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Submitted via https://cara.fs2c.usda.gov/Public/CommentInput?Project=64039

Dear Supervisor Sherman: February 24, 2025

On behalf of Alaska Venture Fund, thank you for the opportunity to provide comments on the draft Assessment reports supporting the revision of the Tongass National Forest land and resource management plan (forest plan or plan). For the last two months, I have worked with a technical team of advisors to put together a thorough review of the draft assessment. I spent many years as a wildlife biologist on the Tongass National Forest, and I currently support the Tongass Initiative through the Alaska Venture Fund. In this letter I am including additional appendices that include research on island endemics, a topic that has driven many specific conservation concerns on the Tongass National Forest and a topic that I was asked to address during the requested external review I did for the USFS internal planning team in 2024.

The detailed review in this letter is not meant to provide critical feedback in opposition to the Forest Service's due diligence in regard to the ongoing planning effort. To the contrary, we hope this detailed review can provide a path forward for agency, community, and tribal partnerships to develop and strengthen throughout the planning process. Without a dedicated FACA, creating lines of communication with the agency may be difficult, and so, we appreciate any and all opportunities to provide feedback through this process. For many of us, myself included, the Tongass is not only a national forest worthy of updated management guidelines and planning, but it is home – *aani* – our land, as we are taught by our Indigenous leaders. All of our deepest relationships are formed by the diversity of this island archipelago. We hope these detailed suggestions can be incorporated into the final assessment that will guide the Need for Change, and we look forward to assisting the USFS on this process.

Although the draft Assessment reports contain myriad information, most reports[1] do not meet the expectations for Assessments set forth in the Forest Service's 2012 Planning Rule. Many draft reports simply establish existing ecological processes or socioeconomic settings, but do not evaluate conditions and trends, and their relationship to a land management plan, in the context of a broader landscape as required by the Planning Rule. 36 C.F.R. § 219.5(a)(1). Because Assessments are to be used during plan revision to determine whether there is a need to change the existing plan and to inform the development of plan components and other plan content, it is essential that the Assessment conduct the requisite "assessment." 36 C.F.R. § 219.7(c)(2). The comments below identify where each draft Assessment report can be improved to put the Tongass on the best trajectory for a successful revision and revised forest plan.

I. The Assessment Process.

[1] A notable exception is the draft *Tongass as an Indigenous Place* Assessment report, which does an excellent job of meeting the expectations of the 2012 Planning Rule.

We reiterate the basic requirements of the Assessments process here. While lengthy, this overview is necessary in order to compare the content of the draft Assessment reports with the requirements of the 2012 Planning Rule.

A. Planning for Diversity.

A key initial step in the Assessment process is identifying the attributes of ecosystem diversity, ecological integrity, and species persistence that will be measured and evaluated in the Assessment. These same attributes would then be considered in the development of plan components and the monitoring program. They may also be addressed as effects in the NEPA process. In order for the responsible official to determine whether plan components provide ecological conditions to maintain the diversity of plant and animal communities, the Assessment must ensure that information is provided about those conditions. The responsible official should include key conditions in the Assessment within the following categories:

- Ecosystem and habitat type diversity (36 C.F.R. § 219.9(a)(2)): variety and relative extent of ecosystems
    - Key characteristics associated with terrestrial and aquatic ecosystem types (and riparian areas)
    - Rare aquatic and terrestrial plant and animal communities
    - Diversity of native tree species

- Ecosystem integrity (36 C.F.R. § 219.9(a)(1)): quality or condition of these ecosystems
    - Composition
    - Structure
    - Function
    - Connectivity
    - Species composition and diversity
    - Focal species (since the stated purpose is inferences about integrity)

- Species persistence (36 C.F.R. § 219.9(b)): a prerequisite for species diversity and ecosystem integrity. Ecological conditions include human structures and uses as well as the biological habitat characteristics that may overlap with characteristics for ecosystem integrity. Amount, quality, distribution and connectivity of habitat should be included among these conditions:
    - Ecological conditions necessary to contribute to recovery of each threatened and endangered species
    - Ecological conditions necessary to conserve each proposed and candidate species
    - Ecological conditions necessary to maintain a viable population of each species of concern within the plan area

In order to make decisions about plan components that will meet diversity requirements of the 2012 Planning Rule, the responsible official must first determine what ecological conditions in the plan area are relevant to development of plan components. The responsible official must then identify existing information about those conditions relevant to the plan area and evaluate possible future trends in those conditions.

1. Identify Tentative Target Species.

The habitat needs of some individual species should be an important consideration in defining ecosystems and selecting their key characteristics. Consequently, the first factor that should be considered for an Assessment is target species for the revised plan.

Target species are those of sufficient interest or concern to monitor key ecological conditions for over time (*see* 36 C.F.R. § 219.12(a)(5)(iv)), and to consider directing management towards through the development of plan components, and therefore to identify and evaluate in the Assessment. Target species would be selected from among federally threatened, endangered, proposed and candidate species, and species of conservation concern identified pursuant to 36 C.F.R. § 219.9(b) (required as part of the Assessment by 36 C.F.R. § 219.6(b)(5)), focal species selected pursuant to 36 C.F.R. § 219.12(a)(5)(iii) (indicators of ecological integrity), and species commonly enjoyed and used by the public selected pursuant to 36 C.F.R. § 219.10(a)(5) (required as part of the Assessment by 36 C.F.R. § 219.12(b)(7)). These three categories of tentative target species represent different levels of responsible official authority and discretion for inclusion.

Public interest species are chosen entirely at the discretion of the responsible official. 36 C.F.R. § 219.10(a)(5). They may be included in the Assessment as ecosystem services (36 C.F.R. § 219.6(b)(7)), or multiple uses (36 C.F.R. § 219.6(b)(8)), but their requirements for ecological conditions may overlap those of species at risk, and they should be integrated into the Assessment of diversity factors.

Federally recognized species (endangered, threatened, proposed, candidate species) must be identified through the coordination with the ESA consulting agencies that is required during the Assessment by 36 C.F.R. § 219.4. These federally recognized species must be addressed by plan components if they "may be present" in the plan area, in accordance with 50 C.F.R. § 402.12, and should be included as target species.[2]

Species of conservation concern are the responsibility of the regional forester. 36 C.F.R. § 219.7(c)(3). The regional forester should designation SCC early enough so that their integration into the Assessment, including identification of key ecological conditions, does not delay the Assessment process. The rule contains only two criteria that the regional forester may use to identify SCC:

- A species must be known to occur in the plan area, and

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[2] This initial Assessment step will also provide an opportunity for the consulting agencies to begin contributing information that may be used to design the proposed action. Early contributions to a new or revised plan by the consulting agencies should help streamline the Section 7(a)(2) consultation process for the plan and increase the likelihood of contributing to recovery of listed species and avoiding listing of proposed and candidate species (*see* 16 U.S.C. § 7(a)(1)).

- Best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area

36 C.F.R. § 219.9(c).

For some species, range-wide viability risk has already been reliably determined,[3] and they must be identified as SCC if they are known to occur in the plan area. (If a species is at-risk range-wide, it is necessarily at risk wherever it is found.) Species with no recent occurrence records in a plan area may be excluded if the best available scientific information indicates they will not naturally repopulate the plan area, and collaborative efforts substantiate that no artificial reintroduction is likely. Species with recent occurrence records may be excluded if the best available science indicates they are accidental occurrences.

The regional forester should evaluate any suggested potential species against the criteria in 36 C.F.R. § 219.9(c) upon request. If the information about a species' abundance, distribution threats, trends or response to management indicates that the species may not continue to persist over the long term in the plan area with a sufficient distribution to be resilient, then the regional forester must select it as an SCC. If not, the regional forester must document the rationale for finding that a potential species does not meet the SCC criteria. Species considered as potential SCC but not meeting the criteria in 36 C.F.R. § 219.9(c) may be selected as public interest species.

This analysis of potential SCC must be included in the Assessment. 36 C.F.R. § 219.6(b)(5)). The regional forester must also document best science currently available and the nature of the information needs, which should be addressed in the monitoring program. 36 C.F.R. § 219.12(a)(4)(i).

During the process of determining if a species is at risk in the plan area, the regional forester should compile information about the ecological conditions necessary to comply with 36 C.F.R. § 219.9(b) for each species, including ecosystem composition, structure, function, and connectivity. These should include the most important habitat elements for a species, and should represent limiting factors or those being threatened by actions that may be influenced by plan components. This information should be largely applicable to a species across multiple plan areas. It would be provided to the responsible official to use in selecting key ecological conditions for these species.

An analysis of population viability may be appropriate to use to determine if a species is currently at risk and should be considered a SCC and should be already available to be used for an Assessment for a revised. A new analysis of projected population viability may be appropriate

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[3] Such species include species with positive 90-day findings under the ESA, recently de-listed species that may be considered for re-listing, species that are classified under the NatureServe system as critically imperiled, imperiled, or vulnerable globally or nationally (G/N/T 1-3), and species listed as sensitive by the Forest Service. The agency should also consider as "potential SCC" species those species that are known to occur in a plan area and for which concerns about the risk to persistence in that particular plan area exist and species with NatureServe S1 and S2 (state) rankings.

as part of the diversity evaluation that occurs in the planning phase pursuant to 36 C.F.R. § 219.9(b).

Identification of SCCs by the regional forester is a preliminary planning step. It consists of applying regulatory criteria to species in the plan area based on best available scientific information. While it requires the exercise of professional judgment, it permits no discretion by the Forest Service. It is appropriate and necessary for this determination to occur prior to most of the Assessment process. Selection of SCC may be revisited throughout the planning process as required by new information applicable to the two criteria in 36 C.F.R. § 219.9(c).

The rule only discusses *focal species* in conjunction with the plan monitoring program developed by the responsible official. 36 C.F.R. § 219.12(a)(5)(iii). However, the purpose of focal species is to provide "meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area." 36 C.F.R. § 219.19. Therefore, focal species should be part of the overall strategy for identifying species at risk and key ecological conditions, and the regional forester should play a role in identifying focal species as well as SCC. Effective monitoring may require that some SCCs be selected as focal species.

2. Identify Land Units for Integrity and Diversity Analysis.

The Planning Rule specifies three kinds of land units for which to evaluate integrity: 1) terrestrial ecosystems and watersheds; 2) aquatic ecosystems and watersheds; and 3) riparian areas. It also requires diversity of ecosystems and habitat types. An ecosystem is "a spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries." 36 C.F.R. § 219.19. An ecosystem is commonly described in terms of composition, structure, function, and connectivity. *Id.* Selected ecosystems should be characterized in a manner that encompasses these elements.

The choice of ecosystems should consider the appropriate scale for the Assessment and for plan components. The Planning Rule allows planning at the most appropriate scale to address issues and resource concerns specific to a plan area, and therefore planning topics must be identified early in the Assessment process. The scale for evaluating ecosystem integrity should recognize the scale of dominant disturbance regimes. In order to describe the relative contribution of the plan area to ecological sustainability, ecosystems may also need to be delineated at a broader scale. Nested ecosystems at multiple scales may need to be identified.

This ecological sustainability requirement of the Planning Rule specifically requires plan components to provide for integrity of riparian areas, and therefore the Assessment needs to address the seven factors listed in 36 C.F.R. § 219.8(a)(3)(i), which include "aquatic and terrestrial habitats" and "ecological connectivity," and widths of potential riparian zones. 36 C.F.R. § 219.8(a)(3)(ii). The Assessment must also include information about riparian areas on which to base decisions about widths for riparian management zones and decisions about appropriate plan components. The Assessment must also address air, soil, and water resources and quality. 36 C.F.R. § 219.6(b)(2). Though these are not directly included as elements of diversity in § 219.9, the Assessment should document how they may affect any of the elements of diversity above.

To facilitate planning across unit and jurisdictional boundaries, ecosystems and watersheds should be identified by regional foresters, in coordination with states and other entities operating at a broad scale. Broader-scale interests should determine what is needed to provide the context for plan area decision-making, including identification of regionally distinctive characteristics of the plan area. Without edge-matching ecosystems, the contributions of sustainability and diversity factors across boundaries may be more difficult to determine. Consistent use of ecosystems will facilitate the regional forester's identification of SCC, and also lead to better and more efficient broader-scale monitoring.

3. Identify Key Ecological Conditions – An Island Archipelago.

The planning rule requires that plan components provide the ecological conditions to maintain the diversity of plant and animal communities and support the persistence of native species in the plan area. 36 C.F.R. § 219.9. Ecological conditions include "habitat and other influences on species and the environment," including structural developments and human uses. *Id*. The Assessment must identify the ecological conditions that will be most relevant and useful for developing plan components for diversity.

While the rule does not directly address the landscape pattern of ecosystems and patches, it is inherent in the dominant ecological conditions of composition, structure, function and especially connectivity. The structure of a landscape is determined by the spatial arrangement, size, shape, number, and kind of patches. Functional attributes are defined by the interactions among spatial elements. Habitat suitability for species at risk based on stand characteristics cannot be divorced from the spatial distribution of habitat types. Consequently, the Assessment should identify appropriate patch metrics as key ecological conditions.

The species composition and diversity aspects of ecological integrity should also be addressed by identifying key ecological conditions for the species at risk. The understanding of the relationship between these key ecological conditions and changes in species populations should be documented so that it can be tested. Grouping species with similar needs for ecological conditions may be appropriate for subsequent analysis if supported by the best available science.

The Tongass National Forest is an island archipelago and the Need for Change should emphasize island-based management planning as a key feature of the new forest plan. The next Tongass forest plan must identify management units at the island, or island group level based on the best available science. A body of research compiled over the last 30 years, including the Forest Service Inventory and Monitoring Program, have identified a suite of endemic species across the Tongass and biogeographic patterns illustrating specific groupings of species. Appendix 2 is a recent paper by one of the research teams that summarizes considerations for forest planning that prioritize island endemism.

During the planning phase, the responsible official must determine whether the likely future ecological conditions under the plan will maintain a viable population of species of concern in the plan area that will persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments. The Assessment should therefore address species population distributions as key ecological conditions for species diversity.

Because they are included in the definition of ecological conditions, it is necessary to consider human structures and uses in the Assessment. Identification of these ecological conditions is needed during the Assessment to provide a basis for plan components that would manage human structures and uses. Ecological conditions include roads[4] and other structural developments and human uses. 36 C.F.R. § 219.19. The Assessment must address these as part of ecosystem services and multiple uses (including recreation) (36 C.F.R. §§ 219.6(b)(7), (8)), and infrastructure (36 C.F.R. § 219.6(b)(11)), but they should also be included in the discussion of species persistence. In most cases, it is likely that roads and their use will be the predominant direct human influence on diversity in the plan area, so these would be good candidates for key ecological conditions.

4. Identify Key Areas that Support Target Species.

For many species, there will be some places within the plan area that are more important than others. Some areas act as source areas or strongholds that export individuals, while in other areas survival and successful reproduction are more challenging. Some areas may provide key linkage zones between populations or source habitats. The location of areas of high value to species at risk should be considered in deciding what plan components to apply where.

The Assessment needs to recognize the relative importance of different areas at scales appropriate to each species. It needs to discuss the relative contribution of the plan area to broader-scale species viability. Within a plan area, specific ecosystems or watersheds or sites should be identified if they provide relatively high-quality habitat for a target species. Developing this context for developing plan components may indicate that species diversity or viability may depend on more protective management of portions of the plan area, or of the plan area as a whole.

5. Evaluate the Existing Information in Terms of Conditions and Trends.

For each of the key ecological conditions, the Assessment must: 1) identify existing relevant information; and 2) evaluate that information. 36 C.F.R. § 219.6(b). The Assessment should also distinguish areas important to species at risk if conditions and trends differ for such areas. For each ecological condition, this evaluation should answer these questions to address conditions, trends and sustainability and their relationship to the land management plan:

- What was the historic condition (where there is existing information)?

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[4] The Forest Service has specific requirements for "roads analysis," which include determining the effects of the road system in the plan area on diversity. FSM 7712.1. This analysis should have been completed prior to revision of a forest plan. FSM 7712.15. The responsible official must use the results and findings of the roads analysis during land management planning (FSM 7712.12a). Information from the roads analysis relevant to diversity should therefore be included in the Assessment.

- What is the current condition?
- What are the relevant drivers and stressors?
- How has management of the plan area contributed to the current condition?
- What scenario is most likely for future drivers and stressors?
- What will the future trend be as a result of those drivers and stressors?
- What will the likely future condition be managing under the current plan?

36 C.F.R. § 219.5(a)(1). Section 219.5(a)(1) provides direction for how to evaluate the information compiled during the Assessment. It states that Assessments will evaluate information about "trends, and their sustainability and their relationship to the land management plan within the context of the broader landscape." It requires the responsible official to evaluate "existing and possible future conditions and trends of the plan area."

The Assessment must therefore consider possible future scenarios for stressors and other relevant factors beyond the control of the agency (including climate change), and identify those most likely to occur based on the best available scientific information. For the purpose of the Assessment, projections of future conditions must assume that current forest plan direction would be followed. (An evaluation of future conditions under a proposed revised plan will be completed during the planning phase.) Important Assessment conclusions will include the key ecosystem conditions in the future, which necessarily reflect a trend from current conditions, and therefore indicate whether current conditions are sustainable.

The rule does not state that the Assessment must include an interpretation of current or future ecological conditions in terms of ecological integrity. Judging the merits of conditions can only occur after establishment of reference conditions that provide for integrity. Establishing reference conditions, and comparing them to future conditions, is part of identifying a preliminary need to change the existing plan and informing the development of a new or revised plan. 36 C.F.R. § 219.7(c)(2)(i).

The final step is to evaluate whether the future condition meets requirements for diversity. However, that evaluation will occur as part of the NEPA process rather than the Assessment, along with evaluation of the proposed new plan and alternatives.

B. Monitoring.

Assessments will also be used to inform the development of the monitoring program. 36 C.F.R. § 219.5(a)(3). The monitoring program must in turn be used to "inform adaptive management of the plan area." 36 C.F.R. § 219.12(d)(2). Adaptive management must therefore be built into the design of the Assessment by using existing information to establish hypotheses for testing. Adaptive management also requires that, where plan components are adopted based on existing information that is incomplete, missing information must be collected and evaluated to determine whether there is a need to change the plan components. The Assessment report must document that missing information. 36 C.F.R. § 219.6(a)(3).

Assessments represent the best opportunity to contribute information for use in the planning process. The responsible official is required to identify and consider information from various sources, both governmental and non-governmental, including private information that is voluntarily provided. The planning rule requires consideration of information contained in studies, monitoring reports, plans, other Assessments, and other kinds of documents, including - for our purposes – Indigenous Knowledge. 36 C.F.R. § 219.6(a)(1). The Assessment should also include the review of planning and land use policies of other entities such as Tribes. 36 C.F.R. § 219.4(b)(2). The responsible official is required to use the best available scientific information, including Indigenous Knowledge, to inform the Assessment. 36 C.F.R. §§ 219.3, 219.6(a)(3). In the Assessment report, the responsible official must document which information is the most accurate, reliable, and relevant to the issues being considered, and the basis for that determination. The responsible official must also document relevant information need. 36 C.F.R. § 219.6(a)(3).

The Assessment should consider the results of prior monitoring, and the Assessment report should include a summary of what was learned from monitoring of the existing plan, focusing on the effects of existing plan components. The Assessment also needs to evaluate the performance of monitoring itself. The best source of information about useful and practical plan monitoring should be prior experience with plan monitoring. Therefore, the Assessment should be designed and used to determine if there is a Need for Change in the monitoring program.

Requirements related to diversity (discussed infra) for the plan monitoring program should be considered during the Assessment and include:

- Island Endemism (isolation by distance, presence of endemics, inbreeding, migration corridors)
- Watershed Conditions
- Ecological conditions including key characteristics of terrestrial and aquatic ecosystems
- Focal species to address the ecological conditions required for species at risk
- Ecological conditions required for species at risk
- Invasive species management (a high risk factor for island endemics)

36 C.F.R. § 219.12(a)(5).

II. Assessment Report Analysis.

In our view, while much useful information is contained in the Assessments, they must do more than just gather information on their subjects: they all must do a better job of demonstrating the purpose and need for this plan revision. As such, they must address specifically how climate change and the stressors it will impose on the Tongass drive that need for change and how management must change holistically and adapt to respond to those changes.

As discussed supra, the information analyzed in Assessments should be used "to identify a preliminary need to change the existing plan and to inform the development of plan components and other plan content." 36 C.F.R. §219.7(c)(2)(i). Similarly, the Assessment report should describe "a clear base of information for identifying a need to change the plan." FSH 1909.12, ch. 10, sec. 11.3.

Overall, stronger linkages between Assessments and the forthcoming Need for Change are necessary in order to meet the 2012 Planning Rule's requirements to "document how best available scientific information was used to inform the assessment, the plan decision, and the monitoring program" and to "[i]dentify what information was determined to be the BASI, explain the basis for that determination, and explain how the information was applied to the issues considered." 36 C.F.R. §219.3.

The final Assessment should more clearly "document information needs" (§ 219.a)(3)) and identify "key assumptions, risks, areas of uncertainty, and how the assessment can inform the development of the monitoring program." FSH 1909.12, ch. 10, sec. 11.3. Identifying these information needs, assumptions, risks, and uncertainties will be essential to structure a more adaptive approach to planning in the future. Some of the Assessment reports identify information needs, but only in a cursory fashion, and there is often no corresponding discussion of how these information needs could be filled and their relevance to the monitoring program. Clearly identifying information needs will be critical to the development of a more adaptive planning framework.

The Tongass should make efforts to frontload information and partners early in the planning process. During the Assessment phase, the Forest Service should have made efforts to better populate the plan with relevant information. In our view, many sources of relevant information were not cited or used to inform the Assessment process such as earlier internal summaries produced by or for the USFS Region 10 planning team (Appendix 1 – wildlife summary and associated reviews). Likewise, partners with relevant information - particularly Alaska Native Tribes - should have been identified and actively invited to share such data early in the process: this does not appear to have occurred for the Tongass Assessment. The Forest should not solely rely on those members of the public who "show up" and provide information. This mode of operation most often results in "hit or miss" data collection and data gaps are the result.

While the draft *Tongass as an Indigenous Place* Assessment report does an excellent job of describing traditional uses of the Forest, the other Assessment reports would be improved by providing a general discussion of historic and traditional uses by Alaska Tribes. Oftentimes cultural and historic resource condition Assessment reports are more focused on cultural archeology than on ethnography and anthropology of current human communities and their uses of the land. Although it is important to address historic uses, it is also imperative that Assessments contain information on current communities and living practices, their importance to the landscape, and the opportunities that exist to engage in balancing natural process and human species through forestland management. In particular, the Assessments should provide information on how traditional human communities are affected by current conditions and discussions on how communities will be affected by trends, stressors, and the future management (or lack of management) of ecosystem resources.

In revising the draft Assessment reports, the planning team should focus on presentation of information to increase utility and functionality (or usability) and applicability. The draft Assessment reports provide a wide variety of information on each of the Assessment topics, and while having a lot of information in one place can be helpful, this approach leads to Assessments that are unwieldy, not as strategically focused as they could be, and missing critical pieces of information necessary to inform the Need for Change and the revised plan.

A. *Tongass as an Indigenous Place.*

The Tongass National Forest has a unique and significant relationship with the indigenous people of Southeast Alaska, including the Tlingit, Haida, and Tsimshian, whose presence in the area spans over 10,000 years. These indigenous communities have a deep connection to the land, which is integral to their cultural practices, subsistence lifestyles, and spiritual beliefs. The Forest Service is required to encourage participation by Tribes and Alaska Native Corporations in the planning process, seeking their input on native knowledge, land ethics, cultural issues, and sacred sites. Indigenous people view the Tongass as their traditional homelands and have historically practiced stewardship of the land, emphasizing sustainable use and reciprocal respect for natural resources. The relationship is characterized by a need for co-stewardship and co-management to ensure that Indigenous perspectives and priorities are integrated into forest management decisions.

The revised forest plan, all Assessments, and indeed all land management the Forest Service conducts on the Tongass National Forest must address the history, needs, and concerns of the Native People who call the Tongass home.

The main challenges faced by Alaska Native tribes, as highlighted in this draft Assessment, include:

1. **Historical Trauma and Dispossession**: The creation of the Tongass National Forest and other federal actions led to the dispossession of indigenous lands without consent or compensation, causing generational trauma and loss of traditional territories. The revised forest plan should acknowledge and seek to address this trauma and dispossession.
2. **Inadequate Consultation**: Tribes often experience inadequate and sometimes disrespectful consultation processes with federal agencies, including the Forest Service, leading to a lack of meaningful input in decision-making that affects ancestral lands and resources. The revised forest plan must not repeat the mistakes of the past and should utilize plan components to establish meaningful substantive and procedural requirements that center Indigenous needs and perspectives in future interactions with the Forest Service.
3. **Climate Change**: Climate change poses significant threats to subsistence resources, traditional practices, and community safety. Stressors include warming stream temperatures, changing precipitation patterns, increased landslides, and the die-off of yellow cedar. The revised plan must address these stressors through the use of plan components tailored to each stressor and its effects on Indigenous uses of the land and resources.
4. **Resource Management Conflicts**: Industrial-scale logging, mining, and other resource extraction activities have historically damaged subsistence habitats and cultural sites. There is also Tribal concern regarding second-growth timber planning and the impacts of tourism that must be addressed in the revised plan.

5. **Access to Cultural Resources**: Tribes face challenges in accessing forest resources for cultural uses, particularly cedar for totem poles and canoes. The bureaucratic process and high costs of harvesting suitable trees further complicate access. These are challenges that must be addressed in the revised plan.
6. **Food Security and Sovereignty**: Ensuring food security and sovereignty is a major concern for Alaska Tribes, including a need to protect traditional hunting, fishing, and gathering areas. Many Tribes believe that the legal term "subsistence" is inadequate to describe their cultural lifeways. The revised plan should better describe the breadth and depth of Tribal uses of natural resources on the Forest, and should manage for those resources beyond a mere "minimum" level: traditional forest resources should be plentiful and robust.
7. **Economic and Workforce Development**: There is a need for coordinated workforce development and economic opportunities that align with Tribal values and needs. This includes local hiring preferences, training centers, and support for Tribal businesses.
8. **Infrastructure and Deferred Maintenance**: Aging infrastructure, such as roads and facilities, affects access to subsistence use areas. Tribes also face challenges in taking over management of underutilized facilities and ensuring proper maintenance. The revised plan should include Management Approaches and other plan components that assist Tribes in the co-stewardship of such infrastructure at Tribal request.
9. **Vandalism and Theft**: Increased exposure of sacred sites has led to vandalism and theft of cultural resources, creating a tension between the sharing of Indigenous Knowledge for protection and keeping sites confidential. The revised plan must include plan components that address this tension.
10. **Trust and Relationship Building**: Building trust with federal agencies is difficult due to the federal government's history of broken promises, political changes, and high staff turnover. Alaska Tribes seek long-term, respectful relationships with consistent engagement and understanding of their cultural context. The revised plan can take steps to rebuild trust with Tribes by providing for the development of co-stewardship agreements and other mechanisms at the request of Tribes.

Addressing these challenges requires meaningful Government-to-Government consultation, co-stewardship, and integration of Indigenous Knowledge and priorities into land management practices as embodied in the revised plan.

The *Tongass as an Indigenous Place* Assessment highlights the historical relationship, and potential future relationship, between the Tongass National Forest and the Indigenous people of Southeast Alaska. Important considerations discussed in the Assessment report that should be carried forward into the Need for Change and revised plan include:

1. **Historical Connection**: The Tlingit, Haida, and Tsimshian people have lived in the area now known as the Tongass National Forest for over 10,000 years, with a deep cultural, spiritual, and subsistence connection to the land.
2. **Stewardship and Management**: Indigenous communities have historically practiced sustainable stewardship of the Tongass, emphasizing respect for natural resources. They seek co-stewardship and co-management roles in forest management to ensure their

perspectives and priorities are integrated into the revised forest plan and all management going forward.

3. **Cultural Significance**: The Tongass is considered the traditional homelands of these indigenous groups, with numerous sacred sites, traditional harvesting areas, and culturally significant resources like cedar trees, salmon, and deer.
4. **Food Security and Sovereignty**: Protecting traditional hunting, fishing, and gathering areas is crucial for the food security and sovereignty of indigenous communities. This includes managing deer habitat and restoring anadromous streams.
5. **Climate Change**: Climate change poses significant threats to the Tongass ecosystem, affecting subsistence resources and traditional practices. Tribes have developed climate adaptation plans and seek proactive management strategies.
6. **Consultation and Trust**: Tribes emphasize the need for early and meaningful consultation in all management and project planning within their traditional territories. Building trust and understanding the historical context of federal policies and their impacts on indigenous communities are essential.
7. **Cultural Use Wood**: Access to cultural use wood, particularly cedar for totem poles and canoes, is a top priority. Tribes seek a long-term management plan and funded harvest program to meet current and future cultural needs.
8. **Economic and Workforce Development**: Tribes and Alaska Native Corporations (ANCs) prioritize coordinated land management, workforce development, and economic opportunities that align with their cultural and community values.

These points underscore the importance of integrating Indigenous Knowledge, priorities, and co-stewardship into the management of the Tongass National Forest. While a full complement of plan components can and should center these perspectives in the revised plan, co-stewardship agreements between Tribes and the Forest Service, entered into at Tribal request, represent perhaps the best way to achieve Tribal desired outcomes and to honor the federal Trust responsibility owed to Tribes. Co-stewardship agreements are crucial for Tribes for several reasons:

1. **Cultural Preservation**: Co-stewardship allows Tribes to actively participate in the management of their traditional homelands, ensuring that cultural practices, sacred sites, and Traditional Ecological and Indigenous Knowledge are respected and preserved.
2. **Sustainable Resource Management**: Tribes have practiced sustainable stewardship of the Tongass for millennia. Co-stewardship agreements enable the braiding of Traditional Ecological Knowledge (TEK) with western management practices, promoting the health and sustainability of the forest ecosystem and its associated human communities.
3. **Food Security and Sovereignty**: Through co-stewardship in land management decisions, Tribes can better protect and manage subsistence resources and First Foods such as deer, salmon, and botanical resources that are vital for Tribal food security and cultural practices.
4. **Climate Change Adaptation**: Co-stewardship agreements allow Tribes to implement proactive climate adaptation strategies, address the impacts of climate change on their traditional resources, and ensure the resilience of their communities. Moreover, co-stewardship agreements can integrate Tribal climate adaptation plans and resilience strategies.

5. **Economic Opportunities**: Co-stewardship agreements can create economic opportunities for Tribes through local hire preferences, workforce development, and the management of tourism and other commercial activities that align with Tribal cultural values.
6. **Building Trust and Relationships**: Co-stewardship fosters a collaborative relationship between Tribes and federal agencies, building trust through mutual respect, shared decision-making, and consistent engagement. Rebuilding these relationships is essential.
7. **Legal and Policy Advocacy**: Co-stewardship agreements provide a platform for Tribes to advocate for their rights and priorities in land management policies, ensuring that their voices are heard, and their needs are addressed.
8. **Youth and Community Engagement**: These agreements can support programs that engage tribal youth and community members in stewardship activities, fostering a sense of ownership and responsibility for their traditional lands.

Overall, co-stewardship agreements are essential for empowering Tribes to protect their cultural heritage, manage their natural resources sustainably, and ensure the well-being of their communities and the entire Tongass National Forest for future generations. The revised forest plan should include plan components that emphasize the use of co-stewardship agreements to better achieve the desired conditions set forth in the plan, which themselves should reflect Tribal priorities in addition to other multiple use objectives.

B. *Terrestrial Ecosystems.*

The revision of the forest plan presents an opportunity to improve adaptive ecosystem and ecocultural management on the Tongass using the framework of the 2012 Planning Rule. The Draft Terrestrial Ecosystems Resource Assessment forms the basis for those changes.

One key opportunity for change in the current plan is the braiding of Indigenous Knowledge and ecocultural values with ecosystem management and adaptation strategies. Eisenberg et al 2024. We recommend that tribal adaptation plans, such as the Tlingit and Haida Climate Adaptation Plan, be directly incorporated into planning, monitoring, and adaptive management processes. The draft *Terrestrial Ecosystems* Assessment acknowledges that "no management standards or guidelines specific to addressing or mitigating the effects of climate change are included in the current Forest Plan" thus highlighting the "blank slate" opportunity to develop meaningful ecocultural adaptation strategies in partnership with tribes. Terrestrial Ecosystems Draft Assessment Report, 14.

In order to make effective Need to Change determinations, it is important to estimate ecosystem trends for ecological integrity with the explicit assumption that existing plan direction remains in place and assuming the influence of a changing climate. FSH 1909.12. In practice, this requires an evaluation of the effect of the current plan on the key characteristics of ecosystem integrity. The draft Assessment touches on current plan direction, for instance noting that 20 percent of the Forest is allocated within development land use designations, but there does not appear to be an evaluation of how the existing LUD framework, and the specific plan direction within the LUDs, affects trends in ecological integrity. References to the results of current plan monitoring programs that could be used to evaluate the effectiveness of current plan direction and Need to Change are limited in the draft report.

Issues of scale are paramount when assessing ecosystem conditions on the Tongass in order to develop effective plan direction to meet ecological integrity and species viability requirements. The Alexander Archipelago is naturally fragmented across more than 10,000 islands, many of which have "distinct climatic, botanical, and faunal differences." Species of Conservation Concern (SCC) Draft Assessment, 11. This fragmentation is both natural and the result of anthropogenic activities and stressors. Human activities, albeit limited to a relatively small footprint (e.g., 4 percent of the Tongass has experienced logging), nonetheless have further fragmented ecosystems and habitats. SCC Draft Assessment, 11. Characteristics of ecosystems, for example landscape structure and connectivity/fragmentation, as well as species distribution and abundance, should be built into the spatial analysis framework.

Assessment of ecological integrity on the Tongass must factor influences of island biogeography and avoid falling into a macro level analysis that limits the evaluation of integrity at appropriate ecological scales to appropriately inform management direction. The Forest Service Directives call out this concern: "Spatial scales…should be sufficiently large to adequately address the interrelationships between conditions in the plan area and the broader landscape, but not so large that these interrelationships lose relevance in guiding land management planning." FSH 1909.12. For example, under the current classification scheme, the Well Drained Forest ecosystem type spans 3.48 million acres (elsewhere the document states that there are 5.5 million acres of productive forest type).

Island Endemism. A bibliography of research papers and syntheses on island endemism are available in the attached Appendix 3. In addition, panels at both the 1995 and 1996 TLMP reviews, as well as the 2006 Conservation Strategy Review, focused on island endemism and provide the FS with specific suggestions for implementing a monitoring program for island endemics.

A key initial step in the Assessment process is identifying the attributes of ecosystem diversity, ecological integrity, and **species persistence** that will be measured and evaluated in the Assessment. These same attributes would then be considered in the development of plan components and the monitoring program and as effects in the NEPA process. For the responsible official to determine whether plan components provide ecological conditions to maintain the diversity of plant and animal communities, the Assessment must ensure that information is provided about those conditions. The responsible official should include key conditions in the Assessment within the following categories:

- Ecosystem and habitat type <u>diversity</u> (36 C.F.R. § 219.9(a)(2)): variety and relative extent of ecosystems
    - Key characteristics associated with terrestrial and aquatic ecosystem types (and riparian areas)
    - Rare aquatic and terrestrial plant and animal communities
    - Diversity of native tree species

- Ecosystem integrity (36 C.F.R. § 219.9(a)(1)): quality or condition of these ecosystems
    - Composition
    - Structure
    - Function
    - Connectivity
    - Species composition and diversity
    - Focal species **including endemics**

- Species persistence (36 C.F.R. § 219.9(b)): a prerequisite for species diversity and ecosystem integrity. Ecological conditions include human structures and uses as well as the biological habitat characteristics that may overlap with characteristics for ecosystem integrity. Amount, quality, distribution and connectivity of habitat should be included among these conditions:
    - Ecological conditions necessary to contribute to recovery of each threatened and endangered species
    - Ecological conditions necessary to conserve each proposed and candidate species
    - Ecological conditions necessary to maintain a viable population of each species of concern within the plan area

The habitat needs of **endemic species** should be an important consideration in defining ecosystems and selecting their key characteristics. Consequently, the first factor that should be considered for an Assessment is target species for the revised plan.

The regional forester should evaluate any suggested potential species against the criteria in 36 C.F.R. § 219.9(c) upon request. If the information about a species' abundance, distribution threats, trends or response to management indicates that the species may not continue to persist over the long term in the plan area with a sufficient distribution to be resilient, then the regional forester must select it as an SCC. If not, the regional forester must document the rationale for finding that a potential species does not meet the SCC criteria. Species considered as potential SCC but not meeting the criteria in 36 C.F.R. § 219.9(c) may be selected as public interest species.

During the process of determining if an endemic is at risk in the plan area, the regional forester should compile information about the ecological conditions necessary to comply with 36 C.F.R. § 219.9(b) for each species, including ecosystem composition, structure, function, and connectivity. These should include the most important habitat elements for an endemic, and should represent limiting factors or those being threatened by actions that may be influenced by plan components. This information should be largely applicable to a species across multiple plan areas. It would be provided to the responsible official to use in selecting key ecological conditions for these species.

An analysis of population viability may be appropriate to use to determine if endemics are currently at risk and should be considered a SCC and should be already available to be used for an Assessment for a revised. A new analysis of projected population viability may be appropriate as part of the diversity evaluation that occurs in the planning phase pursuant to 36 C.F.R. § 219.9(b). Identification of SCCs by the regional forester is a preliminary planning step. It consists of applying regulatory criteria to species in the plan area based on best available scientific information. While it requires the exercise of professional judgment, it permits no discretion by the Forest Service. It is appropriate and necessary for this determination to occur prior to most of the Assessment process. Selection of SCC may be revisited throughout the planning process as required by new information applicable to the two criteria in 36 C.F.R. § 219.9(c).

The purpose of focal species is to provide "meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area." 36 C.F.R. § 219.19. Therefore, focal species, **especially endemics,** should be part of the overall strategy for identifying species at risk and key ecological conditions, and the regional forester should play a role in identifying focal species as well as SCC. Effective monitoring may require that some SCCs be selected as focal species.

The draft Assessment report presents criteria for ecosystem integrity assessment, and states that key characteristics were established per ecosystem. It is unclear what those selected key characteristics are, because they are not listed or described in the report. The selection of key ecosystem characteristics indicative of compositional, structural, functional, and connective ecosystem integrity is vital as they will be the cornerstone for development of measurable Desired Conditions and other plan components, as well as the subject of monitoring and adaptive management strategies. Key ecosystem characteristics play an essential role in the proposed criteria for assessment: according to the criteria listed on page 10, the characteristics may exhibit ranges of variation that were either common or uncommon in the past. To some degree the key characteristics are suggested within the ecosystem write ups; we would recommend documenting the selected characteristics in one place, for example in relation to Table 2 on page 11.

The development of ecosystem specific adaptation strategies are warranted in cases where climate change is driving changes in ecological integrity. In some instances adoption of monitoring provisions may be the primary action taken, for example within alpine and subalpine systems, including monitoring of rare plants.

Evaluating the impacts of historical and ongoing (current plan) timber harvest on key characteristics of ecological integrity is an important issue for analysis. P. 12 of the assessment introduces timber harvest effects on productive old growth (POG) forest and riparian areas. This analysis frame suggests that old growth (and its structure, composition, function, connectivity) is a key system characteristic of the productive forest ecosystem type. Indicators of key characteristics of old growth are suggested on p.13 (canopy layers; interspersion of trees of multiple age classes; presence of snags, decadent trees, and fallen trees; presence of forbs; variation in amounts and distribution of live trees), yet it does not appear that old growth system integrity was evaluated against these definitional characteristics.

The Assessment report should document and evaluate the characteristics of old growth system integrity from the Tongass Old Growth Conservation Strategy[5] to support a determination of

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[5] The old-growth reserve strategy needs a thorough evaluation. While innovative for the time in the 1990's, research over the subsequent decades suggests some of the fundamental assumptions are flawed. *See*, Smith WP, Flaherty EA. *Wildlife studies on the Tongass National Forest challenge essential assumptions of its wildlife conservation*

whether that strategy needs to change to respond to new information and meet Planning Rule requirements. Clear evaluation of the effectiveness of the reserve system and corridor network, along with existing Standards and Guidelines, is necessary to support either status quo or change determinations based on principles of ecological integrity (i.e., landscape structure and connectivity). It is not clear to the reader if the Conservation Strategy is meeting Planning Rule requirements for diversity and integrity, or whether the strategy needs to be updated to accommodate climate adaptation considerations.[6]

As noted above, it is important that the Assessment evaluate ecological integrity at appropriate scales so as to enable effective plan direction. For example, the analysis of Well Drained Forest ecosystems states that these systems exhibit "overall high integrity" because "human disturbances such as timber harvest have occurred on a *relatively small portion* of this ecosystem, with a current trend toward less harvest, particularly in old-growth stands." Draft Terrestrial Ecosystems Assessment Report, 23 (emphasis added). While a measure of relative impact is of interest for understanding system condition, there is also a need to evaluate those impacts on attributes of integrity, particularly within a naturally fragmented planning area. The draft Assessment notes the effects of past harvest on key characteristics of system integrity, including less complex stand structure, less understory plant diversity, and less presence of snags and down wood debris. *Id.* at 25. As important are broader effects to landscape structure (e.g., fragmentation) and connectivity as key characteristics of integrity measured within the broader ecosystem.

The draft Assessment report states that "some areas" of well drained forest ecosystems have experienced more focused impacts (such as loss of old growth forest), and could thus be suffering from compromised integrity. Of the 430,000 acres that has been harvested on the Forest, approximately 50% occurred on the "southern third" of the Forest, with much of that impact on Prince of Wales Island. According to the draft Tongass National Forest Vulnerability assessment: "In Southeast Alaska, large-tree (old growth) forests have been reduced by 28 percent, and landscapes with the highest volume of contiguous old growth by 66 percent, with some bioregions being more heavily harvested than others. For example, on north-central Prince of Wales Island, contiguous high-volumer forest was reduced by 94 percent by logging. The legacy of this non-climate stressor will exacerbate climate-change impacts on species dependent on large-tree conifer forests." Holofsky et al., lines 4506-4514.

Ecological integrity should be evaluated through the lens of natural and anthropogenic fragmentation, species endemism, and climate change impacts. Specific geographic areas within the Forest may warrant tailored ecocultural restoration and adaptation strategies. In addition,

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strategy. The Journal of Wildlife Management 87, e22450 https://doi.org/10.1002/jwmg.22450 (2023). This effort will require a large interdisciplinary team of scientists with advanced planning and scheduling.

[6] Reporting that only 8% of old-growth forest has been harvested is a disingenuous and misleading statistic. The highest volume contiguous old-growth forest in southeast Alaska has been reduced by 66.5%. *See*, Albert DM, Schoen JW. *Use of Historical Logging Patterns to Identify Disproportionately Logged Ecosystems within Temperate Rainforests of Southeastern Alaska*. Conservation Biology 27, 774-784 https://doi.org/10.1111/cobi.12109 (2013). While the Tongass is the major public land owner in Southeast Alaska, it would be helpful to see these types of statistics presented for all landownerships. There have been data sharing MOU's created for these types of processes in the past, and it will be important to renew those relationships through this process to manage watersheds and islands as a whole.

while it is important to note that "very low levels of harvest have occurred from the early 2000s through the present" it is also important to note what level of harvest is allowed under the current plan, particularly within existing unharvested areas that have been subject to focused historical harvest and may suffer from compromised integrity (e.g., Prince of Wales Island) as there is an important planning distinction between how a plan has been implemented and how it *could be* implemented moving forward under existing plan direction.

It is important to understand what types of activities could occur within high integrity unharvested stands under the current plan, specifically where those activities may occur, and whether those activities effectively maintain ecological integrity and are not maladaptive (contribute to vulnerability). The assessment catalogues unharvested forests (well-drained, poorly drained, and riparian) as moderately vulnerable to climate impacts; but the degree to which that vulnerability may be compounded by maladaptive activities allowable under the current plan is unclear thus warranting further examination of the impacts of allowable human activities such as timber harvest and road building on the integrity of unharvested systems within a highly fragmented planning area. This type of geographic specific analysis should be extended beyond timber harvest to other potential anthropogenic stressors to system integrity such as mining, roadbuilding, and energy or other infrastructure developments.

The draft Assessment does a good job of documenting integrity conditions in previously harvested/second growth productive stands to support the development of need to change determinations and plan components. For example, unthinned post-harvest stands include key characteristics that can guide restoration; plan direction to improve understory and stand structure heterogeneity may be warranted after considering what is in the current forest plan and whether it is leading to necessary improvements in integrity. The assessment shows some ambivalence about whether to take actions to accelerate and enhance key stand characteristics of integrity, stating that unthinned stands have low ecological integrity yet "are expected to proceed through structural succession without management assistance" but that pre-commercially thinned stands have moderate ecological integrity and "tend to reach later structural stages more quickly; because tree growth increases substantially." Draft Terrestrial Ecosystems Assessment Report, 31. This same framing appears in the discussion of Poorly Drained and Riparian forests as well. More discussion is warranted on whether the current plan needs to change to facilitate actions that improve the ecological integrity of harvested and unthinned riparian forests, keeping in mind concerns over risks to aquatic resources associated with riparian silviculture treatments.

As a general matter, forest plan direction should be based on the Assessment's characterization of system drivers, including expected climate change impacts. For example, in Well Drained ecosystems, frequent fine-scale, low-intensity disturbance drives and maintains ecological integrity. Silviculture that mimics this disturbance type is warranted to maintain ecological integrity; yet, the draft Assessment report does not reveal if the current plan does so. If climate change is expected to increase the frequency and/or severity of disturbance, this should be recognized as a Need to Change the current plan to develop adaptive silvicultural practices; and spatial data indicating locations on the Forest more likely to experience these changes in disturbance regimes could support condition- or geographic-based adaptive silviculture strategies and prioritization of ecosystem adaptation management activities. This is the case in both the terrestrial and aquatic ecosystem realms.

Based on the draft Assessment report, it appears there is a Need to Change the current plan to enable cultural burning to maintain integrity in Well Drained systems, specifically to improve production of important plant species such as edible and medicinal plants and cedar. The final Assessment should use these as key characteristics of ecocultural integrity and build plan components around them and that support ecocultural Desired Conditions.

The analysis of Well Drained forests highlights the need for clear selection of measurable key ecosystem characteristics in supporting planning for diversity. The draft Assessment states that downed wood and snags in well-drained systems "are important as favorable for snag-dependent wildlife species such as marten and woodpeckers," Draft Terrestrial Ecosystems Assessment Report, 29, but neither establishes levels to support those species nor indicates if the current plan is sufficient or needs to change management of those parameters.

Plan components in Well Drained forests should also be considered for understory vegetation used by deer, non-timber forest products such as berries and mushrooms, and plant and fungi species that are important subsistence foods and sources for traditional medicine. The same recommendation applies to poorly drained ecosystems. Note that the Tlingit & Haida Adaptation Plan suggests resilience strategies for Wild Berries. Tlingit & Haida Adaptation Plan, 37 (Table 8).

The revised forest plan should result in a clear conservation and adaptation strategy for yellow-cedar given widespread mortality over 500,000 acres and clear climate stress.[7] While the draft Assessment notes current management direction for yellow-cedar, it does not forecast integrity trends based on that current direction; nonetheless it seems that there is a Need for Change to conserve this this important ecocultural system. Partnering with Tribes to incorporate strategies from Tribal adaptation plans - including conservation and management activities, assisted migration, and monitoring and reporting processes - is a good course of action for yellow-cedar. *See*, Tlingit & Haida Adaptation Plan, Table 5 ("Resilience Strategies for Cedar").

We also note that there has been more recent spatially-explicit modeling of windthrow patterns in southeast Alaska that should be considered in the final Assessment report.[8] This research suggests there are readily mappable areas where management activities should be limited to avoid adverse resource damage such as loss of riparian buffers on salmon streams. Regional

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[7] There are many more species beyond yellow-cedar with well-studied climate change effects with potential management actions. *See*, Shanley CS*, et al. Climate change implications in the northern coastal temperate rainforest of North America*. Climatic Change 130, 155-170 https://doi.org/10.1007/s10584-015-1355-9 (2015). It would be helpful to have these species and ecosystems climate concerns systematically described with the best available science with potential mitigation actions.

[8] Buma B, Barrett TM. Spatial and topographic trends in forest expansion and biomass change, from regional to local scales. *Global Change Biology* 21, 3445-3454 https://doi.org/10.1111/gcb.12915 (2015); Buma B, Thompson T. Long-term exposure to more frequent disturbances increases baseline carbon in some ecosystems: Mapping and quantifying the disturbance frequency-ecosystem C relationship. *PLOS ONE* 14, e0212526 https://doi.org/10.1371/journal.pone.0212526 (2019); Buma B, Johnson AC. The role of windstorm exposure and yellow cedar decline on landslide susceptibility in southeast Alaskan temperate rainforests. *Geomorphology* 228, 504-511 https://www.sciencedirect.com/science/article/pii/S0169555X14005169 (2015).

experts in wind and landslide modeling should be invited to participate on a technical mapping team.

C. *Threatened, Endangered, Proposed, Candidate Species.*

The draft Assessment appropriately notes the indirect relationship between the Forest and the federally recognized marine species. The revision of the forest plan provides an opportunity to review existing plan direction for these species in light of any relevant new information including information gleaned from engagement and coordination with National Marine Fisheries Service during the planning process. This initial engagement step will provide an opportunity for the consulting agencies to begin contributing information that may be used to design the proposed action.

Existing plan direction should be evaluated in light of requirements for federally recognized species in the 2012 Planning Rule. 36 C.F.R. § 219.9(b) of the rule requires that forest plans provide ecological conditions that contribute to the recovery of federally listed threatened and endangered species and conserve proposed and candidate species (as is the case with the Sunflower sea star). While those updated regulatory requirements may not materially change the existing plan direction, the revision provides an opportunity to carefully examine the Forest's broad role in "contributing to recovery" of listed species. Section 23.13a of the planning directives offer good guidance on thinking about plan components for recovery including "Work beyond the plan area boundary to collaborate and cooperate with U.S. Fish and Wildlife Service, National Marine Fisheries Service, States, Tribes, other partners, landowners, and land managers to support an all-lands approach to species recovery."

There is a need to change the current plan to recognize the Sunflower sea star, which was proposed for federal listing in 2023. Information summarized in the "Population-level drivers and stressors" section, as well as the underlying status review report should be used to develop plan direction to conserve the species. As with listed species, close engagement with the consulting agencies and other relevant partners should result in development of effective plan direction.

D. *Species of Conservation Concern.*

It is important to integrate the ecosystem level analysis (terrestrial and aquatic) with the SCC analysis. The draft SCC Assessment states: "Most species will be maintained by plan components in the revised plan…that maintain broad level ecosystem integrity and diversity." Draft SCC Assessment Report, 5. This can only be the case if coarse-scale plan components provide the conditions necessary for viability. As noted in our comments on the draft Terrestrial Ecosystem Assessment, at this stage it does not appear that key characteristics for system integrity have been systematically selected, thus making it difficult to evaluate whether coarse-filter plan direction would provide necessary conditions for at-risk species. Many plans revised under the 2012 planning rule have crosswalked the habitat needs of individual species with ecosystem characteristics to display how coarse-filter strategies will meet species-specific needs, and the Tongass should do the same.

The draft SCC Assessment lacks key information to enable effective public comment. For example, under the "Methods" section, it states that the Forest "developed a process paper that describes the identification of SCC" for the revision; the reference is "Species of Conservation Concern identification process for Land Management Plan Revision" but we could not locate this document online. The Plan Revision Library and Supplemental Information page, under the SCC Process tab, states that information is "coming soon" despite the draft Assessment stating that "more detailed information on the process of identifying SCC can be found on the Tongass National Forest Plan Revision webpage."

As such, it is difficult to comment on the process undertaken to identify and filter the potential SCC. We understand that 416 initially identified Species to Consider were filtered down to 254 "Species Under Review." It appears that criteria regarding whether the species are native and known to occur on the Forest were applied at this stage, along with ESA-listed or -candidate species. "Known to occur" determinations can be complex and nuanced, so it is therefore important that external parties have access to these screening processes to weigh in and provide effective comment.

The draft Assessment states that 18% of terrestrial wildlife species were not carried forward into the Species Under Review List, including for possibly not meeting NatureServe ranking or local concern criteria. This also applied to 83% of the screened out aquatic species. It is important for the public and others to understand how those criteria have been interpreted and applied. For example, the planning rule Directives state that species with status ranks of G/T3 or S1 or S2 on the NatureServe ranking system "should be considered" as potential SCC. Species with those NatureServe ranks are automatically "of concern" in that they are not "secure" across their range and may be vulnerable or at-risk, including within the Tongass planning area. In those cases, the Forest would determine that notwithstanding established definitive broad concern regarding those species, a determination was made that the species was "secure" within the planning area. While making such a finding is legitimate, it warrants careful and transparent analysis.

Similarly, the "local conservation concern" direction is intended to pick up species that do not appear on definitive lists of concern where additional information indicates such concern in the planning area. In all cases where species have been filtered out of the process, it is imperative that the Forest be able to support a conclusion that the species is "secure" within the planning area after considering all stressors. Documentation should be made publicly available to support any determinations that Regional Forester Sensitive Species that have already been determined to be at-risk are now determined to be secure within the planning area.

Careful attention should be given to determinations that there is insufficient scientific information available to determine if there is substantial concern in the plan area, or if the species are secure. According to the draft Assessment, 65% of species fall into this category. However, for species already identified definitely by NatureServe as being not secure, sufficient scientific information indicating concern *is already available*. As noted, if there is new information that indicates a once not secure species is now secure, the Forest Service must make that information publicly available.

The draft Assessment notes that the Alexander Archipelago is made up of over 5,000 islands and that the Tongass is "naturally fragmented by islands and steep glacial terrain with glacial fjords and major river systems dissecting the mountainous mainland region." Draft SCC Assessment Report, 11. Such natural fragmentation results in "distinct climatic, botanical, and faunal differences" and "many endemic subspecies and genetic lineages." *Id.* This natural fragmentation and endemism has been compounded by fragmentation and ecosystem degradation associated with human activities such as logging and road building. Natural ecosystem fragmentation and endemism are important factors to take into account when making SCC determinations. The Directives recognized this key issue when highlighting that local conservation concern determinations could be warranted in cases of: "Restricted ranges (with corresponding narrow endemics, disjunct populations, or species at the edge of their range." FSH 1909.12. Wildlife inhabiting areas that have been strongly affected and degraded by human activities should be carefully evaluated for triggering local conservation concern and potential SCC status.

The draft Assessment report describes current management practices, stating that existing plan components "include protections for all types of ecosystems, general wildlife, and some specific species" as well as the Tongass Old Growth Conservation Strategy. Draft SCC Assessment Report, 12. An appropriate process to evaluate the Need to Change existing plan direction would be to document the ecological conditions necessary for the viability of each SCC and crosswalk those with existing plan direction for ecosystems; this should also be done in the ecosystem assessment for key ecosystem characteristics and their natural range of variation. By documenting the specific ecological conditions necessary for SCC viability, and factoring in climate impacts, existing coarse filter components can be evaluated for need to change, and the need for additional species–specific (fine-filter) components can be identified.

E. *Watershed Condition and Water Resources.*

Chapter 4 of the Tongass National Forest Climate Change Vulnerability Report (Halofsky et al. 2024) lays out a driving question for assessing the need to change the current land management plan: "There is considerable concern about the impacts that climate change will have on watersheds that drain the TNF, and the capacity for these watersheds to sustain healthy salmon populations in the future." Halofsky et al. 2024, lines 781-783. Given that Southeast Alaska's economy, culture, forest health, and communities depend on healthy salmon habitat and populations, wild salmon are arguably the most important "output" on the Forest: thus, a revised plan that prioritizes protection of unimpaired watersheds and restoring natural watershed processes is essential.

Prioritization of protection, adaptation, and restoration activities based on analysis and robust community engagement will be of vital importance in the revised plan, given the number of watersheds on the Forest (921 subwatersheds) and limited resources.

Bellmore et al. recommend prioritizing conservation of unimpaired watersheds that support current and expected future salmon productivity. Updates and additions to the 77 high value salmon and trout watersheds identified in the 2016 forest plan amendment should be made as needed based on new information and analysis of present and future conservation value, for example areas of projected climate refugia and in those glaciated systems forecast to become more productive. Bellmore et al 1970. The Forest Service should incorporate metrics of salmon habitat productivity into the revised forest plan through plan components and monitoring provisions, and should guide both conservation and watershed/aquatic ecosystem restoration planning and decision making.

One issue warranting further analysis is whether existing forest plan riparian buffers are sufficient to maintain watershed/aquatic habitat integrity given climate change impacts and considerable concern over watershed and salmon population conditions on the Forest. An analysis of the effectiveness of those buffers is likely warranted given that they date from the early 1990s and may not reflect best available science. The 2021 Planning Rule requires that "The plan must include plan components, including standards or guidelines, to maintain or restore the ecological integrity of riparian areas in the plan area, including plan components to maintain or restore structure, function, composition, and connectivity" and "Plans must establish width(s) for riparian management zones around all lakes, perennial and intermittent streams, and open water wetlands." 36 C.F.R. § 219.8(a)(3).

The Directives appropriately note that forest planning teams should evaluate "the effects of climate change on stream flows that may affect the size of riparian management zones" when considering widths. FSH 1909.12 Chapter 20. The forest planning team may consider reviewing portions of Chapter 7 of the *Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area* (PNW GTR 966); that chapter (*The Aquatic Conservation Strategy of the Northwest Forest Plan - A Review of the Relevant Science After 23 Years*) includes a thorough discussion on emerging science concerning riparian zone delineation and management that is likely relevant to the Tongass plan area. However, riparian areas can be difficult to delineate, and "The current spatial distribution of riparian stands across the Tongass National Forest is undetermined, with only approximations provided from spatial modeling, without sufficient field or aerial verification." Halofsky et al., lines 2721-2726.

While the draft Assessment states that all subwatersheds are functioning properly as evaluated under the Watershed Condition Framework, it found that some subwatersheds are bordering on functioning at risk and exhibiting certain indicators rated as fair or poor, including red flags for aquatic habitat conditions, riparian and wetland vegetation condition, and roads and trails condition. Draft Watershed Condition and Water Resources Assessment Report, 12. The report goes on to say that aquatic habitat conditions have declined in 41 subwatersheds (mostly due to acquisition of degraded lands via land exchange) while 6 subwatersheds saw declines in wetland vegetation conditions. *Id*. at 15.

This information suggests that the revised plan may need to update priority watersheds for restoration with updated watershed restoration action plans (WRAPs) to target specific degraded habitat and vegetation conditions in priority areas. The draft Assessment report references new priority watersheds that have already been identified, including those that overlay with the T77 watersheds. Updating and expanding the priority watershed work would build on the success of the Forest's existing WRAP program (which has completed the second highest number of action plans within the NFS), and take advantage of strong partner and community support for watershed restoration.

About five percent of the Forest's riparian forests have been harvested, much of which occurred within sensitive process groups that also contain high quality fish habitat. Draft Watershed Condition and Water Resources Assessment Report, 16. According to the report, *timber harvest* in riparian areas was only expected to affect 10 acres per year, under the 2016 amendment. *Id.* Elsewhere the draft Assessment documents riparian vegetation treatments declining over time and only affecting 20 acres per year since 2017, within young-growth stands (presumably previously harvested stands). The final Assessment should differentiate between purposes, needs, and impacts of timber harvest versus riparian vegetation treatments. Presumably, harvest is the purposeful removal of trees for wood fiber use (and perhaps other multiple use purposes), whereas vegetation treatments are for ecological purposes and do not include a commercial component. Considering declines in riparian vegetation conditions in certain watersheds, there is an opportunity in the revised plan to establish plan direction to increase the number of riparian vegetation improvement projects that are designed (and monitored) to improve riparian area integrity. Given risks to riparian areas under certain management activities, including road building, it is important that the revised plan set robust components governing restoration of riparian vegetation for integrity and habitat improvement purposes. In the same vein, it is important to note that passive management in degraded riparian areas may miss opportunities to enhance key ecological processes, including developing desired structural conditions (see comments on draft Terrestrial Ecosystem Assessment).

The assessment notes trending declines in the number of aquatic and restoration projects accomplished on the Forest, including declines in treating problematic road stream crossings, Draft Watershed Condition and Water Resources Assessment Report, 19, and aquatic habitat improvement projects, *id*. 17. Declines seem related to accomplishment of initial priority restoration and improvement activities followed by a lack of subsequent priorities. A revised forest plan provides an opportunity to set new priorities and objectives for aquatic and watershed restoration activities. If one of the issues is capacity to accomplish restoration activities, Goals, Management Approaches, and other plan content can articulate strategies to work with partners - particularly Tribal partners - to improve capacity to accomplish aquatic habitat and watershed restoration objectives. The Planning Rule encourages "optional plan content" including "partnership opportunities or coordination activities." 36 C.F.R. § 219.7(f)(2). We encourage the Forest Service to engage with local and Tribal communities to develop these strategies.

We noted that the draft Assessment provided no specific metrics on road decommissioning, yet it appears that this activity did contribute to improvements in road and trail conditions in over 100 subwatersheds. Draft Watershed Condition and Water Resources Assessment Report, 15. The revised plan offers an opportunity to establish new priorities and objectives for road decommissioning as a key factor within the Watershed Condition Framework, where appropriate and warranted to improve watershed condition, integrity, and function.

Updates to the watershed components of the forest plan monitoring program may also be warranted. For example, Bellmore et al. suggest "key characteristics" for monitoring including shifts in flow, temperature, habitat, and aquatic food-web conditions. The authors suggest identification of "focal watersheds" for more intensive monitoring of watersheds and salmon populations. The revised forest plan can use Goals to articulate the types of monitoring and research partnerships that are necessary to accomplish this work. 36 C.F.R. § 219.7(e)(2) (Goals are optional plan components that are "broad statements of intent, other than desired conditions, usually related to process or interaction with the public").

