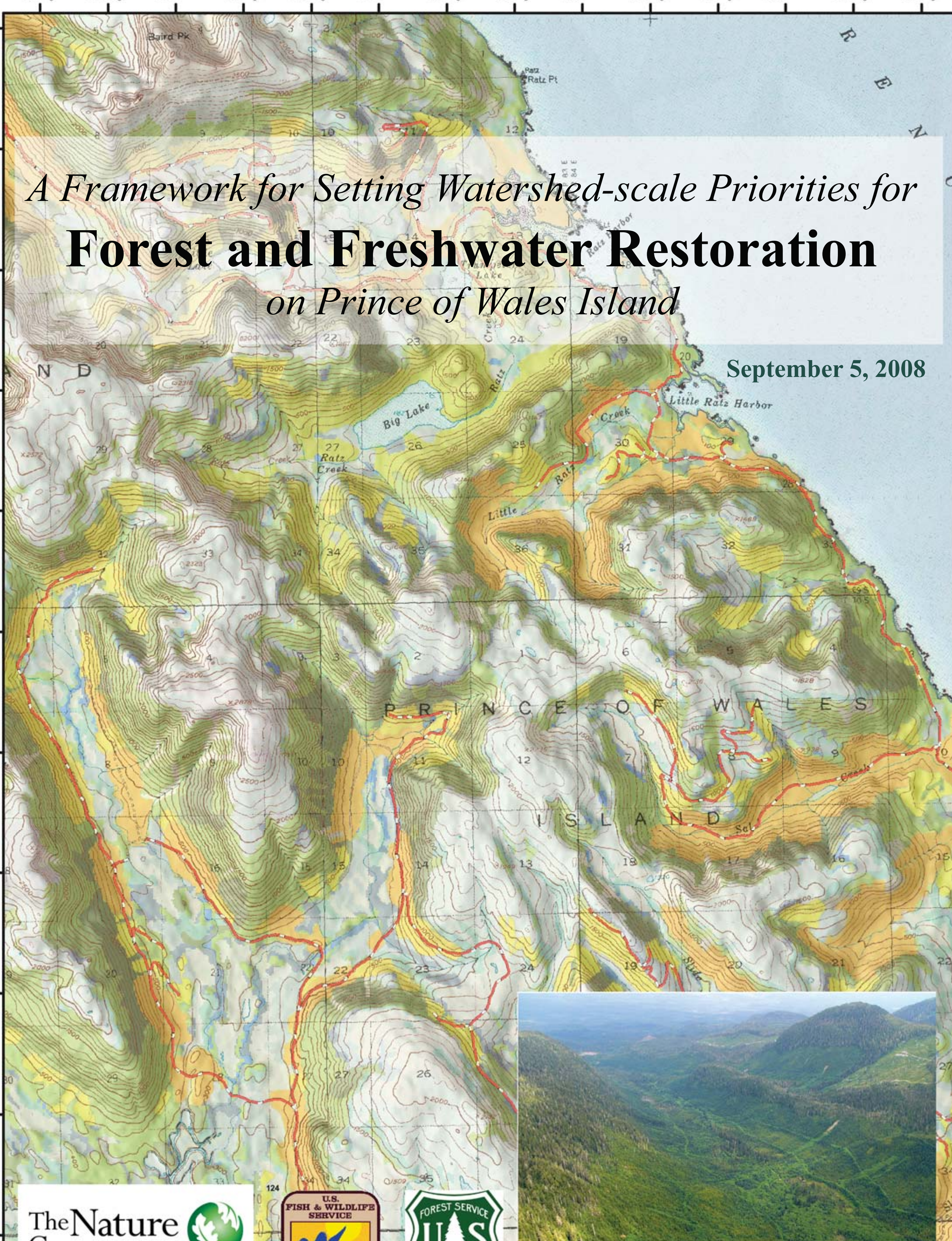
A Framework for Setting Watershed-scale Priorities for

Forest and Freshwater Restoration

on Prince of Wales Island

September 5, 2008



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U.S. Fish & Wildlife Service

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Summary

The purpose of this project has been to develop and implement a systematic framework for prioritizing investment in restoration activities among watersheds on Prince of Wales Island. For the purposes of this report, restoration is defined as the process of reestablishing a self-sustaining habitat that in time can come to closely resemble a natural condition in terms of structure and function (Turner and Streever 2002). The Nature Conservancy's (TNC) methodology involved development of a consensus approach to priority setting, inclusion of the best available science and previous efforts, and a transparent decision framework that can be used across a mix of land ownerships. While this framework is designed specifically for Prince of Wales Island, it can be generalized to evaluate priorities throughout Southeast Alaska.

Using available GIS data, we developed criteria and ecological indices within both freshwater and terrestrial ecosystems for *biological value*, *watershed condition* and *opportunity for leveraging resources*. In the freshwater environment, we estimated biological value based on the number of species and distribution of salmonids in each watershed. In the terrestrial environment, we evaluated the relative abundance and condition of primary winter range for Sitka black tail deer, as well as the relative effort in subsistence hunting and harvest of deer among watersheds. Watershed condition (*need* for restoration) was evaluated based on a variety of measures, including forest condition (% of productive forest in old growth condition) within the riparian zone and on primary winter range for Sitka black-tailed deer, road density and number of culverts blocking fish passage. Opportunity for leveraging resources refers to additional factors affecting the likelihood of success, including logistics, partnerships, economic opportunity, existing research, etc. For our purpose, the availability of commercial-sized young-growth was included as a measure of opportunity for economic return in forest restoration treatments.

We describe watersheds in three situations that can be considered high priority for restoration. The first set includes watersheds with very high biological and / or social values that contain mid-to-high levels of modification of important ecological systems and functions. Based on the biological or social values, these watersheds are considered to be "very high priority" for restoration. In the freshwater environment, these watersheds include Klawock River, Staney Creek, North and Central Thorne River, Harris River, Natzuhini Bay, San Alberto Bay Frontage and Hetta Inlet (Fig 11). In the terrestrial environment, these include Staney Creek, POW - Sea Otter Sound Frontage, Luck Point to Forest Cove, Heceta Island and Eagle Creek / Luck Lake (Fig 12). Priorities based on surface karst features include Survey Creek, Trout Creek, and Sea Otter Sound – all located on Kosciusco Island, Twin Island Lake, Tuxekan Island, East El Capitan Passage, and Neck Lake (Fig 13).

A second set of watersheds were considered a high priority for investment as a result of high levels of modification. Potential candidate watersheds in this category include Survey Creek, Twelvemile Creek, Gravelly Creek, Maybeso Creek, Ratz Creek, Harris River, Long Island, Luck Lake, Black Bear Creek, Kosciusko Island – Sumner Strait, and North Calder Bay. The ultimate priority of action on these sites may depend on site-specific factors and opportunities such as local partnerships and commercially viable young-growth wood products.

This report offers an example of a rapid, cost effective, stakeholder supported approach to prioritizing restoration investments. The ability to systematically evaluate and rank watersheds for investment, and the consensus that supports that ranking, will allow The Nature Conservancy, the Forest Service, Trout Unlimited, watershed councils, private landowners and other partners to be more effective stewards of the land on Prince of Wales Island and beyond.

I. Background

Introduction

In 2007, The Nature Conservancy completed a systematic assessment for the Coastal Forest Ecoregion in Southeast Alaska that provides a scientific basis for Conservancy activities and investments in the region (Albert and Schoen 2007a). This assessment was based upon a systematic characterization of habitat values for a suite of focal species and ecological systems, and an accounting of the extent to which these values are represented within the existing conservation areas under the Tongass Land Management Plan. Among the primary conclusions of this assessment was a recognition of the unique biodiversity and productivity associated with Prince of Wales Island (and neighboring islands), as well as the relatively intensive history of logging and road construction, and the expectation of these activities to continue into the future (Albert and Schoen 2007b). Thus, Prince of Wales was ranked as the highest priority for conservation investment, and we believe it provides an opportunity to catalyze both good conservation and sustainable economic solutions.

Prince of Wales Island is, in essence, a microcosm of the larger coastal forest region. Many of the resource issues common to the region as a whole are expressed on-the-ground on Prince of Wales Island. This is one of the richest and most productive areas in the forest, both in terms of fish and wildlife and timber potential. The North Prince of Wales biogeographic province, which constitutes most of the island, ranks highest for ecological values of all the 22 provinces in Southeast Alaska, containing more productive forest lands and rare, large-tree forests than any other province. With 11,250 miles of stream (including anadromous and resident fish), it also has more miles of salmon stream than any other province, and its karst resources are of international significance (Baichtal and Swanson 1996). Yet North Prince of Wales has also incurred greater than four times the amount of logging of any other island.

There are more towns and villages on Prince of Wales than any other island; it has an extensive network of roads, harbors, airports and ferries unlike any other island or mainland portion of Southeast Alaska. No other island has as many Native entities with land ownership and a significant stake in local resource management, including village corporations from other parts of Southeast Alaska. Communities on Prince of Wales are aggressively seeking ways of diversifying their forest management-based economies and wrestling with questions of how to balance tourism and other economic opportunities while maintaining residents' unique way of life.

In 2004 The Conservancy and the Tongass National Forest entered into a partnership to "…work together to achieve a balance of working forests, habitat reserves and sustainable communities for the benefit of people, fish and wildlife." The Conservancy's Prince of Wales Island Restoration Partnership was formed in 2005 with the goal to maintain functioning freshwater and terrestrial ecosystems within their natural ranges of variability. In 2007, The Conservancy convened a group of stakeholders to help design a systematic method for prioritizing watershed rehabilitation and restoration activities. More information on specific restoration projects throughout the Tongass National Forest can be found http://www.tongassfutures.net/working-groups/restoration .

Ecological systems

Prince of Wales Island is located within the temperate coastal western hemlock forest zone of North America (Baily 1980). Under natural conditions, the forest matrix is characterized by a diverse mosaic of tree ages and sizes with standing dead trees, trees with dead tops, multiple canopy layers, down woody debris and a diverse and abundant herb layer (Schoen et. al 1988, Capp et al 1992). Wind-throw is the primary mechanism of forest disturbance under natural conditions, and patterns of disturbance range from low intensity but high frequency events that create individual tree and small gap disturbances, to high intensity but low frequency catastrophic blowdown events. Moreover, ecological systems are further structured by hydrologic characteristics of soils, slope and geology that control how water flows or is retained within a watershed (Nowacki et al 2001). At this larger scale, upland old-growth forest is highly intermixed with wetland forest types, and non-forest types such as peatland mosaics, shrublands and sub-alpine meadows (USFS 2004).

In an effort to simplify the complex web of landscape functions and relationships, we selected a sub-set of species and systems as indicators of the terrestrial and freshwater ecosystems on the island. Criteria for this selection included species for which relatively comprehensive information was available, high ecological and social values that are relevant to local residents, and sensitivity to forest management activities. For our purposes, we represented issues related to terrestrial ecosystems using habitat values and current conditions for Sitka black-tailed deer, and freshwater ecosystems using systems and ecological processes relevant to wild salmon. Further, we included a watershed-scale review of the density and forest conditions associated with low-elevation karst features because of the high rate of logging in the past and the unique ecological processes associated with karst formations (Baichtal and Swanston 1996). While these systems represent a limited subset of all potential indicators, issues related to salmon, deer and karst forests are among the most important and unique ecosystem processes that are potentially vulnerable to large-scale ecological changes resulting from timber harvest, and were considered adequate for our current purposes.

