionaries to the christians seems increasingly to offer feeble redemption for a life of supremacist/misogynist/transcendentalist vindication of Wilderness, wrested from industry, yes, but also from tribal homelands.

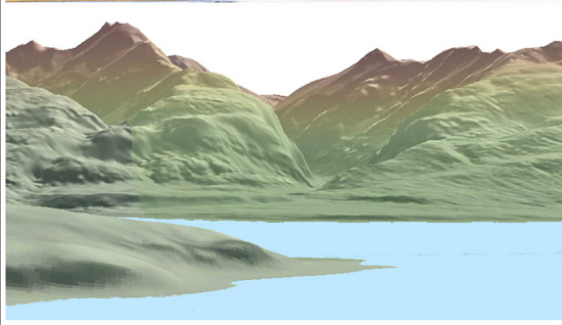
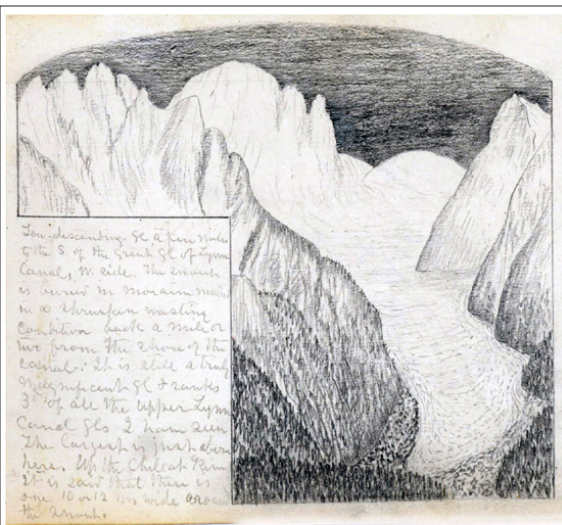
As a privileged suburban white guy aspiring to ethical residence in Lingít Aaní, moving toward wokeness at a pace no speedier than John's, I've realized that one contribution I can make is to mine the journals of my invading predecessors for insights into natural and cultural history. Often, their writings are painfully arrogant, and I don't expect culture bearers to wallow in this language. The trick, as in deLaguna's phrase, is to read history in full awareness that we're looking "through alien eyes."

● **2005 Cruikshank** *Do glaciers listen?: Local knowledge, colonial encounters, & social imagination.* If you seek a more indigenous and place-rooted perspective on Muir, I strongly recommend Julie Cruikshank, Chapter 5, *Bringing icy regions home: John Muir in Alaska.* Here's a sampling:

"As the travelers explored Glacier Bay, their experiences with transformed ecology were disconcerting for everyone, especially for the Tlingits who best grasped the dangers and took Muir's reckless enthusiasm about glaciers as evidence of witchcraft or even of madness. . . .

In some ways Muir the ecotourist approached his guides-&-protectors' animate world-view, more closely than other starched Euros of his day:

"He described glaciers as 'traveling animals that make their own tracks,' and as 'crawling through gorge and valley like monster glittering serpents.' He spoke of glaciers 'in labor' giving birth to mountains, and of falling icebergs emitting 'the outcry of a newborn berg.' Yet he failed to grasp local social conventions associated with glaciers and distressed his crewmembers by disappearing for hours



Sketch by John Muir of "Low descending gl [JM abbreviation for glacier] a few miles to the S. of the Great gl (Davidson) of Lynn Canal, W. side. The snout is buried in morain [?] in a shrunken wasting condition back a mile or 2 from the shore of the canal. It is still a truly magnificent gl and ranks 3rd of all the upper Lynn Canal gls I have seen. The largest is just above here."

Drawn Nov __ '1 while still approaching Chilkat country, before JM was aware of the Davidson's IWG name?

1 So far, I haven't found exact dates for this Nov portion of Toyatte Expedition. Muir's various logs are sometimes good about dating, and sometimes not. In *Travels* (1915) he says they camped just short of "the famous Chilkat or Davidson Glacier" on a Monday. So a calendar for 1879 would help. On next page, sketch of the summit behind "lower Chilkat vil" is dated Nov 6.

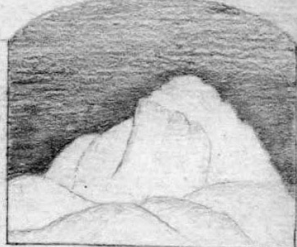
into 'ice-mountains' with no apparent purpose or concern for his fellow travelers."

Muir's legacy is shinier in San Francisco than in the villages of Lingít Aaní:

"On the one hand, then, Muir is extolled as a visionary architect of protected lands and credited with the environmental ethic underlying Glacier Bay National Park. On the other hand, his is faulted for constructing an artifice of wilderness that eventually excluded Huna Tlingit from a bay he claimed to have 'discovered' after they guided him there."

In fairness, we might note that some of this legacy was manipulated by Muir's editor Robert Underwood Johnson:

Summit of mtn back of Lower Chilcat
vil 7000 ft high Immaculate white Nov 6, 1879



Summit of mtn back of Lower
Chilcat Vil 7000 ft high
Immaculate white Nov 6, 1879

Left: vil = JM abbr. for village. Muir probably over-estimated most summit elevations. ● **Right:** "Mouth of Canyon of the lowest tributary of the Chilcat River from Mtn back of Lower Vil." My arcpro 3d2-tab simulation from Geisan (Ripinski) suggests Muir was only about halfway to the top

"If animal sentience could be demonstrated, Muir pondered, should human rights be extended to animals, and perhaps even to women and children? Johnson apparently deemed such ideas too radical for readers of Century Magazine and expurgated such passages from Muir's submissions."

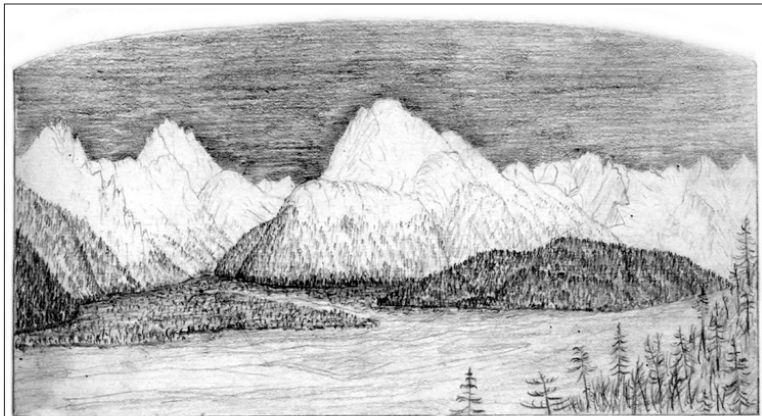
Groomed by Johnson and others for national leadership status, by the time Muir returned to Alaska with Harriman in 1899:

"Railway-sponsored packaged tours were already shifting focus from Muir's educational vision to a more marketable 'experience' in which Tlingit people and glaciers came to share the role of commoditized backdrop, part of the scenery."

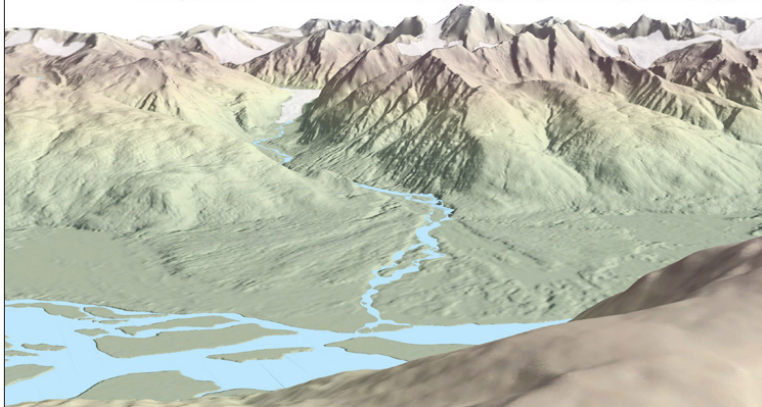
A great deal more can be done with the Muir archives. For our atlas, the obvious gems are these purported field sketches ²

- **botanical and habitat descriptions.** Muir was a good botanist. He made some mistakes, like calling alders birches. But his raw field journals include long lists of genera that demonstrate familiarity, especially with widely distributed alpine flora.
- **cultural geography.** Young—who lived here and considered SE AK his evangelical turf—was better than Muir at geography. Cross-referencing M&Y, you can usually figure out where they were.
- **cross-referencing** published account (*Travels in Alaska* 1915) with original daily journals and sketches.

² I'm actually beginning to think John created them back home in Martinez, at his victorian mansion. Comparing these arch-topped finished-looking drawings to the very quick line drawings made in camp or even from the canoe, it's easier to picture him carefully filling in those forested hills and darkened skies at his desk, with good light, stable dry writing surface, and drafting tools to square off those corners. More thoughts on sequence and method are in my [aakwtaakuhistory.pdf>muir-on-muir](#).



Mouth of Canyon of the lowest tributary of the Chilcat River from mtn back of Lower Vil



Jack Dalton

Mark Kirchhoff—twin brother of my colleague the wild-life biologist Matt—is a historian of Lingít Aaní's Euro era. In 2007, he published an excellent history of Jack Dalton and other important white guys of the era such as EJ Glave and AM Jarvis. To indigenous readers, it's definitely—like the interpretations by Heacox and Henry—a story told through alien eyes. It must chafe, for residents of Tlákw.aan, to hear the ancient trade route called "Dalton Trail."

But Mark pulls no punches concerning Dalton's aggressive self promotion, and ruthless displacement of anybody—euro or Tlingit—daring to oppose his ruthless colonialism. I learned a lot from *The Alaska Pathfinder*, even if he didn't actually find those paths. Like John James Audubon, fabricator without equal (Kaufman, 2024), Jack Dalton was an accomplished myth-maker. But concerning many of his misdeeds and exploits he played his cards close. Little was actually known about his origins and Alaskan travels until Kirchhoff's research.

á é í ó ú
g ǵ k K x X

Raven: Ǵaanax̄teidí Lukaax̄.
ádi

Eagle: Daǵl'aweidí
Kaagwaantaan Shangukeidí
Jil̄koot Jil̄káat Ǵwáan
Lingít Aaní Tlákw.aan

1794 Vancouver's assignment from his Admiralty was more explicitly cartographic. Personally unable, through illness, to leave his motherships anchored outside, ³ he sent rowboat excursions 'inside' in command of Joseph Whidbey. The excerpt on on previous page is almost surely Europe's first map of northernmost Lingít Aani.

My [36-minute slideshow](#) on Whidbey's ventures in July and August, 1794, focuses on Aak'w and T'aakú Aani, but touches on Jilkáat/Jilkoot encounters, and contextualizes Joseph Baker's depiction of this wildest corner of the archipelago. Although drafted under Vancouver's "immediate supervision," it'd more properly be called the Baker Chart for Joe who did the work, and all the underpaid journeymen stipplers who hand-drew each of those barnacle-mountains. ⁴

For all of Jilkáat & Jilkoot Aani, Vancouver's only named feature was at Ayiklutu, *nostril of Ayik; you gotta get ready* (Seduction Point). The "seduction" is remembered quite differently by Tlingit and British historians (Henry, 2017, p39-40)

Although a huge advance over Marchand's French chart, I find Baker's amusingly overstated. Baroquely detailed shorelines imply exhaustive field survey but were merely draftinghouse embellishments from simple point-to-point line drawings by Lts Whidbey & Johnstone. If you drop Baker's chart into ArcMap and try to georeference it, you'll find it accurate only in coarsest features. That's expectable considering celestial observations were taken every few days, and the rest was 'eyeballed.'

For decades after 1794, no map updates showed Taiya Inlet extending north to Shgagwei. Not surprising on this 'original,' considering Whidbey's hasty retreat from "*Emperor of the Lakes*." For all its pomp and artifice, (or because of it?)—certainly looks great on the wall, even authoritative in the pilothouse) Baker's work was durable. Compare, for example, to Davidson's 1868 map, next page, extending up "*Chilkaht R.*" but likewise deadending at today's Port Chilkoot. Even Muir & Young carried "Vancouver charts" in 1879 & 80, and

³ At Port Althorp, named under rules of suck-up for eldest son of GV's boss Spencer, first Lord of Admiralty—actually L'ix' Xágu, *brocken rock sandbar*. As for Lynn [noTN?], that was GV's Norfolk birthplace.

⁴ Look close; like snowflakes they're *not* stamped, however clone-like on first impression.



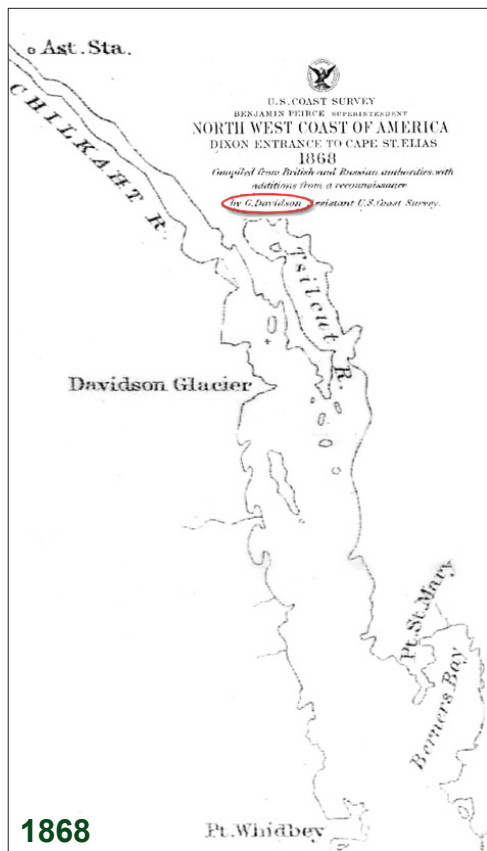
neither left us improved sketchmaps.

1868 Davidson Unlike Muir and Young, George Davidson was a trained surveyor. In August, 1869 he traveled upriver with William Seward to observe a total solar eclipse at "Ast. Sta." just downriver from Tlákw.aaan (Henry, 2017, p61). He'd selected the station on a prior visit in 1867.

Davidson's spellings distinguished Jilkáat from Lk̄koot. Presumably the "British and Russian authorities" and not George himself labeled "Davidson Glacier." Orth (1967) says:

"named in 1867 by USC&GS for George Davidson, 1825-1911, and published in the 1869 Coast Pilot.

So George is acquitted of self-commemoration but probably enjoyed sailing past this icy aggrandizement in 1869.



1868-80 Compilation I discovered this amazing resource—NOAA's HO225-08-1882—when collating and annotating the journals of [Richard Meade](#). The high-res digital scan lay unrecognised partly due to mislabeling by archivists as "Southwest Alaska." Only by accident did I download it. Not published until 1880 following missions by Beardslee and Glass, this '3-cook-broth' was nevertheless largely unaltered from numerous sketchmaps prepared by Meade in 1868&69, for areas not visited by those later commanders.

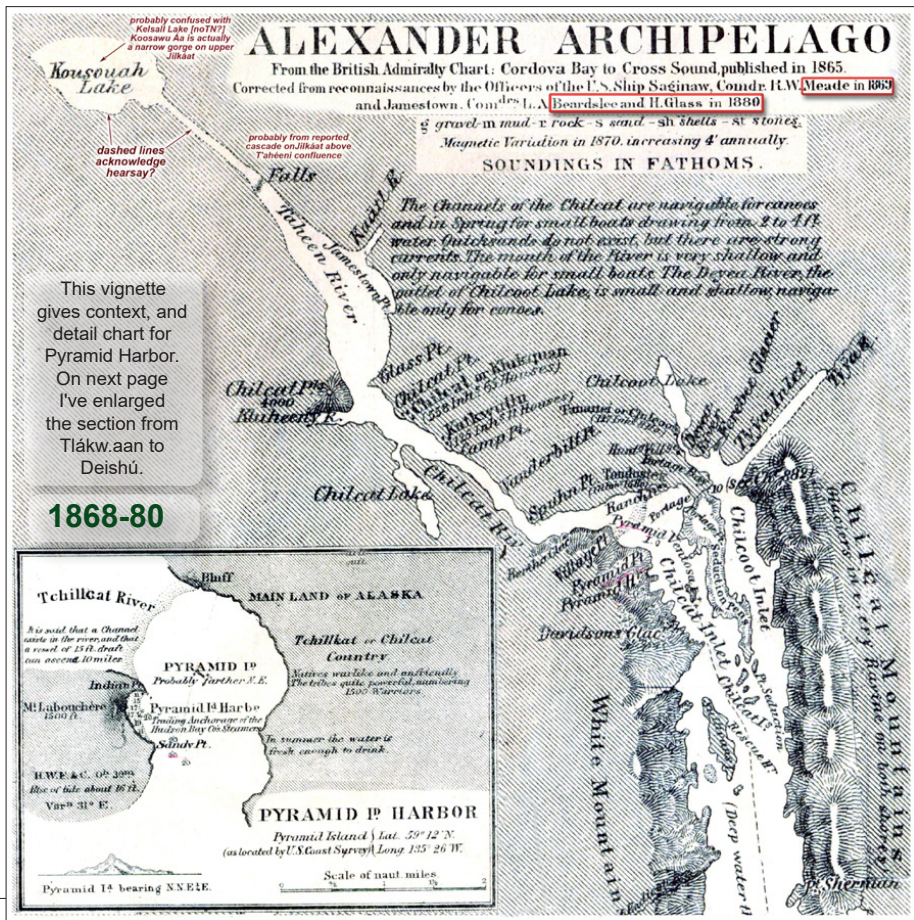
In Chilkat country, due to strategic importance, there was probably input from all three. Thus my 12-year date span: 1868-80.

As if overwhelmed by the task of cramming those 12 years into a single chart, HO225-08-1882 looks cluttered and less professionally drafted than Baker's, more than 80 years prior. Some important labels, such as ("see Ch. 882"), are nearly illegible over hachure background. Yet it undeniably contains an order of magnitude more ground-truthed information than any prior map of Lingít Aaní.

Meade's journal made frequent reference to his maps and plans depicting key anchorages, often near major Tlingit or Haida settlements—therefore of high interest to historians, culture-bearers and naturalists. These crude charts with 3-digit titles—eg Ch.882—were apparently published individually in 1869. I haven't been able to track them down, and can only trust that back in DC, Navy Hydrographic Office cartographers resisted the fanciful embellishments of Baker's day, and faithfully gave us on HO225 what Meade, Beardslee and Glass recorded on original harbor charts and coastline features eyeballed from decks of *USS Saginaw*, *Jamestown* & *Wachusett*.

Not that those fieldsketch maps were qualitatively less impressionistic than Whidbey's or Johnstone's. Errors in eyeballing are simply finer in scale. *The map is not the territory.*

In very little time since Davidson's bare-bones map, Chilkat country was getting fleshed out. Away from steamship waters, officers relied on resident guides: Lukaax̂.ádi, Kaagwaantaan, Gaanax̂teidí, Dakl'aweidí. In consequence, more Lingít place names survived here

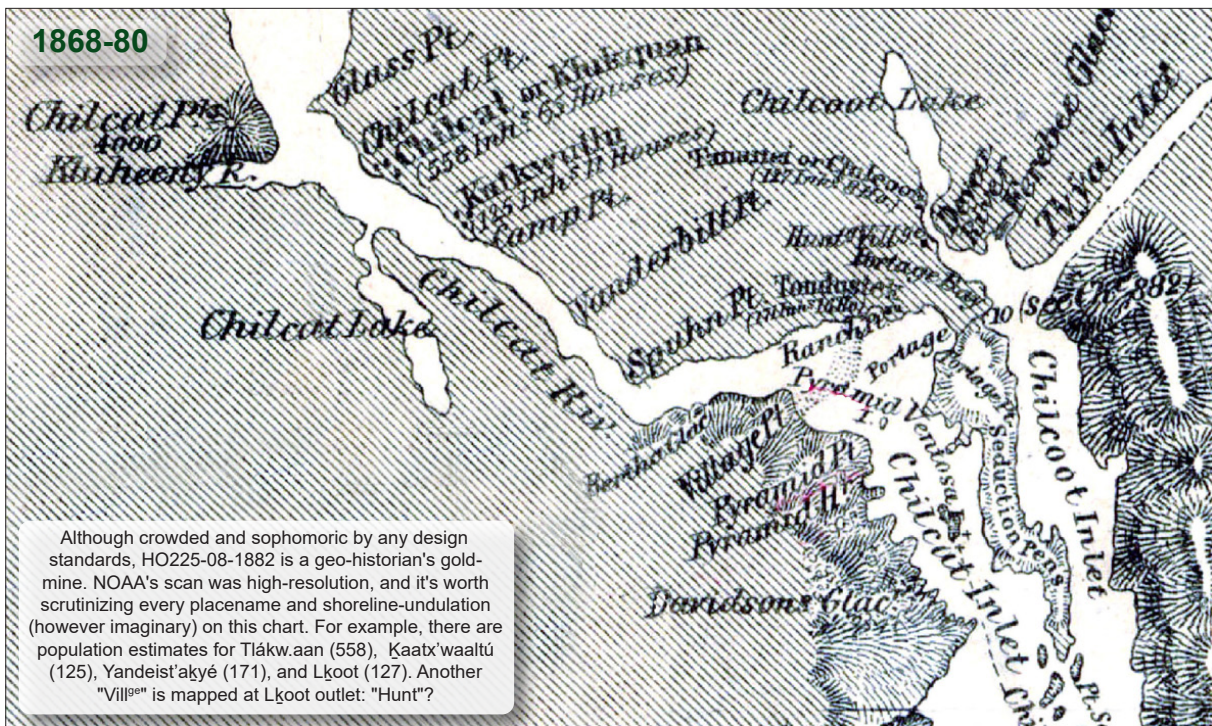


than in probably any other kwáan territory. Afloat with our cannons, it all looks like ours; encamped with only homegrown scouts and porters on unmapped rivers, we listen better.

That said, all the commanders, company CEOs and even their ships were commemorated on HO225-08-1882—even in lands none had probably seen: eg. Jamestown Pt. for Beardslee-&-Glass's warship. Northward from "Glass Pt.", ' a sudden widening of "Taheen" valley (zoomed out version, previous page) bears little resemblance to actual landscapes past or present. Judging from straighter, dashed streamlines and sudden fall-off in annotation density, no Euros had actually pushed upriver from "Glass Point" by 1880. I've annotated some of these hearsay places on the previous context view.

"The territory never gets in at all ... the mental world is only maps of maps, ad infinitum." (Bateson, Steps to an ecology of mind. 1972)

1 On modern maps Glass Point is just a shifting bar across from the 2-square-mile Klukwan alluvial fan. It appears to mark nothing more significant than residue from this fabricated entry into "Taheen River."

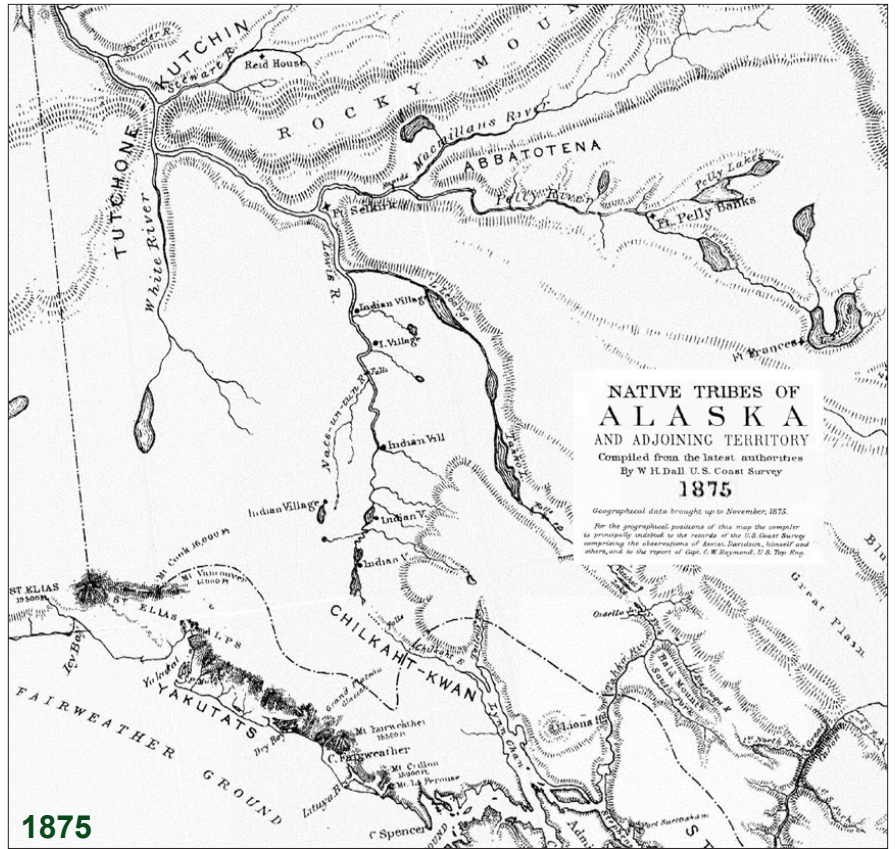


Compared to Whidbey's visit, Meade, Beardslee and Glass met a culture thoroughly evolved in relation to global, cannon-wielding powers. But especially on rivers, great hit s'aatis stood unsubdued, backed by vast armies. Even on the Pyramid Harbor inset, previous

page, commanders remarked:

"Natives warlike and unfriendly. The tribes quite powerful, numbering 1500 Warriors."

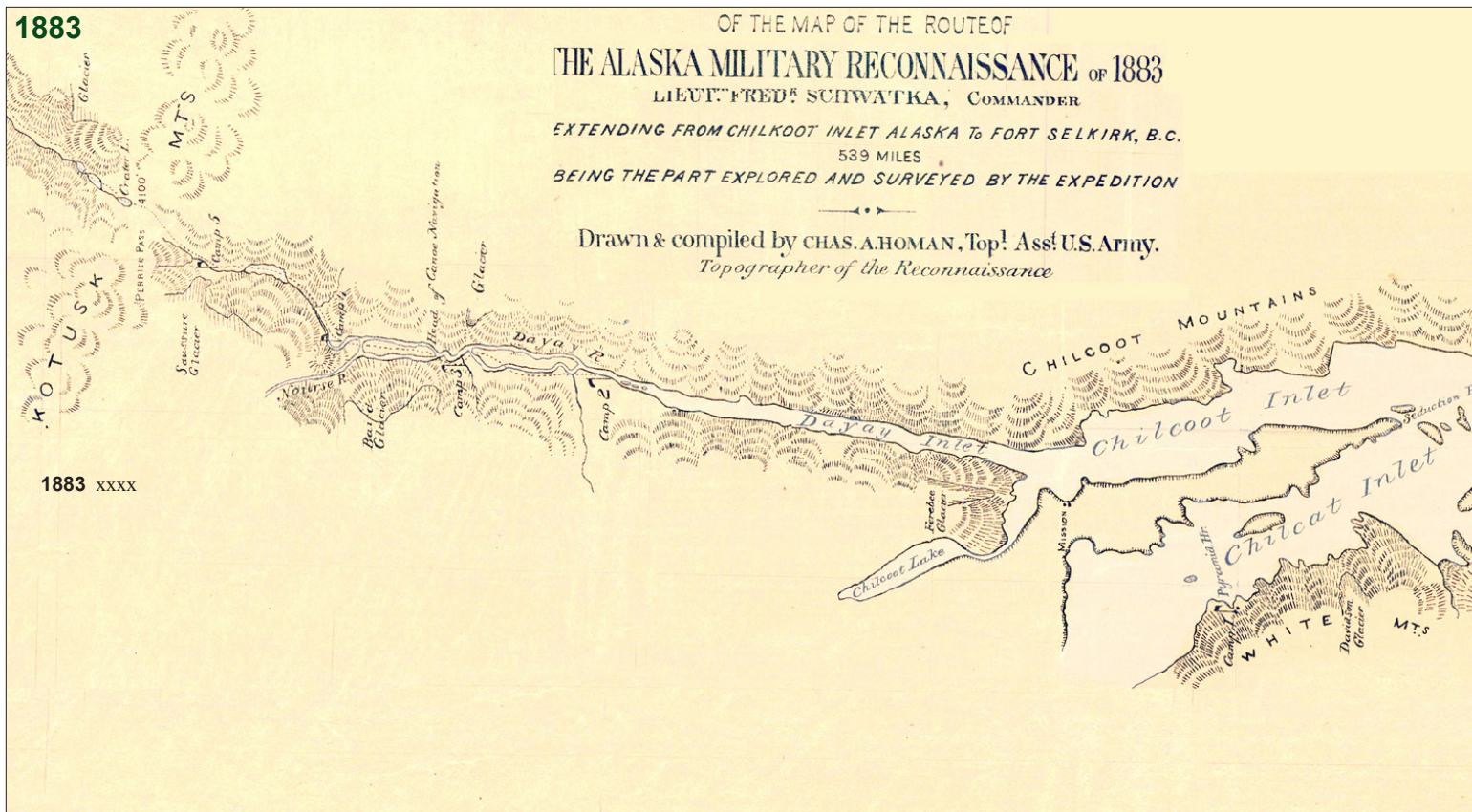
1875 William Dall explored Southeast in 1865, 68, and 71-74, then wrote the Coast Pilot with Marcus Baker in DC between 1875 and 79. Credits on this map title suggest he may not have seen these borderlands between Lingit Aani and interior peoples. But he was one of the most widely traveled Alaskan explorers of his day, and this may be our best pre-goldrush overview of lands where Jilkaat and Jilkoot traders routinely ventured.



