WILD
HERITAGE

Alaska Roadless Rule, USDA Forest Service
Comments Submitted for the Public Record
Submitted via: [www.regulations.gov/document/FS-2021-0007-0006](www.regulations.gov/document/FS-2021-0007-0006);
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On behalf of Wild Heritage ([www.wild-heritage.org](www.wild-heritage.org)), we submit these comments in support of the USDA Forest Service repeal of the Trump administration's 2020 Alaska Roadless Rule. We also fully support the Biden administration's July 15, 2021 announcement to end large-scale old-growth logging on the Tongass while sending much needed sustainable development support ($25 million) to the region. Old forests and IRAs are natural climate solutions and thus protecting them is responsive to President Biden's pledge at the COP26 (https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use/) to end global deforestation and forest degradation needed to slow both the global climate (Ripple et al. 2020, IPCC 2021) and biodiversity crises (IPBES 2019). Notably, according to a Taxpayers for Common Sense (2020), four decades of unsustainable logging cost taxpayers $1.7 billion in below-cost Tongass timber sales; 40% of this was related to roads alone. Tongass logging is not only damaging ecologically and fiscally irresponsible but it generates fewer jobs than the much more productive tourism and hunting/fishing sectors that depend on intact ecosystems for their livelihoods. Additionally, Alaska Natives derive traditional cultural values that thrive within roadless and old-growth ecosystems.

As scientific justification for stepped up protections, we suggest that you reference these globally unique features of the Tongass that include:

- **One of the world's** last relatively intact temperate rainforests (DellaSala et al. 2011a);
- Approximately 12% of the entire Pacific Northwest Coastal Forests (https://www.worldwildlife.org/ecoregions/na0520), which spans several globally distinctive ecoregions and climatic subzones from Coast Redwoods to northern Kodiak Island, and which collectively make up 34% of all the world's temperate rainforests, the largest such collective expanse (DellaSala et al. 2011a);
- Some 85%, totaling 5.3 million acres, of productive forest is old growth among the largest such concentrations for temperate rainforests in the world (DellaSala et al. 2011a, Orians and Schoen 2013);
- About 16% of the nation's total IRAs which, along with the Chugach National Forest, represents the most relatively intact national forests in our nation;

- Abundant salmon (all 6 *Oncorhynchus* species) and wildlife populations, some of which are imperiled in the lower 48 states, and which achieve highest abundance in intact watersheds such as the Tongass 77 priority areas (Smith 2016);
- High levels of endemic subspecies*(Dawson et al. 2007) along with extraordinary lichen richness – lichens are diagnostic of all the world's temperate rainforests and are sensitive to old-growth logging (DellaSala et al. 2011a);
- Approximately one-quarter of all C stores on the entire National Forest System (NFS), which is remarkable considering the Tongass represents just 8% of the total NFS land area;
- Nearly half (48%) of the Tongass carbon (woody biomass, soils) is within productive old growth, evenly split between roaded and IRAs, thus, at least some roaded old growth carbon stores remain vulnerable to logging pressure;
- IRAs (all vegetation types) contain 51% of the total forested carbon; 25% of that carbon is held within productive old-growth forests inside IRAs;
- Nearly 15% of all carbon on the Tongass is stored within T77 watersheds with >80% of that C overlapping with IRAs and half that overlapping with productive old growth – thus T77s add to carbon stores but overlap with other categories;
- Only ~5% of Tongass carbon is within young growth with most (96%) of young growth carbon in roaded-logged areas (some young growth overlaps with IRAs);
- The maritime climate and intact forests provide climate refugia compared to more extreme climatic changes in the interior of Alaska and temperate rainforests further south (DellaSala et al. 2015, Buma et al. 2019, Vynne et al. 2021); and
- Culturally important fish and wildlife that are the food supply of Native Alaskans.

*Island biogeography has played a key role in the evolution of unique subspecies and adaptive radiations (speciation events) on the Tongass. Species richness and turnover rates on islands are related to island size and distance from the mainland. In general, small islands and islands more distant from the Alaska mainland experience high turnover rates –local extinction exceeds colonization due to isolating factors on small islands. Conversely, large islands and those closer to the mainland exhibit more of the mainland population dynamics and species richness as they receive in-migration from nearby mainland source populations. Typically, island systems can handle species turnover rates if they are not exacerbated by anthropogenic disturbances that unnaturally fragment habitat and isolate already localized populations. The situation on Prince of Wales Island is just that and is most critical. While the island is the largest in the archipelago it has also received the vast majority of road building and logging that has disrupted island population dynamics particularly for endemic subspecies like the Alexander Archipelago wolf (*Canis lupus ligoni*). Thus, IRAs play a strategic role in providing refugia for wolves potentially facing population bottlenecks due to over hunting and declining habitat from logging. The importance of IRAs and protected old growth refugia should be summarily discussed in the context of population viability, which has a long-standing interest from the scientific community (for example see Tongass old

growth population viability strategy -
https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5422739.pdf[1]).