Terrestrial

<u>Sitka Black-tailed Deer</u>

The Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) plays a critical role in both the ecological and human systems of Southeast Alaska. Deer are a primary prey species for the Alexander Archipelago wolf (*Canis lupus ligoni*) and black bear (*Ursus americanus*), and play a vital role in subsistence economy of local communities. As with most ungulate species in Alaska, winter range appears to be the primary factor limiting population growth (Klein and Olson 1960, Olson 1979), and both old growth timber harvest and young growth management has a direct and long-lasting impact on the quality, availability and distribution of deer winter range.

The natural pattern of small-scale disturbance within coastal forest ecosystems maintains a structurally complex and diverse canopy that allows both snow intercept and understory productivity for deer in winter (Schoen et. al 1988). In contrast, the practice of clear-cut logging alters the successional pathway of a stand, and results in predictable changes in productivity of forage for deer over time (Fig. 1). In years immediately following clear-cut logging, availability and biomass of forage for deer is high during summer months, but availability may be limited during periods of deep snow (Alaback 1982). Summer forage increases to a maximum at about 20 years post logging. As conifers regain dominance within the young stands, and exclude light from the forest floor, a stem exclusion phase is established by 30-40 years after logging. During this period, forage biomass diminishes during both summer and winter, and remains very low level for at least 120 years. Natural mortality of dominant conifers within the stand may begin the process of recreating old growth characteristics, and higher forage biomass for deer, at ~150-160 years after logging.

Since the 1950's, northern Prince of Wales Island has had approximately 296,000 acres of productive forest harvested, which represents approximately 32 % of all productive forest lands in the province, while Southern Prince of Wales has had about 18,000 acres, or 10%, of the productive forest lands harvested. The average age of young-growth stands on USFS lands for which data were available (n = 218,000 acres) is 31.5 years (USFS Managed Stands Database).

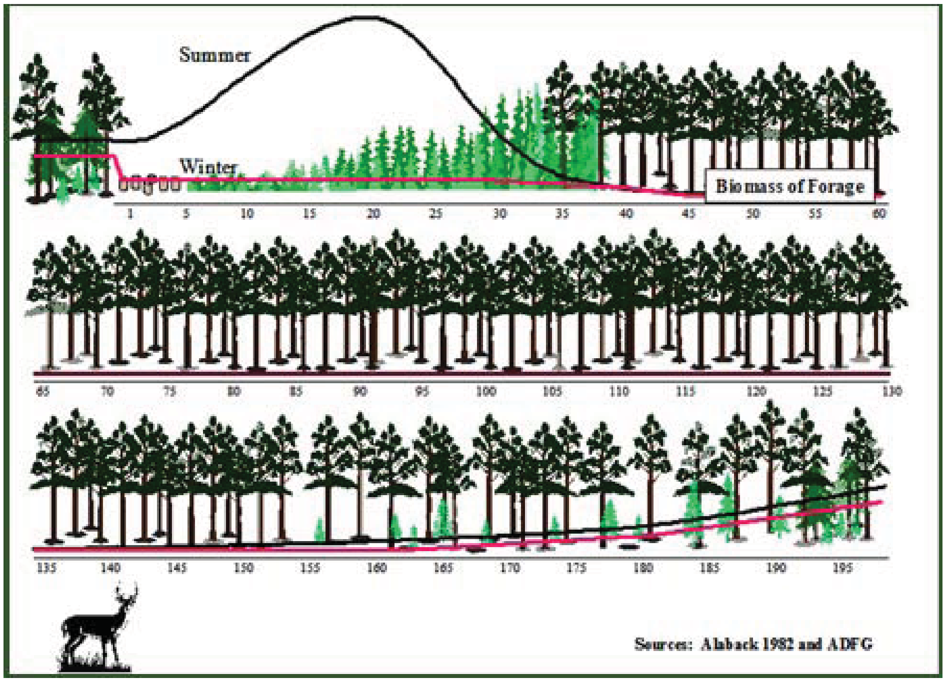

Figure 1. Chronology of forest succession and productivity for deer after logging**.**

Karst

Karst resources on Prince of Wales Island are generally recognized to be of national and international significance (Aley 1993, Baichtal 2007). Prince of Wales is made up of a mix of well-drained sedimentary and metamorphic bedrock substrates, including large patches of high-grade limestone and marble. Unique drainage and chemical composition contribute to the production of superlative large-tree karst forests. Deep karst soils on valley floors and slopes below 400 ft (120 m) tend to be rich in nutrients and provide high value habitat for many species, including salmon with life history traits that allow spawning in the underground, limestone caves (Baichtal and Swanston 1996).

Historically, karst landscapes in Southeast Alaska have been targeted disproportionately for logging, with approximately 44% of all low-elevation karst forests currently in a young-growth condition (Albert and Schoen 2007a). Extensive timber harvest on karst can result in the alteration of the sediment regime and the hydrologic function of cave systems. Sediment transport within karst landscapes is characterized by a downward movement associated with the flow of water into the vertical karst features (Aley 1993). Increased mobilization of sediment and slash associated with logging activity may block cave openings, resulting in overland flooding and further alteration of the hydrologic system (Baichtal 1996). Once vegetation has been removed, retention of productive soils for forest regeneration becomes problematic. In some areas of past harvest, soil loss and nutrient depletion have prevented re-vegetation. In addition, increased rain interception and evapotranspiration in dense young-growth stands may reduce the volume of water flowing through subterranean channels. Thus, thinning of young growth stands within karst landscapes, particularly in areas with a high density of surface karst features, may serve to hasten the hydrologic recovery of the these systems (Jim Baichtal, USFS, pers. comm. 2007).

Freshwater Ecosystems

Salmon

Salmon play a critical role in the ecological and social functions of Southeast Alaska. On Prince of Wales, salmon support virtually all top-level predators including black bear, wolves, eagles and mustelids. Salmon and steelhead also play a vital cultural and economic role providing high quality, fresh food and a source of revenue from commercial fishing, sport fishing, and outfitter and guiding businesses. Past land management actions on Prince of Wales Island, especially logging of riparian forests and road construction, have impacted salmon by increased rates of sedimentation, destabilization of riparian systems and habitat loss through blocking the passage of fish.

Prince of Wales Island supports over 1,640 miles of anadromous stream habitat; which is more than any other province in Southeast Alaska, particularly in the amount of habitat occupied by Coho salmon (*Oncorhynchus kisutch*) and steelhead (O. mykiss *irideus*). Also, the island contains more logging within riparian forests and higher road densities than other provinces in the region (Albert and Schoen 2007). Thus, the condition and status of culverts are of concern, and have been evaluated based on stream channel structure and functions in allowing passage of juvenile salmonids and other fish (Flanders and Cariello 2000):

- Green: conditions are assumed to be adequate for fish passage using defined flow standards;
- Red: Conditions are assumed not to be adequate for fish passage using defined flow standards; and
- Grey: Additional analysis is required to determine if conditions are adequate.

Culverts that do not meet adequate fish passage criteria are place into the red category (i.e., "red pipes") and were used to prioritize restoration activity in this report (Fig. 7).

Riparian Forests

Riparian forests, located along streams and rivers, are characterized by periodic flooding and sediment deposition, and contain distinct flora and fauna depend on proximity to water at some time during their life stage. Moreover, riparian systems provide an important transition between aquatic and terrestrial ecosystems (USDA Forest Service 1995, Gregory et al. 1991). Ecological function of riparian forests include maintenance of water quality, flood control, stream bank stability, temperature regulation and reduced erosion and sediment transport (Brooks et al., 2003). Riparian forests also provide large woody debris (LWD), which is an important feature of stream habitat structure (USFS 2004). Timber harvest and road construction activities in riparian zones have resulted in a myriad of effects on stream and fish habitat: increased sedimentation, altered sediment and bedload transport regimes, changes in stream temperature, bank destabilization, reduced streamflow, loss of connectivity, loss of large wood recruitment into streams, and an overall loss of fish habitat (Murphy et al. 1986, Murphy and Koski, 1989; Hall et al. 2004; Everest et al. 1987; Koski 1993; Tschaplinski et al. 2004)

Risks to Watershed Functions

On Prince of Wales, most serious impairment of watershed processes and function from logging occurred during the era when few environmental safeguards existed. Current federal and state protections are designed to prevent future widespread reduction in watershed functions. Nonetheless, cumulative impacts of historical logging and roading within floodplains and on steep slopes or unstable soils represent the primary risk to the function of some watersheds on Prince of Wales Island. These risks can now be addressed by understanding resulting impacts to upland, riparian, in-stream and karst ecosystem functions (Table 1).

Table 1.Potential impacts to watershed functions resulting from conversion of old growth to young growth forest structure and road failures

❖ *Upland* • Habitat fragmentation • Increased erosion from loss of vegetation on steep slopes; • Nutrient depletion in soils from loss of vegetative cover and increased rates of water flow • Altered maintenance and storage of water in forested wetlands (USFS 2004)	❖ *Riparian and In-stream* • Decreased recruitment capacity for large woody debris contributing to in-stream habitat structure (Fig 2) • Sedimentation regime changes resulting from landslides in uplands and erosion of historical road development • Unmaintained culverts resulting in blocked fish passage • Decrease in large woody debris recruitment has caused loss of pools that provide critical fish rearing habitat, decreased cover for rearing juveniles, channel instability, shifts in aquatic food webs (USDA Forest Service 1995)

❖ *Karst* • Increased surface runoff on karst landscape and adjacent surfaces increasing sediment and debris transport • Increased sediment and debris transport and flooding of underground passages • Flooding resulting in fragile ceiling formations becoming tannin stained and showing signs of dissolution • Filled or blocked cave entrances from logging slash, sediment and debris • Additional runoff generated from road surfaces diverted into karst features

Figure 2. Large-woody debris creates complex stream habitat structure, which plays a major role in providing high quality habitat for salmonids (right). Historical practices, including logged riparian forests and removal of LWD (left) led to impaired stream functions.

II. The Planning Process

The Nature Conservancy uses a collaborative approach with partners to accomplish its mission of protecting biodiversity. To that end, project members assembled a team of stakeholders representing federal and state land management agencies, researchers, and local restoration practitioners. TNC hosted two workshops in the spring of 2007 to develop a method for systematic prioritization of restoration and rehabilitation needs among watersheds on Prince of Wales Island (Table 2). More than 35 people attended each workshop to share previous prioritization efforts, present recent research, and give feedback for restoration needs on Prince of Wales Island (Table 3).

Table 2. Workshops were held in Ketchikan, AK and Craig, AK, spring 2007, to develop methods for watershed restoration needs.

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Workshop I Objectives:

Design a method for systematic prioritization of restoration activities on Prince of Wales Island that includes aquatic and terrestrial habitats;
Review and incorporate the best available science and existing young-growth strategies and planning;
Outline a science-based framework for restoration planning and monitoring.


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Workshop II Objectives:

Evaluate the relative need for restoration and management among watersheds island-wide;
Build consensus on watershed priorities with input from landowners, watershed councils, agency staff, interested stakeholders;
Apply information on priority watersheds to help guide partnerships in restoration work on Prince of Wales Island and provide a decision-making tool for local restoration practitioners.