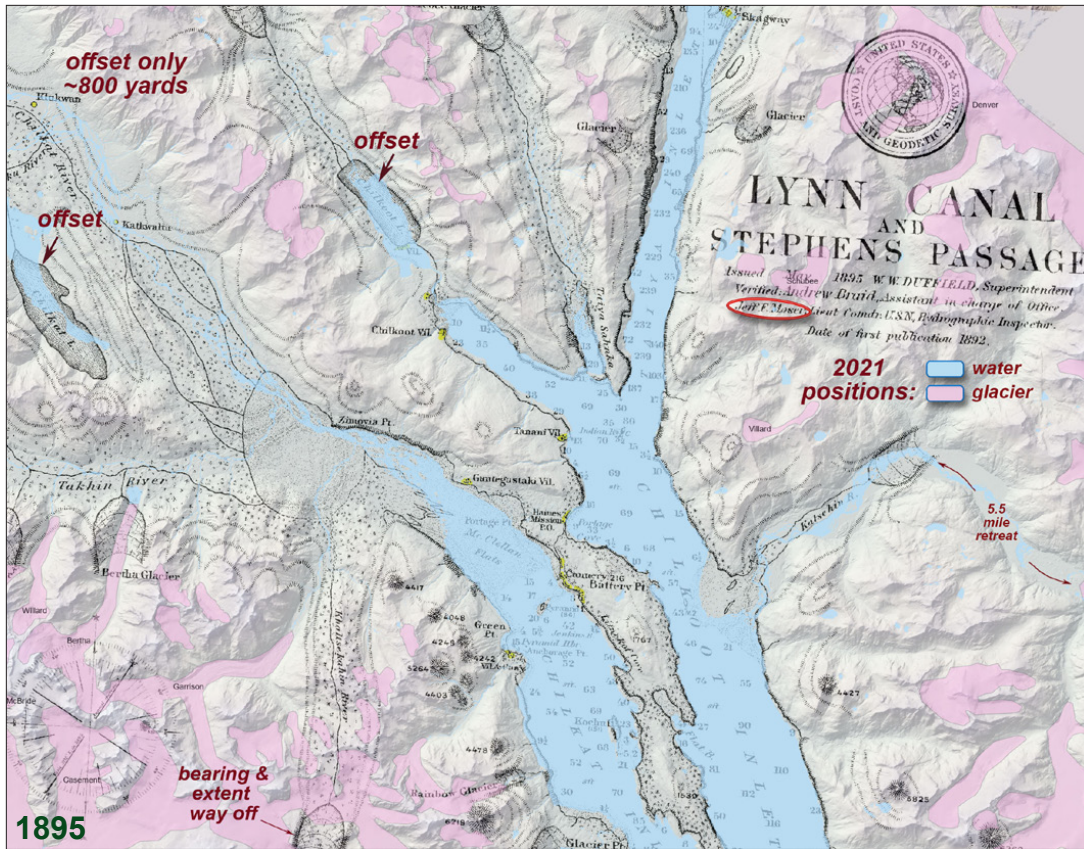
1883

OF THE MAP OF THE ROUTE OF
THE ALASKA MILITARY RECONNAISSANCE OF 1883
 LIEUT. FRED^d SCHWATKA, COMMANDER
 EXTENDING FROM CHILKOOT INLET ALASKA TO FORT SELKIRK, B.C.
 539 MILES
 BEING THE PART EXPLORED AND SURVEYED BY THE EXPEDITION

Drawn & compiled by CHAS. A. HOMAN, Top^t Ass^t U.S. Army,
 Topographer of the Reconnaissance



1883 XXXX



1892>95 Moser Superintendent Duffield was apparently the really *IMPORTANT* white guy, but up-&-coming commander Jefferson Moser—soon to command [steam vessel Albatross](#).—was probably more directly involved in chart production. With drafts ranging from 1892 to 95, this map marks a qualitative jump in cartographic fidelity over preceding examples from the 1880s. To illustrate that, I've overlaid it upon a contemporary hillshade with water in blue and glaciers in pink. Attempting this with previous vignettes would yield only eye-watering misregistrations.

While marine shorelines tightly conform to the hillshade, accuracy slips moving inland—most notably at Chilkat and Chilkoot Lakes. In contrast, Klukwan's position is pretty close, perhaps reflecting ability to transport heavy tripods and instruments by river canoe?

Kaltsexx'i Héen, kicking river (Kicking Horse) is named "Khaltsekahin" here—a commendable approximation in days before standardized orthography. No surprise that it's so far off in an area not visible from steam launch or theodolite station. On the other hand, the swarm of summits above Ldeiniyé (Pyramid Harbor) were well placed, and elevations were only off (in both directions) by about 200 feet.

I can find no person commemorated by the name Bertha Glacier—nor for that matter any of the 5 Bertha toponyms in Alaska. Orth (1967) says only that it was named by US Navy in 1880. That's quite early for a feature not visible from saltwater. For reasons noted we should take glacier

terminal positions with a grain of salt. But it's significant that valley glaciers east and west of Lynn Canal [noTN?] have differed widely in distance of retreat. Bertha, in westside rainshadow, changed little, as confirmed by my air-photo historical series in *Featured landscapes*, section 7. Eastside Wulix'áasi Héen, *waterfall creek* (Katzehin) drains a glacier fed by vast icefields, whose tongues advanced then withered many miles—5.5 miles if Moser's position is correct. ¹

1898 Prichett Emphasizing the Klondike route out of Skagway in the year of The Rush, this chart also maps Dalton Trail to "*Klukshee, Dasardeash and Kusanaghe* lakes, so I've included it in our series. This is only a quarter of a map extending from Shtax'héen (Stikine River) to the Yukon-Porcupine confluence.

Red highlights are apparently last-minute additions from Prichett's team—one for the *Kotusk Mountains* thought to curve through Chilkat, Chilkoot and White passes. Yellow highlights are mine, to bring up those dashed-line Dalton trails as mapped at turn of century.

Another black dot-dash-dot line is not explained anywhere on the map but probably served as a provisional international border, before survey teams replaced it with the zig-zag summit-to-summit line in use today.

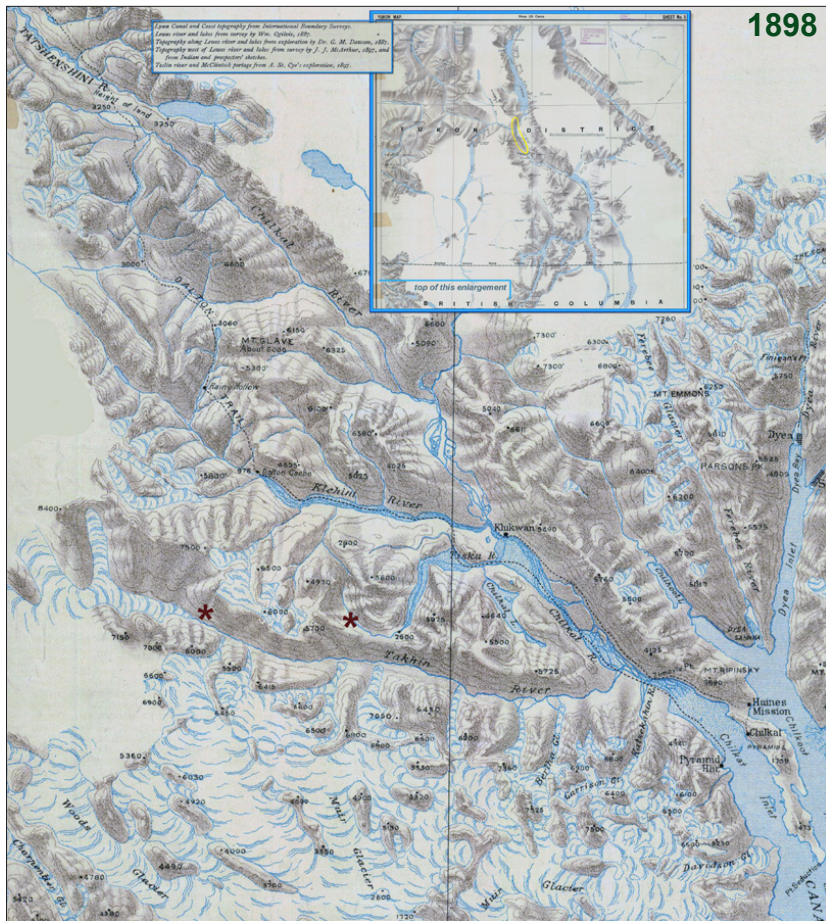
"Dalton's House" on this map is Shāwshe (Dalton Post/Neskatahin), today the put-in point for rafters down T'áchán shahéeni, *stinking king salmon at headwaters* (Tatshenshini). It took awhile for names of transboundary rivers to 'settle down.' T'áchán shahéeni originally applied only to Blanchard River, tributary to the Tat. Similarly, "*Kaskar Wurlch*" (Kaskawulsh on Yukon maps) was an Alsek trib. American and Canadian cartographers eventually decided that what was "*Kaskar Wurlch*" on this 1898 map should be the true Alsek, and what was upper Alsek should be demoted to Tatshenshini. It's unclear where these breaks occurred for the Southern Tutchone Shāwshe people.

Down on "*Tlehini R*" was "*Dalton's Cache*," today retained on US Customs border station at 40 mile. USGS maps say "*Pleasant Camp (aban'd)*."

¹ Meade Glacier commemorates a terrorist whose name should be scrubbed from maps, as we deleted his vessel *Saginaw*. T&M12 gives no Lingit name for this glacier, which on first reading I considered evidence it had never neared the coast at peak Little Ice Age. But Moser's 1892 map shows terminus 4.5 miles from estuary, in direct line-of sight.



1898



1898 Ottawa's routes There are dozens of maps of the goldfields from turn-of-century on [NOAA's magnificent historical-charts archive](#), and on this Canadian one—Yukon Sheet #5—the GCW is only a minor consideration. My bluebox inset shows the top half of this YK-BC chart, of lesser interest to Chilkatians, and a line in lower left for its intersection with this enlargement. I downloaded Sheet 5 mostly out of admiration. As a cartographer, the beauty of this early hand-shaded relief, and the careful, educated, natural history description caught my eye downstream along Lewes River from *Whitehorse Rapids NWMP*. Lovingly fitted to the bank in a curving riparian line by someone who cared about handwriting as well as geo-botanical accuracy:

*"Rolling and knolly surface generally thickly wooded with spruce, pine and small poplar."*¹

But, studying the SW corner devoted to GCW, there are interesting features, some notable for *inaccuracy*. On upper Takhin I've placed two asterisks * marking a misunderstanding of Tsirku Glacier and its outflow. At turn of century, it was assumed to empty via Takhin River. Maps from as late as 1897 showed blank 'no-man's-land' just west of Willard Glacier, so this is an understandable error.

Actually, Tsirku may well have [exited out Takhin](#) at various times in the past ~14,000 years. But since the river would have to climb ~300 feet at Kéet Séedak'u, *killer whale little strait* (Tsirku-Takhin pass), and, since that 'faucet' was well-plugged in 1910 by the snout of Takhin Glacier, it probably didn't happen in the tenure of early-Euro mapmakers, or even that of the Tlingit.

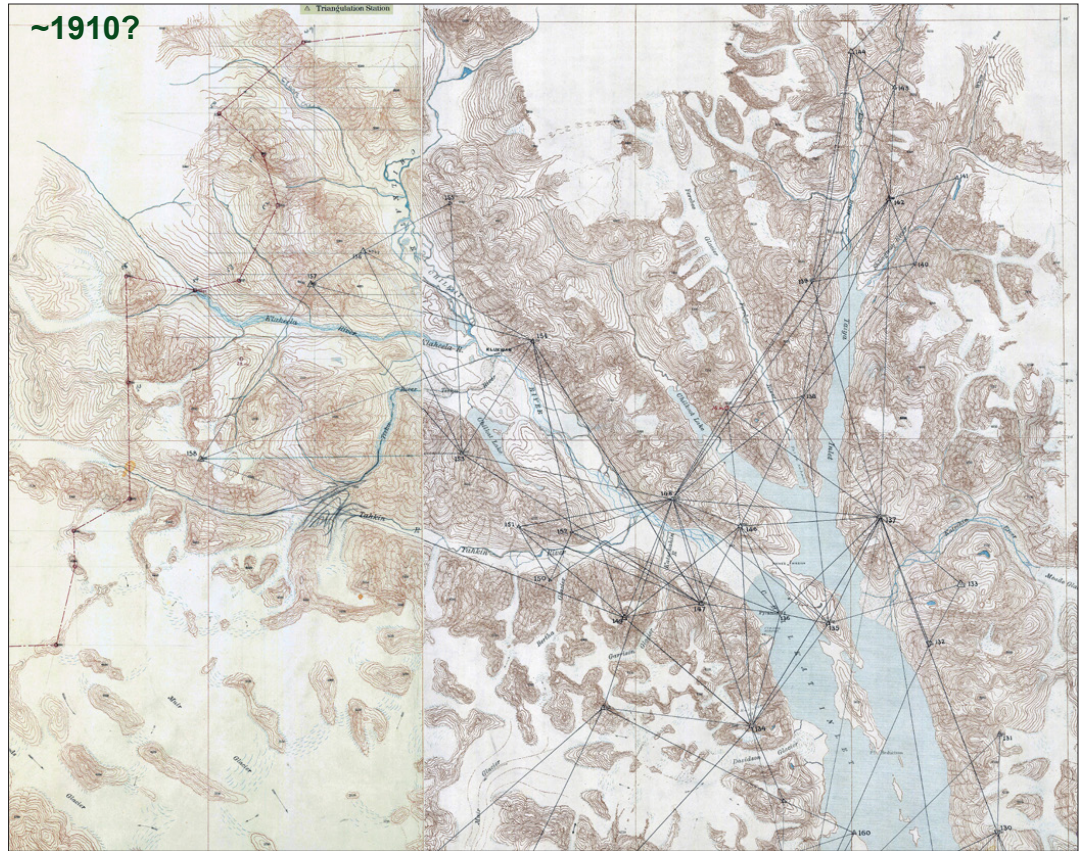
1 Map is from the Surveyor-General's Office, Department of the Interior, Ottawa, March, 1898. As an afterthought, I checked the "Authorities" credited on my master-copy. Sure enough, that naturalist-surveyor was someone I've become fascinated by in my researches farther south in Aak'w Aani, "*Lewes river and lakes from survey by Wm. Ogilvie, 1887.*" There's a whole chapter in my scoping/journal doc for Aak'w T'áak on local summit photos by WO. This was when I first discovered the IBC's triangulation maps, described on next page. Ogilvie apparently spent less time in GCW than his colleague McArthur, but did give us outstanding photos of Davidson Glacier and Mud Bay.

As for McArthur, you can learn more about his GCW activities—and those of Jarvis—in Mark Kirchoff's book about Jack Dalton.

1910~△Triangulation station Researching Canadian boundary surveyor William Ogilvie, I discovered these hand-lettered quad maps. This is my attempt to edge-match Sheets #5 & #6.

Discovery of killerwhale pass and the real origins of Takhin and Tsirku Rivers

Lines connecting summits are XYZ sight lines from glass plate cartographic box cameras, alidades, and theodolites, on tripod-mounted planetables for triangulations that gradually filled in the blank places. Descriptions of this process are in page I just (2025) added to *JuneauNature* titled [History of cartography in northern Lingit Aani](#).



History from the air

As a cartographer—and not one to hang out in libraries or museums collecting written records—my approach to history (Euro versions anyway, since Kittyhawk was post contact) is very much through raven- and eagle-eye perspectives on development and destruction. Maps and orthophotos (the camera's version of a map) are presented mostly in the companion to this *GCW Atlas*, called *Featured landscapes*. I may refer to these in sections on following aspects of Euro-history.

Fur

Trade with interior was largely about fur. This'd make a fascinating cartographic history, using the early exploratory surveys already presented in section on *Colonial maps*

For example, how bout mapping this episode:

Chilkat Tlingit warriors attacked and burned Fort Selkirk, the Hudson's Bay Company post at the juncture of the Yukon and Pelly Rivers, in 1852. The Chilkat had been middlemen between the company and the Athapaskan people of the interior (on preexisting trade routes), and were unwilling to be excluded from the arrangement. [From Wikipedia](#)

Fish

Maybe Ben, Eric and Mark could collaborate on the story of fish industries in the GCW? For the indigenous history, someone in Klukwan?

xxxxx

Timber

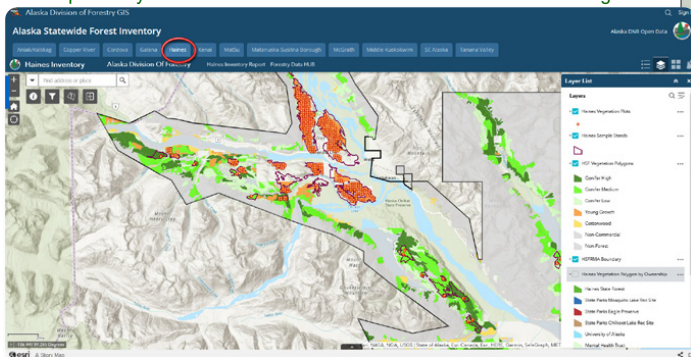
Compared to the rest of Lingit Aani, the Greater Chilkat Watershed is lean pickins for timber. Only when the Tongass golden timber-goose had been plucked near to death did Haines mills start lobbying to strip their own backyard.

From Dan Henry's chapter in Book of the Tongass (1999)

"The Haines-Skagway Land Use Plan allowed for governor Hammond to take the go-ahead for a 15-year timber sale contract, calling the annual harvest of 10.2 million board feet with a ten-year extension 'a balanced approach.'"

Schnabel Lumber Company closed its doors in October 1980 because of an inadequate supply of timber. . . refurbished as Pacific Forest Products, it again slowed to a halt in 1984. . . Through the remainder of the 1980s, the mill struggled. Former Alaska Forest Products manager Ed Lapeyri took over the mill, called it Chilkoot Lumber, and supplied it largely with logs from POW. In 1990, that mill shut down for the last time [but see sidebar; sounds like it lasted a few more years]

[ADOF has a mapping portal](#) you can use for details on past and proposed logging in the GCW. Called the Alaska Statewide Forest Inventory, subunits are opened by tabs across the header. Haines is circled in this screengrab.



Logging history

from the Sheldon Museum website:

<https://www.sheldonmuseum.org/vignettes/timber-industry>

Linda & Rick Shelton, 1978: updated by Barbara Waterbury (1988)

Kathleen Menke (1997) and Blythe Carter, 2013

"When entrepreneur Jack Dalton surveyed the Porcupine gold field for a townsite, he built an onsite sawmill producing 5,000 board feet a day, including lumber for flumes. Largest was a diversion flume for Porcupine Mining Company requiring 1- to 2 million bf. Demand continued because seasonal floods frequently washed out the flumes.

Ft. Seward and canneries were built from lumber shipped by sail or steam from Seattle, Olympia, or Portland. Lumber for the Presbyterian Mission in Klukwan was shipped to Haines and transported to the village by canoe. Small, private mills were operated by some canneries during construction, and for fish traps. Piling for docks was contracted locally. Not treated, they were replaced frequently.

A local mill operated by Combs Lumber Company had a capacity of 25,000 board feet in 1907, destroyed by fire in 1912. Local newspaper ads proclaimed it "*the largest saw and planing mill on Lynn Canal.*" Without a strong outside market, the timber industry remained small for many years, mainly providing firewood.

In 1939, the Schnabel family started the first big lumber business in Haines. A sawmill operated over many years at Jones Point. In 1961, this uninsured mill burned, almost wiping out the company and leaving many without work. Schnabel resumed using small portable mills. Railroad ties were marketed to a Whittier plant, and later, cants (large timber, roughly sawed from logs, for further processing into dimensional lumber) were cut for export to Japan. In 1966 Schnabel started a new mill at Lutak Inlet

Interesting that nowhere in this entire history is there discussion about *where the dangled logs came from*, after the first big mill in 1939. From then until the 1970s, hardly a stick of GCW timber was cut by any Haines mill. Only in 1976 did Schnabel pressure the state to offer sales in Chilkat Valley. We really need a serious history of what stands were targeted and why, in what sequence.

Eric- is that something you could write, if I helped with the maps?



Above: Porcupine Gold Mining Company sawmill and lumber yard, 1914. • Below: Small portable saw mills were used by many for production of rough lumber, 1920s.



In 2022, TWC and LCC began young-growth timber surveys, supervised by forestry consultant Herb Hammond.¹

just past today's ferry terminal. Spruce and hemlock cants were cut for export.

Schnabel Lumber exported one million bf in 1961. Exports peaked at 52 million bf in 1968. His veneer mill was unsustainable due to incompatibility with the cant mill. Slab waste, cull timber, and waste previously left in the forest were chipped and exported to Japanese markets. This mill closed in 1977.

In 1965 another sawmill was built at Jones Pt by Alaska Forest Products, Inc. AFP also cut cants for the expanding Japanese market. Monthly payroll was \$50,000. Favorable market conditions in the 60s & 70s were followed by slumps, higher prices for raw logs, increased operating expenses, and transportation problems. AFP briefly entered the domestic dimensional lumber market, but closed in 1976.

In 1979, Schnabel Lumber reopened the Lutak Inlet facility upgraded to comply with the Clean Air Act, in anticipation of a waste wood electrical generating plant. The State loaned capital. But supply delays forced default on contracts, coupled with double-digit inflation stalling the electrical plant. The State foreclosed in 1983. During its last operation, Schnabel Lumber Co. exported the first Alaskan lumber to China in addition to Japanese and domestic trade. In 1984, Pacific Forest Products purchased the Schnabel facility. A poor market and other factors caused that company's closure within a year.

Ed Lapeyri's Chilkoot Lumber Company negotiated with the State for purchase of the PFP facility in 1986. The Company began renovation in 1987, and opened with 55 local employees. With 100% of its timber coming from the Tongass National Forest [*ie, not GCW wood*], Chilkoot Lumber processed spruce into cants, fitches, and dimensional lumber, and hemlock into 105mm squares, the primary building component in Japanese post & beam construction. The mill produced 35 mmbf annually.

For a few more years Chilkoot Lumber nearly doubled its capacity. The diesel generator blew in 1988, reducing them to a

Schnabel Lumber Mill on Lutak Road just past the current ferry terminal, 1960s-1970s.



refurbished steam power plant operated by Onsite Energy. Chilkoot Lumber cut 60 mmbf in 1990. Depressed market and expensive emission standards reduced their viability. Although finally meeting clean air standards, market conditions forced layoffs throughout 1991, with loss of 145 local jobs and payroll of \$5.2 million. Klukwan Inc [*which by then had zeroed-out its Long Island holdings?*]. and Northern Timber—2 other locally based corporations—also began scaling back.

A February 1993 snowfall collapsed major structures and caused millions in damage, destroying the planer mill, main sawmill, banding and fuel sheds. Although a jury awarded Chilkoot Lumber \$1.22 million from Weyerhaeuser in 1994, it couldn't resurrect the project.

The Southeast timber industry declined more in the mid-1990s as state and federal studies indicated allowable harvest would drop on state and federal lands to keep the industry sustainable while better protecting wildlife and watersheds.

LeRoy "Buster" Benson, who started his private mill in 1976 to serve local construction with rough-sawn lumber, operated the primary local sawmill in Haines until his death in 2008. Buster got his timber from State Forestry sales as well as private land-owners. He purchased logs outright, or sawed half the lumber free in exchange for the other half. Benson produced ~250 mbf of rough cut lumber for the local market annually. Several small, private, portable mills still operate in the Haines area. In addition, two lumber companies in Haines, Lutak Lumber and Haines Home Building Supply, offer imported finish lumber for local construction purposes.

Many fine woodcraft artisans, both native and non-native, operate their business in Haines and use a variety of Alaskan wood and other woods to produce carvings, turned wood items, furniture, boats, cabinets and homes. Some of this wood is cut locally, some comes from elsewhere in Alaska, and some comes from other parts of the nation and the world."