Our specific comments and pdfs when available (open access) are enclosed for the public record. In cases where pdfs are not open access, we provided links to the citations.

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## I. Global Significance of the Tongass Rainforest

One of the first avian-forest research projects (which was funded by the Forest Service) on the Tongass was conducted by myself and colleagues on Prince of Wales Island in the 1990s (DellaSala et al. 1996). At the time, we documented much higher abundance of breeding birds in old growth vs. young growth (untreated 15-20-year old clearcuts), thinned, and canopy gapped young-growth stands (in replicate). Wintering birds also benefited from old growth as the multi-story canopy provided superior snow intercept properties that presumably offered thermal refugia during snowy winters (also beneficial to deer as thermal/winter/hiding cover). That study was followed with a repeated-measures design at the same locations over a decade later (Matsouka et al. 2012) where we again documented the superior habitat benefits of old-growth forests for breeding birds compared to young growth (treated and untreated). In both cases, we recommended full protection of old growth and modifications to the thinning and canopy gap treatments in young growth to restore some of the habitat values degraded by logging. This included removal of logging slash to allow deer access to treated sites (gapped and thinned), and repeat thinning (variable spacings) to extend understory benefits in young forests that otherwise are in the stem exclusion phase with little if any understories and impenetrable conditions due to tight tree spacing. Such restorative treatments, along with culvert enhancements in anticipation of more frequent and intense storms, and road decommissioning should be incorporated into young growth management while the old-growth logging program is terminated.

*Relative intactness is globally outstanding* - the Tongass is **one of the world's last relatively intact temperate rainforests** along with the Great Bear in BC, Valdivia in Chile/Argentina,

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[1] Also see these two studies cited in the USDA document - Suring, L.H., D.C. Crocker-Bedford, R.W. Flynn, C.S. Hale, G.C. Iverson, M.D. Kirchhoff, T.E. Schenck, L.C. Shea, and K. Titus. 1993. A proposed strategy for maintaining well-distributed, viable populations of wildlife associated with old-growth forests in southeast Alaska. Report of an Interagency Committee. Review Draft, May 1993. Juneau, AK. 278 pp. Suring, L.H., D.C. Crocker-Bedford; R.W. Flynn, C.S. Hale, G.C. Iverson, M.D. Kirchhoff, T.E. Schenck, L.C. Shea, and K. Titus. 1994. Response to the Peer Review of: A Proposed Strategy for Maintaining Well-distributed, Viable Populations of Wildlife Associated with Old-growth Forests in Southeast Alaska. Report of an Interagency Committee. May 1994. 11 pp.

and two inland temperate/boreal rainforests in Russia (DellaSala et al. 2011b). Please correct the USDA Alaska roadless notice as it claims that the Tongass is **the largest intact** temperate rainforest in the world. However, technically it is not "the largest" but rather is **one of the largest** as the aforementioned areas have more relatively intact temperate rainforest than even the Tongass (see DellaSala. et al. 2011b for region by region estimates). Nevertheless, the Tongass is globally significant on that measure alone.

*Among the most carbon dense forests in the world* - the Tongass is a global carbon champion along with other primary (unlogged) forests in the Pacific Northwest (Krankina et al. 2014) and *Eucalyptus regnans* in Tasmania (Keith et al. 2009) that have even higher C densities. It is important to note that the high C density on the Tongass is because of primary (old growth) forests and muskegs (Buma and Thompson 2019) as outlined below in our C analysis.

*Primary forests have relatively stable carbon stocks* - primary forests globally store 30 to 70% more carbon per acre than logged forests (Mackey et al. 2014, Zoltan et al. 2020, DellaSala et al. 2020), which is one of the many reasons why primary forests are irreplaceable. Additionally, intact ecosystems like Tongass old growth and IRAs represent more-stable carbon stores compared with logged areas (Moomaw et al. 2019, Cook-Patton et al. 2021). This should be properly acknowledged.

*Climate refugia* - DellaSala et al. (2015) and more recently Vynne et al. (2021) documented general features that may allow the Tongass to function as climate refugia compared to temperate rainforests further south (Pacific Northwest, also see Buma et al. 2019) and the interior of Alaska where climate change velocities are among the fastest on the planet (https://nca2014.globalchange.gov/report/regions/alaska, Carroll et al. 2015). Refugia properties of the Tongass are due mainly to the moderating effects of the maritime current, relative intactness of old-growth forests and IRAs, and minimal large-scale natural disturbances like fires and insect-tree diebacks (DellaSala et al. 2015). Although, notably, there are already significant climatic changes underway across the region, not the least of which is the alarming decline of Alaska yellow cedar (*Cupressus nootkatensis*), due mainly to reduction of late winter snow cover that prevented root exposure to late winter freeze (Hennon et al. 2012). Logging would only intensify yellow cedar, a culturally important species, decline by compounding disturbances over large areas and under compressed timelines that may exceed the adaptive resilience of this conifer. For species like yellow cedar to adapted to climate change, they will need refugia, places where anthropogenic disturbances like logging and road building are prohibited in order to serve as source populations for recolonization into new climate niches. Most importantly, this includes both live and dead cedar as the dead trees are important snags for wildfire and contain carbon stored in dead pools that will remain on site for decades, slowly decomposing while new vegetation sequesters C. Moreover, before those trees died many would have laid a seed bed down that might include new genetic adaptations better suited to the changing climate. Logging would impact that natural reseeding, roadless areas would not.