Certain wild salmon populations should also be considered as Focal Species under the revised forest plan monitoring program. While the draft Assessment does not consider this opportunity, doing so may be warranted based on the functional role that salmon play in maintaining watershed, aquatic and terrestrial system integrity, along with significant contributions to regional social and economic sustainability.

F. *Aquatic Ecosystems.*

In noting that the previous plan "did not evaluate the ecosystem integrity of the Tongass National Forest ecosystem as a whole," the draft Aquatic Ecosystems Assessment report identifies that the plan revision provides an opportunity to emplace direction for the integrity of the Forest's aquatic ecosystems. The Need to Change the current plan is thus quite evident, yet still relies on an evaluation of the performance of the current plan against an ecological integrity benchmark. The driving question for planners and stakeholders at this stage is: How is the current plan performing against benchmark characteristics of aquatic system integrity? The components of the system - the key ecosystem characteristics - are used in the analysis as reference benchmarks for evaluating the need to change the current plan to best meet planning rule requirements.

When assessing ecosystem integrity under the 2012 Planning Rule it is useful to, at the outset, clearly establish the key system characteristics - whether they be compositional, functional, or structural at varying and relevant ecological scales; doing so helps the planning audience understand the logic of the analysis. Overlaying and analyzing drivers and stressors on those selected characteristics then allows for the development of targeted plan components. Of course, in the real and messy world of ecology, it is not always simple to neatly classify ecosystems in this manner.

The need for a clear ecosystem management framework is more pronounced in systems that respond to and that are subject to management intervention (i.e., actions that manipulate elements of system composition, structure, or function). And changes in generally unmanaged systems, such as glacier systems responding to changes in system drivers, can have profound impacts on connected systems that are the subject of management frameworks. The examples of glacier reduction increasing potential salmon habitat or exposing access to mineral development are noted in the assessment. The draft Assessment does a good job of framing this interconnectedness.

River and stream systems on the Tongass are subject to management frameworks, although the draft Assessment, in various places, notes the relatively small footprint of Forest that has been subject to management intervention. It is also worth noting that the absence of historical management action does not necessarily translate into system functionality, as this is the subject of climate adaptation strategies and interventions that respond to system vulnerabilities, even within systems that have not been subject to historical management.

The rivers and streams section of the draft Assessment rightly focuses on the fact that the Tongass is a salmon forest. The revised plan should center and highlight the role of salmon in defining the Forest's "Distinctive Role and Contribution" within the broader landscape of Southeast Alaska (and beyond). Centering the plan revision around salmon will effectively integrate social, cultural, economic, subsistence, and ecological elements of the plan.

The draft Assessment references anthropogenic threats to aquatic system integrity on the Forest, including road building, mining, timber harvest, landslides, dams, and invasive species. These are the management domains that can be governed by the revised forest plan. Yet the draft Assessment does not point to areas in the current plan that may need to change. A summary key finding states that "Development, including timber harvest, mining, and roads may alter aquatic ecosystem integrity at a localized scale." Draft Aquatic Ecosystems Assessment Report, 26. The issue of scale is important here and should be fully fleshed out to understand the effects of the current plan on integrity. The implication seems to be that local impacts to integrity are acceptable given the function of the larger system; however, the function of the assessment and planning process is to demonstrate that plan implementation maintains or restores system integrity (either the current or the proposed plan). Second, degradations of integrity at "local" scales can still have significant implications for system function; the Forest Service should address this relationship and the issue of scale in the final Assessment.

To determine what Needs to Change in the current plan, it is necessary to understand how (and where) these potential stressors are affecting characteristics of system integrity. The draft Assessment states that "Best management practices are used to reduce effects to ecosystems; however, some influences continue to have short- and long-term impacts on the function and condition of ecosystems." Draft Aquatic Ecosystems Assessment Report, 14-15. The Forest Service must expand the discussion of the use of "best management practices" to maintain or restore aquatic ecosystem integrity. Is this a reference to plan components in the existing plan? The planning directives make it clear that the assessment should evaluate "on the ground conditions and estimate the trends, assuming the existing plan remains in place…." FSH 1909.12 Chapter 10. However, there does not appear to be a Status and Trends analysis section in the rivers and streams section of the draft Assessment that evaluates the effectiveness of current plan direction in either maintaining or restoring the selected key characteristics of aquatic system integrity. This analysis will be necessary to make determinations to change or add plan direction to the current plan.

In our experience, we have found that tables (or other means of organizing and presenting complex information) that clearly crosswalk current plan direction with key system characteristics and their measures of integrity (i.e., estimated natural ranges of variation) are useful heuristics for this type of analysis. The Forest Service is encouraged to uses these tools in the final Assessment.

As in the Watershed Condition and Water Resources draft Assessment report, the draft aquatic system Assessment notes the effects of human activities on aquatic system integrity, including degradation of riparian areas due to timber harvest. This report adds additional information regarding degraded previously-harvested riparian areas by noting that "large wood is decreasing in all streams, regardless of management history" and that "fish may have greater opportunities for refuge from late summer, low flow conditions in watersheds with greater than 42% old growth." Draft Aquatic Ecosystems Assessment Report, 15 (*citing* Filtcroft et al. 2022). This information reinforces the opportunity to: 1) examine options for designing plan direction to improve ecological conditions within riparian areas; and 2) to maintain and restore old growth conditions, particularly in watersheds that may be depauperate in that structural condition, as a strategy to conserve fish populations.

The karst section of the report does include a discussion of status and trends, and suggests potential implications of the current plan on system integrity. For example, "Evidence suggests that timber harvest increases available surface waters, thereby increasing sediment and debris transport capabilities and flooding passages which have not flooded for centuries." Draft Aquatic Ecosystems Assessment Report, 19. This conclusion implies an impact to functional integrity based on process measurements that depart from the natural range of variation, and thus may have implications for overall system integrity (and may be a Need to Change).

The Forest Service does note that implementation of the current plan on karst system integrity may not be causing deleterious effects: "Current harvesting techniques leave the slash within the unit, which helps to protect the shallow fragile soils from erosion and drying." Draft Aquatic Ecosystems Assessment Report, 19. This suggests that perhaps the current plan direction for slash retention is effective, and may not need to change; but this analysis of the effectiveness of current plan direction can be presented in a more direct manner.

On the other hand, elsewhere the draft Assessment suggests that the current plan is *not* maintaining system integrity for key characteristics, including soil structure and function with implications for regeneration:

> A considerable percentage of the easily accessible low-level karst areas have been harvested. Timber harvest is now moving onto steeper, higher elevation karst areas which are characterized by shallower, better-drained soils. Observations suggest that with harvest atop these soils, much of the soil may be removed if adequate log suspension is not achieved. Often, only a thin organic mat covers the karst. The exceedingly shallow soils become excessively dry once the protective forest canopy is removed. The high rainfall of the area can rapidly move these fragile soils into the well developed epikarst. Observations suggest that these steeper, higher elevation karst areas show less than desirable regeneration or remain as bare rock slopes within harvested units.

Draft Aquatic Ecosystems Assessment Report, 19. The observed regeneration problems in steep, higher elevation karst areas suggest that such areas may not be suited for timber production or timber harvest for other purposes. The Planning Rule at 36 C.F.R. § 219.11(a)(v) states that if there is "no reasonable assurance that such lands can be adequately restocked within 5 years after final regeneration harvest" those lands shall be identified as not suited for timber production. Similarly, 36 C.F.R. § 219.11(d)(2) states that non-production based timber harvest can only occur "where soil, slope, or other watershed conditions would not be irreversibly damaged" and (d)(3) requires that harvest "be carried out in a manner consistent with the protection of soil, watershed, fish, wildlife, recreation, and aesthetic resources." The final Aquatic Ecosystems

Assessment report should clarify whether the Forest Service should designate these karst lands as not suitable for timber production in the revised plan.

G. *Timber Resources.*

The draft Timber Resources Assessment report appropriately notes not only the importance of the timber resource to the socioeconomic setting of the plan area (as well as its decline), but also that suitability determinations, sustained yield limits, and projected wood and timber sale quantities will be calculated based on the proposed action and alternatives for the revised plan. Other draft Assessment chapters are beginning to examine where the current plan may need to change to meet Planning Rule requirements. We note that managing timber resources must be integrated with other multiple use objectives as required by NFMA and the 2012 Planning Rule. *See*, 36 C.F.R. § 219.11 ("*While meeting the requirements of 219.8 through 219.10*, the plan must include plan components…regarding timber management" (emphasis added)).

This draft Assessment properly includes a discussion of the effectiveness of implementing the current plan (which is missing in many other draft reports), as it suggests potential Needs to Change in the revision. One such Need for Change is better integration of the young growth management strategies into revised forest plan. For example, the draft Assessment notes that forest management and timber harvest goals found in the 2016 plan were not achieved due to a "variety of factors including budgets, staffing, shifting management priorities, and litigation." Draft Timber Resources Assessment Report, 7 (*citing* 2023 Meridian Institute report). The Meridian Institute report found that the 2016 amendment (which was developed under the 2012 Planning Rule) did not effectively integrate with the base plan developed under the 1982 Planning Rule.

In addition to updating the young growth strategy based on implementation experience,[9] there remains a need to integrate the 2016 amendment with updated surrounding content under the 2012 rule framework. One of the prime challenges of the 2016 amendment was drawing boundaries between the amended content and the remainder of the 1982 Rule-era plan given the interconnected nature of the 2012 Planning Rule. Understanding whether conflicts or discrepancies occurred over the past 8 years of implementation between the 2012 Planning Rule and older direction is necessary to formulate an accurate Need for Change.

The draft Assessment notes that precommercial thinning (PCT) presents opportunities for integrating ecological and economic objectives, including aquatic and terrestrial wildlife habitat

[9] A more in-depth discussion of the ecological condition and impact on the hundreds-of-thousands of acres of young-growth forests with deferred maintenance (i.e., no thinning and hanging culverts) seems warranted in the Ecosystems Assessment. There are dozens and dozens of studies that should be synthesized to a succinct set of concerns and management tools to address them. *See*, Gilbert SL*, et al. Potential Futures for Coastal Wolves and Their Ecosystem Services in Alaska, With Implications for Management of a Social-Ecological System*. *Frontiers in Ecology and Evolution* 10, https://www.frontiersin.org/journals/ecology-and-evolution/articles/10.3389/fevo.2022.809371 (2022); Person DK, Brinkman TJ. Succession debt and roads. *North Pacific temperate rainforests: Ecology and conservation*, 143-167 (2017); Committee WT. *Interagency Wolf Habitat Management Program: Recommendations for Game Management Unit 2*. Management Bulletin R10-MB-822. USDA Forest Service, USDI Fish and Wildlife Service, and Alaska Department of Fish and Game. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd537975.pdf (2017).

enhancement. However, the draft Assessment documents that 6,000-8,000 acres of PCT is needed per year within the 85,000 acres that are in need of that treatment.[10] The Meridian 2020 (PCT Task Force Recommendations Report) and 2023 (5-Year Review of the 2016 Amendment) reports offer suggestions on how to better meet PCT objectives. Several of those suggestions could be embedded in the revised plan, including use of plan direction to highlight the importance of PCT to achieve multiple resource benefits and prioritization of PCT where those benefits will be greatest. The PCT Task Force suggested that advancements in remote sensing could be employed to support prioritization; that data and analysis could be integrated into the revised forest plan. Desired Condition DC-YG-01 of the amended plan states that "Treatments occur where highest productivity, harvest operability and access is favorable," which could be modified to include additional resource priorities in the revised plan.

One of the challenges raised in the 2023 Meridian report was budget uncertainty. This raises issues with the vagaries surrounding implementation of a forest plan: for example, planning objectives are to be based on "reasonably foreseeable budgets," 36 C.F.R. § 219.7(e)(ii), yet in the real world budgets may be less than reasonably foreseeable, even if based on trend analysis of recent budget obligations. Offering a range of objectives tiered to different potential budget scenarios is one method to provide for necessary adaptive flexibility.

At this early stage in the planning process it can be challenging to foresee where integration issues and tensions may be surfacing, although there are known touchpoints that can be emphasized in analysis and engagement with the public. One such area is the relationship and compatibility between timber production suitability and the achievement of desired conditions and objectives. In the current (2016) analysis, 393,648 acres were recognized as unsuited for timber production because it is not compatible with other plan components. At the Assessment stage it would be useful to begin to understand if those plan components may be subject to change (either more expansive or diminished) given new Assessment information or due to other factors. It is also likely that climate change impacts are altering system conditions such that previous determinations of production compatibility have now changed: an example of this would be new information on the ability to adequately restock stands in light of changing climatic conditions.

The draft Assessment suggests that even-aged management (typically clearcutting) can be compatible with landscape mosaic (structure or pattern) that is desired for resource protection. Draft Timber Resources Assessment Report, 16. This suggestion is worth more discussion in the final Assessment report, particularly in thinking about the compatibility and effects of even-aged management systems on terrestrial system integrity, at relevant spatial scales (including how regeneration harvests and climate informed reforestation can be used strategically to further cedar adaptation strategies). There could be an opportunity to integrate elements of spatial landscape design with harvest objectives, perhaps taking advantage of new spatial inventory and analysis capacity. *Id*. at 14, FN 2. In young growth, existing DC-YG-03 states that "Harvesting of young growth stands provides opportunities to improve or maintain fish and wildlife habitat by accelerating old growth conditions." The revised plan could include additional direction for

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[10] The draft report notes that young growth suitable for commercial harvest will come online around 2030. Draft Timber Resources Assessment Report, 27. The revised plan must take this into account when developing plan components and harvest schedules.

fish and wildlife habitat that establishes metrics for evaluating habitat improvement (for example by including necessary habitat characteristics for SCC). The same premise applies to DC-YG-04 by establishing or updating fish and wildlife habitat improvement metrics for riparian ecosystems.

PCT can also accelerate timelines for achieving commercial thinning viability by 10 years (from 70 without to 60 with PCT), while improving indicators and characteristics of ecological integrity. Opportunities for commercial thinning on the Forest may be expanding given more research into the practice. For example, a recent publication by Crotteau et al (2022)[11] may be of interest as it discusses findings associated with results of CT on overstory and understory development, among others. The draft Assessment notes that within the 410,000 acres of inventoried young growth on the Forest, 8,750 acres is considered commercially viable in 2026 for a total of approximately 198 MMBF. More discussion is warranted in the final Assessment on what portion of that cohort may be viable for commercial thinning and how that method could contribute to other revised forest plan direction.

Halofksy et al. supports PCT activities and suggests that the "Recent transition towards predominantly young-growth forest management supported by restoration of previously clearcut forests should accelerate return of old-growth forest functions and enhance future climate resilience for Tongass NF wildlife species." Halofsky et al., lines 4378-4381. The final Assessment should discuss the use of PCT and other harvest methods to accelerate development of old-growth forest structures and functions in light of changes in climate stressors.

The draft Assessment identifies other Needs to Change, including the need to develop plan components for land now managed as the Tongass National Forest as a result of a large land exchange, the departure of SeaAlaska from the timber industry, the Southeast Alaska Sustainability Strategy, new information presented by climate change, a new timber demand study (which is scheduled for completion in March 2025), and a smaller harvestable landbase in response to resource protection concerns. The draft Assessment notes that the current plan is unclear on direction for salvage harvest thus clearly indicating a need to change and an opportunity to balance and integrate ecological adaptation strategies that respond to changing drivers and stressors in forest systems (insect and disease outbreaks) with management tools such as salvage harvest that focus on recouping economic value. Finally, the draft report highlights the concerns with yellow-cedar regeneration and sustainability due to climate change: given the importance of yellow-cedar to Tribal communities, the revised plan must include plan components to address this cultural need.

As with many other resources, the draft Timber Resources Assessment report notes that partners - especially co-stewardship with Tribes - can help ameliorate some of the workforce and capacity constraints experienced in the plan area. It explains:

> To meet future opportunities and fill employment demand in the industry, the maintenance of a trained timber and restoration workforce is critical. Several workforce

[11] Crotteau, J.S.; D'Amore, D.V.; Barnard, J.C. 2022. Commercial thinning strategies in Southeast Alaska: establishment and effects of the Prince of Wales commercial thinning study. Gen. Tech. Rep. PNW-GTR-1012. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 77p.

development and training programs have been implemented to help recruit, train, and retain local employees (Meridian Institute 2023). Examples of these include agreements with the State of Alaska Division of Forestry, Prince of Wales Vocational & Technical Education Center, Alaska Youth Stewards, the 2016 Forest Academy, hiring initiatives through the ANILCA, and various community native forest partnerships such as Hoonah Native Forest Partnership, Klawock Indigenous Stewards Forest Partnership, and Keex' Kwaan Community Forest Partnership.

Draft Timber Resources Assessment Report, 25. The draft Assessment goes on to highlight additional opportunities to co-steward with Tribes:

> The Tongass timber management program has offered several recent workforce development and skills enhancement opportunities in the local communities. One notable example is the Forest Academy, held periodically on Prince of Wales Island. The first two Forestry Academies in 2016 and 2017 were the result of a Challenge Cost Share Agreement between the Tongass National Forest and State of Alaska. These initial academies were designed to train locally recruited residents a variety of technical skills in natural resource management such as timber stand inventories and collection of aquatic, wildlife, and cultural resource information. Twenty residents participated in the 2016 and 2017 academies with the majority applying their learned skills in seasonal or permanent jobs with the State of Alaska, USFS, Sealaska, or local forestry contractors. Following the successes of the 2016 and 2017 academies, the Tongass hosted a follow up multi-week Forest Academy in 2019 that included a week of forestry skills, a week of aquatic organism passage survey methods, and a week of learning aquatic habitat mapping techniques. The 2019 academy had sixteen participants and was partially led by four previous academy participants now serving as teachers and field assistants to USFS staff. These Forest Academies have led to additional trainings and workshops with an increasing range of partners, including local community forest partnerships and conservation based non-profit organizations, to continue providing forestry and natural resource management training and workforce development opportunities for residents.
>
> The Alaska Youth Stewards (AYS) is an employment program for rural and Indigenous youth of Southeast Alaska. AYS offers place-based on-the-job experiential education and training to care for our lands, waters, and communities, with varied projects focused on stream restoration, community harvest efforts, forest inventorying, and a suite of other forestry projects.

Id. at 30. The draft report also notes that authorities such as stewardship contracting and Good Neighbor Authority can provide local jobs and stewardship opportunities, and we strongly encourage the Forest Service to include plan content in the revised plan that incentivizes the use of these authorities and to right-size projects using them to serve local community needs.

H. *Soil Resources.*

The draft Soil Resources Assessment report provides a good description of landforms and processes related to the soil resource. While the report could have been more upfront regarding the existing plan direction relating to the protection of the productivity of soil resources, the draft Assessment does eventually disclose that based on "extensive" soil monitoring over the past 35 years (the nature of which is not disclosed[12]), that the Tongass believes that management actions are meeting those requirements. Draft Soil Resources Assessment Report, 14. Noting that vegetation management (timber harvest) and road construction have the greatest deleterious effects on soils, the draft Assessment posits that based on that monitoring, that nutrient rich soils on the Forest may be more resilient to disturbance than initially believed.[13] *Id*., 14-16.

In sum, the draft Assessment concludes that there is *no* Need to Change the existing forest plan provisions pertaining to the soil resource. Draft Soil Resources Assessment Report, 15. However, at the same time, the report acknowledges that climate change is likely to change how carbon is sequestered in soils, and given that most carbon on the Forest is soil carbon, there is room for improvement in plan components that serve to conserve soil function and process: the Forest Service should address this issue in the final Assessment.

Similarly, the draft Assessment only briefly mentions the potential for climate change to exacerbate existing concerns regarding invasive plant species that may compromise soil ecological integrity. Draft Soil Resources Assessment Report, 17. This, too, is an issue the agency should consider addressing with climate mitigation-focused plan components in the revised plan.

I. *Recreation & Tourism Resource.*

This draft Assessment report emphasizes the importance of sustainable recreation management to balance ecological, social, cultural, and economic needs as well as the importance of recreation and different forms of tourism to the Alaska economy. As opposed to some draft Assessments, this report includes several explicit Needs to Change:

- The current plan does not contemplate or address the evolution of the recreation and tourism industry (particularly the growth of the cruise ship industry and its traffic) and the advancement of recreation-based technology (e.g., more powerful snowmachines), which are compromising ecological integrity of the Forest;
- There is a need for more interpretive information and infrastructure (including signage and information in Native languages);
- Existing recreational sites are difficult and expensive to maintain, and the Forest is not keeping up with the need to maintain these sites;

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[12] The draft Assessment also notes that the Forest is studying the effects on soils from the harvest of root wads for restoration purposes. Draft Soil Resources Assessment Report, 17. This is interesting work, and the agency is encouraged to share the results with the public and to consider engaging partners, particularly Tribal entities, in this work.

[13] While this may be true for nutrient rich soils, this statement presents an incomplete picture: elsewhere the Forest notes that Karst soils are not resilient to disturbance and risk the permanent loss of productivity. *See*, Draft Aquatic Ecosystems Assessment Report, 19. In the final Assessment, the Forest Service should ensure that its various subject matter experts are aware of the findings of other subject matter experts and should present a unified conclusion regarding effects of the current plan on the various natural resources.

- There is a need to address unsustainable off-road vehicle use that is harming soils, vegetation, water, and other resources;
- There is a need for boat access for the public and Tribal needs;
- There is a need for new infrastructure at Tribal request;
- There is a need for additional trail connections between communities and more recreational trail access overall;
- There is a need to address an increase in recreational pressure (stressor) facilitated by social media, which is drawing increased visitors to increasingly remote and fragile locations. In addition to compromising the ecological integrity of these areas, increased non-Indigenous access to some areas has resulted in the destruction and theft of cultural resources important to Tribes;
- There is a need to address climate change and how it is affecting all resources on the Forest;
- There is a need to address the changing seasonal and duration recreational use of the Forest and its surrounding waters;
- Increasing recreational use is leading to user conflicts, including conflicts between Indigenous populations and the general public, and voluntary segmentation of uses does not appear to be addressing the issue;
- There is a need to streamline the outfitter and guide permit process, and to institute a Tribal preference program;
- There is a need to protect wildlife from increased recreation stressors;
- There is a need to address declining air quality around cruise ship ports and other infrastructure where vehicular access/use is concentrated;
- There is a need to address the conflict between Tribal cultural and subsistence uses of the Forest with non-Tribal recreation and tourism use;
- There is a need to increase Tribal co-stewardship opportunities; and
- There are conflicting user expectations regarding access to recreational and tourist opportunities, with many Tribes expressing both concern about increased non-Tribal access to sensitive sites and the desire for Indigenous-led tourism businesses and cultural tourism opportunities.

The draft Assessment goes on to explain:

> Some of the important themes to emerge from these conversations include: a desire for diverse recreational opportunities across the forest; the importance of recreational infrastructure and the need for maintenance of existing infrastructure; the need to minimize recreational impacts on subsistence opportunities; a desire for increased education on responsible recreation; a desire for increased flexibility in permitted uses on the forest; the need to preserve the natural environment and wilderness character of the forest; and the need for balance between use, preservation, local recreational use of the forest, and forest-based tourism (USDA 2024, Summary of public feedback).

Draft Recreation & Tourism Resource Assessment Report, 24. These illustrative Needs to Change the existing forest plan provide excellent fodder for the development of plan components to address the identified stressors and facilitate the partnerships that the Forest Service will need to be successful in meeting public and Tribal expectations for sustainable management of the Forest.

While this draft report captures well the Need to Change the current forest plan, the report also acknowledges that it has not collected comprehensive data since 2019, the year before the covid pandemic. Draft Recreation & Tourism Resource Assessment Report, 20. While some information is available showing a general rebound in tourism to the Tongass, given the importance of tourism and recreation to the Forest, the agency should present more current data to inform the revision process.

The draft Assessment is also candid that the Forest is unable to meet many of the recreation and tourism needs on the Tongass, and that partnerships are essential to meeting this demand:

> In the recent past, the amount of money the Forest Service has dedicated to these recreation-related partnerships has been second only to the amount of money dedicated to road maintenance partnerships (Huber-Stearns, 2020). The need has been identified, however, for increased Forest Service involvement with partner organizations to meet the growing recreational demands placed on the forest. The 2022 Tongass National Forest Sustainable Trails Strategy calls out a need for increased Forest Service investment in partner organizations on a monetary and relational level. This is particularly important in the many rural areas and smaller communities of Southeast Alaska where populations aren't as large and the capacity for partnership work may not be as developed as it is in larger communities (Alaska Trails 2022, p. 5-13).

Draft Recreation & Tourism Resource Assessment Report, 35-36. Similarly,

> Ideas identified in the Sustainable Trails Strategy for fostering these partnerships include creating a culture of responsiveness in the Forest Service when approached by partners, sending Forest Service staff to participate in partner planning processes, sharing training resources among partners, regular Forest Service consultation with partners, and including partners in internal Forest Service planning processes (Alaska Trails 2022, p. 14). An additional idea for partnership generated during the Sustainable Cabin Strategy planning process was for the establishment of an adopt-a-cabin program to aid in the maintenance of forest public use cabins (USDA Forest Service, 2020).
>
> "There is also ample opportunity for increased collaboration with tribal organizations for recreation management, cultural education on the forest, and the provision of culturally informed recreation opportunities on the Tongass. These are discussed below in Cultural Sustainability Considerations.

Draft Recreation & Tourism Resource Assessment Report, 36. The Forest Service recognizes that co-stewardship with Tribes is one very powerful tool and partnership resource, explaining that:

> The need for increased co-stewardship is recognized across the Forest Service, and there is the opportunity for the Tongass National Forest to build on these existing successful

> examples (USDA, 2023, Strengthening Tribal Consultations and Nation-to-Nation Relationships). The local tribes have also expressed a need for tribal preferences for permits, a need to assess the number of Native owned operations on the Tongass and the need for tribal priority in management, for example on Admiralty Island Bear viewing areas.

Draft Recreation & Tourism Resource Assessment Report, 37. We strongly encourage the Forest Service to work with its Tribal partners to meet the demand for more co-stewardship opportunities on the Tongass.

J. *Air Quality.*

The draft Air Quality Assessment report is generally very good, showing that there are minor (but growing) concerns near one mine on Admiralty Island and around cruise ship ports. The draft Assessment does a good job of discussing the lichen sampling program, which provides the majority of the air quality data for the Tongass. The Assessment notes that more lichen air sampling points are needed: the revised plan could include plan components to encourage the expansion of this program, monitoring provisions to specifically capture this data, and partnership opportunities to facilitate implementation.

The draft Assessment notes that pollution from one mine (Greens Creek Mine) may be increasing under a new permit issued in 2024. Despite identifying this stressor, the draft Assessment suggests no potential solutions other than unspecified project design, "additional mitigation and monitoring measures," and

> The Forest Service will also seek to establish a Collaborative Integrated Monitoring Panel that will, among other duties, evaluate trends in air quality, fugitive dust, water quality, sediment, and biomonitoring data to validate the effectiveness of BMPs and mitigation measures and consider additional monitoring and adaptive management.

Draft Air Quality Assessment Report, 13-14. The report does not indicate when or how such a panel will be stood up or who would be involved: the Forest Service should clarify in the final Assessment the details of this Panel and/or develop plan components in the revised plan to facilitate its convening and work.

The only mention of Indigenous knowledge in the draft Assessment states: "In general, the incorporation of Indigenous Knowledge and Traditional Ecological Knowledge has been lacking or absent in previous planning efforts regarding air quality. This presents an important data gap that should be addressed." Draft Air Quality Assessment Report, 14. However, the draft Assessment fails to address this data gap. Considering the USFS's admitted need for more lichen sampling, the use of local native personnel and organizations to expand and operate more of the main monitoring program (lichen plot samples) would be a natural fit. Dozens of Alaska Youth Stewards out in the Forest collecting lichen from plots throughout the Forest would be an awesome introduction for the participants to botany, chemistry, atmospheric science, and how connections to the land and science mesh, braiding western and Indigenous science, all in one very useful data program for the Forest Service. Add in a set of participants who interview elders and other tribal members about air quality, lichens, and how that all intertwines with other areas (the health of deer, salmon, and cedar, for example), and the agency would have a great educational program that also gives the Forest Service the data it needs on this issue. Just because "air quality" is, relatively-speaking, a minor issue on the Tongass is no reason to overlook it for a tremendous opportunity for more community involvement that is, compared to some other areas, relatively easy and inexpensive to implement.

K. *Carbon Stocks.*

The draft Carbon Stocks Assessment report explains that the Tongass is a carbon sink and is predicted to remain so through the end of the century, with most carbon stored in the soil (altho a significant and appreciable amount of above-ground carbon is stored in old growth forests more than 200 years old, the most common stand age class on the Forest). The draft Assessment concludes that the Tongass will continue to be a net carbon sink until at least 2100, but outyear projections are unknown. The draft Assessment acknowledges that there is some concern that existing models do not adequately account for soil carbon, which casts doubt on the report's analysis and conclusions. That said, the report's analysis does not include data from Wilderness areas, so overall carbon stores are likely much higher than reported in the draft Assessment.

The assessment acknowledges that climate change will impact the storage and uptake or loss of carbon: as temperatures warm, carbon stocks and stores will change. The draft Assessment does not address how these changes will play out and which will have more impact on the carbon storage of the Forest.

Other than this general background information, however, the draft Assessment does not discuss any existing forest plan content relevant to carbon stocks or how this direction is performing: without that information - which is the purpose of the Assessment - it is impossible to develop an accurate Need for Change. Presumably the existing plan does not contain this direction, but given conclusions in other draft Assessments regarding the effects on those resources from climate change and the framework of the 2012 Planning Rule, the Forest should still have prepared a Carbon Stocks Assessment that presages what the Need for Change could look like. We look forward to reviewing an improved final Carbon Stocks Assessment report.

L. *Cultural & Historic Resources.*

Although this draft Assessment references Indigenous (cultural) sites in passing and acknowledges the long Indigenous occupation of the National Forest (all areas of the Forest are associated with at least one Tribe and cultural resources are found everywhere across the entire Forest), overall the report is more focused on colonial and settler "historic" resources. The draft Assessment also notes that very little of the National Forest has been surveyed for cultural resources, altho what sites have been surveyed range in condition from good to destroyed.

While the draft Assessment report does not identify any existing plan content pertaining to cultural and historic resources (again, the lack of this information precludes the ability to develop an accurate Need for Change analysis), it does identify several stressors including heritage tourism, climate change and associated disturbances (floods, landslides, fire), lack of Forest

Service workforce capacity, likely increase in project size,[14] adverse effects to cultural resources, looting and theft, and lack of availability of data. Despite the increase in heritage tourism on the Forest, there has not been a commensurate increase in funding for interpretation, education, maintenance, and mitigation that is compromising cultural and historic resources. The Forest Service acknowledges that it lacks the financial and human capacity to meet the need to manage cultural sites, provide interpretation, and mitigate adverse effects on these resources: the need for partnerships - including with Tribes - is therefore a Need for Change well-suited to new plan components in the revised plan.

The draft Assessment spends a fair amount of time discussing the Forest Service's struggle with competing philosophies regarding access to cultural sites vs. protecting them from access. There is no known correlation between access and harm to cultural sites, but nor does it appear that this has been well-studied on the Tongass (and the conclusion appears inconsistent with Tribal feedback). Social media has increased access and harm to cultural sites, and Tribes have expressed concerns about this exposure of sites and their locations via social media. While the Forest Service recognizes it has little ability to influence what people post online, this situation still drives a Need for Change in how the agency - along with its Tribal co-stewards - prioritizes, researches, and protects those sites.

The final Cultural & Historic Resources Assessment report should include an analysis of how existing plan components are performing in order to provide a strong foundation for the forthcoming Need for Change analysis. Additionally, given the Indigenous presence on the Forest, and the clear need for partnerships to steward cultural and historic resources on the Forest, the final Assessment should incorporate ways in which Tribal co-stewardship of these resources can help the Forest Service deliver on mission critical expectations.

M. *Designated Areas.*

This draft Assessment lists all currently designated areas and the basic legal parameters regarding such areas. But there is little to no details regarding the ecological integrity of those areas, how the current plan is affecting them, or the need for new or revised designated areas. Importantly, there is nothing in this draft report regarding Tribal interest in special or officially designated areas.

While the draft Designated Areas Assessment report is sorely lacking in this information, the draft *Tongass as an Indigenous Place Assessment Report* does provide some detailed information regarding designated areas:

> *Special Interest Areas*
>
> The 2016 Tongass Forest Plan, Appendix J, Special Interest Areas, identifies a cultural/botanical special interest area designation that was led by Native carvers in Kake. Sukkwan Island near Hydaburg was discussed as receiving a similar designation, but

[14] As projects (fire suppression, vegetation management, recreation) grow in size, the Forest Service will continue to fall short in having the resources to support these projects, all of which require surveys and analysis.

paperwork was never signed. Tribes have expressed increasing interest in these types of designations to protect productive cedar groves.

The North Hamilton River redcedar area is located on Kupreanof Island. It is an 80-acre stand of timber with a high component of red cedar. North Kupreanof is the furthest north where redcedar is present. It occurs only along the western side of Kupreanof Island as a minor component of the forest with a scattered distribution. This stand is unique because of the high proportion of redcedar it contains, which is unusual at this latitude. The stand was identified as being significant for subsistence and cultural uses by the native wood carvers of Kake in 1974, and the Hamilton River Timber Sale was modified to exclude the redcedar area from the sale. A high priority of the citizens of Kake is to set aside the redcedar grove for cultural and subsistence uses. This is the only redcedar in the immediate area that is easily accessible. The traditional uses of redcedar include carving, medicines, sewing materials and construction materials (2008 TLMP Appendix F-4).

Traditional Cultural Property is another designation that has been used to document and protect areas of special Interest for Tribes. Chuck Smythe writes: The X'unáxi Traditional Cultural Property, or Indian Point, encompasses the location of the first Auk Tlingit Village in the Juneau vicinity. Chuck Smythe (n.d.) writes, "It is described by Tlingit people as a shamanic landscape due to the presence of shamans' graves and is considered a spiritual place and a ceremonial space used by contemporary Tlingit people. The area is a place to go for spiritual renewal, a place to acquire spirits, and where Tlingit people feed the spirits of their ancestors.

The village site is listed on the National Register of Historic Places as a traditional cultural property, which provides requires certain conditions to be met for documentation as such and provides a certain level of protection. Other national forests have used the TCP designation to protect larger cultural sites, and the Forest Service should work to make sure Tribes are informed of this designation for critical areas of cultural heritage (Chippewa National Forest, n.d.)

Draft Tongass as an Indigenous Place Assessment Report, 32-33. The final Designated Areas Assessment report should be at least as adequate as the *Indigenous Place Assessment* on the Need to Change the current plan in how designated areas are managed and how new ones are added in the future to address Tribal needs and desired outcomes.

N. *Energy & Minerals.*

Acknowledging that energy and mineral development is an important economic driver in Alaska, the draft Energy & Minerals Assessment report provides an analysis of the energy and mineral development status quo in Southeast Alaska and how development of these resources could grow in the future. Although most of the non-wilderness Tongass is open to mineral exploration, the draft report explains that potential locations of foreseeable mining are all known and under development or permit.

Pertaining to permitting, operation, and reclamation of mining claims, the Assessment points out that "tribes have expressed that they want to work with the Forest Service in developing these reclamation plans, mitigation measures and other decisions about these claims." Draft Energy & Minerals Assessment Report, 15. The draft report goes on to note additional Tribal concerns:

> Concerns were raised during the 2024 assessment public engagement about mineral extraction on the Tongass, expressing the need that any extraction is done in a sustainable, regenerative way that considers generations to come, protecting the Forest long-term (USDA 2024c). The Tribes, especially Tlingit & Haida, Wrangell, Yakutat, Ketchikan, Klukwan, Douglas Indian Association, Saxman, Kake, Craig, Metlakatla, Petersburg, Kasaan and Sitka Tribe of Alaska expressed concern about mineral development and potential contamination on their traditional territories and how it may impact subsistence resources that depend on a healthy ecosystem. Many Tribes also brought up existing mining projects across the border in Canada that have potential for the downstream impacts on salmon and their habitat. The Southeast Indigenous Transboundary Commission elevates the concerns of Indigenous nations on both sides of the borders about these projects and calls for coordination from the State Department. On the United States side of the border, these rivers run through lands of the Tongass National Forest. Tribes have advocated for increased protections of these watersheds.

Id. at 16. And, the draft Assessment acknowledges that

> There are a few key uncertainties regarding the status and trends of renewable energy and mineral resources on the Tongass National Forest. In general, the incorporation of Indigenous Knowledge and Traditional Ecological Knowledge has been lacking or absent in previous planning efforts regarding renewable and non-renewable energy and minerals. This presents a particularly large data gap that should be addressed.

Id. at 18.

Along with other stressors,[15] energy and mineral development is a stressor on ecological integrity and is compromising Tribal cultural and subsistence resources suggesting a clear Need to Change the existing plan.

O. *Geology and Geologic Hazards.*

The plan area's geology and associated hazards are well known and heavily studied. Since the 1997 Plan and subsequent changes, plan components meant to address and mitigate most of these geologic hazards seem to be working as intended.

The draft Assessment does mention repeatedly that climate change will affect (mostly increase) and, in some instances, change many of these hazards and that more adaptive measures will be

[15] The draft Assessment also has a good, albeit cursory, review of how climate change could affect all the different energy sources available into the future and how receding glaciers may allow for the staking of mineral claims in areas heretofore inaccessible. This is another potential stressor that should be addressed with plan components in the revised plan.

needed to respond: clearly there is a Need to Change the existing plan to better address these stressors, but how the need for these adaptations will affect the Plan revision is not discussed.

Road access for Tribal and subsistence use is extremely important to native communities, and yet the draft Assessment report[16] does not discuss how Indigenous Knowledge could be incorporated into the revised plan to mitigate the effects of geologic hazards on infrastructure in the context of a changing climate. A reference to the need to coordinate with other agencies and landowners that deal with roads does not suffice for greater co-stewardship with Native communities to address geologic hazards, particularly landslides[17] that may preclude Tribal access to important sites and resources.

P. *Infrastructure.*

The draft Infrastructure Assessment report identifies road maintenance and its funding are very challenging for the Forest Service, which affects Tribal access to the Forest for cultural and subsistence needs. Specifically:

> The Tribes and other community members in Southeast Alaska have expressed a need for increased consultation and broader community conversations whenever road closures are proposed, as these have become community assets used for subsistence harvesting after periods of resource extraction. For example, increased government-to-government consultation and increased public involvement in Access Travel Management (ATM) plans would be beneficial.

Draft Infrastructure Assessment Report, 9.[18] Furthermore, “Tribes have expressed concerns about the ability of the agency to maintain infrastructure like roads and facilities. Many Tribes

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[16] Other draft Assessments do mention the need to coordinate roads management with Native Peoples and organizations. *See* Draft Infrastructure Assessment Report, 10. The failure to discuss that fact is a major failing of the draft Geology and Geologic Hazards Assessment. Landslides close roads in the Tongass every year and are expected to increase due to climate changes. Working with Tribes to address this stressor and risk is a natural fit, and should be facilitated in the revised plan.

[17] Landslides have become an increased hazard and serious concern for southeast Alaska residents with multiple catastrophic events over the past decade. Murkowski, L. *Commerce Committee Advances Murkowski's Landslides, Earthquakes Legislation*, https://www.murkowski.senate.gov/press/release/commerce-committee-advances-murkowskis-landslides-earthquakes-legislation (2024). With increased winter precipitation due to climate change, landslide risk will likely increase. There have been recent developments in spatial-explicit landslide mapping methods in Southeast Alaska that need to be considered: regional experts and a modeling team should be assembled to address this issue. *See*, Booth AM, Buma B, Nagorski S. *Effects of Landslides on Terrestrial Carbon Stocks With a Coupled Geomorphic-Biologic Model: Southeast Alaska, United States*. Journal of Geophysical Research: Biogeosciences 128, e2022JG007297 https://doi.org/10.1029/2022JG007297 (2023).

[18] Although absent from the draft Infrastructure Assessment report, the draft *Tongass as an Indigenous Place Assessment Report* explains that

> Tribes want to be consulted and have broader community conversations whenever road closures are proposed, as this infrastructure has often become community assets that is used for subsistence harvesting after periods of resource extraction. Tribes and harvesters should be involved when prioritizing or determining road closures. A specific example is government-to-government consultation and increased public involvement in Access Travel Management (ATM) plans. The ATM section should include standards and guidelines on how to work with Tribes' Tribal Transportation Program with Federal

have incorporated National Forest System roads into their road inventories so that they can undertake maintenance responsibilities in order to keep roads open to important harvest areas." *Id*. at 10. Likewise, "There are also two buildings planned for decommissioning. Some Tribes have expressed a desire to take over management of underutilized Forest Service facilities. The Organized Village of Kake has done just this, with an old administrative building in Portage Bay." *Id*. at 11.[19]

Given the Forest Service's lack of capacity and the desire on the part of some Tribes to co-steward infrastructure on the Forest, the final Assessment should explore these opportunities with the objective of including them in the Need for Change analysis.

Q. *Scenic Resources.*

The draft Scenic Resources Assessment report is a disappointment, and misses several key issues. The report does not describe existing plan content related to this resource, and at least in some respects it is not adequately performing. For example, "Flightseeing and other air travel routes are not considered or managed as VPRs in the current Forest Plan." Draft Scenic Resources Assessment Report, 10. Given that both the cruise industry's excursions and other local tourism industry make heavy use of flightseeing and air travel (flights to take hunters and fishers to remote camps and lodges, etc.), especially in the warmer months, consideration of these impacts to scenic resources should have been addressed in the draft Assessment.

Similarly, the draft Assessment has no mention of Tribal concerns or issues pertaining to this resource, despite what appears in other draft Assessments such as:

> Increasingly, some Tribes and many Alaska Native Corporations (ANCs) have made significant investments in businesses that rely on cruise tourism, underscoring the importance of the Tongass National Forest as a scenic and recreational draw. ANCs with large-scale cruise tourism enterprises, such as Huna Totem, Goldbelt, and Shee Atiká, contribute to local economies while relying on public lands for excursions and activities that extend beyond their private land bases. This impacts Forest Service management and priorities regarding road systems, recreation infrastructure, and the need to maintain the forest's scenic appeal. Smaller-scale tourism efforts, like those led by Kootznoowoo and Klawock Heenya, provide more localized opportunities but are similarly connected to the natural beauty and accessibility of the Tongass.

> Highway Administration in assuring important roads stay open, allowing for Tribal Transportation Funds to help with maintenance. ANCs would like greater coordination and management of Forest Service road easements that cross their land and are important to Tribal communities.

This is another instance where Forest Service subject matter experts do not appear to be aware of the work of other subject matter experts preparing other reports: the information in the *Indigenous Place* report should have found its way into the *Infrastructure* report so that information is consistently presented to commenters. We urge the agency to better coordinate amongst its experts in the preparation of the final Assessment.

[19] The draft *Tongass as an Indigenous Place Assessment Report* explains that "Tribes should also be consulted regarding the decommissioning of other public infrastructure, such as trails and cabins, to ameliorate concerns over impacts to subsistence harvesting access." Draft Tongass as an Indigenous Place Assessment Report, 57. We agree, and plan components that provide this process should be included in the revised plan.

Draft Tongass as an Indigenous Place Assessment Report, 56. The draft Scenic Resources Assessment report is silent on these concerns, reflecting a need for collaboration among agency issue experts to ensure that Tribal concerns are adequately and accurately reflected in *all* Assessment reports.

Finally, we note that no information in the draft report has been updated since 2006:

> The data used for both tables above has not been fully updated since 2006, when the data was developed for the 2008 Plan Amendment. There is a need to update the data, to account for many changes, both on the ground and in the types and quality of data that has become available in the 18 years since the data was created. Updating this data will be a key part of the work for this Forest Plan revision.

Draft Scenic Resources Assessment Report, 12. Clearly the lack of current scenic resource data is a Need for Change, but in order to foster adequate comment, this information really must be presented earlier in the process. We look forward to reviewing this information in the final Assessment report.

R. *Drivers, Stressors, & Climate Change.*

The draft Assessment report addressing Drivers, Stressors, & Climate Change notes that climate - along with the island biogeography nature of much of the Forest - drives the vegetation and other biophysical communities on the Tongass. Because the existing forest plan does not contain plan components addressing climate change as a stressor, there is a significant Need to Change the plan to incorporate this information, which the draft Assessment does a good job of acknowledging. Several key areas necessitating Needs to Change the current Tongass forest plan include:

- **Climate Adaptation**: The current plan lacks direction on climate adaptation. The new plan must consider system drivers and stressors, including climate change, and the ability of ecosystems to adapt to these changes.
- **Temperature and Precipitation Changes**: Significant increases in temperature and precipitation are projected, necessitating adjustments in forest management to address these changes.
- **Insect and Disease Outbreaks**: Warming climates are expected to exacerbate insect and disease outbreaks, requiring proactive management strategies.[20]

[20] Recent research suggests that sawfly and budworms are in fact causing widespread tree mortality. *See*, Howe M, Graham EE, Nelson KN. *Defoliator outbreaks track with warming across the Pacific coastal temperate rainforest of North America*. Ecography 2024, e07370 https://doi.org/10.1111/ecog.07370 (2024). This is very concerning with projected climate change as more invasive species potentially move north. *See*, Howe M, Graham EE, Nelson KN. *A shrinking envelope? Climate warming across the Pacific coastal temperate rainforest and its projected impact on a native defoliator*. Climatic Change 178, 31 https://doi.org/10.1007/s10584-025-03870-2 (2025). The Pacific Northwest Research Station Forestry Sciences Lab in Juneau will be an important research group to collaborate with to complete this section adequately. It will be important to develop plausible scenarios and management responses to increased outbreaks.

- **Invasive Species**: The spread of invasive species is a growing concern, and the plan needs to include measures to prevent and manage these threats.
- **Glacial Melt and Sea Level Change**: Accelerating glacial melt and differential sea level changes due to isostatic rebound require adaptive strategies to manage new land surfaces and changing shorelines.
- **Ocean Chemistry and Sea Surface Temperatures**: Ocean acidification and rising sea surface temperatures will impact marine ecosystems and traditional subsistence practices, necessitating integrated management approaches.
- **Fire Management**: Although historically low, the risk of wildfires may increase with changing climate conditions, requiring preparedness and management plans.
- **Wind Dynamics**: Changes in wind patterns and increased storm frequency need to be considered in forest regeneration and management practices.

Draft Drivers, Stressors, & Climate Change Assessment Report, 6. Overall, the draft Assessment emphasizes the need for a comprehensive revision of the Tongass Forest plan to incorporate climate adaptation, address emerging stressors and threats, and ensure the sustainability of the terrestrial and aquatic ecosystems.

The draft Assessment explains that

> Climate change is a top issue for many Tribes. Concerns have been expressed about how climate change will impact the health of harvested resources (especially fish, deer, berries, mushrooms, and cedar) and the habitat that they depend on. In light of this concern, many Tribes have created climate adaptation plans including the Sitka tribe, Central Council of Tlingit & Haida Indian Tribes of Alaska, Metlakatla and the Hoonah tribe. Hoonah Indian Association in particular is planning proactive climate adaptation strategies to create better anadromous stream habitat for fish, to create deeper pools with more oxygen flow.

Draft Drivers, Stressors, & Climate Change Assessment Report, 9. Tribal concerns regarding climate change that should be addressed in the revision include:

- **Impact on Harvested (Subsistence) Resources**: Climate change is expected to affect the health and availability of key resources such as fish, deer, berries, mushrooms, and cedar, which are central to the Tribes' subsistence and cultural practices.
- **Habitat Degradation**: Changes in climate are likely to degrade the habitats that these resources depend on, further threatening their availability at sufficient harvestable levels.
- **Invasive Species**: The spread of invasive species, which can crowd out native plants and disrupt ecosystems, is a significant concern. Tribes are actively working on mitigation plans to address this issue.
- **Yellow-Cedar Decline**: The decline of yellow-cedar, a culturally and economically important species, due to root freezing injury exacerbated by reduced snowpack, is a pressing issue.
- **Stream Habitat for Fish**: Proactive strategies are being planned to improve anadromous stream habitats for fish, which are vital for subsistence fishing.

- **Traditional Food Harvesting**: Sea level changes, ocean acidification, and warming sea surface temperatures are expected to impact the ability to harvest traditional foods and resources, affecting the livelihoods and foodways of local communities.

These concerns highlight the need for climate adaptation strategies that protect and sustain Tribal natural resources and cultural practices on the Tongass National Forest. We urge the agency to incorporate actionable provisions from Tribal climate adaptation plans into the revised forest plan.

In addition, we have included specific suggestions from our contract climate scientist for both the Stressors and Terrestrial Ecosystems assessments that we would like to see in the final assessment in Appendix 4.

S. *Subsistence and Other Harvest (Non-Commercial) Resources.*

The Draft Assessment on Subsistence and Other Harvest (Non-Commercial) Resources[21] provides a substantive but incomplete synthesis of existing, available, and relevant information[22] needed to "identify a preliminary need to change the existing plan and to inform the development of plan components and other plan content."[23] In order to meaningfully meet that requirement, the Draft Subsistence Assessment should be revised to incorporate additional consideration of the legal and historical framework in which the Assessment is being conducted. Though the Assessment includes some important aspects of that context, such as an overview the 2016 Forest Plan and the general structure for subsistence management required by the Alaska National Interest Lands and Conservation Act (ANILCA), the Assessment fails to adequately consider the critical role that forest planning and the corresponding management of subsistence resources play in fulfilling the United States' longstanding trust duties to Alaska Native Tribes.

In addition, the Draft Subsistence Assessment does not include or rely on numerous additional resources that demonstrate how the plan revision process and updates to the forest plan could and should reflect a more comprehensive approach to Tribal engagement and co-stewardship in the management of subsistence resources.

1. Legal and Historical Framework.

Because the health and management of subsistence resources on the Tongass National Forest is a critical component of the United States' government-to-government relationship with the Alaska Native Tribes intimately connected to that region, the Draft Subsistence Assessment should be revised to better consider the legal and historical context in which this forest plan revision is taking place. Doing so could begin to rectify the long-standing and widespread frustration of many Alaska Native Tribes with the management of subsistence resources. On the Tongass, that

[21] U.S. Forest Service, *Subsistence and Other Harvest (Non-Commercial) Resource Assessment: Tongass National Forest Plan Revision* (Nov. 2024) [hereinafter Draft Subsistence Assessment]. Though we rely on the term "subsistence" to avoid confusion, we acknowledge it is merely a legal term of art and inadequately captures the import and context of the traditional and customary uses of natural resources by Indigenous peoples across what is now Alaska since time immemorial.

[22] 36 C.F.R. §219.6.

[23] 36 C.FR. §219.7(C)(2)(i).

frustration largely stems from a consistent failure on the part of the USFS and its forest plans to adequately consider Tribal rights to, perspectives on, and interests in subsistence resources. Thus, the Draft Subsistence Assessment should be revised to inform the need to change the plan revision process and the revised plan to ensure that Tribal rights to and interests in subsistence resources and their management are finally properly represented and reflected.

The Draft Subsistence Assessment does provide some support for this need to change. Importantly, for example, the USFS acknowledges in the Draft Subsistence Assessment that "there is little direction in the existing plan on how best to ensure that the management of the Tongass National Forest prioritizes subsistence uses, as well as for other uses of fish, wildlife, and plant resources."[24] The 2016 Tongass Plan fails to provide substantive protection to "subsistence resources" and offers no meaningful direction for the USFS to make subsistence-related decisions. Instead, the 2016 Plan's "standards and guidelines" mostly restate existing laws, regulations and the Region 10 Subsistence Management and Use Handbook.[25]

But absent from the Draft Subsistence Assessment is any consideration of how the current plan's shortcomings reflect a longer-term trend. Beyond just the 2016 Forest Plan, the USFS has not engaged in any meaningful or systematic consideration of the rights of Alaska Native Tribes in *any* forest planning process relevant to the Tongass. Since the 1979 Forest Plan, which was issued before passage of Alaska National Interest Lands and Conservation Act (ANILCA) in 1980, these forest planning processes have centered on timber management-related conflict, appeals, litigation and piecemeal amendments, often without acknowledging—much less meaningfully considering and incorporating—the concerns and interests of Alaska Native Tribes, such as those set forth in The Tongass as an Indigenous Place.[26]

Those concerns and interests are especially relevant in the context of subsistence resources and their management. As detailed in The Tongass as an Indigenous Place and in the many additional resources discussed below, the forest "is, and always has been, the traditional homelands of the Tlingit, Haida, and Tsimshian people, who hold over 10,000 years of stewardship and recorded history on these lands and waters."[27] The United States, through Congressional enactment of ANILCA, sought to ensure those connections could continue through what it termed "subsistence uses," that Congress found to be "essential to Native physical, economic, traditional, and cultural existence."[28] To do so, Congress established a framework, set forth in ANILCA's Title VIII, to prioritize these uses and to ensure that Federal land management agencies, like the USFS, work to ensure their management decisions protect and uphold that commitment. Congress also called for those agencies to ensure "*a meaningful role* in the management of fish and wildlife and of subsistence uses on the public lands in Alaska" for

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[24] Draft Subsistence Assessment, at 8.

[25] U.S. Forest Service, *Tongass National Forest: Land and Resource Management Plan* (2016), 4-65-4-67.

[26] *See*, *e.g.*, Tongass as an Indigenous Place, at 33-39 (describing existing Alaska Native Tribal rights in the Tongass).

[27] *Id.* at 5.

[28] Alaska National Interest Lands Conservation Act [hereinafter ANILCA], Pub. L. No. 96-487, 94 Stat. 2371 (Dec. 2, 1980), §801(1).

subsistence users most knowledgeable about those resources.[29] In recognition of the unique legal status of Native Nations under federal law, Congress relied in part on its "constitutional authority over Native affairs" as a legal basis for enacting that framework.[30] Thus, although ANILCA's Title VIII also acknowledges the importance of such uses for non-Native rural residents of Alaska, the interests of Alaska Native Tribes in the management and health of subsistence resources are critical to fulfilling ANILCA's mandate and upholding Congress' commitment to honor and protect the millennia of relationship between Indigenous people and those uses.

The Draft Subsistence Assessment does not address the significance of tribal interests to ANILCA and its history. For example, the history of Title VIII is an important starting point because it was enacted "in order to fulfill the policies and purposes of the Alaska Native Claims Settlement Act."[31] Similarly, Title VIII's recognition of the specific importance of subsistence uses as "essential to Native physical, economic, traditional, and cultural existence,"[32] and its corresponding call for a participatory framework that is designed to shape and influence regulations, policies and management decisions pertaining to subsistence,[33] provide necessary context for assessing subsistence management and considering how the existing Forest Plan should change to better reflect those principles.

Congress' recognition in ANILCA of the importance of the interests of Alaska Native Tribes is also rooted in a deeper and longstanding legal relationship between the United States and Tribes. That relationship, the federal trust relationship, rests on over two centuries of government-to-government relations between the United States (and even its sovereign European predecessors) and Native Nations. In some of its earliest decisions, the United States Supreme Court analyzed those relations and concluded that the United States assumed important responsibilities of protection consistent and concurrent with acknowledging the sovereignty of Native Nations.[34]

From those foundations, all three branches of the federal government have routinely and repeatedly acted in furtherance of that duty, which has provided the basis for the federal government's responsibility to consult with Native Nations[35] and work with them to pursue the

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[29] Alaska National Interest Lands Conservation Act [hereinafter ANILCA], Pub. L. No. 96-487, 94 Stat. 2371 (Dec. 2, 1980), §801(5).

[30] Alaska National Interest Lands Conservation Act [hereinafter ANILCA], Pub. L. No. 96-487, 94 Stat. 2371 (Dec. 2, 1980), §801(4).

[31] ANILCA, §801(4)

[32] ANILCA, § 801(1)

[33] 16 U.S.C. §3115. *See also* §801(5) requiring "an administrative structure be established for the purpose of enabling rural residents who have personal knowledge of local conditions and requirements to have a meaningful role in the management of fish and wildlife and of subsistence uses on the public lands in Alaska."

[34] *See* Cherokee Nation v. Georgia, 30 U.S. 1, 17-18 (1831).

[35] *See*, *e.g.*, §2(a) Executive Order 13175 of November 6, 2000, *Consultation and Coordination with Indian Tribal Governments*, 65 Fed. Reg. 67,249 ("The United States has a unique legal relationship with Indian tribal governments as set forth in the Constitution of the United States, treaties, statutes, Executive Orders, and court decisions. Since the formation of the Union, the United States has recognized Indian tribes as domestic dependent nations under its protection.")

co-stewardship of federal lands and waters,[36] among other important federal-tribal interactions. In the early 1990s, the United States affirmed that it maintains the same relationship with the federally recognized Alaska Native Tribes intimately connected to the Tongass region, who "have the same governmental status as other federally acknowledged Indian tribes by virtue of their status as Indian tribes with a government-to-government relationship with the United States; are entitled to the same protection, immunities, privileges as other acknowledged tribes; [and] have the right, subject to general principles of Federal Indian law, to exercise the same inherent and delegated authorities available to other tribes."[37]

Despite the centrality of that government-to-government relationship and its importance to the USFS approach to and obligations for managing subsistence resources, the Draft Subsistence Assessment is silent about the trust obligations of the United States and what those obligations may demand of the USFS and its forest plan.

This context provides an important and necessary starting point for assessing subsistence uses and interests on the Tongass and should be better reflected in revisions to the Draft Subsistence Assessment. The revised Tongass Forest Plan will play a critical role in fulfilling or failing to honor the purposes of ANILCA's Title VIII. The Plan's desired conditions and other plan components will determine the direction by which the USFS carries out Title VIII's subsistence priority and preference scheme. Pursuant to ANILCA, that direction must ensure that forest management causes "the least adverse impact" on subsistence uses, and that the USFS protects "the continued viability of all wild renewable resources," among other requirements provided in §802 and elsewhere in ANILCA. As explained in the USFS's Subsistence Handbook, subsistence-based decisions often "tier" back to the Forest Plan "for prescription and desired future condition."[38] But, as noted above, the 2016 Forest Plan provides little direction in this regard, other than the broad requirements imposed by Title VIII and NEPA.

That lack of direction reflects a deeper need to change how future forest plans can enhance subsistence management going forward. Those revised plans must provide more substantive protections for subsistence resources and, in recognition of the foregoing legal and historical context, commit to empowering Alaska Native Tribes with a meaningful role in developing and implementing those protections. Thus, the Final Subsistence Assessment should more comprehensively acknowledge the extensive legal and historical foundations for moving in that direction and include in its Executive Summary-Key Takeaways a statement that the current Forest Plan does not provide sufficient direction regarding how subsistence-based decisions will be made and that this needs to change. Ideally, in recognition of its trust obligations to Alaska Native Tribes, the USFS will engage in meaningful government-to-government consultation with

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[36] *See* Section 1, Order No. 3403, *Joint Secretarial Order on Fulfilling the Trust Responsibility to Indian Tribes in the Stewardship of Federal Lands and Waters*, 1 (Nov 15, 2021) ("In managing Federal lands and waters, the Departments are charged with the highest trust responsibility to protect Tribal interests and further the nation-to-nation relationship with Tribes.")

[37] U.S. Dep't of the Interior, Bureau of Indian Affairs, *Indian Entities Recognized and Eligible to Receive Services from the United States Bureau of Indian Affairs*, 58 Fed. Reg. 54,364, 54, 366 (Oct. 21, 1993); Federally Recognized Indian Tribe List Act of 1994, Pub. L. 103-454, 108 Stat. 4791 (Nov. 2, 1994); Tlingit and Haida Status Clarification Act, Pub. L. 103-453, 108 Stat. 4792 (Nov. 2, 1994).

[38] U.S. Forest Service Handbook, 2609.25 *Subsistence Management and Use Handbook*, at 46.

Tribes through the next stages of plan development to co-create protocols for further consultation, cooperation, and co-stewardship, and then continue to work collaboratively with Tribes to incorporate them as plan components and "management strategies" in the plan revision.

2. Additional Resources and Information.

To help support and ensure more solid foundations for any "need to change" recommendations for the existing forest plan, the Draft Subsistence Assessment should also be revised to include and assess additional relevant resources. For example, by leaving out pertinent and recently developed reports, the Draft Subsistence Assessment fails to appropriately acknowledge the deep and widespread criticism of subsistence management on the Tongass and throughout the federal public land system in Alaska. Though the Draft Subsistence Assessment includes discussion of the complicated trade-offs and differences of opinion when it comes to managing different facets of subsistence on the Tongass—from timber harvest impacts to roads and road access—it does not offer any suggestion of a need to improve how that management is implemented based on existing critiques. While there may be "no one agreed-upon position by all users" on the particulars of subsistence management,[39] there is broad-based dissatisfaction with implementation of ANILCA's Title VIII. Many of the resources described in this section offer detailed and well-informed critiques of the existing state of subsistence management. Other resources demonstrate the momentum of current trends toward expanded tribal co-stewardship. All of these resources would therefore enhance the information on which the Draft Subsistence Assessment relies, thereby improving and strengthening its conclusions.

Most critically, the Draft Subsistence Assessment appears to ignore a significant amount of work done by both the USDA and the Department of the Interior to gather feedback and assess the United States' efforts to fulfill Title VIII's mandate. The *Federal Subsistence Policy Consultation Summary Report*, issued on June 14, 2022, integrates feedback from roughly 445 individual subsistence users and representatives from Alaska Native Villages, Tribal Consortia, Alaska Native Organizations, and Alaska Native Corporations who participated in the listening sessions and consultations in January 2022.[40]

Several drivers and stressors reviewed in the Draft Subsistence Assessment also emerged as dominant themes in these consultation sessions. However, one overarching theme evident in the sessions—but not detailed in the Draft Subsistence Assessment—is a demand to have "more meaningful involvement" by Alaska Native Tribes in the subsistence decision-making process.[41] Those participating in these sessions suggested several different ways of doing so, from expanding tribal co-stewardship of the Tongass to working more closely with the Southeast Alaska Regional Advisory Council (SEARAC). Notably, although these sessions resulted in changes to the composition of the Federal Subsistence Board (FSB) that added three public members nominated or recommended by federally recognized Tribal governments[42] and

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[39] U.S. Forest Service, Subsistence Assessment, at 16.