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Table 3. Workshop Participants and Restoration Partners

U.S. Forest Service	Trout Unlimited
Craig and Thorne Bay Ranger Districts	City of Craig
U.S. Fish & Wildlife Service	City of Coffman Cove
National Oceanic and Atmospheric Administration	Klawock Watershed Council
Alaska Dept. of Natural Resources	Kasaan Bay Watershed Council
Alaska Dept. of Fish & Game	Prince of Wales Island Chamber of Commerce
Sealaska Native Corporation	Viking Lumber
Volunteers/Residents	Prince of Wales Community Association

A Review of Previous Prioritization and Research Efforts

The restoration workshops provided a forum for participants to share previous prioritization efforts and recent research. This information was used in the analysis of restoration needs on Prince of Wales Island. Representatives from the Forest Service, watershed councils, Pacific Northwest Research Station, and the U.S. Fish and Wildlife Service presented pertinent information on restoration topics. Community members expressed interest in restoration projects as volunteers and gave feedback related to maps and data. A brief overview of prioritization efforts and restoration opportunities follow.

Tongass National Forest Clean Water Action Plan, 2000

The Tongass National Forest's Clean Water Action Plan consists of a watershed based framework to establish priorities for restoration and aquatic resource protection across the Tongass National Forest (Cables 2000). "Coarse screen" indicators derived from land use and other values, were used to rate watershed condition and value (Table 4). Generally, rating criteria for state, private and Wilderness lands were not incorporated into the federal analysis. To incorporate the Clean Water Action Plan's recommendations, TNC applied new data and updated models to the current prioritization methodology.

Table 4. Clean Water Action Plan land use and values criteria

Land use criteria	**Aquatic values & beneficial uses criteria**
• Harvest on unstable slopes (+72%). • Percentage of Riparian Area harvested. • Road density on slopes over 35%. • Percentage of Riparian and Wetland area impacted by roads. • Total number of stream crossings in the watershed.	• Density of Class I fish streams. • # Hydro power sites. • # Developed recreation sites. • # Community water supplies. • # Wild-Scenic-Rec River candidates. • # 303d Impaired Waters listings.

Tongass Young Growth Strategy, 2008

The Tongass Young Growth Strategy describes the existing conditions, desired future conditions, and management approaches for timber production, riparian management and wildlife habitat (Grundy 2008). The strategy also sets forth integrated treatment matrices in order to develop management regimes for various combinations of management outcomes.

Game Management Unit (GMU) 2 Deer Report, 2006

GMU 2 is a geographic area delineated by the Alaska Department of Fish and Game for the purpose of managing wildlife, and encompasses Prince of Wales Island and the adjacent islands. A cooperative effort took place in 2004 to address concerns about Sitka black-tailed deer subsistence use and management. One key observation articulated by stakeholders was that "habitat carrying capacity for deer is declining on Prince of Wales Island as clear cut areas grow into a less productive young growth forest stage, causing a likely decline in deer production" (Shienberg Associates 2006). A look at Figure 1 shows the chronology of forest succession after logging and why biomass of young growth is of concern for deer management.

The GMU 2 report contains the following recommendations for restoring deer habitat:

- Focus on substantially improving data and information about Unit 2 deer harvest, population trends, and the subsistence use of and need for deer;
- Work to increase the deer population in Unit 2 by expanding a USFS program to restore and rehabilitate young growth forests on federal land for the benefit of deer; and
- Implement alternative commercial timber harvest methods on future timber sales that may provide greater benefits to deer.

GMU 2 Deer Habitat/Young Growth Management Strategy, 2006

An interagency group of management biologists, research biologists, forest ecologists, and silviculturists met in 2006 to develop a young growth management strategy for deer as identified in the 2006 GMU2 report (Sheinberg Associates 2006). This effort prioritized treatment areas to provide the greatest benefit for deer and people who use deer. The strategy identified 13 priority wildlife analysis areas (WAAs) for near-term young growth treatments and provided guidance on project design. Priority WAAs for treatment include: Heceta Island, Polk Inlet, Thorne Bay/Kasaan, Klawock, Staney Creek, Hollis, Thorne River, Coffman Cove/Luck Lake, Coffman Cove/Sweetwater Lake, North POW Island, Kosiusko Island, Whale Pass, and El Capitan (Sheinberg Associates 2006).

An important outcome of the young growth management strategy was the development of a list of forest stand attributes to help guide Forest Service staff decisions on where the treatment of stands should take place and the design of these treatments within the priority WAAs, to achieve the strategy's objectives (USFS Alaska Region 2007). The following attributes were mapped and a more detailed list of attributes, "Tier II Attributes, Guidance and Considerations to Apply at Project Planning" is included in table format in Appendix F.

- Forest stands that were cut more than 16 years ago, that are untreated or were treated more than 10 years ago – these stands represent young growth treatment opportunities.
- Forest stands most suitable for treatment, including those that are located on south-facing slopes and at less than 800 feet – Low elevation, south aspect stands would offer the opportunity to rehabilitate important deer winter range.
- Forest stands that were cut more than 16 years ago, but have been treated since 1996 – these stands *do not need treatment in the near-term.*
- Forest stands that are 0-15 years old – These stands *do not need treatment in the near-term.* However, in determining which young stands to treat, it may be beneficial to treat stands adjacent to 0-15 year stands where "hunt-ability" is high, due to relatively high deer use and ease of sighting.
- Natural openings (e.g., alpine, muskeg) – In determining which stands to treat, it may be beneficial to treat young stands adjacent to natural openings such as alpine and muskeg meadows where "hunt-ability" is high, due to relatively high deer use and ease of sighting.
- Productive old growth – In determining which stands to treat, it may be beneficial to treat young stands adjacent to productive old growth habitat.

Watershed Councils

Two community watershed councils on Prince of Wales Island are actively involved in stream channel restoration and water quality improvement. The Kasaan Bay Watershed Council has been working since 2004 on the east-central part of Prince of Wales Island, an area including Sandy Point, Salt Chuck in Kasaan Bay, Karta River, the Kasaan Peninsula over to Grindell Island. The Klawock Watershed Council (KWC) has been meeting since 1999 and has a successful stream restoration program focused on the Klawock River watershed in west-central Prince of Wales.

The Kasaan Bay Watershed Council is focused on drinking water quality problems, declining fish stocks, and contaminated subsistence resources from mining sites. The riparian areas of Kasaan's water source, Linkum Creek, have been heavily logged. A lack of vegetation, in combination with unstable slopes, has resulted in landslides and sedimentation to their drinking water source. The Watershed Council is addressing concerns of sockeye salmon population declines affecting subsistence harvest needs. The Council is conducting stream assessments and monitoring fish populations in order to further prioritize restoration needs.

The Klawock Watershed Council completed a watershed assessment and produced a watershed management plan that prioritized restoration needs. The assessment was a joint effort with the Alaska Dept. of Fish and Game conducting the road condition survey and the Central Council Tlingit Haida Indian Tribes of Alaska and the Tongass National Forest cooperating on the Watershed Condition Assessment. The Klawock Watershed Restoration Plan calls for closing roads and removing structures in the 3 Mile, Southeast Klawock Lake, and Hatchery Creek sub-basins. Results of the Road Condition Survey showed that working on Klawock-Heenya and DOT crossings may offer the biggest benefit to anadromous fish (Stichert, pers. comm.). The KWC has:

- closed 80 miles of road;
- removed 256 culverts and 37 bridges along 45 miles of stream; and
- placed 426 erosion sediment controls (waterbars) along closed roads.

According to Donna Williams, the KWC's former director, future priorities include:

- update the master plan by focusing on 14 major fish streams,
- habitat restoration work at the inlet and outlet of Klawock Lake.
- incorporate a riparian thinning regime for 103 acres identified in the original plan.

The KWC's aquatic habitat restoration priorities within the Klawock watershed will be determined by stream surveys and data from fish sampling work.

III. Methods and Results

Considerations in Setting Priorities for Restoration

The primary considerations we used to prioritize restoration action were measures of the current condition, biological value, and opportunities presented within each watershed. Working with local managers and resource experts, we developed sets of indicators for both freshwater (with a focus on habitat needs for salmon), and terrestrial systems (with a focus on habitat needs for Sitka black-tailed deer). Where possible, we used indicators that: (1) had reliable data available; and (2) had been identified in previous efforts (e.g., GMU 2 Deer) to help prioritize restoration needs (Table 5).

Habitat Condition: Where is restoration needed most?

a. Immediate Need for Restoration: An important step in prioritization of restoration activity is to review information on the urgency of restoration need among watersheds. For example, are there specific cases in which existing hydrologic processes are leading to further deterioration of habitat values that require immediate action? These situations may take precedence over situations in which conditions may need restoration but are relatively stable in the near-term. This information is probably local knowledge on a case-by-case basis, and not the results of GIS modeling.
b. Longer-term Need for Restoration: In general, the need for restoration can be defined as any situation in which a specific habitat function is at risk as a result of human activity. Specific habitat functions can be enumerated (e.g., LWD provides in-stream habitat for salmon) and indices can be calculated using GIS data to estimate current condition (e.g., % of riparian zone in young growth stands). The overall goal of restoration activities is thus to have all indices occur within an acceptable range (i.e., desired conditions) for the full suite of ecosystem functions. These indices can be compared to get a general sense of the magnitude of restoration need among watersheds.

Biological Value: Where will restoration provide most benefit?

c. Index of Biological Values: Watersheds can be characterized based on a variety of biological values, including the extent to which they contribute to specific goals for biodiversity. For example, all things being equal, a watershed with 5 species of salmonids provides a greater contribution to biodiversity than a watershed with only one species. Where restoration need is relatively similar among watersheds, there may be a greater conservation benefit to prioritize restoration activities among higher value watersheds.
d. Relative Index of Social / Economic / Cultural Value: The GMU 2 Deer YG Strategy defined criteria to evaluate the importance of areas for hunters. These criteria can be compared among watersheds to evaluate the relative contribution of restoration activities to maintaining these values. Similar criteria can likely be defined for human uses of salmon.

Restoration Opportunity: Where will restoration efforts be most likely to succeed?

e. Considerations of logistics, potential partners, operability or economic return that affect how likely restoration activities will be successful, and thus should be considered in prioritization ranking.

Table 5. Potential indices that characterize condition, values and restoration opportunities related to terrestrial and freshwater habitats on Prince of Wales Island.

	Habitat Functions	Indicator (for watershed-scale planning)
CONDITION	*FRESHWATER SYSTEMS*	
	Riparian Functions	♦ Percent of riparian forest in young growth (YG) ♦ Acres of YG riparian forest in wood dependent channels
	Connectivity	♦ Number of "red pipe" culverts within watershed
	Water Quality	♦ Road miles and/or density in watershed ♦ Number of stream crossings ♦ Acres of harvest on steep slopes (>67%)
	Water Quantity	♦ Percent of watershed area in YG
	TERRESTRIAL SYSTEMS	
	Deer Winter Range	♦ Acres of YG (not cut or thinned within 15 yrs) o S or W exposure o <800 ft elevation o Large patch size (1/2 home range)
	Karst forest	♦ Acres of YG on high vulnerability karst
	Connectivity	♦ Identify corridors between large intact habitat patches
	Biological / Human Values	
VALUE	*FRESHWATER SYSTEMS*	♦ ADF&G Primary Salmon Producers ♦ Unique or sensitive stocks (Halupka et al. 2000) ♦ Salmon distribution and diversity index
	TERRESTRIAL SYSTEMS	♦ Relative biodiversity index (Albert and Schoen 2007a) o Habitat capability for deer, bear & murrelet o Freshwater salmon distribution o Large-tree forest (riparian, upland, karst) o Estuaries (acres of salt marsh habitat) ♦ Connectivity points (island "bottle necks")
	HUMAN VALUES	♦ Community water supply ♦ Subsistence salmon harvest ♦ Deer & Bear harvest (by WAA) ♦ Guided sport fishing permits
	Opportunity	
OPPORTUNITY	*Commercial YG Potential*	♦ Commercial thinning opportunities (acres x size class) ♦ Fish & wildlife habitat improvement (YG in NDEV)
	Partnerships	♦ Existing watershed councils
	Research Study Sites	♦ Long-term study sites as basis for adaptive management
	Other factors	♦ Logistics, visibility, funding opportunities, etc.