*Old trees are critical to US climate commitments and should be protected in a national strategic carbon reserve or similar designations* - old-growth forests and old trees are in short supply globally due to widespread logging (Lindenmayer et al. 2012, 2013, Lutz et al. 2018), as well as primary forests that generally have declined substantially (i.e., now include only one-third of the world's forests, Mackey et al. 2014). This is why ending the old growth logging on the Tongass along with full IRA protections is of major importance to President Biden's COP26 forest announcement and with the development of the US Nationally Determined Contributions (NDC) to the Paris Climate Agreement (United Nations 2015). Article 5 of the Paris Climate Agreement, which should be acknowledged in the rule change, states:

***"Sinks and reservoirs*** (Art.5) –The Paris Agreement also encourages Parties to conserve and enhance, as appropriate, sinks and reservoirs of GHGs as referred to in Article 4, paragraph 1(d) of the Convention, including forests" (https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement/key-aspects-of-the-paris-agreement). This should be referenced as appropriate context for rejecting the Trump roadless decision.

Ending forest degradation needs to not only include Tongass old-growth and IRA protections but protection for **all mature forests and large trees on federal lands nationwide** (separate rule making needed but stated here for proper context). Doing so, would demonstrate US global leadership in setting meaningful NDC targets and responsible global commitments to forest protections with the intent of creating a national strategic carbon reserve (e.g., see DellaSala et al. https://www.seattletimes.com/opinion/a-strategic-natural-carbon-reserve-to-fight-climate-change/ and Law https://theconversation.com/keeping-trees-in-the-ground-where-they-are-already-growing-is-an-effective-low-tech-way-to-slow-climate-change-154618) or similar designations. The Tongass can lead by example with the nations' first strategic carbon reserve system.

In sum, protecting all old-growth forests (IRAs and roaded) on the Tongass is vital to ecosystem integrity (NFMA 2012 planning rule) and C stores (herein), and would make an invaluable contribution to natural climate solutions at a time when the scientific community has issued multiple warnings of imminent ecosystem collapses (IPBES 2019) and climate disasters are accelerating (IPCC 2020, Ripple et al. 2020) triggered by the unprecedented increases in greenhouse gas emissions across all sectors, especially agriculture and forestry.

## Tongass IRAs are Nationally Significant

*Roads open forests to a "death by a thousand cuts"* - roads are the antithesis of roadless areas, as they compound anthropogenic disturbances that accumulate spatially and over time along a road effect zone (~1 km on either side of the road). We suggest that you include this summary of road related impacts in support of IRA protections.

Ibisch et al. 2017 (see online Supplemental provided) provided perhaps the most comprehensive science-based synthesis of road impacts citing 58 studies across a range of taxa that documented:

(1) reduction of animal abundance, density, and population size;
(2) modification of animal behavior (e.g., physiological stress);
(3) reduction of species richness and diversity;
(4) facilitation of invasive species colonization;
(5) associated deforestation and forest degradation;
(6) alteration of hydrological processes and wildfires;
(7) changes of landscape patterns and fragmentation;
(8) facilitation of resource extraction;
(9) noise and various other impacts;
(10) widespread declines in salmonids

*Note - also see Forman and Alexander (1998), Trombulak and Frissell (2000), Heilman et al. (2002), and Forman et al. (2003) for additional studies of road impacts.

The main conclusions of Ibisch et al. (2017) is apparent from their abstract in *Science* magazine (please factor this into the purpose and need for IRA protections):

> "Roads fragment landscapes and trigger human colonization and degradation of ecosystems, to the detriment of biodiversity and ecosystem functions. The planet's remaining large and ecologically important tracts of roadless areas sustain key refugia for biodiversity and provide globally relevant ecosystem services. Applying a 1-kilometer buffer to all roads, we present a global map of roadless areas and an assessment of their status, quality, and extent of coverage by protected areas. About 80% of Earth's terrestrial surface remains roadless, but this area is fragmented into ~600,000 patches, more than half of which are <1 square kilometer and only 7% of which are larger than 100 square kilometers. Global protection of ecologically valuable roadless areas is inadequate. International recognition and protection of roadless areas is urgently needed to halt their continued loss."