[40] U.S. Department of Interior and U.S. Department of Agriculture, *Federal Subsistence Policy Consultation Summary Report* (June 14, 2022).

[41] *Id*., at 6.

[42] 89 Fed. Reg. 83,622 (Oct. 17, 2024)

reorganized the administrative structure of the Office of Subsistence Management (OSM),[43] the Draft Subsistence Assessment apparently failed to consider the extensive input received by USDA during those consultations.

The 2022 Consultation Report and other recent developments reveal profound frustration with the so-called "dual management" system of subsistence in Alaska, a model that often leaves Alaska Native Tribes caught between federal and state management systems. As stated by the Alaska Federation of Natives in Subsistence Resolution 24-01:

> The failures of state and federal management to protect Alaska Natives' subsistence needs throughout Alaska, including in all navigable waters, have left Alaska Natives inequitably placed in the middle of two inconsistent and insufficiently protective systems, neither of which protects Alaska Native subsistence rights, our way of life, cultures, and traditions.[44]

Another common criticism found in these sources and others is frustration with implementation of §810 of ANILCA. That section requires a two-tiered evaluation of federal land use decisions in light of their impacts to subsistence users and needs. This important provision provides a framework to assess the connections between subsistence and land use, but its application is inconsistent and often places Tribes in a position of having to react and respond to decisions already made or to agency-written proposals that they had no role in shaping. This criticism is found throughout the rulemaking record for the 2020 Tongass Roadless Rule,[45] and was one basis on which the USFS relied when repealing the 2020 Rule in 2023. In doing so, the USFS referenced input from the SEARAC.[46] That input focused on the misapplication of the 810 process, which would have had serious implications across 9.3 million acres of inventoried roadless areas on the Tongass.[47]

Another important source of information not incorporated into the Draft Subsistence Assessment is the 2020 Inter-Tribal Administrative Procedure Act Petition "To Create a Traditional Homelands Conservation Rule for the Long-term Management and Protection of Traditional and Customary Use Areas in the Tongass National Forest."[48] Though discussed in the Tongass as an

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[43] *See* Secretarial Order 3413, *Transfer of the Office of Subsistence management to the Office of the Secretary* (June 27, 2024).

[44] Alaska Federation of Natives, 2024 Annual Convention, Resolution 24-01. Additional background materials and presentations available at https://nativefederation.org/subsistence-updates/. *See also* Alaska Federation of Natives, *The Right to Subsist: Federal Protection of Subsistence in Alaska* (Anchorage, AK: AFN, 2010).

[45] 85 Fed. Reg. 68,688 (Oct. 29, 2020).

[46] 88 Fed. Reg. 5256 (Jan. 27, 2023).

[47] *See e.g.,* Testimony of Southeast Alaska Subsistence Regional Advisory Council members, submitted to Office of Information and Regulatory Affairs and Office of Management and Budget (Sept. 2, 2020).

[48] Organized Village of Kasaan, Organized Village of Kake, Klawock Cooperative Association, Hoonah Indian Association, Ketchikan Indian Community, Skagway Traditional Council, Organized Village of Saxman, Yakutat Tlingit Tribe, Central Council Tlingit and Haida Indian Tribes of Alaska, *Petition for USDA Rulemaking to Create a Traditional Homelands Conservation Rule for the Long-Term Management and Protection of Traditional and Customary Use Areas in the Tongass National Forest* (July 16, 2020) [hereinafter *Traditional Homelands Rule Petition*].

Indigenous Place,[49] it is not referenced in the Draft Subsistence Assessment. The Traditional Homelands Petition provides a vision and set of principles rooted in tribal interests and according to which the Tongass could be managed in the future, with several recommendations pertaining to subsistence management.[50]

Though not a "land use plan" per se, the Petition offers a vision and framework for land management that could be "coordinated" with the Tongass Plan revision, as required in the NFMA planning regulations.[51] The Petition highlights several criticisms of how Title VIII, and §810 in particular, is being implemented—or not implemented at all—by the USFS. The Petition also provides feasible steps that could be taken to fix these problems, all of which rely upon existing tools and legal authorities. The Petition's signatory Tribes expressed deep dissatisfaction with subsistence and other decision-making processes used by the USFS. If a federal rulemaking is not forthcoming in response to the Petition, it provides an important basis on which the Draft Subsistence Assessment could, as Secretary of Agriculture Thomas Vilsack suggested, ensure that the USFS "fulfill the [P]etition's intent through forest planning, consultation, co-stewardship, and decision-making at the local level."[52]

Though referenced in Tongass as an Indigenous Place,[53] the Draft Subsistence Assessment also fails to describe the significant trends in the development of Tribal networks, partnerships, and other programs on the Tongass (e.g., Southeast Indigenous Guardians Network, community forest partnerships, the Alaska Youth Stewards program, Yakutat River Rangers program, Tribal Conservation Districts, Hydaburg Subsistence Fisheries Monitoring Program, etc.). Neither does the Draft Subsistence Assessment reference the recently signed co-stewardship MOUs at Mendenhall Glacier. Though not all of these developments specifically focus on the collaborative management of subsistence resources, they do convey the strong and growing interest, professional capacity, and success for to tribally co- stewardship of subsistence resources on the Tongass. The growth of these networks and partnerships is a significant trend warranting further consideration by the USFS and discussion in the Draft Subsistence Assessment. The 2016 Forest Plan needs to change in order to further encourage and clarify the existing authorities that can be used to nurture, grow, and invest in these mutually beneficial relationships.

Similarly, the 2016 Forest Plan should reflect recent trends in updated laws, policies, and other guidance for the USFS. In fact, the 2012 Planning Rule requires "that plans are to [be] consistent with and complement existing, related Agency policies that guide management resources on the NFS."[54] But much of what is referenced in the 2016 Forest Plan is a carry-over from the 1997 Plan, meaning several legal authorities and developments are not acknowledged at all. The Draft

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[49] Tongass as an Indigenous Place, at 51.

[50] *Traditional Homelands Rule Petition*, at 7.

[51] *See* 36 C.F.R. §219.4(b) ("The responsible official shall coordinate land management planning with the equivalent and related planning efforts of federally recognized Indian Tribes, Alaska Native Corporations, other Federal agencies, and State and local governments.")

[52] Thomas Vilsack, Secretary U.S. Department of Agriculture, Response to Tribal Leaders for Petition to Create a Traditional Homelands Conservation Rule (Aug. 9, 2023).

[53] Tongass as an Indigenous Place, at 51-52.

[54] 77 Fed. Reg. 21162 (Apr. 9, 2012).

Subsistence Assessment provides a broad overview of the federal subsistence management program and its regulations ("Federal Subsistence Management Program" and "Brief History of Federal Subsistence and Current Subsistence Management"). There, the document provides a concise overview of Title VIII and recent changes to its administration, including the move of the Federal Subsistence Board (FSB) to the Department of Interior's Office of Policy, Management and Budget and new regulations requiring the addition of three Tribally nominated members to the FSB.

That discussion leaves out several new laws, regulations, policies, and internal guidance pertaining to tribal rights and interests on forest lands for which the USFS is responsible. This information will help identify a need to change the existing plan and to inform the development of plan components and other content. For example, the USDA Office of General Counsel recently conducted a legal review of Secretarial Order 3403, which reviewed and cataloged a number of these authorities.[55] Furthermore, after doing so, the OGC Report clarified that the USFS has "significant latitude…in the types of co-stewardship agreements or other arrangements that may appropriately support USDA operations without an inappropriate transfer of federal authority."[56] That latitude builds on Title VIII's authorization of cooperative agreements in §809. Several agreements pertaining to the co-stewardship of subsistence resources on public lands have been signed using this authority, including the Kuskokwim, Ahtna, and Gravel-to-Gravel MOUs and agreements. Though within the Department of Interior, the USFS has the same authority under Title VIII's cooperative agreement provision.[57] These are significant trends in the administration of Title VIII that, consistent with the development of additional relevant laws, regulations, policies, and internal guidance, also warrant recognition in the Draft Subsistence Assessment.

3. Summary.

Our review of the Draft Subsistence Assessment aims to provide a resource for considering how that document could be improved. Consistent with the USFS' 2012 Planning Rule, we focused on important information, themes, and trends that are missing from the current draft but that we believe are critical to informing a "need to change" the existing 2016 Tongass Forest Plan. As described in more detail above, the Draft Subsistence Assessment could be improved in this regard by greater inclusion and consideration of:

- The legal and historical context of subsistence resources and management on the Tongass National Forest, specifically:
    - The unique significance of subsistence resources to Alaska Native Tribes (as supported by The Tongass as an Indigenous Place);
    - The meaningful recognition and representation of that importance in ANILCA - both its history/context and text;

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[55] *See* Office of the General Counsel, U.S. Department of Agriculture, Legal Review of Joint Secretarial Order 3403 (2022).

[56] *Id.* at 6.

[57] 43 U.S.C. §1712(b); 36 C.F.R. §219.4(b).

- The federal government's government-to-government trust relationship with Alaska Native Tribes, which further supports and informs both ANILCA and the unique status of those Tribes;
- The failure of the 2016 Forest Plan, as well as prior plans, and existing subsistence management on the Tongass NF to adequately account for, consider, and incorporate those important principles; and
- The importance of forest planning and substantive plan provisions to effective subsistence management and the health of subsistence resources

- Additional resources and substantial available information documenting the current state of subsistence management and the widespread public dissatisfaction with such management, including but not limited to:

    - U.S. Department of Interior and U.S. Department of Agriculture, *Federal Subsistence Policy Consultation Summary Report* (June 14, 2022), https://www.bia.gov/sites/default/files/dup/tcinfo/final-subsistence-consultation-summary-report_6.10.22_508.pdf
    - Organized Village of Kasaan, Organized Village of Kake, Klawock Cooperative Association, Hoonah Indian Association, Ketchikan Indian Community, Skagway Traditional Council, Organized Village of Saxman, Yakutat Tlingit Tribe, Central Council Tlingit and Haida Indian Tribes of Alaska, *Petition for USDA Rulemaking to Create a Traditional Homelands Conservation Rule for the Long-Term Management and Protection of Traditional and Customary Use Areas in the Tongass National Forest* (July 16, 2020), https://www.alaskawild.org/wp-content/uploads/2020/07/FINAL-Southeast-Tribes-APA-Petition-7-17-2020-Nine-Tribe-Signatures.pdf
    - Office of the General Counsel, U.S. Department of Agriculture, Legal Review of Joint Secretarial Order 3403 (2022), https://www.fedbar.org/wp-content/uploads/2023/04/P72-Climate-Change-supporting-1.pdf

T. *Socioeconomic Conditions.*

This draft Assessment report does a good job of collecting and presenting the many various data sets and research about socioeconomic conditions in Southeast Alaska, including the main economic drivers in the plan area. All this gathered data, however, is not used to make a case for the Need to Change the current plan, which is the primary purpose of an Assessment. The Forest Service should address this shortcoming in the final Assessment report.

We note that this report does a poor job of addressing Tribal socioeconomic needs and concerns.[58] While the report acknowledges that the socioeconomic integrity of the plan area is

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[58] The draft Assessment's *entire* section on Tribal socioeconomic issues states: "Tongass National Forest contains the traditional homelands of many Alaska Native Tribes. Management decisions on the forest may affect lands that the tribes assert have cultural or spiritual significance or that are important for subsistence hunting or gathering activities. For more information on Tribal history, significance, and cultural practices, please see the Tongass as an Indigenous Place assessment." Draft Socioeconomic Assessment Report, 50. Subsistence issues are similarly summarily deferred to other Assessment reports: "Collecting and analyzing historic knowledge may supply

directly related to the ecological integrity of the Forest - and that human communities are inextricably linked to ecological communities - it fails to include any meaningful discussion of actual socioeconomic issues relevant to Tribes compared to some other Assessments such as the draft Tongass as an Indigenous Place Assessment report, which does an excellent job of connecting these issues. For example, the draft Socioeconomic Conditions Assessment report states that "In addition to Alaska Native uses for timber and wood products, local community members rely on wood for personal use like firewood and other household needs." Draft Socioeconomic Conditions Assessment Report, 48. But the report does not explain what those "Alaska Native uses" are or what their economic impacts may be. On the other hand, the draft *Tongass as an Indigenous Place Assessment* report specifically provides real-world examples of how Native uses for timber can create a real and entirely quantifiable economic impact. *See*, Draft Tongass as an Indigenous Place Assessment Report, 48-49 ("The total economic estimated costs associated with the commissioning of a single 25-foot pole for the project was $218,500 in direct spending with an additional $65,000 on indirect and induced spending").

The draft Socioeconomic Conditions Assessment report often refers to Native views, issues, and concerns, but never characterizes them as such, which is a major infirmity. For example, the draft report explains that

> In community feedback discussions, many comments focused on developing an interest in high value, low volume timber products, as well as thoughtful timber management for conservation of other subsistence-use species such as deer. Some comments showed interest in preserving old growth near more populated areas and cutting second growth in more remote area to protect viewsheds. There was also interest in keeping processing local, minimizing export of logs, and investing in timber production for local Alaskan needs. Comments also showed a negative opinion of even-aged management. Overall, there was strong interest in regenerative and sustainable practices that consider whole ecosystems.

Draft Socioeconomic Conditions Assessment Report, 48. The draft Tongass as an Indigenous Place Assessment report goes into great detail about how these issues are all very Tribally focused, but in the Socioeconomic Conditions report, these issues are presented as generic public concerns. We again encourage agency staff to coordinate with each other to ensure that relevant subject matter expertise is reflected in all relevant Assessment reports, rather than appearing in isolation.

The only place where this Assessment does discuss Tribal socioeconomic issues pertains to education and partnerships:

> Co-Stewardship efforts like the Alaska Youth Stewards program and the co-stewardship agreement in place at the Mendenhall Glacier Recreation Area are forging new pathways for the Forest Service to fulfill its trust responsibility to tribes and to work with tribal

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information for restoration and mitigation efforts and is crucial to understanding ecological-human dynamics and patterns in harvest reliant communities of Southeast Alaska. For more information about the important of and impacts to subsistence and other non-commercial harvest, see the Subsistence and Other Non-Commercial Harvest and Tongass as an Indigenous Place Assessments." *Id*. at 51.

> entities to develop culturally inclusive programs and materials. Volunteering on National forests gives communities a chance to interact with management projects that may affect their region's ecological, economic, and social well-being. Their participation in projects and activities are also of important value to the forest: Tongass National Forest volunteers contribute a value of over one million dollars a year and in the 2023 fiscal year, volunteers worked a total of 52,289 hours on the Forest.

Draft Socioeconomic Conditions Assessment Report, 50. We agree that partnerships - and in particular co-stewardship and co-management - are essential to the agency's ability to meet public and Tribal expectations on the Tongass, and strongly encourage the Forest Service to highlight these opportunities in the final Socioeconomic Conditions Assessment.

III. Conclusion.

Thank you for the opportunity to comment on the draft Assessment reports for the Tongass National Forest forest plan revision. The Tongass is unique in the National Forest System, and as a result has been the center of attention for not only Southeast Alaska but also the nation. Revising the forest plan presents an opportunity to address numerous shortcomings of the existing plan, particularly the need to center Indigenous perspectives and co-stewardship in the future management of the Forest. Our comments contribute important information and suggestions to assist the Forest Service in achieving these objectives.

Sincerely,

Dr. Natalie Dawson
Director of Strategic Partnerships, Alaska Venture Fund
Haines, AK

Appendix 1 (USFS Internal Review)

Chapter 6. Wildlife Climate Change Vulnerability Assessment for the Tongass National Forest

Authors: Bonnie M. B. Bennetsen, Steve Brockmann, Bruce G. Marcot

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Table of Contents

Summary

Climate change is affecting wildlife in the Tongass National Forest (NF). Effects stem from changes to wildlife habitats and biological processes. The objectives of this chapter are to: (1) document how climate change is likely to affect Tongass NF wildlife habitats and identify species associated with the most vulnerable habitats; (2) detail how climate change is likely to affect biological processes and associated Tongass NF wildlife species; and (3) assess potential climate change vulnerabilities of wildlife species having specific conservation status and identified local population concerns on part or all of the Tongass NF.

For the three objectives, key implications are as follows. (1) Based on current knowledge, the most vulnerable habitats in the Tongass NF include shrinking alpine habitat above shrub and tree ecotones; freshwater habitats including lakes, ponds, streams, and rivers; wetlands, meadows, and muskegs; low-slope tidelands; tidewater glaciers and icebergs; and saltwater habitats. Wildlife associated with these environments span multiple taxonomic groups including mountain goats, deer, bears, wolves, wolverine, marten, otters, marmots, small mammals, ptarmigan, waterfowl, cranes, seabirds, shorebirds, passerine birds, and amphibians, as well as glacier-specialized species such as Kittlitz's murrelet and harbor seals (Table 2, with scientific names). Effects to salmon and other aquatic species are addressed in Chapter 4.

(2) Biological processes likely to be affected by climate change include physiological tolerances, phenological responses, and interspecific interactions. Impacts may include heat stress; loss of insulating snow resulting in diminished subnivean refugia, hibernation impacts, and freeze-thaw impacts; mismatches between key ecological events such as migration or hatching and food availability; mismatches in cryptic pelage or plumage color with declining snow presence or absence of snow; changes in snow persistence and winter storms affecting mobility, food availability, and competitive relationships; and a variety of other interspecific interactions such as with competitors, predators or prey, disease and parasites, and invasive species, with some species benefiting and others not (Table 3). Species for which the Tongass NF encompasses the most northern portions of their range are expected to benefit from warmer temperatures, especially ectotherms such as amphibians and invertebrates. The most important non-climate stressor that likely has exacerbated climate impacts for Tongass NF wildlife has been timber harvest and associated loss of mature and old-forest cover, especially harvest targeting large-tree, old-growth conifer forests, which serve as important habitat to many species.

Recent transition towards predominantly young-growth forest management supported by restoration of previously clearcut forests should accelerate return of old-growth forest functions and enhance future climate resilience for many Tongass NF wildlife species.

(3) Climate change vulnerabilities vary among Tongass NF species with identified local population concerns (Tables 3 and 4). Aleutian tern, Kittlitz's murrelet, and mountain goat are likely very vulnerable; wolverine are likely moderately to very vulnerable; Pacific marten and marbled murrelet are likely moderately vulnerable; rufous hummingbird is likely mildly to moderately vulnerable; and Queen Charlotte goshawk, western screech-owl, northern flying squirrel, Alexander Archipelago wolf, Sitka black-tailed deer, and boreal toad are likely mildly vulnerable to climate change (Table 5).

These findings contribute preliminary insights on wildlife-climate change relationships and vulnerabilities that will help with the upcoming Tongass National Forest Plan revision, ongoing wildlife habitat management and planning in the Tongass NF, and in guiding future studies and assessments.

Introduction

Alaska, often considered to be on the front lines of climate change (Markon et al. 2018), is experiencing monumental temperature shifts (Thoman and Walsh 2019), including warming rates more than double those of the rest of the United States (Chapin et al. 2014). As described in Chapters 2 and 3, the Tongass NF in Southeast Alaska is becoming warmer, more rain dominated and less snow dominated, with localized reductions in growing season water available to plants due to increased evapotranspiration (Abatzoglou et al. 2018). Glaciers are shrinking (O'Neel et al. 2015) and storms are increasing in frequency and intensity, especially in winter (Graham and Diaz 2001, McCabe et al. 2001, Royer and Grosch 2006, Salathé 2006, Haufler et al. 2010, Basu et al. 2013, Hayward et al. 2017. Climate changes have the potential for substantial effects on a variety of systems and resources, including those involving Tongass NF wildlife.

While climate change influences have been studied for some wildlife species and habitats specifically in the Tongass NF (e.g., mountain goats by White et al. 2011, 2018; conifer forests by Buma and Barrett 2015), the Tongass NF currently lacks a comprehensive wildlife climate change vulnerability assessment. Climate change influences wildlife in a variety of ways. Key wildlife habitats on which wildlife species depend for successful reproduction, survival, and shelter may be lost or gained, or otherwise changed in ways that affect how wildlife can use those habitats. Biological processes likewise can be influenced in complex ways. Examples include effects of climate on physiological tolerances, phenological timing shifts, and changes in how wildlife species interact with other species and their environment. Given the complexities and uncertainties involved, this chapter provides a first step towards understanding Tongass NF wildlife vulnerabilities to climate change. This chapter offers preliminary insights on wildlife-climate change relationships and vulnerabilities that will help with the upcoming Tongass Forest Plan Revision, ongoing wildlife habitat management and planning in the Tongass NF, and in guiding future studies and assessments.

Changes to Wildlife Habitats

Kirchoff et al. (2016, data from Albert and Schoen 2007) report generalized quantifications of vegetated and unvegetated land cover in the Tongass NF as part of the Ecological Atlas of Southeast Alaska. These are shared here (Table 1) for reference as they show the relative abundance of some of the habitat types discussed in this section.

Alpine

Alpine environments, characterized by rocky areas, talus slopes, and sparse vegetation including grasses, forbs, lichens, and low shrubs, are used by a variety of taxa. Wildlife common to these environments include ptarmigan, raptors, passerine birds, hoary marmots, small mammals, black and brown bears, deer, mountain goats, wolverine, wolves in areas with mountain goats, and insects and other invertebrates. Some Tongass NF species such as deer (Schoen and Kirchhoff 1985, McCoy et al. 2015) seasonally migrate to the alpine environment to access nutritional summer forage.

Chapter 5 details key losses in the alpine environment from advancing shrubline and treeline elevation and associated conversion of alpine upslope of the shrub and tree ecotone. These losses are countered, and apparently outpaced in the Tongass NF, by alpine creation as glaciers retreat and snowpack is decreased. However, areas vacated by glaciers without the right substrates and soil development may not readily develop vegetation characteristics needed by some wildlife (Halofsky et al. 2011). Although some species like mountain goats, Kittlitz's murrelets, gray-crowned rosy finches, and rock and white-tailed ptarmigans use rocky areas and

Table 1. Generalized quantifications of vegetated and unvegetated land cover in the Tongass NF as reported in Kirchhof et al. (2016; they cite data from Albert and Schoen 2007).

Land Cover	Tongass NF (acres)
Productive Old Growth Forest	
POG - Large tree	534,516
POG – Medium tree	3,679,543
POG - Small tree	772,839
Other Forests	
Clearcut & 2nd-growth	466,056
Conifer <150yrs	91,333
Conifer forest (other)	91,617
Deciduous forest	65,170
Mixed forest	15,256
Muskeg forest	1,133,245
Muskeg woodland	1,253,607
Sub-alpine forest	1,186,709
Nonforest Vegetation	
Alpine tundra	540,044
Slide zone	792,633
Shrubland	952,257
Herbaceous	18,667
Nonforest (other)	186,494
Freshwater wetlands	
Muskeg meadow	252,160
Emergent wetlands	25,623
River bar	20,077
Lake	164,683
River channel	36,690
Coastal wetlands	
Algal bed	1,361
Rocky shore	4,176
Salt marsh	7,073
Sand & gravel beach	10
Tide flat	17
Unconsolidated sediments	8,633
Unvegetated lands	
Ice & Snow	2,189,317
Unvegetated	2,299,167
Urban	749
Totals	**16,789,724**

more sparse vegetation created by glacial retreat and recession, vegetated alpine supports most Tongass NF alpine wildlife species. Further, many alpine areas in the Tongass NF do not have glaciers and some are confined to relatively small areas. As treeline and shrubline ecotones continue to advance in elevation in these areas, alpine environments could become reduced in area and more isolated, and be problematic for species unable to readily move to other alpine areas. Therefore, the alpine losses above shrub/tree ecotones are likely to be important in the coming decades and affect Tongass NF alpine wildlife by decreasing the area of vegetated alpine habitat available to them.

Many of the alpine species mentioned above may be influenced. Mountain goats are of particular concern due to climate-driven projected population declines for this species in the Tongass NF (White et al. 2018). Projected distribution losses have also been identified for five small mammal species in Southeast Alaska due to the transition of biomes from climate change, especially in alpine and coastal tundra (Baltensperger and Huettman 2015; see additional details in the Distribution and Range Shifts section).

Coniferous Forest

Coniferous forests are a dominant terrestrial environment of the Tongass NF and provide shelter, food, and reproduction for a variety of forest-dependent wildlife species. Among these are Sitka black-tailed deer, an important cultural, subsistence, and ecological species throughout the region. Forest-related research in Southeast Alaska has addressed the implications of various forest management regimes on habitat of this commonly-hunted species and the associated forest biodiversity (McClellan 2005, Deal 2007). Aspects of this research are centered on the old-growth coniferous forest environment and the effects of land use practices, such as clearcutting or partial cutting on forage (Wallmo and Schoen 1980, Kirchhoff et al. 1983, Hanley 1993). Evidence detailed in Chapter 5 indicates that coniferous forests are growing (gains exceeding losses; Buma and Barrett 2015) and shifting in distribution and density in ways that will likely continue to support many Tongass NF species in the long-term, although, as noted below, much has already been lost in some areas.

It is important to recognize that not all conifer forests provide the same value to wildlife. As discussed in the Interaction with Other Stressors section, large-tree, old-growth forests that have been a past focus for timber harvest provide structure and function critical for survival and/or reproduction of species including deer, marten, goshawk, marbled murrelets and many others. Large-tree forests, and landscapes with the highest volume of contiguous old growth, have been reduced by 28 and 66 percent, respectively across Southeast Alaska and some bioregions have been more heavily harvested (Albert and Schoen 2013). For example, in the Northern Prince of Wales bioregion on north-central Prince of Wales Island, contiguous high-volume forest was reduced by 94 percent (Albert and Schoen 2013). This non-climate stressor will exacerbate climate change impacts on species dependent on large-tree conifer forests.

Deciduous Forest and Shrub

The deciduous forest and shrub environment provides habitat for species such as moose and a variety of birds. As detailed in Chapter 5, additional deciduous environments may be created in deglaciated lands and in areas disturbed by mechanisms such as landslides, snow avalanches, and flooding, where mostly primary succession leads to colonization by herbaceous cover and broadleaf tree and shrub species. Climate change is increasing rates of deglaciation, landslides, and flooding, thereby also likely increasing creation of deciduous habitats. However, this is countered by natural succession of deciduous habitat not subject to additional disturbance into coniferous forest. Conifer tree gains are documented within the deciduous cover type at higher latitudes in the Tongass NF (e.g., Yakutat area; Buma and Barrett 2015) with similar gains and losses elsewhere. Succession of deciduous habitat into conifer habitat can negatively affect nutritional winter carrying capacity of moose in the Copper River Delta area (Stephenson et al. 2006). These successional effects along with documented conifer gains in deciduous forest in the Yakutat area suggest potential future considerations for moose here as well.

Freshwater Aquatic Systems - Lakes, Ponds, Rivers, and Streams

Freshwater habitat is critical for amphibian breeding and for prey and foraging of a multitude of wildlife species including aquatic invertebrates and insects that, in turn, serve as prey and food for vertebrates. Here, we use information described in Chapters 2, 3 and 4 to touch on these systems, given their importance to Tongass NF wildlife and amphibians. Some Tongass NF waterbodies are decreasing in size due to water deficits and drying (Thoman and Walsh 2019. However, creation of lakes and streams by receding glaciers offsets these losses in overall freshwater available in the Tongass NF. Effects of other changes to these systems such as increasing water temperatures in ponds and lakes and more variably in rivers, and changes to water chemistry, snow-rain dominant hydrology, and flow regimes as well as effects to aquatic prey detailed in Chapters 2, 3, and 4, are profound and will affect freshwater habitat availability and use by wildlife. Additional details as they apply to amphibians and other wildlife species are provided in the Changes to Biological Processes section.

Wetland and Riparian Vegetation

Wetland and riparian habitat includes vegetation along streamsides, lakeshores, floodplains, and other freshwater wetlands and muskegs. Wetland and riparian vegetation interconnects aquatic and terrestrial environments and supports high wildlife species diversity and high-value habitat. Climate change influences on this habitat are detailed in Chapter 5. Evergreen trees are encroaching and converting wetland, meadow, and muskeg vegetation at all latitudes of the Tongass NF (Buma and Barrett 2015), while emerging streams following glacial recession result in overall gains in riparian environments at more northerly latitudes (Pitman et al. 2021), which could include riparian vegetation if such vegetation is able to establish along streams following glacial recession. Conversion of wetland, meadow, and muskeg vegetation will influence species that rely on those habitats, like waterfowl, cranes, shorebirds, gulls and terns, swallows and other birds, beavers, small mammals, and amphibians. Increased riparian vegetation at more northerly latitudes will benefit a plethora of riparian species.

Shoreline Habitats - Marshes, Beach Meadows, Cliffs, Tidelands, Beaches, and Mudflats

Shoreline habitats are important feeding areas for a variety of wildlife, including deer, bear, wolves, otters, minks, and a multitude of shorebirds, passerine birds, mammals, amphibians, and invertebrates. As described in Chapter 3, sea level rise in Southeast Alaska is substantially offset, and is outpaced in northern portions of the Tongass NF by the land rising in isostatic rebound as glaciers lose mass and retreat (Hicks and Shofnos 1965, Motyka et al. 2007, Sato et al. 2011, Larsen et al. 2004, 2005, 2015). Resulting relative sea levels are projected to be as much as 5.9ft lower 100 years from now at northerly latitudes of the Tongass (e.g., Yakutat) and 0.7ft higher at more southerly latitudes (e.g., Kasaan; Johnson et al. 2019). Projected shoreline changes are greatest for low slope habitats such as mud flats, saltwater marshes, and flatter beaches (Johnson et al. 2019) and could impact habitat availability, depending on what vegetation, substrate, and other important characteristics develop with these changes. Shorebirds may be particularly impacted due to the importance of marshy and mudflat areas as key stopover sites during migration. Several birds also breed in these environments.

Tidewater Glaciers and Icebergs

Tidewater glaciers, or glaciers that terminate in the ocean, provide critical habitat attributes to certain specialized wildlife species such as Kittlitz's murrelets and harbor seals. Kittlitz's murrelets are closely tied to tidewater glacial outflow (Kuletz et al. 2003), whereas harbor seals often birth their pups on icebergs that have calved off tidewater glaciers. Kittlitz's murrelets are attracted to tidewater glaciers, likely due to the birds' specialized foraging adaptations (Kuletz et al. 2003) and possibly also due to enhanced productivity in these areas due to freshwater discharge (Kohan et al. 2019). Substantial recent population declines have been linked to tidewater glacial recession (Kuletz et al. 2003) and Kittlitz's murrelet populations seem likely to continue to decline with additional loss of this habitat (Jezierski et al. 2010). In Glacier Bay, which is bordered by the Tongass NF to the north and south, Kittlitz's murrelets declined >85 percent, at about 11-14 percent per year between 1991 and 2008 (Piatt et al. 2011).

Abundance of harbor seals correspond with increased availability of tidewater icebergs (Womble et al. 2021), and seals exhibit high fidelity to tidewater iceberg habitat during the pupping period (Womble and Gende 2013). Unlike terrestrial haulouts that are subject to tidal fluctuations, occurrence of predators, and possible space limitations, tidewater icebergs offer stable, isolated, floating platforms with low risks of predation, disease, and parasites, as well as thermoregulatory benefits to pups (Womble et al. 2021). Tidewater glaciers and icebergs therefore provide an important and often overlooked habitat element for harbor seals.

Availability of tidewater icebergs during the June pupping season depends on a number of factors, including iceberg calving rates for production and air temperatures for iceberg persistence (Womble et al. 2021). Most iceberg calving coincides with peak surface velocities of glaciers and increased ice supply to terminuses (McNabb et al. 2015), and warming ocean temperatures also can play a dominant role in calving rates (Luckman et al. 2015) as well as in quickening the melting and loss of icebergs. Most glaciers globally and locally are losing mass (Arendt et al. 2002, 2006, 2013, Larsen et al. 2007, Arendt 2011, Bliss et al. 2014, Jin et al. 2017, McGrath et al. 2017, Hock et al. 2019, Wouters et al. 2019, Zemp et al. 2019, Yang et al. 2020, Jakob and Gourmelen 2023), and many tidewater glaciers in the region are retreating and experiencing frontal losses (McNabb and Hock 2014, McNabb et al. 2015). For example, glacier volumes across all Alaska coastal mountain drainages shrank by 52 km^3 (12 mi^3) per year during 1980 to 1995, this rate increased to 96 km^3 (23 mi^3) per year between the mid-1990s and 2000-

2001 (Arendt et al. 2002), and rapid shrinking has continued in Alaska more recently (Arendt et al. 2013, Jin et al. 2017, Jakob and Gourmelen 2023). Warm summer sea surface temperatures may provide the trigger for tidewater glacier retreat (McNabb and Hock 2014), but several factors affect tidewater glacier retreats and additional response (Molnia 2008, Motyka et al. 2013, Slater et al. 2019). Importantly, conversion of glaciers from tidewater to land-based can result in immediate loss of tidewater icebergs in a fjord.

There are six existing tidewater glaciers within waters surrounding the Tongass NF. These include the Turner and Hubbard Glaciers in Disenchantment Bay near Yakutat, and the Sawyer, South Sawyer, Dawes, and LeConte Glaciers further south along the mainland coastal mountains. All of these glaciers are generally thinning and retreating (McNabb and Hock 2014). Using the Landscape Change Monitoring System (Housman et al. 2021), we estimate that summer iceberg coverage near the six tidewater glaciers has essentially remained the same, decreasing by only 42 hectares (104 acres), which represents a -0.4 percent change between 1985 and 2020. However, three other former tidewater glaciers near the Tongass NF, East Nunatak in Disenchantment Bay and the Taku and Baird glaciers in the coast mountains, no longer calve tidewater icebergs (Molnia 2008), and therefore no longer provide associated habitat elements for Kittlitz's murrelets or harbor seals. Similarly, the number of actively calving tidewater glaciers in Glacier Bay National Park has decreased from 12 to 5 since 1982 (Womble et al. 2021). Therefore, although ice coverage in front of the six tidewater glaciers near the Tongass NF has not changed substantially in recent decades, the number of tidewater glaciers is decreasing in the region, which may mean ongoing declines in habitat for the murrelet, seal, and other associated species.

Saltwater Habitat

As detailed in Chapter 4, ocean temperatures are increasing globally and regionally, anomalous marine heating events are becoming more frequent, and oceans are becoming more acidic as they take up more atmospheric CO_2. These ocean changes, along with loss of tidewater glaciers discussed above, result in changes in upwelling patterns, nutrient circulation, and oxygen concentration. Ocean acidification further impacts shellfish and other calcium carbonate-dependent organisms (Markon et al. 2018). All of these changes in saltwater habitat impact primary and secondary ocean productivity and food webs involving marine and marine-foraging wildlife (Freeland et al. 1997, Royer et al. 2001, Royer and Grosch 2006, Haufler et al. 2010, Bortner et al. 2010, Tillmann and Siemann 2011b, Chapin et al. 2014, Freeland and Whitney 2014). Further, ecosystem alterations are anticipated to accelerate in ways that are difficult to predict (Markon et al. 2018).

Saltwater habitat changes are particularly important for Tongass NF wildlife given the island archipelago nature of this region and the reliance of many wildlife on marine foraging. Examples of impacts of changes to saltwater habitat for Tongass NF wildlife abound. For instance, warmer waters have led to decreases in the abundance of fish in the Gulf of Alaska with adverse effects on fish-eating birds and mammals (Bortner et al. 2010, Piatt et al. 2011). Climate-mediated cycles in food supply have been identified as a potential factor in widespread declines of murrelets and harbor seals in the Gulf of Alaska during the 1980s to 1990s (Piatt et al. 2011). Further, seabird mortality events have increased in frequency, magnitude, and duration since 2015 alongside anomalously high ocean temperatures (Jones et al. 2018; von Biela et al. 2019, Piatt et al. 2020, Arimitsu et al. 2021, Van Hemert et al. 2020, 2022). Although starvation has been implicated as the apparent cause of death in many of these die-offs due to emaciated condition of the carcasses, paralytic shellfish toxins have been identified as contributing factors.

In the Tongass NF, biotoxin produced by harmful algal blooms from warming oceans was identified as a lead factor in a 2019 mortality event at an arctic tern colony (Van Hemert et al. 2022). Unfortunately, geographic scope, frequency, and intensity of such blooms are projected to expand (Anderson et al. 2021, Glibert et al. 2014). Aleutian terns, a designated Regional Forester Sensitive species, are also impacted. The same marine heatwave resulted in lower food availability, chick provisioning with lower quality prey, and a larger proportion of prey items from sub-prime nearshore foraging areas (Tengeres 2022). Isostatic rebound and coastal uplift from glacial recession could also result in more rapid succession of arctic and Aleutian tern breeding areas into unsuitable vegetation characteristics (e.g., see Holtan 1980: observed with earthquake uplift on Copper River delta changes in river disturbance and associated vegetation structure). Increasing summer precipitation and intensity and frequency of storm events may also affect reproductive success, with increases in mortality of chicks and eggs from exposure and from high surf and flooding conditions (Tengeres 2022). With all of these factors, climate change has been attributed as a contributing factor to observed population declines of Aleutian terns in Alaska (Tengeres 2022).

There are also concerns about potential effects of ocean warming and acidification on invertebrate prey of shorebirds. Impacts may be especially important for migrating shorebirds (Bortner et al. 2010), although breeding shorebirds are also affected. For example, changes in predation avoidance behavior and physiology of mussel and limpet prey with warmer water temperatures in British Columbia has been suggested as causing decreased breeding densities of the black oystercatcher (Hipfner and Elner 2013; Alaska Center for Conservation Science 2019), another Regional Forester Sensitive Species. Further, latitudinal shifts in intertidal invertebrate communities (Sagarin et al. 1999) as well as occurrence of marine vertebrates (e.g., McMahon and Hays 2006) have been documented. All of these demonstrate changes in saltwater habitat that could affect Tongass NF wildlife.

Impacts to Tongass NF wildlife are expected for species that forage in saltwater, shoreline, and estuary habitats, especially for seabirds, waterfowl, shorebirds, and some mammals. For instance, all 67 ocean bird species in U.S. waters were categorized as medium or high vulnerability to climate change due to ocean changes (Bortner et al. 2010). These coastal seabirds, including Aleutian tern and Kittlitz's and marbled murrelets, are vulnerable to climate change due to their low reproductive potential and reliance on saltwater food webs that are also threatened by climate change (Jezierski et al. 2010, Bortner et al. 2010). Many of these species nest in the Tongass NF, and near-shore water conditions affect reproductive success at terrestrial breeding sites.

<u>Wildlife Species Associated with Vulnerable Habitats</u>

We define vulnerable habitats as environments likely to decline the most in occurrence, area, and/or contiguity under ongoing and forthcoming climate change influence. Based on our current knowledge of effects of climate change on Tongass NF habitats summarized above, the most vulnerable habitats from climate change in the Tongass NF include vegetated alpine tundra above shrub and tree ecotones (due to shrub and tree elevation advance; note that total alpine acreage is increasing in the Tongass NF due to increases in unvegetated and sparsely vegetated environments from glacier recession – see Chapter 5); freshwater habitats; wetlands/meadows/muskegs; low-slope tidelands; tidewater glaciers and icebergs; and saltwater habitats (Table 2). We also expect continued decreases of deciduous forest and shrub in more northerly parts of the Tongass NF as glacially-vacated transitory deciduous habitats succeed into coniferous forest. Deciduous forest and shrub habitat was not included in Table 2 due to the transitory and localized nature of this habitat change, but is likely to be important for species such as moose and shrub-dependent landbirds in the Yakutat area.

In total, 165 (71 percent) of the 231 native vertebrate wildlife species that breed or probably breed in the Tongass NF are associated with these habitats during some portion of their life history (Table 2). We considered for Table 2 and subsequent species tables in this Chapter native vertebrate species (species level) with records of breeding or probable breeding in the Tongass NF (MacDonald and Cook 1999, 2007, Andres and Browne 2004, Andres et al. 2004, Johnson et al. 2008, Heinl 2010, Armstrong 2015) to keep the list manageable, while covering the majority of species and the important breeding life history phase. However, we recognize the importance of the Tongass NF for migration and non-breeding use, endemic subspecies of small mammals and other taxa, and invertebrates not considered in this Chapter. Also note that the importance of these habitat vulnerabilities will depend on other species-specific factors, like species population status and trends, and for species with status concerns, the importance of the Tongass NF to the species' global population. These aspects are addressed in the Species Vulnerabilities section. Further, habitat changes are only a part of what determines climate change vulnerability; changes to biological processes addressed in the Changes to Biological Processes section are additionally and perhaps more important for many Tongass NF wildlife species.

Habitats commonly used by Tongass NF wildlife species are represented without prioritization. Future assessments prioritizing habitat for each species as done by Marcot and others (2015), possibly along with more fine-scale ecotype changes (Jorgenson et al. 2015) could provide more detailed understanding of climate change influences on wildlife habitat.

Table 2. Native vertebrate wildlife species that breed or probably breed in the Tongass NF and are associated with vulnerable habitats.

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Canada Goose	*Branta canadensis*	X	X	X	X		X
Trumpeter Swan	*Cygnus buccinator*		X	X	X		

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Gadwall	*Mereca strepera*		X	X	X		X
American Wigeon	*Mareca americana*		X	X	X		X
Mallard	*Anas platyrhynchos*		X	X	X		X
Blue-winged Teal	*Spatula discors*		X	X	X		
Northern Shoveler	*Spatula clypeata*		X	X	X		X
Northern Pintail	*Anas acuta*		X	X	X		X
Green-winged Teal	*Anas crecca*		X	X	X		X
Redhead	*Aythya americana*		X	X	X		X
Ring-necked Duck	*Aythya collaris*		X	X	X		X
Greater Scaup	*Aythya marila*		X		X		X
Lesser Scaup	*Anthia affinis*		X				X
Long-tailed Duck	*Clangula hyemalis*						X
Common Eider	*Somateria mollissima*				X		X
Harlequin Duck	*Histrionicus histrionicus*		X		X		X
Surf Scoter	*Melanitta perspicillata*						X
White-winged Scoter	*Melanitta deglandi*						X
Bufflehead	*Bucephala albeola*		X		X		X
Common Goldeneye	*Bucephala clangula*		X		X		X
Barrow's Goldeneye	*Bucephala islandica*		X		X		X
Hooded Merganser	*Lophodytes cucullatus*		X		X		X
Common Merganser	*Mergus merganser*		X		X		X
Red-breasted Merganser	*Mergus serrator*		X		X		X
Sooty Grouse	*Dendragapus fuliginosus*	X		X			
Willow Ptarmigan	*Lagopus lagopus*	X					
Rock Ptarmigan	*Lagopus muta*	X					
White-tailed Ptarmigan	*Lagopus leucura*	X					

Species	**Scientific Name**	**Alpine**	**Fresh Water**	**Wetlands, Meadow, Muskeg**	**Tide-lands**	**Tidewater Glaciers, Icebergs**	**Salt Water**
Red-throated Loon	*Gavia stellata*		X				X
Common Loon	*Gavia immer*		X				X
Pied-billed Grebe	*Podilymbus podiceps*		X				X
Red-necked Grebe	*Podiceps grisegena*						X
Fork-tailed Storm-Petrel	*Hydrobates furcatus*						X
Leach's Storm-Petrel	*Hydrobates leucorhous*						X
Brandt's Cormorant	*Urile penicillatus*						X
Double-crested Cormorant	*Nannopterum auritum*		X		X		X
Pelagic Cormorant	*Urile pelagicus*				X		X
American Bittern	*Botaurus lentiginosus*		X	X			
Great Blue Heron	*Ardea herodias*		X	X	X		
Osprey	*Pandion haliaetus*		X		X		X
Bald Eagle	*Haliaeetus leucocephalus*	X	X	X	X		X
Northern Harrier	*Circus hudsonius*	X		X	X		
Sharp-shinned Hawk	*Accipiter striatus*	X		X	X		
Red-tailed Hawk	*Buteo jamaicensis*			X			
Golden Eagle	*Aquila chrysaetos*	X					
American Kestrel	*Falco sparverius*	X		X	X		
Merlin	*Falco columbarius*	X		X	X		
Peregrine Falcon	*Falco peregrinus*	X		X	X		
Sora	*Porzana carolina*		X	X	X		
Sandhill Crane	*Antigone canadensis*			X	X		
Semipalmated Plover	*Charadrius semipalmatus*				X		
Killdeer	*Charadrius vociferus*				X		

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Black Oystercatcher	*Haematopus bachmani*				X		
Spotted Sandpiper	*Actitis macularius*		X	X	X		
Solitary Sandpiper	*Tringa solitaria*			X	X		
Greater Yellowlegs	*Tringa melanoleuca*		X	X	X		
Lesser Yellowlegs	*Tringa flavipes*		X	X	X		
Least Sandpiper	*Calidris minutilla*			X	X		
Short-billed Dowitcher	*Limnodromus griseus*			X	X		
Wilson's Snipe	*Gallinago delicata*			X	X		
Red-necked Phalarope	*Phalaropus lobatus*		X	X	X		X
Black-legged Kittiwake	*Rissa tridactyla*				X		X
Bonaparte's Gull	*Chroicocephalus philadelphia*		X	X	X		X
Short-billed Gull	*Larus brachyrhynchus*		X	X	X		X
Herring Gull	*Larus argentatus*		X	X	X		X
Glaucous-winged Gull	*Larus glaucescens*		X	X	X		X
Aleutian Tern	*Onychoprion aleuticus*		X	X	X		X
Arctic Tern	*Sterna paradisaea*		X	X	X		X
Caspian Tern	*Hydroprogne caspia*				X		X
Parasitic Jaeger	*Stercorarius parasiticus*		X	X	X		X
Long-tailed Jaeger	*Stercorarius longicaudus*						X
Common Murre	*Uria aalge*				X		X
Thick-billed Murre	*Uria lomvia*				X		X
Pigeon Guillemot	*Cepphus columba*						X
Marbled Murrelet	*Brachyramphus marmoratus*						X

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Kittlitz's Murrelet	*Brachyramphus brevirostris*	X				X	X
Ancient Murrelet	*Synthliboramphus antiquus*				X		X
Cassin’s Auklet	*Ptychoramphus aleuticus*				X		X
Parakeet Auklet	*Aethia psittacula*						X
Rhinoceros Auklet	*Cerorhinca monocerata*				X		X
Horned Puffin	*Fratercula corniculata*				X		X
Tufted Puffin	*Fratercula cirrhata*				X		X
Northern Hawk Owl	*Surnia ulula*	X					
Short-eared Owl	*Asio flammeus*	X		X	X		
Common Nighthawk	*Chordeiles minor*	X		X			
Black Swift	*Cypseloides niger*	X	X	X	X		
Vaux's Swift	*Chaetura vauxi*		X	X	X		
Rufous Hummingbird	*Selasphorus rufus*	X		X			
Belted Kingfisher	*Megaceryle alcyon*		X	X	X		X
Red-Breasted Sapsucker	*Sphyrapicus ruber*			X			
Olive-sided Flycatcher	*Contopus cooperi*			X			
Alder Flycatcher	*Empidonax alnorum*			X			
Yellow-bellied Flycatcher	*Empidonax flaviventris*			X			
Say’s Phoebe	*Sayornis saya*	X					
Black-billed Magpie	*Pica hudsonia*	X		X	X		
American Crow	*Corvus brachyrhynchos*			X	X		
Common Raven	*Corvus corax*	X		X	X		
Horned Lark	*Eremophila alpestris*	X			X		
Tree Swallow	*Tachycineta bicolor*		X	X	X		

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Violet-green Swallow	*Tachycineta thalassina*		X	X	X		
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*		X	X	X		
Bank Swallow	*Riparia riparia*		X	X	X		
Cliff Swallow	*Petrochelidon pyrrhonota*		X	X	X		
Barn Swallow	*Hirundo rustica*		X	X	X		
Pacific Wren	*Troglodytes pacificus*				X		
American Dipper	*Cinclus mexicanus*		X		X		
Mountain Bluebird	*Sialia currucoides*			X	X		
Townsend's Solitaire	*Myadestes townsendi*	X					
Gray-cheeked Thrush	*Catharus minimus*	X					
American Robin	*Turdus migratorius*	X		X	X		
American Pipit	*Anthus rubescens*	X		X	X		
Common Yellowthroat	*Geothlypis trichas*			X			
Chipping Sparrow	*Spizella passerina*			X			
Savannah Sparrow	*Passerculus sandwichensis*			X	X		
Song Sparrow	*Melospiza melodia*			X	X		
Lincoln's Sparrow	*Melospiza lincolnii*			X	X		
Golden-crowned Sparrow	*Zonotrichia atricapilla*	X					
Dark-eyed Junco	*Junco hyemalis*			X	X		
Snow Bunting	*Plectrophenax nivalis*	X			X		
Red-winged Blackbird	*Agelaius phoeniceus*			X	X		
Rusty Blackbird	*Euphagus carolinus*			X	X		

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Brown-headed Cowbird	*Molothrus ater*			X	X		
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	X			X		
Common Redpoll	*Acanthis flammea*			X	X		
Hoary Marmot	*Marmota caligata*	X					
Arctic Ground Squirrel	*Spermophilus parryii*	X					
American Beaver	*Castor canadensis*		X	X			
Meadow Jumping Mouse	*Zapus hudsonius*			X			
Western Jumping Mouse	*Zapus princeps*			X			
Brown Lemming	*Lemmus trimucronatus*	X		X			
Long-tailed Vole	*Microtus longicaudus*	X			X		
Root Vole	*Microtus oeconomus*	X		X			
Singing Vole	*Microtus miurus*	X					
Meadow Vole	*Microtus pennsylvanicus*			X			
Northern Red-backed Vole	*Myodes rutilus*	X					
Common Muskrat	*Ondatra zibethicus*			X			
Northwestern Deer mouse (Keen's)	*Peromyscus keeni*				X		
Western Heather Vole	*Phenacomys intermedius*	X					
Northern Bog Lemming	*Synaptomys borealis*		X	X			
Collared Pika	*Ochotona collaris*	X					
Dusky Shrew	*Sorex obscurus*	X			X		
Western Water Shrew	*Sorex navigator*		X	X			
Silver-haired Bat	*Lasionycteris noctivagans*			X			

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Coyote	*Canis latrans*				X		
Alexander Archipelago Wolf	*Canis lupus ligoni*	X	X	X	X		
Black Bear	*Ursus americanus*	X	X	X	X		
Brown Bear	*Ursus arctos*	X	X	X	X		
Steller Sea Lion	*Eumetopias jubatus*				X		X
Harbor Seal	*Phoca vitulina*				X	X	X
Wolverine	*Gulo gulo*	X			X		
North American River Otter	*Lontra canadensis*		X		X		
American Marten	*Martes americana*		X				
Pacific Marten	*Martes caurina*		X		X		
American Ermine	*Mustela richardsonii*	X		X			
Beringian Ermine	*Mustela erminea*	X		X			
Haida Ermine	*Mustela haidarum*	X		X			
American Mink	*Neovison vison*			X	X		
Moose	*Alces alces*			X			
Sitka Black-tailed Deer	*Odocoileus hemionus sitkensis*	X		X	X		
Mountain Goat	*Oreamnos americanus*	X					
Northwestern Salamander	*Ambystoma gracile*		X	X			
Long-toed Salamander	*Ambystoma macrodactylum*		X	X			
Rough-skinned Newt	*Taricha granulosa*		X	X			
Boreal (Western) Toad	*Anaxyrus boreas*	X	X	X	X		
Columbia Spotted Frog	*Rana luteiventris*		X	X			

Species	Scientific Name	Alpine	Fresh Water	Wetlands, Meadow, Muskeg	Tide-lands	Tidewater Glaciers, Icebergs	Salt Water
Wood Frog	*Lithobates sylvaticus*		X	X			

Changes to Biological Processes

Changes to habitats are only part of the climate change influences on wildlife. Equally or more important are impacts on biological processes that affect various life history stages and the abilities of Tongass NF wildlife species to survive and reproduce. Such responses are often non-linear and complex and are not directly represented in habitat changes (Burkett et al. 2005). Climate influences on biological processes stem from a multitude of physiological, phenological, and interspecific interactions, can be influenced by other, non-climate stressors, and often result in distribution and range shifts.

Physiological Effects

Few studies have addressed how climate change might challenge physiological processes and tolerances of wildlife species that live in the Tongass NF (although see White et al. 2018 for an exception). An understanding of how changes in ambient temperatures, hydrology, and weather events affect physiological functions can help inform our assessment of vulnerability. Following a brief review of how animals manage environmental temperature variations, we discuss how expected increases in temperatures and modification of hydrologic cycles may affect physiological processes of wildlife in Southeast Alaska, and how impairment or enhancement of those processes are likely to affect populations and distribution.

Ectotherm Physiology

Temperature variations and water availability are affected by climate change and can have direct and indirect effects on physiological functions of animals (Martin and Nagy 2002). Cold-blooded species (i.e., “ectotherms”) rely entirely on heat from their environment and do not produce metabolic heat as warm-blooded “endotherms” do, so ambient temperature changes more directly affect their physiological processes.

Ectotherms in the Tongass NF include a broad variety of invertebrates, including insects and other arthropods, mollusks, nematodes, annelids, and others (ADFG 2015), six native and two introduced amphibians (MacDonald and Cook 2007) and four reptiles (sea turtles) that only occasionally reach Alaska's marine waters (ADFG 2015). Our discussion of ectotherm physiology focuses primarily on the region's amphibians and insects, although the principles likely apply generally to the other invertebrates in Southeast Alaska.

Because they do not produce metabolic heat, ectotherms must rely on behavioral responses (basking or moving to warmer or cooler microhabitats, for example) to maintain suitable body temperatures, which can decrease foraging activity, energy efficiency, and reproduction (Lillywhite et al. 1973, Hillman et al. 2009, Ma et al. 2018, 2021). They also adjust foraging rates in response to temperatures.

Boreal toads, for example, maximize feeding at 27°C (81°F), reduce food consumption at lower temperatures, and move to cooler microsites when food availability is reduced in laboratory trials (Lillywhite et al. 1973). In the wild, the toads construct "home burrows" that are used daily to avoid the coldest and warmest temperatures (Smits 1984), although they remain active well below their preferred body temperature of 24 to 27°C (75 to 81°C) (Lillywhite et al. 1973, Smits 1984, Ream 2013), which is above typical summer temperatures in Southeast Alaska.

Among cold-blooded taxa, temperature acts as a controlling factor for many physiological processes, including water balance, appetite, digestion, oxygen uptake and transport, muscular contraction, vision, hearing, emergence, calling, developmental rate (including metamorphosis), growth, regeneration, mitosis, sex determination, and immune functions (Willmer 1982, Hillman et al. 2009, Blaustein et al. 2010, Stange and Ayres 2010). Physiological functions generally improve exponentially with temperature increases as catalytic enzyme reactions accelerate until optimum temperature is reached. Beyond this optimum temperature, performance typically declines rapidly toward a "critical maximum temperature" at which enzymes and other proteins are denatured, oxygen delivery is compromised, and cellular ion balance is disrupted, causing a physiological function to fail (Willmer 1982, Amarasekare and Savage 2012, Paaijmans et al. 2013, Ma et al 2021). Individual physiological functions respond at differing rates to temperature changes, with various bodily functions declining and failing at progressively warmer or colder temperatures.

Repeated extreme heat events can suppress insect populations and alter invertebrate community structures, exerting greater influence than increases to identical mean temperatures with lower fluctuations; thus, maximum daily temperatures are often more biologically relevant than mean daily temperatures (Ma et al. 2021). Optimum temperature for any given physiological function is typically much closer to critical maximum temperature than it is to critical minimum temperature, so organisms in the warmer parts of their range typically live closer to their thermal limits (and are therefore more vulnerable to local heat waves) than are those in cooler parts of their range (Ma et al. 2021), as is the case for many species in the Tongass NF.

Warmer temperatures accelerate development of insect larvae and pupae, resulting in earlier hatching of larvae and earlier emergence of metamorphosed adults if optimum temperatures are not exceeded. Mating and egg laying are also likely to be earlier under warmer conditions (Gordo and Sanz 2005, Stange and Ayres 2010, Yang and Rudolf 2010, Tillmann and Siemann 2011). Temperature sensitivity of development (growth and maturation of individuals) appears to exert greater influence than either fecundity (reproductive output) or survivorship in population-level demographic responses of insects to changing climate (Amarasekare and Savage 2012).

While higher temperatures increase metabolic rates and other physiological functions, they can also expose animals to greater evaporative water loss, potentially limiting movement, reducing habitat availability, and compromising fitness (Tracy et al. 1993; Bartelt et al. 2004, 2010; Hillman et al. 2009). Many ectotherms also rely on open water and moist upland microsite conditions for parts of their lifecycles, so changes in hydrology can directly affect reproductive success and survival (Tracy et al. 1993, Bartelt et al. 2004, Evans et al. 2020).

Despite their close connection to open water for breeding and larval development, though, terrestrial amphibians generally have greater tolerance to dehydration than other vertebrates. Various species of toads, for example, can tolerate water loss up to approximately 45 percent of their body mass, as compared to humans, whose dehydration tolerance is limited to approximately 10 to 12 percent (Hillman et al 2009). Boreal toads from the Puget Sound area, for example, survived dehydration of up to 43 percent of their body weight, while more aquatic frogs such as the wood frog and leopard frog tolerated loss of 30 to 36 percent of their body weight. Tree frogs such as the Pacific chorus frog were intermediate in their desiccation tolerance, surviving up to 39 percent dehydration, by weight (Thorson and Svihla 1943). Columbia spotted frogs are likely more vulnerable to dehydration given close association and overwintering in aquatic habitat (Waters 1992, MacDonald 2003).

Overall increases in precipitation are projected across Southeast Alaska (5 model average), with declining proportions of snow (Chapter 2). Seasonal increases will be most pronounced in fall (9.8-21.7 percent), winter (1.9-9.4 percent), and spring (4.7-11.1 percent), while in summer, some individual climate models project decreases in precipitation in some locations. This suggests that water stress is unlikely to be a widespread or common threat for amphibians or invertebrates across much of the Tongass NF, despite projected increases in potential evapotranspiration and potential summer decreases in precipitation that could cause drying in some areas and possibly localized habitat limitations such as drying ephemeral streams and ponds. Scherer et al. (2008) found no significant correlation between environmental moisture and annual survival in boreal toads in Colorado, although the range of moisture levels may have been limited during the years they evaluated.

Seven of the eight amphibian species in Southeast Alaska (i.e., all but the wood frog) are at or near the northern extents of their ranges, where warmer temperatures are expected to result in accelerated growth and development (Martin and Nagy 2002, Blaustein et al. 2010, Lawler et al. 2010). We expect this trend to be most pronounced in low-elevation, rainfall-dominated stream and wetland systems, which are typically 5 to 12°C (41 to 54°F) warmer than snow- or glacier-dominated systems (Fellman et al. 2014, Shanley et al. 2015). Streams in glaciated watersheds get colder as warm air promotes glacial melting, a condition that is expected to prevail until watersheds are substantially deglaciated (Fellman et al. 2014).

We do not expect increases in amphibian populations in colder, glacially-fed rivers and streams, but glacial outwash ponds (depressions left by retreating glaciers that fill with water) are among the most productive amphibian breeding habitats in Southeast Alaska (Waters 1992). These ponds, which are disconnected from mainstem surface currents, are expected to increase in abundance as glaciers recede, although it might not yet be known what proportions and at what locations they will be permanent, astatic, or ephemeral. They, along with non-flowing riverine sloughs, are likely to warm with increasing air temperatures and solar heating (Adelfio and Oehlers 2020) and are likely to support increased invertebrate and amphibian productivity as climate warms.

Warmer winter temperatures may also increase overwinter survival of hibernating boreal toads, as demonstrated in at least three boreal toad populations in Colorado (Scherer et al. 2005, 2008). Lack of insulating snow during extreme cold has been hypothesized as contributing to mortality of wintering toads in traditionally cold sites in the Tongass NF (Carstensen et al. 2003, Armstrong and Hermans 2004, Ream 2013). However, Scherer et al. 2008 found only weak influence of snow depth on overwinter survival of boreal toads in Colorado, while Scherer et al. (2005) showed no such correlation. With higher minimum winter temperatures, lack of snow may become less critical in the Tongass NF, depending on how much warmer those minimum temperatures become. Boreal toads hibernate (often communally) in burrows that protect them from winter cold across their range. Toads in the Tongass NF are near the northern extent of their range, so we can expect that where cold winters limit their survival, warmer temperatures are likely to result in greater survival. Effects are likely to vary considerably among sites, though, and will probably depend on microsite conditions such as soil type and depth, and site exposure.

Wood frogs are the only amphibians in the Tongass NF that are not near the northern edge of their range, as they reach into arctic Alaska and Canada (MacDonald and Cook 2007). This species tolerates freezing of its tissues during its hibernation. Freezing and subsequent thawing, though, are energetically expensive events, so decreased depth or persistence of snow cover that leads to increases in freeze–thaw cycles can deplete energy reserves of hibernating wood frogs, impacting overwinter survival and, where effects are not lethal, post-emergence reproductive success (Sinclair et al. 2013). Predicting the effects of warmer winters with reduced snow accumulation on the energetics and survival of hibernating wood frogs is complicated. Opposing forces include shorter, warmer winters reducing the risk of exceeding lethal ice content levels of >2/3 body water frozen and less snow cover, allowing greater temperature fluctuations and more energetically-costly freeze-thaw events (Fitzpatrick et al. 2020). We expect these effects to be inconsistent across the Tongass NF, although it has not been explicitly studied.