Biological and Social Values

Watershed Database

For these analyses, we used the hydrologic units database (HUC567) obtained from the USFS. This database contains a nested hierarchy of Hydrologic Unit Codes (HUCs) including groups of watersheds (5th-field HUCs; n = 18), true watersheds (6th-field HUCs; n = 147) and sub-watershed basins (7th-field HUCs; n = 720). While these guidelines generally apply, some large watersheds (e.g., Thorne River) are characterized by sub-watershed basins within 6th-field HUC code. Additionally, within this database, contiguous areas of small coastal drainages lacking larger river systems are grouped into "frontage watersheds". These "frontage watersheds" are typically named according to the salt water body (e.g., Sea Otter Sound – Prince of Wales Island), and in some cases may be heterogeneous in their biological value and habitat conditions, particularly at the larger spatial scales This is a necessary consequence of the level of data generalization required to conduct an island-wide analysis.

Freshwater Salmon Distribution

The freshwater distribution of salmonid species on Prince of Wales Island was estimated using the ADF&G Fish Distribution Database (FDD), which documents 414 miles of salmon streams on Prince of Wales Island. This database is generally recognized to underestimate the actual distribution of anadromous fish, so we developed a process to include Class I stream segments contained the USFS Streams Inventory that are located within the anadromous floodplain of FDD streams using the SRTM Digital Elevation Model (Albert and Schoen 2007a).

We estimate approximately 1,640 miles of freshwater habitat occupied by anadromous fish on Prince of Wales Island (Figure 3, Appendix A). Coho salmon was the most widely distributed species (1,533 miles), followed by pink salmon (1,043 miles), chum salmon (650 miles), steelhead trout (560 miles) and sockeye salmon (349 miles). Salmon occur within 73% (n = 107) of all watersheds (6th-field), and anadromous watersheds account for nearly 93% of the total land area (3,466 sq. miles). Nine stocks on Prince of Wales were identified as having unique characteristics (Halupka et al. 2000; Table 6).

Table 6. Salmon stocks with unique genetic and population characteristics (Halupka et al. 2000)

Watershed	Species	Rationale
Disappearance Creek	chum	High productivity per unit area; large population size; stream originates in limestone caves
Karta River	sockeye; pink	Large body size, particularly age 1.2 males; sex ratio skewed in favor of males. Late run-timing in pink salmon
Klawock River	pink	Large escapement
Luck Lake	sockeye, pink	Reverse sexual size difference (females larger); Late run-timing in pink salmon
Nutkwa Creek	pink	Late run-timing; large escapement
Port Real Marina	chum	Genetic similarity to Queen Charlotte Is. Stocks
Shipley Lake	sockeye	High mean freshwater age (MFWA); high proportion of age 2.3 females; large sexual difference in MFWA; declining population
Staney Creek	pink	Large escapement
108 Creek / Whale Pass	pink	Late run timing

Relative Biodiversity Index and Unique Stocks

To estimate the relative value of watersheds for salmon, we defined a salmonid relative biodiversity index (RBI) as:

$$\mathrm{RBI}_w = \frac{\sum_{i=1}^{n}\left(h_w / h_{total}\right)}{n}$$

where:

w = watershed
h_w = freshwater habitat for species (i) within watershed (w)
h_{total} = total freshwater habitat for species (i)
n = number of species

Thus, the salmon RBI can be interpreted as the average percent contribution of each watershed to the total freshwater distribution of salmonids on Prince of Wales Island. With the lack of systematic data on escapement or other measures of productivity among watersheds, the linear distance of freshwater habitat occupied by salmon provides a reasonable indicator of watershed value. Moreover, this measure accounts for differences in relative distribution between the more widely distributed (e.g., coho) and narrowly distributed species (e.g., steelhead or sockeye). Thus, watersheds with relatively more freshwater habitat, and those with the greater number of species were considered to be of higher conservation value for salmon (Fig. 11).

Salmon Harvest

Commercial, sport, and subsistence salmon catch can all be considered indicators of salmon productivity from Prince of Wales Islands. Subsistence level data was readily available and mapped on a watershed basis. Total harvest of salmon by subsistence users from Prince of Wales Island watersheds reported to ADF&G during 1985 – 2001 was 173,720 fish. Harvest was reported to have occurred from a total of 43 watersheds, with the largest harvest reported from Klawock River, Hetta Inlet, Karta River, Sarkar Lakes, and Hatchery Creek (Fig 4).

Deer harvest and subsistence hunting

To compare relative value of deer hunting areas among watersheds, we combined data on harvest by recreational and subsistence hunters with place-based survey data representing areas used for deer hunting by subsistence hunters (Fig 5). Harvest data was available by Wildlife Analysis Area (WAA) for the period 1987-2004. To evaluate the relative distribution of hunting effort among watersheds within a WAA, we used the Tongass Resource Use Cooperative Survey (TRUCS). These data were collected in the mid-1980's and reflect a systematic effort to interview residents about areas used for subsistence activities. Data from all communities on Prince of Wales Island were combined into a weighted-average by population, and then summarized among watersheds (HUC6). This provides a relative index of the value of areas for hunting of deer based on both harvest and estimated level of use among watersheds (Appendix C).

The total harvest of deer on Prince of Wales Island reported to ADF&G during 1987 – 2007 was 45,932 or an average of 2,552 deer per year. Highest ranked WAA for harvest include Staney Creek, Klawock Lake / Big Salt, Thorne River, Kasaan Peninsula and North POW. Based on the combined index of harvest and use, top watersheds include Staney Creek (n = 2,275); POW – Sea Otter Sound (n = 2,268), Luck Point to Fores Cove (n = 1767) and Heceta Island (n = 1,701).

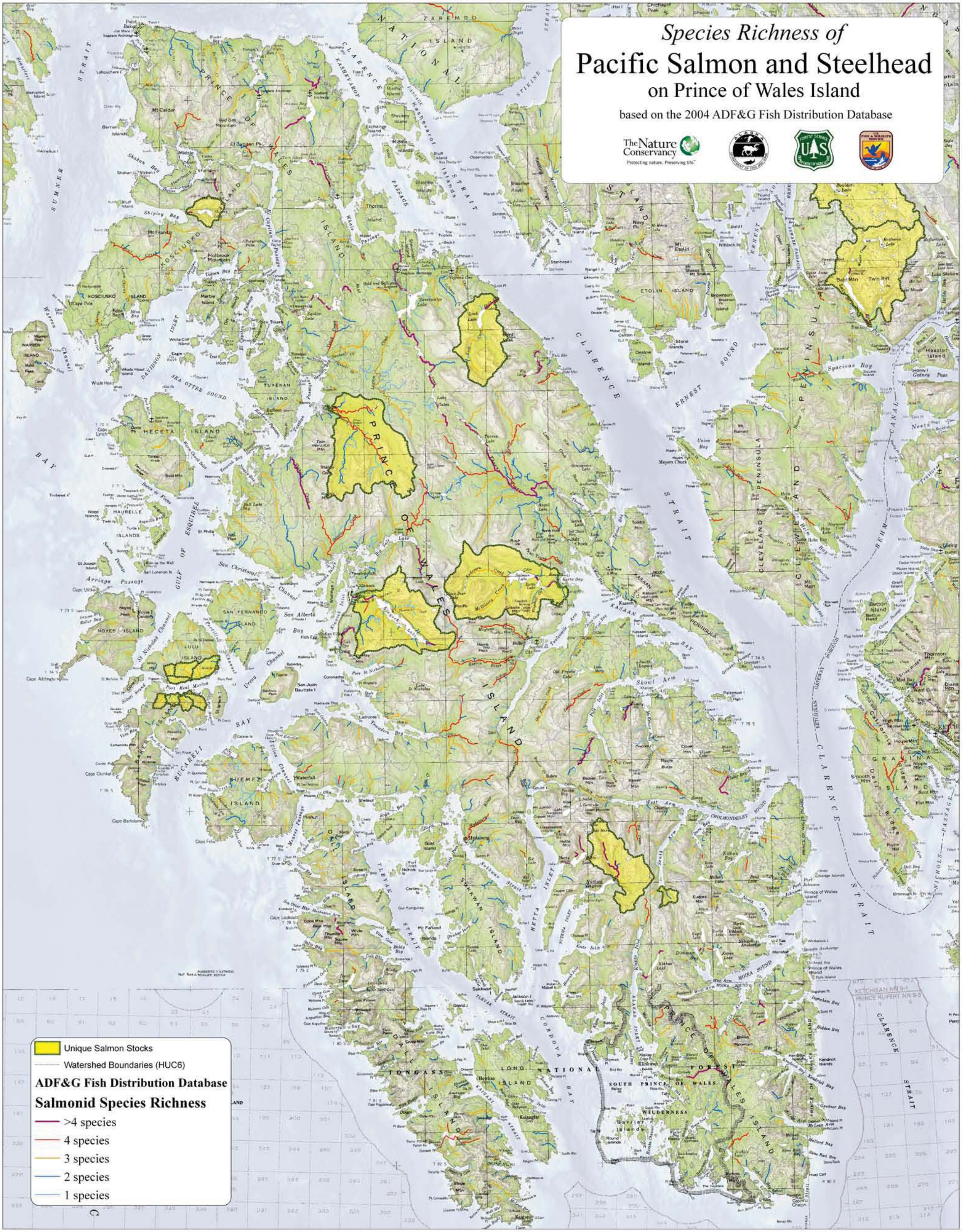

Figure 3. Species richness of Pacific salmon and steelhead among watersheds on Prince of Wales Island, and stocks with unique genetic characteristics.