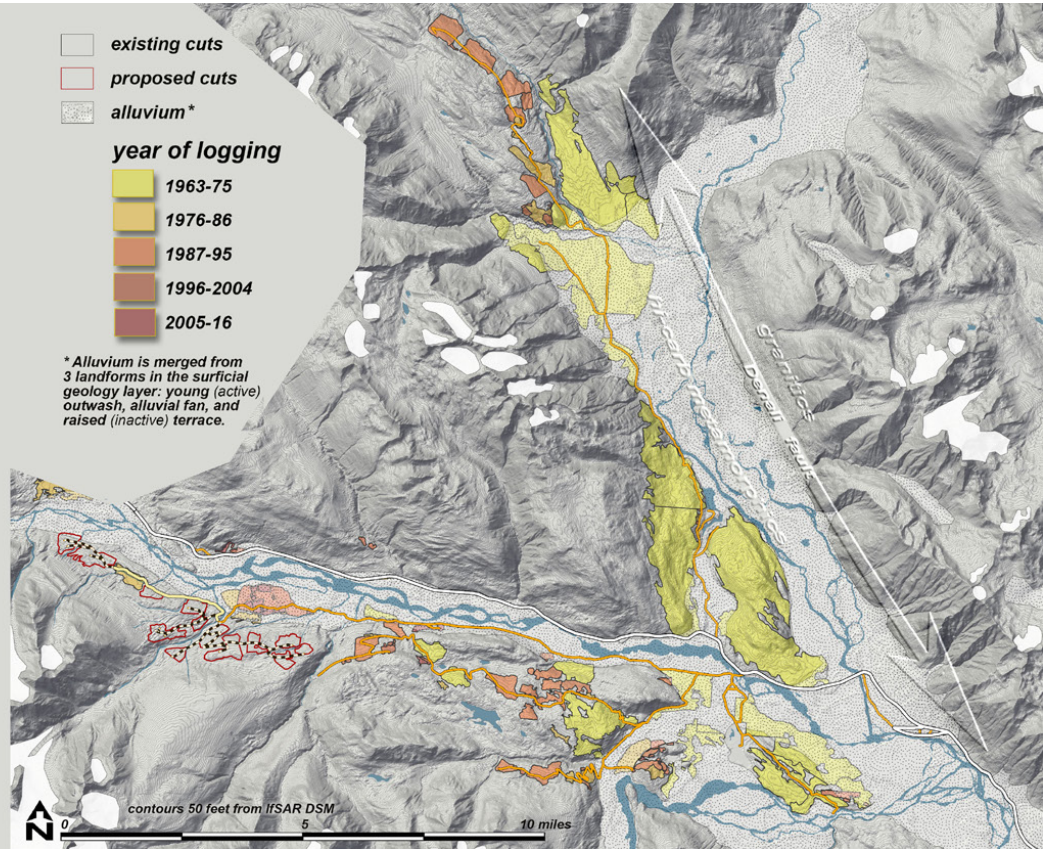
¹ 2024: As far as I know, this collaboration has languished. Herb's recommended protocol grouped surveys within "ecosystem types" but I'm unsure how we are to define these. I

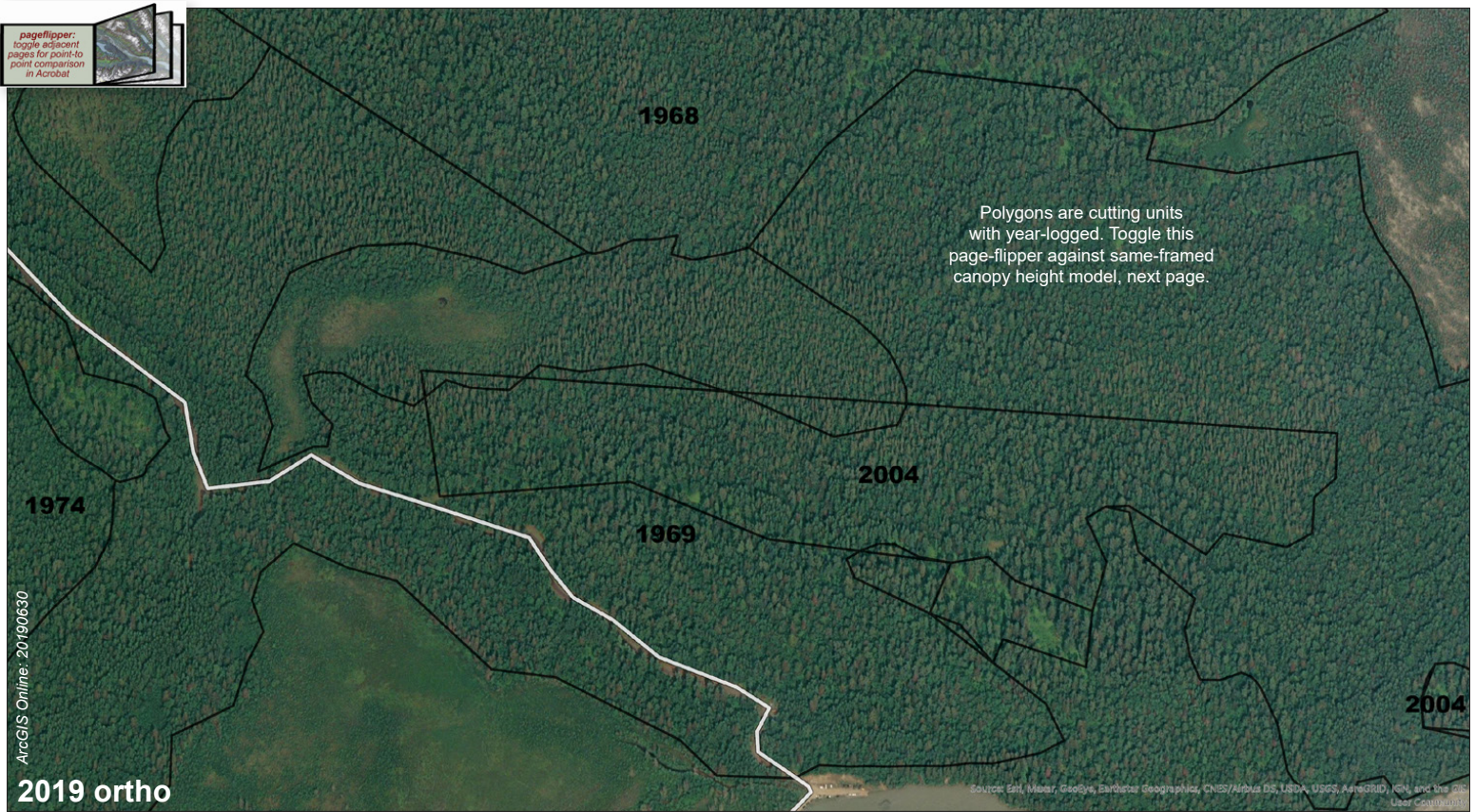
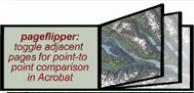
f I were to design a sampling method, we'd simply go to where the earliest 1960s logging happened and try to reconstruct what those forests looked like. We call it a 'ghost-forest assessment.' Hopefully, we can pull off both a retrospective and a look at the trajectory and future of these lost conifer stands.

Logging history in the upper Chilkat can be illustrated by a 'decade-origin' color spectrum. As on National Forest timberlands southward from GCW, State administrators met mill owners' requests to log most desirable stands first, leaving "the best of the rest" for future, hungrier loggers. Thus, the yellow-to-brick spectrum is also a crude index of commercial value at time-of-sale. Proposed (redborder) units in Baby Brown are mostly hemlock "close to a monoculture." (Palmieri, p33, ADNR 2018).

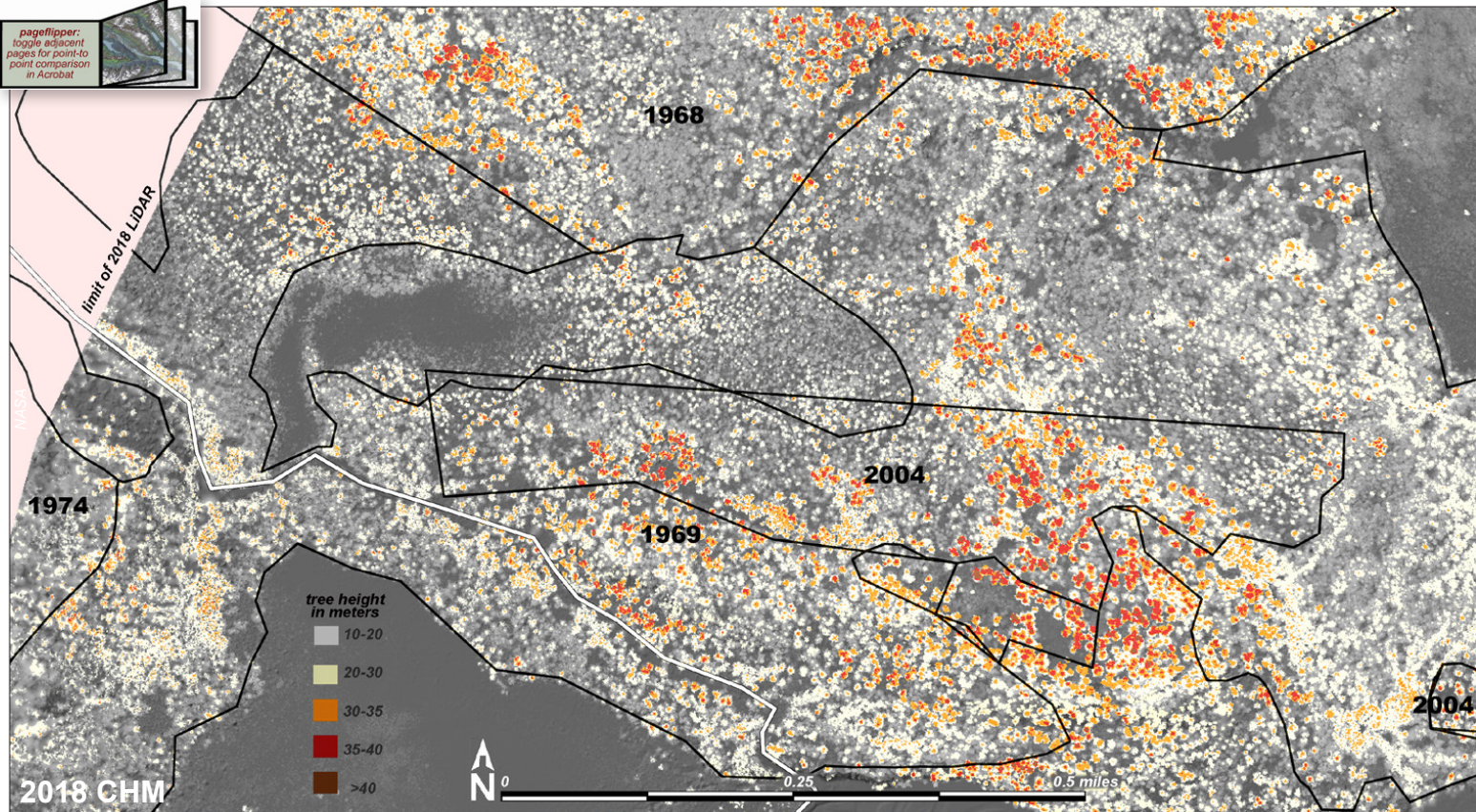
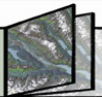
Bedrock and surficial geology strongly influence forest type and productivity in the GCW. East of Denali fault, bedrock is largely Tertiary to Jurassic granitics, supporting only scrubby forests. To the west, bedrock is a melange of older metamorphics and metavolcanics, almost all rich in carbonates fostering deeper, more nutritious soils where logging focused.

Surficial landforms most attractive to loggers—at least before buffer-regs prevented stripping to bank and yarding down stream channels—are lumped here as 'alluvium.' From my surficial geology layer I've separated 3 types: 1) lowest, active floodplain, *oy*; 2) raised, marginal terraces, *t*; and 3) steeper gradient alluvial fans, *f*. In the GCW, type-1 generally supports only shrubland or poplar woodland. Types 2 & 3 once fostered fast-growing spruce, almost all removed in the 1960s & 70s from State timberlands. For this map I've merged the 3 types as a stipple overlay, to distinguish alluvial from upland logging. Only low, rolling hills on Baby Brown support remnants of the mature upland conifer type; higher, steeper slopes grade quickly to shrubland.

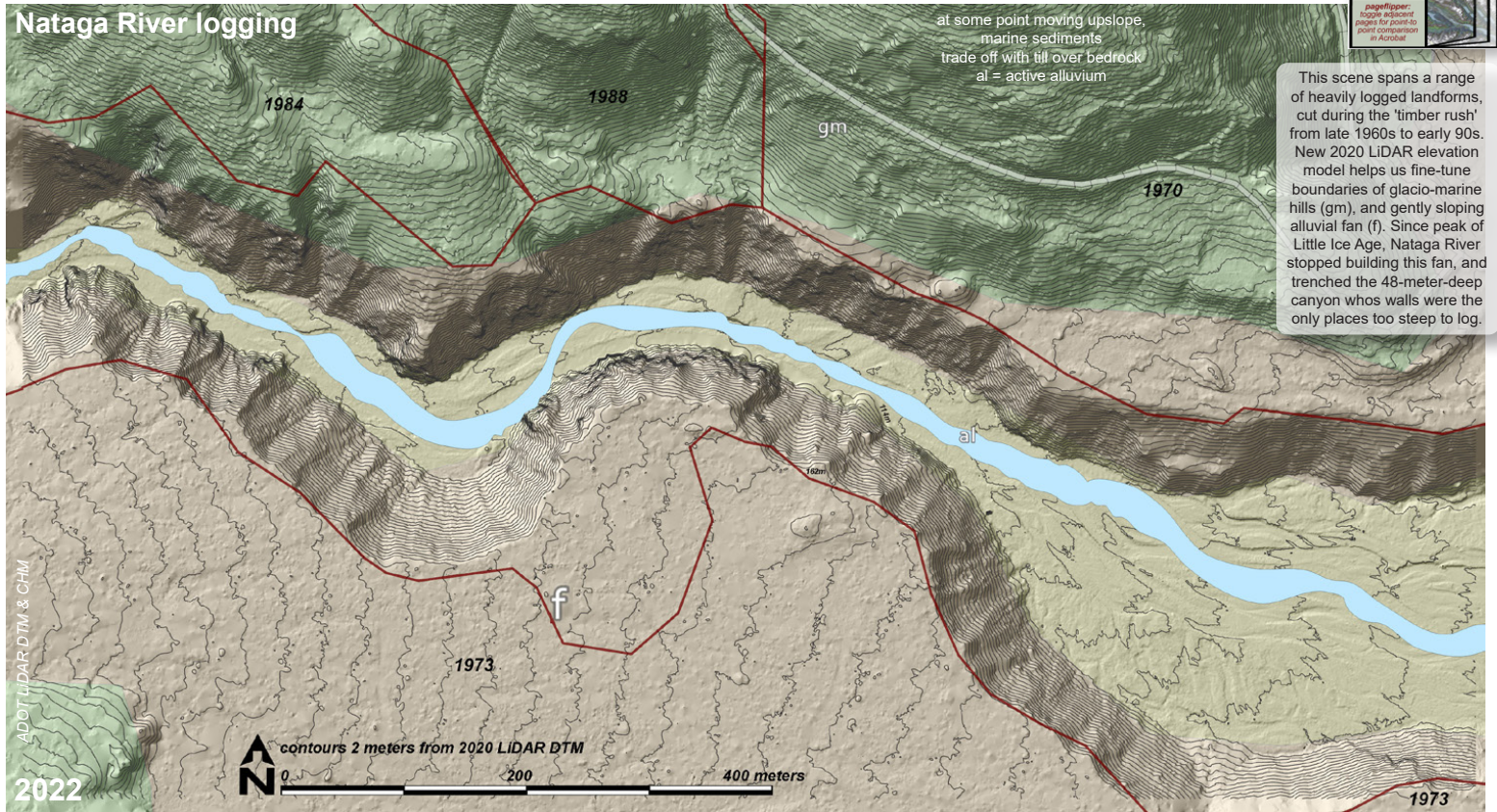




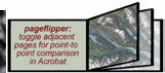
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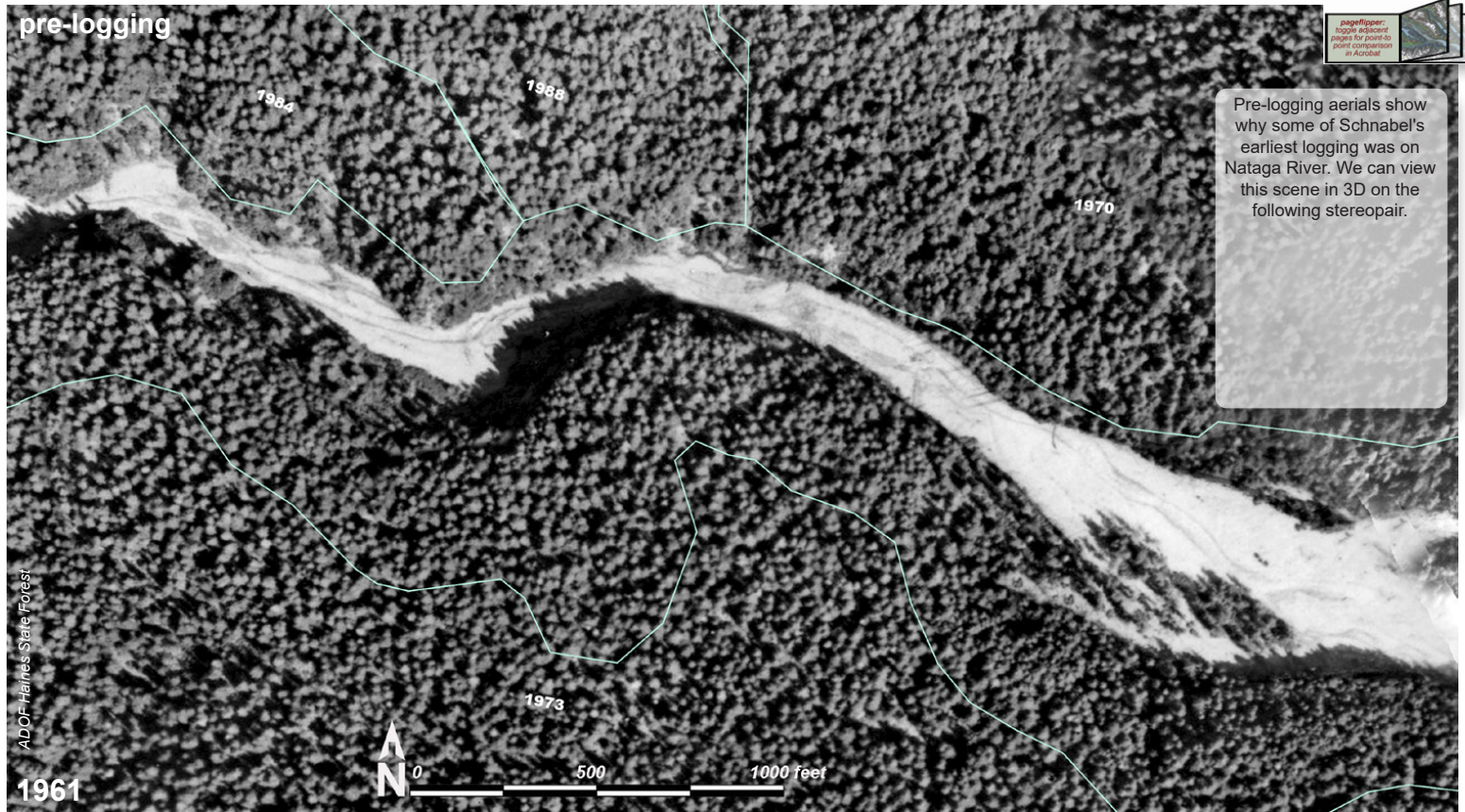
Nataga River logging



pre-logging



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Pre-logging aerials show why some of Schnabel's earliest logging was on Nataga River. We can view this scene in 3D on the following stereopair.

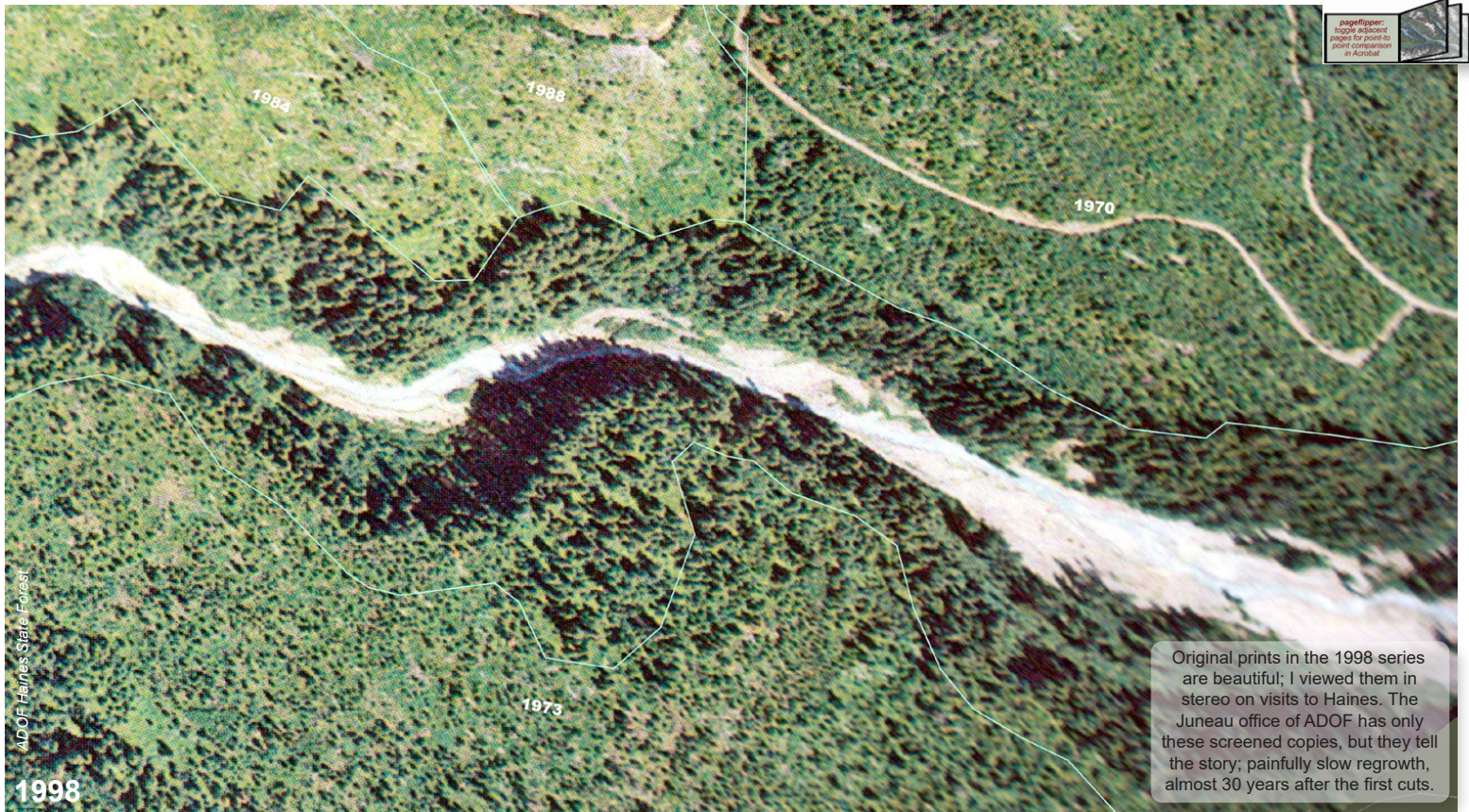
By 1978, prime spruce were gone.

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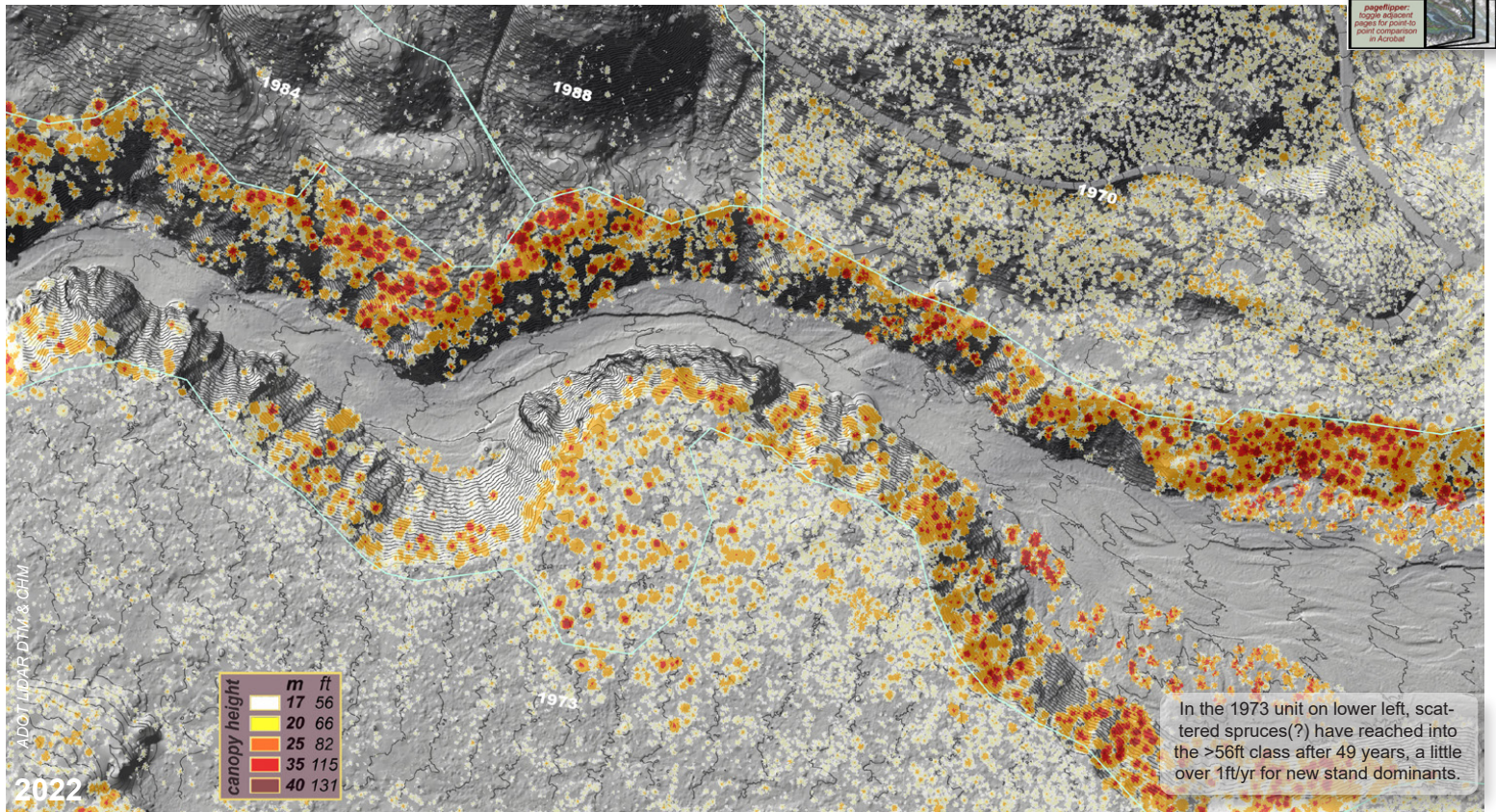


ADOOF Haines Slate Forest

1978









conservation issues summarizing nearly every section or chapter on habitats, species, etc. That's probably a good format for this publication as well

Mining

This should be a thorough chapter, as mining is the most immediate and pressing threat to human livelihoods and ecology of Greater Chilkat Watershed.

VMS: volcanogenic massive sulfide. ¹

Conservation

XXXXX

In the Audubon TNC conservation assessment—both the original encyclopedic version (Schoen & Dovichin, eds, 2007) and the condensed version (Smith, ed, 2016)—there's a concluding section on conservation strategy, plus short synopses on

¹ From https://en.wikipedia.org/wiki/Volcanogenic_massive_sulfide_ore_deposit

VMS is a type of metal sulfide ore deposit, mainly copper-zinc, created by submarine volcanic hydrothermal events. Density generally 4500 kg/m³—stratiform sulfides precipitated from hydrothermal fluids on or below the seafloor. Significant source of the world's copper, zinc, lead, gold and silver ores, with cobalt, tin, barium, sulfur, selenium, manganese, cadmium, indium, bismuth, tellurium, gallium and germanium as co- or by-products.

Appendices

1 Botanical 4-letter codes

Botanists use a shorthand system for species lists, especially useful in expediting field note taking. In journals I plan to share, I typically write out the full botanical or common name, but often use 4-letter codes when noting a lengthier plant assemblage.