Similar effects have been shown for invertebrate ectotherms. Harris et al. (2019) documented declines in beetle populations due to decreases in insulating snow during the coldest months. Williams et al. (2012b) demonstrated that energy demands and mortality were higher during warmer winters than during colder winters for butterfly species with comparatively higher metabolic rates, but not for species with greater metabolic suppression during hibernation. Williams et al. (2012a) attributed greater energy demands and mortality of butterflies during hibernation to temperature fluctuations, especially during fall, when lack of insulating snow would allow for greater and more frequent temperature swings.

Increased productivity and survival of some amphibians is plausible in many locations in the Tongass NF, but will depend on additional factors, including adequate availability of food to support accelerated growth and larger populations. Warmer temperatures do appear likely to result in greater availability of food for amphibians, including phytoplankton, algae, and other items consumed by tadpoles, as well as invertebrates consumed by carnivorous larvae and adults (Blaustein et al. 2010, Stange and Ayres 2010).

Many species of birds, mammals, and fish also prey on invertebrates, and would likely benefit from their increased availability. Yom-Tov and Yom-Tov (2005), for example, documented increased body size of masked shrews in Alaska since the mid-1900s, which they attributed to greater availability of invertebrate prey due to progressively warmer winter temperatures. Increased availability of insects is also anticipated to increase productivity of nesting shorebirds, at least initially, if they are able to change their migration and nesting schedules to coincide with progressively earlier peaks in insect availability (Bortner et al. 2010), although evidence from arctic studies suggest increasing mismatch of shorebird nesting and invertebrate prey availability (Kwon et al. 2019, Shaftel et al. 2021). Species that prey on amphibians (e.g., herons, mink, weasels, etc.) are also likely to benefit if warmer temperatures result in larger amphibian populations.

Climate change, though, can negatively alter reproductive timing, competition, community structure, parasite and pathogen vulnerabilities, and other processes (discussed below), which react at different rates to changing conditions, complicating prediction of population-level responses (Blaustein et al. 1994, 2010; Burkett et al. 2005; Ream 2013). Diseases including chytrid fungus and ranavirus that can be fatal to amphibians, for example, may be more prevalent and virulent at higher temperatures, particularly for species adapted to cooler temperatures (Pounds et al. 2006, Scherer et al. 2008, Brand et al. 2016, Cohen et al. 2019), likely compromising potential amphibian population increases and range expansions. Overall, we expect populations of many invertebrates and amphibians in the Tongass NF to increase, but also expect these increases to vary among species and locations. Inconsistent effects on predators of ectotherms are also likely, due to myriad influences of various habitat and process-related variables.

Endotherm Physiology

Warm-blooded species (i.e., "endotherms") generate metabolic heat and use active evaporative cooling (e.g., sweating and panting) to maintain more stable body temperatures (homeothermy) which reduces direct effects of fluctuations in ambient temperatures (Martin and Nagy 2002, Mitchell et al. 2018). The range of temperatures over which endotherms (i.e., birds and mammals) maintain their basal metabolic rate while at rest is known as the thermoneutral zone. As ambient temperatures drop below this range, an animal must expend energy to either move to a warmer location or generate metabolic heat. At temperatures above the thermoneutral zone, endotherms can either reduce heat-generating activity, move to a cooler location, or initiate evaporative cooling (through sweating or panting). Like ectotherms, though, endotherms have critical maximum and minimum temperatures beyond which bodily functions fail (Martin and Nagy 2002, Withers et al. 2016, Mitchell et al. 2018).

Endotherms have higher energy and water requirements than ectotherms of similar body size, largely to support maintenance of body temperature, which allows greater physical functionality across a wider range of environmental conditions. When water, nutrients, or energy are limited, homeothermy (along with other physiological functions including reproduction) can be compromised. Body temperature can return to normal if the animal replenishes its energy and/or water reserves, but chronic hypo- or hyperthermia, which may be seasonal in temperate environments, can reduce fecundity (reproductive success), leading to population declines and local extirpation (Mitchell et al. 2018, White et al. 2018). Acute hypo- or hyperthermia can result in death of the animal.

Examples of heat stress events are already known from the Tongass NF. A report of six little brown myotis bats (*Myotis lucifugus*) found dead at a maternity colony in a Wrangell warehouse during a summer heat wave in 2019 (J. Delabrue personal communication) is a likely example. Likewise, marmots are subject to heat stress from summer solar radiation with effects documented on survival and reproduction (Armitage 2017).

Other examples exist of species using behavioral plasticity to reduce such impacts. For instance, rufous hummingbirds seasonally adjust nests to different levels and types of trees for optimal climatic conditions (Horvath 1964).

White et al. (2011, 2018) evaluated population-level responses of mountain goats (a cold-adapted alpine specialist) to projected climate scenarios and showed that increases in summer temperatures are likely to substantially impact goat populations across their range in coastal Alaska, including in the Tongass NF. Projected population declines and extirpations resulted primarily from the inability of mountain goats to assimilate adequate nutrient and energy reserves during summer to survive harsh winter conditions (White et al. 2018). Although mountain goats can alter their behavior to help partially compensate (Frederick 2015), higher summer temperatures force goats to reduce foraging activity and use suboptimal feeding sites to avoid heat stress (White et al. 2018). Progressively earlier emergence and accelerated growth and maturation of forage plants are also anticipated to result in shorter periods when nutritious young plant growth is available, followed by an abundance of lower-quality, less-digestible food with higher lignin (woody) content (White et al. 2018). Impacts of this nutritional stress are expected to be particularly acute for juvenile goats, which require higher levels of nutrition to support growth and over-winter survival.

Wolverines in Southeast Alaska may also be adversely affected by warming conditions. Spring snow cover (which is projected to decline with warming) is understood to be critical for providing thermal protection for newborn wolverines in reproductive dens, and a limiting factor for the species at the southern margins of their circumboreal range (Aubry et al. 2007, Copeland et al. 2010, Carroll et al. 2021). Warm summer temperatures, ranging from about 14 to 24°C (57 to 75°F) average maximum August temperature, may also limit wolverine distribution, restricting the animals to higher elevations across the southern portion of their range (Copeland et al. 2010). Increased mobility of fishers from reduced snow persistence could further impact this species through increased competition for food (Fisher et al. 2022, also see Other Winter Effects section). In Southeast Alaska, wolverines are limited to the mainland and a few of the larger near-shore islands (MacDonald and Cook 2007), where they are found primarily in alpine habitats, which are also projected to decline as shrub- and tree-line ecotones move upward. Wolverines are currently found at low densities (e.g., 10 individuals per 1,000 km^2 or 386 $mile^2$; Royle et al. 2011) in limited portions of the Tongass NF. Influences of summer heat, reduced persistence of spring snow that protects denning newborns from cold, reduced snow persistence on competitive relations, and changes in alpine habitat on wolverines have not been studied in the Tongass NF, but concern for conservation of this species is reasonable based on studies documenting detrimental effects elsewhere (Fisher et al. 2022).

Like many temperate-zone ectotherms, several endotherms use snow to insulate against extreme cold and winter temperature variations. Ptarmigan, grouse, fisher, marten, ermine, marmots, mice, voles, lemmings, and shrews all use snow as insulation and could be adversely affected if extreme cold occurs during snow-free periods, or if snow is present but too shallow, dense, or icy (Wolken et al. 2011, Pauli et al. 2013). Desiccation and exposure to acute cold without snowpack, for example, was the primary factor explaining recent hoary marmot declines in the Washington Cascades (Johnston et al. 2020) as well as reduced survival of this species in the Yukon (Patil et al. 2013). Brown bears also select den sites that provide deep and stable snow conditions to maximize thermal efficiency (Crupi et al. 2020) and diminished snow cover could affect hibernation and emergence times (also see Hibernation section, below).

Phenological Shifts

Accelerated development among ectotherms (and plants) at higher ambient temperatures results in phenological consequences. These include earlier timing of a broad suite of processes, creating potential for mismatches among species and processes that react at different rates to temperature increases, respond to alternative cues unaffected by climate (such as photoperiod), or are less vulnerable to changes in ambient temperatures (through homeothermy, for example).

Many studies have documented temporal shifts in seasonal events (phenology), including earlier plant emergence and flowering, insect emergence and migration, amphibian emergence and breeding, bird migration and nesting, and delayed plant bud set and dormancy, fall migrations, breeding, and hibernation (e.g., Parmesan and Yohe 2003, Root et al. 2003, Gordo and Sanz 2005, Parmesan 2006, Jezierski et al. 2010, Stange and Ayres 2010, Yang and Rudolf 2010, Cook et al. 2012, Cohen et al 2018, Franks et al. 2018, Kudo and Ida 2013, Satake et al. 2021). Because species react at different rates to temperature changes and to different environmental cues for various events, phenological mismatches can develop between plants and herbivores, plants and pollinators, migrant birds and their prey or nectar sources, hosts and parasites, resident predators and prey, and other processes (Kudo and Ida 2013, Cohen et al. 2018, Piao et al. 2019). In general, greater phenological impacts occur to species with more complex life cycles (e.g., amphibians, invertebrate prey; Wellborn et al. 1996, McCaffery and Maxell 2010, Matthews et al. 2011). The degree to which species use photoperiod cueing of events also determines their susceptibility to mismatches. For example, photoperiod cueing of breeding onset is more common in longer-lived mammals, making mismatches more common in this group compared to shorter-lived mammals (Bronson 2009).

Plants and Herbivores

One example of a potential mismatch between plants and herbivores was reported by White et al. (2011, 2018), who reviewed evidence that early emergence and accelerated maturation of alpine plants would reduce nutritional quality of forage available to mountain goats during critical summer periods when forage is typically abundant. Juvenile goats, in particular, must have access to high quality food to support growth and subsequent over-winter survival, but accelerated plant growth is predicted to result in higher lignin (woody) content and lower quality nutrition by mid-summer when young of the year switch from nursing to browsing. This mismatch is expected to increase vulnerability of first-year goats to harsh winter conditions.

Plants and Pollinators

Emergence and growth of plants, like that of insect pollinators, is largely regulated by temperature, with earlier emergence and faster growth noted as climate warms (Miller-Rushing et al. 2006, Piao et al. 2019). Timing of flowering for many plants, however, is triggered by various combinations of temperature, photoperiod (daylight length), and precipitation, with different species relying on different cues (Satake et al. 2021). Photoperiod, which is stable from year to year and independent of temperature, is often a dominant trigger for activation of flowering, particularly in temperate climates (Satake et al 2021). Some plants rely on chilling during fall or winter (vernalization) to allow a plant to flower in response to spring warming. Inadequate or delayed vernalization can delay or prevent subsequent flowering (Cook et al. 2012). Plants that rely on stable photoperiods or vernalization to trigger flowering are likely to experience progressively longer periods of faster vegetative growth (which is temperature regulated) before flowering is triggered. Once flowering begins, flowers are also likely to develop faster at warmer temperatures.

Synchronization between plants and their pollinators has not been studied in Southeast Alaska to our knowledge, but reviews have suggested that plant phenology and pollinator emergence have generally advanced at similar rates thus far (Hegland et al. 2009). As climate continues to warm, though, there is potential for ectotherm pollinators (insects and other invertebrates) to emerge too far in advance of nectar-producing flowers that will not emerge until triggered by photoperiod, vernalization, or other cues not linked to spring temperature. Lack of suitable early-season flowers could depress pollinator populations, which could impact a range of other flowering plants, and reduce seed production and populations of some plants (Kudo and Ida 2013).

Endotherm pollinators (including nectar-sipping hummingbirds and warblers) that time their migrations based on temperatures may be similarly impacted. Birds that use photoperiod (Gwinner 1996) or other cues more directly related to flower availability to time their migrations are likely to maintain better synchrony with flowers that also rely on photoperiod for flowering (see below for further discussion of migration timing).

Rufous hummingbirds are the primary endotherm nectar feeder in the Tongass NF. Males typically arrive in early spring before many nectar-producing flowers are available, relying largely on sap from trees and shrubs, and recently-emerged insects and spiders (Ehrlich et al. 1988, p. 334). Migrations are delayed during years of low flower density along southward fall migration routes as hummingbirds stay longer at stopovers sites to acquire adequate body reserves to continue (Russell et al 1994). Similar dynamics seem plausible during northward spring migrations, as suggested by slower migration rates of rufous hummingbirds as they approach their northerly breeding areas (Courter 2017). Timing appears to be related directly to food availability (Phillips 1975, Courter 2017, Russell et al. 1994), likely reducing vulnerability of hummingbirds, and the plants that depend on them for pollination, to phenological asynchrony in Alaska. Because migrating hummingbirds rely on many feeding sites along their (different) spring and fall routes, though, they may be vulnerable to climate-related impacts elsewhere in their annual home ranges.

Specific flowering cues are not well understood for most wild plants (Hegland et al. 2009), which inhibits our ability to predict how most plant and pollinator communities in the Tongass NF might be affected. Modeling of systems elsewhere suggests that multi-species pollinator networks can be resilient but may experience significant structural changes when perturbed (Hegland et al. 2009).

Migratory Birds and Invertebrate Prey

Birds that rely on insect prey, rather than nectar, are also at risk of phenological asynchrony if their migrations are not timed to take advantage of progressively earlier insect abundance facilitated by warmer winter and spring temperatures (Gordo and Sanz 2005, Both et al. 2009, Robinson et al. 2009, Bortner et al. 2010, Matthysen et al. 2011, Saino et al. 2011, Franks et al. 2018, Rotics et al. 2018). Phenological mismatches have also been documented for shorebirds and their invertebrate prey from changes in timing of snowmelt (Kwon et al. 2019). Seabirds can be similarly vulnerable to phenological shifts if their nesting periods are not synchronized with seasonal abundance of marine forage fish and invertebrates (Bortner et al. 2010) as can marine mammals (also see Saltwater Habitat section). Predators of seabirds, such as the peregrine falcon, may also be affected through trophic cascades. Huntington et al. (2023) also report that one effect of climate change in Southeast Alaska is earlier arrival of trumpeter swans.

Egg-producing females and growing nestlings both require high levels of nutrition (Ehrlich et al. 1988, pp. 587-589; Vatka et al. 2011). Thus, nesting seasons generally correspond with peak food availability across many avian species. Some birds have apparently adopted earlier spring migration dates that maintain access to insect emergence prior to nesting and brood-rearing (e.g., Huppop and Huppop 2003, Gordo and Sanz 2005, Miller-Rushing et al. 2008, Wiebe and Gerstmar 2010, Vatka et al. 2011, Usui et al. 2017, Franks et al. 2018). Earlier spring arrival also allows birds to acquire higher quality territories, nesting locations, and mates, and produce relatively early-hatching offspring with higher post-fledging survival rates. Early migration can, however, expose birds to harsh environmental conditions enroute and upon arriving at the breeding grounds (Rotics et al. 2018), and result in reduced embryonic development rates (Burger 2012), where warmer temperatures do not coincide with early migration.

Species that use photoperiod or other cues not well correlated with temperature to trigger their migrations may be at risk of arriving at their northern breeding grounds after peaks in insect abundance. Both (2010) suggested that photoperiod during hatchling and nestling stages could influence subsequent migration dates for some long-distance migrants, resulting in later spring departures for birds hatching at more northerly latitudes. Franks et al. (2018) found that bird species in the United Kingdom with the greatest phenological mismatches had long-term population declines, but only marginal declines in annual productivity that could not fully account for long-term population declines.

Several studies have concluded that long distance migrants are more vulnerable to phenologic asynchrony than short-distance migrants that can rely on temperature cues (e.g., Gwinner 1996, Miller-Rushing et al. 2008, Both et al. 2009, Robinson et al. 2009). Migrant birds that winter in the tropics cannot use local weather cues to reliably predict conditions on their temperate breeding grounds, so their spring departures are often based on photoperiod or other cues not related to temperature, resulting in asynchrony with peaks in insect prey abundance (Rotics et al. 2018). Long-distance migrants such as swifts and larger-bodied flycatchers that feed on aerial insects are expected to be particularly vulnerable (Bortner et al. 2010). Franks et al. (2018), however, found that while long-distance migrants frequently exhibited asynchrony with insect emergence on their breeding grounds, productivity (as measured by the ratio of fledglings to adults captured at banding sites) was not substantially less than measured for short-distance migrants, and likely not a primary driver of observed population declines.

Bitterlin and Van Buskirk (2014) evaluated migration records for several hundred northern-hemisphere bird species from across North America and Europe and found that advancement of spring migrations averaged about 1-day per decade when considering median, rather than earliest, arrival dates. This trend was weaker in long-distance migrants, but short- and long-distance migrants differed significantly in their migration timing only for the earliest individuals in spring -- not in the timing of the center of distribution of migrating individuals. This suggested that even long-distance migrants have access to cues that can trigger earlier spring migration or that these species have somehow evolved earlier migration.

Species that nest in habitats where insect abundance is associated with relatively brief periods of spring plant emergence also appear to be particularly vulnerable. Temperate deciduous forests in Europe are characterized as having narrow peaks of insect abundance, when emerging herbivorous insects (primarily caterpillars) take advantage of new growth of trees breaking dormancy in the spring, as compared to later and less peaked abundance of insects in conifer forests and marshes, that have less-pronounced availability of new vegetative growth. Insectivorous birds nesting in deciduous forests were therefore considered at greater risk of phenologic mismatches than those using other habitats with more protracted availability of insect prey (Both et al. 2009). Little is known about the plasticity and degree to which insectivorous species can adjust to such timing mismatches, such as by engaging in prey-switching or other survival behaviors.

The Tongass NF is dominated by conifer forests of hemlock and spruce, mixed with cedar in some areas. These forests are expected to have longer periods of insect availability than temperate deciduous forests (Both et al. 2009). Deciduous forests dominated by cottonwood and alder, often mixed with spruce or other conifers, are confined largely to major river floodplains. Early successional forests dominated by alder are also common on recently disturbed sites and where primary succession occurs in front of receding glaciers. Migratory birds that nest exclusively or predominantly in these deciduous forests in Southeast Alaska include several warblers (*i.e*., yellow, MacGillivray's, Tennessee, northern waterthrush, American redstart, magnolia, and blackpoll; the latter two warbler species are rare migrant breeders and probable breeders, respectively in transboundary watersheds; Johnson et al. 2008), vireos (*i.e.,* red-eyed, Cassin's, and warbling), and cedar waxwing. These species may be particularly vulnerable to phenologic mismatches if their migration dates are not responsive to temporal advances in comparatively brief insect emergence and abundance (Both et al. 2009). Similar vulnerabilities may also exist for migratory birds that nest in deciduous shrub communities that dominate riparian zones and early-successional plant communities in the Tongass NF such as fox sparrow, Wilson's warbler, and orange-crowned warbler.

While spring migrations now occur earlier for many species, fall migrations have been delayed in many cases, as temperatures have increased. These fall migration delays have been more pronounced in large-bodied birds, and in species that feed on seeds, insects, or fruits (all of which generally benefit from warmer temperatures). Species that feed on fish and other animals have shown less migration delay during fall (Bitterlin and Van Buskirk 2014).

Favorable fall conditions also appear to offer advantages to species that produce multiple broods, and to those that molt prior to fall migration (which includes most of the species studied) (Bitterlin and Van Buskirk 2014). These phenologic interactions with climate in autumn do not appear to be vulnerabilities in most cases, but likely offer benefits for some species, as long as later departures do not subject migrants to greater frequency of seasonal storms.

Predators and Salmon

Each year, millions of salmon migrate from the ocean into over 5,000 rivers and streams throughout Southeast Alaska. Salmon are the anchor for biological productivity of Southeast

Alaska's coastal temperate rainforest and are considered a keystone species because of the important role they play in supplementing the food web of this coastal ecosystem. For example, over 100 species of terrestrial, aquatic, and marine vertebrates and invertebrates annually consume salmon along the north Pacific Coast (Willson and Halupka 1995, Cederholm et al. 2000, Gende et al. 2002, Levi et al. 2020). Maintaining the productivity of Pacific salmon stocks throughout Southeast Alaska is an essential component for maintaining the ecosystem integrity for wildlife of this coastal temperate rainforest.

Climate change effects on salmon are addressed in Chapter 4. Key sources of effects include altered habitat structure and biological processes from changes in precipitation and flooding intensity, frequency, and seasonal occurrence; periods of local drought and heat; changes in water temperatures, oxygen content, and sediment transport; and shifts in hydrologic regimes. Impacts are anticipated to include shifts in anadromous salmon distribution and productivity, egg scour and reduced viability, and changes to species growth, vigor, mortality, and phenology.

Many wildlife biological processes in the Tongass NF are driven by returns of spawning salmon to area streams and rivers in summer and early fall, followed by emergence of fry during the subsequent spring. Bald eagle (*Haliaeetus leucocephalus*) nesting in Southeast Alaska, for example, is well timed to take advantage of abundant, easily-accessible salmon when food demands of large, late-stage nestlings and fledglings are high. Fledglings are particularly reliant on carcasses of spawned-out salmon, as the young birds have not yet developed effective hunting skills (Armstrong and Hermans 2004). During the fall and early winter, many eagles gather along streams and rivers that support late-season spawning salmon (Hansen 1987, Levi et al. 2015). Notably, the proportion of active bald eagle nests is greatest and the timing of laying during the following breeding season earliest where salmon are most abundant (Hansen 1987).

The synchrony between bald eagle concentrations and salmon in the Pacific Northwest is becoming influenced by changes in the timing and frequency of flood events, which remove salmon carcasses from the system (Rubenstein et al. 2019), as well as by increasing carcass decomposition rates with warming temperatures (Harvey et al. 2012). These changes appear to be associated with recent bald eagle population declines in that region (Rubenstein et al. 2019).

Bears and other species rely on spawning salmon to build fat reserves prior to winter. Both black and brown bears are also considered keystone species for the important role they play in transporting partially eaten salmon several hundred yards from stream banks throughout the flood plain and beyond, where they are scavenged by a variety of birds, mammals, and insects. On the Kenai Peninsula, Hilderbrand et al. (1999) estimate that individual female brown bears consume over 2,200 pounds of salmon during the summer and fall salmon spawning season. Bears that consume salmon attain larger size, have greater litter size, and occur at higher densities than bears without access to salmon. Nutrients from bear scats and decomposing salmon also leach into the forest soil and are taken up by riparian plants, from spruce to devil's club (Ben-David et al. 1998). The annual influx of marine-derived nitrogen significantly enhances the biological productivity and food-web diversity of this coastal ecosystem (Stokes 2014, Wagner and Reynolds 2019). Schoen and Gende (2016) identify management opportunities to help protect these high-value habitats.

Because spawning events typically stretch across many weeks (or months) in most stream systems in the Tongass NF, and especially in systems with multiple salmon species (Sergeant et al. 2015), shifts of even several days seem unlikely to cause significant asynchrony with species dependent on spawning salmon. Further, many wildlife species that rely on spawning salmon such as eagles, gulls, bears, marten, and wolves are highly mobile and likely able to perceive and adjust their foraging patterns to spawning events, possibly making them more resilient to altered salmon prey phenology (Levi et al. 2015, Sergeant et al. 2015, Deacy et al. 2017). However, given other flood and temperature influences on salmon carcass availability as discussed for bald eagles in the Pacific Northwest, further observation is warranted.

Incubation and hatching of salmon fry are regulated largely by stream temperature, and progressively earlier outmigration of salmon fry through freshwater systems and to nearshore marine waters in response to warmer temperatures is expected to result in arrival of salmon fry before adequate food is available in the marine environment, potentially reducing growth and survival. This phenologic mismatch is expected to affect primarily pink and chum salmon, which migrate to saltwater over a relatively brief period, immediately upon hatching (Kelly et al. 2007). Wildlife species such as kingfishers, mergansers, and dippers that rely on emerging and out-migrating salmon fry (White 1936, Obermeyer et al. 2006) could also be impacted if they are unable to adjust their nesting periods to coincide with changes to the timing of this annual pulse in food availability.

Winter Molt Color and Snow

A common phenologic adaptation to temperate-zone winter is pelage or plumage color change to provide seasonally-appropriate white camouflage in winter, and brown in summer. In the Tongass NF, this adaptation is used by snowshoe hares, ermine (or short-tailed weasel), and three species of ptarmigan (Armstrong and Hermans 2004, MacDonald and Cook 2007). These color changes are triggered by photoperiod and are likely synchronized with long-term average snow presence through local selection pressure, with higher predation rates on individuals with seasonal color mismatches. With reduced snowfall, and shorter periods of snow presence, we can expect higher incidence of seasonal mismatches (i.e., white individuals during snow-free periods), increasing vulnerability of prey species to predation (Wolken et al. 2011; Mills et al. 2013, 2018; Atmeh et al. 2018; Zimova et al. 2018).

Laboratory trials have demonstrated that the fall molt in snowshoe hares can be initiated and arrested by subjecting hares to artificially longer daylight periods (Lyman 1943). This reliance on photoperiod, independent of weather conditions, was confirmed in a study of wild snowshoe hares in a northwestern Montana forest, where fall molt initiation dates and duration were stable for fall color molts (brown to white) during three winters with widely varying snow appearance and duration. Spring molts (from white to brown) in contrast, began at the same time each year but averaged 16 days longer to complete during the winter with greatest snow duration as compared to the winter with the shortest snow duration (Mills et al. 2013). Artificial manipulation of photoperiod similarly found that spring molts were less sensitive to photoperiod, as prolonged short daylight periods delayed or curtailed, but did not prevent, spring molts (Lyman 1943). The precise physiological mechanisms responsible for variation in spring molt duration in snowshoe hares remain unclear, but this plasticity suggests that the species does have some ability to adjust its molt to match local conditions, at least in the spring. In weasels, both spring and fall molts can be induced or reversed through photoperiod manipulation, suggesting little plasticity to respond to changing environmental conditions (Bissonnette and Bailey 1944).

Among species that use seasonal color change molts, some individuals do not turn white, but stay brown through the winter, particularly in areas with low snow cover (Jones et al. 2018, Mills et al. 2018). This condition is genetically controlled and appears to result from historical hybridization (introgression) with closely-related species that do not change color seasonally (Jones et al, 2018). The ratio of brown to white individuals varies geographically within species, and this variation has been modelled and mapped across the full range of several species (Mills et al. 2018). The proportion of brown individuals is predicted to be higher for snowshoe hares across Southeast Alaska than for ermine (Mills et al. 2018), suggesting that hares may be better able to adapt to conditions with less snow than ermine.

The ermine is a predator of various rodents and small birds, and prey of several predators, including larger mustelids (especially marten in the Tongass NF) and various canids, felids, owls, and other raptors. Effective camouflage likely offers benefits for the ermine as both predator and prey. Prey and predator species vary with local availability, but where prey diversity is limited, as is often the case on islands, ermine may be at greater risk of predation from larger predators with fewer options when their primary prey are in short supply. For example, Prince of Wales Island in the Tongass NF naturally lacks North American red squirrels, sooty grouse, and snowshoe hares, all of which are common prey for goshawks elsewhere in Southeast Alaska (Lewis et al. 2006). Ermine that complete their fall molt before snow is present and remain white after snow is gone in the spring may be particularly vulnerable to goshawks or other predators with few alternative prey options, especially during the winter when many migratory birds are gone for the season. Lewis et al. (2006) documented five instances of goshawks preying on ermine in Southeast Alaska.

The limited genetic diversity of island populations can restrict their adaptive abilities. Some ermine populations could be at risk, for example, if they lack the genetic ability to evolve shorter periods of white pelage relatively quickly, as predation removes mismatched individuals. This could become a conservation issue for the Haida ermine (*M. haidarum*), known only from Prince of Wales and Suemez islands in the Tongass NF, and Grand and Moresby islands of Haida Gwaii, British Columbia, to the south. Long recognized as a subspecies of ermine, this genetically distinct weasel has been recently proposed as a full species, endemic to these four islands (Colella et al. 2021). Each of these islands has limited and comparatively incomplete prey faunas, potentially increasing vulnerability of ermine to predation.

As with ermine, seasonal color change molts of ptarmigan appear to be triggered and regulated entirely by photoperiod, independent of temperature or presence of snow (Höst 1942). Three species are present in the Tongass NF, including Rock, Willow, and White-tailed Ptarmigan (Armstrong and Hermans 2004, Heinl 2010).

Ptarmigan use various behaviors to reduce their vulnerability to predation during periods of potential color mismatch. For example, while still mostly white, the hens usually sit on the snow to feed on protruding willow and dwarf birch; when partly pigmented on the back, they prefer the border zone between snow and bare ground; and when mostly pigmented they feed exclusively on bare ground (Steen et al. 1992). Females molt into cryptic summer plumage earlier than males, which retain their white winter camouflage as conspicuous breeding plumage, often well after snow is gone. Males do have higher predation rates during this period as a result. After their mates have begun laying eggs, the males begin soiling their plumage which reduces their visibility and reduces otherwise high predation rates (Montgomerie et al. 2001).

Most ptarmigan molt into entirely white plumage in the winter, but Rock Ptarmigan on Amchitka Island in the Aleutian chain grow dark feathers on their head, neck, and back during winter (Jacobsen et al. 1983), suggesting that some genetic diversity is present in the species. If birds in Southeast Alaska carry such diversity, they may have some ability to adapt to less-snowy conditions in the Tongass NF.

Early warming and snow dispersal in spring has been linked to increased reproductive success of Rock Ptarmigan in the western Italian Alps. Climate projections, however, suggest that delay of snow arrival in the fall, which increases predation risk due to plumage color mismatch, is more likely than is early snow disappearance in the spring. Thus, on balance, climate change in combination with other stressors, is expected to contribute to local extinctions of ptarmigan in Italy (Imperio et al. 2013).

Hibernation

Many species, including both ectotherms and endotherms, use hibernation (long-term reduction in metabolism and body temperature) to reduce energy demands during environmentally unfavorable conditions and seasons. In the Tongass NF this is primarily related to minimizing exposure to cold during winters.

With warmer spring temperatures and reduced snow persistence, emergence from hibernation is becoming earlier. For example, increasing spring average monthly maximum temperature by 4 °C (7 °F) resulted in grizzly bears emerging from dens 10 days earlier (Pigeon et al. 2016). Similarly, warmer temperatures are strongly associated with black bear denning chronology, reducing the duration of hibernation and expediting emergence in the spring (Johnson et al. 2018). For bears, temperature within the den is the most relevant cue for emergence, with bears likely becoming too warm and seeking cooler temperatures outside of the den (Evans et al. 2016).

Early hibernation emergence can have both positive and negative effects. Most species, hibernators and non-hibernators alike, are expected to benefit from a longer growing season and greater primary productivity (Wolken et al. 2011). For example, brown bears will benefit if earlier emergence allows them to take advantage of the longer growing season and increased foraging opportunities (Pigeon et al. 2016). On the other hand, early emergence for this species could result in exposure and increased infanticide of less developed, more vulnerable cubs or a greater propensity for early spring human-bear interactions (Pigeon et al. 2016).

Other Winter Effects

As detailed in Chapter 2, seasonal snow persistence and snow water equivalent will decrease due to warming temperatures, but the frequency and severity of winter storms and rain-on-snow events are projected to increase in the region, leaving uncertainties and likely variability on how these factors will manifest. Heavy winter storms may impact survival of resident wildlife that do not migrate or shelter themselves through hibernation or other means. There are also likely to be effects on species that start their reproduction during the winter, especially for those with exposed nests. For species that have trouble moving through snow and/or accessing food with abundant snow or ice, effects of reduced seasonal snow persistence will likely be beneficial, but heavy winter storms will likely cause impacts.

Deer are particularly vulnerable to deep snow, both from challenges with mobility and associated energy expenditure as well as from the inability to find quality forage (Parker et al. 1984, 1999; Hanley et al. 1986, 1989; Kirchhoff and Schoen 1987; White et al. 2009). They exhibit behavioral plasticity in that snow depth and habitat interactions drive deer movements in winter (Gilbert et al. 2017). However, this strategy requires accessible large tree, high volume old-growth forest habitat within their home range. Deer rely on such forests during deep-snow conditions due to the mosaic of snow interception and accessible forage provided. As discussed below in the Interactions with Other Stressors section, old-growth stands have been disproportionately harvested in the region. Some watersheds (Brinkman et al. 2011, Person and Brinkman 2013) and bioregions (Albert and Schoen 2013) have been substantially converted from old growth to even-aged young growth that does not meet forage or snow interception needs for deer, leading to long-term carrying capacity concerns (Wallmo and Schoen 1980;

Schoen and Kirchhoff 1990, 2016; Person and Brinkman 2013). Reduced seasonal snow from climate change is overall expected to benefit deer in the Tongass NF as predicted on the Chugach NF (Morton et al. 2017). However, old-growth forests will still be critical to avoid population crashes during heavy winter storms that are also projected to increase in both frequency and intensity (Graham and Diaz 2001, McCabe et al. 2001, Royer and Grosch 2006, Salathé 2006, Basu et al. 2013, Hayward et al. 2017).

Other species will also experience improved mobility with less persistent snow. For example, greater snow depths increase energetic costs of movement by martens (Martin et al. 2020) and less snow should facilitate winter movement (Raine 1981, 1983). However, this may be offset by increased rain on snow events, which have been shown elsewhere to lower thermoregulation capacity and hamper marten movements by creating an ice crust on the surface and reducing access to subnivean areas (Suffice et al. 2020). Fisher are more restricted by deep soft snow than marten (Raine 1981, 1983) and wolverines (Fisher et al. 2022), so less persistent snow will also likely result in increased competition from fisher (Suffice et al. 2020, Fisher et al. 2022). Climate-mediated expansion of fishers is anticipated within Southeast Alaska due to increased mobility with shorter seasonal snow persistence, ready abundance of prey such as porcupines, and little predation pressure (without mountain lions for example).

Altered snow conditions and differential mobility in snow are anticipated to affect mesocarnivore distributions in Interior Alaska, where effects on five species (coyote, red fox, Canada lynx, wolverine, and marten) are expected to vary with specific conditions of snow depth and compaction (Pozzanghera et al. 2016). Similar effects may play out with mesocarnivores in Southeast Alaska under changing seasonal snow conditions.

Reduced snow persistence and longer breeding seasons may also benefit raptors and other species in the Tongass NF. As suggested for the arctic peregrine falcon (Bruggeman et al. 2015), more snow-free nest sites and lengthened breeding season could increase the likelihood of nest success. And for some species, especially resident or short-distant migrant birds such as American robins and dark-eyed juncos, lengthened breeding seasons may allow for subsequent successful broods. However, some of these benefits could be offset by mismatches between breeding and food availability as discussed in the Phenological Shifts section.

Another example of a species that will likely benefit from changes to winter food availability is the western screech owl. Kissling and Lewis (2009) documented the importance of unfrozen freshwater streams to western screech-owl and their invertebrate prey during winter/early spring territory establishment and found greater occupancy of this species in areas with these characteristics. Warming winters and early ice melt will therefore likely benefit this species. However, these benefits are expected to be substantially offset by continued barred owl expansion into Southeast Alaska. Barred owls are known predators and competitors of western screech owls and may be narrowing the distribution of western screech owls in southern portions of the Tongass NF (Kissling and Lewis 2009).

<u>**Interspecific Interactions**</u>

Species Responses and Implications for Their Key Ecological Functions

One aspect of how system stressors, including climate change, influence organisms pertains to species-specific responses to changes in the quality of their preferred habitats. An example is the specific effects of climate change on populations of five Alaskan seabird species in the Aleutians (Goyert et al. 2018), with generally positive population responses to the Pacific Decadal Oscillation and negative responses to the North Pacific Index, as well as decades-long decreases in zooplankton (krill) prey and significant increases in sea surface temperatures. The seabirds exhibited species-specific population responses, however, with some increasing and others declining in population size. These are species-specific dynamics, because the concept of habitat is very much itself species-specific (Hall et al.1997).

However, a broader view of how ecological systems can change under climate stressors pertains to how those stressors may affect the ecological roles and functions played by organisms (Fontúrbel et al. 2018). Such roles are termed *key ecological functions* (KEFs; Marcot and Vander Heyden 2001). Categories of KEFs denote the ways that the ecological roles of organisms create or affect the environment of other species. Examples of KEF categories include primary cavity excavation in live and dead trees, and secondary occupation of those cavities by other species; primary burrow excavation and secondary burrow occupation; nutrient cycling relations; and much more (Marcot 2013, Marcot and Vander Heyden 2001). The full suite of ecological roles of a biota may be subject to change and reduction as individual species respond differently to climate change (Parmesan 2006).

Another example is moose, which serves as an ecosystem engineer by regulating forest carbon, vegetation structure, below-ground nitrogen cycling, and predator-prey dynamics (Jennewein et al. 2020). During warmer and more fire-prone periods in boreal and arctic regions of Alaska, moose, being heat sensitive, were found to select more for wetland habitats, tall and dense forest cover, and to avoid solar insolation. Such shifts in their habitat selection suggest that their key ecological functions may influence environments differentially over periods of climate warming. Secondary effects of those functional shifts on other aspects of ecosystem diversity are yet to be studied, including in the Tongass NF.

Generally, KEF relationships among wildlife species have been little studied in Southeast Alaska *per se*. In another example from the Pacific Northwest of CONUS, suites of mammals have been identified as associated with large trees in conifer forests of, including 13 species of bats, 11 species of arboreal rodents, and 6 species of forest carnivores, and the collective set of their KEFs include: insect predation and potential control of insect populations; nutrient transport by bats; dissemination of conifer seeds, dwarf mistletoe, and beneficial ectomycorrhizal fungi by arboreal rodents; long-distance dissemination of fruits, mast crops, and other propagules by forest carnivores including black bears; and much more (Aubry et al. 2003, Marcot and Aubry 2003). These and other functions also occur among the forest biota in the Tongass NF, particularly species associated with older forests that have been subject to reduction from timber harvesting and may be further vulnerable from climate change.

The full suite of KEFs performed by organisms in an ecosystem that is undisturbed by human activities constitutes what may be referred to as a fully-functional ecosystem. As human activities -- including human-induced climate change, harvest of old forests, and much more – alter ecosystem conditions, the suite of KEFs will change, with some functional categories enhanced and others diminished or eliminated. Changes in functional conditions can be projected at least categorically with wildlife-habitat relationships databases that include denotations of each species' habitat conditions and their KEF categories, Such databases have been developed for forest and subbasin assessments and planning in the interior Columbia River Basin (Marcot 1997, Marcot et al. 2006), Washington and Oregon (Marcot and Vander Heyden 2001, Marcot 2002), and elsewhere (Marcot et al. 2002), and could be developed on wildlife for Tongass NF.

Many KEF categories provide the basis for some ecosystem services, which represent resources and conditions of specific interest and value to people. As part of the Fifth National Climate Assessment, Huntington et al. (2023) report with medium confidence that many ecosystem services and goods providing for people are expected to diminish because of climate change in Alaska, and require careful management to avoid further stress on fish, wildlife, and their habitats, and to avoid compounding effects on ecosystems.

Competitors and Competitive Relationships

One general category of KEFs relates to competitive impacts of one species upon another, and the response of species as either changes in their habitat selection, use, and distribution (functional response) or in their population size, trend, and productivity (numerical response). In a case example from Finland (Ahola et al. 2007), a migratory species of flycatcher appeared to respond to climate change with increased population size (numerical response) and took over nesting sites of a resident species of tit; it was changes in local temperature regimes and differential responses to these changes between the two species that seemed to be the root cause of the increase in flycatchers and the local demise of the tits. Similar climate-change sensitivities were noted in southwest U.S. for ground-nesting songbirds affected by nest site overlap and browsing by ungulates that reduced the availability of their preferred nesting sites (Auer and Martin 2013). Tillmann and Glick (2013) annotated how changes in climate phenology and weather events can create vulnerabilities for the over half of western U.S. forest birds that are restricted to a single habitat type. Habitat specialists in the Tongass NF may also be vulnerable, especially in cases of increased climate-mediated competition. Range expansion and expansion into environments that were previously inaccessible to competitors is of concern for some species. For example, as discussed in the Other Winter Effects section, declining snow persistence will likely affect competitive relationships between wolverine, fisher, and marten in the Tongass NF.

Predation Pressure and Prey Abundance

Climate change stressors can result in changing balances of predation pressures and impacts on prey population. Parmesan (2006) noted that predator-prey interactions have been disrupted when interacting species have responded differently to warming. In northern Alaska, Arctic peregrine falcons (*Falco peregrinus tundrius*) may benefit from regional warming with increased access to snow-free nest sites and a lengthened breeding season (Bruggeman et al. 2015), but with unknown impacts on their prey and potential for prey-switching as existing and potential prey populations themselves change. Prey-switching was noted with bald eagles in the Aleutian Archipelago under varying conditions of sea otter (*Enhydra lutris*) abundance that was initially hypothesized to affect the biotic diversity and prey availability for the eagle (Anthony et al. 2008).

One aspect of carnivore predation pertaining to a key ecological function is that of providing sources of carrion for facultative scavenger communities that include magpies, ravens, wolves, coyotes, bears, and more. As carnivore predators may be adversely impacted by environmental changes and other stressors, their role of carrion provision may suffer. However, in the Gustavus Forelands near Glacier Bay in Southeast Alaska, Lafferty et al. (2016) noted how a fall moose hunt provided carrion for a variety of such wildlife species. This may be noted as a key ecological function and useful role of hunters, as unintentional as it may be.

Relationships with Plants

As climate change and regional warming affect the diversity of floral communities, dependent wildlife may undergo increased stress with declining populations. One example is the observed decline of caribou (*Rangifer tarandus*) herds in central and northern Alaska that have been attributed, at least in part, to declines in their preferred lichen food source, as regional warming has induced green-ups (Potter and Alexander 2020) that reduce the lichens, increase incidence of tundra fires, and increase intraspecific competition for available lichen forage (Joly et al. 2009). The same regional greening is projected to adversely influence some ground-dwelling herbivorous mammals such as arctic ground squirrels (*Urocitellus parryii*; Wheeler et al. 2015). Changes in vegetation can have both negative impacts (e.g., increases in woody vegetation that reduce availability of burrows and burrow systems) and positive (e.g., increases in forb cover serving as an additional food source) (Wheeler et al. 2015). We can expect similar types of influences in alpine habitats in Southeast Alaska, with increases in woody vegetation above shrub- and tree-lines reducing habitat value for burrowing mammals in these areas, but increasing forb cover in deglaciated alpine areas with appropriate soils supporting some alpine wildlife.

There may be secondary or indirect impacts on wildlife associated with some plant species, as the key ecological functions of some pollinators are reduced by climate shifts in boreal and arctic regions (Parmesan 2006, Filazzola et al. 2020, Cirtwill et al. 2023). One result of climate warming is increased phenological mismatches between flowering periods and emergence of pollinators (Kudo and Ida 2013, Forrest 2015, also see Phenological Shifts section).

A variety of responses by plants to climate shifts may serve to change resources and habitat conditions for many wildlife species. Such plant responses may include, but are not limited to (from Lawler et al. 2014):

- Disrupted mutualistic relationships (e.g., pollination and seed dispersal) from increased CO_2 and temperatures.
- Increased insect herbivory from increased CO_2 and temperatures.
- Increased pollination from lower spring and early summer precipitation.
- Increased cone crop production and associated food web productivity.
- Changes to bud burst and fruiting and associated impacts on food availability.
- Changes to leaf out and leaf loss and associated impacts on shelter and forage.

Fricke et al. (2022) noted how losses or shifts in populations of key mammal and bird seed dispersers, affect rates of seed dispersal, associated ability of plants to adapt to climate change through range shifts, and vegetation community resilience. This suggests that climate change influences on key mammal and bird seed dispersers in the Tongass NF (e.g., black bears) would likely have broader effects on vegetation communities.

Disease and Parasite Interactions

The etiology and spread of disease components can be exacerbated by regional warming and changes in precipitation rates and seasonal phenologies (Bradley et al. 2005). Parasites and free-living bacteria that are limited by lower temperatures may benefit from warming trends. Increased ambient temperatures may provide for increased overwinter survival of parasites and vectors, increases in frequencies of outbreaks, shortened development rates, and expansion of their ranges, densities, diversity, and transmission rates. Vectors such as mosquitoes and ticks that transmit disease may also benefit as well as the diseases they spread. Under regional warming, wildlife hosts that become more heat-stressed may become more susceptible to disease and parasite loads. Further, climate warming may increase the release rates of persistent environmental pollutants which can adversely impact immune systems or favor increased rates of some diseases (Bradley et al. 2005). Huntington et al. (2023) noted recent outbreaks of western blackheaded budworm and hemlock sawfly in southeast Alaska as stemming from regional climate change.

Handel et al. (2010) and Van Hemert and Handel (2010) noted the sudden rise of abnormalities in the beaks of 30 species of birds in Alaska, with no clear evidence of the etiology of the deformities, termed "avian keratin disorder." Further studied by Van Hemert (2012), the disorder is unlike previous malformations in avian beaks and the cause of this sudden and widespread condition is still under study. Whether there are ultimate impacts of climate change on more proximate causes, including transmission of a pathogen or disease vector, remains to be determined.

Stream temperatures in Cook Inlet in southcentral Alaska are predicted to increase by about 3 °C (5.4 °F) at most sites, a magnitude of change that is considered significant for the incidence of disease in fish populations (Kyle and Brabets 2001). For example, *Ichthyophonus* has been reported as an emerging disease in Chinook Salmon in interior Alaska, likely owing to increased water temperatures (Kocan et al. 2004).

A major concern exists for the potential impact of climate change on the establishment and spread of chytrid fungus, *Batrachochytrium dendrobatidis*, and its devastating impact on native amphibians (Skerratt et al. 2007, Cohen et al. 2019). A prevailing hypothesis (Cohen et al. 2019) posits that widespread species declines or even extinctions, such as of amphibians, can be caused by increasing temperatures and intensified pathogen infection rates of diseases including chytrid fungus. Woodhams et al. (2008) discovered, through laboratory work, that chytrid fungus can also grow at high rates in a range of environmental conditions including cold montane environments. This increases the concern that, once chytrid is established in a region, as it has been in Southeast Alaska, it can still spread in colder, higher-elevation locations. Chytrid has been documented across almost all ranger districts in the Tongass NF, though at only a fraction of sites sampled in each district (Bennetsen 2023, unpublished report). Recent anecdotal boreal toad increases after a couple of decades of believed declines suggest a potential post-chytrid upturn for this species at least in some portions of the Tongass NF. Regardless, management and education to reduce spread of this disease to new sites will help minimize impacts of this climate-mediated stressor and potential other amphibian diseases and parasites such as Bsal (*Batrachochytrium salamandrivorans*), Ranavirus, or Perkinsea.

There is also concern regarding the anticipated spread into Southeast Alaska of the fungus that causes white-nose syndrome in bats. This disease has spread and wreaked havoc on bat populations across the United States and Canada. It was reported in Washington State in 2016 (Lorch et al. 2016) and the fungus that causes white nose syndrome was recently detected in bat guano in British Columbia (Segers et al 2023). Little brown myotis bats are expected to expand northward in Alaska within the next 80 years as winter temperatures, along with shorter winters, change towards conditions ideal for hibernation (~2 °C, ~36 °F in hibernacula; Humphries et al. 2002), and this may apply to other bat species too. However, as noted in the Endotherm Physiology section above, little brown myotis appear sensitive to hyperthermia in poorly insulated maternity roosts based on six deaths reported from a warehouse in Wrangell in 2019 during a particularly notable summer heat wave. A crispy, dead silver-haired bat (*Lasionycteris noctivagans*) was also found during the summer of 2019 on the outside of a Forest Service cabin on Zarembo Island, suggesting the possibility that other bat species may also be vulnerable to Southeast Alaska heat waves. If introduced white-nose syndrome also spreads to Southeast Alaska, projected benefits of climate change to bat hibernation could be offset by potential impacts from disease and heat stress. Several factors specific to Southeast Alaska may slow the spread and reduce impacts of white-nose syndrome on local populations of little brown myotis bats. These include cold temperatures at hibernation sites that are well below the optimal growth range of the fungus that causes white-nose syndrome, the dispersed nature of hibernacula that are used by individual bats and small groups rather than colonially, and the close proximity of hibernacula to summering areas (Blejwas et al. 2021) as well as greater genetic structure (Blejwas et al. 2023).

Other parasites may also be of concern. As noted in Douglas et al. (2022:143), invasive parasites in interior Alaska include non-native anecic earthworms, Ixodid ticks affecting domestic dogs, and tularemia infecting hares. Ticks are of particular concern because they can pass disease to hares and other wildlife such as moose, with potentially fatal results (Douglass et al. 2022; see also Durden et al. 2016).

Invasive Species

Invasive species in Southeast Alaska can be of any taxonomic group, including plants (Vose et al. 2012, Tillmann and Glick 2013, Tillmann and Siemann 2011), invertebrates, amphibians, birds (Bortner et al. 2010, North American Bird Conservation Initiative 2022), and mammals. Non-native invasive vertebrates documented in the Tongass NF include northern red-legged frog (*Rana aurora*), Pacific tree frog (*Pseudacris regilla*), and Atlantic salmon (*Salmo salar*), and the Norway rat (*Rattus norvegicus*) is of potential concern (USDA 2014). In general, invasive species may outcompete native species in a changing climate.due to more adaptable phenologies, good dispersal abilities, high population growth rates, short generation times, and tolerance for a wider range of climatic conditions than native species.

Interactions with Other Stressors

Land Use Changes

Land use changes can exacerbate climate change effects by fragmenting habitat, thereby reducing its availability, suitability, and connectivity. Human activities may alter the rate and direction of system response to climate change (Burkett et al. 2005). Timber harvest, road building, and human development are examples of land uses that can reduce the ability of species to thrive in and move across landscapes. Wildlife populations that are stressed by land use changes may be more susceptible to and synergistically affected by climate-induced changes to habitat and biological processes (La Sorte and Thompson 2007, Fox et al. 2014, Betts et al. 2019, Halsch et al. 2020). Further, human land-use and activity patterns constrain the ability of many species to modify their migratory routes and may increase the impacts induced by climate change (Robinson et al. 2009).

In Southeast Alaska, it has been suggested that one of the greatest challenges for management of biodiversity in a changing climate could be maintaining an adequate area and distribution of specialized habitats such as highly productive, low-elevation old-growth forests targeted by historical logging patterns (Alaback 1996). As discussed previously, large-tree, high-volume old-growth forests have been disproportionately reduced by timber harvest (Albert and Schoen 2013) and are of particular importance to several species in the Tongass NF. Recent transition towards predominantly young-growth forest management will alleviate future effects, supported by efforts to restore previously clearcut young-growth forests to more rapidly return old-growth function and enhance climate resilience for many Tongass NF wildlife species.

Roads, often associated with past logging in Southeast Alaska, are also problematic for some Tongass NF wildlife. Roads can fragment habitat, facilitate trapping and hunting of harvested species, cause erosion and watershed function issues, and result in direct vehicular mortality. Some species are particularly vulnerable to roads. For example, road-related mortality (hunter harvest and vehicle strike) was the largest known source of death for the Prince of Wales spruce grouse (Nelson 2010). Similarly, high road densities and the access and human-caused mortality they facilitate have been identified as a key driver of wolf mortality on Prince of Wales Island (Person and Russell 2008, Person and Logan 2012, Wolf Technical Committee 2017, Gilbert et al. 2022), although Roffler et al. (2018) documented seasonal selection for densely-roaded areas by wolves on Prince of Wales Island, which may facilitate movement and access to prey. These stressors, along with others, can interact with climate change stressors to increase species vulnerabilities.

The Tongass NF benefits from largely pristine, connected, and functioning ecosystems, low vulnerability to wildfire, and relatively low levels of human development and impacts that will help make its ecosystems and the wildlife species that reside therein more resilient to long-term climate-change impacts (Law et al. 2023). As such, the Tongass NF provides important contributions to carbon stocks and landscape integrity and supports high proportions of key wildlife species on NFS lands, such as bald eagles, brown bears and wolves, giving it high priority for protection and conservation to meet climate and biodiversity goals (Law et al. 2023). Thoughtful land-use planning and management actions involving restoration of impacted lands can further minimize and mitigate anticipated climate change impacts to vulnerable species and habitats.

Effects of Changing Forest Disturbance Mechanisms

Likely increases in large-scale wind disturbance, landslide frequencies, and forest insect outbreaks along with potential for localized increases in fire as a disturbance mechanism are detailed in Chapter 5 as related to vegetation. Despite increasing forest disturbance with climate change, Buma and Barrett (2015) projected overall gains in Southeast Alaska conifer forest, suggesting that increased disturbance in this habitat type may be offset by other factors (e.g., conifer forest gains due to increasing temperatures, drying, and conifer succession). Therefore, effects of changing disturbance mechanisms on conifer forest habitat are likely negligible at the broader Tongass NF context, though there will be influences at more localized scales.

Recreation Activity

Spring, summer, and fall recreation opportunities and tourism are likely to increase as temperatures warm and seasons lengthen (Yu et al. 2009a, 2009b; Albano et al. 2013). Winter recreation may span a shorter season due to shorter seasonal snow persistence, but also could increase during this period if increased winter storms enhance quality for activities such as skiing (Yu et al. 2009b). Associated warm season recreational activities could occur in all wildlife habitats, but are likely to be especially concentrated along shorelines, at fresh waterbodies and streams, and possibly in alpine habitat accessible by trails. Winter recreation is likely to occur most often in higher-elevation alpine habitats. Effects to wildlife in these areas could include reduced habitat quality and increased disturbance. Effects will be more significant when activities overlap prime habitats. For example, Crupi et al. (2020) found overlap of moderate to high intensities of helicopter skiing flights and prime brown bear denning habitat and documented evidence of late season den abandonment due to disturbance from helicopter skiing.

Nutrients, Contaminants, and Toxins

As discussed in Chapter 3, climate change also influences nutrients and contaminants. Examples of interactions include changes in nutrient transport into and within aquatic systems, increasing algal blooms that limit nutrients and oxygen, increasing contaminant mobilization and concentration in wetlands, temperature and pH effects on toxicity of contaminants and rates of biological uptake, and increasing disease susceptibility with contaminant exposure. Natural toxins also play a role. For example, as mentioned in the Saltwater Habitat section, Van Hemert et al. (2022) found that intensified algal blooms from ocean warming produced biotoxins that likely caused a mortality event of an arctic tern colony in the Tongass NF. Further, marine debris, especially toxic plastics can be problematic. All of these factors influence productivity and food webs important to Tongass NF wildlife, especially for species dependent on freshwater, wetland, and ocean systems.

Ocean Noise

Ocean acidification results in significant decreases in sound absorption for frequencies <~10 kHz (Hester et al. 2008), making increasing ocean noise an unanticipated consequence of climate change. Projections of future ocean pH values suggest a decrease in sound absorption of almost 40 percent by mid-century (Hester et al. 2008). These effects may be exacerbated by increasing human activities, tourism, and associated motorized marine use. Marine mammals and possibly birds that rely on auditory communication or acoustics for foraging in coastal waters surrounding the Tongass NF are likely to be affected.

Wildlife Species Associated with Changes to Biological Processes

Of 232 vertebrate wildlife that breed or probably breed in the Tongass NF, 78 species (34 percent) were identified in previous sections (literature review and professional inference) as likely to be impacted by climate-mediated effects on biological processes (Table 3). Of these 78 species, 37 species were identified as associated with physiological impacts and 50 with phenological impacts; nine of these species were associated with both physiological and phenological impacts. The physiological processes were related to heat tolerance (four species) and reduced persistence of insulating snow (35 species; two to both heat and snow) and potential impacts to subnivean refugia, hibernation, frost-freeze, and competitor release by increased mobility. The phenological processes included potential mismatches between key ecological events and food availability (43 species) and mismatches in pelage/plumage color with snow (7 species). Interactions with other species and stressors are likely to exacerbate these climate change impacts.

Given the paucity of studies of wildlife-climate relationships from Southeast Alaska, uncertainties with inference from studies done elsewhere, and the complexities involved with climate relationships and biological processes, caution is warranted in interpreting these results. Though we expect many species to benefit, especially with the Tongass NF at the northern edge of the range of many taxa, it is likely that other species not identified here will also be affected through the myriad climate change influences described herein. For comparison, meta-analyses indicate globally coherent signals of climate-change impacts across multiple ecosystems and taxa (Parmesan 2006) with a surprisingly high proportion of species affected. Indeed, an estimated 41 percent of all species studied (655 of 1,598) responded to recent, relatively mild climate change (global average warming of 0.6 ^{o}C, 1.1 ^{o}F, Parmesan and Yohe 2003, Parmesan 2006).

Table 3. Select Tongass wildlife species that are potentially affected by changes to biological processes as a result of climate change.

Species	Scientific Name	Heat tolerance	Reduced snow persistence: subnivean refugia, hibernation, frost-freeze, mobility-competitor release	Phenological mismatch with food	Winter molt color and snow
Common Merganser	*Mergus merganser*			X	
Red-breasted Merganser	*Mergus serrator*			X	
Ruffed Grouse	*Bonasa umbellus*		X		
Spruce Grouse	*Canachites canadensis*		X		
Sooty Grouse	*Dendragapus fuliginosus*		X		
Willow Ptarmigan	*Lagopus lagopus*		X		X
Rock Ptarmigan	*Lagopus muta*		X		X
White-tailed Ptarmigan	*Lagopus leucura*		X		X
Bald Eagle	*Haliaeetus leucocephalus*			X	
Peregrine Falcon	*Falco peregrinus*			X	
Spotted Sandpiper	*Actitis macularius*			X	
Solitary Sandpiper	*Tringa solitaria*			X	
Greater Yellowlegs	*Tringa melanoleuca*			X	
Lesser Yellowlegs	*Tringa flavipes*			X	
Least Sandpiper	*Calidris minutilla*			X	
Short-billed Dowitcher	*Limnodromus griseus*			X	
Wilson's Snipe	*Gallinago delicata*			X	
Red-necked Phalarope	*Phalaropus lobatus*			X	

Species	Scientific Name	Heat tolerance	Reduced snow persistence: subnivean refugia, hibernation, frost-freeze, mobility-competitor release	Phenological mismatch with food	Winter molt color and snow
Aleutian Tern	*Onychoprion aleuticus*			X	
Caspian Tern	*Hydroprogne caspia*			X	
Arctic Tern	*Sterna paradisaea*			X	
Parasitic Jaeger	*Stercorarius parasiticus*			X	
Long-tailed Jaeger	*Stercorarius longicaudus*			X	
Black Swift	*Cypseloides niger*			X	
Vaux's Swift	*Chaetura vauxi*			X	
Rufous Hummingbird	*Selasphorus rufus*			X	
Belted Kingfisher	*Megaceryle alcyon*			X	
Olive-sided Flycatcher	*Contopus cooperi*			X	
Cassin's Vireo	*Vireo cassinii*			X	
Warbling Vireo	*Vireo gilvus*			X	
Red-eyed Vireo	*Vireo olivaceus*			X	
Black-billed Magpie	*Pica hudsonia*			X	
Common Raven	*Corvus corax*			X	
American Dipper	*Cinclus mexicanus*			X	
Cedar Waxwing	*Bombycilla cedrorum*			X	
Tennessee Warbler	*Leiothlypis peregrina*			X	
Yellow Warbler	*Setophaga petechia*			X	
Magnolia Warbler	*Setophaga magnolia*			X	
Blackpoll Warbler	*Setophaga striata*			X	

Species	Scientific Name	Heat tolerance	Reduced snow persistence: subnivean refugia, hibernation, frost-freeze, mobility-competitor release	Phenological mismatch with food	Winter molt color and snow
American Redstart	*Setophaga ruticilla*			X	
Northern Waterthrush	*Parkesia noveboracensis*			X	
MacGillivray's Warbler	*Geothlypis tolmiei*			X	
Hoary Marmot	*Marmota caligata*	X	X		
Arctic Ground Squirrel	*Spermophilus parryii*		X		
Meadow Jumping Mouse	*Zapus hudsonius*		X		
Western Jumping Mouse	*Zapus princeps*		X		
Brown Lemming	*Lemmus trimucronatus*		X		
Long-tailed Vole	*Microtus longicaudus*		X		
Root Vole	*Microtus oeconomus*		X		
Singing Vole	*Microtus miurus*		X		
Meadow Vole	*Microtus pennsylvanicus*		X		
Southern Red-backed Vole	*Myodes gapperi*		X		
Northern Red-backed Vole	*Myodes rutilus*		X		
Bushy-tailed Woodrat	*Neotoma cinerea*		X		
Common Muskrat	*Ondatra zibethicus*		X		
Northwestern Deermouse (Keen's)	*Peromyscus keeni*		X		
Western Heather Vole	*Phenacomys intermedius*		X		

Species	Scientific Name	Heat tolerance	Reduced snow persistence: subnivean refugia, hibernation, frost-freeze, mobility-competitor release	Phenological mismatch with food	Winter molt color and snow
Northern Bog Lemming	*Synaptomys borealis*		X		
Snowshoe Hare	*Lepus americanus*				X
Cinereus (Common) Shrew	*Sorex cinereus*		X		
Dusky Shrew	*Sorex obscurus*		X		
Western Water Shrew	*Sorex navigator*		X		
Little Brown Myotis	*Myotis lucifugus*	X			
Coyote	*Canis latrans*			X	
Alexander Archipelago Wolf	*Canis lupus ligoni*			X	
Black Bear	*Ursus americanus*		X	X	
Brown Bear	*Ursus arctos*		X	X	
Steller Sea Lion	*Eumetopias jubatus*			X	
Harbor Seal	*Phoca vitulina*			X	
Wolverine	*Gulo gulo*	X	X		
American Marten	*Martes americana*		X		
Pacific Marten	*Martes caurina*		X		
Fisher	*Pekania pennanti*		X		
American Ermine	*Mustela richardsonii*		X		X
Beringian Ermine	*Mustela erminea*		X		X
Haida Ermine	*Mustela haidarum*		X		X
Mountain Goat	*Oreamnos americanus*	X		X	
Wood Frog	*Lithobates sylvaticus*		X		

Distribution and Range Shifts

A species' distribution on the landscape reflects the condition of many factors affecting survival and reproductive success, including availability of food, cover, water, physiological tolerances, and functionality of all conditions and processes necessary to meet the species' needs. Species distribution explicitly includes consideration of how population density (number of animals per unit area) varies across the species range (the geographical limits of the species' distribution). Density is typically higher where (and when) conditions are favorable, and lower where conditions are marginal. Where one or more necessary resources or conditions are inadequate, the species is unable to persist. In some cases, absence of a species from otherwise suitable habitat reflects existence of barriers to immigration, rather than onsite conditions. Distribution, therefore, integrates and reflects the full range of conditions affecting a species.