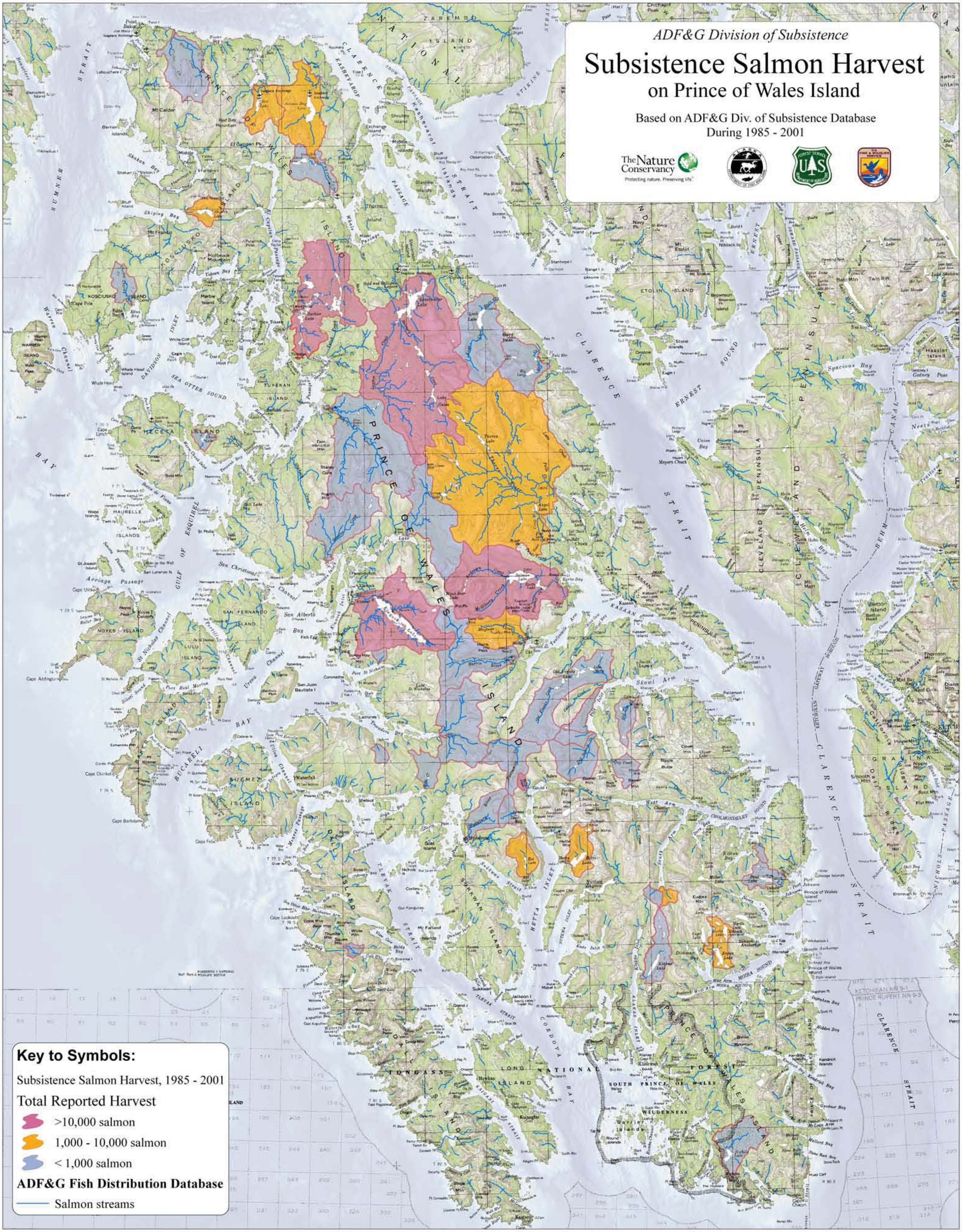

Figure 4. Estimated harvest of salmon by subsistence users on Prince of Wales Island during 1985 - 2001

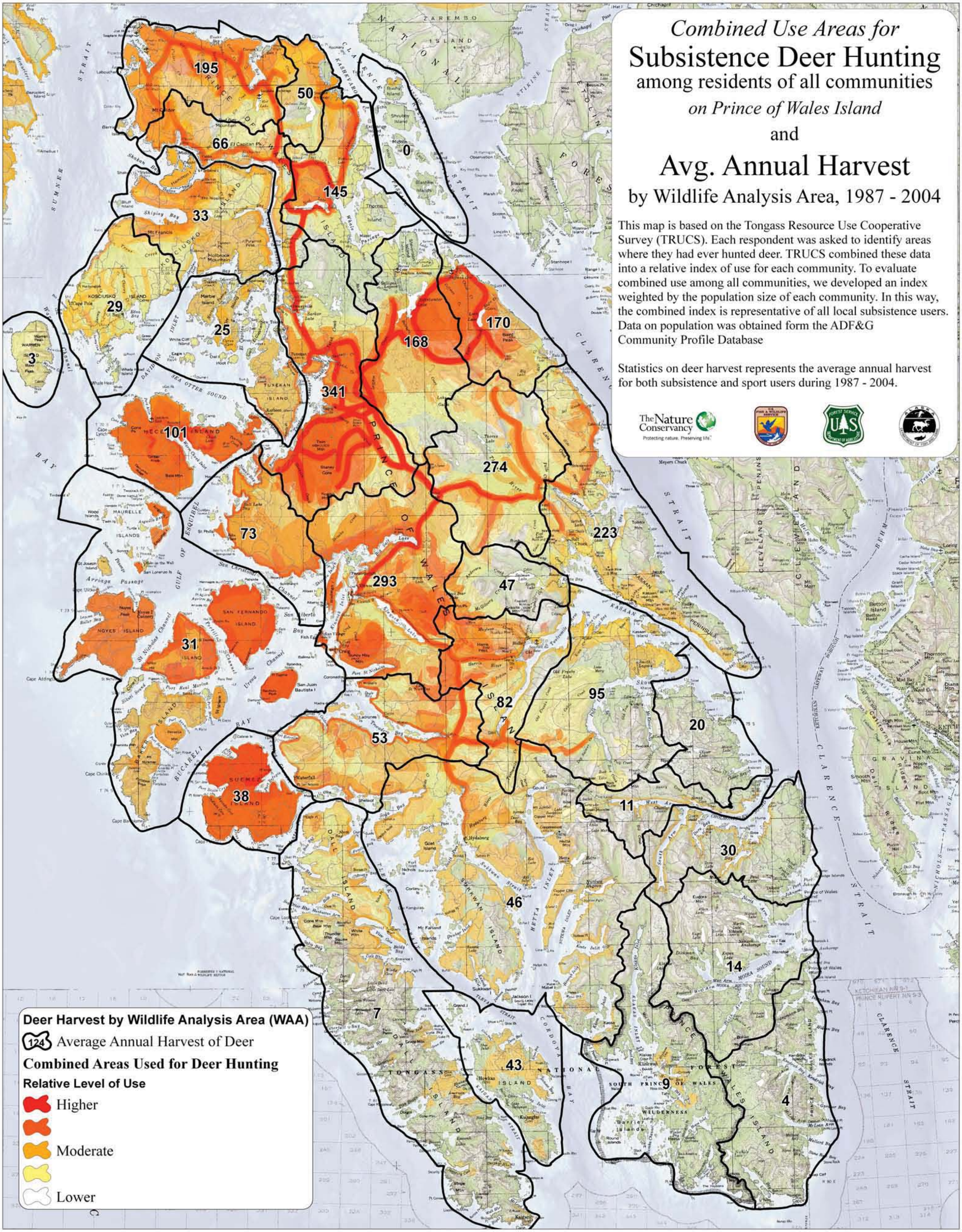

Figure 5. Combined use areas for subsistence deer hunting and harvest of deer by Wildlife Analysis Area during 1987 – 2004.

Density of low-elevation karst features

The USFS has identified (n = 4,953) surface karst features on Prince of Wales and neighboring islands, 95% of which are located in the north and northwestern portion of the study area (Figure 6). These features have primarily been identified during EIS planning, and effort has not been distributed systematically across the island. Watersheds with the highest average density of mapped karst features include Trout Creek (21.8 / mile^2) and Survey Creek (21.6 / mile^2) on Kosciusco Island, Twin Island Lake (18.1 / mile^2), Heceta Island (11.8 / mile^2) and Tuxekan Island (10.4 / mile^2). On average, 30.6% of all lands within a 100 ft. radius of mapped karst features are in young growth condition. Thirteen watersheds have >50% of lands in within 100' of mapped karst features in young growth condition (Fig 13, Appendix D).

Watershed Condition

Stream connectivity, road density and riparian condition

Habitat functions related to freshwater ecosystems that may be useful in evaluating restoration priorities include riparian functions; stream connectivity, water quality and water quantity (Table 5). Potential indicators for the condition of these functions for which data are available at a landscape scale include: percent of entire watershed or percent of riparian forest in young-growth; number of non-functioning ("red pipe") culverts; number of road miles and total road density within a watershed (Fig. 8).

Forty-three percent of HUC 6 watersheds (*n* = 63) within the Prince of Wales Island group currently contain no roads, and represent 33% of the total land area (*n* = 557,000 acres). Conversely, roaded watersheds (*n* = 84) represent approximately 66% of the total land area (n = 1,137,513 acres). Among these roaded watersheds, a total of 3,462 miles of road, across all land jurisdictions, currently exist with an average density of 1.27 miles of road per mile^2 (Fig 14, Appendix B). Moreover, 482 culverts (USFS lands only) are classified as "red pipes" that do not allow adequate passage of juvenile salmonids or resident fish. Finally, young-growth conditions exist on approximately 32.6% all riparian forests within roaded watersheds (*n* = 681 ac.). A total of nine watersheds currently have less than 50% of productive riparian forests in old growth condition including Gravelly Creek (47%), Harris River (43%), Black Bear Creek (42%), Twin Island Lake (40%), Maybeso Creek (39%), Long Island (26%), Twelvemile Creek (26%), Survey Creek (14%) and Hetta Inlet (9%) (Appendix B).

Winter habitat for Sitka black-tailed deer

For the purpose of this analysis, we characterized high-value winter range as all productive forest lands that occur at elevations less than 800' with a southerly or westerly exposure (135 – 315 degrees) (Table 4). Within these lands, we defined the relative condition of deer habitat as the percent of all productive forest lands in young growth that is >25 years old (i.e., closed canopy), young growth that is <25 years old or in old growth condition. In general, we interpreted the need for restoration to be proportional to the percent of all winter range that is in closed canopy young growth within a watershed. At a landscape scale, areas where such closed-canopy young growth comprise a high percentage of all winter range within an average deer's home range (Fig. 9, shown in red) are likely places where deer populations are most in need of habitat enhancement and restoration.

Based on this analysis, we identified 373,849 acres characterized as primary winter range; 75.6% of which is currently in old-growth condition, and 24.4% of which is in young growth. Moreover, approximately 11% of all primary winter range is in young growth >25 years old (Appendix C).