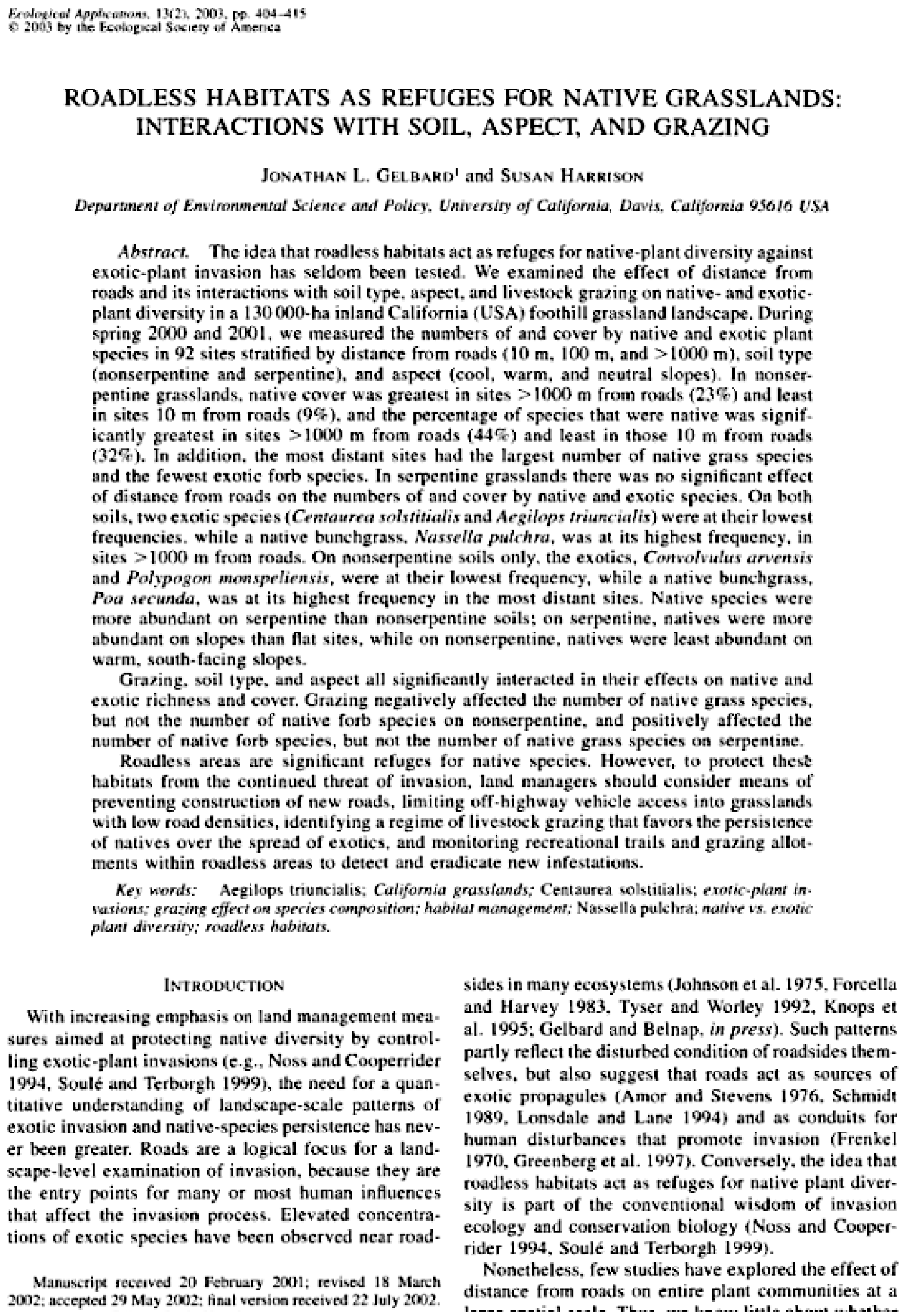
The length of roads globally is projected to increase by >60% (14.4 million miles – or enough to circle the Earth 600 times) from 2010 to 2050 (Laurance et al. 2015) and thus there is an urgent need to protect remaining roadless areas before they are gone (Ibisch et al. 2017). The Tongass underscores global roadless area importance and the damages caused by an expansive roads network outside IRAs. **For instance, there are some 5,000 road miles on the Tongass (https://www.fs.usda.gov/detail/tongass/home/?cid=FSEPRD760082), which is nearly enough to span the roundtrip distance from Juneau to New York City. Many of these roads should be permanently decommissioned and natural hydrology restored along with upgrading culverts in anticipation of greater storm intensities perhaps using funds from the recently approved Infrastructure bill.**

*Roadless areas are essential to biodiversity, climate refugia, and sustainable development* - roadless areas serve as vital refugia for countless species and ecological processes (see Ibisch et al. 2017 for global assessment). Some of the widely recognized values include:

(1) higher numbers, abundance, and diversity of wildlife;

(2) strongholds for aquatic species, particularly salmonids;
(3) presence of intact hydrological and natural disturbance processes;
(4) refugia for wide-ranging species such as large carnivores;
(5) resilience to climate change due to intact patch sizes, connectivity, and ecosystem functionality;
(6) lower levels of invasive species; and
(7) clean water repositories due to their association with drinking water source areas and headwater streams.