As conditions important to any species change, we can also expect distributions to change. Recent latitudinal and elevational shifts in many species have been attributed to changes in climate (Haufler et al. 2010, Tillmann and Glick 2013). Meta-analyses done by Parmesan and Yohe (2003) of Northern Hemisphere birds, butterflies, and alpine herbs indicate poleward range shifts averaging 6.1 km (3.8 mile) per decade and elevational shifts of 6.1 m (20.0 feet) per decade upwards. However, shifts are occurring more rapidly now than previously reported, by about two to three times; median latitudinal shift rates are 16.9 km (10.5 mile) per decade poleward and elevational shifts are 11 m (36 ft) per decade upwards (Chen et al. 2011). These shifts result in modifications of species communities, creating potential for impacts to many interspecific processes, such as predator-prey interactions, parasite-host and disease dynamics, etc. Trees and other plants are slower to respond than animals so habitat changes often limit animal community shifts (Lawler et al. 2014).

Distribution and range shifts are constrained by functional barriers to plant and animal dispersal. Functional barriers can result from physical barriers, lack of suitable habitat, and refugia without habitat connectivity. The island geography of the Tongass NF limits dispersal of many species that might otherwise benefit from climate change but cannot swim, raft, or fly across saltwater channels (e.g. frogs, salamanders, small mammals, flightless terrestrial and freshwater invertebrates). Boreal toads and rough-skinned newts are found on many islands which suggests they are not as dispersal limited as the frogs and salamanders of the region which are limited largely to the mainland and a few nearshore islands (MacDonald and Cook 2007).

Indeed, there is evidence supporting likely boreal toad dispersal across salt water (Taylor 1983, Armstrong and Hermanns 2004). Increases in severe flooding (from rain on snow events, for example) could accelerate colonization of islands by amphibians and small mammals rafting across saltwater on trees uprooted during floods. Saltwater barriers may also "trap" some species and populations on islands that become too warm or otherwise unsuitable, leading to local extinctions.

The Tongass NF is likely to see range shifts in passerine birds. Warming winters have resulted in a northward shift in winter ranges in 68 percent of 305 North American bird species studied (Niven et al. 2010). These shifts were especially present in forest birds, and were seen in a variety of wetland, shrub, and generalist birds, but not grassland birds. The average distance moved was 35 miles over 40 years (Niven et al. 2010). Positive latitudinal trends were evident for the northern boundary, center of occurrence, and center of abundance (La Sorte and Thompson 2007). Range shifts were associated with population increases at more northerly latitudes (Soykan et al. 2016). This relationship may be largely influenced by each species' thermal range; populations breeding close to their thermal minimum have higher growth rates even when controlling for latitude (Jiguet et al. 2010). It is notable that the magnitude of temperature change is multiple times greater than the magnitude of community shifts (Santangeli and Lehikoinen 2017). In addition to winter range shifts, summer breeding ranges of North American birds are also projected to shift northwards (Hitch and Leberg 2007). Changes in bird distributions due to climate change may seem inconsequential but could cause important disruptions to ecosystem services (Price 2003). However, in general, conifer forest birds are predicted to fare better in a changing climate than birds in other habitats because of their larger ranges and higher reproductive potential (Bortner et al. 2010).

One species common to the Tongass NF, the pine siskin, shifted its mean annual latitudinal center of abundance on average 288 miles north between 1966 and 2004 based on Audubon Christmas bird count data from southeast Alaska (Jezierski et al. 2010). Distribution and abundance of this species as well as other cardueline finches such as white-winged and red crossbills are additionally influenced by and considered irruptive based on food resources, such as cone seeds. Sunny heat waves with little precipitation in Southeast Alaska seem to be associated with extensive plumes of wind-dispersed conifer pollen, likely resulting in mass pollination events and subsequent bumper cone crops. Such Sitka spruce masting events are exploited by irruptive species like the pine siskin (Furness and Furness 2021) and therefore also likely to influence distribution changes of this and other similarly irruptive cardueline finches. Other cone-dependent species like North American red squirrels and squirrel predators like goshawks may also benefit.

Other examples of anticipated distribution and range shifts exist. As mentioned, the distribution of the little brown myotis bat is expected to expand northward in Alaska due to change towards conditions ideal for hibernation (Humphries et al. 2002), though these benefits may be offset by white nose syndrome if it spreads to the Tongass NF and possible impacts from heat stress. Physiology may play a role in limiting or reducing summer distributions for other species too (Burkett et al. 2005), for example with mountain goats and wolverines, as previously described.

Changes are also anticipated to whole biomes, species assemblages, and vegetation and animal communities. For example, Murphy et al. (2010) demonstrate that nearly half of Southeast Alaska is projected to transition from the N. Pacific Maritime to the Canadian Pacific Maritime biome. Similarly, due to climate-caused biome changes, distributions of interior community small mammals are projected to be reduced or eliminated from the southern extents of their ranges in Southeast Alaska, whereas distributions of southern community species are projected to gain in area (Baltensperger and Huettman 2015). Notable species' distribution changes projected in the Tongass NF by Baltensperger and Huettman (2015 – their Figure 3) include: area-wide losses in cinereus shrew and to a lesser degree western water shrew as their distributions shift toward interior Alaska as a contraction and expansion, respectively; northern Tongass NF losses of northern red-backed vole and root vole and central-island losses of meadow vole; northern and inland gains of northern collared lemming (which we are not aware of currently occurring in the Tongass NF; MacDonald and Cook 2007); and area-wide gains of dusky shrew, northern bog lemming, and meadow jumping mouse. Small mammal community composition and population densities influence mesocarnivore and other predator communities, suggesting that slight differences in climate can be associated with substantial changes to ecosystems, constrained by functional barriers.

Species Vulnerabilities

Our concern is greatest for species with previously-identified conservation issues that also appear to be vulnerable to climate change. These are typically species with observed population declines or otherwise thought to be at risk. We therefore approach this species vulnerabilities section by addressing 1) species with recognized conservation status and 2) species identified as having local conservation concerns on part or all of the Tongass NF.

Species with Recognized Conservation Status

We identified recognized conservation status using the following criteria:

- NatureServe Global or State rankings of 1-3, using subspecies rank when the subspecies exclusively occurs in the Tongass NF (e.g., Alexander Archipelago wolf, Queen Charlotte goshawk, Sitka black-tailed deer).
- Alaska State Wildlife Action Plan (Alaska Department of Fish and Game 2015) species with greatest conservation need for the Southeast Alaska bioregion,
- USFS Regional Forester Sensitive Species for the Tongass NF,
- Federally listed under the Endangered Species Act, and
- U.S. Fish and Wildlife Service Birds of Conservation Concern 2021 list for Alaska Bird Conservation Region 5 (U.S. Fish and Wildlife Service 2021).

These criteria resulted in a list of 138 vertebrate species that breed or probably breed in the Tongass NF with recognized conservation concerns, including 106 birds, 26 mammals, and six amphibians. Of these 138 species, 105 species also associate with climate vulnerable habitat or biological processes detailed previously in Tables 2 and 3. Ninety-four of these species associate with vulnerable habitats, 40 associate with biological process vulnerabilities, and 29 species are potentially associated with both habitat and biological process vulnerabilities (Table 4). How and to what degree these species are likely to be affected is still uncertain. Although other species might also be affected, given recognized conservation status along with identified potential climate change concerns, the species in Table 4 are a good place to start for exploring more detailed species vulnerabilities in future assessments. This list could be further prioritized by stewardship responsibility, essentially factoring in the importance of the Tongass NF to each species' global population (as done by Handel et al. 2021). For example, some species such as magnolia warbler, snow bunting, and brown-headed cowbird very rarely breed in the Tongass NF, while the Tongass NF hosts a significant portion of the global breeding population of rufous hummingbirds, bald eagles, and others, justifying greater stewardship responsibility towards these latter species.

Table 4. Species with recognized conservation status that are associated with identified climate-vulnerable habitats or potential climate-mediated changes to biological processes. Nature Serve rankings include Global and State rankings 1-3. SGCN = species of greatest conservation need for Southeast Alaska bioregion as identified by ADF&G (2015). RFSS = Regional Forester Sensitive Species. ESA = federally listed under the Endangered Species Act. BCC = Bird of Conservation Concern as identified by USFWS (2021). Vulnerable habitats and biological processes are detailed for each species in Tables 2 and 3, respectively.

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
Trumpeter Swan	*Cygnus buccinator*	G4 S3	X				X	
Redhead	*Aythya americana*	G5 S3					X	
Ring-necked Duck	*Aythya collaris*	G5 S2					X	
Common Eider	Somateria mollissima	G5 S3					X	
White-winged Scoter	*Melanitta deglandi*	G5 S5	X				X	
Hooded Merganser	*Lophodytes cucullatus*	G5 S3					X	
Lesser Scaup	*Aythia affinis*	G5 S3	X				X	
Long-tailed Duck	migonly	G5 S4	X				X	
Pied-billed Grebe	*Podilymbus podiceps*	G5 S2					X	
Brandt's Cormorant	*Urile penicillatus*	G5 S1	X			X	X	
Double-crested Cormorant	*Nannopterum auritum*	G5 S3					X	
Pelagic Cormorant	*Urile pelagicus*	G5 S5	X				X	
American Bittern	*Botaurus lentiginosus*	G5 S3					X	
Great Blue Heron	*Ardea herodias*	G5 S3					X	
Osprey	*Pandion haliaetus*	G5 S3					X	

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
Bald Eagle	*Haliaeetus leucocephalus*	G5 S5	X				X	X
Northern Harrier	*Circus hudsonius*	G5 S4	X				X	
Sharp-shinned Hawk	*Accipiter striatus*	G5 S3					X	
Queen Charlotte Goshawk	*Accipiter gentilis laingi*	T2 S2	X	X				
Red-tailed Hawk	*Buteo jamaicensis*	G5 S4	X				X	
Golden Eagle	*Aquila chrysaetos*	G5 S3	X				X	
Peregrine Falcon	*Falco peregrinus*	G4 S3	X				X	X
Sora	*Porzana carolina*	G5 S3					X	
Killdeer	*Charadrius vociferus*	G5 S3	X				X	
Black Oystercatcher	*Haematopus bachmani*	G5 S2	X	X		X	X	
Spotted Sandpiper	*Actitis macularius*	G5 S5	X				X	X
Lesser Yellowlegs	*Tringa flavipes*	G5 S5	X			X	X	X
Short-billed Dowitcher	*Limnodromus griseus*	G5 S4	X			X	X	X
Black-legged Kittiwake	*Rissa tridactyla*	G5 S5	X				X	
Short-billed Gull	*Larus brachyrhynchus*	G5 S5	X				X	
Herring Gull	*Larus argentatus*	G5 S5	X				X	
Glaucous-winged Gull	*Larus glaucescens*	G5 S5	X				X	
Aleutian Tern	*Onychoprion aleuticus*	G3 S3		X		X	X	X
Caspian Tern	*Hydroprogne caspia*	G5 S1					X	X
Arctic Tern	*Sterna paradisaea*	G5 S4	X				X	X
Fork-tailed Storm-Petrel	*Hydrobates furcatus*	G5 S4	X				X	
Pigeon Guillemot	*Cepphus columba*	G5 S5	X				X	
Marbled Murrelet	*Brachyramphus marmoratus*	G3 S3	X			X	X	
Kittlitz's Murrelet	*Brachyramphus brevirostris*	G2 S2		X		X	X	

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
Ancient Murrelet	*Synthliboramphus antiquus*	G4 S4	X			X	X	
Cassin's Auklet	*Ptychoramphus aleuticus*	G4 S4	X			X	X	
Common Murre	*Uria aalge*	G5 S5	X				X	
Horned Puffin	*Fratercula corniculata*	G5 S5	X				X	
Tufted Puffin	*Fratercula cirrhata*	G5 S5	X			X	X	
Band-tailed Pigeon	*Patagioenas fasciata*	G4 S3						
Western Screech-Owl	*Megascops kennicottii*	G4 S2	X			X		
Northern Pygmy-Owl	*Glaucidium gnoma*	G4 S3						
Barred Owl	*Strix varia*	G5 S3						
Short-eared Owl	*Asio flammeus*	G5 S4	X				X	
Northern Saw-whet Owl	*Aegolius acadicus*	G5 S3						
Black Swift	*Cypseloides niger*	G4 S2	X			X	X	X
Vaux's Swift	*Chaetura vauxi*	G5 S2				X	X	X
Rufous Hummingbird	*Selasphorus rufus*	G4 S4	X			X	X	X
Belted Kingfisher	*Megaceryle alcyon*	G5 S5	X				X	X
Red-breasted Sapsucker	*Sphyrapicus ruber*	G5 S5	X				X	
Downy Woodpecker	*Dryobates pubescens*	G5 S5	X					
Hairy Woodpecker	*Dryobates villosus*	G5 S5	X					
American Three-toed Woodpecker	*Picoides dorsalis*	G5 S5	X					
Olive-sided Flycatcher	*Contopus cooperi*	G4 S4	X			X	X	X
Western Wood-Pewee	*Contopus sordidulus*	G5 S4	X					
Yellow-bellied Flycatcher	*Empidonax flaviventris*	G5 S2					X	
Western Flycatcher	*Empidonax difficilis*	G5 S4	X					
Red-eyed Vireo	*Vireo olivaceus*	G5 S3						X
Steller's Jay	*Cyanocitta stelleri*	G5 S5	X					

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
American Crow	*Corvus brachyrhynchos*	G5 S3					X	
Common Raven	*Corvus corax*	G5 S5	X				X	X
Tree Swallow	*Tachycineta bicolor*	G5 S5	X				X	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	G5 S3					X	
Barn Swallow	*Hirundo rustica*	G5 S4	X				X	
Black-capped Chickadee	*Poecile atricapillus*	G5 S5	X					
Chestnut-backed Chickadee	*Poecile rufescens*	G5 S5	X					
Brown Creeper	*Certhia americana*	G5 S4	X					
Pacific Wren	*Troglodytes pacificus*	G5 S5	X				X	
Golden-crowned Kinglet	*Regulus satrapa*	G5 S4	X					
Ruby-crowned Kinglet	*Corthylio calendula*	G5 S5	X					
Mountain Bluebird	*Sialia currucoides*	G5 S3					X	
Swainson's Thrush	*Catharus ustulatus*	G5 S5	X					
Hermit Thrush	*Catharus guttatus*	G5 S5	X					
Varied Thrush	*Ixoreus naevius*	G5 S5	X			X		
American Pipit	*Anthus rubescens*	G5 S5	X				X	
Cedar Waxwing	*Bombycilla cedrorum*	G5 S3						X
Tennessee Warbler	*Leiothlypis peregrina*	G5 S2						X
Orange-crowned Warbler	*Leiothlypis celata*	G5 S5	X					
Yellow Warbler	*Setophaga petechia*	G5 S5	X					X
Magnolia Warbler	*Setophaga magnolia*	G5 S2						X
Townsend's Warbler	*Setophaga townsendi*	G5 S4	X					
American Redstart	*Setophaga ruticilla*	G5 S3	X					X
MacGillivray's Warbler	*Geothlypis tolmiei*	G5 S4	X					X

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
Common Yellowthroat	*Geothlypis trichas*	G5 S4	X				X	
Wilson's Warbler	*Cardellina pusilla*	G5 S5	X					
Chipping Sparrow	*Spizella passerina*	G5 S4	X				X	
Savannah Sparrow	*Passerculus sandwichensis*	G5 S5	X				X	
Fox Sparrow	*Passerella iliaca*	G5 S3	X					
Song Sparrow	*Melospiza melodia*	G5 S5	X				X	
Lincoln's Sparrow	*Melospiza lincolnii*	G5 S5	X				X	
Golden-crowned Sparrow	*Zonotrichia atricapilla*	G5 S5	X				X	
Dark-eyed Junco	*Junco hyemalis*	G5 S5	X				X	
Snow Bunting	*Plectrophenax nivalis*	G5 S5	X				X	
Red-winged Blackbird	*Agelaius phoeniceus*	G5 S4	X				X	
Rusty Blackbird	*Euphagus carolinus*	G4 S3	X				X	
Brown-headed Cowbird	*Molothrus ater*	G5 S3					X	
Gray-crowned Rosy Finch	*Leucosticte tephrocotis*	G5 S3					X	
Pine Grosbeak	*Pinicola enucleator*	G5 S5	X					
White-winged Crossbill	*Loxia leucoptera*	G5 S5	X					
Common Redpoll	*Acanthis flammea*	G5 S5	X				X	
Pine Siskin	*Spinus pinus*	G5 S4	X					
Northern Flying Squirrel	*Glaucomys sabrinus*	G5 S5	X					
Arctic Ground Squirrel	*Spermophilus parryii*	G5 S5	X				X	X
North American Red Squirrel	*Tamiasciurus hudsonicus*	G5 S5	X					
Meadow Jumping Mouse	*Zapus hudsonius*	G5 S5	X				X	X
Western Jumping Mouse	*Zapus princeps*	G5 S3					X	X

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
Brown Lemming	*Lemmus trimucronatus*	G5 S5	X				X	X
Long-tailed Vole	*Microtus longicaudus*	G5 S5	X				X	X
Root Vole	*Microtus oeconomus*	G5 S5	X				X	X
Meadow Vole	*Microtus pennsylvanicus*	G5 S5	X				X	X
Southern Red-backed Vole	*Myodes gapperi*	G5 S4	X					X
Northern Red-backed Vole	*Myodes rutilus*	G5 S5	X				X	X
Northwestern Deermouse (Keen's)	*Peromyscus keeni*	G5 S5	X				X	X
Northern Bog Lemming	*Synaptomys borealis*	G5 S5	X				X	X
Collared Pika	*Ochotona collaris*	G5 S3	X				X	
Snowshoe Hare	*Lepus americanus*	G5 S5	X					X
Cinereus (Common) Shrew	*Sorex cinereus*	G5 S5	X					X
Dusky Shrew	*Sorex obscurus*	G5 S4	X				X	X
Western Water Shrew	*Sorex navigator*	G5 S4	X				X	X
Silver-haired Bat	*Lasionycteris noctivagans*	G3 S4	X				X	
California Myotis	*Myotis californicus*	G5 S4	X					
Keen's Myotis	*Myotis keenii*	G3	X					
Little Brown Myotis	*Myotis lucifugus*	G3 S3	X					X
Long-legged Myotis	*Myotis volans*	G4 S3	X					
Northern Hoary Bat	*Lasiurus cinereus*	G3						
Alexander Archipelago Wolf	*Canis lupus ligoni*	T3 S3	X				X	X
Steller Sea Lion	*Eumetopias jubatus*	G3 S3			X		X	X
Northwestern Salamander	*Ambystoma gracile*	G5 S3	X				X	
Long-toed Salamander	*Ambystoma macrodactylum*	G5 S3	X				X	

Species	Scientific Name	Nature Serve	SGCN	RFSS	ESA	BCC	Habitat	Process
Rough-skinned Newt	*Taricha granulosa*	G5 S4	X				X	
Boreal (Western) Toad	*Anaxyrus boreas*	G4 S3	X				X	
Columbia Spotted Frog	*Rana luteiventris*	G4 S2					X	
Wood Frog	*Lithobates sylvaticus*	G5 S5	X				X	X

Species with Local Conservation Concerns

A number of Tongass NF wildlife species have had known population declines and associated conservation concerns identified on part or all of the Tongass NF (Table 5). These species include the Queen Charlotte goshawk, Aleutian tern, marbled murrelet, Kittlitz's murrelet, western screech-owl, rufous hummingbird, northern flying squirrel, Sitka black-tailed deer, mountain goat, Alexander Archipelago wolf, wolverine, Pacific marten, and boreal toad.

Given the importance of these species to Tongass NF wildlife habitat management and potentially in future revision of the Tongass NF Forest Plan, we provide more detailed climate change vulnerability assessments for each of these species. We consider three categories of influence on vulnerability: 1) Exposure – the degree to which species-relevant aspects of climate will change, especially related to changes to habitat and biological processes. 2) Sensitivity – how much climate change a species can tolerate. 3) Adaptation Capacity – extent to which human social, economic, and ecological systems can anticipate and adjust to climate change (Marcot 2013).

Queen Charlotte Goshawk

Goshawks are expected to be mildly vulnerable to climate change. Conifer forest is gaining in area in the Tongass NF, so habitat change will be less relevant, except as it relates to timber harvest as a non-climate stressor. Summer heat waves could endanger young birds in the nest especially in more southerly latitudes, though deep conifer canopies from large nest trees would likely lessen and possibly prevent any impacts under expected Tongass NF temperatures. Goshawks could also be affected through their prey, which vary across the Tongass NF, but consist primarily of grouse (where present), North American red squirrels (where present), and ptarmigan, with crows, jays, various passerine birds and small mammals contributing less.

Grouse and ptarmigan may be affected by shrub and conifer encroachment along alpine ecotones and meadows as well as from reductions in insulating snow when temperatures are still cold. We also expect mismatches in plumage color and snow for ptarmigan. North American red squirrel abundance fluctuates largely with cone crops, so that any climate change effects on masting and longevity of cones, positive and/or negative, could affect this prey species. As mentioned, an important non-climate stressor, past timber harvest targeted towards large, old-growth trees, has substantially impacted some areas of the Tongass NF, though transition to young-growth harvest, along with young-growth forest restoration that promotes early development of goshawk foraging and nesting habitat characteristics in conservation areas, will help offset impacts from this stressor and improve climate resilience.

Aleutian Tern

The Aleutian tern is likely very vulnerable to climate change. Ocean warming and marine heatwaves, along with associated algal blooms and toxins are affecting forage fish in the North Pacific Ocean, decreasing food availability and causing starvation, mass-mortality events, and breeding failure of seabirds. Aleutian terns are also impacted by marine heatwave changes in food availability, and climate change has been identified to observed population declines in Alaska. Isostatic rebound and coastal uplift from glacial recession could also result in more rapid succession of Aleutian tern breeding areas into unsuitable vegetation coverage. Increasing summer precipitation and intensity and frequency of storm events, are also likely to impact reproductive success via increased chick and egg mortality from exposure and from high surf and flooding conditions. Other non-climate stressors include predation, contaminants, egg harvesting, and human and domestic dog disturbance. Focused management at specific colonies could help with localized predation and disturbance.

Kittlitz's Murrelet

The Kittlitz's murrelet is likely very vulnerable to climate change. Influences to forage fish as previously discussed, along with losses of favored foraging habitat in front of tidewater glaciers in Southeast Alaska are likely to impact this species. Increasing competition for food with other marine predators moving into these foraging areas may also impact Kittlitz's murrelets. Climate stressors are believed to be significant factors in recent population declines. Notably, this species nests in remote rugged areas near glaciers, which are less prone to direct human impacts. At sea, non-climate stressors could include oil spills, other pollution, bycatch, and vessel disturbance that could exacerbate climate change stressors.

Marbled Murrelet

The marbled murrelet is likely moderately vulnerable to climate change. Though this species will also be impacted by changes to forage fish described previously, it is not as tied to tidewater glaciers as the Kittlitz's murrelet, so will not be as vulnerable to glacial recession and loss of tidewater glaciers. Tongass NF marbled murrelets nest with similar frequency on ground nest sites such as rocky cliff faces, steep alpine scree, or rocky slopes near or above tree line as on platform branches of large old-growth trees (Barbaree et al. 2014). The most important non-climate stressor in the Tongass NF is past timber harvest targeted towards large, old-growth trees that was especially prevalent in some biogeographic regions. However, nest habitat loss is likely a contributing factor but does not explain population declines in areas with little to no logging. Rather, declines are likely related to combined and cumulative effects from climate-related changes in the marine ecosystem (most likely the 1977 regime shift) and human activities (logging, gillnet bycatch, oil pollution; Piatt et al. 2007). Transition to young-growth harvest, along with young-growth forest restoration that accelerates development of old-growth characteristics, will help offset impacts from this stressor and improve climate resilience.

Western Screech-Owl

Western screech-owls are likely mildly vulnerable to climate change. Warming temperatures may increase availability of unfrozen, freshwater streams during winter and early spring, a preferred habitat of this species. During the critical period when Western screech-owls are establishing territories, their prey largely consist of invertebrates that may also benefit from warming temperatures. The most important other stressor is the spread of barred owls into Southeast Alaska and their influence as a predator and competitor of western screech-owls and purported cause of population declines in British Columbia.

Rufous Hummingbird

The rufous hummingbird is likely mildly to moderately vulnerable to climate change. Encroachment of conifers into alpine and meadows may slightly diminish habitats used by this species, especially during fall migrations. Thermoregulatory needs of this species may benefit from warming temperatures in the Tongass NF where it is near the northern extent of its range that now extends up toward Anchorage and the Kenai Peninsula. Though extreme storms and heat waves could negatively affect nesting birds, this species seasonally adjusts nests to different levels and types of trees for optimal conditions. Phenological mismatches between flower and insect availability could be important, and reliance on many feeding sites along their migration routes through different habitat types could increase vulnerability. However, because this species tracks resources as it migrates and feeds on a wide variety of plants and insects, such mismatches are less likely.

Northern Flying Squirrel

Northern flying squirrels are likely mildly vulnerable to climate change. Though their favored forage mychorrhizal fungi may benefit from warming and precipitation changes, effects are uncertain. Preferred conifer forest habitat for this species is gaining in areas in the Tongass NF. However, as mentioned previously, not all conifer forests are the same; northern flying squirrels in Southeast Alaska prefer forests with high densities of large trees and understory cover (Smith et al. 2005). Past timber harvest has substantially impacted some bioregions of the Tongass NF, resulting in habitat connectivity and future conservation concerns for the Prince of Wales Island subspecies of northern flying squirrels. As with other forest-dwelling species, transition to young-growth harvest, along with young-growth forest restoration that accelerates development of old growth characteristics will help offset impacts from this non-climate stressor and improve climate resilience.

Alexander Archipelago Wolf

Wolves are expected to be mildly to moderately vulnerable to climate change, depending on the primary ungulate prey of the area. Both habitat generalists and opportunistic predators, wolves have high levels of behavioral plasticity and potential to disperse long distances including across some straits. Alternate prey such as salmon and marine mammals and invertebrates comprise a small proportion of their diet across the Tongass NF, so effects from changes to hydrology and marine systems are expected to be minimal.

In areas where wolves eat primarily deer, such as on Prince of Wales Island where wolf population concerns have been previously identified, mild climate vulnerability discussed for deer is likely to confer to wolves. Where moose are the primary prey, such as in the Yakutat area, benefits in moose forage accessibility from decreased snow persistence will likely be offset by decreases in deciduous forest and shrub habitat as glacially-vacated, transitory deciduous habitats succeed into coniferous forest. Therefore, moose, and thereby wolves are expected to be mildly vulnerable to climate changes in the northern Tongass NF. Where wolves rely on highly climate-vulnerable mountain goats as their primary prey along the mainland coast, climate impacts to wolves could be more substantial. Again, the generalist and opportunistic nature of wolves will help ameliorate impacts, resulting in wolves being mildly to moderately vulnerable to climate change in areas with goat prey, and overall mildly vulnerable to climate change.

Wolverine

Wolverine are likely moderately to very vulnerable to climate change in the Tongass NF. Though we are not aware of any studies citing population concerns for this species in the Tongass NF, population and climate vulnerability concerns throughout this species' range, including more southerly and northerly latitudes, warrant its inclusion here. Wolverines are sensitive to high temperatures, and anticipated summer temperatures may limit summer habitat use though not as much as to the south and potentially north interior portions of its range. Concerns also exist regarding diminished snow and the importance of snow dens in insulating newborn wolverines from cold winter temperatures. Diminished seasonal snow may also reduce the competitive advantage wolverines have over their fisher relatives that do not travel as well in snow. Roads and human development are other important stressors elsewhere, but these are not substantial issues in the highly remote and rugged range of this species in the Tongass NF, although mining and recreation likely have some influence.

Pacific Marten

Pacific marten are expected to be moderately vulnerable to climate change, but highly vulnerable to other stressors. Reduced seasonal snow persistence is likely to diminish subnivean resting spots used by this species and benefit potential competitors like fisher that do not travel as well over snow; however, fisher do not presently occur on Kuiu or Admiralty islands, the last two islands in the Tongass NF that support Pacific marten.

Pacific marten prey are likely to be affected by climate change. Their primary prey of voles and other small mammals are likely to experience higher energy expenditure and reduced survival from reduced insulating snow cover when temperatures are still cold enough to be problematic. Alternate prey, such as salmon and tidal marine invertebrates may also incur impacts from changes in freshwater hydrology and temperatures and saltwater acidification and warming, respectively.

The most pressing non-climate stressor for Pacific marten in the Tongass NF is gene swamping associated with colonizing American marten. Pacific marten no longer exist on Kupreanof Island and theoretically on other islands due to introgression and gene swamping by American marten. American marten are also becoming well established on Kuiu Island, leading towards similar genetic impacts there. Though historical transplants occurred on some islands possibly leading to subsequent loss of Pacific marten on those islands, American marten are not yet known to occur on Admiralty Island. Timber harvest, especially on Kuiu Island, is another stressor as Pacific marten are highly sensitive to forest fragmentation and canopy openings. Conserving and ensuring connectivity of higher value Pacific marten habitat on Kuiu would help partially offset impacts from climate change and these other stressors.

Sitka Black-tailed Deer

Sitka black-tailed deer are likely to be mildly vulnerable to climate change. Population declines of this species in the Tongass NF have been historically associated with severe winters, due to reduced accessible forage and mobility with heavy snowfall. Deep snow impacts are exacerbated in areas that experienced heavy timber harvest due to deer dependence on old-growth forests for forage and thermal cover during heavy snows. Transition to predominantly young-growth timber harvest and efforts to restore young-growth forests towards old-growth function should help alleviate impacts from this stressor. Deer are expected to benefit from diminishing seasonal snow persistence and mean snow water equivalent. However, increased winter storm frequency and intensity, and uncertain associated effects on snow depths seem likely to at least partially offset these benefits during some years. Longer growing seasons may also benefit deer with increased forage, especially in the spring when energy demands are high. On the other hand, most deer in the Tongass NF seasonally migrate to alpine for summer forage, and diminished availability of nutritional alpine plants during earlier green-up and hotter summers could impact this species.

Mountain Goat

Mountain goats are likely very vulnerable to climate change. Decreased winter survival rates of mountain goats in the Tongass NF were attributed to a combination of heat stress and poorer nutritional forage during prior summers, despite evidence of mountain goats being able to alter their behavior to help partially compensate for these effects. Further, projected impacts from increased summer temperatures outweigh benefits from reduced winter snowfall on population trajectories. These effects, along with documented mismatch between juvenile goat browsing needs and nutritional plant availability, reduced habitat based on temperature tolerance models, and conifer encroachment along alpine ecotones suggest potential future mountain goat population viability concerns due to anticipated climate changes in the Tongass NF. Influences from mining, recreation, and other land uses could additionally exacerbate these vulnerabilities without careful management.

Boreal Toad

The boreal toad is likely to be mildly vulnerable to climate change. As an ectotherm in the northernmost portions of its range, boreal toad reproduction, development and other ecological functions are expected to benefit in the Tongass NF from increased water and air temperatures. Though there may be some localized drying of wetlands and there is evidence of ubiquitous conifer encroachment in these habitats, increased summer precipitation is expected to offset drying on much of the Tongass and freshwater habitat appears to be increasing across the Tongass due to creation of rivers, ponds, and lakes by glacial recession. There is potential for amphibian diseases to become more problematic with warming, but current occurrence of chytridiomycosis across almost all ranger districts in the Tongass, along with recent increased observations of toads in distribution and numbers following suspected declines over the past couple of decades suggests this species could be on a post-chytrid upturn.

Vulnerability Analysis Conclusions

Table 5 shows the 13 species with identified local population declines on part or all of the Tongass NF along with associated literature documenting population concerns, as well as whether they were associated with identified climate vulnerable habitats or potential changes to biological processes from Tables 2 and 3 respectively, and the conclusions provided in the species assessments above regarding how vulnerable they are likely to be to climate change. As expected, climate change vulnerability varies among these species. Aleutian tern, Kittlitz's murrelet, and mountain goat are likely very vulnerable; wolverine are likely moderately to very vulnerable; Pacific marten and marbled murrelet are likely moderately vulnerable; rufous hummingbird is likely mildly to moderately vulnerable; and Queen Charlotte goshawk, western screech-owl, northern flying squirrel, Alexander Archipelago wolf, Sitka black-tailed deer, and boreal toad are likely mildly vulnerable to climate change (Table 5).

Table 5. Wildlife species and literature documenting local conservation concerns identified on part or all of the Tongass NF, whether each species is associated with identified climate vulnerable habitats or potential changes to biological processes ("X") or not (blank), and what conclusion is made regarding how vulnerable they are likely to be in the Tongass NF.

Species	Scientific Name	Literature Documenting Local Conservation Concerns	Habitat	Process	Climate Change Vulnerability
Queen Charlotte Goshawk	*Accipiter gentilis laingi*	Smith 2013, Sonsthagen et al. 2012, Smith and Flaherty 2023			mildly
Aleutian Tern	*Onychoprion aleuticus*	Renner et al. 2015	X	X	very
Kittlitz's Murrelet	*Brachyramphus brevirostris*	Drew and Piatt 2008, Kissling et al. 2011, Piatt et al. 2011, USFWS 2011	X		very
Marbled Murrelet	*Brachyramphus marmoratus*	Piatt et al. 2007, Kissling et al. 2011	X		moderately
Western Screech-Owl	*Megascops kennicottii*	Kissling and Lewis 2009: stable occupancy, narrowed distribution in southern Tongass NF where barred owls occur. Declines in BC associated with barred owl expansion (COSEWIC 2002, Elliott 2006).			mildly
Rufous Hummingbird	*Selasphorus rufus*	Handel and Sauer 2017 (declines in offroad surveys; no declines in road-based surveys, may be tied to feeders)	X	X	mildly to moderately

Species	Scientific Name	Literature Documenting Local Conservation Concerns	Habitat	Process	Climate Change Vulnerability
Northern Flying Squirrel	*Glaucomys sabrinus*	Smith et al. 2013			mildly
Sitka Black-tailed Deer	*Odocoileus hemionus sitkensis*	Person and Brinkman 2013, Gilbert et al. 2020	X		mildly
Mountain Goat	*Oreamnos americanus*	White et al. 2011, 2018, 2021; White 2021	X	X	very
Alexander Archipelago Wolf	*Canis lupus ligoni*	Roffler et al. 2019; Gilbert et al. 2022; USFWS 2023	X	X	mildly
Wolverine	*Gulo gulo*	N/A	X	X	moderately to very
Pacific Marten	*Martes caurina*	MacDonald and Cook 2007, Colella et al. 2018	X	X	moderately
Boreal (Western) Toad	*Anaxyrus boreas*	reports of anecdotal declines: Carstensen et al. 2003, Anderson 2004, Pyare et al. 2007, Ream 2016, Surdyk and Waldo 2018, Ream et al. 2019	X		mildly

Conclusion

This chapter has assessed how climate change is likely to affect Tongass NF wildlife habitats and biological processes, species associated with the most vulnerable habitats and climate-mediated changes to biological processes, and potential climate change vulnerabilities of wildlife species with recognized conservation status and identified local population concerns. This chapter is only a starting point. We hope that the uncertainties we've described herein, along with this preliminary understanding of species' vulnerabilities to climate change will inspire additional focused monitoring, study, and adaptation planning. The Tongass NF is fortunate amidst global climate change threats to have largely pristine, connected, and functioning ecosystems that will help make such ecosystems, and the wildlife species that reside therein, more resilient to long-term climate-change impacts. There are also management actions we can take to help minimize and mitigate anticipated impacts to vulnerable species and habitats. Foundational information in this chapter will help inform ongoing Tongass NF land management and planning and the upcoming Tongass National Forest Plan revision. Adaptation and conservation measures may be further integrated into management and planning to help protect species with population and climate vulnerabilities that intersect with land management objectives.

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Chapter 6. Wildlife Climate Change Vulnerability Assessment for the Tongass National Forest

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Reviewer: Dr. Natalie Dawson

Summary Statements

The current draft document provides a brief overview of some climatic vulnerabilities associated with impacts to wildlife in changing environmental conditions. However, the current review is summarized using three "key implications" outlined in lines 68-76.

-Suggestion: Include a "key implication" that addresses the fact that this is not a contiguous national forest (using the example of the Mt. Hood/Willamette/Columbia River Gorge National Forests) but an oceanic island archipelago – exacerbating any continental climate stresses because of the nature of island systems. This should be included as a key implication in Lines 68-76. Examples of supporting literature are included at the end of this review, but also see: Macinnis- Ng et al. 2021 (*Front Ecol Environ* 2021; 19(4): 216–224, doi:10.1002/fee.2285) as an example of this supporting literature.

Beginning with Line 133 – authors should include an entire section on Island Biogeography – addressing the distinct nature of this island archipelago and associated species assemblages, as well as the vulnerabilities presented by climate change and associated plant and animal species. For example, many assumptions are made that with "warming trends" certain species will go up and down, but it is not mentioned that without immigration or emigration processes on and off islands, whether or not depopulation, local extirpation or complete extinction may be possible because recruitment of new diversity is limited on island systems, including islands in the Alexander Archipelago. At the end of this summary, I have included a long list of research and literature not cited in the current draft that points to the vulnerability of this island archipelago.

E.g. recent discovery of inbreeding depression in wolves on Prince of Wales Island illustrates that local populations of specific species, even those with higher dispersal capabilities, are vulnerable to extinction processes associated with island systems.

For reference, see: Zarn 2019 (https://scholarworks.umt.edu/etd/11497/)

Beginning on Line 1247 – Interactions with other Stressors – the authors should again highlight island endemism and the fragmented nature of island populations across the Alexander Archipelago, as well as the disproportionate impact of habitat modification through logging and long-term isolation (endemism). See: Albert 2019 for additional information including this summary below and an example of disproportionate habitat modification on some islands that will lead to inequitable vulnerabilities for fish and wildlife on islands:

94%f large tree riparian old growth is missing from specific places like POW - it was a study by Dave Albert (below), or you could pull percentages from this 2013 paper (which is older and predates the biggest sales on prince of wales that occurred after 2013).

https://defenders.org/sites/default/files/2020-02/2019_12_14_albert_conservation_significance_of_tongass_roadless_areas.pdf

“Large-tree POG Forests Large-tree forests (defined as stands with tree-size >21” quadratic mean diameter) occur on approximately 542,800 acres and represent approximately 10% of all productive forest lands (Table 2). We conservatively estimate that the original distribution of large-tree old-growth forests was 795,680 acres, which represents a region-wide decline of 31.8% from pre-industrial forest conditions (Albert & Schoen 2013). In this region naturally isolated among islands and further fragmented by high elevation mountains and extensive wetlands, contiguous forest landscapes were always relatively rare. We estimate that in 1954, approximately 39.4% of all productive forests (2.4 million acres) were part of contiguous old-growth forest landscapes, and the remaining 60.6% (3.7 million acres) were in fragmented patches at a landscape scale. In 2018, only 27.6% of old-growth forests (1.5 million acres) were part of contiguous forest landscapes and the remaining 72% (3.8 million acres) were characterized by fragmented old- growth forest landscapes. Thus, contiguous forest landscapes have been reduced by 39.4% region-wide, with the highest loss evident on North Prince of Wales Island, where contiguous old-growth landscapes have been reduced by 77.5% (Table 3). Contiguous Old-growth Forest Landscapes Forests that are contiguous over a landscape scale (defined as >70% canopy of medium-to-high volume productive old growth forest per sq. km) originally accounted for approximately 2.5 million acres region-wide, tended to occur on the southern and central islands (Table 3). The Prince of Wales Island group originally accounted for 27.7% of the regional total, with 10.2% of that found on North Prince of Wales alone. Regionwide, these forests have been reduced by 39.2% to approximately 1.5 million acres in 2018. Likewise, the proportional loss of contiguous forest has been the most dramatic on North Prince of Wales (Fig. 4), where contiguous forests have been reduced by 77.5%, followed by Kupreanof / Mitkof (55.9% loss), East Baranof (55.5% loss) and West Baranof (50% loss). East Baranof has a very small proportion of the regional distribution (1.3%), but 93.1% of that is found in large inventoried roadless areas. Other provinces with the highest proportion of remaining contiguous forests in LRIA include East Chichagof (78.3%), West Baranof (77.4%), Dall Island Complex (76.8%), and Lynn Canal (75.9%). The province with the highest proportion of contagious forests vulnerable to future development include Kupreanof / Mitkof (48.5%), East Baranof (45.4%) and Etolin / Zarembo 13 (43.2%). The cumulative ecological risk region-wide, considering both past and potential for future fragmentation represents approximately 54.1% of the original distribution of these types of forests. Provinces with the highest cumulative risk include North Prince of Wales (85.2%), Kupreanof / Mitkof (77.3%), East Baranof (75.7%) and Etolin / Zarembo (70.4%) (Table 3).”

And this paper from 2023 includes additional shortcomings in the current conservation strategy and need to evaluate island endemism as a major driver of ecological processes on the Tongass:
https://wildlife.onlinelibrary.wiley.com/toc/19372817/2023/87/6

Species Vulnerabilities (Line 1449) should include an entire section on island endemics as first described in the 1997 TLMP. Using the literature, listed below, the authors could contribute a section on the continued importance and significance of island endemism. In many cases, these are species and subspecies found only on the Tongass National Forest, and no where else in the world. Or, in the case of species such as the Alexander Archipelago wolves, they represent a distinct genetic diversity found only in this region, and in no other locale of the gene pool for the species – highlighting their importance for species persistence and overall health in adaptation (through genetic diversity).

The 1997 TLMP included specific recommendations for island endemics – including forest management practices that formed a significant portion of the Old Growth Conservation Strategy Review (see Appendix D, Old-Growth Habitat Conservation Strategy, Wildlife Standards and Guildines, and Wildlife Viability). This review should include a status update of these original metrics, followed by a recommendation for implementation of endemic-related management prescriptions from the 2012 planning rule (which were never implemented for the Tongass National Forest). Together, these could form the basis for a new updated set of prescriptions to inform a future planning process.

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Chapter 6. Wildlife Climate Change Vulnerability Assessment for the Tongass National Forest
Authors: Bonnie M. B. Bennetsen, Steve Brockmann, Bruce G. Marcot

Review 5 May 2024 Joseph A. Cook

This overview manuscript aimed to synthesize habitat and species' vulnerabilities to climate change for wildlife on the Tongass National Forest. According to the request for review, "the review will be published as a General Technical Report with a number of other chapters that assess climate change vulnerabilities across Southeast Alaska and its natural resources. Because the Tongass National Forest is starting the forest plan revision process, this chapter will be used to inform the forest plan revision. Forest plans set management goals and actions for a forest for the next ~15 year time period".

USDA (and to a lesser extent USFWS and USGS) initiated reviews of wildlife have tended to focus on old growth associated species on the Tongass. More recently, "young growth" or secondary forests that are slowly emerging following clearcuts have become a major focus. This manuscript is largely in keeping with that long tradition and tends to focus on a relatively small number of species (goshawks, murrelets, deer, etc) for which the federal government has invested substantial resources over decades to monitor. Nearly 30 years ago a group of investigators began to look at the regional fauna from the perspective of the effects of isolation (endemism)---a major driver in evolutionary biology. First, the region is largely isolated from the remainder of North America by the coastal mountains with just a few river corridors connecting Southeast Alaska to BC. Second, the archipelagic landscape of much of the Tongass is a classic example of complexity wrought by isolation (with each island potentially representing an independently evolving set of wildlife populations). And third, clearcut logging had transformed many corridors into barriers or in some cases completely annihilated ("skinned") old growth habitat on entire islands that potentially held endemic populations. All three of these scales can isolate populations and cause divergent evolution.

Unfortunately, there was extremely limited documentation of diversity (and potentially endemic populations) across this vast archipelago at that time. What was the consequence? Heaviest deforestation occurred on Prince of Wales Island, an island where we have subsequently learned we also find the signature of highest endemism across wildlife species. Not a good outcome and that kind of federal mismanagement will lead to poor outcomes. Complex questions (and landscapes) require data to make informed decisions and TLMP should clearly direct the USDA Forest Service to continue to develop the biodiversity infrastructure necessary to manage this incomparable landscape in more robust and thoughtful ways.

Resource allocations for wildlife studies have continued to flow toward a few high profile species over the past 3 decades (you can see the list of "important" species by simply noting the names of the scientific panels convened (in 1996) for the 1997 TLMP. However, there was one review panel that raised the issue of endemic taxa in the 1997 exercise and it would be valuable for planners to finally address this shortfall in critical information.

As a review of vulnerabilities of Tongass wildlife to climate change, this manuscript should point to significant gaps in our knowledge base:

1) There is a surprising lack of focus on the unique landscape of the Tongass (an oceanic archipelago!). In the wildlife conservation literature, islands stand out as landscapes of high concern (think Hawaii, Galapagos, Caribbean, Haida Gwaii, etc) and yet there was no significant discussion or even serious acknowledgement of this central issue. One simply needs to look south to Haida Gwaii to see how changing environmental conditions have upended wildlife management priorities in the last decade. A large body of general work has been written about island conservation and climate change—next to none of it is cited in this chapter. **Island endemism will become the dominant issue for wildlife managers on the Tongass in the future. Management of an archipelago requires special consideration of island-focused conservation, especially when considering climate disruption. Of the 3 primary options for species response to climate change (Move, Adapt, or Die), the first is either diminished or off the table on much of the Tongass. Adaptation is also diminished in small, genetically-depauperate insular populations. Hence, Die (extirpation or in the case of endemics extinction) is a very real outcome. Worldwide, island endemics dominate the history of vertebrate extinctions over the past 400 years and we have way too little information on the endemics of the Tongass. Preliminary investigations suggest the Alexander Archipelago has elevated levels of endemism. Very little of this literature is cited or the work acknowledge. This forest is complex and distinctive from most other USDA National Forests. The complexity of "island biology" must set the foundation for wildlife management for the next TLMP.**

2) Similarly, a large body of research has been published in the past 2 decades that focused on how climate change has structured the complex, contemporary Tongass wildlife. One might start by reading the Cook and MacDonald 2013 review, published in the same volume as Marcot 2013 (North Pacific temperate rainforests ecology and conservation. University of Washington, Seattle WA). Given that endemism was the single topic that delayed the 1997 TLMP (by the courts), this omission is surprising. A number of investigators have attempted to raise the issue of endemic conservation in Southeast Alaska. Those studies (appended at the end of this review) are just scratching the surface of the extent of endemism because this is an extremely complex landscape and much of the region (**most islands**) is poorly surveyed or studied. Essentially none of that existing literature is acknowledged in this review. Why?

   Here, it is important to note one example from the 1997 TLMP (conducted in 1996) when the scientific review convened a panel that focused on only a single species of marten in the Tongass (*Martes americana*), yet subsequent molecular genetic work clearly pointed to the validity of two distinctive species on the forest (as was originally proposed more than a century before). One of these, the Pacific marten (*Martes caurina*), is now found only on Kuiu and Admiralty islands in Southeast Alaska and is likely to disappear on the former island soon. Overharvest of the Pacific marten in the 20th century on some islands or subsequent introduction of the wrong species (*M. americana*) to *M caurina* islands or deforestation (or a combination of all) may have led to the demise of endemic *M. caurina* populations, but we have to little information. Still TLMP was managing these two species as the same as late as the early 2000's (and effectively still does)

3) Multiple habitat corridor areas within this complex landscape may be of special importance to the conservation of mammals and should be acknowledged by the next TLMP. These include the habitats likely to experience climate effects along the Alsek, Chilkat, Taku, Stikine, Unuk, Kelsall, Whiting, Bradfield, and Chickamin river systems that potentially link the North Pacific Coast with the remainder of North America and between islands (see define biogeographic units) or within islands (pinch points on topographically complex islands like Kuiu—where logging has impacted corridors for wildlife movement).

4) The introduction of non-native animals, plants, and pathogens to Southeast Alaska should be avoided and monitored through coordination with ADF&G. The introduction and resulting spread of Red Squirrels to various islands in the Alexander Archipelago may prove detrimental to a number of populations of nesting birds. Similarly, the recent introduction of Elk to Etolin I. may be considered too "successful". Introductions elsewhere have had disastrous effects on island biotas. And with endemic Haida ermine (*Mustela haidarum*'s global distribution is just a few islands in this region) and Pacific marten, the management of human pathogens (SARS CoV2) and human pets (canine distemper) are cause for concern (remember more than 1.5 million mink were destroyed in Belgium alone).

Currently, the discussion of threats specific to island endemics in this manuscript only mentions lack of genetic diversity and island geography as barriers to adaptive migration. This discussion is found on

- (Lines 925-933;

"The limited genetic diversity of island populations can restrict their adaptive abilities. Some ermine populations could be at risk, for example, if they lack the genetic ability to evolve shorter periods of white pelage relatively quickly, as predation removes mismatched individuals. This could become a conservation issue for the Haida ermine (M. haidarum), known only from Prince of Wales and Suemez islands in the Tongass NF, and Grand and Moresby islands of Haida Gwaii, British Columbia, to the south. Long recognized as a subspecies of ermine, this genetically distinct weasel has been recently proposed as a full species, endemic to these four islands (Colella et al. 2021). Each of these islands has limited and comparatively incomplete prey faunas, potentially increasing vulnerability of ermine to predation."

[Note that the Haida ermine has national conservation status in Canada (Threatened, COSEWIC 2015). The management plan by the Council of the Haida Nation (1993, 2010, 2019) uses ecosystem-level monitoring to update management practices over time with the goal of **maintaining endemism** and wildlife abundance.]

- Lines 1383-1394).

  "Distribution and range shifts are constrained by functional barriers to plant and animal dispersal. Functional barriers can result from physical barriers, lack of suitable habitat, and refugia without habitat connectivity. The island geography of the Tongass NF limits dispersal of many species that might otherwise benefit from climate change but cannot swim, raft, or fly across saltwater channels (e.g. frogs, salamanders, small mammals, flightless terrestrial and freshwater invertebrates). Boreal toads and rough-skinned newts are found on many islands which suggests they are not as dispersal limited as the frogs and salamanders of the region which are limited largely to the mainland and a few nearshore islands (MacDonald and Cook 2007). Indeed, there is evidence supporting likely boreal toad dispersal across salt water (Taylor 1983, Armstrong and Hermanns 2004). Increases in severe flooding (from rain on snow events, for example) could accelerate colonization of islands by amphibians and small mammals rafting across saltwater on trees uprooted during floods. Saltwater barriers may also "trap" some species and populations on islands that become too warm or otherwise unsuitable, leading to local extinctions."

  Looking just a bit south of the Tongass, we can already see issues emerging on Haida Gwaii related to classic island specific conservation concerns (e.g., introduced invasive species, introduced pathogens, small population size and restricted distributions, habitat loss, etc). These topics (Taylor and Kumar 2016), are either minimally developed in this manuscript or not dealt with at all. The lack of recognition and limited focus on the special challenges of managing natural resources and wildlife across an island archipelago is surprising given what we know about vertebrate declines and extinctions worldwide. External scientific review of the TLMP in 1997 (Shaw et al. 2000, Boyce and Szaro 2005, Smith 2005) prompted the inclusion of monitoring of endemics. Although the TLMP called for "surveys for endemic mammals prior to any project that proposes to substantially alter vegetative cover" since 1997, more than 2 decades later, no protocols or funding have been defined for long-term monitoring of endemics. Island endemics are especially sensitive to anthropogenic disturbance, as evidenced by the overrepresentation of insular endemic taxa among recently extinct (>54% for all vertebrate groups, Fernandez-Palacios 2021) and critically endangered vertebrate species globally (>35%, Tershy et al. 2015). The idiosyncratic nature of extinction and colonization on islands, combined with recent translocations or invasions (Doherty et al. 2016), complicate regional management and highlight the need to identify (i) appropriate units of conservation for endemics (e.g., Distinct Population Segments; DPSs) and (ii) goals for these units, before making decisions that impact endemics (Shafer et al. 2011, Larson et al. 2012, Pauli et al. 2015). As defined by the United States Fish and Wildlife Service (USFWS; Fay and Nammack 1996), a DPS represents a discrete population or group of populations that are significant – ecologically, genetically, morphologically, or otherwise – relative to the entire species and which may be granted protected status under the US Endangered Species Act (16 U.S. Code Chapter 35). DPSs extend to subspecies and lineages or discrete populations with a distinct evolutionary history. Islands are landscapes that likely support DPS of native species.

Other considerations:

- They should include a specific subsection on threats and considerations specific to island species and habitats (check out extensive conservation literature for Hawaii, Puerto Rico, the Galapagos, etc). The federal resources now being invested in Hawaiian bird conservation (related to climate change) due to invasive pathogens and vectors is substantial. Will the Tongass being doing the same soon?
- There is little to no mention of cultural and economic importance of habitat and species, and the subsequent impacts on local communities. Maybe this falls outside the scope of what they were tasked with, but it could enhance the assessment.
- While the manuscript notes that this synthesis could/will be used to inform adaptation planning, there is limited discussion of how that will happen and no substantial guidance for how the science can be translated to action/strategic planning. It might be useful for the planning process to lay out some basic guidance on management action for resource managers related to how they can incorporate all of these different threats into their planning given management priorities (ie. considerations for adaptation planning to mitigate impacts on vulnerable species and habitats)

Again, the lack of development of climate issues surrounding island conservation in this review of the wildlife of the Tongass is curious given the very difficult history of the 1997 TLMP which was much delayed due to the lack of attention related to persistence of island endemics. Because the Tongass is spread across an island archipelago, and climate change is projected to have disproportionate impacts on island endemics worldwide, the United States Forest Service will fail to meet fundamental wildlife mandates if it does not more closely monitoring endemic taxa, as was acknowledged (but not effectively articulated) by the Tongass Land Management Plan in 1997. Geographic isolation and small population sizes increase the strength of genetic drift in island populations, which can lead to relatively rapid evolution of novel diversity and endemism. Conversely, small populations hold less genetic variation, potentially reducing the possibility that populations will be able to adapt to changing conditions.

Today, complex regional topography enforces isolation between distinct island populations (Smith 2016). Ice age refugia, either in Southeast or Haida Gwaii enhance the likelihood of deep, divergence and endemism (like *Mustela haidarum*). Preliminary molecular investigations have uncovered deep phylogenetic breaks along the North Pacific Coast that are shared by diverse organisms and suggestive of the effects of long-term allopatric isolation and divergence that is characteristic of paleoendemics. These species are likely just the "tip of the iceberg" when it comes to endemism across the Alexander Archipelago. Sadly, lack of proactive and meaningful incorporation of the principles of island conservation into management plans in Southeast Alaska by state and federal natural resource managers will likely lead to loss of endemic taxa and potentially difficult and complex litigation under ESA 1973 and NFMA 1976. How do we build resilience into Tongass management headed into changing environmental conditions? For one, we need to maintain evolutionary potential. Lack of information about endemics will lead to expensive mistakes for future generations.

I urge the authors to consider a more island-focused approach to their review and urge USDA to take a more holistic and more comprehensive approach to their responsibility in managing US biological heritage.

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REVIEW

Phylogeography of mammals in Southeast Alaska and implications for management of the Tongass National Forest

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Abstract

Insular evolution on archipelagos generates a significant proportion of global biodiversity, yet islands are among the ecosystems most sensitive to accelerating anthropogenic disturbance, introductions of non-native species, and emerging pathogens, among other conservation challenges. The Alexander and Haida Gwaii archipelagos along North America's North Pacific Coast support a disproportionate number of endemic taxa compared to other high-latitude terrestrial ecosystems. In this region, endemics in Canada are explicitly protected, but in the United States, endemics have been operationally ignored. We reviewed regional research on terrestrial mammals and endemics from 2000–2022 to guide wildlife management. Elevated regional endemism is due to a combination of deep and shallow temporal processes (i.e., long-term refugial isolation vs. recent colonization). With adequate sampling, genomic analyses are well-suited to identifying nuanced patterns of divergence and endemism, thereby facilitating a deeper understanding of regional diversity. We identified 18 mammalian endemics in Southeast Alaska, USA, at varying taxonomic scales, but research effort has significant taxonomic biases and sampling infrastructure remains inadequate. Of the 66 terrestrial and aquatic mammal species in Southeast Alaska, only 55% are represented by ≥10 archived samples over the last 2 decades. Across taxa, major spatial and temporal sampling gaps limit interpretations of wildlife responses to changing environmental conditions. The Tongass National Forest is spread across an island archipelago, and climate change is projected to have disproportionate impacts on island endemics worldwide. In this case, the United States Forest Service is not closely monitoring endemic taxa, as was required by the Tongass Land Management Plan in 1997. Our review underscores a need for increased consideration of how endemism can be incorporated into land and wildlife management across the Alexander Archipelago. Moving forward, we encourage state and federal agencies, Indigenous communities, and international collaborators to continue to partner with natural history biorepositories to ensure strategic wildlife sampling infrastructure is built and made accessible to the broader scientific community as part of the land management process.

KEYWORDS

biorepository, conservation, endemics, insular, islands, Tongass Land Management Plan, United States Forest Service, wildlife monitoring

The largest remaining temperate rainforest in the world is situated along a narrow stretch of coastline and 2 near-shore archipelagos: the Alexander Archipelago in Southeast Alaska, USA, and the Haida Gwaii Archipelago, 80 km to the south, off the western coast of British Columbia, Canada (DellaSala et al. 2011, Orians and Schoen 2013). For its latitude, North America's North Pacific Coast boasts disproportionately high endemism (Cook and MacDonald 2001, Cook et al. 2006). Two hypotheses have been proposed to explain regional endemism: either endemics persisted *in situ* through the Last Glacial Maximum (LGM) 20 thousand years ago (kya; paleoendemics) or they colonized post-glacially and have since diverged (neoendemics; Klein 1965, Cook and MacDonald 2001). Molecular data from a wide range of animal and plant taxa has accumulated mixed support for both hypotheses (Cook and MacDonald 2001, Greiman et al. 2013, Roberts and Hamaan 2015, Sikes and Allen 2016, Gamlen-Greene 2022), with the degree of genetic differentiation between insular and continental taxa used as a measure of the age of divergence. Neoendemics are distinctive from their continental relatives, but minimal divergence suggests that their isolation began following colonization of the region after the retreat of the Cordilleran Ice Sheet (<10 kya; Klein 1965). In contrast, paleoendemics are more deeply diverged from their sister lineages, hypothetically the result of long-term persistence in ice-free glacial refugia in or near the region during the LGM (Cook et al. 2001, Dawson et al. 2007). Together, both deep- and shallow-time evolutionary processes have shaped the complex mosaic of species now present along the North Pacific Coast, with major implications for regional endemism, conservation, and natural resource management.

Although the Alexander Archipelago is a continental or near-shore archipelago, numerous geophysical attributes have converged to produce a distinct and biodiverse fauna. The extreme prominence (~2,500 m) of the Coast Mountain Range to the east isolates the North Pacific Coast from the rest of the North American continent. River corridors, including the Unuk, Stikine, Whiting, Taku, Chilkat, and Alsek rivers in Southeast Alaska, are the primary colonization routes into and out of the region, but their broad coastal deltas form barriers to dispersal along the coast (Dawson et al. 2007). Also, along the coastline, glacier-scoured fjords, up to 900 m deep, create heterogeneous tidal patterns (Weingartner et al. 2009) that may impede inter-island movement and, farther west, the fragmented island landscape fuels the generation and maintenance of regional endemics through the process of vicariance. Geographic isolation and small population sizes increase the strength of genetic drift in island populations, which can lead to relatively rapid evolution of novel diversity (Kirchman 2012, Wiens et al. 2022). Today, islands are separated by a complex network of bays, fjords, and inlets (Smith 2016); during the LGM, however, glaciation complicated local biogeographic patterns by exposing now-submerged areas of continental shelf, temporarily connecting islands, and pushing terrestrial organisms into ice-free areas, or refugia. There was at least one large refugium (Beringian) to the northwest of the major North American ice sheets and another to the south, in the continental United States (Southern; Hultén 1937, Pielou 1992). The area between those refugia was assumed to have been covered by ice, with glacial cycles leading to repeated episodes of extirpation and recolonization by terrestrial species (Pielou 1992). Counter to this clean slate (*tabula rasa*) model, other lines of evidence suggest that some taxa persisted through the LGM in smaller, *in situ* refugia, either in Southeast Alaska (Klein 1965; Cook et al. 2001; Carrara et al. 2003, 2007) or Haida Gwaii (Foster 1963, Calder and Taylor 1968, Mathewes and Clague 2017, Mathewes et al. 2019). Molecular investigations, for example, have uncovered deep phylogenetic breaks along the North Pacific Coast that are shared by disparate organisms from across taxa (e.g., plants, mammals, birds, insects, amphibians) and suggestive of long-term allopatric isolation and divergence, characteristic of paleoendemics (Soltis et al. 1997, Pruett et al. 2013, Roberts and Hamaan 2015, Sawyer et al. 2019, Colella et al. 2021*b*). Although human occupation is not documented in Southeast Alaska until after 14 kya (McLaren et al. 2020), oceanic currents, seasonal sea ice, and exposed coastline may have facilitated temporary colonization and, ultimately, the peopling of the Americas (Royer and Finney 2020, Hebda et al. 2022, Praetorius et al. 2023).