First 2 letters of genus, followed by first 2 letters of species. Here's a preliminary list of codes used in this journal. I'll flesh it out in later updates.

this one's just a placeholder from the Chilkat journal. May or may not need it in the Atlas. . . . Nice to have a species list, regardless of whether the codes are used in final products.

PS 202008: Should add Koren's full species list for the invasive plant surveys from 10 to 18 mile.

code	botanical name	common name
trees		
PISI	<i>Picea sitchensis</i>	Sitka spruce
TSHE	<i>Tsuga heterophylla</i>	western hemlock
TSME	<i>Tsuga mertensiana</i>	mountain hemlock
PICO	<i>Pinus contorta</i>	shore pine
ALRU	<i>Alnus rubra</i>	red alder
ALSI	<i>Alnus sinuata</i>	Sitka alder
POTR	<i>Populus trichocarpa</i>	black cottonwood
MAFU	<i>Malus fusca</i>	Oregon crabapple
SOAU	<i>Sorbus aucuparia</i>	European mountain ash

shrubs		
RUSP	<i>Rubus spectabilis</i>	salmonberry
RUPA	<i>Rubus parviflorus</i>	thimbleberry
RIBR	<i>Ribes bracteosum</i>	grey currant
VAspp	<i>Vaccinium spp</i>	blueberry, multiple species
MEFE	<i>Menziesia ferruginea</i>	rusty menziesia
OPHO	<i>Oplanax horridum</i>	devil's club
herbs		
HELA	<i>Heracleum lanatum</i>	cow parsnip
VEVI	<i>Veratrum viride</i>	false hellebore
COCA	<i>Cornus canadensis</i>	ground dogwood
RUPE	<i>Rubus pedatus</i>	five-leaved bramble
MADI	<i>Maianthemum dilatatum</i>	deerberry
STRO	<i>Streptopus roseus</i>	rosy twisted stalk
CALY	<i>Carex lyngbyei</i>	Lyngbye sedge
LEMU	<i>Leymus mollis</i>	beach rye
PLMA	<i>Plantago maritima</i>	goose-tongue
TRMA	<i>Triglochin maritimum</i>	arrowgrass
ATFE	<i>Athyrium felix-femina</i>	lady fern
DREX	<i>Dryopteris expansa</i>	spiny shield fern
EQAR	<i>Equisetum arvense</i>	meadow horsetail
mosses		
RHTR	<i>Rhytidadelphus triquetrus</i>	electrified cat's tail

Acknowledgements

This ongoing 'living atlas' project is a collaboration across a growing number of agencies, NGOs and individuals. ¹

• Lynn Canal Conservation: *Jessica Plachta, ED, Eric Holle, Pres.*

• Takshanuk Watershed Council: *Derek Poinsette ED*
 • Chilkat Indian Village (CIV)
 • Jilkaat Kwaan Heritage Center (JKHC): *Lani Hotch, Dir*
 • Chilkoot Indian Association (CIA)
 • Klukwan School: *Bradley King, Principal*
 • *Canadian partnerships?*
 • SEACC: *Chilkat Watershed Organizer. Shannon Donahue*
 • TNC
 • Alaska Audubon, *Natalie Dawson, ED* ²
 • ADF&G: *Kevin White, Anthony Crupi, Karen Blewjas . . . who for fish?*

• DOF Division of Forestry, *Joel Nudelman, Juneau, Greg Palmieri, Haines.* ³

• Rock, Paper Fish: *Travis Rummel, Victor Murillo, Mark McNamara, Mario Benassi, Brian Rivera Uncapher, Marcus Reynerson*

• AK Outdoor Sciences: *Scott Ramsey*
 • Alaska Nature Tours: *Dan Egolf, Daniel Bertsch*
 • **Individuals:** *Irene Alexakos, Jim Baichtal, Mario Benassi, Annisa Berry, Donna Catotti, Clay Frick, Rob Goldberg, Judy Hall, Dan Henry, Lani, Marsha, Jones P., Don & Justina Starzynski*

¹ *Acknowledgements* isn't numbered as an appendix because it'll eventually be moved forward into the *Introduction*. In this period when draft Intro pdfs will be excerpted for JuneauNature downloads, I'll just tuck the thank-yous & a few other miscellaneous notes to reviewers back here. . . .

² On the subject of Audubon's Birding Trail descriptions. Uncredited to any individual but obviously written by someone who knows GCW well *and* is a good birder (or possibly a collaboration of several people with those skills?) Maybe Natalie can help us figure out who that was?

³ *I haven't yet met Greg, but Joel says he's good on Haines logging history. Also can help with historical imagery such as the 1929s*

To reviewers. Working with a professional editor on the 3rd edition of *Nature of SE AK*, I adopted a convention some writers use for single vs double quotation marks: 'xxx' vs "xxx." **Doubles**, sometimes called 'scare quotes,' are used only to mark a word or phrase used by someone else, or to indicate skepticism about such claim. In this atlas actual quotes from other writers of a sentence or longer will be additionally set off with an indented, smaller-font paragraph style. **Single quotes** mark words or phrases that are unusual in the context at hand, that might cause confusion if not somehow

- John Meikle – Kwanlin Dūn First Nation 1-867-633-7859 I've been seeing great, recent posts to iNaturalist from John. His profile says land planning in YK for 30 years. Would be a great contact for the Canadian side. Can't find an email . . .

- Paul Norwood. lives in Sitka but has a lot of iNaturalist posts in the GCW.

Discussed but dropped: Survey 123 for ArcGIS
Next step up from Avenza—more user-control over vector/raster displays, & more targeted tool for data collection prioritized by LCC.

In March, 2020, just before the pandemic shut down such gatherings, I attended a Bob Christensen conference in J-town for mostly-agency GIS geeks, on how to design and use ESRI field-data collection apps. Got me pretty inspired. Back home created a draft *Survey123* app for Chilkat habitat mapping, only to discover that a glitch prevented easy user-validation from my Discovery ArcOnline account, without which 123 is dead in the water.

20200602: Bob just checked in from The Island, saying he's found a workaround! Should allow anyone in GCW with phone or tablet and decent home internet to load the app and refresh the projects. So we could soon get started with *Survey123*.

But for folks allergic to pulldown menus (myself included), there's many ways to collect useful field observations, and send em to me for incorporation. The Atlas's current *Table of Contents* is just a scaffolding that members of LCC and other residents of GCW can collectively steer toward a variety of outcomes in this first-year phase. I'm looking to LCC for guidance in selection of topics most urgent, and/or most interesting.

20210213: Well, time has passed, and I'm no closer to this app-idea. Two things get in the way: 1) Chilkaters, for the most part, don't seem overeager to geek out on devices. Something to salute, in this time of digital distraction. and . . . 2) I too, while somewhat drawn to hightech datagathering *in theory*, am in actuality unsuited to the discipline that's needed, to shepard data-scouts, reward em with immediate feedback, and massage the databank into a useful&appealing product.

Hotch, Nick Jans, Ben Kirkpatrick, John Norton, Elsa Sebastian, Tim Shields, Greg Streveler, Kimberley Strong, Nicholas Szatkowski, Carol Tuynman,

- Allreds still in Haines ? ⁴

- *Jessica & Eric: please help me flesh out this list. Not just those who have already contributed, but potentials as well . . .*

- Gunalchéesh to the elders and culture bearers of Jil̄k̄áat and Jil̄k̄oot Kwáans.

- The PGC requires this acknowledgement for use of their public-domain Arctic DEMs: *DEMs provided by the Polar Geospatial Center under NSF-OPP awards 1043681, 1559691, and 1542736.*

⁴ Do any LCC members know Milo Burcham, Cordova photographer? I first noticed his name in credits for photos on Audubon's site descriptions for the local Birding Trail pages. For example, a yellowthroat in willows for the Little Salmon destination. He seems to be a professional but might be willing to contribute pics to the Atlas. I could contact him but a request might best come directly from LCC. I'm guessing his pics were given gratis to AK Audubon. Extraordinary quality. Check him out at:

<https://www.milosphotos.com/home.html>

2 Cartography

Maps are the foundation of this publication. To interpret these maps—to understand their accuracy and limitations—it helps to know: **1**) how they were created, **2**) limits of their resolution, and **3**) where we are in the course of understanding and extracting their full potential. Most maps created in GIS¹ consist of some combination of base (*raster*) imagery and *vector* overlays.²

First, some basic definitions:

Scale In this atlas, to avoid confusion, we'll steer clear of the expressions "large scale" and "small scale." In cartography a given object is larger on a large-scale map, and smaller on a small-scale map. But among lay readers and even younger cartographers, "large scale" often flips this meaning, mistakenly indicating maps of larger area. For small scale and large scale, I typically substitute 'broad-scale' and 'fine-scale,' respectively—terms less apt to be misconstrued.

Scale is expressed by cartographers as a ratio. Inch-to-the-mile, for example, or 1:63,360, means that one inch on the map covers a mile on the actual ground. This is a useful convention on a paper map, but meaningless and even misleading for labeling digital maps like those in this pdf, which may be viewed at any scale on displays from phones to laptops to auditorium screens. In, ArcMap, or any phone-based navigation app, scale-ratio windows constantly adjust with every click of the mouse roller, or squeeze of your fingers on the LCD. Instead of scale-ratio, my ArcMap-exports usually have a fixed scalebar, which expands or contracts commensurately.

Resolution 'Scale' applies to both rasters and vectors. Resolution is irrelevant to

1 Geographic Information Systems. GIS is more than a high-tech way to make maps. It interfaces between maps, imagery, and databases, allowing quantitative analysis of spatial patterns. Since the late 1990s, GIS has revolutionized the way we assess and portray landscapes, habitats, and cultural features.

2 We've tried to minimize technical jargon in this atlas. But the raster-vector distinction is fundamental for anyone using or creating maps. A **raster** is an image, with a fixed number of pixels. At some point, zooming in, it begins to look grainy (pixelated). In contrast, a **vector** looks sharp at all scales. It's a mathematical calculation defining a point, line or polygon. In GIS, vectors—for example the amoeboid polygon outlining a forest type—are often layered as transparencies atop rasters—for example, a rectified (spatially-'pinned') air photo, or hillshade generated from DEM (digital elevation model).

I hope this appendix doubles as sort of a mini-course in Alaskan cartography, with GCW as case-in-point. A companion piece was prepared for the [Connor-Carstensen Landforms class, tracing evolution of mapping technologies on the NW Coast: from impressionistic deck-side shoreline sketches to drones & photogrammetry.](#) • *PS 2025: just isolated that section as [History of cartography in northern Lingit Aani](#)*

vector points, lines or polygons, which look sharp at any scale. It applies only to rasters, and for digital display is expressed in pixel size.

In this atlas, as of 2024, our finest air-photo resolution is about 2.5-cm (1-inch) pixels from drone photography, ranging out to about 30-meter pixel for broad-scale hillshades showing the entire GCW and large expanses of adjoining rainforest and boreal landscape. To understand raster pixels it helps to zoom in so close in ArcMap that we can actually measure the distance across an individual pixel with the ruler tool.

In the following 4-panel series for downtown Klukwan we also have a graphic introduction to the meaning of what cartographers call "*bare earth*." That's really only possible with technologies such as LiDAR that collect elevation data in the form of a 'point cloud' that can be manipulated to show desired features like actual ground. From optical or photo-based elevation models, we can't see through vegetation; thus the term Digital [Surface Model \(DSM\)](#), as opposed to veg-cleared Digital [Terrain Model \(DTM\)](#).

To build a raster hillshade in GIS, cartographers start with a digital elevation model (DEM). Until recently, in Southeast Alaska and worldwide, these models derived from old-school stereoscopy,³ giving only 20- or 30-meter-pixel resolution. They're fine for broad-scale mapping, but shed no light on subtleties of landforms, for example, or intricacies of forest structure.

Let's examine 4 fairly recent sources of elevation data from which hillshaded landscapes can be generated, working from coarse (IFSAR 5m-pixel) to Arctic DEM (2m-pixel) to fine-detail LiDAR (1m-pixel), and SFM (structure from motion, 0.21m-pixel)⁴

3 Since about World War II, cartographers have measured and mapped topography from comparison of overlapping air photos taken along grids of flight lines (**photogrammetry**). Viewed under a stereoscope, these photo-pairs deliver a 3D image of terrain. First manually, then mechanically, contour lines were generated from the 3D perspective. As mapping became computerized, contour maps were converted to **digital elevation models (DEM)** with elevations assigned to pixels representing, say, a 30-meter square on the ground. Today, the old stereoscopic DEMs are increasingly being fine-tuned and replaced by non-photographic processes such as IFSAR and LiDAR, described below.

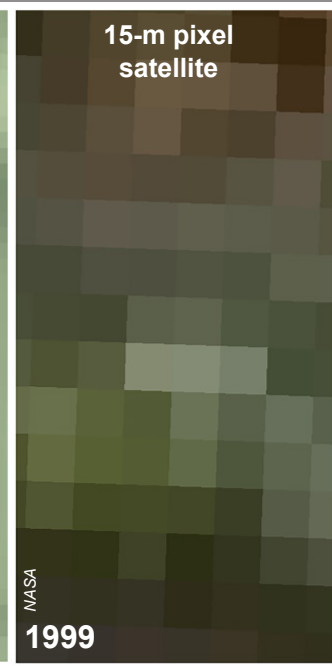
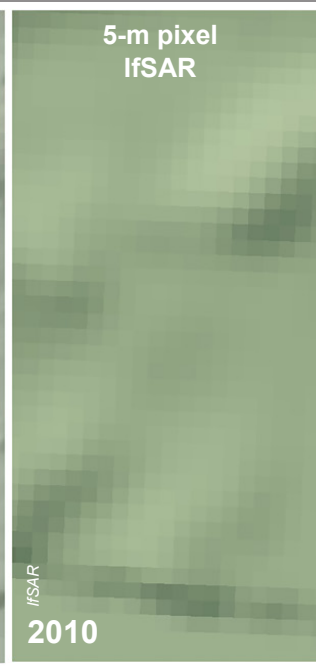
4 Broadest-scale maps in this *Atlas*, showing more than the entire GCW, don't require even 5m-pixel. For these I use transboundary DEMs at 15-to-30-m pixel.

Rasters over Tlákw.aan, eternal village (Klukwan) at decreasing resolution.

Left to right: Orthophoto commissioned by ADGGS (AK Div of Geological & Geophysical Services).

One pixel covers 0.2 meters, or 8 inches on the ground. • Meter-pixel bare earth from Chilkat Ridge LiDAR mission flown in 2018. Bare-earth algorithms normally strip away buildings, bridges, etc, leaving only house pads in developed areas. In this scene, a few buildings 'slipped through.'

• For this small area of a block or so, hillshade from 5-meter IfSAR DSM (digital surface model) looks pretty coarse. My scale bar—applicable across all 4 panels—confirms those pixel-cells or 'boxes' are 5 m across. DSM includes vegetation surface, so the 2 deciduous patches (alders? cottonwoods?) show as fuzzy lumps. • Older 15-meter satellite image from NASA is useless on this zoomed-in view, but one of our best sources for habitat mapping at full-watershed scale.



IfSAR

Interferometric Synthetic Aperture Radar is a remote-sensing tool capable of generating finer elevation models than traditional photogrammetry, and under challenging conditions such as cloud cover and extreme topography. Beginning in 2010, the U.S. Geological Survey (USGS) National Geospatial Program (NGP) collaborated with other federal and Alaska

State partners to create a sort of interim product, until finer resolution (1-m-pixel) technologies such as LiDAR, described below, become available. IfSAR gives us 2 kinds of 5-meter digital elevation models for the entire state:

- 1) Digital Surface Models (DSMs) give elevation values of earth's highest surface *including* vegetation and buildings.
- 2) Digital Terrain Models (DTMs) purport to give elevation of



underlying terrain or 'bare earth' with vegetation and human structures removed. While LiDAR DTMs can be extremely detailed and reliable, algorithms delivering IFSAR DTMs in the SE Alaskan mission result in 'smushed', or 'dumbed-down' landscapes. I've therefore used the IFSAR DSMs for hillshade generation in maps throughout this atlas. That's fine, as long as viewers recognise we're seeing actual vegetation structure—*not ground*. Forest, for example, appears rougher and taller than adjacent thicket, tundra, or tidal barrens. Clearcuts less than 20-years-old look like cookie-cutter divots on the hillside.

Most broad-coverage US-side hillshades in this atlas are based on IFSAR. It gives the most universal, glitch-free landscape view, and looks great at scales to about 1:50,000, or roughly inch-to-the-mile. From that 'virtual elevation,' if more detail

were available, your eyes couldn't use it. IfSAR's only limitation for our purposes in studying broad-scale views of Greater Chilkat Watershed is that it stops at the Canadian border.

Arctic DEM

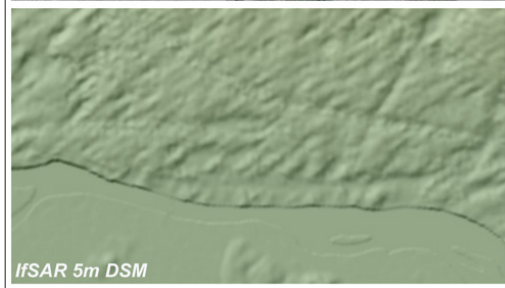
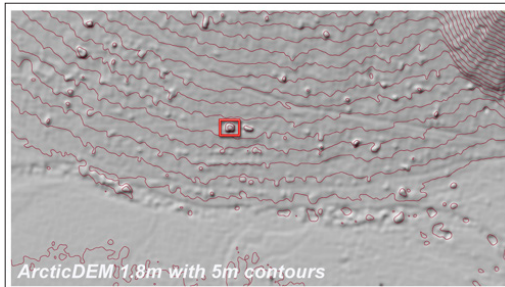
Stereoscopic cartography from traditional photographs didn't just disappear with advent of point-cloud-based remote sensing such as IfSAR and LiDAR. A recent collaboration of NGA (National Geospatial-Intelligence Agency) and NSF (National Science Foundation) has produced a high-res DSM of the entire earth north of 60° latitude (with southerly extensions through the Aleutians and SE Alaska—graphic, left) using optical satellite-based stereo and photogrammetry software. Eight 2-gig tiles cover our greater project area. In May, 2020, thanks to my neighbor Koren Bosworth's souped-up internet connection, I snagged em.'⁵

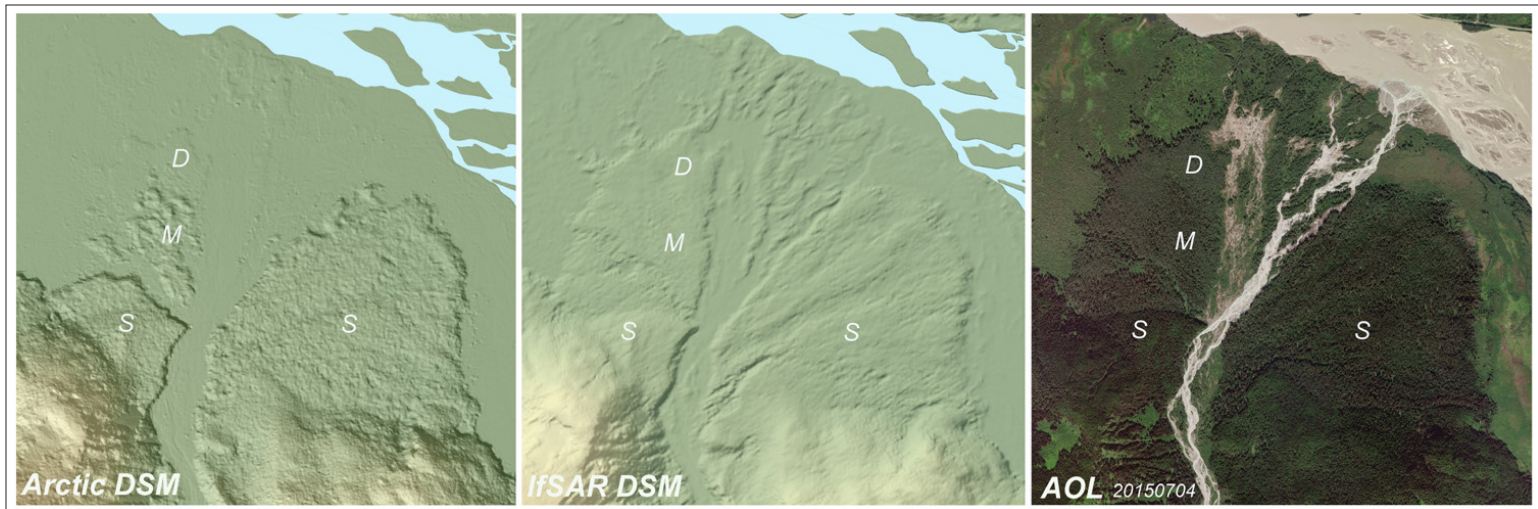
Arctic DEM hillshade is transboundary and detectably more detailed at close scales—say, 1:12,000 or finer—than IfSAR. On the down side, it's full of holes, like a moth-eaten sweater. University of Minnesota's PGC (Polar Geospatial Center) intro page, under "*weaknesses*" notes that because it's optically derived:

5 <https://www.arcgis.com/apps/webappviewer/index.html?id=aff5fa8f5d5548c6bff44cc8be385f61>

Top to bottom: The upper sample of Tlákwaan (Klukwan) from Arctic DEM is based on 2-m DSM, source of this hillshade and 5-m contours. ● Ortho-photo from ESRI's AOL server (ArcGIS Online), taken 20190630. ● IfSAR DSM (*remember*; DSMs show *all* veg surface, not ground, or 'bare earth')

Unlike IfSAR DSM at bottom, Arctic DEM picks up some larger buildings, as marked with red-box in center. I'm still not positive (20200521) what those other pimples are, in areas lacking human structures, but have a suspicion that anyone in Klukwan with GPS could quickly test. They don't stand out on the ortho in center, and are too narrow-crowned to have registered on the coarser 5m IFSAR. Could these be scattered spruces, in a mostly deciduous matrix? Following example from Kicking Horse explains my reasoning.





"Clouds, fog, shadows, and other atmospheric obstructions can obscure the ground and make it impossible to extract terrain."

That probably explains why data-gaps within our GCW project area mostly 'stack against' steep hillsides, where clouds hovered at time of satellite snapshots. Fortunately, the inhabited valley bottoms are pretty clean and universally-covered by Arctic DEM terrain models. So, for zoomed in lowland views excluding those 'moth-eaten' hillslopes, and not yet covered by LiDAR, Arctic DEM is currently the hillshade of choice. It's important, though, to recognise what types of forest-&-shrubland canopy you're seeing or not seeing. The above comparison suggests IfSAR may be a better way to display deciduous woodlands.

LiDAR

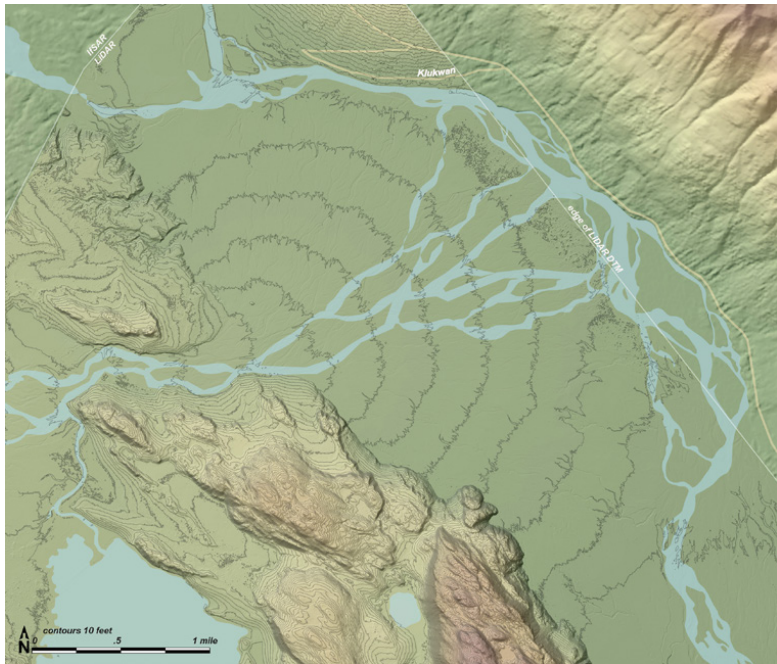
Light Detection And Ranging. LiDAR aerial surveys use pulsed laser light to measure terrain and vegetation. From the LiDAR DTM (digital terrain model) with vegetation digitally removed, we get a spectacularly detailed 'bare earth. From its 'point cloud, we measure and display forest structure.

Left to right: Hillshade of Kicking Horse alluvial fan, generated from a DSM by the PGC's Arctic DEM. ● Same from an IfSAR DSM ● ArcGIS Online ortho taken July 4, 2015.

As with the preceding comparison for Klukwan, discrepancies in forest canopy from the 2 types of DSM are initially puzzling. If Arctic DEM has better than twice the pixel resolution of IfSAR, how does it miss the outermost forest and shrub stands extending north almost to Chilkat River? I suspect the answer can be seen on AOL's July orthophoto. I've labelled 3 veg-types across all three panels: **S**: spruce forest; **D**: Deciduous: probably some mix of cottonwood, alder and willow; **M**: mixed spruce-deciduous. The deciduous type picks up quite distinctly in IfSAR but not on Arctic DEM. Was the latter's satellite imagery acquired during a leaf-off season?

As of 2024, there have been one large and several smaller LiDAR missions within Greater Chilkat Watershed. They were flown in 2011, 2014, 2018, and 2020, followed by an emergency mission just after the Beach Road Landslide on 20201202. The most recent and largest was acquired in 2022 but hasn't been loaded to the DGGs portal, and only became available to us in 2024. More on that one at [end of this section](#).

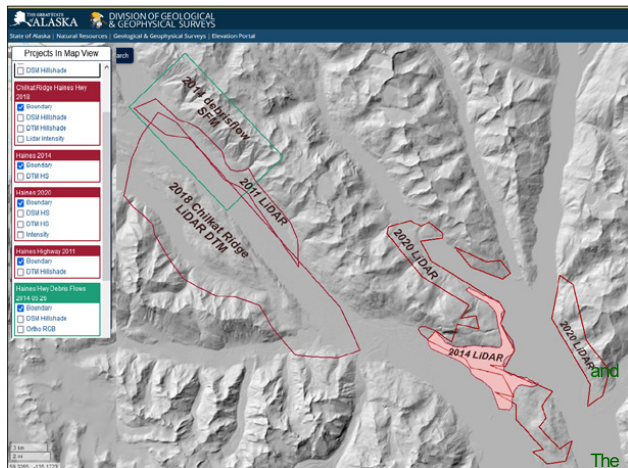
On DGGs's map portal, LiDAR missions are outlined in red. The SFM mission (Structure from Motion, described below) is the green box labeled 2014. The first 2011 LiDAR mission covered 11 square miles in a narrow belt along Haines Highway. The next, more extensive LiDAR mission included 53 mi² centering on potential timberlands along Chilkat Ridge, including Chilkat Lake and much of the



Left: Tsirku fan on 2018 LiDAR DTM, from which both hillshade 10-foot contours have been generated..

• **Right:** state's DGGs

site (**Division of Geologic & Geophysical Surveys**) has evolved into a primary portal for Alaskan cartography from all sources. Red outlines show LiDAR missions; the green outline was done optically, with SFM (structure from motion). Visit at: <https://elevation.alaska.gov/>



river downstream from Klukwan. The village itself really scored; it's included in all 3 missions—LiDAR & SFM—while neighboring Haines has no high-res elevation covers at all.