Several other published studies summarize roadless values that should be cited: Strittholt and DellaSala 2001, Loucks et al., 2003, Gelbard and Harrison 2003, DellaSala et al. 2011c, Selva et al. 2011, Ibisch et al. 2017, and Watson et al. 2018. Only the abstract was available to Gelbard and Harrison 2003 – copied here



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# ROADLESS HABITATS AS REFUGES FOR NATIVE GRASSLANDS: INTERACTIONS WITH SOIL, ASPECT, AND GRAZING

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*Abstract.* The idea that roadless habitats act as refuges for native-plant diversity against exotic-plant invasion has seldom been tested. We examined the effect of distance from roads and its interactions with soil type, aspect, and livestock grazing on native- and exotic-plant diversity in a 130 000-ha inland California (USA) foothill grassland landscape. During spring 2000 and 2001, we measured the numbers of and cover by native and exotic plant species in 92 sites stratified by distance from roads (10 m, 100 m, and >1000 m), soil type (nonserpentine and serpentine), and aspect (cool, warm, and neutral slopes). In nonserpentine grasslands, native cover was greatest in sites >1000 m from roads (23%) and least in sites 10 m from roads (9%), and the percentage of species that were native was significantly greatest in sites >1000 m from roads (44%) and least in those 10 m from roads (32%). In addition, the most distant sites had the largest number of native grass species and the fewest exotic forb species. In serpentine grasslands there was no significant effect of distance from roads on the numbers of and cover by native and exotic species. On both soils, two exotic species (*Centaurea solstitialis* and *Aegilops triuncialis*) were at their lowest frequencies, while a native bunchgrass, *Nassella pulchra*, was at its highest frequency, in sites >1000 m from roads. On nonserpentine soils only, the exotics, *Convolvulus arvensis* and *Polypogon monspeliensis*, were at their lowest frequency, while a native bunchgrass, *Poa secunda*, was at its highest frequency in the most distant sites. Native species were more abundant on serpentine than nonserpentine soils; on serpentine, natives were more abundant on slopes than flat sites, while on nonserpentine, natives were least abundant on warm, south-facing slopes.

Grazing, soil type, and aspect all significantly interacted in their effects on native and exotic richness and cover. Grazing negatively affected the number of native grass species, but not the number of native forb species on nonserpentine, and positively affected the number of native forb species, but not the number of native grass species on serpentine.

Roadless areas are significant refuges for native species. However, to protect these habitats from the continued threat of invasion, land managers should consider means of preventing construction of new roads, limiting off-highway vehicle access into grasslands with low road densities, identifying a regime of livestock grazing that favors the persistence of natives over the spread of exotics, and monitoring recreational trails and grazing allotments within roadless areas to detect and eradicate new infestations.

*Key words:* Aegilops triuncialis; *California grasslands;* Centaurea solstitialis; *exotic-plant invasions; grazing effect on species composition; habitat management;* Nassella pulchra; *native vs. exotic plant diversity; roadless habitats.*

## INTRODUCTION

With increasing emphasis on land management measures aimed at protecting native diversity by controlling exotic-plant invasions (e.g., Noss and Cooperrider 1994, Soulé and Terborgh 1999), the need for a quantitative understanding of landscape-scale patterns of exotic invasion and native-species persistence has never been greater. Roads are a logical focus for a landscape-level examination of invasion, because they are the entry points for many or most human influences that affect the invasion process. Elevated concentrations of exotic species have been observed near roadsides in many ecosystems (Johnson et al. 1975, Forcella and Harvey 1983, Tyser and Worley 1992, Knops et al. 1995; Gelbard and Belnap, *in press*). Such patterns partly reflect the disturbed condition of roadsides themselves, but also suggest that roads act as sources of exotic propagules (Amor and Stevens 1976, Schmidt 1989, Lonsdale and Lane 1994) and as conduits for human disturbances that promote invasion (Frenkel 1970, Greenberg et al. 1997). Conversely, the idea that roadless habitats act as refuges for native plant diversity is part of the conventional wisdom of invasion ecology and conservation biology (Noss and Cooperrider 1994, Soulé and Terborgh 1999).

Nonetheless, few studies have explored the effect of distance from roads on entire plant communities at a

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In addition, Ibisch et al. (2017) showed how roadless protections are consistent with United Nations' Sustainable Development Goals and these goals should be considered by the Forest Service as fundamental to sustainable development measures you seek for the region.

**SDG 15**: **Protect, restore** and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

**SDG 9: Build resilient infrastructure**, promote inclusive and sustainable industrialization and foster innovation.

Note: too many roads causing ecological damage is not **resilient infrastructure** and thus restoration is warranted in this regard alone and the Forest Service should consider taping into infrastructure funding to decommission and repair failing roads and culverts.