Understanding of the paleogeological history of the North Pacific Coast is mixed and incomplete. Topographic and bathymetric reconstructions of the western edge of the Cordilleran Ice Sheet, for example, have identified numerous potential refugia along the outer islands of Southeast Alaska (Carrara et al. 2003, 2007). Palynology and radiocarbon dates from sediment cores from Baranof, Mitkof, and Pleasant islands suggest that there was suitable terrestrial habitat for forests and, perhaps, associated biotas that persisted in these areas during the LGM. Spruce trees (*Picea* spp.), for example, seem to have persisted in the region and rapidly expanded after the LGM (Hansen and Engstrom 1996; Ager 2007, 2019). In contrast, dating of other sites shows instead that parts of outer islands were covered by ice or snow until approximately 17–15 kya (Lesnek et al. 2018). To date, geologic dating within the North Pacific Coast has focused primarily on exposed surfaces (Lesnek et al. 2018, 2020). Thus, additional exploration of offshore areas, particularly now-submerged sites that may have been above sea level during the LGM, is needed to fully reconstruct local glacial extent, coastlines, and regional geologic dynamics (Mathewes and Clague 2017, Mathewes et al. 2020). Reconstructions of submerged LGM refugia, however, are further complicated by regional volcanism (Praetorius et al. 2016) and complex patterns of isostatic (i.e., rise and fall of land in response to the weight of glaciers) and eustatic (i.e., changes in sea level caused by variation in water volume) flux that occurred as ice sheets expanded and contracted (Baichtal and Carlson 2010, Shugar et al. 2014, Lesnek et al. 2020, Baichtal et al. 2021). While geological research has narrowed the potential locations of ice-free refugia, incomplete and conflicting results make the study of biological communities an important and complementary line of evidence for understanding and interpreting regional history.

The fossil record similarly shows mixed support for the presence of North Pacific Coast refugia. Fossils of ice-associated mammals, including arctic foxes (*Vulpes lagopus*), dated to the LGM, suggest that larger mammals may have been able to disperse among and between islands when sea levels were lower, but fossils of smaller organisms are scant (Heaton and Grady 2003, Cooper et al. 2006). Pre-LGM fossils are documented from Prince of Wales Island (Heaton and Grady 2003, Lesnek et al. 2018) and Haida Gwaii (Mathewes and Clague 2017, Mathewes et al. 2019). Revisiting fossils using carbon-14 analysis (Lesnek et al. 2018) uncovered nearly continuous deposition in Shu'ká Káa cave on Prince of Wales Island starting around 40 kya, with a gap between 17–20 kya (Lesnek et al. 2018). Combined with evidence of substantial species turnover before and after the LGM, their results suggest that the Shu'ká Káa cave site was covered by ice or snow during this period (Heaton and Grady 2003, Lesnek et al. 2018). Until recently, no pre-LGM fossils had been documented on the other outer islands of the Alexander Archipelago (da Silva Coelho et al. 2023), although the presence of karst (landscapes where dissolving limestone bedrock forms an intricate network of caves, springs, and sinkholes) along the western edge suggests there may be other, unexplored caves in the area (Baichtal and Swanston 1996, Heaton 2002).

Although the 2 North Pacific Coast archipelagos—Alexander and Haida Gwaii—have shared biogeographic histories (Demboski et al. 1999, Cook and MacDonald 2001), they are managed by separate international governments. In 2018, the Haida Gwaii Management Council, composed of representatives from the Indigenous Haida Nation and British Columbia, Canada, established land use objectives designed to balance biodiversity protections with socio-economic interests. Their plan uses ecosystem-level monitoring to update management practices over time with the goal of maintaining endemism and wildlife abundance (Council of the Haida Nation 1993, 2010, 2019). With that model in mind, we focused on Southeast Alaska, where wildlife and their habitats are largely regulated by the United States Forest Service (USFS) Tongass National Forest Land and Resource Management Plan (TLMP; USFS 1997), the Alaska Department of Fish and Game (ADFG), and other state and federal laws (e.g., the Endangered Species Act; 16 U.S. Code Chapter 35). The TLMP is revised approximately every 15 years and is currently (2024) undergoing formal revision.

Unlike the Haida Gwaii Management Council's holistic approach, the current TLMP focuses primarily on timber resource management (Orians and Schoen 2013) in response to the history of industrial-scale logging in Southeast Alaska, which removed 31.8% of large-tree (high volume), old-growth stands in the Tongass National Forest (Albert and Schoen 2013). Although an external scientific review of the TLMP in 1997 (Shaw et al. 2000, Boyce and Szaro 2005, Smith 2005) prompted the inclusion of monitoring of endemics, subsequent revisions of the plan (USFS 2008, 2016) continued to focus on old-growth-dependent species and failed to maintain meaningful monitoring of endemics. While old-growth forests are an undeniably valuable natural resource, isolated patches of old-growth forest are insufficient to sustain many sensitive island populations, especially endemics (Smith and Flaherty 2023), and second-growth forests in Southeast Alaska will not provide habitat for most wildlife for many decades (Parker et al. 1996). Recognizing that old-growth dependent species are part of a larger, equally important community of organisms, the 2012 planning rule (USFS 2012:21190) aimed to guide "science-based development, amendment, and revision" of the TLMP, among other management plans, to promote social and economic sustainability, ecosystem services, and the ecological integrity and diversity of natural communities. This rule, and litigation by the Natural Resources Defense Council (Natural Resources Defense Council v. United States Forest Service 2005), prompted the last revision of the TLMP in 2016, but as of mid-2024, there are no formally recognized focal wildlife species.

Further, although the TLMP has called for "surveys for endemic mammals prior to any project that proposes to substantially alter vegetative cover" since 1997 (USFS 1997:4–117), more than 2 decades later, no protocols or funding have been defined for long-term monitoring of endemics. Island endemics are especially sensitive to anthropogenic disturbance, as evidenced by the overrepresentation of insular endemics among recently extinct (>60%) and critically endangered (>35%) vertebrate species globally (Tershy et al. 2015). The idiosyncratic nature of extinction and colonization on islands, combined with recent translocations or invasions (Doherty et al. 2016), complicate regional management and highlight the need to identify appropriate units of conservation for endemics (e.g., distinct population segments [DPSs]) and goals for these units before making decisions that affect endemics (Shafer et al. 2011, Larson et al. 2012, Pauli et al. 2015). As defined by the United States Fish and Wildlife Service (USFWS; Fay and Nammack 1996), a DPS represents a discrete population or group of populations that are significant ecologically, genetically, morphologically, or otherwise relative to the entire species and which may be granted protected status under the United States Endangered Species Act (16 U.S. Code Chapter 35). The DPSs are not limited to species but extend to subspecies and lineages; that is, discrete populations with a distinct evolutionary history.

We summarized published research from 2000–2022 on the evolution and biogeography of Southeast Alaska mammals to update perspectives on endemics that can be integrated into adaptive resource management planning. We also reviewed the availability of voucher specimens to identify sampling gaps within the Tongass National Forest that continue to limit the application of cutting-edge molecular methods and other new technologies.

Literature published before the year 2000 was summarized by Shafer et al. (2010) and earlier work by Soltis et al. (1997), Brunsfeld et al. (2001), and Cook et al. (2006). Because there is still no monitoring plan in place for Southeast Alaska endemics, we predicted that available sampling would be insufficient for population-level analyses of endemism in most species and that research effort would be uneven with respect to taxonomy and geography. Based on the preliminary biogeographic patterns identified for Southeast Alaskan mammals (Cook et al. 2001, Sawyer et al. 2019) and hypothesized refugia along the western edge of the Alexander Archipelago (Carrara 2003, 2007), we further predicted that endemics would be geographically clustered on more isolated, peripheral islands.

STUDY AREA

We define Southeast Alaska as the terrestrial area of the Alaska panhandle, south and east of Yakutat Bay and bordered by Canada. The period of our study is 2000–2022. The region is approximately 90,000 km^2 and fractured into >1,000 named islands that comprise the Alexander Archipelago, plus a narrow strip of coastline (Dawson et al. 2007). The Coast Mountain Range, which bounds Southeast Alaska to the east, is among the highest coastal mountain ranges in the world, rising from sea-level to over 4,000 m (Smith 2016). This coastal temperate rainforest (DellaSala et al. 2011) is characterized by variable rainfall (70–1,158 cm annually), persistent cloud cover, and minimal annual temperature variation (generally, 0–20°C). Late spring and early summer is the driest period, with the rainy season beginning in July and peaking in October, and snowfall occurring in November and peaking in January (Smith 2016). Complex regional topography generates heterogeneous biotic assemblages, with western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Alaska yellow cedar (*Chamaecyparis nootkatensis*), and lodgepole pine (*Pinus contorta*) as the dominant trees (Smith 2016). As a high latitude continental archipelago, the area hosts no reptiles and few amphibians (MacDonald and Cook 2007).

Over 80% of the study region is managed by the USFS as part of the Tongass National Forest (65,000 km^2). Glacier Bay National Park and Preserve (13,287 km^2), located in the northwestern corner of the region, is managed by the National Park Service. Haines State Forest (1,157 km^2), in the northeast, is managed by the Alaska Department of Natural Resources Division of Forestry, and other lands are managed by the United States Bureau of Land Management, municipalities, or Indigenous Peoples. The ADFG regulates harvest of game animals across 5 game management units (GMUs) in Southeast Alaska: GMU1 (coastal mainland and south central islands), GMU2 (Prince of Wales Island complex), GMU3 (central islands), GMU4 (Admiralty, Baranof, and Chichagof [ABC] islands), and GMU5A (Yakutat; ADFG 2022). Five major biogeographic regions have also been empirically defined within Southeast Alaska based on shared organismal communities and evolutionary histories (MacDonald and Cook 1996, Cook et al. 2006, Albert and Schoen 2007, Sawyer et al. 2019). Those regions include the northern inner islands (e.g., Admiralty), the northern outer islands (e.g., Baranof, Chichagof), the southern outer islands (e.g., Prince of Wales Island, Dall), the middle and southern inner islands (e.g., Etolin, Kuiu, Kupreanof, Mitkof, Wrangell, Revillagigedo), and the coastal mainland, including the Cleveland Peninsula (Figure 1).

METHODS

Literature review

To assess regional research effort, we performed a literature review through Web of Science on 17 January 2024 through the University of New Mexico Libraries' web portal. We queried publications released between 1 January 2000 and 31 December 2022 that contained the search terms Alaska and mammal. We restricted results to journal articles or review articles and manually removed publications not relevant to the study area and those pertaining to cetaceans (whales, dolphins, and porpoises). We reviewed the remaining publications in detail and recorded the

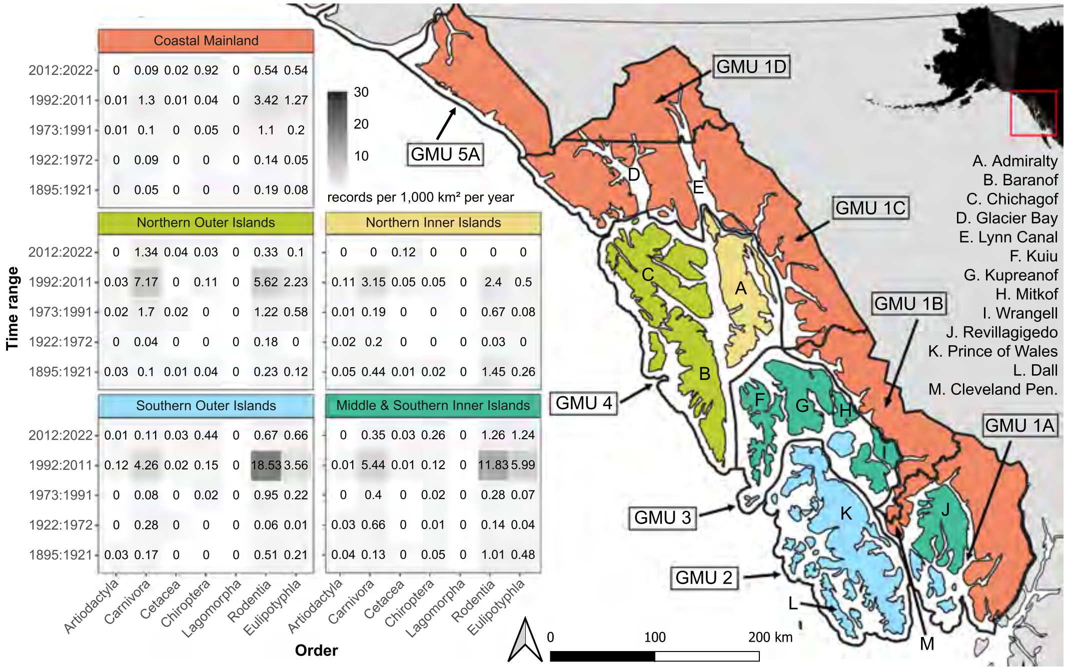

FIGURE 1 Biogeographic regions in Southeast Alaska, USA, as defined in Cook et al. (2006). Heat maps (left) report the number of mammal specimens per 1,000 km^2 in each biogeographic region per year that were sampled and preserved from each mammalian Order. Time periods on the y-axis reflect the history of regional faunal surveys from 1895–2022. Major islands, peninsulas (pen.), geographic features, and game management units (GMUs) are labeled A–M.

authors, publication year, title, digital object identifier (DOI), focal taxon or taxa, island(s) addressed, data type(s) used (e.g., molecular, isotopic, occurrence, telemetry), general results, and a link to the primary literature (Table S1, available in Supporting Information). For molecular investigations, we also recorded the number and type (e.g., mitochondrial, nuclear, multilocus, mitogenome, genomic) of marker(s) used. We also recorded description(s) of endemic taxa at any level of divergence (i.e., lineage, subspecies, species), and where they are known to occur in the region. Because many nominal endemics have not been reevaluated in decades and recent molecular investigations have identified cryptic endemics that still require formal taxonomic review, our revised list of regional endemics provides a critical foundation for management action. To determine whether research effort varied significantly across time, we performed a chi-squared test on the number of publications per year (H_0: equal number of publications each year) and a regression (H_0: no significant relationship between number of publications and year). We used the same framework to test for a taxonomic research bias, but calculated the number of publications per genus because not all studies identified taxa to species.

Assessing specimen availability

To gauge whether existing sample infrastructure is sufficient to establish molecular baselines necessary to assess endemism, we evaluated the availability of physical specimens across geography, taxonomy, and time. We queried the Global Biodiversity Information Facility (GBIF) on 8 February 2023 for preserved specimens collected in Southeast Alaska since the first documented expedition to the region in 1895 (MacDonald and Cook 2007). Preserved specimens are those with ≥1 part (e.g., skin, skeleton, tissue) archived in a publicly accessible biorepository (i.e., natural history museum) that, with increasingly powerful molecular methods, could be sequenced. We curated search results by removing fossil specimens, domestics, duplicates, and records georeferenced outside of the study area. We evaluated records of species not known to occur in the region (MacDonald and Cook 2007) on a case-by-case basis, with consideration of the specific locality, collector, and available molecular resources. We updated GBIF taxonomy to correspond to the American Society of Mammalogists' Mammal Diversity Database (Burgin et al. 2018). We calculated terrestrial area (km^2) of each GMU and biogeographic region (Cook et al. 2006) in ArcMap (calculate geometry tool; Esri, Redlands, CA, USA) from OpenStreetMap (www.openstreetmap.org) shapefiles. For temporal comparisons, we defined time windows that correspond to the history of regional collecting, as opposed to using arbitrarily fixed time units (e.g., decades), which would divide a single survey project across multiple time bins (MacDonald and Cook 2007). Early scientific collection occurred between 1895–1921, led by scientists from the Smithsonian National Museum of Natural History (Washington, DC, USA) and Museum of Vertebrate Zoology (Berkeley, CA, USA). There were few specimens preserved from 1921–1972, after which scientific collecting resumed, led by the University of Alaska Museum of the North, from 1973–1985. The most active collecting period occurred from 1991–2011, with support from a series of federally funded (National Science Foundation, USFWS, and USFS) natural history surveys awarded to Dr. Joseph A. Cook and collaborators at University of Alaska Museum of the North, Idaho State University, and the Museum of Southwestern Biology, University of New Mexico. Three projects specifically, ISLES (Island Surveys to Learn about Endemic Species project, 1991–2011; Conroy et al. 1999; Cook and MacDonald 2001, 2013), the Beringian Co-Evolution Project (1999–2012), and the Collaborative Integrative Investigations of Biomes of the Arctic Project (2013–2016; Cook et al. 2017) supported voucher-based fieldwork in Southeast Alaska. Together, these projects sampled and preserved tens of thousands of mammal specimens and their parasites from across Alaska and Canada for use and reuse in diverse scientific research (McLean et al. 2016). As these projects concluded or shifted focus, collection activity declined from 2012–2022.

We tabulated raw counts of specimens for each mammalian Order for all biogeographic regions across 5 time windows. We divided specimen totals by the size of that biogeographic region (km^2) and number of years in that time window to facilitate comparison (Figure 2). To assess sampling completeness, we compared the number of species in each Order known to occur in Southeast Alaska to the number of species represented by ≥1 or ≥10 voucher specimens (Figure 2). Collection methods and regulating agencies differ for taxa in the Order Artiodactyla; therefore, counts are reported separately for ungulates and cetaceans within that Order.

The GBIF has limited ability to search for specimens with high-quality preserved tissues; therefore, we queried the Arctos database (arctos.database.museum) on 8 February 2023 for specimens from Southeast Alaska with tissue available. Arctos includes data from >40 biocollections and is regularly published to aggregators, including GBIF. Arctos hosts data for the 3 biorepositories that house most Southeast Alaska specimens collected since 1895: University of Alaska Museum of the North (n = 19,004), the Museum of Southwestern Biology (n = 6,752), and the Museum of Vertebrate Zoology (n = 1,336). We applied the same filtering and taxonomic updates as for the GBIF data set. For records missing a collection year, we inferred the year from the verbatim collection date where possible or excluded ambiguous records.

RESULTS

Literature review

Our Web of Science search returned 2,622 journal articles published between 1 January 2000 and 31 December 2022 that included the words Alaska and mammal. Two hundred and ninety-nine of those manuscripts pertained, to some degree, to mammals in Southeast Alaska. Among those, 82 focused on cetaceans. Rather than restrict results to publications with an explicit focus on biogeography, we chose search terms that would recover publications from a variety of subdisciplines. Some relevant publications were not recovered by our search because they did not contain both prescribed search terms (Bidlack and Cook 2002, Harlin-Cognato et al. 2006, Lausen et al. 2019) in fields searched

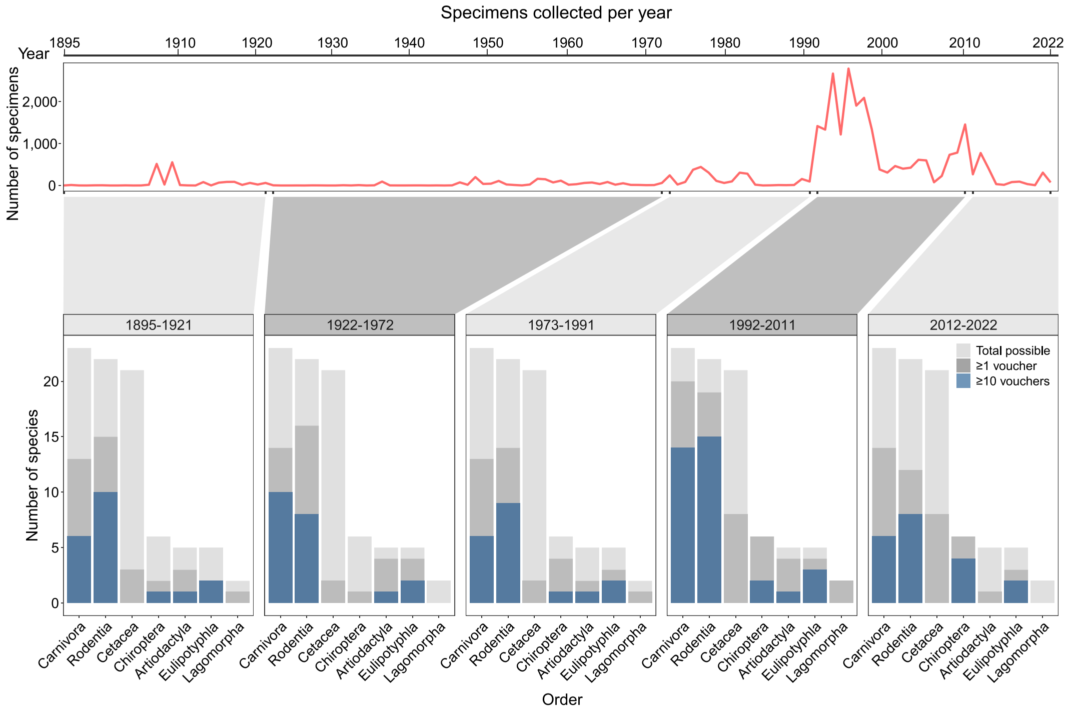

FIGURE 2 Timeline of the history of scientific collecting of mammals in Southeast Alaska, USA (top), from 1895 (left) through the end of 2022 (right). The 5 temporal windows correspond to pulses of historical sampling in the region. We also present stacked bar charts for each temporal window (bottom) to illustrate the total species diversity of Southeast Alaska per mammalian Order (light gray) compared to the subset of species with 1 (dark grey) or 10 (blue) samples available through biorepositories.

by Web of Science. Nevertheless, our literature review provides a general measure of regional research effort and a cross-section of the types of methods used over the last few decades. The remaining 217 relevant papers (Table S1) address 45 of 66 (68%) of mammal species in Southeast Alaska. Research effort, as measured by publications per year, did not differ across years ($\chi^2 = 14.639$, $P = 0.877$), and there was no relationship between year and the number of publications (adjusted $R^2 = -0.030$, df = 21, $P = 0.559$). Research effort was biased toward aquatic mammals ($n = 115$; e.g., sea otters, pinnipeds) compared to terrestrial mammals ($n = 102$), and 17 papers addressed both. If research effort was even across taxonomy, we expected 3.3 publications per species. Yet, some taxa are overrepresented and others understudied. For example, more than a quarter of relevant papers ($n = 68$) focused on Steller's sea lions (*Eumetopias jubatus*). Bears were the most studied terrestrial group, with 18 relevant papers: 12 on brown bears (*Ursus arctos*), 6 on black bears (*Ursus americanus*), and 4 on polar bears (*Ursus maritimus*), with some papers addressing >1 species. Most species, including hoary marmots (*Marmota caligata*), Keen's myotis (*Myotis keenii*), and bushy-tailed woodrats (*Neotoma cinerea*), were represented by a single publication, and 16 species were not represented in the literature search. Seventy-seven relevant papers (35%) used some type of genetic data: 27 of those used ≥1 mitochondrial genes, 4 used complete mitogenomes, 15 used microsatellites, 22 used multilocus data (i.e., ≥1 unlinked loci), and 8 used genomic-scale data (i.e., whole-genome sequencing, metagenomics, or >1k single nucleotide polymorphisms [SNPs]). We record a clear trend of increasing multilocus and, more recently, genomic-scale investigations through time (Figure S1, available in Supporting Information).

To compile an updated list of regional endemics, we started with the list published by Cook et al. (2001). We harmonized taxonomy to the American Society of Mammalogists Mammal Diversity Database and then updated the list based on our literature review and additional targeted literature searches. We classified neoendemic and paleoendemic lineages based on available data (e.g., genomic, morphological) and estimated dates of divergence. We limited endemic taxa to those occurring only in Southeast Alaska or in both Southeast Alaska and Haida Gwaii, and excluded taxa with a range beyond this area, including Haida Gwaii-only endemics. We identified 18 regional endemics (Table S2, available in Supporting Information).

Availability of specimen resources

Our GBIF query returned 29,247 preserved specimens collected in Southeast Alaska. Of these records, 27,293 (93%) are permanently archived at biorepositories that use the Arctos database (Table S3, available in Supporting Information). Of the 23,591 GBIF records collected after 1990, when tissue samples began to be consistently collected, only 14 GBIF specimens are not held at institutions with specimens and data hosted on Arctos. Therefore, our Arctos query for specimens with frozen tissues is a nearly complete representation of available tissue resources. Permanently archived tissues were available for 20,293 mammals collected in Southeast Alaska. Of those, 7,418 were collected between 2000 and 2022 (Table S4, available in Supporting Information). Fifty-one of 66 Southeast Alaska species (77%) had ≥1 tissue sample recorded from the region from 2000–2022. Only 36 species (55%) had ≥10 samples available from that period. Most endemic taxa are defined below the species level (e.g., subspecies, lineage, DPS; Table S2), such that their sample availability is even lower. Four species not included in MacDonald and Cook's (2007) documentation of Southeast Alaska fauna had archived tissues available. Two were newly documented to the region: Yuma myotis (*Myotis yumanensis*; collected between 1990–2014 from Revillagigedo Island and the southern mainland, archived at University of Alaska's Museum of the North) and black rat (*Rattus rattus*; an invasive species collected from a residence in Sitka on Baranof Island, archived at the Museum of Southwestern Biology). The 2 other recent detections are the result of taxonomic revision: American ermine (*Mustela richardsonii*) and Haida ermine (*Mustela haidarum*). The Haida ermine was originally described from Graham Island (Preble 1898) and was later reported on Moresby Island (Hall 1951) and reduced to a subspecies (*M. erminea haidarum*). Later, the subspecies' range was extended to include Prince of Wales and Suemez islands in southern Southeast Alaska (Eger 1990) and re-elevated to species status (Fleming and Cook 2002; Colella et al. 2018, 2021*a*).

The most complete documentation of Southeast Alaska mammals occurred from 1992–2011, although even during that period, 11 of Southeast Alaska's 66 non-human mammal species were not documented by a single specimen, and 31 species (47%) have <10 vouchers available. Since 2012, 28 species have no vouchers available and 46 (70%) have <10. Some biogeographic regions are better sampled than others. For example, the northern inner biogeographic region is severely under-sampled, with zero terrestrial mammals archived since 2012. Samples are also not evenly distributed taxonomically. There are nearly 5 times more vouchers archived for each of Southeast Alaska's 22 rodent species (mean = 696.7) than for each of the region's 6 bat species (mean = 130.2).

Regional endemics

An endemic is a DPS (i.e., distinct lineage) or formally named taxon (i.e., subspecies, species) that shares common ancestry and an entire distribution that is restricted to a particular geographic area. We sorted extant terrestrial and aquatic mammals into 4 groups: paleoendemics, neoendemics, recent colonists that have not yet diverged, and taxa with insufficient data to make a determination (Table S2). Six subspecies (Admiralty Island beaver [*Castor canadensis phaeus*], island mink [*Neogale vison neolestes*], Prince of Wales Island river otter [*Lontra canadensis mira*], glacier marmot [*Marmota caligata vigilis*], Alaska jumping mouse [*Zapus hudsonius alascensis*], and Yakutat root vole [*Alexandromys oeconomus littoralis*]) and one species (Glacier Bay water shrew [*Sorex alaskanus*]) were not reevaluated over the last 2 decades, so there is no new information with which to validate these earlier descriptions. Overall, we identified 15 paleoendemics, 3 neoendemics, 10 recent colonists, and 7 taxa that have not been reevaluated. We suspect that this conservative inventory excludes unexamined or morphologically cryptic endemics because of poor sample availability.

We identified 15 paleoendemic mammals in Southeast Alaska (Table S2), including the only endemic species to the region, Haida ermine. This species has been documented from 7 islands and is represented by 2 subspecies. Suemez Island ermine (*Mustela haidarum seclusa*) is endemic to Suemez Island, while Prince of Wales Island ermine (*M. h. celenda*) is endemic to Prince of Wales Island and 4 islands in the Haida Gwaii Archipelago (Hall 1944). Still, not all island populations have been characterized genetically. Two paleoendemics have mixed support: the Dall Island black bear (*Ursus americanus pugnax*) and Sitka brown bear (*Ursus arctos sitkensis*; da Silva Coelho et al. 2023). These subspecies are listed in both the paleoendemic and neoendemic categories but were only counted towards paleoendemic totals to avoid inflation of the total number of endemics. Paleoendemics are found in every biogeographic region but are most common in the southern outer islands ($n = 11$). Divergence date estimates for paleoendemics cluster around 65–300 kya, although Dall Island black bear is estimated to have diverged 360 kya–1.0 Mya (Byun et al. 1997), and Haida ermine and the Sitka brown bear coastal lineage are estimated to have diverged 0.9 and 1.5 Mya, respectively (Lindqvist et al. 2010, Dawson et al. 2014, Colella et al. 2018). Most paleoendemics were described using a single mitochondrial marker but multilocus datasets and, most recently, whole-genome resequencing data have also been used. As noted in previous studies (Cook et al. 2006, Smith 2016), endemic species richness is inversely related to total species richness in Southeast Alaska, with the greatest number of endemics occurring on the relatively species-poor southern outer islands (Figure 3).

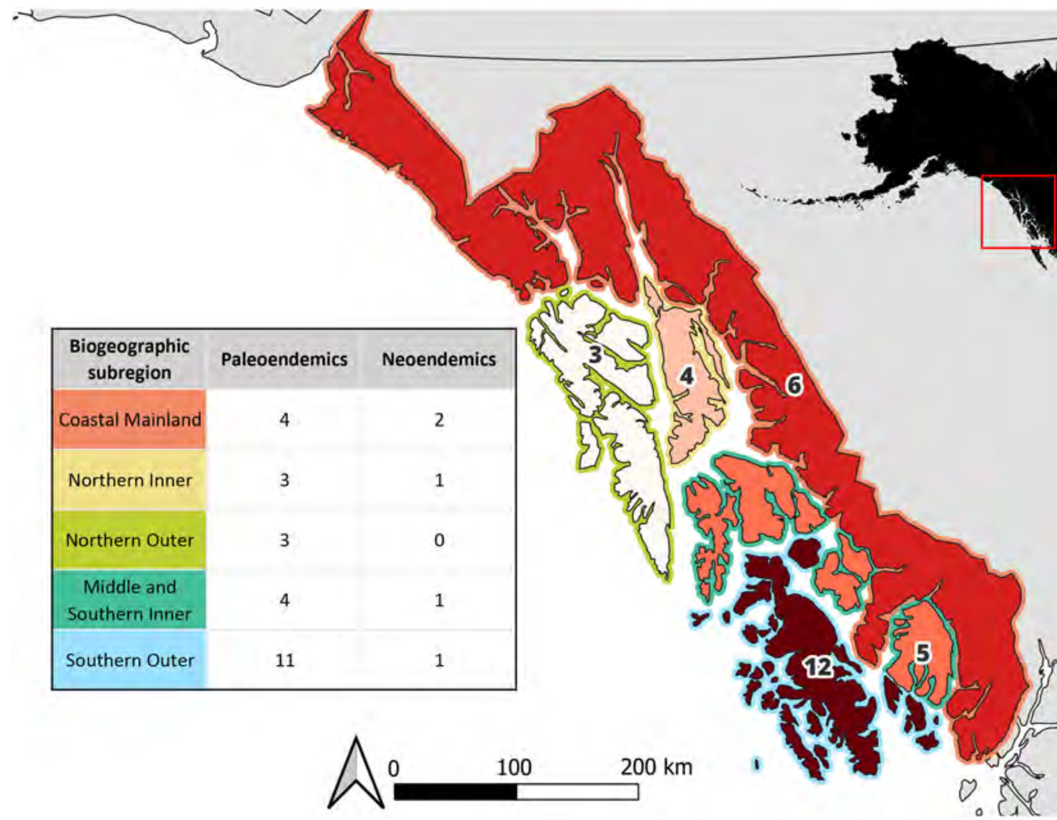

FIGURE 3 Biogeographic regions of Southeast Alaska, USA (outline colors), shaded based on the number of endemic mammal taxa identified from 1895–2022, with darker red indicating higher endemic richness. Each region on the map is labeled with the total number of endemic mammals. The numbers of paleoendemics and neoendemics in each biogeographic region are reported in the inset table.

Given the relatively short time since the LGM, neoendemics at the species level are not expected. Three distinctive lineages are recognized as neoendemics restricted to Southeast Alaska: 2 subspecies (the Alexander Archipelago wolf [*Canis lupus ligoni*]; Weckworth et al. 2015; and the Admiralty Island meadow vole [*Microtus pennsylvanicus admiraltiae*]; Jackson and Cook 2020) and some wolverines (*Gulo gulo*) in Southeast Alaska exhibit unique haplotypes within a coastal lineage, but limited gene flow from adjacent British Columbia may counterbalance insular divergence (Krejsa et al. 2021). Neoendemics are in every biogeographic region except the northern outer, and are most common on the coastal mainland (*n* = 2) region. Divergence dates were not explicitly estimated for neoendemics in the literature, but shallow divergence is interpreted to post-date the LGM. Molecular studies identify neoendemic colonization of Southeast Alaska from both Beringian and Southern refugia. Molecular methods used to describe neoendemics included multilocus datasets, microsatellites, and, in one case, reduced representation sequencing.

Ten purportedly endemic taxa in Southeast Alaska (Table S2) showed no evidence of divergence from their continental relatives. Although interpretation is complicated by historical wildlife translocations, several recently colonizing species occur on the coastal mainland (*n* = 4) and middle and southern inner islands (*n* = 5), while the biogeographic region with the fewest recent colonizations is the southern outer islands (*n* = 1). Routes of colonization were inferred for 7 of these taxa, with 4 expanding from a southern refugium and 3 from Beringia. Species that expanded from Beringia occurred only in the coastal mainland, northern outer, and northern inner biogeographic regions, while species that expanded from southern refugia occurred in every biogeographic region. Over the last 2 decades, single locus mitochondrial DNA, nuclear and mitochondrial multilocus, microsatellites, mitochondrial DNA, and, recently, whole genomes were employed to investigate the extent of endemism and timing of recently colonizing species.

DISCUSSION

The regional mammalian fauna of Southeast Alaska encompasses a mosaic of species that are paleoendemic, neoendemic, or recent arrivals. Molecular methods applied to Southeast Alaska wildlife over the past 3 decades have completely altered our understanding of regional endemicity and the biogeographic processes shaping this biome. Our curated list of regional and Southeast Alaska endemic mammals (Table S2) includes 15 paleoendemics and 3 neoendemics. In some cases, purported endemics were taxonomically invalid (e.g., Revillagigedo Island red-backed vole [*Clethrionomys gapperi solus*] and Wrangell Island red-backed vole [*C. g. wrangeli*]; Runck et al. 2009), whereas in other cases, deeply divergent cryptic taxa with complex histories of gene flow were uncovered (meadow vole [*Microtus pennsylvanicus*], Jackson and Cook 2020; Haida ermine, Colella et al. 2021*a*,*b*; martens [*Martes* spp.], Colella et al. 2018, 2021*b*). Availability of biological specimens has substantially improved our understanding of regional fauna through morphological, isotopic, and molecular investigations; however, substantial knowledge and sampling gaps remain. The intentional, collaborative development of temporally deep and geographically broad sample archives is a necessary investment to understand the distribution and status of endemic taxa and to monitor overall ecosystem health through time. Such a foundation is critical to adaptive management of wildlife, as it can provide insights into community assembly, shifting environmental baselines, invasive species (i.e., predators, competitors, pathogens), genetic variability, and, more generally, an understanding of change during a period of substantial environmental perturbation (Table 1).

Biogeography of Southeast Alaska

Biogeographic patterns shared across ecologically diverse species may reflect similar responses to deep-time environmental and geological processes, which can help guide conservation and management strategies. Because of their limited dispersal abilities, the phylogeographic patterns of non-volant terrestrial mammals are influenced by landscape-level changes in connectivity and isolation in ways that can provide insight into broader biogeographic processes and the long-term trajectory of populations (da Silva and Patton 1998, Avise 2000). The complex regional

TABLE 1 Proposed actions to document and monitor endemics in Southeast Alaska, the research need or knowledge gaps that may impede these actions, threats to insular species and systems addressed by each action, and desired outcomes for wildlife management on the Tongass National Forest.

Action	Research need or knowledge gaps	Threats addressed	Outcomes
Inventory endemic taxa	Population distribution, size, history or levels of connectivity to other populations or islands are unknown for most Southeast Alaska mammals, especially non-game taxa. Consensus is needed for the endemic unit that should be managed (lineages, distinct population segments, evolutionarily significant units, subspecies). For most endemics, level of divergence (and status as paleoendemic or neoendemic) remains untested. Although there are extensive opportunities for collaboration to obtain baseline information from specimens, funding and staffing shortages necessitate careful prioritization of this action to meet United States Forest Service mandates.	Habitat loss and fragmentation, introduced species, pathogens, overexploitation, and climate change	Specimen-based field inventories should be used to empirically estimate, then develop predictive models for occupancy, density, and extinction probability. Inventories and rigorous genomic investigations will help to resolve endemic taxa that have been described within different frameworks.
Identify species of conservation concern	Because sampling effort was low before 1990 and declined sharply post-2010, the trajectory of Southeast Alaska mammals and current population health are unknown.	Habitat loss and fragmentation, overexploitation	With broad population trends and population health and resiliency quantified objectively through genomic methods, management can be adapted to preserve declining endemic populations and their associated communities on a per-island scale.
Monitor endemics	Population trends for endemics are unknown on a forest-wide scale. Abundance estimates for even large game species have proven to be inaccurate (e.g., Alexander Archipelago wolf), and population trends for nongame species are not monitored on a forest-wide scale.	Habitat loss and fragmentation, introduced invasive species and pathogens, increasing accessibility, climate change, and overexploitation	The spread of introduced or invasive species can be detected quickly, and risk factors for invasion can be predicted for non-native species that are cosmopolitan (e.g., rats) or known to occur near the region. Distinctive island lineages and endemic taxa are protected from genetic swamping, outbreeding depression, and pathogenic

TABLE 1 (Continued)

Action	Research need or knowledge gaps	Threats addressed	Outcomes
			organisms to which they are naïve. Short-term population changes can be used to adaptively inform management actions.
Predict and document responses to climate change	Local ecological and behavioral adaptation of taxa within Southeast Alaska remains largely unexamined, and responses to short-term extreme weather and long-term climatic change have been speculated but only modeled or documented for a handful of species.	Climate change	Island populations are especially vulnerable to changing environments as they often cannot move off the island. Naturally low population size and limited connectivity among islands should be accounted for when modelling responses to climate change. Data input for climate response models should be informed by the distribution of lineage(s) found in Southeast Alaska with evidence for local adaptation. Monitoring data should be used to understand short-term responses to extreme weather events.

topography of Southeast Alaska has produced a mosaic of neoendemics and paleoendemics, many of which are now in contact with recent colonists into the region.

Although controversial, paleoendemic distributions are well explained by longer-term persistence in coastal refugia. Those taxa are also most common in the southern outer biogeographic region, which may have been west of the maximum extent of the Cordilleran Ice Sheet or proximal to now submerged refugial areas located even farther west (Carrara et al. 2007, 2009; Matthews and Clague 2017; Ager 2019; Sawyer et al. 2019). Populations in these glacially persistent refugia would have been isolated from continental populations, leading to divergence over time. Except for black bears, the only paleoendemics on the Southeast Alaska coastal mainland identified to date are small mammals. Medium- and large-bodied paleoendemics (e.g., Haida ermine, Sitka brown bear) are restricted to outer islands, and are also often found on Haida Gwaii. Small mammals may have more easily dispersed eastward from coastal refugia to interior islands and eventually reached the mainland, as their larger population sizes and shorter generation times can buffer against stochastic processes (e.g., genetic drift) that may lead to extirpation in larger bodied organisms (Burger et al. 2019). Explicit tests to identify colonization routes into Southeast Alaska are needed to understand the degree of isolation, connectivity, and resiliency of metapopulations to disturbance. Such tests are tractable only with expanded geographic sampling and genomic analyses.

On outer islands, extra vigilance for human-mediated invasions is needed to maintain the integrity of unique communities. Potential source populations for introductions or genetic rescue should be chosen to preserve the deeper history and potential adaptive divergence of island lineages. Further, many of the outer islands identified as centers of endemism experienced heavy logging under prior USFS timber management regimes. The Prince of Wales Island complex, for example, has a high concentration of endemic mammals (Cook et al. 2006, Dawson et al. 2007) but has had over a third of its productive old-growth forest stands harvested, with up to 77.5% of contiguous old-growth forest lost in the northern part of the island (Albert 2019). The substantial infrastructure associated with this history of deforestation (6,760 km of roads) leaves little unaffected habitat for endemics (Smith 2016).

Neoendemics are found across biogeographic regions. River corridors, which provide the primary terrestrial colonization routes through the Coast Mountains into Southeast Alaska, were glaciated until ≥11 kya (Lesnek et al. 2020). As glaciers melted, sea levels rose, resulting in a narrow window of time for leading-edge, continental colonists to reach the Southeast Alaska coastline and disperse westward before the landscape became fragmented into islands. The northern inner islands host 3 neoendemics, highlighting an emerging biogeographic theme in Southeast Alaska: there is a phylogenetic break between the northern outer (i.e., Baranof, Chichagof) and northern inner islands (i.e., Admiralty). Based on the distribution of endemics, we can further infer that colonization routes from the coastal mainland to nearby island groups (northern inner, middle and southern inner biogeographic regions) remained open for longer than routes connecting to the outer islands (Bidlack and Cook 2001, Runck and Cook 2005, Weckworth et al. 2011, Jackson and Cook 2020). While recently colonized mammals are rare on outer islands, there are examples (e.g., American ermine, Sitka deer [*Odocoileus hemionus sitkensis*], root vole [*Alexandromys oeconomus*]) that show limited to no evidence of differentiation from coastal mainland congeners.

Exceptions to general biogeographic trends may reflect differences in distribution, persistence, and colonization ability. Exceptions may also be due to a lack of comprehensive geographic sampling or use of a small set of genetic markers (Brito and Edwards 2009). An updated management framework should reflect current understanding of regional biogeography because the 5 biogeographic regions have distinctive histories of community assembly that will require specialized, mindful management. One size does not fit all regions or islands.

Genomic perspectives in Southeast Alaska

Molecular methods offer an affordable, expedient, and objective means of identifying and monitoring endemics, regardless of taxonomic level. Until recently, Sanger DNA sequencing or microsatellites were the only tractable molecular methods for most wildlife (i.e., non-model systems). These techniques were applied to at least 26 Southeast Alaska mammals between 2000 and 2022. Recently, a few taxa have been assessed using more detailed genomic data (e.g., bears, Liu et al. 2014, Cahill et al. 2015; wolves, Zarn 2019; weasels, Colella et al. 2021*a*,*b*). In cases where genomic data are available, a more nuanced biogeographic history has been revealed. In the case of brown bears, for example, whole genomes show evidence of a deep phylogenetic split between bears on Admiralty Island and bears on Baranof or Chichagof islands (Liu et al. 2014, Lan et al. 2022). Admiralty Island brown bears are more closely related to brown bears from Yukon Territory, Canada, and Montana, USA, than they are to bears on neighboring Chichagof and Baranof islands. That geographic disjunction is explained by a mitochondrial capture event that was not observable when only mitochondrial DNA was examined (Lindqvist et al. 2010, Liu et al. 2014, Lan et al. 2022, de Jong et al. 2023). Notably, 2 bear taxa originally described as paleoendemics in numerous early molecular studies were recently flagged as neoendemics. Mitogenomes from pre- and post-LGM fossil black bears and brown bears from Dall and Coronation islands suggest replacement of Southeast Alaska bears by new arrivals occurred during the LGM but does not rule out post-LGM genetic swamping of a refugial population or population contraction and genetic drift in endemic Southeast Alaska bears (da Silva Coelho et al. 2023). Paleogenomics using ancient DNA, environmental DNA, or sedimentary DNA is an exciting new avenue for interpreting complex phylogeographic patterns in Southeast Alaska mammals (Bohmann et al. 2014). Multiple lines of evidence (e.g., historical, contemporary, biological, geologic) can then more holistically inform interpretation of the complex history of this region; however, those approaches also require well-distributed sampling.

Among the Southeast Alaska taxa examined with multilocus or genomic data, geographic sampling has been limited to only a handful of major islands (Latch et al. 2009). Whole-genome resequencing of Pacific martens, for example, hints at the presence of a coastal endemic, currently recognized at the subspecies level (Pacific coast marten [*Martes caurina nesophila*]), but only 2 genomes have been sequenced from this island clade, each from a different island population (Colella et al. 2021*b*). Similarly, initial descriptions of several endemics include records from only one or a few islands. Thus, it remains unclear whether these are truly single-island endemics or part of a more widely distributed lineage. Dall Island black bear, for example, is a Southeast Alaska subspecies described within the context of a wide-ranging western lineage (Byun et al. 1997, Stone and Cook 2000) but which may be distinctive within that lineage (Puckett et al. 2015). One paleoendemic lineage corresponds to no nominal subspecies of mountain goat (*Oreamnos americanus* coastal lineage; Shafer et al. 2011), which underscores the urgent need to unite or validate taxonomy with phylogeographic studies based on spatially broad sampling (Table 1).

While the majority of infraspecific endemic diversity in the region was originally described in terms of subspecies, recent molecular studies have shifted toward delimiting lineages. Although the definition of an endemic species is relatively straightforward, the geographic and phylogenetic level at which an infraspecific endemic taxon (i.e., subspecies or lineage) becomes a focal conservation unit is not (Crother and Murray 2011). The inclusion of endemic lineages in conservation plans is supported by the legal framework for species conservation in the United States through the concepts of evolutionarily significant units (ESUs) and DPSs (USFWS 1996). Genetic evidence provides critical insight into whether populations in Southeast Alaska are distinctive from conspecifics outside of the region.

Sampling, or lack thereof?

Mammals are among the best-studied organisms in Southeast Alaska. As a result of multiple federally funded surveys in the region, Southeast Alaska is better sampled than much of the world (Hughes et al. 2021), but given the landscape complexity of the region, we still have an incomplete picture of endemism. Of the 66 terrestrial and aquatic species in Southeast Alaska, only 55% are represented by ≥10 archived samples since the year 2000, the minimum required for many population-level analyses (Gautier et al. 2013, Lou et al. 2021), depending on the type and depth of coverage of genomic data (Pruett and Winker 2008, Fumagalli 2013). The quality of these samples aside, 10 tissue samples is likely insufficient for characterizing population-level variation in a highly heterogeneous landscape when diagnosing endemics or other taxonomic units or assessing spatial or temporal variation.

Despite regular permitted harvests, carnivores, game species, and marine mammals represent major sampling gaps in Southeast Alaska, which limits the power of genetic studies and prevents assessments of risk or change through time for these taxa. Wolves, for example, are among the mammals least represented in biorepositories, with just 28 tissue samples archived since 2000. Wolves were identified as a management indicator species in early versions of the TLMP (USFS 2008, 2016) and remain a controversial insular endemic subspecies (Cronin et al. 2015, Weckworth et al. 2015) that exhibits both novel phenotypes and feeding strategies (Roffler et al. 2021). Annual wolf harvests (Bogle 2019, ADFG 2020) offer an easy avenue for regulation-based sampling that, if proactively connected to a wildlife biorepository, would significantly increase permanent sample availability for this species. In Alaska, thousands of draw, subsistence, and general season harvest permits and trapping licenses are issued annually (Alaska National Interest Lands Conservation Act 1980, Dombrowski 2007) and further sampling is regularly conducted by agency biologists and other researchers. Regardless of their original collection purpose, archiving salvage samples in established biobanks is ethical, critical for scientific replication and extension, and useful for monitoring organismal and ecosystem change across space and time (Colella et al. 2020). A renewed investment in coordinating efforts among state and federal agencies and local communities to contribute to specimen-based biorepositories would provide powerful infrastructure for future management initiatives. There is also a curious disconnect between sample availability and research output for aquatic species. Steller's sea lions have 327 samples publicly available (1.6% of all queried tissue samples) in biorepositories, yet this species was the subject of >30% of all publications related to Southeast Alaska mammals published since 2000. Marine and aquatic mammal species are generally more poorly known and more threatened than terrestrial species (Schipper 2008); therefore, emphasizing the need for improved public sample availability, or at least improved archival practices from stranding networks and other sources that contact marine mammals, could significantly benefit management.

Building biorepositories to monitor change in endemic wildlife

Resource management plans guide the implementation of science into decision-making on public lands. Because 80% of the Alexander Archipelago falls within the jurisdiction of the USFS, the current revision of the TLMP is an opportunity to incorporate research on endemic mammals into contemporary land management planning in a way that reflects the archipelagic complexity of this national forest. The USFS Pacific Northwest Research Station played a central role in addressing knowledge gaps identified during the drafting of the 1997 TLMP (Boyce and Szaro 2005), but resulting inventories of endemics were limited (Hanley et al. 2005). Future planning efforts should prioritize island endemics as indicators of overall landscape health and predictors of environmental change and long-term sample archival with biorepositories.

Landscape- and population-level sampling that build holistic biorepositories establish baselines that are critical for monitoring changing conditions. Voucher specimens are essential for extensible and replicable science (Nachman et al. 2023) and capture patterns of biodiversity better than unvouchered observation records (Daru and Rodriguez 2023). Motion-sensitive cameras and other passive monitoring techniques cannot provide the depth or integration of information on organismal and population health and ecology that voucher-based population genomics, viromics, and isotopic chemistry can (Cook et al. 2016). Many species, especially small mammals, are difficult or impossible to identify to species from photographs (Kays et al. 2022). Further, as there are no baseline data on the abundance of most Southeast Alaska taxa, genomic data are uniquely able to provide rigorous estimates of effective population sizes and historical demographic trajectories. Still, specimen availability is uneven across species, time, and geography, and many taxa remain understudied or unsampled. The Alexander Archipelago presents an extremely complex landscape that will require a substantial commitment to sustained sampling to effectively manage.

Recognition of biogeographic regions enables coherent management action

Game management units, which establish state management regulations in the region, are not well aligned with biogeographic regions in Southeast Alaska. This complicates application of a single comprehensive management strategy to the entire region or even per-GMU. A single GMU may encompass vastly different species assemblages with distinctive evolutionary histories. For example, GMU4 lumps the ABC islands together, despite recent evidence that Admiralty is distinct from Baranof and Chichagof islands (Liu et al. 2014, Jackson and Cook 2020, Colella et al. 2021*b*, Lan et al. 2022). Similarly, Revillagigedo and surrounding smaller islands are biogeographically distinct from the rest of the coastal mainland included in GMU1 (Hope et al. 2016, Sawyer and Cook 2016). Biogeographic regions, delimited almost 20 years ago (MacDonald and Cook 1996, Cook et al. 2006), have been empirically validated with a variety of data types, including morphology (Merriam 1897, Eger 1990, Colella et al. 2018), molecules (Lucid and Cook 2004, Dawson et al. 2007, Sawyer et al. 2019, Colella et al. 2021*a*, Lan et al. 2022), and ecology (Smith and Nichols 2004, O'Brien et al. 2018, Roffler et al. 2021).

Correcting the mismatch between GMUs and biogeographic regions would provide a powerful scaffold for regional management priorities across this complex landscape. Evolutionary and biogeographic patterns are, on some level, being incorporated into management efforts through specialized restrictions within GMUs, at least for game species (ADFG 2024). For example, specific management prescriptions to limit marten trapping on Kuiu Island resulted from research conducted on endemic island marten populations (ADFG 2023). Documenting the effects of island endemism, in this case insularity and associated hybridization leading to potential population declines, can result in management decisions that reflect biogeographic realities.

Interagency cooperation is needed for effective wildlife management

The USFS has an obligation to sustainably manage and conserve wildlife on federal lands (National Forest Management Act [16 U.S. Code Chapter 1600]; Zellmer et al. 2017). This is often done through federal programs that fund states' implementation of wildlife conservation. For example, the state of Alaska has received federal funding from the State Wildlife Grant program to proactively work towards the recovery of imperiled species before they meet the criteria for federal listing. Twenty-eight Southeast Alaska mammals are included in ADFG's Species of Greatest Conservation Need, but few are highly ranked, despite endemism being factored into the rankings (ADFG 2015). Alaska's Wildlife Action Plan will be updated in 2025, but little new information has been generated for these poorly studied species since the 2015 revision, a challenge that ADFG has recognized. Most of its high-ranking Species of Greatest Conservation Need are those that have already been intensively studied (e.g., Alexander Archipelago wolf; ADFG 2015). Given USFS management of the majority of land that supports island endemics in Southeast Alaska, meeting the mandates of TLMP and ADFG to prevent further loss of endemic biodiversity will require greater coordination and cooperation between state and federal agencies.

Climate change and anthropogenic activity threaten insular endemics

Human activities, from industrial- to subsistence-scale, have transformed the landscape and wildlife of Southeast Alaska. Wolves on Prince of Wales Island, for example, exhibit levels of inbreeding depression similar to that of wolves in Isle Royale National Park, where inbreeding has led to severe population crashes (Zarn 2019). The purported pressures of hunting, trapping, and habitat loss led to a positive 90-day finding for listing this subspecies under the United States Endangered Species Act (16 U.S. Code Chapter 35; USFWS 2020), but, after 2 deferrals, a not warranted 12-month finding was issued in August 2023, in spite of severe inbreeding and the fact that gene flow between Southeast Alaska wolves and wolves in British Columbia has yet to be examined (USFWS 2023). Identification and proactive monitoring of other endemics may help avoid the costly and risky endeavor of recovering already-endangered populations. Conversely, some mammals appear to be thriving, including introduced species (e.g., elk [*Cervus canadensis*]) and natural expansions (e.g., moose [*Alces alces*]). The effects of these new colonizers have also been inconsistently monitored (but see Harper 2014).

Numerous translocations and invasions have reshuffled species among islands, with some better documented than others (Paul 2009), and these manipulations now serve as natural experiments. American martens, for example, were introduced from multiple mainland sites onto Prince of Wales and Baranof islands, among others (MacDonald and Cook 2007, Pauli et al. 2015). Such manipulations can lead to unintentional introductions of parasites or pathogens with potentially devastating consequences for naïve island species and ecosystems (Table 1; Wikelski et al. 2004, Durden et al. 2016). Notably, the only mammalian species endemic to the region, Haida ermine, is not listed for protection at the state or federal level in the United States (Colella et al. 2019). Previously considered a subspecies of the Beringian ermine (*Mustela erminea*), Haida ermine have been protected by trapping restrictions in British Columbia since 1985 and are listed as Threatened under Canada's Species at Risk Act (Edie 2001). The 2 subspecies of Haida ermine in Southeast Alaska occupy ranges of 6,670 km^2 and 152 km^2 on Prince of Wales and Suemez islands, respectively. Considering these extremely limited ranges, the susceptibility of insular mustelids to pathogens of humans or their pets (i.e., distemper, SARS-CoV-2) is cause for concern and should be monitored.

Management recommendations

We propose 4 recommendations for the TLMP revision. The first is to establish and implement a plan for systematic identification, characterization, and monitoring of endemics based on holistic biorepositories. This is the first step toward designating focal taxa and measuring change through time, including gauging the results of management initiatives. A working list of endemic taxa (extending beyond mammals) would provide the initial framework for a holistic specimen-based monitoring program. Many taxa remain data deficient or unexamined, and limited sampling hinders understanding of regional biogeography and prevents the application of data-driven predictive models for guiding regional management. Improved salvage networks, along with holistic, spatially representative, and temporally regular sampling, will provide essential information on the status of endemics and overall community responses to management actions and global change. Given the expense and logistic difficulties of field work in remote Alaska, we propose to expand existing collaborative specimen networks between agencies and community members that have, over the years, resulted in a substantial series of high-latitude mammal samples (Cook et al. 2017). The challenges of maintaining long-term archives and associated databases are being met by biorepositories (Hedrick et al. 2020, Miller et al. 2020).

Second, we recommend leveraging new technologies to better characterize and monitor insular communities. Genetic studies beginning 30 years ago have provided key insights into endemicity and complexity in Southeast Alaska, but our understanding remains superficial. New high-throughput sequencing methods (e.g., genomic, proteomic, transcriptomic) provide an objective means of monitoring biological units relevant to conservation and management (Hogg et al. 2022). Such protocols could be formally considered through the land management planning process and included in plan requirements. The revelations provided thus far from genomic data hint at our incomplete understanding of endemism in the region and underscore the need to identify and monitor endemics using increasingly affordable molecular techniques. Most endemics from Southeast Alaska were originally identified morphologically at the subspecific level. Given the variable definitions of subspecies across taxonomic groups (Zink and Klicka 2022), genomics will be key to providing phylogenetic and temporal context for divergence in these taxa, a critical component of conservation status (Faith 2002, 2008; Moritz 2002) High-quality tissues collected and preserved long-term, with genomic applications in mind, can also be analyzed with other emerging technologies to tackle a range of questions relevant to management, including ecological and physiological analyses of stable isotopes (O'Brien et al. 2018, Manlick et al. 2024) and contaminants (Witt et al. 2024). Integrating sustainable collection, archival, and digitization of specimens with biorepositories will give researchers the raw material needed to deploy these new technologies to inform management of organismal responses to local and global changes, obtain critical historical context for these changes, and prioritize conservation actions.

Third, we need to prioritize climate change in an island-based management plan. Island archipelagos provide special challenges for managers under a regime of accelerating climate change. Many island species cannot move or migrate as environments change in response to climate disruption. Potential impacts from indirect threats, such as invasive species, increase on islands (Table 1; Whittaker et al. 2017, Macinnis-Ng et al. 2021). For example, warmer winters and a pattern of more rain on snow events are causing declines in Alaska yellow cedar, one of the few tree species found in both Haida Gwaii and the Alexander Archipelago (Mercer et al. 2022). Scientific reviews and assessments, prior to initiating formal forest planning, should include robust modeling of climate change impacts on isolated island populations and identification of potential vulnerabilities of island endemics (Leclerc et al. 2020). An effective monitoring program will also include studies of ecological requirements for each endemic taxon to ensure that landscape-level requirements are met within the context of projected climate and anthropogenic changes to the region. Given the high proportion of taxa and islands that have never been examined and the interdependence of species in insular communities (Simberloff 2019, Smith and Flaherty 2023), faunal and floristic surveys and rigorous monitoring protocols are needed before new extractive activities. Recognizing its importance in global natural climate solutions (Leighty et al. 2006, DellaSala et al. 2022), management of the Tongass National Forest should prioritize both climate change mitigation and biodiversity conservation.

Last, we emphasize the need for both greater international cooperation (U.S.-Canada) and formalized Tribal co-management of North Pacific Coast archipelagos to achieve conservation goals at a meaningful scale and scope, as our literature review confirms that many North Pacific Coast endemics are shared between the southern Alexander and Haida Gwaii archipelagos (Cook and MacDonald 2001). There is already a framework for Indigenous co-management of Haida Gwaii wildlife that could be emulated on USFS-managed land. Small steps have already been made in this direction: a handful of culturally significant sites in the Tongass National Forest are being co-managed in various ways by 3 Tribal organizations (The Hoonah Indian Association, The Organized Village of Kake, and The Organized Village of Kasaan), in accordance with Joint Secretarial Order 3403 (United States Departement of Agriculture and Department of the Interior 2021). Authorities exist to both create and financially support co-management agreements to steward biological diversity across the Tongass National Forest (Mills and Nie 2022). Especially given the cultural and economic interests of self-governing Alaska Native Tribes in both private lands adjacent to the Tongass National Forest and public lands managed by the USFS, a shared or co-produced management framework should be expanded to better incorporate Traditional (Timeless) Ecological Knowledge into wildlife management by including Tribal governments in landscape-level planning efforts.

MANAGEMENT IMPLICATIONS

Though changes can be made to monitoring programs outside of formal planning processes, the Tongass National Forest is now undergoing new management planning that should highlight the importance of island endemism and biodiversity conservation in the face of climate and ecosystem change. Despite past collecting efforts across the complex landscape of Southeast Alaska, we still find a concerning lack of specimen-based resources from which the current status of and future outlook for endemic mammals can be evaluated. We outlined a list of priority endemics for which distribution and ecological relationships can be defined and monitoring programs established to meet forest planning legal requirements. To this end, we recommend that the USFS and other cooperating management agencies, Tribal governments, and diverse stakeholders in the region prioritize biodiversity infrastructure through partnerships that will obtain, preserve, and openly share natural history specimens. The knowledge generated from these actions will equip agencies to work towards sustaining viable wildlife populations in a complex, incomparable, and rapidly changing region.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

This study did not involve sampling or handling of wild mammals. Specimens examined were collected according to the American Society of Mammalogists' guidelines for handling of wild mammals (Sikes and the Animal Care and Use Committee of the American Society of Mammalogists 2016) and Institutional Animal Care and Use Committees, following updated American Veterinary Medical Association Guidelines, with appropriate state and federal permits.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supporting information.

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SUPPORTING INFORMATION

Additional supporting material may be found in the online version of this article at the publisher's website.

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Appendix 4 - Review of the Draft Carbon Stock Assessment for the Tongass National Forest Plan Revision

- This draft carbon stock assessment does a great job of reviewing the high-level literature to date to recap much of what we already know: the TNF is a dense carbon sink and that will remain the case for the foreseeable future. In the next phase of the assessment, it will be very important to drill down to smaller spatial scales to understand what opportunities clearly exist to actively manage carbon more thoughtfully. For example, it would be helpful to see a standard set of summary statistics and analyses developed at the biogeographic province scale[1, 2] (see Albert and Schoen 2013[3]). When any analysis of this nature is conducted over the entirety of the TNF, important regional variation is completely lost.

- I appreciated the brief discussion on the value and trade-offs of fast growing young-growth stands versus old-growth's forests accumulated carbon stores. This discussion needs to be vastly expanded with clear illustrations, conceptual diagrams, and basic scenarios for the public to better understand the trade-offs. What is the carbon trade-off between cutting a slower growing old-growth tree with 500-years of carbon accumulation (a certain percentage of which ends up in a durable wood product) and replacing it with a dense fast growing young-growth forest – how long does it take for those carbon balance trajectories to cross? This is an important discussion even if only small scale old-growth sales are available.