The DGGs website, right, is primarily a download portal for GIS users. But it can be used by anyone to view LiDAR or SFM terrain models—variably, DTMs or DSMs—in extraordinary detail, and is worth visiting simply to get an up-close look at the future of cartography. Simply check and uncheck whichever mission covers your area of interest, and zoom in for revealing views of the terrain. Missions to date have been 'issue-based,' such as road improvement projects, slope-stability assessment, and timber-scoping. LiDAR missions were commissioned from private vendors at large expense. But ADGGs now has its own LiDAR sensor, so we may anticipate more LiDAR of Greater

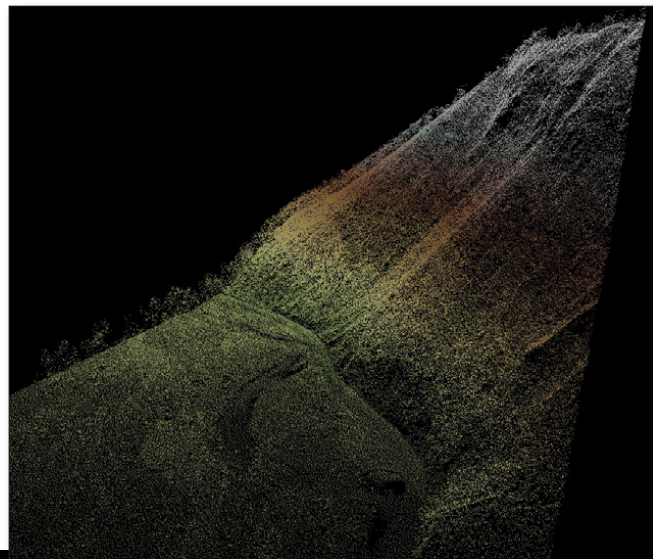
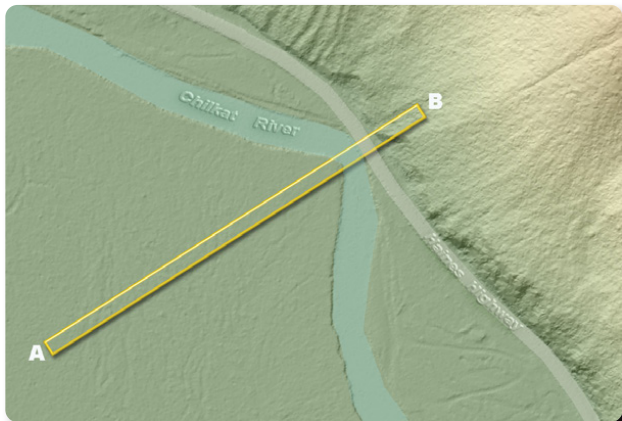
Chilkat Watershed in coming years.

LiDAR missions are typically delivered to clients as GIS packages with a variety of elevation-derived products, both ground- and vegetation related, and other outputs can be generated quickly by arc-enabled recipients. In addition to DEM-based hillshades, very fine contour maps can be generated. Dendritic stream channel networks can be modeled based upon relative elevation of adjacent sampling-cells.

I've downloaded and incorporated elevation models from DGGS's LiDAR & SFM sources into my master ArcGIS project for the GCW.

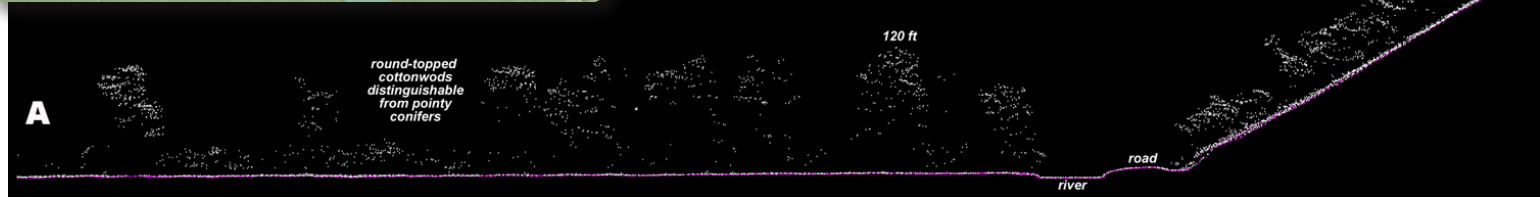
The point cloud Of equal importance to terrain models, but more technically demanding to access

and display, is forest structure information from LiDAR or SFM point clouds. I've been using point-cloud data to assess wetlands and conifer forests since 2013, when the CBJ (City and Borough of Juneau) commissioned LiDAR for wetland surveys conducted borough-wide with Cathy Pohl and Koren Bosworth. I've not



Clockwise: Bare earth from 2011 LiDAR DTM at 16-mile where river presses against road berm.

- Oblique view of canopy structure in the LiDAR point cloud, in free app FUGRO
- FUGRO transect through belt A-B, from sparse poplar woodland on active floodplain, up into dense mixed forest (what species?) on steep colluvial fan.



yet had the opportunity to use point-cloud data to study mixed-forest types such as cottonwood-spruce or birch-pine, so I eagerly anticipate discoveries that will surely emerge.

LiDAR notes & correspondence

20200810: Clay Good just sent me a CVN article (sidebar following) announcing another, larger LiDAR and multispectral imagery collection slated for completion by this September. Runs from town to Mosquito Lake. (PS: actually much farther!).

20220316: Jessica just asked about LiDAR for evaluation of Haines State Forest regrowth projections. Could potentially be very useful. I didn't take good notes on how the FUGRO profile and oblique view (previous page) were generated, or, unfortunately even where the LAZ tile came from. I don't see a source on the State's DGGs portal, so it was probably from the USGS [National Map](#). That site has an expandable section in the TOC called *Elevation Source Data*, which includes LAZ & LAS tiles. Today, however, zooming in on northern SE AK, I see only the CBJ and Glacier Bay(!) datasets. (I'm testing one for Bartlett Cove!)

I did take some notes on pointcloud workflow in my arcpro cheatsheet. Here's the 2020 notes with a 2022 breakthrough I just discovered:

20200603 display .laz in localscene I downloaded a point cloud from the Haines Highway 2011 lidar in the form of an .laz file. seems like bob told me pro could handle these directly, but when trying to add it, the .laz doesn't appear as an option in its source folder. I can display it in fugro, but of course want to take advantage of the cool new tools in pro.

So, learned that view>geoprocessing>convert LAS goes in any direction between LAS, ZLAS, and LAZ. It sees and accepts the LAZ for input. Even starts to run. But I soon get a failed message, apparently because of an unknown coordinate system. DGGs doesn't appear to offer metadata, nor do I see a place to assign projection if I knew it. **ps 2022**, retrying, copied the

projection as a prj file into the chilkat>lidar folder and used it to assign coordinate system. it then appears as "current" in the pulldown. But jeez, I wish I recorded where I FOUND the dang .laz. apparently not in the state DGGs server. Probably in the National Map, but they don't show las, laz for the Chilkat.

Converting laz to las takes a lot of time, and it'd sure be nice to just get everything in the las on a large capacity drive. For anything beyond tile-by-tile needs, I'll have to check in with DGGs site administrator Michael Hendricks in Fairbanks. Joel Nudleman gave me his number: 451-5029. For his work at Division of Forestry, Joel requests small-area point-cloud tiles at need from Mike. Maybe I can mail up a drive or SD card for MH to load with the entire 2018 and 2011 .las tile collections?

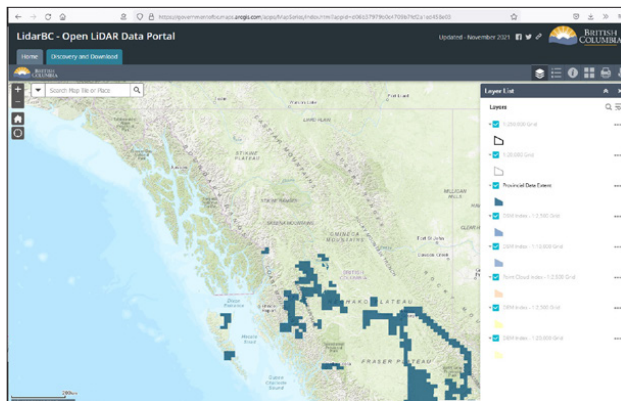
20220902 DSM minus DTM = CHM The Canopy Height Model (or normalized vegetation as we called it back in CBJ's wetland surveys) is something I assumed only vendor-wizards could deliver But it turns out its one of the easiest 3D Analyst tools. Apparently I didn't write down the workflow back in April when I succeeded in creating a [CHM for Jessica from the 2018 LiDAR](#). In *Geoprocessing* search on *minus*. Simple tool subtracts the value of the second input raster from the value of the first input raster on a cell-by-cell basis. Delivers a beautiful default raster, with tallest trees palest.

Tried it for the new 2019 eaglecrest LiDAR and it works great!

PS 20240707: And just did it again for the awesome 2022 DTM and DSM.

BC LiDAR:

Recently searching on BC GIS sources I was excited to see a [portal serving LiDAR covers](#) including point clouds. Unfortunately, the Tat-Alsek Triangle isn't even close to the nearest Provincial mission.



Beach Road Landslide and the 2020 LiDAR As of midsummer, 2021, I'm still waiting on the supposed 2019 Mosquito-to-Deishu LiDAR and 2020 orthophotography promised in the following [CVN sidebar](#). Nothing from those missions is yet hosted on the [DGGs portal](#). Meanwhile, though, an ameoid, meandering LiDAR project outline has been added, labeled '2020,' that overlaps the prior 2014 coverage that I distinguished in pink. I don't yet know the motivation or agency authorship for this mission, but it seems to have been flown shortly after the December 2nd landslide—in part at least for assesment of earth-movement?

PS 2024: Finally! Although Palmieri gave CVN a 2019 flight date, deliverables were apparently not until 2021-22. And I still don't know what became of associated orthophotography by Quantum Spatial for the same area. ● PPS 20240915. Ooops. Studying this LiDAR, we all agree it's an entirely different mission from Greg's more timber-oriented one. More below. . . .

SFM

Structure From Motion

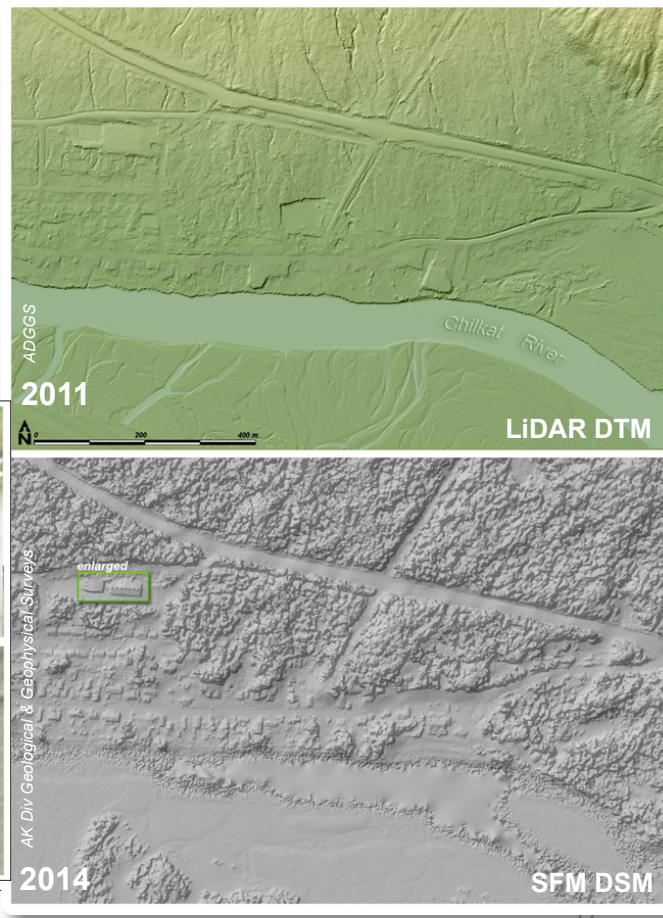
The State's SFM mission was flown in 2014, covering 35 mi² of landslide-prone slopes on Takshanuk Ridge. You could think of this technology as 'poor-person's LiDAR' in the sense that earth-elevation models and even veg-canopy point clouds can be generated from a folder of plain old photographs, without use of expensive LiDAR sensors.

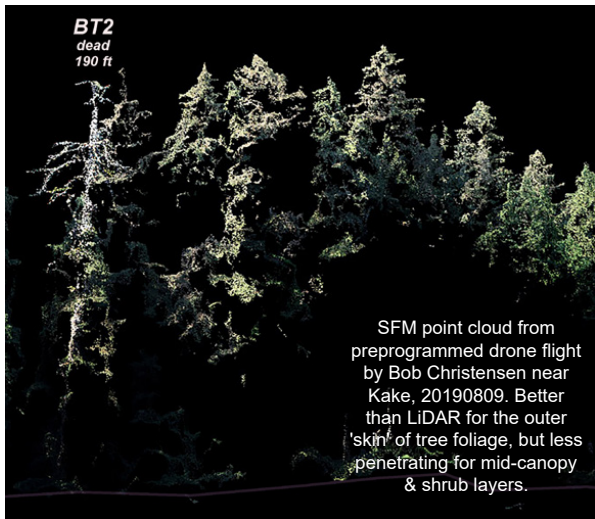
Led as always by my always-pioneering ground-truthing partner & tech mentor Bob Christensen, even some of us intermediate-level fliers have been testing SFM apps. By triangulation from hundreds of still photos, taken at set intervals along a predetermined flight grid, cloud-based programs churn for an hour or so and deliver:

- 1) respectable small-area coverage such as contours, DSMs and
- 2) .las datasets from which we can generate beautiful tree foliage profiles (example, next page). I'm excited about

Three views of Klukwan. Clockwise: 2011 bare earth DTM from early LiDAR mission along Haines Highway. Processing algorithms remove buildings & bridges but accentuate road berms & building-pads. Toe of steep colluvial fan in upper right. At 2-meter resolution, this DTM is coarser than 1m models now standard.

- Hillshade generated from optical (not LiDAR-based) DSM acquired in May 26, 2014. SFM derives canopy surface from photogrammetric comparison of hundreds of still images taken along a flight-grid. Interesting artifacts over river channel, where moving water (?) may have 'confused' the model. At 0.2m-pixel, this raster has 10x finer resolution than the LiDAR model above. But DTMs and DSMs are 'apples and oranges.' • Enlargement of green box on 2014 DSM shows impressive detail delivered by this sub-meter elevation model. • The orthoimage, like the DSM, was processed at 0.2m ground sample distance. Original jpgs from 36-megapixel Nikon D800.





SFM point cloud from preprogrammed drone flight by Bob Christensen near Kake, 20190809. Better than LiDAR for the outer 'skin' of tree foliage, but less penetrating for mid-canopy & shrub layers.

creating my own SFM point clouds of forest types unique to the Greater Chilkat, such as the giant-tree cottonwood forest in the Klukwan-Little Salmon area.

In 2014, with funding from the State Dept of Transportation, ADGGS commissioned a photo survey over . . . :

" . . . large debris fans and their alpine source areas on the west side of the Takshanuk Mountains in support of cryosphere hazards mapping and monitoring efforts." Wolken et al, 2017.

Fairbanks Airborne Remote Sensing flew this mission on May 26th from a Cessna 180 at 1,341 m (4,400 ft), collecting 872 photos with 80% endlap, mapping 107 km² (41 mi²). Two products downloadable from the DGGS website are an orthomosaic (currently the

Haines forest management enters 21st century ¹

Ceri Godinez, August 6, 2020. Chilkat Valley News

"The Alaska Division of Forestry is using state-of-the-art Geographic Information System (GIS) to update geographic data. GIS involves computers to overlay datasets and images to better understand forest composition. For DOF, that influences activities such as timber harvest and road construction.

Last year, the division contracted with Alaska Division of Geographical and Geophysical Surveys (ADGGS) to collect LiDAR for an area **between Mosquito Lake and town, bounded by Takhin and Takshanuk ridges**. This includes forest lands with proposed activities in the current Haines State Forest 5-year management plan, forester Greg Palmieri said. ²

This year, DOF has contracted Quantum Spatial, a company that collects and analyzes geospatial data to take high-resolution, low-altitude images of the same area. In recent weeks, an employee of **DOWL**, the company hired by Quantum Spatial to collect the aerial images, has been reaching out to residents in the area to place 'ground control points,' markers to improve accuracy of final data when images are stitched together.

The high-res will allow the division to 'get to know the ground within a foot of accuracy,' Palmieri said. And they are multispectral, meaning they capture a broader range of light than visible to the naked eye. DOF can use near-infrared light to distinguish between live and dead trees. LiDAR data and aerial images can be analyzed separately or in conjunction using GIS.

'We put those two things together—very detailed images and 3-D modeling—to do different types of resource analysis from steepness of slope to hydrology analysis,' Palmieri said. *'This data has become the standard for resource management work.'* Together, LiDAR and multispectral images will allow division employees to understand the composition of large areas of forest to a precision previously only possible on a small scale, after hours of field data collection.

'I could determine a particular tree

1 Impressive, but doesn't that mean they're 20 years late?

2 Joel says DGGS now (2020) has its own LiDAR sensor.

height if I wanted to,' Palmieri said. *'It would have taken 8 to 12 people before.'*

New applications for GIS in relation to resource management are still being discovered, Palmieri said, but at present, it hasn't replaced fieldwork. *'Some are arguing that it will, but we're not there yet,'* he said.

Before GIS, aerial photos were the prevailing technology for large-scale forest analysis. The most recent division of forestry images of the area were taken in 1998 using analog cameras.

Palmieri said the division didn't have funding available to image the entire forest this time, so they selected the smaller area running between Mosquito Lake and town.

In total, the multispectral imagery taken this year will cost the state roughly \$136,000. The funding comes from capital project dollars set aside for this purpose some time ago, according to Palmieri. He expects the project will be completed by end of September. **RC: ie, we should have seen this on DGGS portal by late 2020.**



RC, 202407: Based on the above **boldd** description, this is about the coverage I expected to see, 4 years ago. So **where is it?!** Compare to orange outline on next page for the more avalanche-oriented 2022 mission.

finest resolution aerials for any subset of the GCW; see *Orthophotography*, below) and a digital surface model or DSM. ¹ Only in terrain free of woody vegetation such as tide flats or alpine tundra does SFM give an actual terrain model or DTM.

2022 LiDAR

As of July, 2024, we are *finally* in possession of the LiDAR promised in preceding CVN sidebar (At least I *think* it's the same mission; more on this below). Whatever the relationship between forestry and landslide objectives and deliverables, area of coverage, etc, it was worth the wait!

Derek connected me with Mort Larsen, at Landslide Hazards, ² who replied that "*our portal* [the dggs clearinghouse] *hasn't been updated,*" but instead sent me [this link for downloads](#). Options include:

LAS classified point files 113G • DSM-6.2G • DTM-9G • LiDAR intensity-6G.

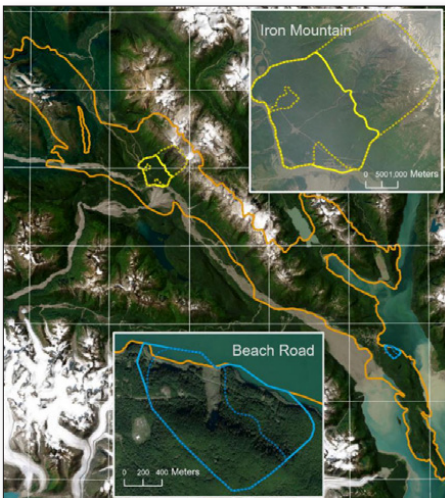
I don't see on this page any way to download selected LAS tiles, or an index to those presumed tiles, and haven't heard back yet from Mort on whether there's a process. I remember Joel Nudelman saying that he requested point clouds on a tile-by-tile basis from DGGS when he worked at DOF. Even with Koren's fast connection, downloading 113 gigs could be a slog—not to mention that none of us would ever need access to more than a fraction of 1% of those data. Sure would be nice, though, to grab tiles surgically when analysing, say, a proposed HSF cutting unit.

A report from Zechmann *et al*, 2024, explains that the survey

"provides snow-free surface elevations for assessing landslide hazards and, in 2 active slide areas (dashed lines, cover figure), elevation changes between Octobers of 2021&22. Ground control nov1-3, 2021, aerial lidar oct24-6, 2021 & oct2-4, 2022. Released as a Raw Data File with an open end-user license. All available to download on the dggs website

¹ I was first alerted to this mission and coverage by Ben Kirkpatrick at our July, 2019 meeting in Haines. If I understand correctly, there was a landslide after the 2011 road-corridor LiDAR. From the 2014 SFM-based elevation model, cartographers were able to measure the deposit using before-after elevation differences.

² Mort Larsen • Landslide Hazards Program Manager • Division of Geological & Geophysical Surveys • Alaska Department of Natural Resources • martin.larsen@alaska.gov • Office: 907.465.3771 • Mobile: 907.209.3234

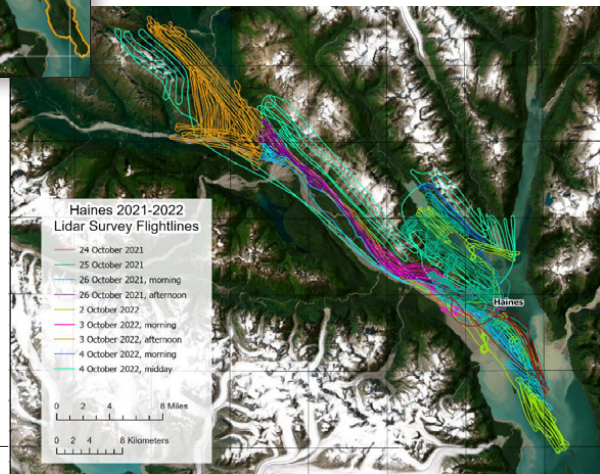


at <https://doi.org/10.14509/201034>"

But nothing comes up at that address. Still in limbo, I guess?

DGGS used a Riegle VUXI-LR laser scanner and an IMU designed by Phoenix LiDAR Systems. (they have their own now, according to Joel?) Pulse-refresh 200-400k over forest and 50-100k over alpine. Bell Jet Ranger survey from 50-700m above ground, scan angle 80 to 280°. Total survey area 471km² (182mi²).

"We used ArcPro to derive rasters from the point cloud. A 50cm DSM was interpolated from maximum return values from ground, veg, bridge deck, and building classes. A 50cm DTM from all ground class returns. Additionally 4 closeup DTMS: 20cm for Iron Min from both 2021 & 2022 data, & same for BRLS. . . . We thank Greg Palmeri [sic] of the AK Div of Forestry and Fire Protection for his help in select-ing survey area priorities."



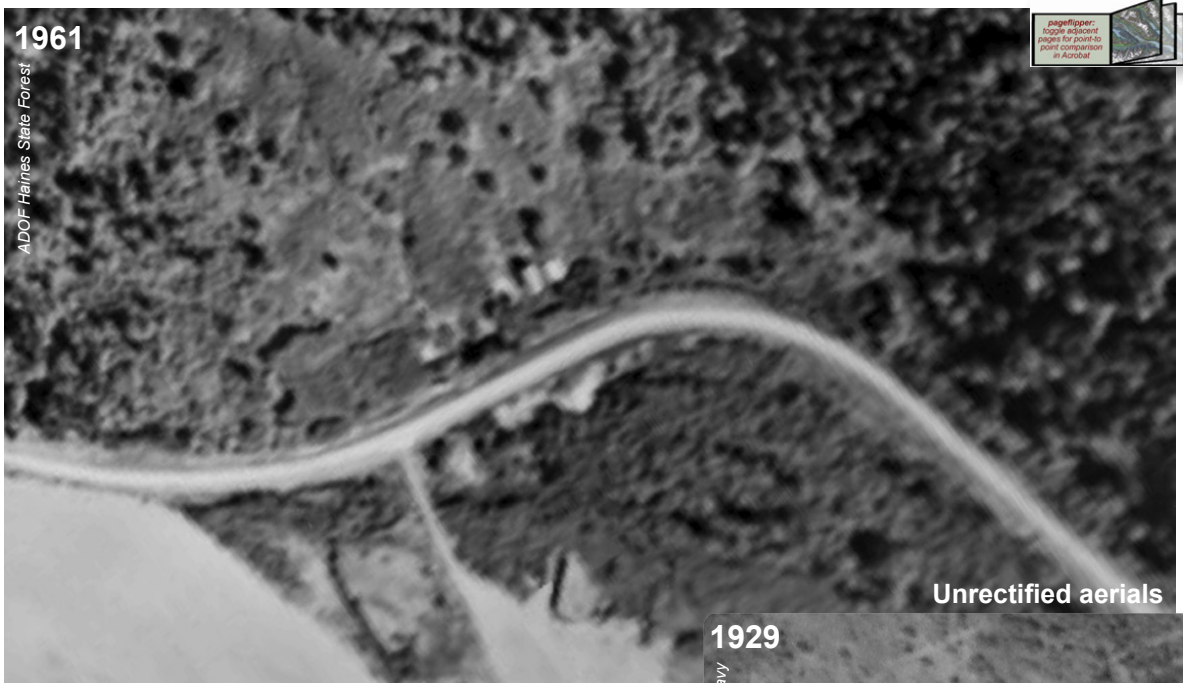
Except for DOF's 13-mile proposed sale, it seems as though the State's main timber priorities were completely omitted. Still no Baby Bear LiDAR. The CVN conversation with Palmieri led me to believe this was primarily about helping him measure trees on forest lands . . .

"with proposed activities in the current Haines State Forest 5-year management plan."

Rationale according to Zechmann *et al* was more focused on avalanche hazard and aftermath assessment. And date of capture was 2 years *after* the missions described by CVN: 2021&22 vs 2019&20. Those earlier ones couldn't have simply been delayed, because the LiDAR at least was already reportedly 'in the bag', just not processed at time of publication.

Could we be talking about 2 different sets of missions? And has the data set described by Palmieri still not been released to the public, or even made known to the Landslide folks? If for internal DOF use only, why would he have described it to a reporter? Maybe changed his mind about sharing on consideration of what we could do with it?

Whatever the backstory, we're suddenly on a whole different plane of



Unrectified aerials

cartographic power, for a huge chunk of the GCW. On this and the following 3 pages, let's use the old village of Yandeist'akyé, *faraway stuff drifts ashore*, just above Haines Airport, to explore some of the power of this new resource. The 'flippers' will also serve as advance sampling of *Unrectified historical aerials*, described in a [following section](#).

Long before any shoreline or upriver roads, Yandeist'akyé was principle



village of Jilkoot Kwaan. Buildings gradually faded through the 1900s, but I've included the 1961 aerial to mark positions of a few of the remaining ones. Hold your cursor to the largest clanhouse on the 1961 image, and flip back and forth through the 4-page series.

I haven't been up there in 35 years, but it looks from this 2021 ortho and following 2022 hillshade as though part of the roof, now settled to ground (?) sits propped and 'unbuilding-like,' or enough so to confuse the DTM's structure-erasing algorithm.³

Yandeist'akyé is a classic example of brush capture on a culturally enriched surface. (Same is true on Aak'w Aani's best known village site of Aanchgaltsóow at Auke Rec). For more than a century, the dense thicket of

³ DTM deliverables typically remove houses and bridges by 'teaching' the processor to recognise certain unnatural looking shapes, and erasing them down to the level of surrounding ground surface. In towns and suburban tracts, this often produces a pretty believable image of rectangular house pads. Airborne LiDAR sensors can't of course see under a bridge, but post-processing can predict the stream bed by assuming smoothly dropping channel from upper to lower sides of that bridge.