**Notably, the Tongass is nationally significant in having ~16% of the entire national forest roadless area network, which is by far more than any other national forest**. Many of the IRAs overlap with the Tongass 77 watersheds identified as priority because they include the highest ranked watersheds in all 14 biogeograpical provinces on the Tongass for the six salmonid species; marbled murrelet (*Brachyramphus marmoratus*) nesting habitat; black bear (*Ursus americanus*) and brown bear (*Ursus arctos horribilis*) summer habitat; Sitka black-tailed deer (Odiocoileus *hemionus sitkensis*) wintering habitat; estuaries and riparian large-tree old-growth forests (Smith 2016). Most of these species are of cultural importance to Alaska Natives and attain highest populations in intact watersheds as noted.

**The Tongass' Nationally Significant Carbon Stocks Have Been Depleted by Decades of Unsustainable Logging** (based on DellaSala et al. manuscript in preparation)

*Relatively Stable and Nationally Significant Carbon Stocks* **- no other national forest comes close to the total C stocks on the Tongass National Forest, which represent 8% of total C stores on all US forests (Leighty et al. 2006), or approximately one-quarter of total C on all national forests** (compared with total C estimates in Heath et al. 2011). The Tongass is unique in having relatively stable and accumulating C due to the rainforest climate and low incidence of large fires and insect die-offs (DellaSala et al. 2011a, DellaSala et al. 2015, Buma et al. 2019, Vynne et al. 2021, DellaSala et al. in prep). Old growth C stocks along with high C sequestration rates in young forests should be managed as a Forest-wide carbon reserve network. The Tongass also has an opportunity to support sustained C uptake in young forests by allowing at least some of them in developed areas several more decades to accumulate C by forgoing logging (aside from precommercial thinning for restoration), a process referred to as "proforestation" (Moomaw et al. 2019).

*Post-logging regeneration and harvested wood products are no substitute for old growth carbon stores* - natural regeneration/C uptake in young forests and wood product C pools by no means makes up for the substantial C debt created by over a century of old-growth logging. The C emitted a century ago, for instance, is still in the atmosphere and previously logged but regenerating young forests that are on short-rotation logging cycles in no way make up for the C debt created by logging centuries old forests (see Law et al. 2018, Hudiburg et al. 2019, Harmon 2020). Consider Tongass logging typically results in up to 50% or more "fall down" – that is clearcuts are left with massive downed logs, tree stumps, root wads, and abundant logging slash – all of which is released to the atmosphere, in addition to soil losses.

*Carbon life cycle analysis is needed on logging projects* - Leighty et al. (2006) demonstrated that a no-logging alternative would sequester and store far more forest C than any logging alternative at the time. Since then Forest Service researchers (Heath et al. 2011, Barrett 2014, Birdsey et al. 2019, D'Amore and McGuire 2020) and congressional policy reviews (CRS 2020) have recognized the importance of C in federal forests. However, the Forest Service has repeatedly undervalued C stocks by trivializing old-growth logging emissions using the wrong spatial scale (e.g., by comparing logging emissions to total US emissions), bypassing comprehensive carbon accounting. Instead we suggest that the agency focus on determining its contributions to reduced emissions by also maximizing C stored in forests. That is the Forest Service should manage the Tongass as both "carbon sinks" (i.e., sequestration/uptake) and "carbon reservoirs" (i.e. long-term stores) pursuant to Article 5.1 of the Paris Climate Agreement and with the backing of proper C life cycle assessments in evaluating forest management alternatives that include whatever old growth logging it intends to allow (see Law et al. 2018, Hudiburg et al. 2019, Harmon 2019 for ways to do this). Doing so, would make an important contribution to the US NDC and to the UN request for countries to take specific actions that conserve and enhance nature-based climate solutions (United Nations 2015), which have gained broad scientific appeal (Griscom et al. 2017, Moomaw et al. 2019, Cook-Patton et al. 2021), including recent calls to protect C stocks in primary forests globally (Mackey et al. 2014, DellaSala et al. 2020).

*Tongass Carbon Stocks* – Based on FIA data and published carbon sources, we estimate that the total C stocks on the Tongass is ~2.7 Pg or 2700 Tg (also see Leighty et al. 2006). This represents ~one-quarter of the entire National Forest C stock (11,604 Tg C = 11.6 Pg; Heath et al. 2011). Additionally, the prior estimates that we submitted to the Forest Service in our comments on roadless and old-growth decision documents are now being updated herein based on new information and mapping—our manuscript in prep is summarized as follows:

- Nearly half (48%; 1,283.3 million tons, MtC) of Tongass C is in productive old growth, split between soil (52.7%; 676.5 MtC) and woody biomass (47.3%; 607.3 MtC). This carbon is also evenly split between roaded and IRA old growth. The other half is in other vegetation types (e.g., muskeg).
- IRAs account for just over half (51.3%; 1,373.7 MtC) total C, with soil and woody biomass accounting for 61.5% (845.4 MtC) and 38.5% (528.3 MtC), respectively. About half of IRA carbon (25%) overlaps with productive old growth IRAs, the rest is in other vegetation types.
- About 15% (392.9 MtC) of all C on the Tongass is stored within T77 watersheds, with >80% (328.1 MtC) of T77 C in IRAs and half of that (163.7 MtC) in productive old growth T77s (categories overlap with above).