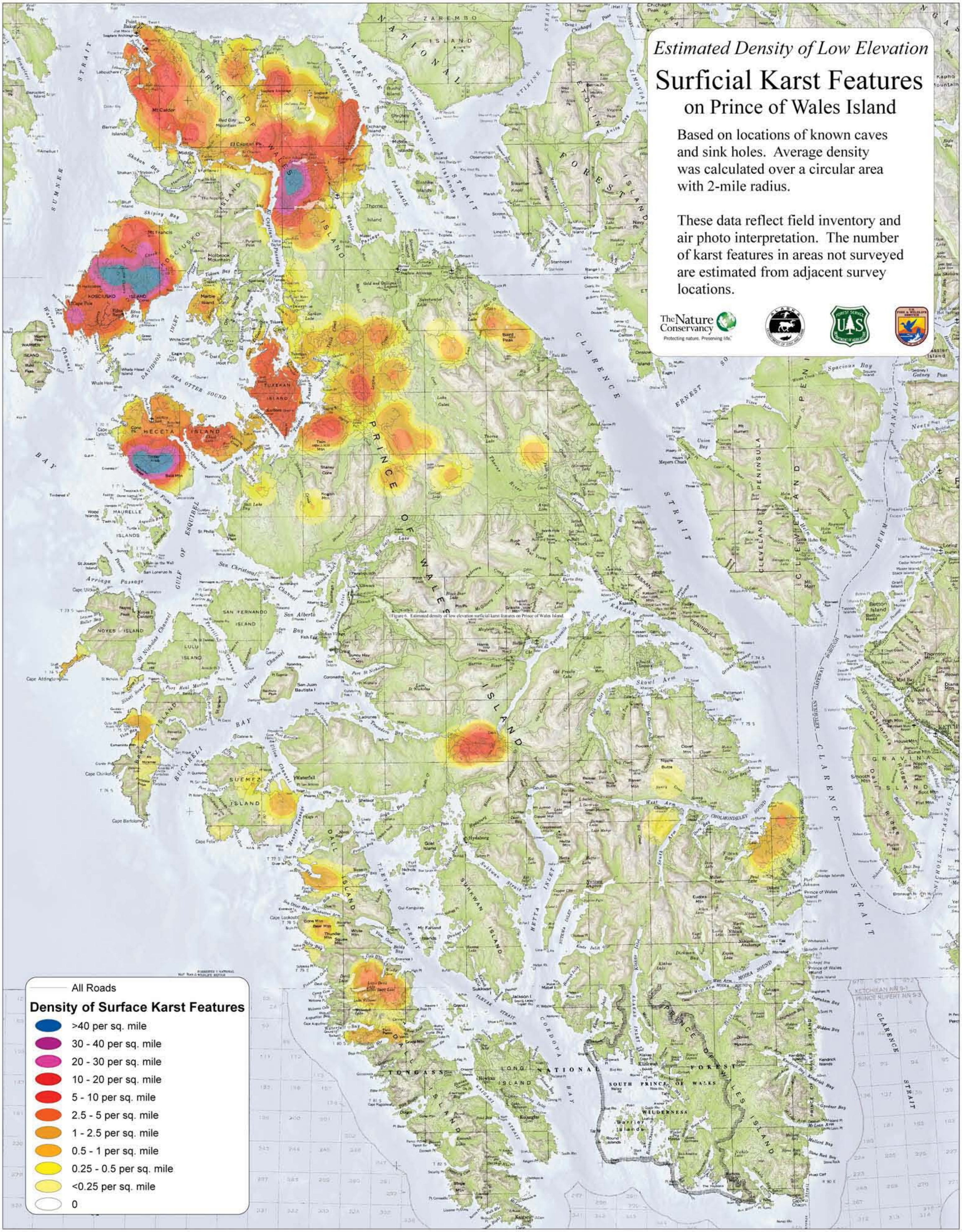

Figure 6. Estimated density of low elevation surficial karst features on Prince of Wales Island.

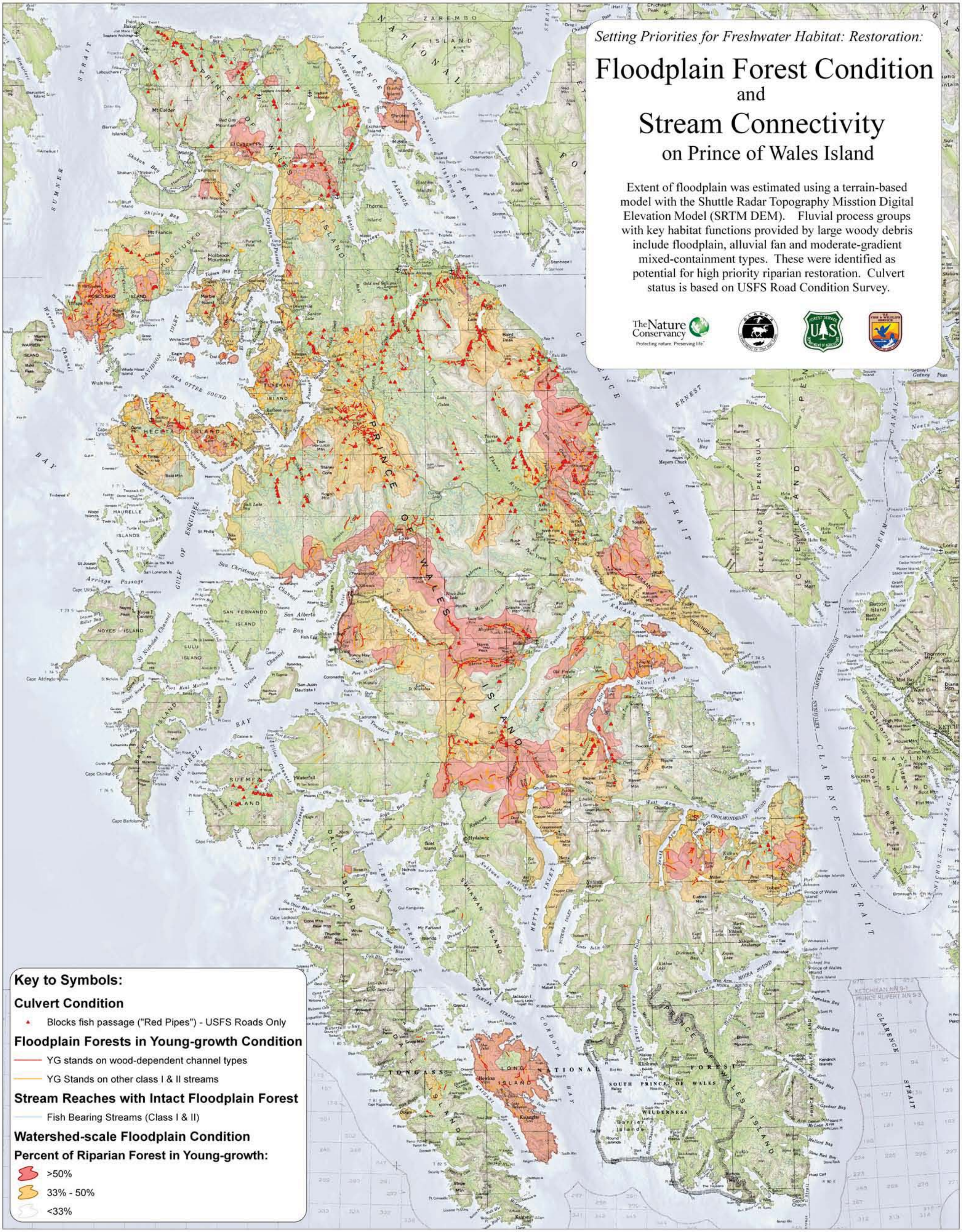

Figure 7. Floodplain forest condition and stream connectivity on Prince of Wales Island.

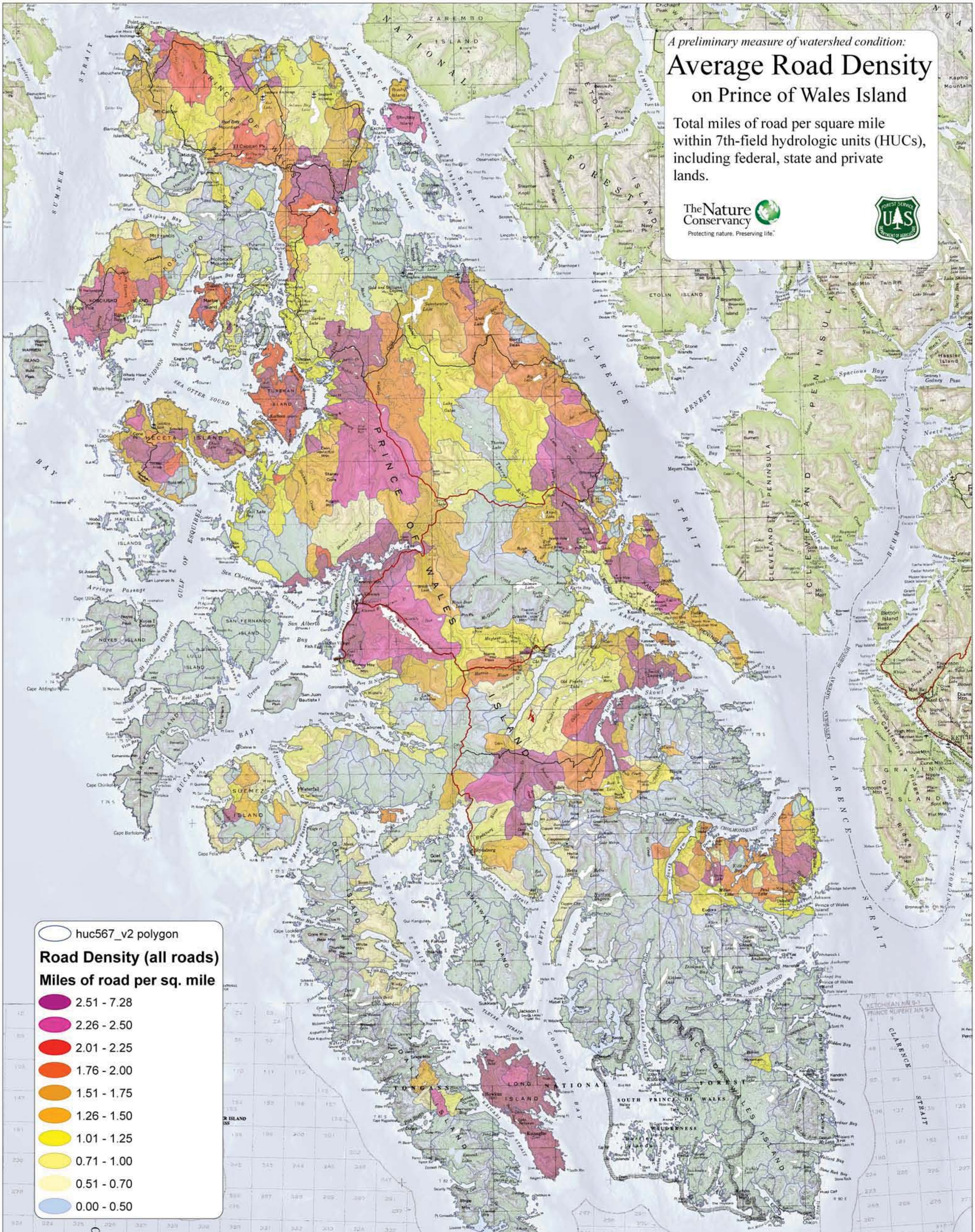

Figure 8. Road density on Prince of Wales and neighboring islands.