The DSM, in contrast, keeps all LiDAR points up to the tops of trees, and inclusive of most buildings and flat-surfaced human structures. Subtracting DTM from DSM is what gives us the canopy height model (CHM)



shrubs, underlain by herbs and mosses, prevents feathery seeds of conifers from reaching mineral soil, which they need for germination.

Pushing through these d7 thickets,⁴ it can be hard to make sense of ground contours. You can be standing on a relict house pad without

⁴ Bushwacking difficultly on scale of 1 to 10. Developed for Groundtruthing Project. [Download the pdf](#) from JuneauNature.

recognising it. On these sites, a hillshade generated from the DTM is like a non-invasive mower, exposing shapes on the ground as subtle as a slumping roof-crest. Most of us have seen the spectacular LiDAR images of Mayan ruins, long overgrown by tropical jungle, undiscovered before archeologists began to use this survey method.

Remains of Northwest Coast architecture and settlement are far more subtle—wood fades quicker than stone. But a trained eye can make out anthropogenic features like terraces, garden rows, drainage ditches, storage pits and leveled longhouse pads. The 2022 LiDAR DTM has 50cm-pixel resolution, which is okay for scanning miles of old raised beaches, etc for potential 'humanized terrain.'

Once found, a targeted, low-level drone-based survey could deliver 1 to 2 orders' magnitude better resolution over known cultural sites such as Yandeist'akyé. This sample for the old village is zoomed in to show the potential of LiDAR terrain models. But what stands out for the 2022 mission compared to all previous ones in Greater Chilkat Watershed is *extent*. We now have ridgetop to valley bottom coverage for a 9-mile-long swath running down the GCW's central fault valley, extending for the first time to tip of Chilkat Peninsula, and northeast to Halutu Ridge and Dayeisáank'i Héen (Ferrebee River). On the north it reaches to the confluence of the Nataga with Yéil Héeni, *raven's river* (Kelsall).

The new LiDAR also covers a huge landscape of alpine tundra, which will assist with bedrock and surficial landforms mapping. Other places in Lingít Aaní with very large LiDAR



covers—Tàan (Pr of Wales Is), Áak'w & T'aaakú Aaní (CBJ), Xunaa Káawu (north Chich) include a little alpine but it's comparatively subdued. My quick, first-pass cruise through 2022 LiDAR for the rugged Takshanuks was thrilling.

Even more exciting and *surprising*, to me as a landforms geek are several strange 'blowouts' cutting into otherwise smooth early Holocene marine

deposits in random-seeming places on Chilkat Peninsula. I'll be including examples of this in [Geology>Surficial>Landforms>Marine](#).

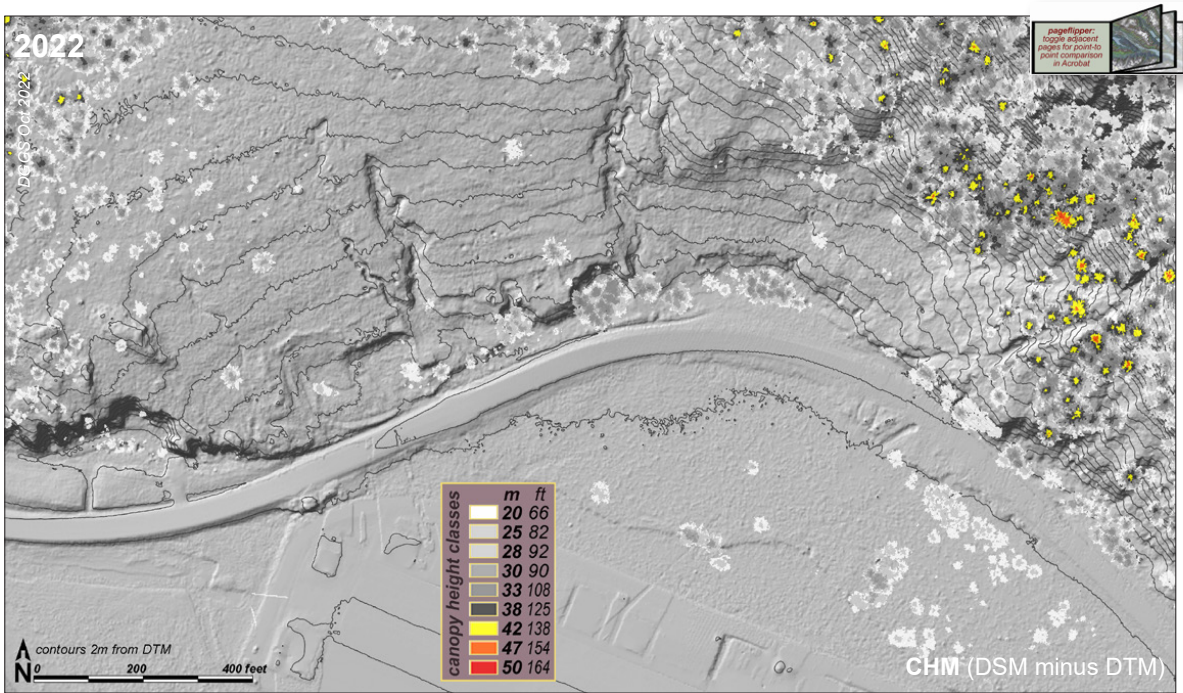
Moving from geology to forestry, we shift from DTM to the digital surface model, or DSM. As described above for the [2018 LiDAR](#) over State cutting units, a canopy

height model (CHM) can be prepared in ArcPro using the geoprocessing tool called *Minus*. Simply subtracting the DTM values, pixel-by-pixel, from the DSM, we get a model of tree heights that can be color coded into classes. My fairly fast computer churned for 2 hours before spitting out this CHM for 182 square miles!

In wetland mapping we use a code that emphasizes subtleties of low-vegetative structure: knee height, head height, etc. This code is useful in assessing songbird nesting habitat, for example.

But for forest and woodland analysis, especially in mostly brushy country like this scene around Yandeist'akyé, where tallest trees stand well apart, I find it better to assign no color to lower classes, so that the bare earth model can be appreciated. This classification shows no trees until we reach the height of 20 meters, or 66 feet.

First application on creation of the 2022 CHM was analysis of postlogging regeneration on [lower Nataga River](#).



Orthophotography

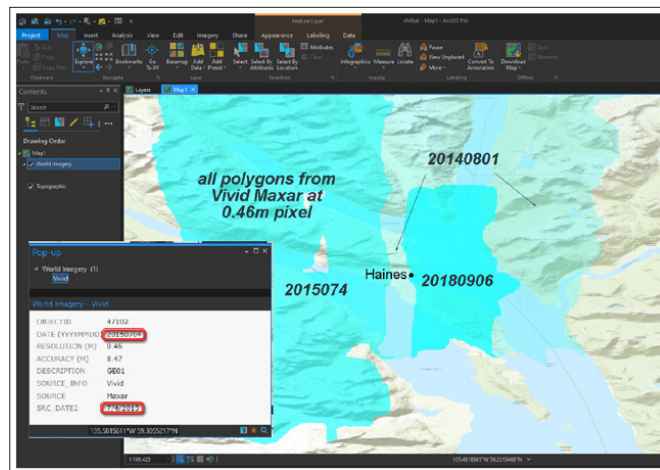
An orthophoto, or orthomosaic, is vertical imagery (a raster), spatially referenced for use as a map in GIS. It's usually composed of many, rather low-elevation photos, edge-matched into a mosaic. Borders of component photos can be recognised by sudden changes in apparent direction of tree-lean. Orthophotography for most of Southeast Alaska has been regularly updated by the US Forest Service, and partners such as NASA. In the GCW, beyond the borders of Tongass, we've had several air-photography missions sponsored by the state's Division of Forestry, and earlier missions by the US Navy, but they're not rectified. So it takes a bit of work, for example, to create a precisely-aligned historical series, showing successional change or cultural developments. More on this below in the section on *Unrectified historical air photography*.

Until this year I've copied USFS orthomosaics to hard drive for use in my ArcMap projects. For this GCW project entirely north of Tongass coverage, I'm relying more upon orthos distributed online, described below. No problem at my home in Áak'w Aaní, but cloud-computing presents challenges in areas of slow and patchy internet coverage such as most of Jilkáat and Jilkoot Aaní. As our 'atlasing' evolves, these connectivity issues will need to be addressed, both for GCW residents at home on the computer, and for navigation with phone or tablet-based apps farther afield.

ArcGIS Online (AOL) ESRI (Environmental Systems Research Institute) is the world leader in GIS (Geographic Information Systems) cartography. Their online portal ¹ is so complete that I rarely use Google Earth or BING (Microsoft's answer to GE) anymore. AOL's *World Imagery WGS84* is typically superior in resolution and currency for any area-of-interest. Personal accounts are free, and you don't need ESRI's arcmap software to use the AOL viewer. I encourage anyone who frequently uses those better-known map portals but would like more options in "*Basemap imagery*" (mostly rasters) plus access to thousands of user-created AOL projects with custom-built layers, to start a [personal or organizational account](#).

ArcGIS Online presents high-res satellite and aerial imagery, typically within 3-5 years of currency, for most of the world. The map gives at least 0.5m resolution imagery in the continental US from Maxar. Additional sub-meter imagery is offered in small areas, such as the golf course

¹ <https://www.arcgis.com/home/index.html> A few fairly primitive examples of AOL embedded windows can be found on [JuneauNature](#), for example of [Surficial geology](#). But the possibilities are limitless, and I hope to build out many more, including some for the GCW pages. You may already use AOL-based maps, maybe without noticing their unobtrusive host. For example, the Haines Borough Parcel Viewer, described below, is hosted by ArcGIS Online

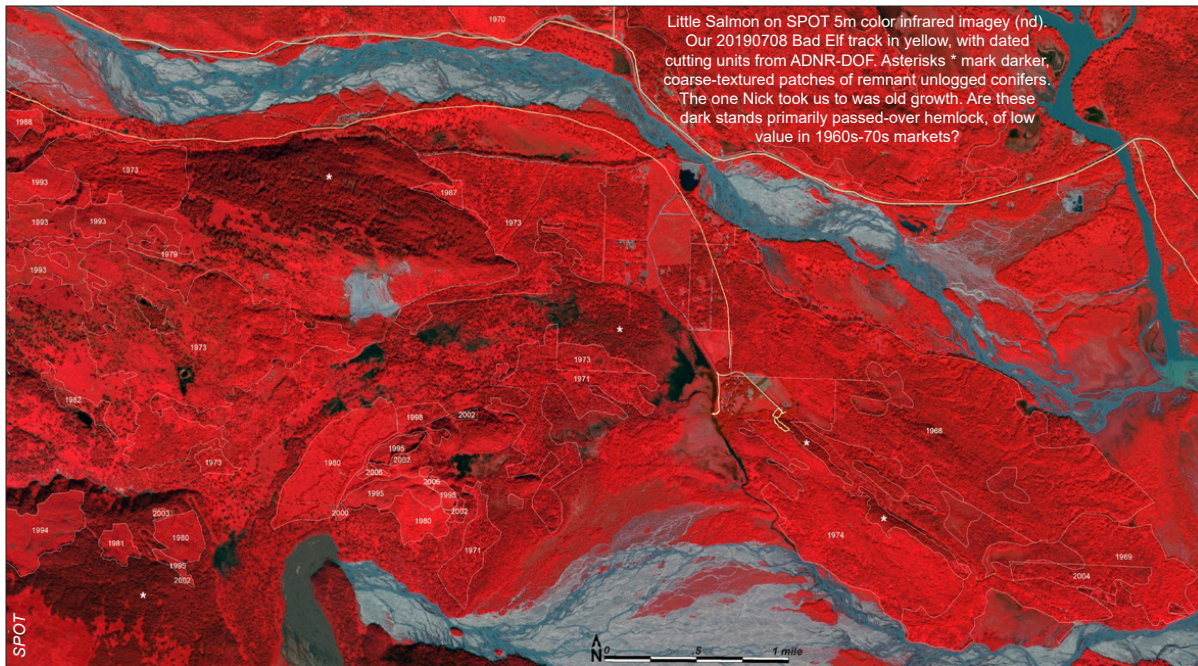


Determining date of AOL (ArcGIS Online) World Imagery acquisition requires setting up a separate map tab in ArcGIS Pro. See, however, ESRI's [Wayback App](#), which not only gives you dates of current and past AOL imagery, but is a good way to quickly create historical series.

on Sawmill Wetland. Fine-scale imagery at different resolutions has been contributed by the GIS user community.

Determining date of photo acquisition for AOL isn't as simple as in Google Earth, which displays that on its footer. Instructions ² involve creation of a new map tab in ArcGIS Pro, downloading World Imagery index file, and clicking with *Explore* tool to display polygons. I clicked 3 on the sample window. As claimed by ESRI's "3-5 years of currency," oldest as of early 2021 is 2014.

² <https://support.esri.com/en/Technical-Article/000018129>



Quality of World Imagery varies across the GCW. For example, the current (202006) orthos around Klukwan are high-res but disappointingly dim. These were acquired on June 30, 2019. Our scoping visit to Jil̓káat Aaní ³ was only a week later, when smoke

³ http://juneanature.discoverysoutheast.org/content_item/chilkat-journal-20190706-08/

from interior fires still spread haze over the entire GCW!

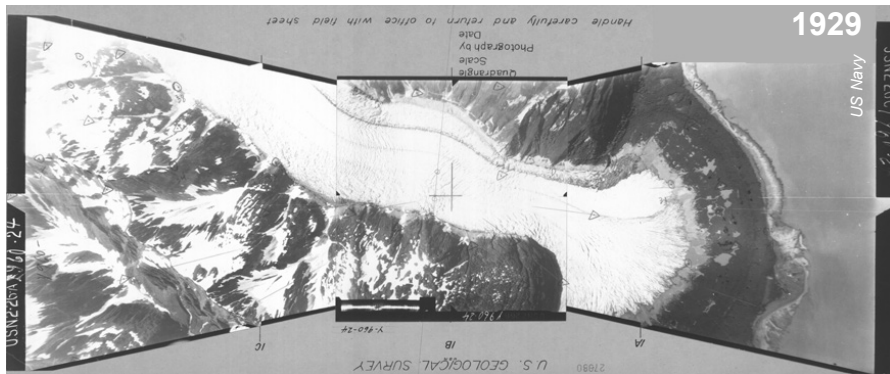
SPOT SPOT (*Satellite Pour l'Observation de la Terre*) is a commercial satellite system created in 1982 by the French Space Agency. Photos are freer of distortion than low-level orthomosaics, and offered in both true-color and color infrared (CIR). Resolution is only 2.5- to

5-m pixel, coarse compared to AOL's submeter resolution for World imagery. But especially when it comes to mixed conifer-deciduous forest types so common and diverse in the GCW, CIR accentuates differences that can be subtle at peak growing season on true-color imagery.

For example, this SPOT CIR (no date provided) can be used to delineate remnant conifer patches that include regionally rare hemlock old growth, which managed to escape stand-replacing fire. In our July, 2019 scoping meeting, LCC president Eric Holle noted that we don't yet have a good map of these oldest forest types in the GCW.

CIR could also help us understand differences between post-fire and post-logging succession. Which species are best adapted to each disturbance type? ⁴

⁴ 202006: In ArcGIS Pro, *View>Catalog Pane>Portal* tab. In search box, type "alaska spot." About 30th down is *Alaska SPOT CIR 2.5meter*. Right-clicking, doesn't give option to open within *chilkat.aprx*. But it opens in a separate tab, where vector files drop into it fine—most importantly ADNR's *timbersales* layer.

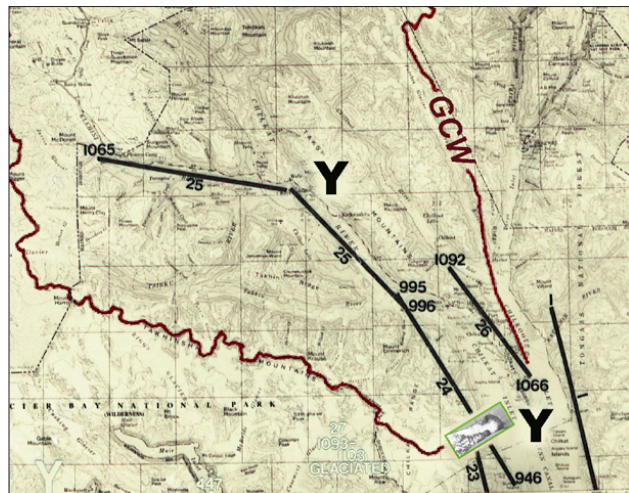


Sit'i X'aayi, *glacier point* (Glacier Point: Davidson Glacier) from the Navy's tri-lens cameras. Position shown on Y flight line through index map on right. (These were actually mistakenly labeled "Z" lines, as pointed out by Greg Palmieri, ADOF; I've retouched the index accordingly.) Photos from this mission were simultaneously shot from one nadir and 2 side-looking cameras, from a belly hatch in amphibious biplanes. Laid-up on card stock, with 'wing' pics fanning out laterally for consistent scale, this triptych delivers stereo throughout when paired with adjacent sets in the flightline. For examples, go to [Geology>Glaciers>Post Little Ice Age recession](#).

Unrectified historical aerials

In work throughout Lingít Aani, one of my first steps in analysis for any region is to acquire and compare all available historical aerial photo missions. For the GCW project—outside the National Forest for which I've already collected the basic photo resources—this step required more time than usual: many days of scanning and downloading.

1929 US Navy Generally a photo series for SE Alaska begins with the first US Navy photos in 1926 or 29. My core collection of these 'tri-lens' images was copied from a Forest Service drive that stopped at the northern limits of Tongass National Forest. The mouth of Chilkat river was at the very tip of the northernmost image in that USFS collection. ' The last 2 'tri-photos' in that line gave a stereo view of



Sawmill Wetland, but missed Deishú, *trail's end* (Haines).

So I was delighted to discover a reference table for the Navy's *Alaskan Aerial Survey Expedition Photographs* (Kreig & Palmieri, 2014) indicating a Y flightline continued all the way to Jarvis Glacier at the border. One reason these images have been underutilized may be that the original index map mistakenly labeled this flightline "Z."

Compared to digital scans of the more comprehensive 1948 mission, described next, the 1929s—at least in the center, vertical image—actually offer better resolution. (flaring 'wing' shots have more distortion)

1948 US Navy Not that we need another World War, but it must be

of their open-air cockpits. Several of these captured downtown Haines, and are included in [Appendix 3, Repeat photography](#). This introduction to aerial photography deals only with imagery used in mapping.

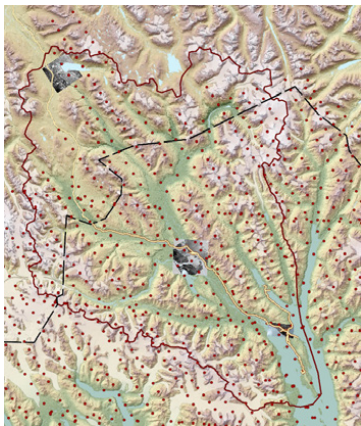
1 In addition to tri-lens belly-hatch cartographic aerials, Navy photographers also took opportunistic obliques over the sides

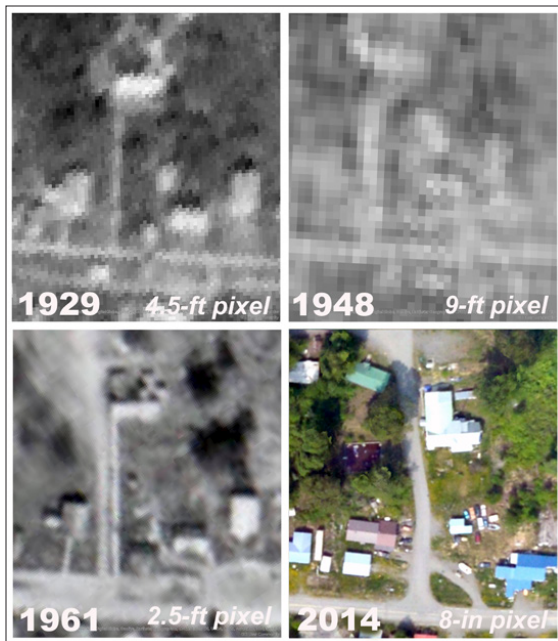
admitted that they're great for advances in photogrammetry. Two decades after their post-WWI visits to Alaska in 1926 and 29, the Navy returned to fly even more comprehensively, post-WWII. They based in Southeast Alaska for the entire summer of 1948, biding time through storms and launching in clearweather windows. Most USGS inch-to-the-mile topographic maps in use today are still based on this 1948 mission.

Nation-wide, and across many federal and state agencies, especially since the shift to digital photo-missions, there's been a movement toward consolidation of physical photo collections that tend to take up too much file-cabinet space in small offices. The original 9x9-inch prints in the 1948 Navy series were eventually removed to Sioux Falls. In 2009, John Caouette, then USFS, initiated efforts to repatriate them to Juneau Geometrics. Although the prints were never physically transferred, my wife Cathy Pohl—then at TNC—finally convinced NRCS to load us an external drive with scans and indices for the 1948 collection.

While low in resolution compared to the earlier 1929s, the value of the 1948 collection is its completeness. Virtually every acre in Southeast Alaska was flown at least once and often twice. Overlapping images provide stereo, which is useful at extracting maximum information from relatively coarse imagery. This example for downtown Deishú is about as close as you'd want to zoom with the '48s.

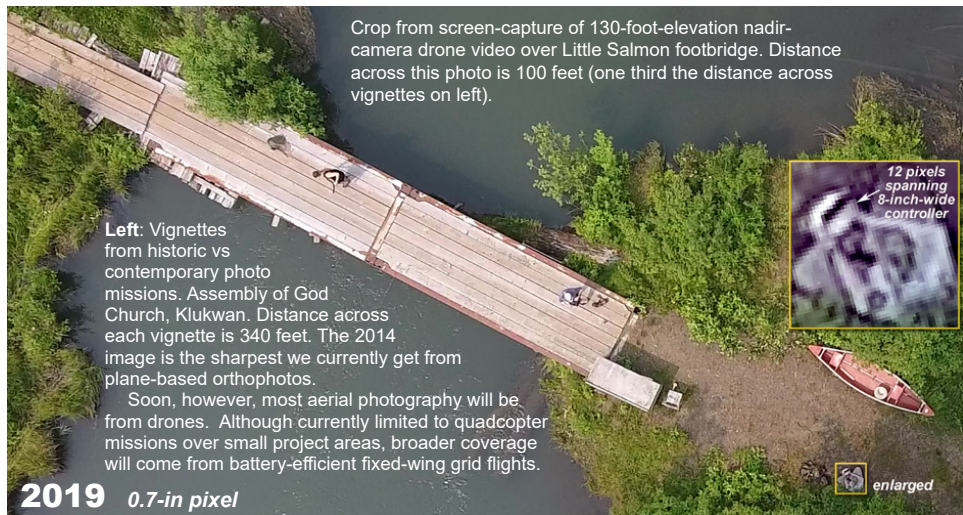
Centerpoint index for 1948 aerals. Probably the only place where US pilots extended their flight lines more than a mile or so beyond the Canadian border. Photos at top give 70-year-old stereo over Kelsall Lake, BC.





1960s through 90s, State Forest By the early 1960s, as logging ramped up across the southern Tongass on federal timberlands, Haines mill owner John Schnabel began lobbying the State to open the Chilkat country. ² In anticipation, photo

² From Henry, (1999): "Fearing a diminished [federal] timber supply, Schnabel began calling for a sustained allowable cut closer to home. in a 1976 treatise published in the local newspaper under the title *The forest industry and the future of Haines*, Schnabel sounded the clarion call for a local harvest plan



Crop from screen-capture of 130-foot-elevation nadir-camera drone video over Little Salmon footbridge. Distance across this photo is 100 feet (one third the distance across vignettes on left).

Left: Vignettes from historic vs contemporary photo missions. Assembly of God Church, Klukwan. Distance across each vignette is 340 feet. The 2014 image is the sharpest we currently get from plane-based orthophotos.

Soon, however, most aerial photography will be from drones. Although currently limited to quadcopter missions over small project areas, broader coverage will come from battery-efficient fixed-wing grid flights.

2019 0.7-in pixel

missions were flown at much lower elevation and finer detail than the 1948 Navy aerals. The first, pre-logging B&W collection at a scale of about 1:12,000, from May through July of 1961, is most comprehensive. More focused missions were flown in August 1970 (B&W at 1:12,000) and in July, 1976 (true color at 1:15,840) as foresters zeroed in on the more commercially viable stands, and these captured the earliest clearcuts as well as those forests next down on the desirability list.

In May, 2020, Joel Nudelman at ADNR Division of Forestry loaned me, sequentially, several heavy boxes of these 9x9-inch prints. They've never been digitized, and flight indices are missing, at least for the 1961 series. Scanning the entire collection would have taken months, so I prioritized: **1)** communities like Haines and Klukwan; **2)** culturally and ecologically significant marine shorelines; **3)** alluvial fans and floodplains; **4)** unique landforms and forest types such as old burns, and **5)** forest stands subsequently logged. Between

... 'It is the industry's suggestion that Chilkat Valley be offered as a management unit, much like the Tongass.' The mill could only be sustained if a long-term contract was forged between the State and the Haines mill."

scanning, georeferencing, organizing, and assembling stereoviews, this process was about a week's work—and another week for subsequent photo-missions. But there's no better way to 'virtually explore' a watershed, and we now have a library of landscape history that can readily be consulted for the dozens of GCW favorites identified by project leaders.

First challenge in the no-index 1961s was figuring out where photos were taken. Starting from no-brainers—eg, downtown Haines—other images in each flight line could be identified. Scanned at 444 dpi, and mostly cleared of grease pencil markups,³ stitched mosaics of 3-to-4 adjacent images are then ready to georeference—*ie*, scaled and 'pinned' to current orthophotography. Once rectified, they can be used in two ways:

First, a **historic series** can quickly be exported from ArcMap using all of our aerials for any given location. My favorite way to present these is on successive pages of a pdf, arranged so that a click of the mouse roller toggles back and forth, for easy comparison across the decades. Many of these, with up to 6 photo per series, are in *specialplaces.pdf*. Full-screen 'toggle-series' are also effective in slide shows, preferably with a slow dissolve.