- Young growth accounts for only ~5% (128.8 MtC) of total C stores, with nearly all young growth C (96%; 124.0 MtC) outside IRAs.
- Notably, protecting C stocks comes with a suite of ecosystem benefits and biodiversity (Brandt et al. 2014) in these rainforests and this should be noted in the context of the multiple values secured via C protections.

Overall, our results underscore the importance of IRAs and old-growth forests (both roaded and unroaded old growth) in keeping most of the forest C on the Tongass in the forest and stored in a relatively stable condition instead of the atmosphere.

*Carbon flux from logging is climatically impactful* – We processed USDA Forest Service datasets on timber volume sold on the Tongass by four discrete logging time bins: (1) early (ca 1908-1952); (2) pulp era (1950-2000); (3) post-pulp/pre-transition (2001-2015); and (4) early transition (2016-2020) (manuscript with citations in prep). We also projected timber volume out to the end of the century based on volume projections in the Tongass transition plan amendment of 2016. Our preliminary results are demonstrated in Figure 1 and summarized as follows:

- Logging hit a historic high in 1980 (~600 million board feet, ~30,000 logging trucks full), declined precipitously after the pulp era contracts expired in 2000, but is poised to ramp up in 2033, with a projected leveling off at 103 million board ft annually (~5150 fully loaded logging trucks) through this century.
- Logging emissions remain in the atmosphere for decades and are expressed herein as vehicle emissions equivalents using both back-casting (1900s to 2020) and forecasting (based on the forest plans 2021-2100) models (manuscript underway).
- **Annual emissions peaked with timber volume sold in 1980s at ~300,000 vehicle emissions equivalents.**
- **Future emissions are estimated at rate of 50,000 vehicle equivalents annually beginning in 2033 during the transition ramp up phase.**
- **Back-casting and forecasting estimates reveal that logging will have generated the equivalent of >9 million vehicle emissions over two-centuries (1900s-2100)[2] and that C remains in the atmosphere contributing to the climate emergency.**
- Timber sold on the Tongass generated **$21 million in the peak timber year in 1980**, and was lowest at **$469,591 in 2020**. By comparison, the social cost of carbon is estimated at **~$15 million annually as logging ramps back up in 2033 even though it is coming from young-growth forests[3].**

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[2] Hoover, C., R. Birdsey, B. et al, 2014. Chapter 6: Quantifying Greenhouse Gas Sources and Sinks in Managed Forest Systems. In Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory. Technical Bulletin Number 1939, Office of the Chief Economist, US Department of Agriculture, Washington, DC. 606 pages.

[3] Based on mean value from global estimates of $54.7/tCo2 and Tongass logging levels 2033-2100. Wang, P., et al. 2019. Estimates of the social cost of carbon: a review based on meta analysis. J. Cleaner Production https://doi.org/10.1016/j.jclepro.2018.11.058