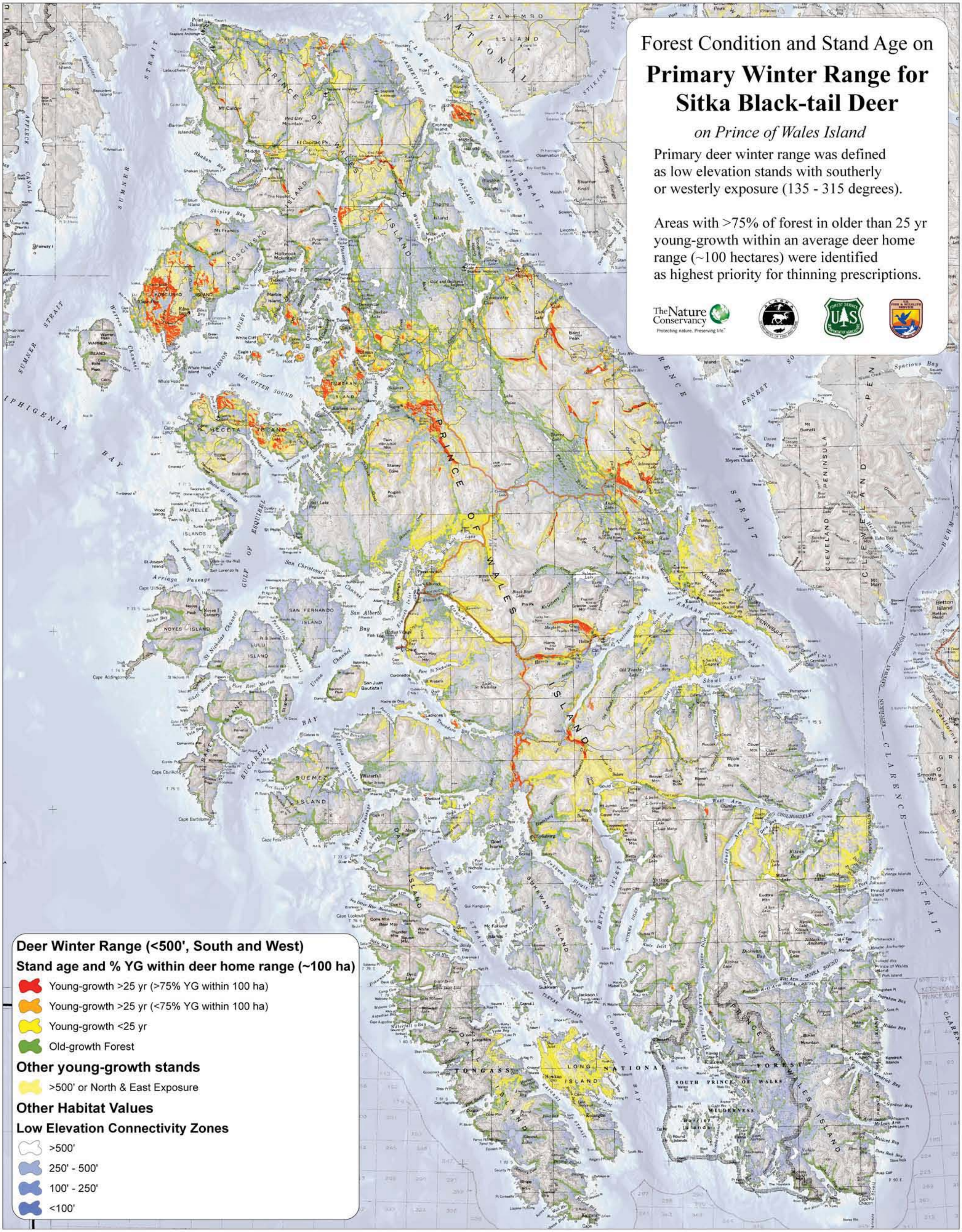

Figure 9. A landscape-scale assessment of the condition of winter range for Sitka black tailed deer on Prince of Wales Island

Restoration Opportunity

Systematically measuring restoration opportunities on Prince of Wales Island is more difficult to illustrate geographically than measures of watershed value and condition. Considerations for restoration opportunities include on-going restoration activities and planning, logistics, potential partners and funding opportunities, operability or economic return, and existing research sites. While not all of these factors for opportunity could be mapped, they should still be considered in the prioritization ranking. Currently, the primary restoration activities which address the terrestrial and aquatic functions include:

- Commercial thinning for wildlife;
- Riparian thinning within stream buffers to maintain long-term fish habitat integrity;
- Road storage and decommissioning to reduce erosion and stream sedimentation and to restore hydrologic function to hill slope drainages;
- Removal or replacement of road crossing structures to maintain and restore fish passage; and
- Stream channel reconstruction and large-woody debris structural treatments to maintain channel stability and improve fish habitat conditions.

Commercial Opportunity in Young Growth Forests

One aspect of opportunity for achieving habitat objectives in older young growth stands can be measured in acres of forest that approach or have achieved commercial sized trees, in that commercial value can help offset costs of restoration treatments. While additional work is required to develop a detailed inventory and timeline of commercial thinning opportunities, we used a simple measure of the acres of young growth within each watershed that have attained >50 and >40 years old as estimates of current and near-term potential for commercial thinning treatments (Fig. 10, Appendix E). We have further characterized these stands based on the Land Use Designation (LUD) to reflect the range of potential management objectives as "Development", "Natural Setting", "Beach Fringe" and "Riparian Buffer".

Based on the USFS Managed Stands inventory, a total of 49,551 acres of young-growth forest exist on Prince of Wales Island that is at least 40 years old; with 41,568 ac. in 40-50 years and 7,983 ac. in > 50 year-old young growth (Appendix E). Of the acres >50 years old (representing current potential for commercial thinning); 4,535 acres (56.8%) occur within Development LUDs, 516 acres (6.4%) occur in Natural Setting; 2,065 acres (25.8%) occur within Beach Fringe and 867 acres (10.8%) occur within Riparian Buffers under the 1997 TLMP. Kosciusco Island contains a total of 3,751 acres of >50 year-old young growth, which represents 47.0% of all such stands in the Prince of Wales Island group. Other areas with high potential for commercial thinning (i.e., >50 year old young growth) include Northwest Prince of Wales Island (1,015 acres; 12.7%) including Staney Creek and POW – Sea Otter Sound, and Skowl Arm (849 acres; 10.6%) which includes the Polk Inlet – Skowl Arm Frontage. Within the Beach Fringe, largest areas of >50-year young-growth include within Northwest Prince of Wales (471 acres), Kasaan Bay (388 acres), Skowl Arm (261 acres),, and Tuxekan Island (223 acres); and Southwest Prince of Wales (222 acres). The Prince of Wales Island – Sea Otter Sound "watershed" (HUC6) within the Northwest Prince of Wales area (HUC5) is the site of the Winter Harbor project to improve habitat values for deer using commercial thinning as a primary treatment.

Within the >40 year-old cohort, the distribution of young growth opportunity shifts to the Luck Point to Fores Cove (i.e., Cobble Landscape, 5,387 acres); Harris River (2,930 acres), Twelvemile Creek (2,913 acres), Maybeso Creek (2,889 acres); and Ratz Creek (2,364 acres). Collectively, Kosciusco Island (6,428 acres) and Thorne River (5,070 acres) also contain a significant area of young growth in the 40-50 year old cohort.

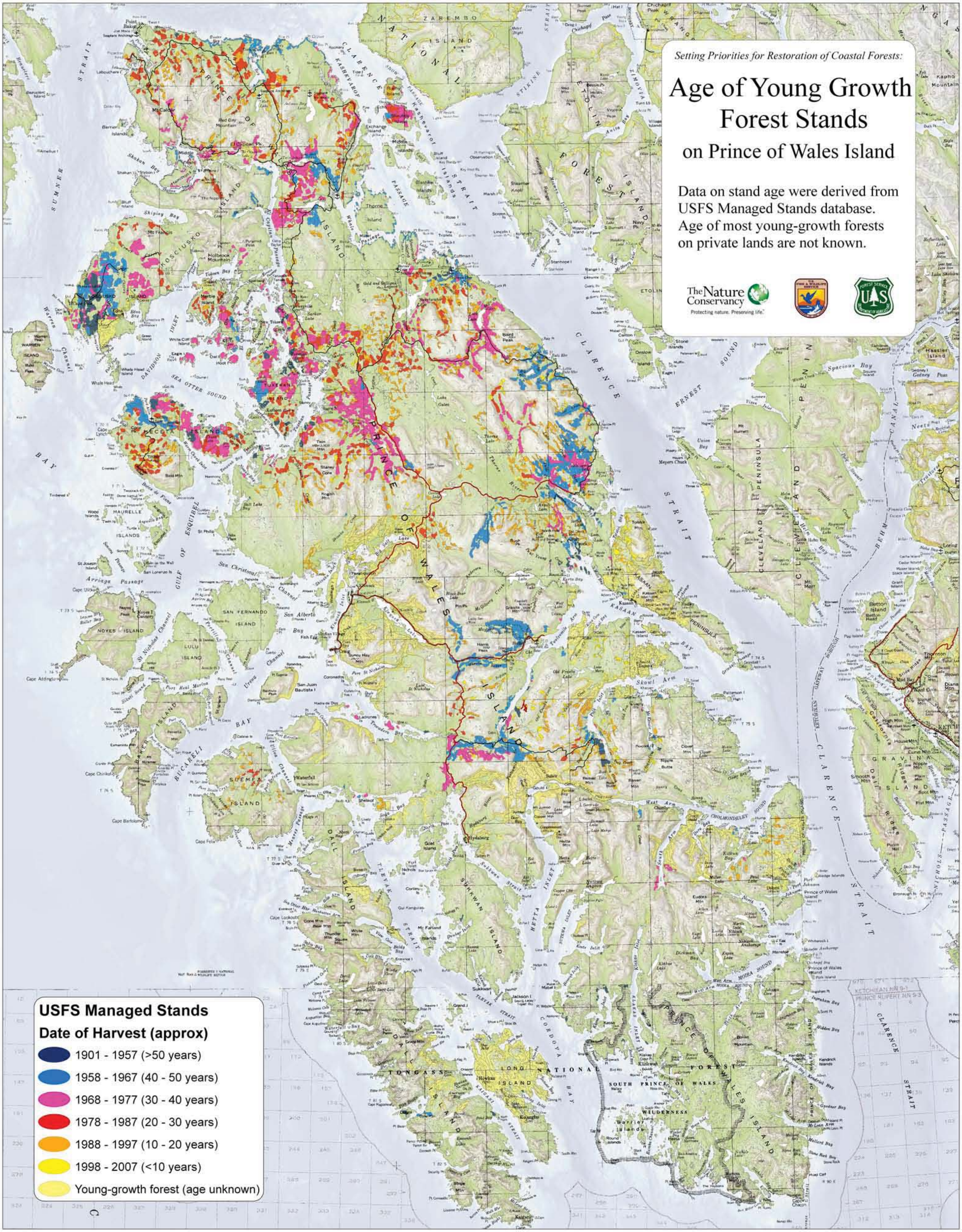

Figure 10. Age of young growth stands on Prince of Wales Island

IV. Conclusions

The purpose of this effort was to apply a set of systematic criteria on biological, social and economic values, in combination with measures of habitat conditions and restoration needs to develop a framework for decision-making on priorities, partnerships, and other opportunities. To this end, we have applied a set of criteria to evaluate priorities for restoration in freshwater habitats important for salmon (Fig 3), terrestrial habitats important for Sitka black-tailed deer (Fig 4) and karst forests (Fig. 6). There are other criteria that could be developed and applied and other features that need to be evaluated (e.g., commercial opportunities for young growth). This work represents a starting place and illustration of such a methodology.