Stereo for 3D viewing

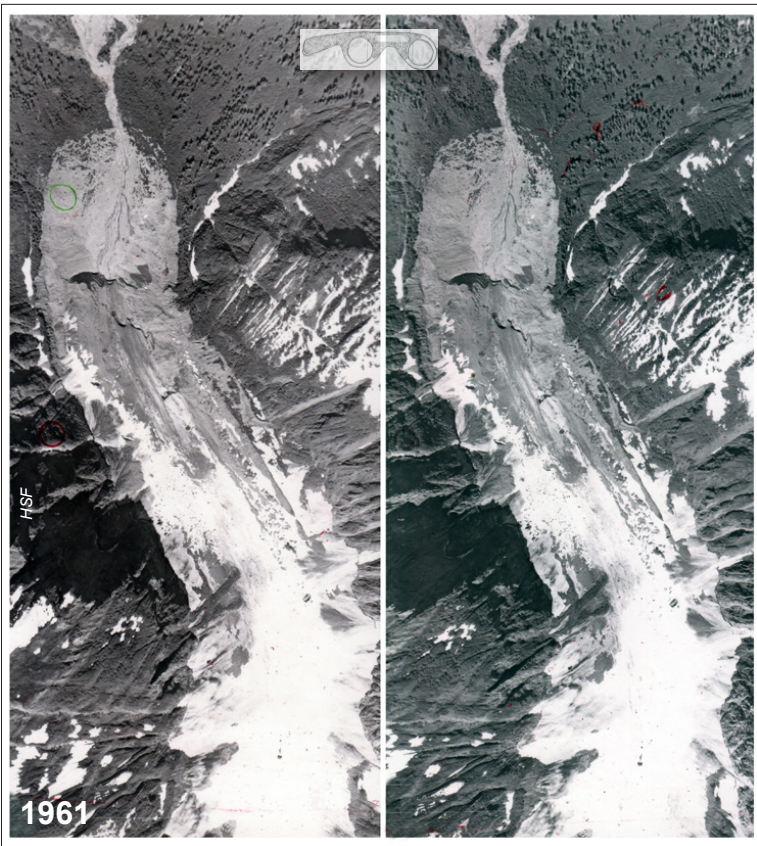
Secondly, a **3D stereogram** can be assembled by exporting the overlapping portion of two successive images in the flight line. Best way to view these stereopairs is under a pocket stereoscope on a high-resolution tablet. You can also see stereo on your computer monitor, but screen resolution is usually grainy under the 2x lenses

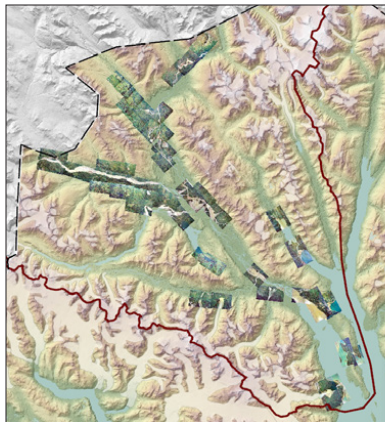
³ Many historic "resource photos," in these and federal collections, were heavily red-lined under mirror stereoscopes by foresters outlining and labeling prospective timber stands. These marks distract the eye and make it hard to view stereopairs in 3D. Photoshop's rubber-stamp tool to the rescue! 'Brush' is sized to only a pixel or two wider than blemishes, always sampling from like-textured canopy to minimize false-information.

Stereopairs are generously sprinkled throughout our companion atlas, *Featured landscapes*, so you'll definitely want to order a stereoscope! In this document I include just a few samples, by way of introduction to a fading art and interpretive tool that deserves renaissance in this age of

This pair shows terminus of Willard Glacier [noTN?] in 1961, which has since (next page) wasted up-canyon beyond this scene. 3D makes clear what 2D cannot—that the grey "bulge" is an ice-purged depression, not a till-mantled convexity.

Ironically, while my old photo collections are 'stereo-rich,' it's harder to assemble 3D pairs from contemporary digital photo missions, where deliverables rarely include raw, pre-rectified .tifs. For Aak'w & T'aakú Aaní I copied the entire 2013 collection of original imagery. But it consumes an order of magnitude more drive space than the processed orthomosaics.





Above: georeferenced 1998 aeriels. Scanned from 9x9-inch prints, they're stitched into short 'runs' of 2- to 4 photos each, then 'pinned' or georeferenced onto current AOL orthophotography. This later expedites assembly of precisely aligned historical series for any area-of-interest.

Right: Stereotriplet for Willard terminus in 1998. Perhaps there's a bit of ice buried deep in those collapsing till mounds, but it's no longer attached to the receding glacier.

I don't use this 3-panel layout often, but it does permit broader examination to both sides of the valley.



of a stereoscope. This example for Willard Glacier [noTN?] ⁴ is a good example of landform information inaccessible on 2D imagery that 'pops out' in a stereogram. Three dimensions also offer vastly richer environments for grasping subtleties of tree height and forest structure.

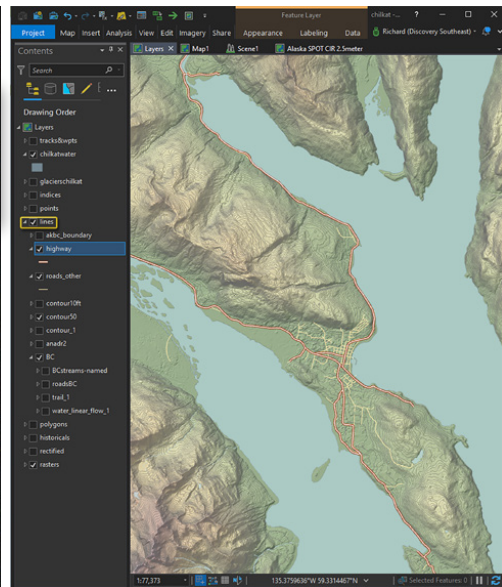
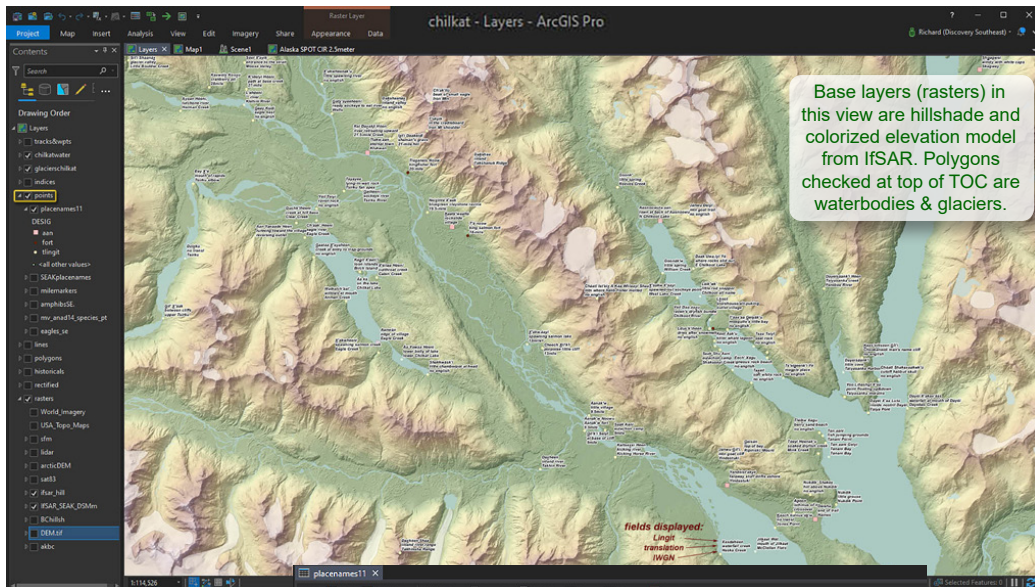
More tips and background on stereoscopy and all-things-3D

⁴ Willard was named for the Reverend who arrived in 1881 to "save" the Tlingit—yet another top candidate for renaming. It's one of a row of mountain glaciers descending into Takahin Valley from GCW's border with Glacier Bay National Park. During the recent Little Ice Age, a few blocked the river, causing outbursts, but none was vigorous enough to become a true valley glacier.

can be found at [JuneauNature>TOOLS>Photography>Stereophotography](#).

1998 Although limited photo-flights happened in 1970, 76 and 78, the first broad-coverage mission by the State since 1961 was almost three decades later. ADNR needed better mapping capacity on timberlands opened at request of northern mills to make up for declining quantity and quality on federal forests to the south. In scanning this collection, I've tried to be comprehensive in the more heavily logged places such as Chilkat and Klehini valleys.

The Alaska Division of Forestry continues to commission aerial photo series and other cartographic resources such as LiDAR, but

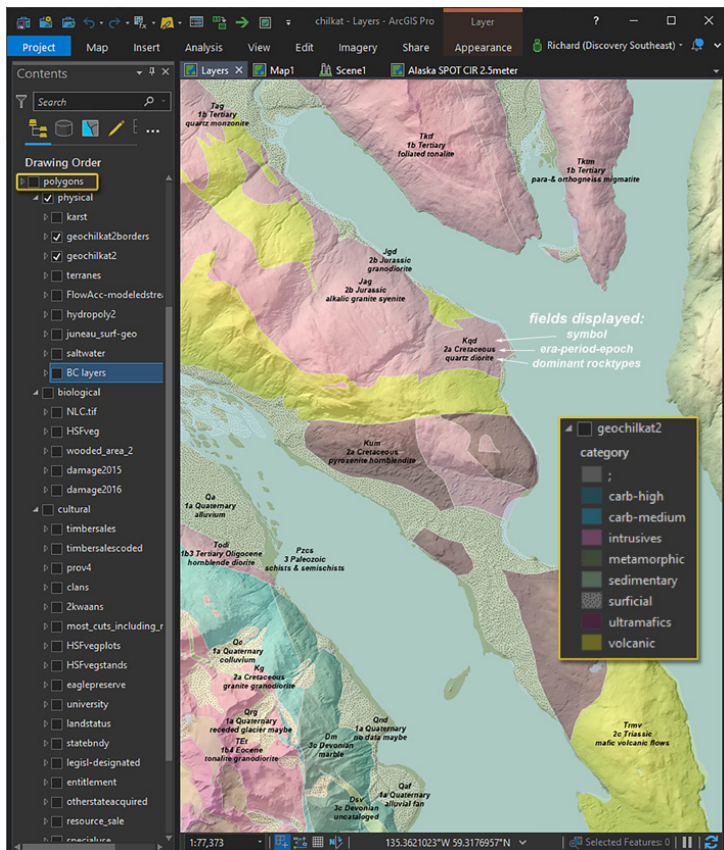


Vector layers

To this point, I've been describing large, memory-heavy *raster* layers (defined in [footnote 3](#)) used in GIS projects. Now we switch to smaller, non-pixelated, formula-defined *vector* layers that stay sharp at all scales. We can subdivide

IWGN	feature	bioprovince	lingit name	translation	k'wáan	cían
21.5-mile Creek	tingit	Chikát	Kai Da<UND>x</UND>áki Héen	river retreating upward	Jikáat	Gaanasteidi
21-mile hill	tingit	Chikát	[<UND>x</UND>+1] Daakeidi	shaman's grave	Jikáat	Gaanasteidi
20-mile fort	Chikát	Tla<UND>x</UND>aneis Noow	kingfisher fort	Jikáat	Gaanasteidi	
19.5-mile	tingit	Chikát	Nee<UND>x</UND>ánte X'aak	bluegreen claystone ra...	Lukaaá Jid	
Torku fan apex	tingit	Chikát	Tayayee	lying-in-wait rock	Jikáat	Gaanasteidi
no english	tingit	Chikát	Yéil Tséyi	raven rock	Jikáat	Gaanasteidi
Clear Creek	tingit	Chikát	Guchk'iheni	creek at hill base	Jikáat	Gaanasteidi
18-mile	fort	Chikát	T'a now	king salmon fort	Jikáat	Lukaaá Jid
Eagle Creek	tingit	Chikát	Ch'áak' Héeni	eagle mer	Jikáat	Gaanasteidi
no english	tingit	Chikát	<UND>g</UND>+aataá <UND>x</UND>+ayahéen	creek at entry to trap...	Jikáat	Gaanasteidi
Birch Island	tingit	Chikát	Ka<UND>g</UND>+x</UND>+X'ááti	loon islands	Jikáat	Gaanasteidi
Cabin Creek	tingit	Chikát	X'étaa Héeni	cuthroat creek	Jikáat	Gaanasteidi
Arman Creek	tingit	Chikát	Wáttáak'áat	willows at mouth	Jikáat	Gaanasteidi
13mile-	tingit	Chikát	<UND>x</UND>+ákw'áayí	spanning salmon lake	Jikáat	Kaagwaantaan
13mile	tingit	Chikát	Chéech<UND>x</UND>+áwí	porpoise little cliff	Jikáat	Kaagwaantaan

Above left: ArcGIS Pro window with TOC expanded at yellow box to show all point layers. I've checked the one called *placenames11*, my latest draft for Lingit place names. It's further expanded showing symbology, which distinguishes towns and forts from other geo-features. Fields labeled on separate lines are Lingit name, translation & IWGN (Important White Guy Name). **Table:** GIS is the intersection of maps and databases. Beside the labeled & symbology fields in this attribute table are biogeographic province, *k'wáan*, and *cían*. **Above right:** TOC expanded at yellow box to show all 'polyline' layers in this Arc project. Roads are parsed into trunk and spurs. 50-foot contours generated from IfSAR elevation model. BC layers grouped separately



TOC expanded at yellow box to show all 'polygon' layers, which are in turned grouped into physical, biological and cultural features. There are far more of these in the Greater Chilkat Watershed project than point or line layers. This includes many from BC—for the most part analogous to and easily 'appended' to their Alaskan counterparts—but not expanded here for lack of space.

Most of the layers stacked under *polygons*>*cultural* are developed and managed by the State Division of Forestry. Thanks to Joel Nudleman for directing me to DOF layers hosted on AOL (ArcGIS Online).

these into point, line and polygon layers (eg: placenames, roads and parcel boundaries, respectively).

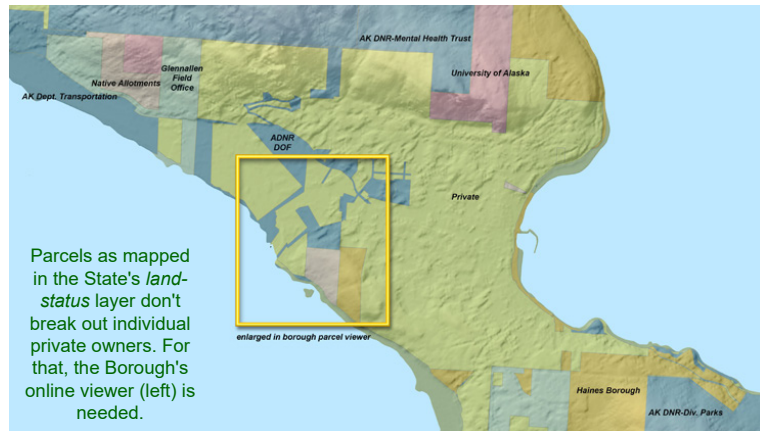
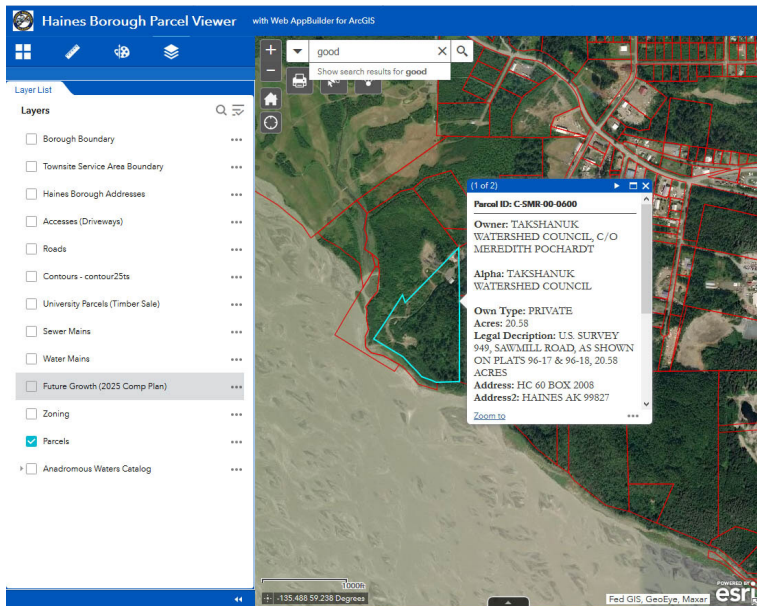
ArcGIS project windows typically have a table-of-contents bar (TOC) on the left. Position of each layer reflects 'stacking' sequence in the TOC. Best order for display purposes is points over lines over polygons, since the latter can hide (or dim, if translucent) the former.

In this example for geology units, our *category* field is chosen for symbology. Color families were explained in *Geology*>*Bedrock*. As illustrated above for the *placenames* point file, 3 separate fields are included, on separate lines, in my labelling. Top is the code, with capital letter representing time period. Second line is the era or period or epoch (each has a separate place in geological timelines). And third line lists the principal rock types found in this polygon unit.

It's not my purpose here to exhaustively review all of the vector shapefiles and geodatabases embedded in *chilkat.aprx*, but rather to give a sense of how they are used in preparation of maps throughout this atlas, and in spatial analysis for physical, biological and cultural features.

Mapping water: lines versus polygons? Best vector layer for streams, Tongass-wide, is the Forest Service's *chantype.shp*. Administered by Steve Paustian and colleagues, this polyline layer subdivides streams into geomorphological categories and subcategories. Unfortunately, this layer's coverage stops at the northern limit of National Forest, just below our project area.

Of course, for larger streams it would be nice to have not a polyline but a polygon file, mapping out the variable widths of braided glacial rivers. Granted, these change fairly rapidly over time, and Working with high-res LiDAR bare earth at very fine scales on Tàan, *sea lion* (Prince of Wales Island), I began to trace my own polygon 'stringers' that actually showed channel width. I have started (20200527) to do this on the GCW, for areas where



parcel owners. To view these, follow the above link to the Borough's viewer. Like most online parcel maps, we can't label all parcels with fields such as owner, but clicking in a polygon brings up the full record, as in this example for the TWC property at *Kaach kulnux'ák'w* (Jones Point)

Culverts I don't see a culverts layer yet.

Takshanuk GIS what do Derek & Stacie have?

LiDAR DTMs exist. A hydro-polygon layer exists for lakes and the Chilkat's largest rivers. Building upon this with a combination of LiDAR bare earth and World Imagery from AOL, I'm trying to create a fairly complete polygon layer for the GCW's most important waterways. This entailed tracing additional side channels along Haines Highway that are perennial problems for road maintenance.

Haines Borough Parcel Viewer online While DOF's layer for *landstatus*, embedded now in our *chilkat.aprx* ArcPro project, has pretty complete parcel boundaries for all land ownerships, in areas such as downtown Haines it does not break out individual

Mapping habitat An ever-more complicated (but also more rewarding!) task for eco-cartographers is delineating habitats or vegetation communities. The ideal 'veg-map' for Greater Chilkat Watershed has become a moving target, as new technologies described above are acquired, processed, explored, argued over, and finally 'stratified'—*ie*, massaged into a useful portrayal of ecologically meaningful vegetation-structure categories. As of 2019, an 'unsupervised' vegetation map for Hoonah Native Forest Partnership (HNFP) has been developed that combines LiDAR metrics with multiband image classification to parse **xx** forest and 15 nonforest veg-types. Biologists and

cartographers are also mapping Tàan, *sea lion* (Prince of Wales Island) from a similar combination of LiDAR and aerial photography. Those Tàan cartographers can't simply apply algorithms developed for the HNFP, because Hoonah, for example, lacks redcedar, yet does have coastal wetlands responding to glacial rebound that are absent on Tàan.

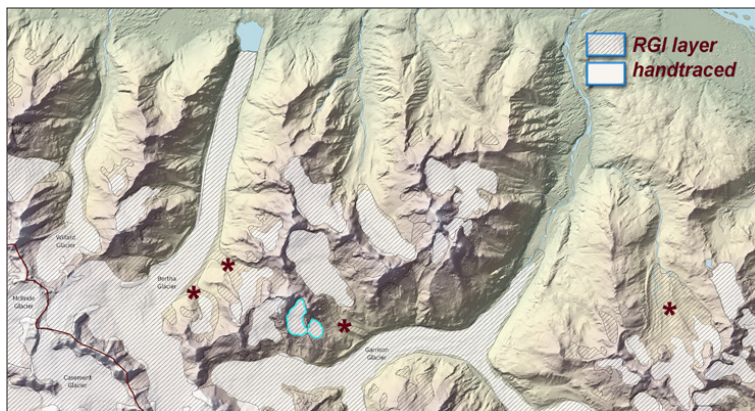
The same applies in spades to our more northerly borderlands project. Differences between Tàan and Hoonah are minor compared to vegetational diversity *within* the Greater Chilkat Watershed! Tall deciduous forest on Tongass islands, for example, is limited mostly to second-growth red alder. In the Chilkat, it could be alders, or a complex array of cottonwood forest or woodland, or birch-pine 'fire-forest.' In the case of game-changing technologies such as LiDAR, it probably would require 10 years between initial receipt of raw data layers, and consensus on an ecologically meaningful veg-map that sheds light on why, for example, a telemetered Chilkat black bear moves from unit A to unit B in mid-September.

Because these cartographic challenges are so integral to habitat descriptions, technical details are deferred to relevant chapters in *Habitats*.

Mapping glaciers *January, 2022*: I feel somewhat remiss in only recently stumbling across the spectacular Randolph Glacier Inventory (RGI) – A Dataset of Global Glacier Outlines: Version 6.0. The Alaskan subset of this worldwide GIS layer can be viewed or downloaded from the State's [Open Data Geoportal](#). As this dataset was being developed—beginning around 2014 for Alaska (RGI Consortium, 2017)—I had grown frustrated with then-existing glacier layers, and created my own for Lingít Aaní. ¹ Although it was a time-consuming process, I don't regret the glacier-mapping adventure, since my boundaries are in some cases more accurate than the excellent RGI layer. Having 2

¹ Prior to adopting the RGI in my cartography I created my own Southeast-wide glaciers layer from IfSAR. This layer and process is described in *Appendix 2 Cartography*, of *Heart & edge: biogeographic provinces of Southeast Alaska*.

Until the Alaskan RGI, and receipt of IfSAR enabling my hand-traced glaciers, our best GIS was in 2 forms, both pretty crude. One was *mv_glacier_1mil_py.shp*, downloadable from the ADNR clearinghouse, dating to around 1998. The other layer was called *se ak glaciers.shp*. Both heavily overestimated extent of glaciers even at time of creation—let alone subsequent wastage. They appear to have been auto-traced, perhaps from satellite imagery (presumably late summer?), and could not distinguish between glaciers and perennial snow. Tiny fragments were clearly too small to be glaciers, and some even sprinkled lowlands, far from viable glacial climate zones.



RGI versus hand-traced glaciers. Asterisks show areas where the RGI 'overmaps' current glacial extent. On the other hand, it correctly detected small cirque glaciers that I had overlooked, and have gradually been adding to the traced (white) layer.

glacier layers for GCW allows merging—adopting the best from both—will be really useful as we fine-tune the story of Chilkat glacial history.

The Randolph Glacier Inventory protocols and history are well documented (RGI Consortium, 2017). As for my hand-traced layer, this has derived from an assortment of GIS resources of variable resolutions and dates-of-acquisition.

Zooming in on glaciers with 5-meter-pixel IfSAR DSM and hillshade, [described above](#), you can usually find a satisfyingly 'bulged' margin on lateral and terminal edges. Along headwalls that edge is sometimes marked by distinctive bergshrunds, but often ambiguous, where high-elevation snowfields merge subtly onto glacial ice. Even here, anyone familiar with glaciers can trace a believable edge, such that total glacier surface is probably accurate to $\pm 5\%$. This was so much fun that I ended up spending several days drawing and naming glaciers. I started with a few areas of special interest such as Glacier Bay and the Juneau Icefield, then backed out and did a full sweep, starting

at Yakutat, mapping down to the Soule—Alaska's southernmost named glacier—then jumping out to the glaciers of Shee (Baranof Island). Accuracy of my tracing has varied primarily with proximity to human residence—with more care taken in areas where we work and play.

Alaska State Library offers a point-file for glacier names. No associated polygons, but I translated their .kml to .shp, dropped the names on my new polygon file, and typed in the (wince) CNs (commemorative names). As with mountains, only a tiny fraction of Alaskan glaciers have Lingit names.

Within and near the Greater Chilkat Watershed, I've made a special effort to precisely delineate even the smallest cirque glaciers. Comparing to the RGI layer has been valuable, as it detects small ones I overlooked, or assumed at first glance to be mere snow patches. Most errors in the RGI are from overly expansive outlines. Since they mostly derive from imagery dating to around 2010, much of this is due to shrinkage.

Following was written before stumbling onto the Randolph Glacier Inventory (RGI), described in [Appendices>2 Cartography>Vector layers](#). I'll keep it here for awhile as it may help in understanding different iterations of glacier polygons in *chilkat.aprx*

Mapping glaciers Existing GIS maps of Alaskan glaciers are based upon imagery that can't distinguish between highcountry snow patches and glacial ice. So they heavily over-estimate glacial cover. Several years ago, on receipt of a Southeast-wide mosaic for the 5-meter resolution [IfSAR](#), I began to trace a new glaciers layer for the entire region. Especially in highcountry cirques, IfSAR bare earth hillshade allows for reliable distinction between smooth glacier surfaces and typically more 'roughened' surfaces of adjacent bedrock with shallow snow cover. More recently, I've further fine-tuned GCW glacial limits with 2-m-pixel [ArcticDEM](#).

IfSAR and ArcticDEM topography is especially telling at headwalls of glaciers, where **bergschrunds** form. At the downslope end, active termini are equally obvious on terrain models when bulging or steep-faced. But they're more challenging where wasting glaciers gently feather out, merging with seasonal snow cover. For the GCW, I fine-tuned this glaciers layer from late summer imagery on ArcGIS Online, taken when most ephemeral snow had melted away.

Canadian GIS Across the border, our BC and Yukon neighbors have mapped glaciers, in a layer called *permanent_snow_and_ice*. Their assumption, wisely, is that one can't distinguish on orthoimagery between moving glaciers and stationary ice patches that are mostly smaller, or marginal snow and ice that fringes genuine glacial ice. Zooming in on it this BC-YK layer, polygons are clearly far more accurate and detailed than equivalent US glacier layers, with unit sizes as small as 1.5 acres. It's been my goal to bring the Alaskan-side mapping up to Canadian standards.

That said, on downslope edges, many or most of the BC-side polygons extend well beyond limits indicated by current orthoimagery. A date field in the *permanent_snow_and_ice* attribute table gives 1979 for all units within the Greater Chilkat boundary. Of course, 40 years can see a lot of shrinkage in this time of global warming. In the above example I've marked a mile-long lobe that no longer exists.

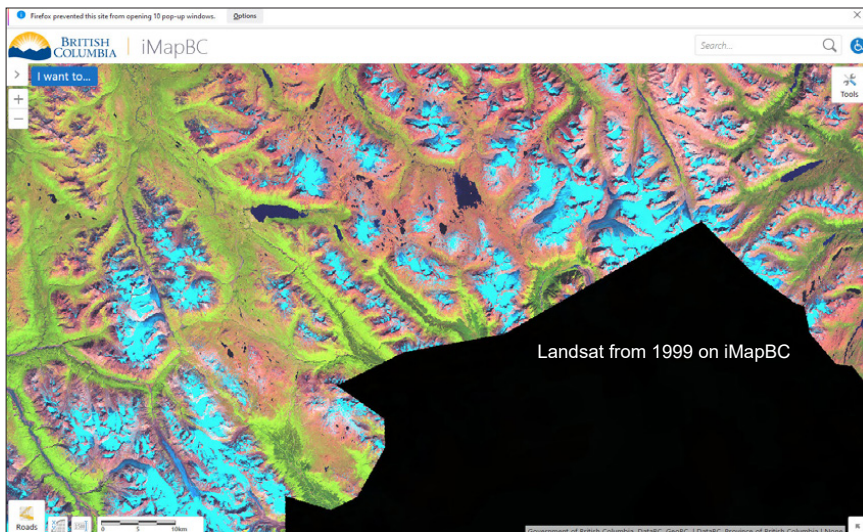
ADNR>DOF GIS online The Division of Forestry has a map portal for non-GIS folks. I described this back in [Culture>Euro history>Timber](#).

20200513: I'm in discussion with SAWC about doing GIS for them from Joel's state datasets. This could be a great way to pool resources for mutually desirable outcomes.