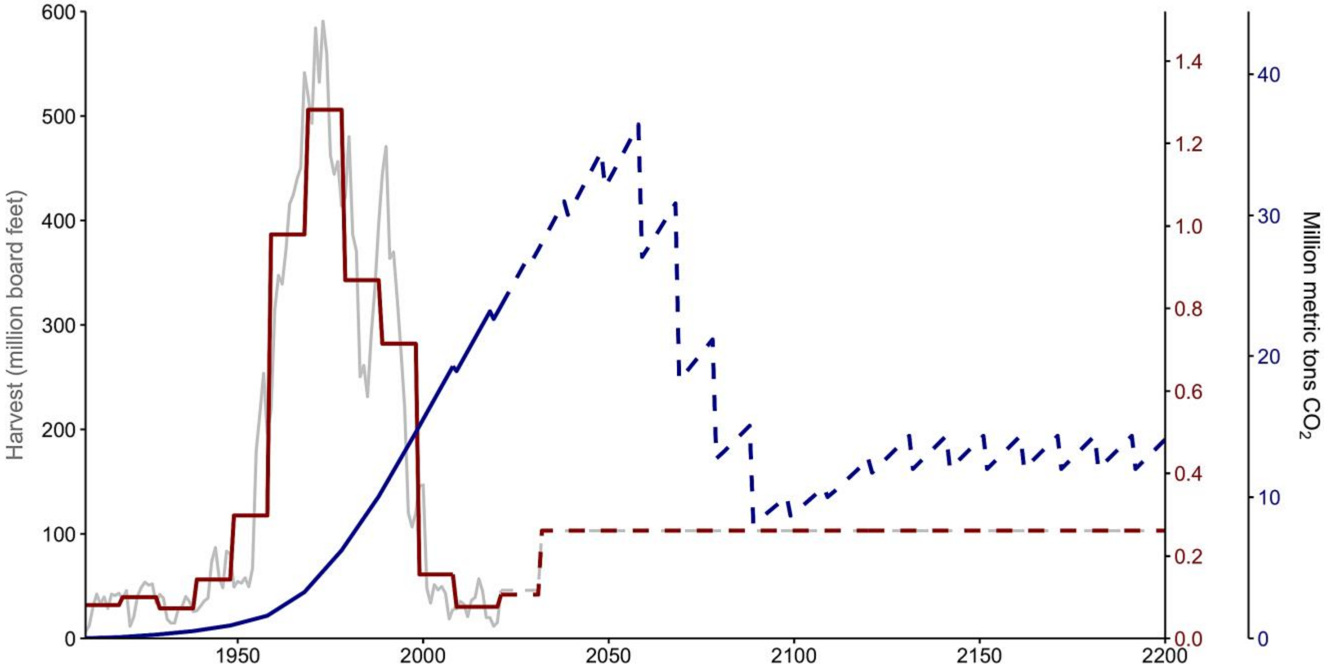

Figure 1. Historical timber harvests (gray; million board feet) and associated average decadal (red) and cumulative (blue) 100-yr emissions (million metric tons $CO_2$). Historic observations indicated with solid lines and future projections indicated with dashed line. . Logging emissions were estimated by converting annual board feet sold (FY Tongass timber sale reports) to $CO_2$ equivalents to vehicle emissions (preliminary). Z-axis reflects both the estimated accumulated (blue) and annual (red) emissions equivalents. Grey line is actual board ft data. End of pulp era 2000, Obama transition 2016, Transition 2021-2100.

**It is abundantly clear that Tongass logging has treated the atmosphere like a $CO_2$ emissions dumping ground. Any further old growth logging is inconsistent with the Biden administration's forward-looking climate policies based on avoided emissions alone.**

We reiterate that logging emissions are not made up for by regenerating forests, especially if they are logged again on short timber rotations, nor by storing a small portion of C in harvest wood product pools, which are at best a delayed emission (that is wood products do not last nearly as long as an old-growth tree, Hudiburg et al. 2019 and Harmon 2020, and there is considerable fall down on logged sites). Proper life cycle and C accounting of all upstream (on site) and downstream (processing, manufacturing, transport) emissions would bolster the importance of Tongass C stores and account for the region's climatically, ecologically, and culturally damaging logging and road building.

## Closing Comments

I have been working on the Tongass since 1990 as a researcher because of its many global superlatives. The Tongass has been at the cross-roads of controversy reflected in the century-long unsustainable logging and road building program that is not based on best science reflective of the region's unique attributes. All ecosystems have limits and we have pushed far too many of them to the brink of collapse during what many are calling the "Anthropocene," the age of humanity's enormously growing ecological footprint (Ripple et al. 2020). The Tongass has a unique opportunity to set the pace of forest protection and ecological restoration nationally while providing a global model of US commitments to forest protections and shifting the region increasingly into sustainable development. We urge the Forest Service to showcase the Tongass as an important example of the president's forest pledge that needs to be followed with a national rule to protect all mature forests and trees on federal lands via a strategic national carbon reserve (starting with the Tongass) or similar protective designations. Federal forests are just too vital to the climate, biodiversity, clean water, tourism/fishing, traditional cultural values, and future generates to continue chipping away at them in a climate and biodiversity crises.

Most countries with primary forests eventually reach a tipping point where nearly all of their primary forests have been replaced by industrial forests with substantial losses to biodiversity and ecosystem services and lasting climate consequences. The Tongass can choose a different path by protecting all remaining old growth and IRAs before hitting that point of no return where most of the landscape is so degraded and fragmented by roads and clearcuts (e.g., much of Prince of Wales Island is dangerously close) that it drives unprecedented species losses and accelerated climate change impacts (especially on island systems as noted). Importantly, even though some 85% of Tongass old growth remains, most of the highest volume old growth stands were logged during the 50-year contracts that left an indelible scar on the region (Albert and Schoen 2013) that persists to this day in the hundreds of thousands of acres of young stands lacking carbon and biodiversity of the original forest. Many of the logged areas are on the most productive sites (e.g., karst) that would benefit from restoration and proforestation (i.e., grow back the old growth). It is indeed time to do it differently on the Tongass, to recognize its irreplaceable values, and to restore the landscape that so many Native Alaskans and tourism/fishing/hunting sectors depend upon and that are anchored by the remaining old-growth forests and roadless areas.

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