- I appreciated the reliance on FIA data as the gold-standard for forest carbon accounting, however, almost a million hectares of the TNF has LiDAR readily available[4, 5] with statistically valid forest metrics such as aboveground biomass[6], and the entire TNF will have LiDAR coverage before the revision is complete. This information needs to be leveraged where it exists to both help quantify and illustrate opportunities to manage forest carbon. For example, it is clear from the spatial data that young-growth stands – while fast growing – are far less carbon dense than neighboring old-growth remnants in many areas. What is the opportunity for additional carbon storage on the landscape if those young-growth stands were put on a longer rotation or never cut again? At what percent of maximum carbon storage capacity are these forests now? These types of analyses have been conducted in Washington and Oregon and have been helpful for setting state-level carbon targets[7, 8].
- One of the most significant ways forest management on the TNF currently effects the carbon balance is through forest thinning treatments to improve commerical timber and

wildlife habitat values. I was surprised to see no mention of it in this document. Every year thousands of acres are thinned for a short-term carbon loss, but this is a critical management tool for improving valued Sitka black-tailed deer habiat – a important subsistence hunting species. Again, it will be important to outline the best available science on this carbon impact over time and outline the trade-offs to help the public understand what the TNF is prioritizing and why. This is another example of how the scale of analysis is so important for evaluating carbon management options. While the TNF is millions of acres, the scale of annual active management activities that effects the carbon balance is on the scale of thousands of acres. The public needs to understand how much carbon is actively managed on an annual basis, and the scale of opportuntity to effectively evaluate trade-offs for climate mitigation, such as investing in hydroelectic power or biomass energy[9] to replace diesel generators for meeting regional and national climate mitigation goals.

- The Forest Planning Software (FPS) that will be used by the TNF for evaluating young-growth timber harvest scenarios tracks the CO2e in the trees under different management regimes. It will be important to display and discuss those results alongside the timber-yeild tables for the public to see (a) the current carbon stores of the young-growth timber base, (b) what are their potential maxium carbon stores left uncut or put on a longer harvest rotation, and (c) the effect on the carbon balance under different annual yeild scenarios.
- It is made clear that soils hold the highest percentage of carbon on the TNF but it is not clear if there is any active or planned management activity that has a potential impact on these carbon stores such as road building. It would helpful to better understand what activities might effect soil carbon on a meaningful level as compared to active forest management. Furthermore, the type of climate vulnerablity assessment that Zhu and McGuire completed in 2016 for the whole state of Alaska at a 1km resolution, needs to be updated at a finer spatial scale (e.g., 30 meters[10]) specifically for southeast Alaska. As the boreal forests of the nothern hemisphere tip from being a carbon sink to a carbon source and the resilience of the coastal forests become all the more important, there needs to be a better handle on those ecological thresholds when, for example, soil carbon stores in peatland muskegs are not able to maintain low decomposition rates. This needs to be added to the growing list of global tipping points we don't want to surpass.

Commented [1]: we would expect to see this kind of analysis in the DEIS, probably not yet in the Assessment or N4C.

Commented [2]: I'll note that the soil resource report talks about the harvest of rootwads for aquatic restoration and how that might affect soil resources and C storage: the USFS Is monitoring that activity and expect to report on it.

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Elements of the Tongass Old-Growth Conservation Strategy

Compiled and annotated by
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August 2023

Contents

Introduction

In 1997, the U.S. Forest Service adopted a revised Land and Resources Management Plan ("Forest Plan" or "Plan") for the Tongass National Forest ("Tongass") in Southeast Alaska that included a comprehensive strategy intended to provide for long-term viability of old-growth associated wildlife, well-distributed across Southeast Alaska. This strategy, referred to as the Tongass Old-Growth Conservation Strategy ("Conservation Strategy" or "Strategy"), was retained with minor modifications through 2008 and 2016 amendments of the Forest Plan.

The Strategy includes a network of habitat reserves linked by corridors of old-growth forest and a collection of Standards and Guidelines that provide additional protection for vulnerable wildlife species. Elements of the Strategy are dispersed thoughout the Forest Plan. This report presents all elements of the Conservation Strategy as it exists in the current Forest Plan (USFS 2016 Plan). Notes are included to describe the origin and intent of each element, its location in the Forest Plan, and complete text of the element.

This annotated compilation of the various elements of the Conservation Strategy, isolated from the remainder of the Forest Plan, is intended to clarify which lands and Forest Plan components are formally part of the Conservation Strategy. The intent is to help inform development, analysis, and comparison of Forest Plan alternatives, and to facilitate communication consistency with employees, partners, and the public during the upcoming Forest Plan revision.

The compilation begins with a brief summary of the Strategy's origin, followed by documentation of the reserve system, connecting corridors, and species-specific Standards and Guidelines. Conservation Strategy elements or supporting information quoted directly from Forest Plans, Records of Decision (RODs), or environmental analyses (FEISs) are indented and reproduced in Times New Roman font, to distinguish them from background discussion and annotations, which are presented in Calibri font.

Origin of the Conservation Strategy

The Conservation Strategy was initially developed in the 1990s by a team of wildlife biologists representing three agencies (U.S. Forest Service [USFS], Alaska Department of Fish and Game [ADF&G], and U.S. Fish and Wildlife Service [USFWS]). This interagency team, known as the "Interagency Viable Population Committee" or "VPOP", screened 356 vertebrate species that occur in Southeast Alaska and identified eight species associated with old-growth forest habitats for which there were viability and/or distribution concerns. These species, which served as design species for the strategy, included:

- Alexander Archipelago wolf (*Canis lupus ligoni*)
- brown bear *(Ursus arctos*)
- American marten *(Martes americana*)
- river otter (*Lutra canadensis mira*)
- mountain goat *(Oreamnos americanus)*
- northern flying squirrel (*Glaucomys sabrinus*)
- northern goshawk (*Accipiter gentilis laingi*),
- great blue heron *(Ardea herodias fannini*),

The VPOP committee's proposed strategy (Suring et al. 1993, pp. 25-36) included a network of Large, Medium, and Small habitat reserves connected by forested corridors, and species-specific management guidelines to provide additional protection in the managed "matrix" lands outside the reserves for species with needs that would not be fully met by the reserve system alone (Suring et al. 1993). The reserve system was developed as a coarse filter element to meet the needs of species requiring forested tracts of various sizes and was intended to provide umbrella habitat protection for a broad diversity of species beyond the eight old-growth associated species that were used to guide design of the system. Species-specific standards were added as fine-filter elements to provide additional protection deemed necessary to maintain viability and distribution of six of the eight original design species (i.e., all except marten and flying squirrel).

When designing the reserve system, the committee relied first on areas already protected from logging and other development through congressional action (e.g., Wilderness, National Monuments, etc.), lands administratively classified as not suitable for timber harvest, and lands with operability or access constraints that made them difficult to log. Dedicated "Habitat Conservation Areas" (HCAs) were delineated outside the non-development Land Use Designations ("LUDs") to provide the desired size, spacing, and composition (e.g., amount of productive old-growth forest, salmon spawning streams, etc.). Connectivity between adjacent reserves was provided through protected corridors of old-growth habitat. Marine and estuary beach fringe forest and freshwater riparian buffers were identified as the primary corridors, with additional corridors to be designated as necessary during project-level environmental analyses.

Following a scientific peer review (Kiester and Eckhardt 1994) and NEPA analysis of several variations of the draft Strategy (USFS 1997 FEIS), a revised version of the Strategy was adopted as an integral part of the 1997 Forest Plan (USFS 1997 ROD, pp. 6-7). Elements of the Strategy were dispersed throughout the Forest Plan and included a reserve system of non-development LUDs and mapped Old Growth Reserves ("OGRs" or "Reserves"), forested corridors connecting adjacent Large and Medium OGRs, Standards and Guidelines for various species and species groups, and relevant Appendices providing background and guidance (USFS 1997 Plan).

Reserve System

Origin and Intent

The original reserve system was developed by the VPOP committee to “Maintain sufficient habitat to ensure that species which require large tracts of old-growth forest have a high likelihood of continued existence throughout their current range in southeast Alaska” (Suring et al. 1993, p. 25). The proposed strategy included specific criteria for size, spacing, and composition of Large, Medium, and Small reserves (Suring et al. 1993, pp. 26-29 and p. 57).

Large reserves were designed to provide enough habitat to support populations of sufficient size to be resistant to most stochastic events and provide source populations to recolonize adjacent Large and Medium reserves that may become vacant. Large tracts of habitat dominated by old-growth forest were intended to ensure that populations of marten, goshawks, and brown bears would be secure, and produce enough marten and goshawks to recolonize vacant Medium reserves within these species' dispersal ranges. The Large reserves were also intended to provide habitat adequate to reduce the risk of local extinction of goshawks to a level lower than in more fragmented habitats, and to allow for production of young goshawks that would disperse to other suitable habitats. Because of minimal road access within the tracts, Large reserves were also intended to provide important refugia for wolves and brown bears. They were sized to support at least 5 female brown bears, 25 female marten during winters of poor prey, and 8 pairs of goshawks (Suring et al. 1993, pp. 26-27).

Medium reserves were intended to provide habitat for small, local populations that may be prone to frequent, local extinctions, but located close enough to the Large reserves or to other Medium reserves for recolonization to occur. They were sized to support at least 5 female marten during winters of poor prey, and 2 pairs of goshawks (Suring et al. 1993, p. 28).

Small reserves were intended to provide temporary functional habitat for animals dispersing between Large and Medium reserves and to ensure that species of concern (including the 8 design species listed above) would have a relatively high likelihood of occurring in each 10,000+ acre watershed. Small reserves were designed to contribute to the landscape matrix between Large and Medium reserves, help reduce risk of mortality to dispersers, and enhance population stability. They were sized to support at least at least 1 female marten during winters of poor prey and 20 to 40 flying squirrels within each major watershed (~10,000 acres) (Suring et al. 1993, pp. 28-29).

To the extent possible, the VPOP Committee sited reserves in congressionally designated conservation lands such as Wilderness Areas and National Monuments, other administratively-designated non-development lands, and forest lands considered unsuitable or otherwise difficult to harvest, to minimize the impact of the reserve system on lands available for timber harvest (Suring et al. 1993, p. 23).

1997 Forest Plan OGR Criteria

A modified version of Suring et al.'s (1993) reserve system was adopted as part of the 1997 Forest Plan. The ROD that formally adopted the 1997 Forest Plan described three distinct elements of the reserve system:

> The Forest Plan's reserve system is composed of three elements:
> 1. All non-development LUD's, including Wilderness, Legislated LUD II, Wild River, Remote and Semi-remote Recreation, Research Natural Area, Municipal Watershed, and other LUD's that essentially maintain the integrity of the old-growth ecosystem;
> 2. 38 large (40,000-acre minimum), 112 medium (10,000-acre minimum), and a network of 237 small (approximately 1,600 acres) mapped Habitat Conservation Areas (HCA's), allocated in part to the Old-Growth LUD and in part overlapping with other LUD's; and
> 3. Full protection of all islands smaller than 1,000 acres.
>
> (USFS 1997 ROD, p. 7)

Size, spacing, and composition criteria for Large, Medium, and Small reserves were detailed in Appendix K of the Forest Plan (USFS 1997 Plan, Appendix K). These design criteria were not repeated in subsequent (2008 and 2016) Forest Plan amendments, but both of the amendments referred to the criteria in their Forest-wide Goals and Objectives sections, and in some of the Forest-wide Standards and Guidelines. The 1997 Appendix K criteria are therefore included here as foundational to the reserve system:

Appendix K
Old-growth Habitat Reserve Criteria

Introduction:
These criteria serve as guidelines for further evaluating the design of reserves at the project level as described in the Old-growth Habitat Land Use Designation Standards and Guidelines (Wildlife section). Consider first, in any modification of mapped reserves, "non-development" Land Use Designations that maintain the integrity of the old-growth forest ecosystem and contribute to a Forest-wide system of reserves (e.g., Wilderness, Monument, LUD II, Remote and Semi-remote Recreation, Wild River, Municipal Watersheds, etc.). Where "non-development" Land Use Designations do not fulfill size, spacing, and composition criteria of the Forest-wide system of old-growth habitat reserves, add or modify old-growth reserves to meet criteria.

Rules Applicable to all Reserves:

A. Spacing should generally consider the four cardinal directions.

B. Reserves should be more circular rather than linear in shape to maximize the amount of interior (secure from the effects of forest edge) forest habitat.

C. Minimize to the extent feasible, the amount of early seral habitat and roads within mapped reserves.

D. Consider site-specific factors in placing reserves to help meet multiple biodiversity or wildlife habitat objectives. Factors include, but are not limited to:

1. Important deer winter range to maintain important deer habitat capability to meet public demand for use of the deer resource (see Wildlife Forest-wide Standards and Guidelines.)
2. Known or suspected goshawk nesting habitat (see TES Forest-wide Standard and Guidelines.)
3. Known or suspected marbled murrelet nesting habitat (see TES Forest-wide Standard and Guidelines.)
4. The largest remaining blocks of contiguous old growth within a watershed. 5. Rare features such as underrepresented forest plant associations or stands with some of the Forest's highest volume timber stands.

Basic Criteria for Allocating Reserves:

A. **Large Reserves:** a contiguous landscape of approximately 40,000 acres, of which at least 20,000 acres must be productive old growth forest. At least 10,000 acres of the productive old growth forest (over 8,000 board feet per acre) component should be in the high volume class strata (greater than 25,000 board feet per acre). Large reserves shall not be greater than 20 miles apart, edge to edge, across the entire forest. Landscapes within the range of brown bears should include at least 1 Class I anadromous fish stream.

B. **Medium Reserves:** a contiguous landscape of approximately 10,000 acres of which at least 5,000 acres must be productive old-growth forest. At least 2,500 acres of the productive old growth forest component should be in the high volume class strata. Medium reserves shall not be greater than 8 miles from the nearest Large or Medium reserve across the entire forest.

C. **Small Reserves:** a contiguous landscape of at least 16% of the area of each Value Comparison Unit (VCU), and 50% of that area shall be productive old-growth forest.

Specific Design Criteria for Small Reserves:

Small reserves are required in all VCU's except as noted below. When needed, small reserves shall be 16% of the area of a VCU and at least 50% of that size shall be productive old growth forest. The preferred biological objective is for each reserve to contain at least 800 acres of contiguous productive old-growth forest, but may contain a minimum of 400 acres of productive old-growth forest.

A. Additional criteria for assessing the need for and designing of small reserves:
   1. VCU's that have been separated (as denoted by decimal extensions, e.g., 597.1 and 597.2)may be combined for computation purposes.
   2. In very large VCU's that that contain relatively little old growth and the computational rule requires an amount of old growth that exceeds 50% of the existing old growth in the VCU, map a reserve of at least 800 acres of productive old growth.
   3. Small reserves are not required:
      a) In VCU's that already contain sufficient acres (16%/50% calculation) of productive old growth forest in a non-development Land Use Designation (LUD).
      b) In VCU's with less than 800 acres of productive old-growth forest.

B. Mapping of old growth computational allocation:
   1. In VCU's that are partially allocated to a non-development LUD, compare the computed acreage required to the acres of productive old growth in the non-development LUD. If productive old growth acres within the non-development LUD exceed the computed acres for the small reserve, no further allocation is necessary in that VCU. If the non-development LUD acres are less than the area necessary for a small reserve, first use the productive old growth acres in the existing non-development LUD to establish a small reserve and then add additional acres of productive old growth to achieve the required small reserve size and composition.
   2. In very large VCU's, the allocated old growth may be mapped in separate reserves as long as each reserve has a minimum of 800 acres of productive old growth. However, larger contiguous reserves are preferred to fragmented smaller reserves.
   3. In VCU's that are separated by saltwater channels, reserves may be separated but attempt to retain 800 acres of productive old growth in each.
   4. Where VCU boundaries do not match watershed or ecological boundaries, up to 30% of the allocated old growth acres in a VCU may be mapped in an adjacent VCU if the resulting reserve achieves old growth reserve objectives. The resulting small reserve in both VCU's must be contiguous.
   5. In VCU's with a computational allocation of less than 800 acres of productive old growth forest, attempt to design the reserve contiguous with old growth acres in a non-development LUD in an adjacent VCU to establish a larger contiguous reserve. Do not map isolated reserves with less than 400 acres of productive old growth.
   6. Attempt to avoid existing roads, clearcut units, and log transfer facilities within small reserves.
   7. Attempt to identify and map contiguous blocks of productive old growth forest. Old growth forest that constitutes scattered fragments of unsuitable timberland does not contribute to meeting small reserve design. Including riparian, beach and estuary habitats as contributing elements to contiguous old growth reserve design is acceptable.

C. In designing small reserves, include consideration of landscape linkages between larger reserves.

(USFS 1997 Plan, Appendix K)

2016 Forest-wide Goals and Objectives

The Forest-wide reserve system was retained, along with other elements of the Tongass Old-growth Conservation Strategy, through both the 2008 and 2016 amendments of the Forest Plan. The reserve system was specifically included among objectives listed in the 2016 Forest Plan to accomplish Forest-wide goals (Chapter 2) for Biodiversity:

> Goal: Maintain ecosystems capable of supporting the full range of native and desired nonnative species and ecological processes. Maintain a mix of representative habitats at different spatial and temporal scales.
>
> Objectives: Maintain a Forest-wide system of old-growth and other Forest habitats (includes reserves, nondevelopment LUDs, and beach, estuary, and riparian corridors) to sustain old-growth associated species and resources.
>
> a) Ensure that the reserve system meets the minimum size, spacing, and composition criteria described in Appendix K.
>
> (USFS 2016 Plan, p. 2-3)

Note that Appendix K of neither the 2008 or 2016 Forest Plan amendments included size, spacing, or composition criteria for Large or Medium OGRs, as it did in the 1997 Plan. Element a) of the Objective quoted above must, therefore refer to Appendix K of the 1997 Forest Plan, for projects affecting Large or Medium reserves.

Also note that "nondevelopment LUDs" are listed along with "reserves" and "corridors" as elements of the "Forest-wide system".

LUD Management Prescriptions

The reserve system incorporates many different non-development LUDs to provide adequate habitat for old-growth-associated wildlife across the Forest. As quoted above in the 1997 Forest Plan ROD (p. 7) and the 2016 Goals and Objectives (p. 2-3), the 2008 Final Environmental Impact Statement (USFS 2008 FEIS) Appendix D confirmed that the reserve system specifically included "all" non-development LUDs:

> The OGRs include a system of large, medium, and small Habitat Conservation Areas (HCAs) allocated to the Old-Growth Habitat LUD, and full protection of all islands less than 1,000 acres in size. <u>The reserve network also includes all other non-development LUDs</u>. These include Wilderness, National Monument, Legislated LUD II, Wild River, Remote and Semi-Remote Recreation, Research Natural Area, Municipal Watershed, <u>and all other LUDs that essentially maintain the integrity of the old-growth ecosystem.</u>
> (emphasis added) (USFS 2008 FEIS App. D, p. D-2)

Management Prescriptions, which define the limits of allowable activities for each LUD, are provided in Chapter 3 of the Forest Plan. Commercial old-growth timber harvest is allowed in four "development" LUDs totaling approximately 3.6 million acres. Old-growth forest land is classified as "not suitable for timber production" in all other LUDs, although various forms of salvage, personal use, and specialty product timber harvest is allowed in some of these "non-development" LUDs. Collectively, the non-development LUDs constitute the full reserve system, which totals approximately 13.4 million acres (USFS 2016 Plan, p. 3-2).

The Old-Growth Habitat LUD, which is used to identify and define management of OGRs established within the matrix of development lands, covers 1.2 million acres (USFS 2016 Plan, p. 3-2). Management Prescriptions for this LUD are specified on pp. 3-58 to 3-63 of the 2016 Forest Plan and are reproduced here because they were specifically designed as an element of the Conservation Strategy. Full text of the Management Prescriptions for other non-development LUDs is not included, but all other non-development LUDs are also considered part of the reserve system. The Old-Growth Habitat LUD represents only a subset of the reserve system (as documented above).

OLD-GROWTH HABITAT LUD

Goals

Maintain areas of old-growth forests and their associated natural ecological processes to provide habitat for old-growth associated resources.

Manage early seral conifer stands to achieve old-growth forest characteristic structure and composition based upon site capability. Use old growth definitions as outlined in Ecological Definitions for Old-growth Forest Types in Southeast Alaska (R10-TP-28).

Objectives

Provide old-growth forest habitats, in combination with other LUDs, to maintain viable populations of native and desired non-native fish and wildlife species and subspecies that may be closely associated with old-growth forests.

Contribute to the habitat capability of fish and wildlife resources to support sustainable human subsistence and recreational uses.

Maintain components of flora and fauna biodiversity and ecological processes associated with old-growth forests.

Allow existing natural or previously harvested early seral conifer stands to evolve naturally to old-growth forest habitats or apply silvicultural treatments to accelerate forest succession to achieve old-growth forest structural features. Consider practices such as thinning, release and weeding, pruning, and fertilization to promote accelerated development of old-growth characteristics.

To the extent feasible, limit roads, facilities, and authorized uses to those compatible with old-growth forest habitat management objectives.

Desired Condition

All forested areas within this LUD have attained old-growth forest characteristics. A diversity of old-growth habitat types and associated species and subspecies and ecological processes are represented.

Apply the following Forest-wide Standards and Guidelines located in Chapter 4:

Category	Section	Subsections
Air	AIR	All
Beach and Estuary Fringe	BEACH	All
Facilities	FAC	All
Fire	FIRE	All
Fish	FISH	All
Forest Health	HEALTH	All
Heritage Resources/Sacred Sites	HSS	All
Invasive Species	INV	All
Karst and Cave Resources	KC	All
Lands	LAND	All
Minerals and Geology	MG	All

Plants	PLA	All
Recreation and Tourism	REC	All
Riparian	RIP1	All
	RIP2	All
Rural Community Assistance	RUR	All
Scenery	SCENE	All
Soil and Water	SW	All
Subsistence	SUB	All
Timber	TIM	All
Trails	TRAI	All
Transportation	TRAN	All
Wetlands	WET	All
Wildlife	WILD1	I-III; V-XIX
	WILD2,3,4	All

Apply the following Plan Content located in Chapter 5:

Category	Section	Plan Component
Young-growth Direction	All	All except DC-YG-05, and S-YGSCENE-01
Renewable Energy Direction	All	All except S-RE-LAND-01 and S-RE-TRAN-01
Transportation Systems Corridors Direction	All	All except S-TSC-LAND-01
Forest-wide Plan Components	All	All

Apply the following LUD Standards and Guidelines:

FACILITIES
Facilities Improvements: FAC2 and FAC3
A. Allow administrative and recreational facilities when compatible with LUD objectives.
FIRE
Fire Suppression: FIRE1 *Suppression Action*
A. Suppress wildfires using the suppression option identified in the Alaska Interagency Wildland Fire Management Plan.
B. Suppression tactics are limited only by the standards for this LUD, such as soil and watershed concerns.
Fuel Improvements: FIRE2 *Prescribed Fire*
A. Allow management-ignited prescribed fire only where its use maintains old-growth characteristics.
B. As a general management practice, do not use prescribed natural fire. (Consult FSM 5142.)
FISH
Fish Habitat Planning: FISH2
A. Emphasize the protection and restoration of fish habitat, fish production, and aquatic biodiversity. Enhancement projects that may change the natural distribution of fish species within a watershed are consistent with LUD objectives.
FOREST HEALTH
Forest Health: HEALTH1
A. Insect and disease management measures consistent with this LUD may be implemented to protect the old-growth forest component and adjacent resources.
Forest Insect and Disease Survey and Inventory: HEALTH2
A. Survey and inventory visible outbreaks.
HERITAGE
Heritage Resource Activities: HSS1 *Inventory/Evaluation*

A. Develop priorities and schedule management activities to implement heritage resource inventory, evaluation, protection, and interpretation.
   1. Identify, classify, and evaluate known heritage resources.
   2. Identify heritage properties to be nominated to the National Register of Historic Places.
   3. Identify heritage properties that require stabilization or other protective measures.
   4. Identify opportunities for interpretation of heritage resources for public education and enjoyment.

KARST AND CAVES

Cave Management Program: KC2

A. Identify opportunities for interpretation of caves for public education and enjoyment. Interpretation may occur inside or outside of this LUD.

LANDS

Special Use Administration (Non-Recreation): LAND2

A. Permit only improvements (such as tent platforms, fish weirs, minor waterlines, minor powerlines, etc.) that are compatible with LUD objectives.

MINERALS AND GEOLOGY

Minerals and Geology Resource Preparation: MG1*Resource Preparation*

A. Prepare geologic, paleontologic, and historic mining interpretations, where appropriate.

Minerals and Geology Administration: MG2 *Forest Lands Open to Mineral Entry*

A. Forest lands within this LUD are open to mineral entry.
B. Assure prospectors and claimants their right of ingress and egress granted under the General Mining Law of 1872, Alaska National Interest Lands Conservation Act of 1980 (ANILCA), and Forest Service Mining Regulations 36 CFR 228.
C. Permit reasonable access to mining claims, leases, and material sites and authorization of orderly mineral resource development with the provisions of an approved Plan of Operations in accordance with Forest Service Mineral Regulations 36 CFR 228 and FSM 2800.

RECREATION AND TOURISM

Recreation Use Administration: REC3

Recreation Management and Operations

A. Manage recreation and tourism use to meet LUD objectives for fish and wildlife resources and habitat.
   1. Design and locate recreation-related structures to be compatible with habitat needs of old-growth associated species.
B. Generally provide for Semi-Primitive ROS settings, recognizing that more developed settings may be present due to authorized activities, existing use patterns, and activities in adjacent LUDs.
C. Designation of motorized routes for off-highway vehicles is generally not allowed. Designation may only occur where documented local traditional use has occurred and the route does not degrade water quality or flow.

Recreation Special Uses

A. Minor recreation and tourism developments may be compatible with the LUD objectives depending on the scope, purpose, and magnitude of the proposal. Proposals will be evaluated on a case-by-case basis. Refer to the Recreation and Tourism Forest-wide Standards and Guidelines.

SCENERY

Scenery Operations: SCENE1

A. Apply Forest-wide Standards and Guidelines for High Scenic Integrity Objective. Design activities to not be visually evident to the casual observer.
B. Exceptions for small areas of non-conforming developments, such as recreational developments, transportation developments, log transfer facilities, and mining development, may be considered on a case-bycase basis. Use designs and materials that are compatible with forms, colors, and textures found in the characteristic landscape.

SOIL AND WATER

Watershed Resource Improvements: SW4

A. Undertake watershed improvements only where deteriorated soil and hydrologic conditions create a threat to the goals and objectives for which the old-growth habitat is managed. Rehabilitation or stabilization projects will seek to enable the area to retain its natural appearance.

TIMBER

Timber Resource Planning: TIM4

A. Old-growth forest land is classified as not suitable for timber production.
B. Beach log salvage is compatible with this LUD.
C. Avoid Old-growth Habitat areas when other feasible locations for personal use sawtimber, firewood, and Christmas tree cutting are available. If personal (free) use timber harvest is allowed, personal use permit requirements must satisfy LUD objectives (refer to Chapter 4, Personal Use Program, Section TIM4). Personal use timber harvest will be regulated and its cumulative effects monitored in LUDs that are unsuitable for timber harvest to ensure that the LUD objectives are fulfilled.
D. Harvest of bridge stringer logs is allowed.

Timber Sale Preparation: TIM5

A. Salvage of dead or down material is permitted but is limited to roadside windfall and hazard trees immediately adjacent to existing permanent roads and catastrophic windthrow events or large insect or disease outbreaks (generally exceeding 100 acres). Limited standing undamaged timber (up to 20 percent of total salvage) may be removed only for safety reasons or for feasibility of salvage operations. Salvage sales must be compatible with LUD objectives as determined through the environmental analysis process. Stands once salvaged will be managed to achieve old-growth habitat characteristics. During the environmental analysis, consider the scale of the affected area salvaged. If reserve design criteria are no longer met, adjust reserve locations to better meet reserve size, spacing, and composition criteria if lands are available (see Wildlife Habitat Planning, section B below, and Appendix K).

TRANSPORTATION

Transportation Operations: TRAN

A. New Road construction is generally inconsistent with Old-growth Habitat LUD objectives, but new roads may be constructed if no feasible alternative is available.
   1. Perform integrated logging system and transportation analysis (including Access and Travel management planning) to determine if other feasible routes avoiding this LUD exist during the project environmental analysis process. If no feasible alternative routes exist, locate, design, and construct roads in a manner that minimizes adverse impact to fish and wildlife resources to the extent feasible, and will be compatible with LUD objectives. Keep clearing widths to the minimum feasible. Consider enforcement costs of road closures in the integrated logging system and transportation analysis.
   2. If reserve design criteria are no longer met, adjust reserve locations to meet reserve size, spacing, and composition criteria if lands are available (see Wildlife Habitat Planning, section B below, and Appendix K).
   3. For timber salvage, use logging systems that do not require additional permanent road construction.
B. Manage existing roads to meet LUD objectives.
   1. In Old-growth Habitat LUDs with existing roads, develop or update road management objectives to meet LUD objectives (see Wildlife [brown bear and wolf] and Transportation Forest-wide Standards and Guidelines). Use of existing roads may continue pending the update of the access and travel management plan.
   2. Road management objectives may include temporary or permanent road closures, and may be specific to individual road specification types (e.g., keep mainlines open, close arterial and spur).
   3. Road maintenance and reconstruction may be permitted if consistent with road management objectives.
C. Sites for log transfer facilities are generally not appropriate in this LUD. If no other feasible alternative sites exist, locate, design, construct, and manage these facilities in a manner that will be compatible with LUD objectives. Consider the Log Transfer Facility Guidelines (Appendix G) when making the selection for the facility.

WILDLIFE

Wildlife Habitat Planning: WILD1

A. Maintain contiguous blocks of old-growth forest habitat in a forest-wide system of old-growth reserves to support viable and well-distributed populations of old-growth associated species and subspecies.
B. A system of large, medium, and small old-growth habitat reserves has been identified and mapped in the Forest Plan as part of the Old-growth Habitat Conservation Strategy. The mapped large and medium reserves generally achieve reserve strategy objectives, and few major modifications are

anticipated. The small mapped reserves have received differing levels of ground-truthing and integration of site-specific information in their design. During project-level environmental analysis, for projects areas that include or are adjacent to mapped old-growth habitat reserves, the size, spacing, and habitat composition of mapped reserves may be further evaluated (consult Appendix K).

1. Adjust reserves not meeting the minimum criteria to meet or exceed the minimum criteria.
2. Reserve location, composition, and size may otherwise also be adjusted. Alternative reserves must provide comparable achievement of the Old-growth Habitat LUD goals and objectives. Determination as to comparability must consider the criteria listed in Appendix K.
3. Adjustments to individual reserves described in 1 and 2 above are not expected to require a significant plan.

(USFS 2016 Plan, pp. 3-58 to 3-63)

Chapter 5 of the 2016 Forest Plan identifies lands within the Old-growth Habitat LUD as suitable for young-growth timber production, unless they do not meet suitability requirements of Appendix A (USFS 2016 Plan, p. 5-2, SUIT-YG-01). This plan component does not contribute to functionality of the OGRs and should not be considered part of the Conservation Strategy. LUD standards WILD1 and WILD2 (included in the Management Prescription reproduced immediately above) both allow treatment of early seral forest stands to accelerate attainment of old-growth characteristics, which is compatible with OGR functionality, and part of the Strategy.

Note that Wildlife Habitat Planning Guideline (WILD1) refers to the OGR criteria of Appendix K. The 2016 version of Appendix K includes size and composition criteria for Small OGRs, but not for Large and Medium OGRs, as it did in 1997. Criteria for Large and Medium OGRs can be found in the 1997 Forest Plan Appendix K.

Riparian Forest-wide Standards and Guidelines also contain guidance relevant to OGRs, in the Riparian Planning Standard for Wildlife Resources:

Riparian Planning: RIP2

II. General Standards and Guidelines by Activity

F. Wildlife Resources

1. Integrate RMAs into any modifications to the design and location of small old-growth reserves. (Consult the Old-growth Habitat LUD and Appendix K.)

(USFS 2016 Plan, p. 4-51)

Islands Smaller Than 1,000 Acres

A third element of the reserve system, after OGRs and other non-development LUDs, is protection of islands smaller than 1,000 acres (USFS 1997 ROD, p. 7). Timber harvest was prohibited on these smaller islands in the 1997 Forest Plan, to reduce potential risks to endemic taxa:

> ***Endemic Mammals.*** Special management consideration has been given to potentially endemic taxa. A PNW reviewer identified a concern for small island endemic taxa, which may be more susceptible to local extinction. The Other Mammal Assessment Panel which assessed risk to viability for these species also expressed concerns relative to endemic taxa. In response to these concerns, the Forest Plan classifies all islands smaller than 1,000 acres as unsuitable for timber harvest.
>
> (USFS 1997 ROD, p. 35)

This commitment was confirmed in the 2008 Forest Plan FEIS, with additional clarification:

> ***Small Islands:*** The Tongass Forest Plan protects all islands less than 1,000 acres from additional harvest of old-growth forest. These areas are mapped as non-development LUDs, typically Semi-Remote Recreation.
> (USFS 2008 FEIS App D, p. D-7)

The 2016 Forest Plan retained the protection provided for smaller islands:

> Based on principles of conservation, a network of large, medium, and small sized OGRs allocated to the Old-Growth Habitat LUD plus all small islands less than 1,000 acres remain intact.
> (USFS 2016 ROD, p. 21)

There are no Forest Plan components that directly address islands smaller than 1,000 acres. Instead, as explained in the 2008 FEIS Appendix quoted above, protection of smaller islands was provided by their non-development LUD classification, which is "typically Semi-Remote Recreation" (USFS 2008 FEIS App D, p. D-7). These smaller islands, therefore, may be considered a subset of the "all other non-development LUDs" element of the reserve system.

Presentation of this element separately from the other non-development LUDs helps to underscore the potential sensitivity of biota on these smaller islands, where vulnerable populations may have few or no dispersal options or immigration/recolonization opportunities. Habitat modifications or other disturbances in such settings may have much higher impacts to resident wildlife than similar projects in areas with larger populations and better habitat connectivity that allows for dispersal and immigration.

Modification of Reserves

Appendix K of both the 2008 and 2016 Forest Plans focused on procedures for reviewing and modifying OGRs when necessary, for projects with potential to impact integrity of individual reserves or the collective reserve system. The procedures described in Appendix K (reproduced below) are a refined version of an interagency review process initially described in a guidance document titled "Tongass National Forest Land and Resource Plan Implementation Policy Clarification" (TPIT 1998). This guidance addressed a wide range of issues associated with implementation of the 1997 Forest Plan, including several aspects of the Conservation Strategy.

The interagency review process described in the 1998 clarification guidance was implemented and further developed between 1998 and 2008, when interagency OGR reviews were routinely conducted for each proposed timber sale, and during a 2006-2007 interagency effort to finalize Small OGR locations across the entire Forest (USFS 2008 FEIS Appendix D, p. D-28). The 2008 Forest Plan adopted final locations for 224 of the 237 Small OGRs, so project-level reviews of the Small OGRs are no longer required for most projects. Proposed projects that would affect any of the 13 Value Comparison Units (VCUs) with Small OGRs that were not finalized, and projects that would have new impacts on otherwise finalized OGRs (e.g., land conveyances, salvage or young-growth harvest, new powerline or mine construction, etc.) still require an interagency OGR review. Design criteria for Large and Medium OGRs (which still apply) are not included in the 2016 Appendix K but can be found in the 2008 FEIS Appendix D and the 1997 Forest Plan Appendix K (see above).

Because all non-development LUDs are part of the reserve system (as established above), any projects that affect non-development LUDs (not just Old-growth Habitat LUD) should be reviewed using the procedures described in Appendix K, to ensure that size, spacing, composition, and connectivity criteria of the reserve system continue to be met. The impending Forest Plan revision may offer an opportunity to clarify this point.

Appendix K

Old-growth Habitat Reserve Modification Procedures

Introduction

This appendix describes criteria for changing the boundaries of old-growth reserves (OGRs) at the project level as described in the Old-growth Habitat Land Use Designation (LUD) Standards and Guidelines (Wildlife section). For a complete review of the Conservation Strategy, including assumptions for the design of the OGR system, refer to Appendix N of the 1997 Final EIS and Appendix D of the 2008 Final EIS.

Significant modifications to OGRs (e.g., in the case of a land exchange) require consideration of other factors outside the scope of this appendix. Factors include connectivity, size, and shape of the reserve, as well as basic assumptions behind the location of the reserves. Some activities (i.e., major land conveyance or substantial timber harvest in non-development LUDs) could significantly affect the integrity of the Conservation Strategy. In this case, an overall review of the effects on the Conservation Strategy would be necessary. These activities are anticipated to be infrequent events.

Review of OGRs

During the 2008 Amendment process, the USDA Forest Service, U.S. Fish and Wildlife Service (USFWS), and Alaska Department of Fish and Game (ADF&G) reviewed all of the small OGRs and a few of the medium and large OGRs.

These were reviewed primarily because under the 1997 Forest Plan, small OGRs were not adequately mapped, so it was necessary to review and designate them at the project level. Medium and large OGR locations were finalized in the 1997 Forest Plan and brought forward. The location of the majority of the small OGRs was completed during the 2008 Forest Plan review; therefore, project-level reviews are not necessary, except as outlined below.

Minor modifications to any OGR boundary as a result of imprecise mapping are considered an administrative change. The changes will not be considered changes in the Forest Plan and may be completed without project level or other review provided that changes meet OGR goals and objectives. Changes should only be completed to follow physical and other recognizable on-the-ground features or defined boundaries (e.g., roads, streams, LUD, watersheds). Under limited circumstances, a line officer may decide to modify the size and location of an OGR. Modifications of OGRs, other than minor as described above, will require the completion of a project level review. This review may be necessary if:

A. The project occurs in VCUs 1930, 2010, 5371, 5620, 6100, 6140, 6150, 6160, 6170, 6320, 6710, 6750, and 6760. A project-level review is required because critical site-specific information for these small and medium OGRs was not available for the 2008 Forest Plan review. Th s review requires an assessment of landscape connectivity (refer to Appendix D of the Final EIS). Once a review and approval through the NEPA process is complete, no further review for these OGRs is necessary.
B. The project proposes young-growth harvest in the Old-growth Habitat LUD.
C. Site-specific information for a small OGR indicates that the OGR habitat criteria are not met in the mapped location.
D. Actions are proposed within the OGR that will reduce the integrity of the old-growth habitat in the OGR.
E. The OGR will be affected by a land conveyance, power line, mine, or other project that was not considered in the Forest Plan. An overall review of the Conservation Strategy is not necessary for a modification to an individual small OGR, but it could be necessary for modifications to medium and large OGRs, or if a proposal affects multiple OGRs. If an overall review is deemed unnecessary by the

line officer for modification to medium and large OGRs, documentation of the rationale will be done through the NEPA process.

Project-Level Review

Project-level reviews will ensure that OGRs meet Forest Plan OGR criteria while addressing forest-wide multiple use goals and objectives. There are two levels of review included in the project-level review:

1) the interagency review, and
2) the decision process.

Step 1, Interagency Review Process—The purpose of an interagency review is to identify the biologically preferred location for the OGR. An interagency team of USDA Forest Service, USFWS, and ADF&G biologists will jointly evaluate the location and habitat composition of the OGR by reviewing all the large productive old growth blocks within a Value Comparison Unit (VCU). The interagency review team will develop a proposal for the OGR that meets the criteria of this appendix and document why other proposals were not recommended. The review will include the following steps:

A. Review the purpose and rationale for current location of the Forest Plan OGR as documented in the current Tongass Old Growth database.

B. Assess whether the purpose and rationale for the location of the OGR has changed.
C. Use the design criteria to define the biologically preferred location for the OGR.
D. Document this proposal as the interagency proposed OGR in the Tongass Old Growth database and in an Interagency OGR Review report.

Step 2, Decision Process—Line officers will incorporate the interagency review team OGR recommendation in the NEPA process, considering the best biological location for the OGR while balancing other considerations. The interagency team will work with the decision maker to develop alternate proposals, if necessary to meet other Forest Plan objectives. The implemented OGR must meet the minimum criteria as described below. The Decision process will include the following steps:

A. Attempt to develop a viable project that avoids conflicts with the biologically preferred OGR. At a minimum, the biologically preferred OGR will be considered in an alternative in the NEPA document.
B. Where modifications to the biologically preferred OGR are required to meet Forest-wide multiple use goals and objectives: 1. Follow the management prescriptions as defined for the Old-growth Habitat LUD; and 2. Document the rationale for modifications to the biologically preferred OGR.
C. Changes to the OGR LUD require a NEPA analysis and a Forest Plan amendment.
D. Analyze the amount of land suitable for timber production impacted by the change in OGR.
E. Add the updated information (including the rationale for the final location) to the Tongass Old Growth database.

Criteria for Small OGRs

A. Review Appendix D of the Final EIS, which includes the assumptions for the design of the old-growth reserve system.
B. Small reserves are a contiguous landscape of at least 16 percent of the National Forest System land area of each VCU and at least 50 percent of the small reserve, should be productive old growth. The size and location of small OGRs will consider the following:

1. OGRs shall contain a minimum of 400 acres of productive old-growth forest. Do not map isolated reserves with less than 400 acres of productive old growth.
2. The preferred biological objective is for each reserve to contain at least 800 acres of productive old-growth forest.
3. In VCUs that are partially allocated to a Non-development LUD, compare the computed acreage required to the acres of productive old growth in the Non-development LUD. If the Non-development LUD acres are less than the area necessary for a small reserve, first use the productive old growth acres in the existing Non-development LUD to establish a small reserve, and then add additional acres of productive old growth to achieve the required small reserve size and composition.

4. In VCUs that are separated by saltwater channels, reserves may be separated, but attempt to retain 800 acres of productive old growth in each.
5. In very large VCUs, generally larger than 10,000 acres, the allocated old growth may be mapped in separate reserves as long as each reserve has a minimum of 800 acres of productive old growth. However, larger contiguous reserves are preferred to multiple smaller reserves.
6. In very large VCUs that contain relatively little productive old growth and the computational rule requires an amount of productive old growth that exceeds 50 percent of the existing productive old growth in the VCU, map a reserve of at least 400 acres of productive old growth.
7. Where VCU boundaries do not match watershed or ecological boundaries, up to 30 percent of the allocated old growth acres in a VCU may be mapped in an adjacent VCU if the resulting reserve achieves old-growth reserve objectives. The resulting small reserve in both VCUs must be contiguous. Total acreage is attributed to the VCU with 70 percent of the OGR.
8. OGR boundaries should follow recognizable features that are identifiable on the ground. Features should be permanent and easily identifiable. Features may include but are not limited to streams, roads, distinctive ridges and ridge-tops, watershed boundaries, and v-notches.

(USFS 2016 Plan, App. K)

Tongass OGR Tracking Table

Direction in the 1997 Forest Plan required review of Small OGRs during project-level analyses, because the Small OGR locations had not been adequately reviewed prior to adoption of the Forest Plan. The VPOP committee had mapped proposed locations for Large and Medium OGRs and those locations had been reviewed and refined by the interagency (USFS, ADF&G, and USFWS) review team developing the Conservation Strategy for the Forest Plan. Proposed locations for Small OGRs were mapped by USFS staff but the interagency team did not have adequate time to review the Small OGRs. Project-level reviews of Small OGRs were therefore required under Management Prescription WILD122-B for the Old-Growth Habitat LUD (USFS 1997 Plan, pp. 3-80 to 3-81).

Between 1997 and 2007, Small OGRs were reviewed during environmental analysis of 23 timber sales and one mine, and many of the OGRs were modified by the project RODs (USFS 2008 FEIS App D, pp. D-17 to D-18). In 2006 and 2007, in preparation for the 2008 Forest Plan amendment, an interagency team reviewed the history, location, and composition of each of the 237 Small OGRs and identified biologically preferred locations for each OGR. The interagency team subsequently worked with Ranger District staff to adjust proposed OGR locations to accommodate additional multiple-use objectives. The Forest Supervisor reviewed the District-level proposals, and further modified some of the proposed locations (USFS 2008 FEIS App D, p. D-28). Modifications made during Ranger District and Forest Supervisor reviews generally compromised the reserves to facilitate road access or timber harvest opportunities.

Statistics on composition and notes on locations and issues for each of the reserves were documented for each of these iterations in a large spreadsheet, known as the “OGR Tracking Table”. The Tracking Table is part of the administrative record for the 2008 Forest Plan process, and is not technically an element of the Conservation Strategy proper. It remains, however, an important source of background information on each of the Small OGRs. It is currently located on the Forest Service computer system at:
T:\FS\Reference\GIS\r10_tnf\Data\FP2008\FP_old_growth_reserves\Tables

Connecting Corridors

Origin and Intent

The original VPOP Conservation Strategy proposal recommended that corridors of old-growth forest habitat be provided to increase the likelihood of successful dispersal of the species of concern throughout the landscape. Specifically, the committee recommended maintenance of beach buffers at least 500 ft wide wherever the coastline was forested and old-growth riparian buffers at least 100 ft on each side of streams to aid in the dispersal of old-growth associated species. They recognized that additional biological corridors might need to be designated during project level analyses to assure sufficient movement of old-growth associated species between reserves. They specified that breaks in old-growth travel corridors should not exceed 65 feet to ensure that flying squirrels could glide across the openings (Suring et al. 1993, p. 30).

The PNW peer review of VPOP's proposed strategy recommended wider connecting corridors, particularly for marten (Keister and Eckhardt 1994). The Forest Plan adopted in 1997 included 1,000-foot buffers along all marine and estuary shorelines, and riparian management standards and guidelines to provide connecting corridors and sustain old growth riparian habitat. The new Forest Plan also provided specific direction to provide additional connectivity where project-level analysis indicated that beach fringe and riparian buffers were not sufficient to meet objectives for connectivity (USFS 1997 ROD, p. 7). These elements were retained in the amended 2008 and 2016 Forest Plans.

The primary elements of connectivity are contained in the Standards and Guidelines of Chapter 4 in the 2016 Forest Plan, for Beach and Estuary Fringe, and Riparian. Additional guidance on project-level reviews to ensure adequate connectivity is contained in Chapter 4, Forest-wide Standards and Guidelines for Wildlife, in Wildlife Habitat Planning: WILD1, for Landscape Connectivity. These sections are essential elements of the Conservation Strategy and are reproduced below.

Beach and Estuary Fringe Standards and Guidelines

Management Objectives for Beach and Estuary Fringe (USFS 2016 Plan, pp. 4-4 to 4-5) include maintenance of the ecological integrity of beach and estuary fringe forested habitat to provide sustained natural habitat conditions for wildlife, plants, fish, recreation, heritage, scenery, wilderness, and other resources. One of the primary roles identified in the Management Objectives is to provide a relatively continuous forested corridor linking terrestrial landscapes. Protection of 1,000-foot buffers as habitat and as corridors is a focus of the Standards and Guidelines for Beach and Estuary Fringe. The full plan component is reproduced below:

BEACH and ESTUARY FRINGE

Beach and Estuary Description: BEACH1

I. Objectives and Identification

A. Management objectives of the beach and estuary fringe habitat.

1. To maintain the ecological integrity of beach and estuary fringe forested habitat to provide sustained natural habitat conditions and requirements for wildlife, plants, fish, recreation, heritage, scenery, wilderness, and other resources.

2. To provide a relatively continuous forested corridor linking terrestrial landscapes.
3. To provide a variety of recreation opportunities, typically of a Primitive or Semi-Primitive nature and retain the scenic quality.
4. To maintain an approximate 1,000-foot-wide beach fringe of mostly unmodified forest to provide important habitats, corridors, and connectivity of habitat for eagles, goshawks, deer, marten, otter, bear, and other wildlife species associated with the maritime-influenced habitat. Old-growth forests are managed for near-natural habitat conditions (including natural disturbances) with little evidence of human-induced influence on the ecosystem.
5. To maintain an approximate 1,000-foot-wide estuary fringe of mostly undisturbed forest that contributes to maintenance of the ecological integrity of the biologically rich tidal and intertidal estuary zone. Habitats for shorebirds, waterfowl, bald eagles, goshawks and other marine-associated species are emphasized. Old-growth conifer stands, grasslands, wetlands, and other natural habitats associated with estuary areas above the mean high tide line are managed for near-natural habitat conditions with little evidence of human-induced disturbance.

B. Beach fringe identification.

1. The beach fringe is an area of approximately 1,000 feet slope distance inland from mean high tide around all marine coastline.

C. Estuary fringe identification.

1. The estuary fringe is an area of approximately 1,000 feet slope distance around all identified estuaries. Estuaries are ecological systems at the mouths of streams where fresh and saltwater mix, and where salt marshes and intertidal mudflats are present. The landward extent of an estuary is the limit of salt-tolerant vegetation (not including the tidally influenced stream or river channel incised into the forested uplands), and the seaward extent is a stream's delta at mean low water.

Beach and Estuary Management: BEACH2

I. Management

A. Management is governed by the Land Use Designation (LUD) in which the beach or estuary area is located. Some LUDs (such as Wilderness and some of the Natural Setting LUDs) highly restrict development. Where the LUD allows development (e.g., moderate and intensive Development LUDs), the standards and guidelines discussed below will apply.

1. Allow facility developments that require in-water access (e.g., docks, floats, or boat ramps).
   a) Locate facilities more than 300 feet from the mouths of intertidal channels of known Class I anadromous fish streams, or tidal or subtidal beds of aquatic vegetation to avoid significant impairment.
   b) Avoid filling of intertidal and subtidal areas to the extent feasible.
2. Permit reasonable access to mining claims in accordance with the provisions of an approved Plan of Operations. Assure prospectors and claimants their right of ingress and egress granted under the General Mining Law of 1872, Alaska National Interest Lands Conservation Act of 1980 (ANILCA), and National Forest Mining Regulations at 36 CFR 228.
   a) Take advantage of topographic and vegetative screening when locating drill rigs, pumps, roads, rock quarries, structures, and marine transfer facilities.
   b) Consider timing restrictions to minerals activities to avoid adverse impacts to fish and wildlife resources during critical periods.
3. Emphasize natural recreation settings and continue to provide the spectrum of outdoor recreation and tourism opportunities.
   a) Where feasible, schedule activities to avoid change to the existing Recreation Opportunity Spectrum (ROS) class in marine recreation settings. Emphasize the more primitive ROS class when activities are considered in the Wilderness or Wilderness Monument LUD.
   b) In locations where scheduled activities change the recreation setting(s), manage the new setting(s) in accordance with the appropriate ROS guidelines with emphasis on marine-related recreation activities.
   c) Design and locate recreation-related structures (e.g., recreation cabins, lodges, and wildlife viewing structures) to be compatible with beach and estuary fringe objectives.
   d) Manage off-highway vehicle (OHV) use as documented in the Travel Management Plan.
   e) Manage recreation and tourism use to maintain fish, wildlife, and rare plant habitats.
4. Allow subsistence and other personal use of timber in accordance with ANILCA, Title VIII, and other standards and guidelines (e.g., the 330-foot buffer around bald eagle nests). Personal use is generally

inconsistent with beach and is only allowed when the accessibility of other lands suitable for timber production are not feasible, such as when the eligible permittee lives in an unroaded area with no feasible access to designated "suitable timber" lands suitable for timber production, and when the LUD objectives can be met." Personal use timber harvest will be regulated and its cumulative effects monitored in LUDs that are not suitable for timber production to ensure that the LUD objectives are fulfilled.

5. Beach log salvage is permitted.
6. (See Forest-wide plan components in Chapter 5)
7. (See Forest-wide plan components in Chapter 5)
8. Road construction is discouraged in the beach and estuary fringes. Where feasible alternatives are not available, road corridors may be designated.
   a) Provide or maintain recreation or community access where needed as identified through project analysis.
9. Log transfer facilities may be constructed.
   a) Use the Alaska Timber Task Force Siting Guidelines (see Appendix G and the log transfer facility standards and guidelines in the Transportation Forest-wide Standards and Guidelines section).
10. Wildlife habitat restoration of young-growth conifer stands is encouraged to accelerate development of advanced seral stand structure. Treatments may include thinning of young stands, release, pruning, and fertilization.
11. Other authorized activities (e.g., powerlines, fish camps) may be allowed in the beach and estuary fringe where feasible alternative locations are not available.

(USFS 2016 Plan, pp. 4-4 to 4-5)

Standards BEACH2 I.A.6. and BEACH2 I.A.7. above refer to Forest-wide plan components in Chapter 5, which describe management intended to accelerate transition away from old-growth harvest by expanding opportunities to harvest of young growth, promote development of renewable energy, and manage the transportation system. These Forest Plan components are not essential to the connectivity function of the beach and estuary fringe (and potentially counter to it, depending on how they are applied) and should not be considered part of the Conservation Strategy. Standard I.A.10. above encourages treatment of young growth in the Beach and Estuary Fringe to restore advanced seral stand structure. Such treatment contributes to the connectivity function and is an element of the Strategy.

Riparian Standards and Guidelines

Riparian Forest-wide Standards and Guidelines (USFS 2016 Plan, pp. 4-48 to 4-52) address conservation of riparian areas to provide for continued productivity of a broad range of aquatic and terrestrial species and resources. Wildlife travel corridors are explicitly included as one value to be considered in the Riparian Planning Standard (RIP2) for Wildlife Resources (p. 4-51). This guideline directs staff to:

> "Use riparian corridors in the design of wildlife travel corridors to provide horizontal connectivity between watersheds, and vertical connectivity between lowland and alpine areas."

(USFS 2016 Plan, p. 4-51)

In practice, riparian corridors tend to connect patches of old-growth forest to beach and estuary buffers, which provide most of the horizontal old-growth connectivity between watersheds on the Tongass.

The entire set of Riparian Standards and Guidelines are reproduced below. Portions particularly relevant to the Conservation Strategy include sections on identification and designation of Riparian Management Areas (RMAs), which serve as old-growth corridors in the Conservation

Strategy. These RMAs are designated only where timber sales or other proposed projects have prompted environmental analysis requiring RMA identification. Where no RMAs have been designated, connectivity is provided by natural conditions, except where impacts predating the 1997 Forest Plan exist.

RIPARIAN

Forest-wide Standards and Guidelines

Riparian area: RIP1

I. Definition

A. Riparian areas encompass the zone of interaction between aquatic and terrestrial environments associated with streamsides, lakeshores, and floodplains, and display distinctive ecological conditions characterized by high species diversity, wildlife value, and resource productivity.

II. Objectives

A. Maintain riparian areas in mostly natural conditions for fish, other aquatic life, old-growth and riparian-associated plant and wildlife species, water-related recreation, and to provide for ecosystem processes, including important aquatic and land interactions. For further direction, refer to the Fish, Wildlife, Recreation and Tourism, Beach and Estuary Fringe, and Soil and Water Forest-wide Standards and Guidelines, as well as the Riparian Standards and Guidelines criteria for each process group contained in Appendix D. The following is a list of objectives pertaining to riparian areas. (Consult Forest Service Manual [FSM] 2526.)

1. Protect riparian habitat.
2. Manage riparian areas for short- and long-term biodiversity and productivity.
3. Maintain natural streambank and stream channel processes.
4. Maintain natural and beneficial quantities of large woody debris over the short and long term.
5. Protect water quality by providing for the beneficial uses of riparian areas. (Consult Best Management Practices [BMPs], Chapter 10 of the Soil and Water Conservation Handbook, FSH 2509.22.)
6. Maintain or restore the natural range and frequency of aquatic habitat conditions on the Tongass National Forest to sustain the diversity and production of fish and other freshwater organisms.
7. Consider the management of both terrestrial and aquatic resources when managing riparian areas. Consider the effects of terrestrial and aquatic processes on aquatic and riparian resources.
8. In watersheds with intermingled land ownership, cooperate with the other landowners in striving to achieve healthy riparian areas.
9. Design and coordinate road management activities to provide for the needs of wildlife and provide passage of fish at road crossings. (Consult the Fish Forest-wide Standards and Guidelines and the Aquatic Habitat Management Handbook, Forest Service Handbook [FSH] 2090.21.)
10. Evaluate the effect of management (including windthrow) of adjacent areas on riparian habitats.
11. Coordinate and consult with state and federal agencies on riparian management issues, as appropriate.
12. Coordinate and consult with Alaska Department of Environmental Conservation (ADEC) regarding management of public water systems source watersheds.

Riparian Planning: RIP2

I. Project Planning

A. Identify and delineate Riparian Management Areas (RMAs) for each project where ground disturbance will occur or resources will be extracted. RMAs are areas of special concern to fish, other aquatic resources, and wildlife. They are generally delineated as identified in the Process Group direction in the Riparian Forest-wide Standards and Guidelines. Riparian areas are differentiated from adjacent reserve areas, such as wildlife reserves or areas managed to provide reasonable assurance of windfirmness.

B. Complete a watershed analysis before making site-specific adjustments to Process Group Standards and Guidelines (see Appendix D). Riparian guidelines may be adjusted only if the stream process group objectives can be met. Consult Appendix C of the Forest Plan for direction on adjusting riparian guidelines.

C. On those projects and activities that are in, or influence, RMAs, ensure interdisciplinary involvement and consideration of riparian resources in project planning and in the environmental analysis process.

1. The location and design of wildlife habitat reserves and mitigation measures should be closely integrated with the design and layout of RMAs.

2. Logging engineers and aquatic specialists should conduct joint reviews of preliminary harvest unit designs to ensure that site-specific stream protection measures meet riparian objectives, as well as logging system feasibility and timber harvest economic objectives.

D. Ensure that permit holders, contractors, and/or purchasers understand RMAs and riparian management objectives.

E. Evaluate RMA windthrow risk when locating and designing adjacent management activities (Reasonable Assurance of Windfirmness [RAW] Guidelines: Landwehr 2007 and subsequent versions). Minimize accelerated windthrow in RMA buffers. In situations where a high risk of blowdown factors is present, indicating a high windthrow risk, a RAW buffer should be prescribed. In situations where multiple low risk factors are present and high risk factors are minimal, a RAW zone addition to riparian buffers is not warranted. Where high-value aquatic resources (such as a Class I stream or drinking water supplies) are at-risk, use of a wider buffer may be warranted even when the risk of windthrow is judged to be low or moderate. The RAW zone is not necessarily a no-harvest zone; partial harvest may be appropriate in RAW buffers depending on site-specific conditions. (Consult BMP 12.6a of the Soil and Water Conservation Handbook—FSH 2509.22 and the Process Group Standards and Guidelines.)

II. General Standards and Guidelines by Activity

A. Special use administration(Non-Recreation)

1. Permit activities, consistent with other special use direction, that do not significantly reduce the capability of RMAs to 1) maintain or improve associated fish or wildlife habitat, or 2) protect water quality for beneficial uses.

B. Minerals and Geology Administration, Plan of Operations

1. Use state-of-the-art techniques for developing minerals to reduce impacts to riparian resources to the extent feasible. Include mitigation measures that are compatible with the scale of proposed development and commensurate with potential resource impacts.
2. Apply appropriate Transportation Forest-wide Standards and Guidelines to the location, construction, and maintenance of mining roads affecting riparian areas.
3. Manage mineral exploration and development activities to be compatible with the Process group goals and objectives for RMAs.
4. Manage mineral activities to maintain the present and continued productivity of anadromous fish and other foodfish habitat to the maximum extent feasible. (Consult the Alaska National Interest Land Conservation Act of 1980, Section 505 [a].) Plan of Operations for mining must comply with Clean Water Act, Sections 401, 402, 404, as applicable. (Consult FSM 2817.23a.)
5. Apply timing restrictions to instream construction and other minerals activities to protect fisheries habitat and mitigate adverse sedimentation, and to avoid critical wildlife mating, hatching, and migrating periods.
6. Minimize the effects of mineral development and related land disturbance activities on the beneficial uses of water by applying BMPs.
7. Locate material sites and marine transfer facilities outside RMAs if reasonable alternatives exist.
8. Ensure that disturbed areas are revegetated in accordance with project plans.
9. Approve reclamation plans in which mineral activities

C. Recreation Use Administration

1. Locate, design, and operate only those recreation projects that are necessary to accommodate public use of the water and shoreline areas (i.e., boat or floatplane docks, launching ramps, and associated access roads and trails). Where feasible, locate parking, campgrounds, sanitation, and other recreation facilities outside the RMAs to avoid adverse effects on water quality and riparian function.
2. For existing facilities, consider relocating the facility outside of the RMA. Consideration should be based on current and anticipated effects on riparian values, desired recreation experience, public issues, application of BMPs to minimize the effects of recreation facilities on the beneficial uses of water and costs of relocating the facility.

D. Watershed Resource Planning

1. Manage activities to meet state water quality standards and protect aquatic and terrestrial riparian habitats, channel and streambanks, and provide for flood plain stability.
   a) Identify soil and water quality requirements for project-level activities.
   b) Apply BMPs to minimize the effects of land disturbing activities on the beneficial uses of water.
   c) Determine flood plain values and plan to avoid, where possible, the long- and short-term adverse impacts to soil and water resources associated with the occupancy and modification of flood plains.

d) Complete a watershed analysis before making project-level, site-specific adjustments to Process Group Standards and Guidelines. Adjustments to the guidelines may be made only if the objectives of the process group(s) can be met. Consult Appendix C of the Forest Plan for direction on watershed analysis. The intensity and scope of watershed analysis will vary according to the issues of concern.