Canadian GIS online British Columbia has excellent data portals covering the northern 30% of the Greater Chilkat Watershed. In some cases accuracy of their point-, line-, and polygon vector covers exceeds that of analogous US layers, just across the AK-BC border. Structure of attribute tables differs, and I've not tried to merge or append, for seamless cross-border display. As of early 2022, I've only attempted to match symbology, allowing visual (but not quantitative) examination.

Bedrock geology is a good example of this border-straddling cartography. [BC Digital Geology](#) offers packaged download of bedrock and surficial (*BC_aternary*) polygon files, along with a polyline file for faults.

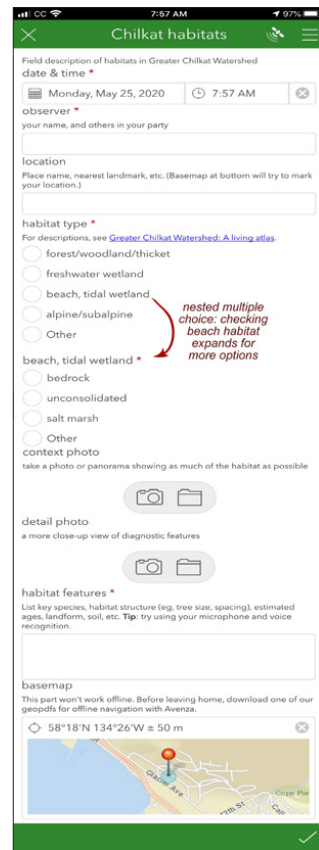
A one-stop clearinghouse for all-things cartographic is [iMapBC](#).



It's also a good viewer for folks who don't have GIS capability. Hundreds of vector and a few raster layers you can load and scale, then export as .jpg or .pdf.

I need Whitehorse GIS contacts. Much is available to anyone through BC/YK geospatial servers, but custom cartography in the borderlands will require personalized assistance.

Draft veg-classification app window for GCW habitats. As of mid 2021, I'm no longer considering ESRI's Survey 123 for data collection in this project.



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4 Lingít place names

From Thornton & Martin, eds (2012). I've entered these into a *placenames12* point file for ArcPro. On maps, selected elements from the attribute table are displayed in 3 lines with colonial name (CN) last:

Lingít
translation
CN

Here, they're listed in that order but in a single line. One other difference for names lacking an English equivalent is that—since location on a map is obvious—the CN entry is simply "*no english*." On the following Lingít-first list, CN entry references the nearest useful placename.

Place-name precision There are many inaccuracies in numbered dot placements in the printed cultural atlas. My points are far more accurate. In populating the touch table at Sealaska's Soboleff Center, staff have fine-tuned some of the point locations, and added audio-links and background information. My hope is that we can ultimately cross-walk that effort with my own, taking the best of each database in spirit of the never-finished *Living Atlas*.¹

Unfortunate defaults As noted in [Place names convention](#), where Lingít was not recorded, we may temporarily default to colonial name. Oddly, (*and inexplicably*; *elders and linguists have so far been unable to*

¹ All of us working on place-name restoration have different backgrounds and potential contributions to this effort. SHI staff linguists include fluent speakers who notice, for example, dialectal differences and clues to meanings and locations. They interview both living and deceased speakers (through massive audio archives), sometimes tracking down the stories and clan histories behind names.

My knowledge of Lingít is minimal

answer my queries as to why) some of our largest landscape features have no known Lingít name.

This includes Lynn Canal, named for Vancouver's birthplace, King's Lynn—prime example of ridiculous and culturally insensitive commemorative naming. I recommend that SHI, GHF, CCTHITA² USFS Region 10 Cartographer Jacob Hofman and UAS, perhaps under leadership of X'únei Lance Twitchell, collaboratively assemble a committee of fluent speakers and South-east biogeographers to appoint and nominate to the US Board on Geographic Names as set of more place-based, respectful names for about 50 of these region-defining landscape features—the large fiords and islands.

River-journey place names Ranging over Lingít Aani, if we were to quantify ratios of imposed-colonial to retained-indigenous placenames on federally sanctioned maps, at least one pattern would stand out. A lot more Native names—albeit typically misspelled & nearly unrecognizable to speakers—made it onto the maps of big, transboundary rivers.

It takes only a little reading of early exploration and settlement history to understand why. Ship commanders such as Vancouver and Meade imposed names on distant bays or mountains without ever setting foot on shore. Vancouver, in fact, named many features he never personally saw, merely from lines and dots on maps his Lieutenants brought back from rowing forays. That includes all of his names for GCW, to which he never got closer than Yées Keini (Port Althorp), near X'óot'k' (today's Elfin Cove).

Marine captains could level any coastal settlement

² Central Council of Tlingit & Haida Indian Tribes of Alaska

with canons, and had little knowledge of or respect for the archipelago's residents. They made no distinction between *kwaans* & clans, for example—a dangerous shortcoming for officers tasked with arbitrating inter-&-intra-village conflicts. By Meade's day, American commanders had been advised to 'set examples' of naval firepower, resulting in aggressions at Aangóon, *isthmus town* (Angoon), and Skanáx Aani, *noisy beach country* (Saginaw Bay, renamed for the destroying gunship).

In contrast, moving upriver from the coast, all early European explorers were guided by Tlingit companions to whom they trusted their lives. Around campfires, these more 'embedded' cartographers heard stories of shaman journeys, or titanic battles between opposing mountaintops. Far from coastlines claimed by distant kings and presidents, these mid-level officers were likelier to honor homegrown, multigenerational names for rivers (*eg* Klehini) or settlements (Klukwan). And those early Euro river-runners—usually mid-level if military, or even rogue independents like Dalton; certainly not ship commanders—were less beholden than marine leadership to sponsors and dignitaries back home, who needed buttering up with a commemorative cove or island.

This river-as-refuge phenomenon also explains the persisting autonomy of Tlákw.aan, *eternal village* (Klukwan), long after all other principal Tlingit villages, clans and *kwaans* had come under irresistible Euro-suppression.

PS 20220922: I'm updating underline characters for this list, so that cut&paste won't drop them. Help with detecting spelling errors and mis-translations is appreciated!

Alphabetically by the Lingit:

Áa ka, *on the lake* (Chilkat Lake)
 Áa Yuwaa Héeni, *lower belly of lake* (Chilkat Lake)
 Áalséix, *resting* (Alsek River)
 Aanyakax'áat'i, *island in front of village* (Anyaka Island)
 Áanák'w, *little village* (9.5mile)
 Áanák'w Noowu, *Áanák'w fort* (9.5mile)
 Aanwán, *edge of village* (Chilkat Lake fan)
 Aan Yanaade Héen, *running toward the village* (reversing outlet)
 Aasnooowuta.aan, *town at back of aasnooowu* (N Chilkoot)
 Áax'w Sáani Xoo, *among the little lakes* (Log Cabin)
 Agóon, *isthmus of it* (behind Haines)
 A Shakée, *top of it* (Chilkoot Pass)
 Ayaan Héeni, *tutchone river* (Herman Creek)
 Ayiklutu, *nostril of Ayik* (Seduction Point)
 Ch'áak' Héeni, *eagle river* (Eagle Creek)
 Ch'ak'alú, *beak of small eagle* (Iron Mtn)
 Cháatli Ist'ééj'í A Káa Wílaayaí Shaa, *mtn where halibut fisher melted* (in Takshanuks)
 Cháatli Shakaxaakw'ú, *cutoff halibut skull* (N of Taiya Pt)
 Cheech Gil'k'i, *porpoise little cliff* (13mile)
 Chookan Áa, *grassy lake* (lower Kelsall)
 Daak Uwa.iyi Yé, *where rocks slid out* (E Chilkoot Lake)
 Dak'héen, *inland river* (Takhin River)
 Dak'héen Shaa, *inland river range* (Takhinsha Range)
 Dakshaa, *inland* (Takshanuk Range)
 Dakshaanáx, *inland valley* (behind Klukwan)
 Daxanáak, *between 2 points* (Berners Bay)
 Dayéi, *to pack* (Dyea valley)
 Dayéi Héen, *to pack river* (Taiya River)
 Dayéi X'akax'áas, *waterfall at mouth of Dayéi* (Dayebas Creek)
 Dayéi X'aa Lutú, *inside nostril Dayéi* (Taiya Point)
 Dayeisáank'i, *Dayei little cove* (Taiyasanka Harbor)
 Dayeisáank'i Héen, *Taiyasanka creek* (Ferebee River)
 Deishú, *end of trail* (Haines)
 Dzixkú, _____ (Tsirku)
 Éech' Xágu, *igneous rock beach* (W Lutak)
 Éexnax.á Jigei, *southern crook of arm* (Glacier River)
 Eey X'é, *mouth of rapids* (Devil's Elbow, Tsirku)
 Gaatáa X'ayahéen, *Creek at entry to trapping grounds* (W Chilkat L.)
 Gagan Gooni, *sun spring* (N of Letnikof)
 Gathéeni, *sockeye stream* (Tsirku River)
 Gatx'ayeehéeni, *ready sockeye to eat river* (Wells)
 Gaay Kúdi, *eagle nest* (27-mile S-side)

Géelák'w, *little mountain pass* (into Dry Bay country)
 Geisán, *top of bay* (Mt Ripinski)
 Gil'k'i Seiyi, *at base of cliff* (9mile)
 Gil'yaká, *in front of cliff* (E Lutak)
 Gil' X'áak, *between cliffs* (upper Tsirku)
 Goonák'w, *little spring* (William Creek)
 Goonk', *little spring* (Reeves Creek)
 Goon Héeni, *springs creek* (Rustaback Creek)
 Guchk'héeni river *at hill base* (Clear Creek)
 Guwakaan Teiyi, *deer rock* (Chilkoot River mouth)
 Íxt'i Daakeidi, *shaman's coffin* (21-mile hill)
 Jánwu Deiyí, *mtn goat trail* (upper Chilkoot Lake)
 Jánwu GĠil'i, *mtn goat cliff* (above Yindastuki)
 Jilkáat, *cache* (Chilkat River)
 Jilkáat Wát, *mouth of Jilkáat* (McClellan Flats)
 Jilkoot *transl variable*³
 Kaach kulnux'ák'w *no transl* (Jones Point)
 Kaas'eiltseen Gil'i, *Chookaneidi man's name cliff* (E of Taiyasanka)
 Kadagoon, *island with springs* (Kataguni Island)
 Kaltsex'xi Héen, *kicking river* (Kicking Horse)
 Kagit X'áat'ií, *loon island* (Birch Island)
 Kaab'waaltú, *rockslide* (19-mile village)
 Kaxla Ku.aa, *puking into* (Nourse River)
 Kaxwéix Koogú, *cranberry pit* (28-mile)
 Kéet Aak'u, *killer whale lagoon* (head Lutak)
 Kéet Séedák'u, *killer whale little strait* (Tsirku-Takhin pass)
 Kei Daxáakji Héen, *river retreating upward* (21.5-mile creek)
 Ketlgaxyé, *where dog cries* (Battery Point)
 K'ideiyi Héeni, *path at base* (27 mile)
 Koosawu Áa, *narrow lake* (gorge, upper Chilkat)
 Kuxdeinú, *whirlpool/eddy* (Battery Pt Cove)
 Kwaan Haat Jiwdagoodi, *epidemic came to fight* (E Lutak)
 Laxách' _____ (Pyramid Island)
 Ldeiniyé, *no transl* (Pyramid Harbor)
 Ldus'kihéen, *dries after snowmelt* (upper Lutak)
 L'ehéeni, _____ river (Klehini)
 Léik'wk', *little red snapper* (Chilkoot Lake alt-name)
 Léix'w Noow, *ochre fort* (Paradise Cove)
 Ligooshi X'áa', *island with thumb* (Shikosi Island)

³ I've placed Jilkoot here more for cut&paste convenience than as a place name. At the new Klukwan heritage center, a culture-bearer told us (somewhat conspiratorially?) that the real translation isn't "storehouse" but "puking", perhaps referring to outbursts from the lake.

Lkoot, *storehouse* (Chilkoot Lake outlet village, but see fn#3)
 Lkoot Ka Áa, *on top of Lkoot* (Chilkoot Lake alt-name)
 Lkoot T'áak, *back side of Lkoot* (Lutak Inlet)
 Lkoodaséits'k, *glacier's name* (Rainbow Glacier)
 Náanax.á Jigei, *northern crook of arm* (N of Glacier Pt)
 Nánde Héeni Yei Kéich Yé, *sits in water facing north* (3 Guardsmen)
 Neixinté X'aak, *bluegreen claystone ravine* (19.5-mile)
 Núkdik', *little grouse* (Núkdik Pt)
 Núkdik' Shakée, *little grouse hill* (hill above Núkdik Pt)
 Saak Shu Aani, *eulachon camp* (Shakuseyi Creek)
 Saak Aani, *eulachon camp* (9mile)
 Salwán, *no transl* (Sullivan Island)
 Salwán T'áak, *back of Salwan* (delta inside Sullivan)
 Séet X'ayik, *entrance to the strait* (Moose Valley)
 Shakuwúx'k'u, *little wide-head* (Chilkoot Lake)
 Shakkwák'i, *little chamberpot at head* (Chilkat Lakehead)
 Shgagwei, *rudded water* (Skagway)
 Sit'i Shaanáx, *glacier valley* (Little Boulder Creek)
 Sit'i X'aa'yí, *glacier point* (Glacier Point)
 Sí.áat'i Goon, *cold spring* (Moose Meadows Creek)
 T'ahéeni, *king salmon river* (Tahini River)
 T'á noow, *king salmon fort* (18-mile)
 Tan.aani, *king jumping grounds* (Tanani Point)
 Tan.aani Geiyi, *Tanani Bay* (Tanani Bay)
 T'áax'aa Geiyák'u, *mosquito's little bay* (Lutak head)
 Téedáil, *soft white rock* (W Lutak)
 Tayayee, *lying-in-wait rock* (Tsirku fan apex)
 Téeyi Héenak'u, *soaked dryfish creek* (Mink Creek)
 Tlákw.aan, *eternal village* (Klukwan)
 Tlaxaneis Noow, *kingfisher fort* (20-mile)
 Tléikw Xágu, *berry sand beach* (N of Tanani Pt)
 Tsaa Teiyi, *seal rock* (E Lutak)
 Ts'eigeenk'i Yé, *magpie place* (E Lutak)
 Tsikhéeni, *roasting spit river* (Bear Flats Creek)
 Tsísk'u Gil'i, *owl cliff* (Chilkoot entry)
 T'u'yik, *in the cradleboard* (Iron Mtn shoulder)
 Watkalch'áal, *willows at mouth* (Anman Creek)
 Wooshdakánté, *quarreling rocks* (N of Tanani)
 Wulix'áasi Héen, *waterfall creek* (Katzhehin River)
 X'aask'i.áa, *lake at base of waterfall* (upper Chilkat R)
 X'áakw X'aa'yí, *spawned-out sockeye point* (West Lake Creek fan)
 X'ákw.áayi, *spawning salmon lake* (13mile+)
 X'ákw'héeni, *spawning salmon creek* (Eagle Creek)
 X'ákashaanáx, *valley at the mouth* (mtn cirque)

X'akwheenak'u, *little spawning river* (above Wells)
 Xalāk'ach' Héeni, *porcupine river* (Porcupine River)
 Xasdaheen, *waterfall creek* (Haska Creek)
 Xixch' Kanduwataayi Yé, *where frog packs drift ashore* (S of Katzehin)
 X'éitaa Héeni, *cutthroat creek* (Cabin Creek)
 Xixch'i Shaayi T'eik, *behind frog mountain* (S Frog Mtn)
 Xóots Héeni, *brown bear river* (Assignment Creek)
 Xuni'i Áa, *__lake* (Mosquito Lake)
 Yakwyaax, *alongside boat* (Big Boulder Creek)
 Yandeist'akyé, *faraway stuff drifts ashore* (Yindastuki near airport)
 Yaana.eit Xágu, *heracleum sandbar* (delta inside Sullivan Is)
 Ya_Kei Diakwt Aan, *where sheep* paw up the side* (Goat Mtn)
 *probably mistranslated: tawéi = *dall sheep*
 Yéil Daa.áaxu, *raven's dryfish bundle* (lower Chilkoot River)
 Yéil Háatl'i, *raven shit* (Penn-W)
 Yéil Héeni, *raven's river* (Kelsall)
 Yéil Teiyí, *raven rock* (Clear Creek outlet)
 Yéil Áx' Sh Wułgeigi Yé, *where raven swung* (Mt Sinclair canyon)
 Yoo Lihashgi X'aa, *point floating up&down* (Taiyasanka moraine)
 Yoo Lititgi X'aa, *undulating point* (Dalasuga Island)

Alphabetically by the English:

As noted earlier, many Lingít names have no direct colonial name equivalent. These are listed here by closest geographic feature. Where useful, that English name may be followed by an azimuth, helping to 'home-in' on the Lingít-placename location. For example:

Haines—W Agóon, isthmus of it

Agóon refers to the isthmus or crossover from harbor to Sawmill wetland. Since it's not the actual Lingít name for Haines (that would be Deishú) but rather somewhat to the west, the entry in this list says "*Haines—W.*"

Alsek River Aalséix, *resting*
 Anyaka Island Aanyakax'áatl'i, *island in front of village*
 Assignment Creek Xóots Héeni, *brown bear river*
 Battery Point Ketlgaxyé, *where dog cries*
 Battery Pt Cove Kuxdeinú, *whirlpool/eddy*

Battery Point S Yéil Háatl'i, *raven shit*
 Berners Bay Daxanáak, *between 2 points*
 Boulder Creek, Big Yakwyaax, *alongside boat*
 Boulder Creek, Little Si'ti Shaanáx, *glacier valley*
 Chilkat Lake Áa ka, *on the lake*
 Chilkat Lake Áa Yuwaa Héeni, *lower belly of lake*
 Chilkat Lake—fan Aanwán, *edge of village*
 Chilkat Lake—outlet Aan Yanaade Héen, *running toward the village* (reversing outlet)
 Chilkat Lake—Anman Creek Watkalch'áal, *willows at mouth*
 Chilkat Lake—Birch Island Kagit X'áatl'i, *loon island*
 Chilkat Lake—Cabin Creek X'éitaa Héeni, *cutthroat creek*
 Chilkat Lake—Clear Creek Guchk'héeni *river at hill base*
 Chilkat Lake—Clear Creek mouth Yéil Teiyí, *raven rock*
 Chilkat Lake—Eagle Creek X'ákwhéeni, *spawning salmon creek*
 Chilkat Lake—head Shakkwásk'i, *little chamberpot at head*
 Chilkat River Jilkáat, *cache*
 Chilkat River—McClellan Flats Jilkáat Wát, *mouth of Jilkáat*
 Chilkat River—9mile G'il'k'i Seiyi, *at base of cliff*
 Chilkat River—9mile Saak Aaní, *eulachon camp*
 Chilkat River—9.5mile Aanák'w, *little village*
 Chilkat River—9.5mile Aanák'w Noowu, *Aanákw' fort*
 Chilkat River—13mile Cheech G'il'k'i, *porpoise little cliff*
 Chilkat River—13mile+ X'ákw.áayi, *spawning salmon lake*
 Chilkat River—18mile T'á noow, *king salmon fort*
 Chilkat River—19mile village K'aat'waaltú, *rockslide*
 Chilkat River—19.5mile Neixinté X'aak, *bluegreen claystone ravine*
 Chilkat River—20mile Tlaxaneis Noow, *kingfisher fort*
 Chilkat River—21mile-hill l'xt'i Daakeidi, *shaman's coffin*
 Chilkat River—21.5mile Kei Daxakji Héen, *river retreating upward*
 Chilkat River—27mile K'ideiyi Héeni, *path at base*
 Chilkat River—27mile S-side Gaay Kúdi, *eagle nest*
 Chilkat River—28-mile Kaxwéix Kooqú, *cranberry pit*
 Chilkat River—upper gorge Kooosawu Áa, *narrow lake*
 Chilkat River—upper X'aask'i.áa, *lake at base of waterfall*
 Chilkat River—Bear Flats Cr Tsikhéeni, *roasting spit river*
 Chilkat River—Goat Hollow Ya_Kei Diakwt Aan, *where sheep paw up the side*
 Chilkoot Lake—outlet village L_koot, *storehouse/puking*
 Chilkoot Lake (alt-name) L_koot Ka Áa, *on top of L_koot*
 Chilkoot Lake (alt-name) Léi'kw', *little red snapper*
 Chilkoot Lake (alt-name) Shakuwú'x'k'u, *little wide-head*
 Chilkoot Lake—N Aasnoowuta.aan, *town at back of aasnoowu*
 Chilkoot Lake—NE Jánwu Deiyi, *mtn goat trail*

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Chilkoot Lake—E Daak Uwa.yi Yé, *where rocks slid out*
 Chilkoot Lake—W Gaatáa X'ayahéen, *creek at entry to trapping grounds*
 Chilkoot Lake—West Lake Creek X'áakw X'aayi, *spawned-out sockeye point*
 Chilkoot Lake—William Creek Goonák'w, *little spring*
 Chilkoot Lake—Reeves Creek Goonk', *little spring*
 Chilkoot Pass A Shakée, *top of it*
 Chilkoot River—mouth Guwakaan Teiyí, *deer rock*
 Chilkoot River—mouth Tsisk'u G'il'i, *owl cliff*
 Chilkoot River—lower Yéil Daa.áaxu, *raven's dryfish bundle*
 Dalasuga Island Yoo Lititgi X'aa, *undulating point*
 Dayebas Creek Dayéi X'akax'áas, *waterfall at mouth of Dayéi*
 Dyea Dayéi, *to pack*
 Eagle Creek Ch'áak' Héeni, *eagle river*
 Ferebee River Dayeisáank'i Héen, *Taiyasanka creek*
 Frog Mountain Xixch'i Shaayi T'eik, *behind frog mountain*
 Glacier Point Si'ti X'aayi, *glacier point*
 Glacier Point—N Náanax'á Jigei, *northern crook of arm*
 Glacier River (Davidson) Éexnax'á Jigei, *southern crook of arm*
 Haines Deishú, *end of trail*
 Haines—W Agóon, *isthmus of it*
 Haines—Nukdik Pt Núkdik', *little grouse*
 Haines—above Nukdik Pt Núkdik' Shakée, *little grouse hill*
 Haska Creek Xasdaheen, *waterfall creek*
 Herman Creek Ayaan Héeni, *Tutchone river*
 Iron Mtn Ch'ak'ilú, *beak of small eagle*
 Iron Mtn—shoulder T'ukyik, *in the cradleboard*
 Jones Point Kaach kulnux'á'k'w, *no trans/*
 Kataguni Island Kadagoon, *island with springs*
 Katzehin River Wulix'áasi Héen, *waterfall creek*
 Katzehin River S Xixch' Kanduwataayi Yé, *where frog packs drift ashore*
 Kelsall River Yéil Héeni, *raven's river*
 Kelsall—lower Chookan Áa, *grassy lake*
 Kicking Horse River Kaltse'x'i Héen, *kicking river*
 Klehini River L'ehéeni, *no trans. river*
 Klukwan Tlák'w.aan, *eternal village*
 Klukwan—NE Dakshaanáx, *inland valley*
 Letnikof Cove—N Gagaan Gooni, *sun spring*
 Log Cabin Áax'w Sáani Xoo, *among the little lakes*
 Lutak Inlet L_koot T'áak, *back side of L_koot*
 Lutak Inlet—E G'il'yaká, *in front of cliff*
 Lutak Inlet—E K_waan Haat Jiwdagoodí, *epidemic came to fight*

Lutak Inlet—E Tsaa Teiji, *seal rock*
 Lutak Inlet—E Ts'eigeenk'i Yé, *maggie place*
 Lutak Inlet—W Éech' Xágu, *igneous rock beach*
 Lutak Inlet—W Taxéil, *soft white rock*
 Lutak Inlet—head Kéet Áak'u, *killer whale lagoon*
 Lutak Inlet—head Ldus'k'ihéen, *dries after snowmelt*
 Lutak Inlet—head T'áax'aa Gëiyák'u, *mosquito's little bay*
 Lutak Inlet—Shakuseyi Cr Saak Shu Aani, *eulachon camp*
 Moose Meadows Creek (E Penn) Sí.áat'i Goon, *cold spring*
 Moose Valley (Mosq Lk) Séet X'ayik, *entrance to the strait*
 Mosquito Lake Xuni'i Áa, *lake*
 Nourse River Kaḵla Ku.aa, *puking into*
 Paradise Cove Léix'w Noow, *ochre fort*
 Porcupine River Xalák'ach' Héeni, *porcupine river*
 Pyramid Harbor Ldeiniyé, *no transl*
 Pyramid Island Laxách', *no transl*
 Rainbow Glacier Lkoodaséits'k, *giant's name*
 Ripinski, Mt Geisán, *top of bay*
 Rustaback Creek Goon Héeni, *springs creek*
 Seduction Point Ayiklutu, *nostril of Ayik*
 Shikosi Island Ligooshi X'áa', *island with thumb*
 Sinclair mountain canyon Yéil Áx' Sh Wulgeigi Yé, *where raven swung*
 Skagway Shgagwei, *rugged water*
 Sullivan Island Salwán, *no transl*
 Sullivan Island—W Salwán T'áak, *back of Salwan*
 Sullivan Island—W Yaana.eit Xágu, *heracleum sandbar*
 Tahini River T'ahéeni, *king salmon river*
 Taiya Point Dayéi X'aa Lutú, *inside nostril Dayéi*
 Taiya Pt—N Cháatl Shakaxaakw'ú, *cutoff halibut skull*
 Taiya River Dayéi Héen, *to pack river*
 Taiyasanka Harbor Dayeisáank'i, *Dayei little cove*
 Taiyasanka—E Kaas'eiltseen Gíl'i, *Chookaneidi man's name cliff*
 Taiyasanka—moraine Yoo Lihashgi X'aa, *point floating up&down*
 Takhin River Dak'héen, *inland river*
 Takhinsha Range Dak'héen Shaa, *inland river range*
 Takshanuk Range Dak'shaa, *inland*
 Takshanuk Range—N X'akashaanáx, *valley at the mouth (cirque)*
 Takshanuk Range—SE Cháatl Ist'eixi A Káa Wlilaayi Shaa, *mtn where halibut fisher melted*
 Tanani Bay Tan.aani Gëiyi, *fish jumping grounds bay*
 Tanani Bay—Mink Creek Téeyi Héenak'u, *soaked dryfish creek*
 Tanani Point Tan.aani, *fish jumping grounds*
 Tanani Point N Tléikw Xágu, *berry sand beach*
 Tanani Point N Wooshdaḵanté, *quarreling rocks*

Three Guardsmen Nánde Héeni Yei Kéich Yé, *sits in water facing north*
 Three Guardsmen—NW G'éelák'w, *little mountain pass (into Dry Bay country)*
 Tsirku River lower Gaḥéeni, *sockeye stream*
 Tsirku River upper Dziḡkú, *no transl*
 Tsirku River—fan apex Tayayee, *lying-in-wait rock*
 Tsirku River—upper Gíl' X'áak, *between cliffs*
 Tsirku River—pass to Takhin Kéet Séedak'u, *killer whale little strait*
 Tsirku River—Eey X'é, *mouth of rapids (Devil's Elbow)*
 Wells Gat'ayeehéeni, *ready sockeye to eat river*
 Wells N X'akwhéenak'u, *little spawning river*
 Yindastuki Yandeist'akyé, *faraway stuff drifts ashore*
 Yindastuki NE Jánwu Gíl'i, *mtn goat cliff*