E. Timber Resources

1. No commercial timber harvest is allowed within 100 feet horizontal distance either side of Class I streams and Class II streams that flow directly into a Class I stream. (Consult the Tongass Timber Reform Act.)
   a) Included in the definition of Class II streams flowing directly into a Class I stream are all Class II tributaries of a Class II stream that flow into a Class I stream without an intervening Class III segment. Mandatory minimum 100-foot buffers will not apply to
      1) a Class II stream that flows directly into the ocean or joins a Class I stream only at lower than mean high tide; and
      2) a Class II tributary stream segment that flows into a Class III stream that in turn flows into a Class I stream.
   b) The 100-foot measure is a horizontal distance measure from the bankfull margins.
2. Protect RMAs, in accordance with the intent of the Alaska Anadromous Fish Habitat Assessment (1995), through application of the direction contained in Process Group Standards and Guidelines (Appendix D). Apply additional BMPs (National Core BMP Technical Guide FS-990a and Alaska Region Soil and Water Conservation Handbook FSH 2509.22) to minimize the effects of timber harvest and related land disturbance activities on beneficial uses of water. In situations where multiple high risk factors are present, indicating a high windthrow risk, a Reasonable Assurance of Windfirmness (RAW) zone adjacent to the RMA buffer should be established (see RAW Guidelines: Landwehr 2007 and subsequent versions).
3. Avoid RMAs when other feasible locations for personal use wood cutting are available. If personal (free) use timber harvest in RMAs is allowed, free use permit requirements must satisfy process group objectives (refer to Personal Use Program, section TIM4). Personal use timber harvest will be regulated and its cumulative effects monitored in LUDs that are not suitable for timber production to ensure that the LUD objectives are fulfilled.
4. Provide protection to fish and wildlife during critical periods of their life cycles by applying seasonal restrictions on timber harvest and road use activities, to the extent feasible. 5. When stream crossings are required to harvest timber, assess the environmental effects of road crossings versus yarding corridors, and select the action of least environmental impact where practicable.
6. Streamcourse protection plans (consult BMP 13.16) are required for harvesting activities within the required minimum 100-foot buffers designated in E (1) above.

a) Provide thorough documentation of RMA design and BMP mitigation provision on timber sale unit cards and maps. “As-laid-out” (or phase II) unit cards are a useful tool for facilitating application of RMA and streamcourse protection during sale administration, and for monitoring compliance with and implementation of Riparian Forest-wide Standards and Guidelines.

7. Allow no commercial timber salvage within 100 feet in width on each side of Class I streams or on those Class II streams that flow directly into Class I streams. In addition, allow no timber salvage in RMAs defined for each process group, with the following exception: salvage could be allowed, with Line Officer approval, following watershed analysis if the salvage activity is needed to meet or further riparian management objectives for the process group (see Appendix C for guidance on watershed analysis). RMA salvage timber will not contribute toward the Projected Timber Sale Quantity (PTSQ).
8. Plan timber harvest settings that cross or are immediately adjacent to streamcourses (Class I, II, III, and IV Channels) so as to avoid adverse impacts to RMAs, and soil and water resources. (Consult FSH 2409.18 and FSH 2509.22.)
9. Stream process group-specific standards and guidelines for timber harvest are presented in Appendix D, along with descriptions of each process group and channel type. The standards and guidelines (except for the minimum 100-foot buffers required by TTRA) may be adjusted for a project on a site-specific basis following completion of a watershed analysis. Adjustments to the standards and guidelines may be made only if the objectives of the process group(s) can be met. Consult Appendix C for direction on watershed analysis.

F. Wildlife Resources

1. Integrate RMAs into any modifications to the design and location of small old-growth reserves. (Consult the Old-growth Habitat LUD and Appendix K.)
2. Use riparian corridors in the design of wildlife travel corridors to provide horizontal connectivity between watersheds, and vertical connectivity between lowland and alpine areas.
3. Consider wildlife needs in the design and management of RMAs. Give special emphasis to habitats of riparian associated species, for example, designated brown bear feeding areas. (See Wildlife Forest-wide Standards and Guidelines.)

G. Transportation Systems

1. Use road closures, maintenance, and other measures to keep road-surface and road-side erosion at low or near background levels. Ensure long-term fish passage through structures at road crossings on Class I and II streams as described in Process Group direction and the Fish Standards and Guidelines. Use BMPs (National Core BMP Technical Guide FS-990a and Alaska Region Soil and Water Conservation Handbook FSH 2509.22 [BMP 14-20]) to control effects of transportation systems on water quality and fish habitat. Also refer to the Alaska Forest Practices Act (11 AAC 95.320) for road closure requirements.

(USFS 2016 Plan, pp. 4-48 to 4-52)

Chapter 5 of the 2016 Forest Plan includes elements relevant to management of riparian areas intended to accelerate transition away from old-growth harvest by expanding opportunities to harvest of young growth, facilitate development of renewable energy generation, and manage transportation systems. These Forest Plan components are not essential to the connectivity function of riparian management areas and potentially counter to it depending on how they are applied. These plan components <u>should not be considered part of the Conservation Strategy</u>.

Connectivity Analyses

Landscape connectivity reviews are required during environmental analysis of "projects proposing to harvest timber, construct roads, or otherwise significantly alter vegetative cover… to determine whether forest connectivity exists among old-growth blocks in large and medium reserves and natural setting LUDs" (USFS 2016 Plan, p. 4-87). Where existing (beach and riparian) corridors do not provide sufficient connectivity between blocks of old-growth in OGRs and other non-development LUDs, additional corridors are to be designated. This direction has been included in each of the three Forest Plans approved since 1997. Clarification on how these reviews are to be conducted, with lists of reserves requiring additional connectivity, was provided by TPIT (1998, pp. 14-15).   It is not known how many additional corridors have been recommended or approved since the Conservation Strategy was adopted in 1997.

The Standards and Guidelines from Chapter 4 of the Forest Plan that describe the required landscape connectivity analyses are reproduced below.

WILDLIFE
Forest-wide Standards and Guidelines
Wildlife Habitat Planning: WILD1w

VI. Landscape Connectivity

A. Design projects to maintain landscape connectivity.

1. The objective is to maintain corridors of old-growth forest among large and medium old- growth reserves (Appendix K) and other forested Non-development LUDs at the landscape scale.
2. During the environmental analysis for projects proposing to harvest timber, construct roads, or otherwise significantly alter vegetative cover, conduct an analysis at the landscape scale to identify

blocks of contiguous old-growth forest habitat within large and medium reserves and other Non-development LUDs to determine whether forest connectivity exists among old-growth blocks in large and medium reserves and natural setting LUDs. Consider existing features of the old-growth strategy such as the beach fringe, small old-growth reserves, riparian buffers, or other lands not suitable for timber production as contributing to maintaining connectivity among large and medium Old-growth Habitat reserves and Non-development LUDs. Use the following parameters to determine if a large or medium reserve is connected:

a) only one connection is needed;
b) the beach fringe serves as a connector; and
c) the connection does not have to be the shortest distance between reserves.

Where these features do not provide sufficient productive old-growth forest connectivity to meet the objective in 1 above, provide stands, where they exist, of productive old-growth forest or other forest that provides adequate wildlife habitat values (i.e., older young growth that provides adequate snow intercept for deer). Designed corridors should be of sufficient width to minimize edge effect and provide interior forest conditions. Consider elevation, natural movement corridors, length of corridor, tree heights, adjacent landscapes, and windthrow susceptibility in corridor design.

B. Forest-wide, within the beach fringe, riparian buffers, and other lands not suitable for timber production, consider designing young-growth treatments to accelerate old-growth characteristics in order to increase connectivity for wildlife.

(USFS 2016 Plan, p. 4-87)

(Note that the second to last sentence of element A.2. begins with the word “Designed”. The word “Designated” might be a better choice here.)

Tongass GIS Layers:

Spatial elements of the Conservation Strategy include reserves (Old-growth Habitat and other non-development LUDs) and corridors (beach, estuary, and riparian buffers). Each of these elements are delineated in forest-level default geodatabases, which is the authoritative dataset used for Forest management purposes. Changes and updates to the default database to reflect modifications adopted in project-level RODs are done by Tongass GIS staff with administrator role privileges.

The GIS dataset on LUDs is found at:
Database Connections\r10_tnf_default_as_s_r10_tnf.sde\S_R10_TNF.LUD\S_R10_TNF.LandUseDesignation

Beach and estuary fringe buffers, which provide a critical element of connectivity between adjacent reserves and non-development LUDs, are delineated in:
Database Connections\r10_tnf_default_as_s_r10_tnf.sde\S_R10_TNF.Planning\S_R10_TNF.BeachBuffersMaxHW

Datasets showing Riparian Management Areas (RMAs), which provide another critical element of old-growth connectivity, are found at:
Database Connections\r10_tnf_default_as_s_r10_tnf.sde\S_R10_TNF.RiparianMgtArea\S_R10_TNF.RMA

These data files showing locations of designated reserves and corridors should be considered essential elements of the Conservation Strategy.

RMAs have only been delineated where environmental analyses have been done for proposed timber sales or other projects. The RMA data, therefore, provides an incomplete picture of riparian corridors that exist between adjacent reserves. A more comprehensive view could be developed through a query of streams and forest cover, to show the full extent of existing riparian old-growth connectivity.

Tongass GIS staff does not maintain a GIS file showing the full system of corridors including beach, estuary, and riparian buffers, along with additional corridors designated following project-level connectivity reviews.

Connecting corridors have reportedly been designated in some project-level RODs, but have apparently not been consolidated in any way. All of these project-level corridors should be identified through a systematic review of landscape connectivity analyses and RODs associated with timber sales and other major projects since 1997, and delineated in a discrete GIS shapefile. Such a data layer would be an important element of the Conservation Strategy.

Criteria on composition of OGRs include minimum acreages of productive old-growth forest. Corridors are intended to link patches of old-growth and must be composed of productive old-growth or, where that is not available, mature second growth. Identification and evaluation of the reserve and corridor system, therefore, relies on accurate data on location of forest cover. Productive old growth is queried from the Tongass NF Size-Density feature class, found at:
Database Connections\r10_tnf_default_as_s_r10_tnf.sde\S_R10_TNF.SizeDensity\S_R10_TNF.Size_Density

The Size-Density dataset is not considered part of the Conservation Strategy, but is an important tool for evaluation or modification of the Strategy.

Species Specific Standards and Guidelines

Origin and Intent

The original VPOP proposal included Standards and Guidelines for management of forest resources to ensure existence of viable, well-distributed populations of species with identified conservation concerns that could not be adequately addressed by the Reserve System alone (Suring et al. 1993, pp. 32 to 36). Direction was provided for six of the original eight design species: great blue heron, northern goshawk, gray wolf, brown bear, river otter, and mountain goat. Peer reviews and subsequent expert panel reviews recommended modifications and additional constraints for several of the species considered by Suring et al. (1993). Standards were added to address risks to endemic terrestrial mammals (USFS 1997 ROD, p. 31 and 35). The 2008 Forest Plan amendment included modifications to the goshawk, marten, wolf, and endemic terrestrial mammal Standards and Guidelines. These modifications were retained in the amended 2016 Forest Plan.

The Standards and Guidelines reproduced below are from the Wildlife Section of Chapter 4, Standards and Guidelines (USFS 2016 Plan, pp. 4-85 to 4-97). Several additional Standards and Guidelines are included in the Wildlife section that were not initially developed by the VPOP committee or in response to subsequent reviews of the Conservation Strategy and so are not included here as elements of the Strategy.

Brown Bear (Habitat Management)

IX. Bear Habitat Management

A. Continue to implement strategies, in cooperation with the Alaska Department of Environmental Conservation, ADF&G, cities, and boroughs, that prevent habituation of bears to human foods/garbage and reduce chances of human/bear incidents. Strategies that can be used to reduce human/bear incidents include the following:

1. Phasing out and rehabilitating any remaining open garbage sites on National Forest System land. Establish timetables for phase out and rehabilitation in cooperation with appropriate state agencies. (Consult Lands Forest-wide Standards and Guidelines on sanitary landfills.)
2. Requiring incinerators and/or other bear-proof garbage disposal methods at work camps, recreation sites, administrative and research facilities, and special use authorizations in bear habitats.
3. Where feasible, locating seasonal and permanent work camps, recreation facilities, mineral exploration and operational facilities, LTFs, where allowed by the LUD, more than one mile from sites of important seasonal bear concentrations to reduce chances of human/bear confrontations.
4. On Forest Service-approved projects and special use authorizations in brown bear habitat, minimizing adverse impacts to the habitat and seeking to reduce human/bear conflicts. Specific plans could include seasonal restrictions on activities and other measures determined on a case-by-case basis.
5. Maintaining an aggressive public education program on bear behavior to reduce the number of human/bear incidents.
6. Requiring storage of human food in ways to make it unavailable to bears to reduce habituation of bears and reduce human/bear incidents.

B. During project planning, evaluate the need for additional protection of important brown bear foraging sites (e.g., waterfalls used as fishing sites) in addition to the buffers already provided by the Riparian and Beach and Estuary Fringe Forest-wide Standards and Guidelines, and the Old-growth Habitat and other Non-development LUDs. Consult with the ADF&G in identifying and managing important brown bear foraging sites. Establish forested buffers, where available, of approximately 500 feet from the stream at sites where, based upon the evaluation, additional protective measures are needed to provide cover among brown bears while feeding, or between brown bears and humans. This may be especially important on Class I anadromous fish streams within the Moderate Gradient/Mixed Control and Flood Plain Process Groups (see Appendix D) where a large amount of bear feeding activity on salmon occurs. Consider the combination of bear foraging behavior, stream channel types, and adjacent landform to help identify probable important feeding sites.

C. Manage human/bear interactions to limit brown bear mortality from both illegal kills and defense of life and property. Work with the ADF&G to develop and implement a bear management program that considers both access management and season and bag limits to manage bear mortality rates within sustainable levels.

D. Manage road use where concentrations of brown bear occur to minimize human/bear interactions and to help ensure the long-term productivity of brown bears. To meet this direction, develop and implement road management objectives through an interdisciplinary process. (Consult Transportation Forest-wide Standards and Guidelines.)

E. Cooperate with the state to develop sites for safe public bear viewing opportunities.

(USFS 2016 Plan, pp. 4-88 to 4-89)

Great Blue Heron (Nest Protection)

XIII. Heron and Raptor Nest Protection

A. Provide for the protection of raptor (hawk and owl) nesting habitat and great blue heron rookeries.

1. Conduct project-level inventories to identify heron rookeries and raptor nesting habitat using the most recent inventory protocols.
2. Protect active rookeries and raptor nests. Active nests will be protected with a forested 600-foot windfirm buffer, where available. Road construction through the buffer is discouraged. Prevent disturbance during the active nesting season (generally March 1 to July 31).
3. Protection measures for the site may be removed if the nest is inactive after two consecutive years of monitoring.
4. Bald eagle nest protection standards are outlined in WILD1 Section VIII.

5. Northern goshawk and osprey nest protection standards are included under Threatened, Endangered, and Sensitive species Forest-wide Standards and Guidelines for wildlife (WILD4 Section II).

(USFS 2016 Plan, p. 4-90)

Gray Wolf (Alexander Archipelago Wolf subspecies)

XIV. Alexander Archipelago Wolf

A. Implement a Forest-wide program, in cooperation with ADF&G and USFWS, to assist in maintaining long-term sustainable wolf populations.

1. Where wolf mortality concerns have been identified, develop and implement a Wolf Habitat Management Program in conjunction with ADF&G. To assist in managing legal and illegal wolf mortality rates to within sustainable levels, integrate the Wolf Habitat Management Program (including road access management) with season and harvest limit proposals submitted to federal and state boards.
   a) Participate in interagency monitoring of wolf populations on the Forest.
   b) Where wolf population data suggest that mortality exceeds sustainable levels, work with ADF&G and USFWS to identify probable sources of mortality. Examine the relationship among wolf mortality, human access, and hunter/trapper harvest. Conduct analyses for smaller islands (e.g., Mitkof Island), portions of larger islands, or among multiple wildlife analysis areas (WAAs).
   c) Where road access and associated human-caused mortality has been determined, through an interagency analysis, to be a significant contributing factor to locally unsustainable wolf mortality, incorporate this information into Travel Management planning and hunting/trapping regulatory planning. The objective is to reduce mortality risk and a range of options to reduce this risk should be considered. In these landscapes, both open and total road density should be considered. Total road densities of 0.7 to 1.0 mile per square mile or less may be necessary. Options shall likely include a combination of Travel Management regulations, establishing road closures, and promulgating hunting and trapping regulations to ensure locally viable wolf populations. Local knowledge of habitat conditions, spatial locations of roads, and other factors need to be considered by the interagency analysis rather than solely relying upon road densities. Road management objectives would be developed and implemented through an interdisciplinary Access and Travel Management or comparable process. (See Transportation Forest-wide Standards and Guidelines.) Suggested wolf hunting and trapping changes would be developed and forwarded to the Federal Subsistence Board and the Alaska Board of Game.
2. Provide, where possible, sufficient deer habitat capability to first maintain sustainable wolf populations, and then to consider meeting estimated human deer harvest demands. This is generally considered to equate to the habitat capability to support 18 deer per square mile (using habitat capability model outputs) in biogeographic provinces where deer are the primary prey of wolves. Use the most recent version of the interagency deer habitat capability model and field validation of local deer habitat conditions to assess deer habitat, unless alternate analysis tools are developed. Local knowledge of habitat conditions, spatial location of habitat, and other factors need to be considered by the biologist rather than solely relying upon model outputs.
3. Design management activities to avoid abandonment of wolf dens.
   a) Maintain a 1,200-foot forested buffer, where available, around known active wolf dens. Road construction within the buffer is discouraged and alternative routes should be identified where feasible. No road construction is permitted within 600 feet of a den unless site-specific analysis indicates that local landform or other factors will alleviate potential adverse disturbance.
   b) If a den is monitored for two consecutive years and found to be inactive, buffers described in a), above, are no longer required. However, in the spring, prior to implementing on-the-ground management activities (timber harvest or road construction), check each known inactive den site to see if it has become active.

(USFS 2016 Plan, p. 4-91)

American Marten (also applies to Pacific Marten)

XVIII. American Marten

A. Implement a Forest-wide program, in cooperation with ADF&G, to assist in maintaining long-term sustainable marten populations.

1. Where marten mortality concerns have been identified through interagency analysis, cooperate with ADF&G to assist in managing marten mortality rates to within sustainable levels. Both access management and hunter/trapper harvest regulations administered by the ADF&G shall be considered.
   a) Participate in interagency monitoring of marten populations on the Forest.
   b) Where marten harvest data suggest that mortality exceeds sustainable levels, work with ADF&G to identify probable sources of mortality. In an interagency analysis, examine the relationship between hunter/trapper marten harvest and human access.
   c) Where road access and associated human-caused mortality has been determined, through this analysis to be the substantial contributing factor to unsustainable marten mortality, incorporate this information into Travel Management planning with the objective of reducing mortality risk. Local knowledge of habitat conditions, spatial location of roads, and other factors need to be considered by the biologist rather than solely relying upon road densities. Road management objectives would be developed and implemented through an interdisciplinary Access and Travel Management process or comparable process. (Consult Transportation Forest-wide Standards and Guidelines.)

(USFS 2016 Plan, pp. 4-92 to 4-93)

Endemic Terrestrial Mammals

XIX. Endemic Terrestrial Mammals

A. The objective is to maintain habitat to support viable populations and improve knowledge of habitat relationships of rare or endemic terrestrial mammals that may represent unique populations with restricted ranges.

1. Use existing information on the distribution of endemic mammals to assess projectlevel effects. If existing information is lacking, surveys for endemic mammals may be necessary prior to any project that proposes to substantially alter vegetative cover (e.g., road construction, timber harvest, etc.). Surveys are necessary only where information is lacking to assess project-level effects.
   a) Survey islands smaller than 50,000 acres in total size (e.g., Heceta Island and smaller) that have productive old-growth forest on lands suitable for timber production. Conduct surveys on larger islands if there is a high likelihood that endemic taxa are present and a high likelihood that they would be affected by the proposed project.
   b) The extent and rigor of surveys will be commensurate with the degree of existing and proposed forest fragmentation, and potential risk to endemic mammals that may be present.
   c) Surveys should emphasize small (voles, mice, and shrews) and medium sized (ermine and squirrels) endemic mammals with limited dispersal capabilities that may exist within the project area.
   d) Use the most recent inventory protocols for surveys.
2. Assess the impacts of the proposed project relative to the distinctiveness of the taxa, population status, degree of isolation, island size, and habitat associations relative to the proposed management activity.
3. Where distinct taxa are located, design projects to provide for their long-term persistence on the island.

B. Consider habitat needs of endemic mammals in design of thinning treatments.

(USFS 2016 Plan, p. 4-93)

Northern Goshawk (includes Queen Charlotte goshawk subspecies)

Threatened, Endangered, and Sensitive Wildlife Species: WILD4

II. Sensitive Species

A. Northern Goshawk (including the Queen Charlotte goshawk subspecies).

1. Preserve nesting habitat around all goshawk nest sites. Protection measures may be removed from probable nest stands if, after two consecutive years of monitoring, there is no further evidence of confirmed or probable nesting.

a) Consider the following evidence for determining confirmed nest sites:

(1) A goshawk observed on or near a nest;

(2) Nestlings or branchers (young not able to fly) observed on or near a nest;

(3) Goshawk feathers or eggs obtained from the nest;

(4) One or more nest structures indicative of goshawk were found with goshawk prey remains, but without positive identified goshawk on the nest and without positive identified feathers from nest;

b) Consider the following evidence for determining probable nest sites:

(1) Aggressive, territorial breeding season adults vocalizing or attacking an observer (without locating a nest); or

(2) Adults observed during the breeding season in a territory and recently fledged young were observed (without locating a nest).

c) Nesting Habitat: Maintain an area of not less than 100 acres of productive old-growth (POG) forest if it exists, or the largest diameter young-growth forest if sufficient POG is not adjacent to the nest, generally centered over the nest tree or probable nest site to provide for prey handling areas, perches, roosts, alternate nests, hiding cover, and foraging opportunities for young goshawks. Vegetative structure should include, where available, multi-layered, closed (over 60 percent) canopy stands, a relatively open understory, with large trees (usually 20+ inches diameter at breast height) and low ground vegetation.

d) Management: No commercial timber harvest is permitted Existing roads may be maintained. New road construction is permitted if no other reasonable roading alternatives outside the mapped nesting habitat exist. Permit no continuous disturbance likely to result in nest abandonment within the surrounding 600 feet from March 15 to August 15. Activity restrictions are removed for active nests that become inactive or unsuccessful. Other management activities that maintain the integrity of the forest stand structure are consistent with the objectives for this area. Activities such as cabin, trail, or campground construction should be consistent if designed with minimal vegetative manipulation.

e) Consider surrounding landscapes when managing for goshawk nest sites. Plans for an alternate nest management strategy to c) and d) above may be implemented if the rationale is documented.

f) Conduct inventories to determine the presence of nesting goshawks for proposed projects that affect goshawk habitat. Use the most current inventory protocols developed in cooperation with state and federal agencies.

(USFS 2016 Plan, pp. 4-95 to 4-96)

Habitat-Feature Standards and Guidelines

Legacy Forest Structure

In 2008, Standards and Guidelines that had previously required retention of forest structure in timber harvest units to provide habitat for goshawk and marten were replaced with a Legacy Forest Structure Standard and Guideline that applied only to harvest units larger than 20 acres (rather than two acres as required in the 1997 Forest Plan) over a larger portion of the Forest. This modification was retained in the 2016 Forest Plan (USFS 2016 Plan, pp. 4-86 to 4-87).

IV. *Legacy Forest Structure*

A. Objectives

The intent of the Legacy Standard and Guideline is to ensure that sufficient residual trees, snags, and clumps of trees remain in timber harvest units within value comparison units (VCUs) that have had concentrated past timber harvest activity and are at risk for not providing the full range of matrix functions (as shown in Section D), in order to meet the intent of the conservation strategy while providing flexibility to address on-the-ground implementation issues.

B. Legacy Standard

In harvest units greater than 20 acres within VCUs identified in Section D, leave 30 percent of the entire unit (based on area) in legacy forest structure. For the purpose of this standard, the unit is defined as the original Logging System/Transportation Analysis (LSTA) boundary prior to field verification. Legacy forest structure should remain indefinitely after harvest and shall be tracked through the life of the next stand. Salvage logging of legacy trees is generally prohibited unless the rationale is clearly documented and the effects are clearly neutral or an improvement.

C. Distribution and Composition of Legacy Forest Structure

Legacy forest structure should be arranged primarily in clumps. The intent of leaving legacy forest structure is to provide structure within the opening; therefore, clumps should be left well inside the unit, compatible with logging system capabilities. Clumps may be placed along the external yarding boundaries within harvest units in situations where cable logging systems make leaving residual trees in other parts of the unit impractical due to operational or safety considerations. Structure left within units for other resources counts towards the 30 percent, provided it meets the old growth stand characteristics below. Mapped TTRA stream buffers do not count toward the 30 percent. Legacy forest structure shall be representative of the existing old-growth stand characteristics, including age, size class, species composition, and structural components. Clumps and dispersed retention trees should include some of the largest, oldest live trees, decadent or leaning trees, and hard snags occurring in the unit.

D. VCUs where the Legacy Standard Applies

This standard is to be applied in VCUs where 33 percent or more of the productive old growth has been harvested from 1954 to 2005, or VCUs where less than 33 percent has been harvested but more than 67 percent of the productive old growth is projected to be harvested by the end of the Forest Plan planning horizon (see glossary). In 2008, there were 49 VCUs in this category; they are listed below by Ranger District:

Craig Ranger District 6100, 6200, 6210, 6240
Hoonah Ranger District None
Juneau Ranger District None
Ketchikan/Misty Ranger District 7360, 7380, 7560
Petersburg Ranger District None
Thorne Bay Ranger District 5320, 5350, 5371, 5380, 5390, 5440, 5450,
5460, 5500, 5542, 5550, 5560, 5570, 5580,
5590, 5600, 5610, 5620, 5700, 5710, 5720,
5790, 5810, 5830, 5840, 5850, 5860, 5871,
5872, 5880, 5900, 5972
Wrangell Ranger District 4550, 4570
Sitka Ranger District 2930, 2990, 3070, 3120, 3130
Yakutat Ranger District 3620, 3640, 3670

Legacy Standards and Guidelines do not apply in other VCUs because they contain enough old-growth forest to provide habitat for old-growth associated species. See Appendix D in the 2008 FEIS. VCUs should be verified during project-specific planning and analysis to see if Legacy Standards and Guidelines apply based on the criteria above.

(USFS 2016 Plan, pp. 4-86 to 4-87)

Reserve Tree/Cavity-Nesting Habitat

The Reserve Tree/Cavity-Nesting Habitat Standards and Guidelines (USFS 2016 Plan, p. 4-87) were originally included in the 1997 Forest Plan to provide for a wide range of cavity-dependent species. Language was added to element A in 2008 acknowledging that the (then new) legacy forest structure standard and guideline considered snags and replacement snag needs, and that retention in corridors and reserves would also provide snags.

V. Reserve Tree/Cavity-Nesting Habitat

A. Provide habitat for cavity-nesting wildlife species. The legacy forest structure standard and guideline considers snags and replacement snag needs for those VCUs at risk for not providing sufficient snags within the watershed. Other VCUs will have snags retained within the development LUDs because habitat will be maintained in riparian buffers, the beach fringe, old-growth habitat reserves, and other Non-development LUDs within the VCU.

1. Retain reserve trees in all LUDs.

a) Retain reserve trees (which may be soft or hard snags) with a reasonable assurance of windfirmness, while meeting management objectives and considering safety needs for people and equipment. Use the Reserve Tree Selection Guidelines (R10-MB-215) for guidance.

b) Reserve trees do not need to be evenly distributed; clumped distributions are preferred.

c) Favor saving reserve trees away from roads to reduce loss from firewood gathering activity.

d) After timber harvest in an area, remaining reserve trees may be designated as wildlife trees and marked to make them illegal for cutting.

e) Retain live trees for future reserve tree recruitment.

(USFS 2016 Plan, p. 4-87)

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Endemic Mammals of the Alexander Archipelago

Natalie G. Dawson, Stephen O. MacDonald
and Joseph A. Cook

...should civilized man ever reach these distant lands, and bring moral, intellectual, and physical light into the recesses of these virgin forests, we may be sure that he will so disturb the nicely-balanced relations of organic and inorganic nature as to cause the disappearance, and finally the extinction of these very beings whose wonderful structure and beauty he alone is fitted to appreciate and enjoy.

Alfred Russell Wallace (1869)

During the last few decades, wildlife management and conservation across the Tongass National Forest has primarily focused on establishing priorities for the remaining old-growth forests (Samson et al. 1989, U.S. Forest Service [USFS] 1997), evaluating potential benefits of second-growth (Hanley 2005, Hanley et al. 2005), and managing old-growth affiliated species and charismatic species of economic or recreational importance. Largely neglected in current management and conservation priorities for the Tongass are the individual nature of islands, the biotic complexity within and across the islands, and most importantly, the endemic organisms found only within this archipelago (Fig 1).

FIG 1. Aerial view of southwestern Prince of Wales and adjacent islands in the southern Alexander Archipelago of southeastern Alaska. Many endemic species and subspecies are known to inhabit this archipelago but the inventory of endemics is far from complete. (John Schoen)

THE DEFINITION OF AN ENDEMIC

An endemic is a distinct, unique organism found within a restricted area or range. A restricted range may be an island, or a group of islands, and in the case of some endemic mammals within the Alexander Archipelago, a restricted region such as the North Pacific Coast.

The term "endemism" holds special importance on island systems, because many organisms are restricted in distribution to a single island or groups of islands. For example, of the known bird species throughout the world, 20% are considered "island endemics" because they are found only within island systems (Frankham 1998). The North Pacific Coast is a hot spot for endemism (Cook and MacDonald 2001; Cook et al. 2006) because of its historical isolation, ecological complexity, and narrow distribution between the Pacific Ocean and coastal mountain ranges. Within Southeastern Alaska (Southeast), almost 20% of known mammal taxa (species and subspecies) have been described as endemic to the region (MacDonald and Cook 1996). The long-term viability of these endemic populations is unknown, but of increasing concern.

Island endemics are extremely susceptible to extinction because of restricted ranges, specific habitat requirements, and sensitivity to human activities such as species introductions (Soule 1983). They usually experience high rates of inbreeding resulting from small population sizes and therefore suffer from the consequences of reduced genetic variation (Frankham 1998, Brown and Lomolino 1998). Finally, the land masses of islands are smaller than those of nearby continents, and are more susceptible to random climatic events (such as storms) or massive habitat disruption (Reichel et al. 1992). More than 81% of mammalian extinctions in the last 500 years have been insular, endemic mammals (Ceballos and Brown 1995). Islands, which tend to harbor extremely high biodiversity concentrated in a relatively small area, may be major driving forces in diversification and ultimately speciation. Therefore, archipelagos are essential to maintaining and increasing global biodiversity (Emerson and Kolm 2005, Filardi and Moyle 2005). It is impossible to measure the current susceptibility of endemics within the Alexander Archipelago because little information is known about their occurrence, distribution, population sizes, and vulnerabilities. Current research on endemics throughout the Alexander Archipelago is primarily focused on mammals, but should include other organisms. The number of endemic plants, birds, amphibians, and invertebrates are not known for this archipelago. Because mammals often have the lowest percentage of endemics within an island system (World Conservation Monitoring Centre 1992), other organisms may show much higher levels of endemism within the Alexander Archipelago.

ENDEMICS IN SOUTHEASTERN ALASKA

Early explorers and naturalists identified the Alexander Archipelago as a distinctive geographic region, the "Sitkan District" (Nelson, 1887; Swarth 1911, 1936). Distinctive organisms were described on several islands in the archipelago even though fewer than 25 islands were visited. Some endemics were described from only one specimen found on one island (for example, Suemez Island ermine *[Mustela erminea seclusa])* while others were described from multiple islands *(M. erminea celenda* on Prince of Wales [POW], Dall, and Long islands). Altogether, 24 of 107 mammal taxa were recognized as endemic based on morphological characteristics (MacDonald and Cook 1996). Recent technological advances provide independent perspectives on these endemics based on molecular genetic characters. Many of these new techniques provide a more rigorous assessment of levels of divergence among island endemics and mainland populations than the early surveys described above. These new approaches successfully evaluated the status of endemics on archipelagos elsewhere across the globe (Heaney et al. 2005) and now are being applied to endemics within the Alexander Archipelago (Table 1 on page 11). Molecular studies have uncovered hidden diversity and are providing new insight into the status of island populations as endemics. Eight endemic mammalian lineages have been identified within the Alexander Archipelago. More mammals and a suite of other organisms need to be examined to paint a more accurate picture of all endemics within the Alexander Archipelago.

DESCRIPTIONS

Ermine

Ermine are small carnivores distributed across the Northern Hemisphere from Europe and Asia to North America. Five subspecies were originally described within Southeast (Hall 1951). Long considered one species, new molecular studies within the Alexander Archipelago have identified three distinct lineages within Southeast. These three groups may represent distinct species of ermine. One group, the "island" group has been found on only a few islands in the Alexander Archipelago and on Haida Gwaii (the Queen Charlotte Islands) in nearby British Columbia (Fleming and Cook 2002), where they are currently listed on the Canada List of Threatened and Endangered Species (Committee on the Status of Endangered Wildlife in Canada 2005). Current investigations are focused on measuring the geographic extent of this island clade (related taxonomic group), and the level of divergence within the other two lineages of ermine found within Southeast. Because the region is the only site worldwide that hosts all three distinctive ermine, it supports a large portion of the genetic diversity for this species (or set of species).

Marten

Using molecular techniques, researchers detected two distinct types of marten within the Alexander Archipelago, *Martes americana* (American marten) and *M. caurina* (Coastal marten). These two distinctive species were originally described as separate species (Merriam 1890) but later were reclassified as separate subspecies based on apparent introgression of morphological characters (Wright 1953). Molecular studies indicate that these two marten are distinct species (Carr and Hicks 1997, Small et al 2003, Cook et al. 2006). Both species of marten currently co-occur only on Kuiu Island within the archipelago (Fig 2). The coastal endemic marten are also found on Admiralty Island. These molecular studies also suggest that the Coastal marten found on Admiralty and Kuiu islands are genetically distinct from each other and from other populations of Coastal marten found farther south along the coast. This distinctive signature reflects long-term isolation of these endemic populations on these islands. Indeed, a recent examination of genetic variation in a parasitic nematode of marten (*Soboliphyme baturini*) indicates the presence of coastal marten on Chicagof Island prior to the introduction of American marten by humans (Koehler 2006). This limited distribution likely reflects a significant reduction in the former range of this coastal endemic.

In contrast, American marten have gone through a recent range expansion into Southeast (Small et al. 2003) and were subsequently introduced by humans to a number of islands across the Alexander Archipelago (Fig 2). Current investigations are focused on quantifying different levels of endemism, and characterizing potential hybridization between the two marten species within Southeast (N. Dawson, University of New Mexico, unpublished data).

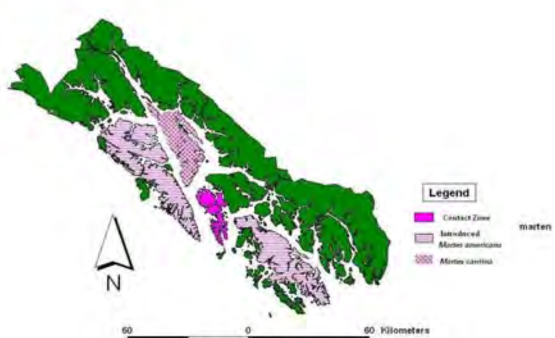

FIG 2. Map of coastal marten (*Martes caurina*) and introduced populations of widespread, American marten *(Martes americana).*

Black Bear

Two subspecies of black bear were described based on morphology within the Alexander Archipelago. *Ursus americanus pugnax* is a distinct subspecies found along the North Pacific Coast, including the Alexander Archipelago (based on 12 specimens by Swarth 1911).

Recent molecular studies (Stone and Cook 2000, Peacock 2004) also define two lineages of black bears: a continental lineage that recently entered the Alexander Archipelago after the last glaciation and an older (pre-last glacial) coastal lineage of black bears. Both lineages co-occur on several islands in the Alexander Archipelago (Peacock et al. in review), and low levels of hybridization do occur between lineages (Peacock 2004). Further investigation is needed to characterize the extent and dynamics of hybridization of these distinctive black bears in Southeast.

Northern Flying Squirrel

The northern flying squirrel *(Glaucomys sabrinus)* has been found on 15 islands within the southern half of the Alexander Archipelago (south of Frederick Sound). Historically, a distinct subspecies of flying squirrel *(G. sabrinus griseifrons)* was described for POW Island (Howell 1934) based on two specimens. Additional specimens from nearby islands, combined with recent molecular research, corroborate the distinctiveness of this endemic flying squirrel (Demboski et al 1998a, Bidlack and Cook 2001; Bidlack and Cook 2002) on 11 islands within the POW Island complex. This squirrel is the only island endemic within the Alexander Archipelago to be listed as endangered by the International Union for the Conservation of Nature (IUCN) and previously was considered a Category II subspecies *(Glaucomys sabrinus griseifrons)* by the U.S. Fish and Wildlife Service (Demboski et al. 1998b).

Brown Bear

Two distinct brown bear *(Ursus arctos)* lineages exist in Southeast: brown bears of the ABC (Admiralty, Baranof, and Chichagof) islands and mainland populations of brown bears (Talbot and Shields 1996a, 1996b). The ABC brown bear population represents an ancient and unique lineage that apparently separated from other brown bear populations approximately 550,000–700,000 years ago. The antiquity of the ABC bears also supports the hypothesis that portions of the Alexander Archipelago encompassed a nonglaciated refugium during the Wisconsin glaciation (Heaton et al. 1996, Talbot and Shields 1996b). Paetkau et al. (1998) determined that the Baranof and Chichagof island populations are distinct from the Admiralty Island population of brown bears.

Alexander Archipelago Wolf

The distinctive Alexander Archipelago wolf *(Canis lupus ligoni)* was first described by Goldman (1944) as a subspecies of the widespread North American gray wolf *(C. lupus)*. Investigations have uncovered distinctive ecological and behavioral adaptations within the endemic wolf, such as feeding habits that differ from other wolf populations within North America (Szepanski et al. 1999). Recent molecular studies have confirmed the unique genetic insularity of *C. l. ligoni* and have illustrated the presence of this endemic wolf throughout the southern Alexander Archipelago and along the coastal mainland (Weckworth et al. 2005). This endemic wolf is divergent from all other North American wolves (Weckworth et al. 2005), and Southeast populations retain a significant portion of the genetic variation found among all extant wolf populations in North America.

Dusky Shrew

Five subspecies of dusky shrew *(Sorex monticolus)* are currently recognized in Southeast (Hall 1981, Alexander 1996). One of these, *S. m. malitiosus*, is known only from Warren and Coronation islands. However, as pointed out by Alexander (1996), further analysis is needed to clarify the status of the dusky shrews from the coastal islands of Southeast, including Forrester Island, and British Columbia. Using molecular techniques, only two distinct lineages (highly divergent and likely representing separate species) occur within Southeast: a coastal clade (Glacier Bay south to coastal Oregon) and a continental clade (upper Lynn Canal and Yakutat, as well as elsewhere in Alaska and western Canada southward) (Demboski and Cook 2001).

Other Endemics

The Keen's mouse *(Peromyscus keeni)* has several endemic forms within Southeast (Table 1) with an especially deep lineage found on Gravina Island (Lucid and Cook 2004). Similarly, five species of bats have been recorded within Southeast (MacDonald and Cook 1999). Of these, only *Myotis lucifigus* has been examined genetically and Southeast populations represent a new species endemic to the region, *M. alascensis* (Baker et al. 2003; T. Dewey, University of Michigan, Ann Arbor Michigan, personal communication 2005). Of the other endemic mammals (Table 1), none has been reevaluated with molecular tools. These endemics include the Glacier Bay hoary marmot *(Marmota caligata vigilis)*, restricted to Glacier Bay National Park, and an endemic beaver *(Castor canadensis phaeus)* and meadow vole *(Microtus pennsylvanicus admiraltiae)*, found only on Admiralty Island.

HISTORICAL COMPLEXITY

Genetic analyses of endemic mammals within Southeast also provide a framework for deciphering the historical processes that drove the formation of the temperate rainforest ecosystem. Reconstruction of the past histories of individual species has identified routes of colonization into this coastal region and approximate times when particular species colonized Southeast. The trans-coastal river systems (such as Stikine and Taku rivers) were major historical colonization routes, and are currently critical corridors for faunal exchange between interior and coastal populations (Fig 3). Evidence of movement down these natural corridors includes recent colonization into the region by moose *(Alces alces)*, and possibly fisher *(Martes pennanti)* and cougar *(Puma concolor)*.

FIG 3. Aerial view looking up the mouth of the Stikine River. The Stikine River is one of the major transboundary rivers of southeastern Alaska and a major colonization route from interior to coastal regions. (John Schoen)

Evidence of colonization is also recorded in the molecular genetic variation of species within Southeast. Coastal lineages have persisted for a long time and have characteristic genetic signals, whereas continental lineages represent recent colonizers (Cook et al. 2001, Cook et al. 2006). These shared patterns illustrate the influence of a complex geologic history of the region on the structure of biotic diversity and periods of recolonization after glaciations. Mammals that have a deep history in the region (and therefore are of great conservation concern) can be distinguished from those that are recent (<12,000 years old). For example, black bear have been found deep in the fossil record (Heaton and Grady 2003), and these likely reflect the coastal lineage that is found in the Alexander Archipelago and farther south along the North Pacific Coast. In contrast, the Alexander Archipelago wolf is a recent colonizer, arriving in the last 10,000 years (Weckworth et al. 2005).

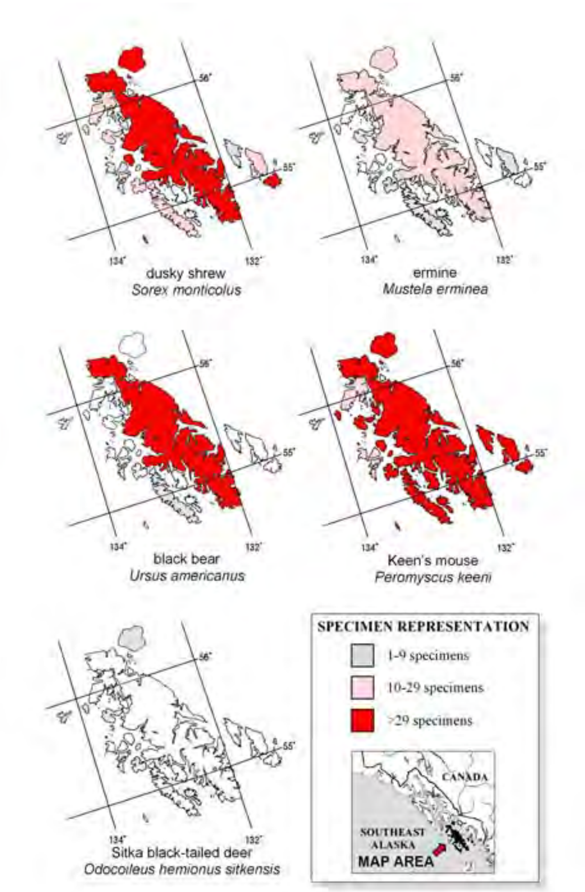

FIG 4. Number of specimens for 5 mammals found on Prince of Wales and nearby islands in the southern Alexander Archipelago.

ISLAND BIOGEOGRAPHY

Mammalian species within the Alexander Archipelago are currently distributed according to both area and isolation (Conroy et al 1999). Endemic organisms within the Alexander Archipelago are not structured (nested) by area or isolation, meaning that neither the distance from the island of occurrence to the mainland, nor the size of the island, explains their distributions (N. Dawson, University of New Mexico, unpublished data). Therefore, management decisions cannot simplistically assume that protecting islands of a particular size or generalized location will account for the phenomenal diversity of endemics found in this archipelago. An incomplete understanding of endemic lineages will miss significant components of structure and diversity.

From review of mammalian distributions, five biogeographic provinces within the Alexander Archipelago have been proposed (MacDonald and Cook 1996; Cook et al. 2006). These biogeographic provinces were reevaluated with the use of information about endemic organisms, and clear patterns began to emerge (Fig 4). For example, a majority of endemic organisms within the Alexander Archipelago are restricted to southern outer islands such as POW, which also has one of the longest and most complete fossil records of any of the islands across the archipelago (Heaton and Grady 2003). POW may have been a refugial region during the last glaciation (~12,000 years before present) (Carrara et al 2003), and the incredible endemic diversity on this complex of islands (Kondzela et al. 1994, Dickerman and Gustafson 1996) likely reflects the long-term isolation of these organisms. Community assemblages and geological history are comparable to nearby Haida Gwaii, which has also been described as a possible refugium during the last glacial period (Byun et al. 1997).

OLD-GROWTH FOREST ASSOCIATION

Some endemic mammals have clear associations with old-growth forests (Fig 5). For example, the marten requires expanses of old-growth because it

FIG 5. The structural characteristics of old-growth forest include: uneven-aged trees of variable size, multiple canopy layers, dominant trees > 300 years old, dead and down trees with large-diameter snags, productive understory plant communities, arboreal lichens, and structural diversity both vertically and horizontally across the stand. (John Schoen)

needs large stumps and tree hollows for denning (Chapter 6.5). Within Southeast, it spends most of its time in forested habitats. The marten has been characterized as an old-growth-restricted mammal across North America (Buskirk and Ruggiero 1994, Thompson and Harestad 1994). None of the previous ecological research on marten in Southeast has focused on the Coastal endemic marten found on Kuiu Island and Admiralty Island (Flynn and Schumacher 2001). Ecological and behavioral differences may exist between the two marten species with regard to use of old-growth forests and tolerance of disturbed areas such as roadsides (N. Dawson, University of New Mexico, unpublished data). Black and brown bears are also associated with old growth, particularly riparian forests with salmon spawning streams (Chapter 6.2, 6.3). The flying squirrel relies on old-growth habitat for denning sites (Bakker and Hastings 2002) and for the abundance of fungi and lichen associated with old trees (Kiester and Eckhardt 1994) (Chapter 6.6). It is usually found in highest densities within old-growth stands (Carey 1995).

Old-growth and riparian areas are especially important to bat species (Parker et al 1996). Second-

FIG 6. Characteristics of second-growth forests in southeastern Alaska include: even-aged trees of similar size, dense single-layered canopy cover with little sunlight penetration to the forest floor, limited understory plant community, no large diameter snags, few arboreal lichens, and low structural diversity. (John Schoen)

growth does not provide suitable habitat for these organisms, and dense 30–90 year old second-growth is unproductive and supports relatively low vertebrate diversity (Schoen et al. 1988) (Fig 6).

MAMMALS AS MODELS

Most of the information on endemic organisms across the Alexander Archipelago has been limited to mammals. Only 5% of all recorded extinctions on islands worldwide have been mammals, compared to 30% of all insect species on islands and 20% of island bird species (World Conservation Centre 1992). Therefore, extinction probabilities within the Alexander Archipelago may be much higher for plants, birds, and other organisms. One way to evaluate potential areas of highest concern is to use the current information on endemic mammals to project important areas of endemism for other organisms. For example, based on genetic data from ermine, flying squirrels, and wolves (Bidlack and Cook 2001, Fleming and Cook 2002, Weckworth et al. 2005), POW and nearby islands are distinct. This pattern of high endemism occurs in other organisms. Preliminary studies of grouse (*Dendragapus* sp.) (Dickerman and Gustafson 1996) and salmon (*Oncoryhnchus* sp.) (Kondzela et al. 1994) also indicate that the POW Island complex is a "hot spot" of endemism. Corresponding "hot spots" of endemism for multiple taxa may occur throughout other islands across the archipelago (like Kuiu), but without investigations of multiple species, it is impossible to distinguish these patterns. Using mammal distributions as models, researchers can focus on certain regions with high potential for endemism.

ENDEMICS AND FOREST PLANS

The 1997 Tongass National Forest Land Management Plan (TLMP) (USFS 1997) lists the geographic, population, and habitat information for endemic mammals as important "information needs." During the TLMP Risk Assessment Panel process, one panel was specifically assigned to "other mammals – endemics" to evaluate the impact of various forest plans based on information that was available for endemic mammals in the mid-1990s. Although

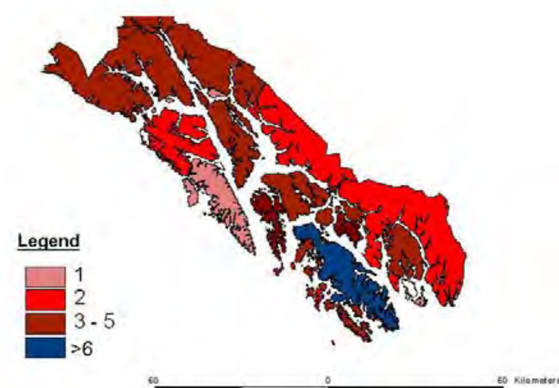

FIG 7. Map of endemic mammals across Alexander Archipelago (relative densities based on number of endemic lineages found on each island). High concentrations of endemics suggest that Prince of Wales Island is a hot spot of biodiversity.

endemics were addressed in the final TLMP (USFS 1997), a specific research and monitoring agenda was never developed. For example, rigorous surveys of endemic mammals (or other organisms) have yet to be implemented before preparing environmental impact statements for individual timber sales. Without adequate surveys of each island within the Alexander Archipelago, conclusive range maps cannot be produced. At this time, even the most common species have been minimally inventoried (Fig 7). Conclusive geographic ranges of many endemics cannot be produced because such a small portion of islands within the Alexander Archipelago have been at least minimally surveyed (~127 out of >2,000 named islands) or taxonomically reevaluated. Extensive habitat information for endemic mammals within the Alexander Archipelago is not available, and extrapolating ecological relationships from other systems, particularly those on the mainland should be done cautiously. Endemic mammals were listed as a priority in the TLMP (USFS 1997), but lack of a formal survey plan for endemic mammals has stalled efforts to evaluate their status.

Wildlife managers and conservation organizations are beginning to recognize the importance of endemic mammals (Smith 2005), but all efforts have suffered from lack of a management plan that is specifically centered on island systems (Samson et al. 1989). Endemics also have been included in subsequent forest plan revisions since the 1997 TLMP. Although roadless area designations and subsequent redesignations have attempted to include information on endemic mammals and the important role they played in the development of the 1997 TLMP (Johnston 2000), the plan offered no suggestions for roadless designations based on this information.

CONSERVATION IMPLICATIONS

> *Lest those islands still seem to you too remote in space and time to be relevant to our modern societies, just think about the risks... of our increasing globalization and increasing worldwide economic interdependence.*
>
> Jared Diamond

Global Significance

Across the globe, a number of areas of endemism have been identified as biodiversity hot spots (Myers et al. 2000), regions with disproportional numbers of endemic taxa under increasingly great development pressures. At this time, the Tongass National Forest is not recognized as a biodiversity hot spot because little attention has focused on the insularity of the region. Elsewhere (such as Chile) temperate rainforest systems have been identified as biodiversity hot spots. The POW Island complex is a center of endemism for the Alexander Archipelago, a finding with profound implications for management. In the last five decades, POW Island was extensively logged, leaving the greatest road infrastructure of any island (more than 2,500 mi [4,020 km] of roads) in the archipelago. POW is also the site of highest endemism. Therefore, the islands that should be designated biodiversity hot spots have instead experienced some of the greatest habitat alteration of any area within the Tongass. Careful delineation of centers of endemism would provide managers and conservation organizations with a foundation for establishing priorities for protecting specific islands, or in the case of POW, reducing further timber harvest and fragmentation caused by roads.

Managing a Land in Pieces (a Highly Fragmented Archipelago)

The inclusion of endemics in management plans for the Tongass National Forest will require developing an island-centered scheme, one that focuses on the individuality of islands instead of a single forest system. Patterns of endemism indicate the potential for substantial differences between geographically close islands (Fig 4). For example, Kuiu Island has few marten (Flynn et al. 2004, N. Dawson, University of New Mexico, unpublished data), but nearby Admiralty Island harbors very healthy marten populations. Flying squirrels on POW are morphologically (Howell 1934), genetically (Bidlack and Cook 2001), and ecologically distinctive (Pyare et al. 2002) from mainland flying squirrels and should be recognized as such when managers evaluate their status within Southeast (Winston and Nichols 2003). Individual islands harbor distinctive combinations of prey (such as small rodents) and predators. Substantial differences among islands, such as fluctuations in population numbers, are characteristic of this naturally fragmented landscape. Several important features of insular systems need to be addressed to properly manage and conserve the highly productive biomes of the Tongass:

1. Introductions of exotic species/diseases to islands within the Alexander Archipelago and their effects on native populations and functional ecosystems.

2. Increasing human disturbance on an already fragmented landscape. For example, some islands experience very heavy human use because of roads, towns, and tourism. Other islands do not have those same pressures.

3. Natural fragmentation of islands. Some islands are close to the mainland and have lots of species of mammals; other, remote islands have different species assemblages and often more endemics.

4. Scales of disturbance. The level of disturbance on one island does not constitute the same measure of disturbance on another island. For example, spraying herbicides across a small area of POW Island is very different from spraying herbicide across that same size of land on Long Island.

Endemic mammals provide a framework for initiating an individual-island management scheme. Preliminary investigations support the conclusion that the POW Island complex, Kuiu Island, and Admiralty Island are particularly important places for endemic mammals, and should be accorded additional protective measures. Further inventories of endemic organisms of all major taxonomic groups should become a priority for the Tongass National Forest. It is suspected that patterns of endemism reflected in the mammals may be even stronger in other species throughout the archipelago.

The Alexander Archipelago is slowly being recognized as a highly insular, ecologically distinct island archipelago (Hanley et al. 2005) that is facing many of the same management challenges and conservation concerns as other island archipelagos, such as the Galapagos and Hawaiian Islands. Researchers call the Queen Charlotte Islands to the south of Dixon Entrance “the Canadian Galapagos” (Vaillant 2005) because of their rich diversity and island-centered biogeographic structure. The Alexander Archipelago is no less an ecological and evolutionary focal area and constitutes a hot spot for endemism along the North Pacific Coast. With collaborative efforts among government agencies, independent researchers, community organizations, and nonprofits groups, the Tongass National Forest can be managed effectively as a highly fragmented island system. It has the potential to become a model system for future island-management plans across the globe as the major conservation concerns on island archipelagos become increasingly prominent in scientific research, resource management, and conservation.

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TABLE 1. Endemic Mammals in Southeast Alaska (original Taxa names based on morphological descriptions)

*Distinct lineage column refers to the species/subspecies across Southeast Alaska and may encompass more/other islands than those listed in Distribution column. Distinct lineages are defined as CNT=Continental lineage, BER=Beringian lineage, and ISL=island lineage.

**Not originally described as endemic, but later identified as endemic through molecular analyses.

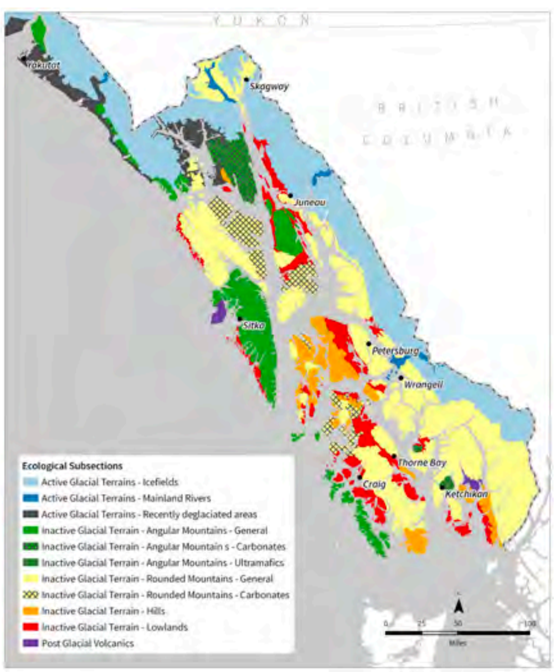
Taxon	Distribution	N	IUCN Status	Distinct lineage*	Nuclear DNA	MtDNA
Sorex monticolus malitiosus	**Warren I., Coronation I.**	**21**		**Y**	**N**	**Y**
Sorex alaskanus	**Glacier Bay**	**2**		**?**		
Marmota caligata vigilis	**Glacier Bay**	**8**	**DD**	**?**		
Tamiasciurus hudsonicus picatus	**Southeast Alaska**	**36**		**?**		
Glacomys sabrinus griseifrons	**Prince of Wales I.**	**2**	**EN**	**Y**	**Y**	**Y**
Castor canadensis phaeus	**Admiralty I.**	**6**	**DD**	**?**		
Peromyscus keeni hylaeus	**Alexander Arch., coastal mainland**	**163**		**?**		**Y**
Peromyscys keeni oceanicus	**Forrester I.**	**2**		**?**		**Y**
Peromyscus keeni sitkensis	**Baranof I.,Chichagof I., Warren I., Duke I., Coronation I.**	**54**		**?**		**Y**
Clethrionomys rutilus glacialis	**Glacier Bay**	**18**		**?**		
Clethrionomys gapperi stikinensis	**Stikine River Delta, Cleveland Pen.**	**29**		**?**		
Clethrionomys gapperi solus	**Revillagigedo I.**	**31**	**DD**	**?**		
Clethrionomys gapperi wrangeli	**Wrangell I., Sergief I., Stikine River Delta**	**13**		**?**		
*Martes caurina***	**Admiralty I., Kuiu I.**	**110**		**Y**	**Y**	**Y**
Microtus pennsylvanicus admiraltiae	**Admiralty I.**	**53**		**?**		
Microtus oeconomus sitkensis	**Baranof I., Chichagof I.**	**10**	**DD**	**N**	**Y**	**Y**
Microtus longicaudus coronarius	**Coronation I., Warren I., Forrester I.**	**22**	**DD**	**Y**	**N**	**Y**
Canis lupus ligoni	**Southeast Alaska**	**27**		**Y**	**Y**	**Y**
Ursus americanus pugnax	**Southeast Alaska**	**9**		**Y**	**Y**	**Y**
Mustela erminea alascensis	**Coastal Mainland**	**24**	**DD**	**Y (CNT)**		**Y**
Mustela erminea initus	**Baranof I., Chichagof I.**	**6**	**DD**	**Y (BER)**		**Y**
Mustela erminea celenda	**Prince of Wales I., Long I., Dall I.**	**25**	**DD**	**Y (ISL)**		**Y**
Mustela erminea salva	**Admiralty I.**	**26**	**DD**	**Y (BER)**		**Y**
Mustela erminea seclusa	**Suemez I.**	**1**	**DD**	**Y (ISL)**		**Y**
Mustela vison nesolestes	**Alexander Archipelago**	**3**		**N**		

Example of Need for Change and incomplete analyses in the draft Terrestrial Ecosystem assessment chapter

The ecological subsections of Southeast Alaska (Nowacki 2001) are not the correct way to ecologically stratify the landscape based on more recent research results. These subsections are based on geology, terrain and physiology, but do not reflect the biotic compositions on the Tongass National Forest. The 1997 Tongass National Forest Land and Resource Management Plan (TLMP) also used these subsections, but subsequent research indicates that when examining the Tongass National Forest, it is most important for the persistence of species, to focus on "island biogeography" stratification of the national forest, which sits wholly within the Alexander Archipelago.

Figure 1 illustrates the biogeographic subregions based on 30 years of research compiled. In these research results, we have indicated that some islands act as "sources" and others as "sinks", in other words, animals and plants migrate between islands, but not always in both directions. In addition, because this is an island archipelago, islands that are more distant from mainland, are thus more "isolated" – and this "isolation by distance" creates additional vulnerability in species because they are more isolated from any other nearby population.

The 11 "higher groups" is not an accurate analysis for the terrestrial ecosystems in the Tongass National Forest. Again, this kind of geologic and physiographic lumping may be sufficient for a contiguous national forest in some other part of the United States, but creates a false sense of unification for the ecosystems of the Tongass National Forest. Below, I provide a specific example of how this is an inadequate analysis of ecological regions.

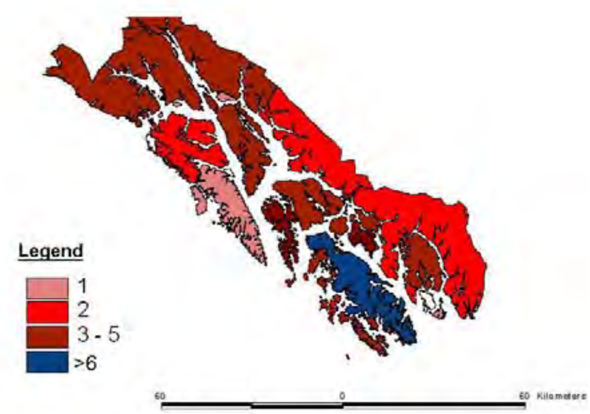


Inaccuracies in lumping these 11 categories (examples):

Category 1 – active glacial terrains – lumps the entire Coast range into one unit, without indicating the individual drainages (migration corridors) and separation of each of these corridors from each other by significant icefields, which will act as barriers to any north-south movement for wildlife and plant species colonization within the archipelago.

Category 2 – active glacial terrains – mainland rivers – the map does not adequately reflect the multiple transboundary river systems along the Coast range, and instead, for some reason, only highlights the Stikine, Taku and Chilkat. This category should actively reflect all the transboundary rivers that flow from the various ice sheets into the ocean waters of Southeast Alaska in order to adequately reflect much of the salmon habitat. However, this alone cannot reflect the species assemblage differences in each of these mainland river corridors. Salmon habitat could be used as a proxy for identifying ecological units that would be much more accurate than just lumping them together because they are all close to ice.

An example of a different way to group islands and mainland localities would be to examine boundaries based on known exchanges and assemblages of flora and fauna across the region.



This is a map of endemic mammals across Alexander Archipelago (relative densities based on number of endemic lineages found on each island). High concentrations of endemics suggest that Prince of Wales Island is a hot spot of biodiversity from Dawson et al. 2007. This map illustrates a different way to group different islands together using biogeographic information instead of physiographic information.