Based on this methodology, we have identified watersheds in two situations that can be considered high priority for restoration (Table 7). The first set includes watersheds with very high biological and / or social values that contain mid-to-high levels of modification of important ecological systems and functions. Based on the biological or social values, these watersheds are considered to be "very high priority" for restoration. In the freshwater environment, these watersheds include Klawock River, Staney Creek, North and Central Thorne River, Harris River, Natzuhini Bay, San Alberto Bay Frontage and Hetta Inlet (Fig 11). In the terrestrial environment, these include Staney Creek, POW – Sea Otter Sound, Luck Point to Forest Cove (Cobble Landscape), Heceta Island and Eagle Creek / Luck Lake (Fig 12). For mapped karst forest systems, these include Trout Creek, Survey Creek, Twin Island Lake, Sea Otter Sound, Heceta Island, Tuxekan Island, East El Capitan Passage, and Neck Lake (Fig 13).

Table 7. A preliminary ranking of restoration priorities among watersheds on Prince of Wales Island based on value and condition of freshwater, terrestrial and karst ecological systems.

Type 1: Highest Value Watersheds

	Ecological System		
Rank	Freshwater	Terrestrial	Karst
1	Klawock River	Staney Creek	Trout Creek (Kos)
2	Staney Creek	POW – Sea Otter Sound	Survey Creek (Kos)
3	N. Thorne River	Luck Point to Forest Cove	Twin Island Lake
4	Harris River	Heceta Island	Sea Otter Sound (Kos)
5	Natzuhini Bay	Eagle Creek / Luck Lake	Heceta Island
6	San Alberto Bay		Tuxekan Island
7	Hetta Inlet		E. El Capitan Passage
8			Neck Lake

Type 2: Most Modified Watersheds

	Ecological System		
Rank	Freshwater	Terrestrial	Karst
1	Survey Creek (Kos)	Survey Creek	North Calder Bay
2	Long Island	Gravelly Creek	Shakan Bay
3	Twelvemile Creek	Maybeso Creek	El Capitan Passage
4	Black Bear Creek	Twelvemile Creek	Sweetwater Lake
5	Maybeso Creek	Ratz Creek	Kos – Sumner Strait
6	Eagle Creek / Luck Lake	Twin Island Lake	POW – Sumner Strait
7		Harris River	

A second set of watersheds are a high priority for investment as a result of high levels of modification with moderate to high biological/social values. In some cases, ecological systems within these watersheds may risk losing key functions and services, with natural processes leading to further degradation rather than recovery. At this time, it is not possible to draw generalized conclusions about ecological functionality based on thresholds within the coarse data used in this analysis. However, potential candidate watersheds include Survey Creek on Kosciusco Island (with >90% of deer winter range in >25 year-old young growth and >85% of riparian forest in young growth condition) and Twelvemile Creek (73% of deer winter range in >25 year-old young growth and 74% of all riparian forest in young growth condition). Other candidate watersheds in this category related to winter deer habitat include Gravelly Creek, Maybeso Creek, Ratz Creek, Twin Island Lake and Harris River (Fig 12). Within the freshwater realm, watersheds in this category also include Long Island, Luck Point to Forest Cove (Cobble), Maybeso Creek, Luck Lake, Black Bear Creek, Ratz Creek, among others (Fig 11). The candidate watersheds with high density of mapped karst features in the high priority category include Kosciusko Island – Sumner Strait, North Calder Bay, Flicker Creek, Shakan Bay, El Capitan Passage, Sweetwater Lake (Fig 13). The ultimate priority of action on these sites may depend on site-specific factors and opportunities such as local partnerships and commercially viable young-growth wood products.

The next phase of the restoration process on Prince of Wales Island is to field verify the sites identified in this preliminary framework, to develop restoration plans at the watershed scale, prescriptions for project level work, organize partnerships and funding opportunities, and finally to implement the watershed restoration plans. There is much work to be done on Prince of Wales Island, and this report provides a decision support tool for moving forward.

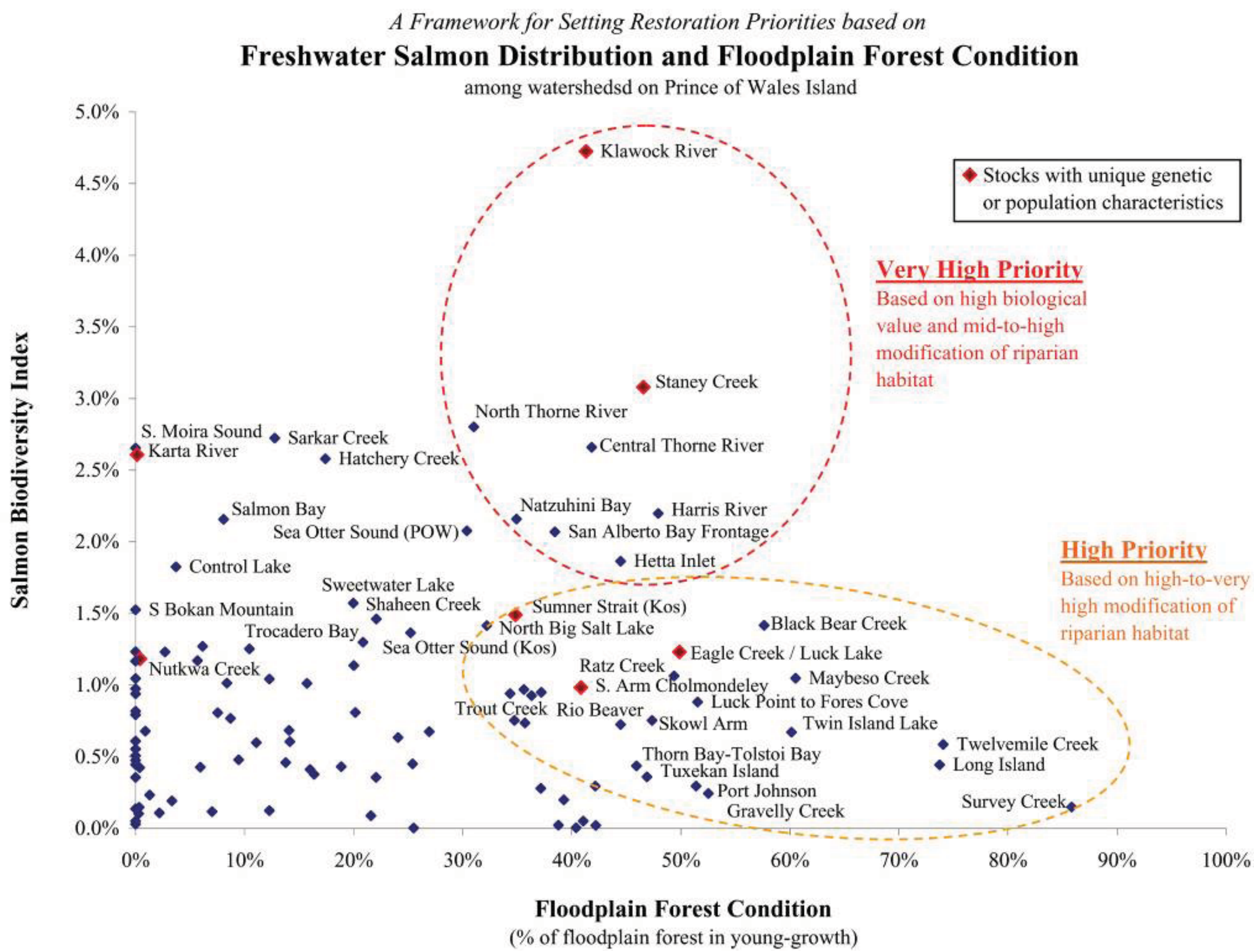

Figure 11. A framework for setting restoration priorities based on freshwater salmon distribution and floodplain forest condition among watersheds on Prince of Wales Island.

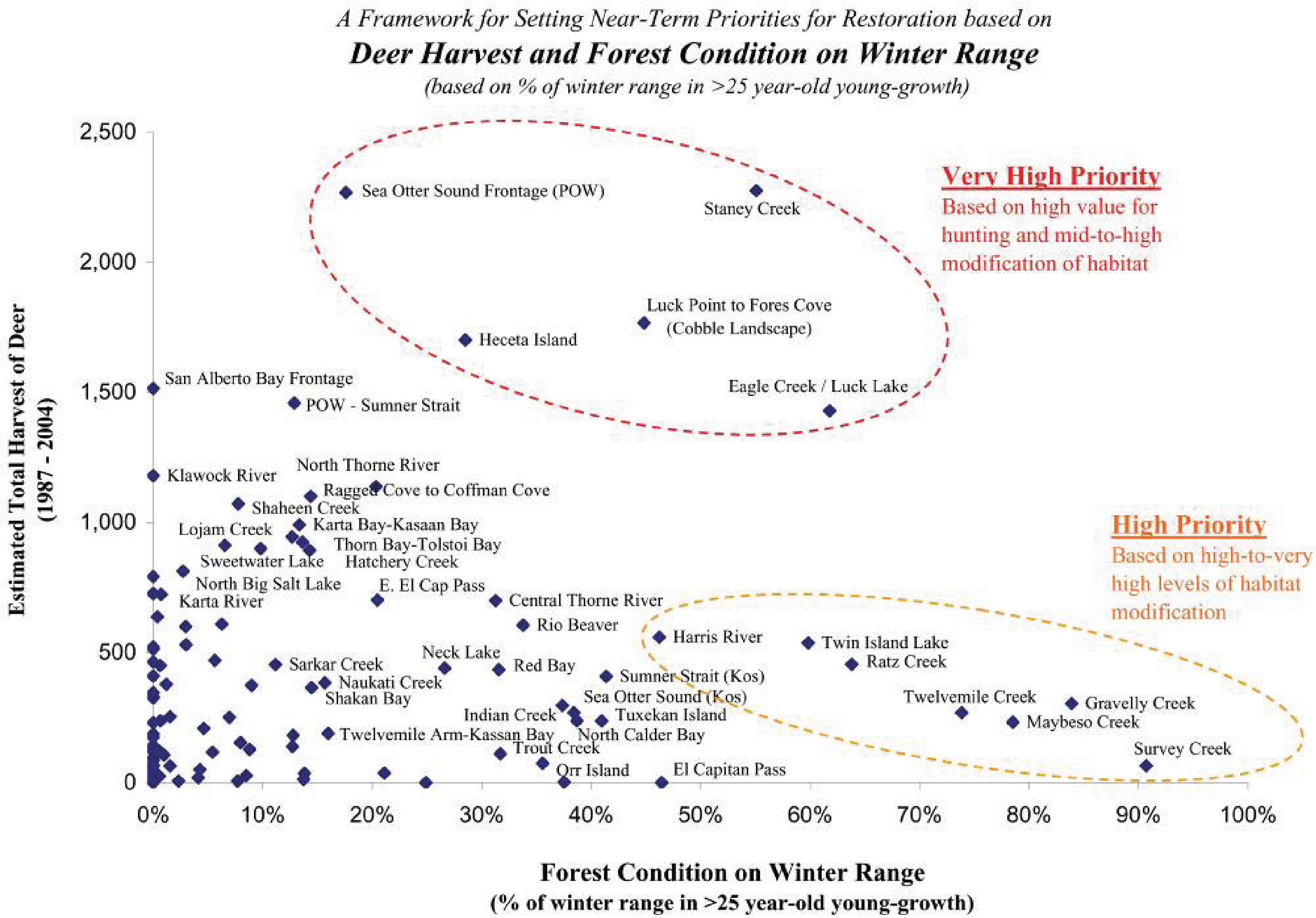

Figure 12. A framework for setting restoration priorities based on deer harvest and forest condition on winter range among watersheds on Prince of Wales Island.

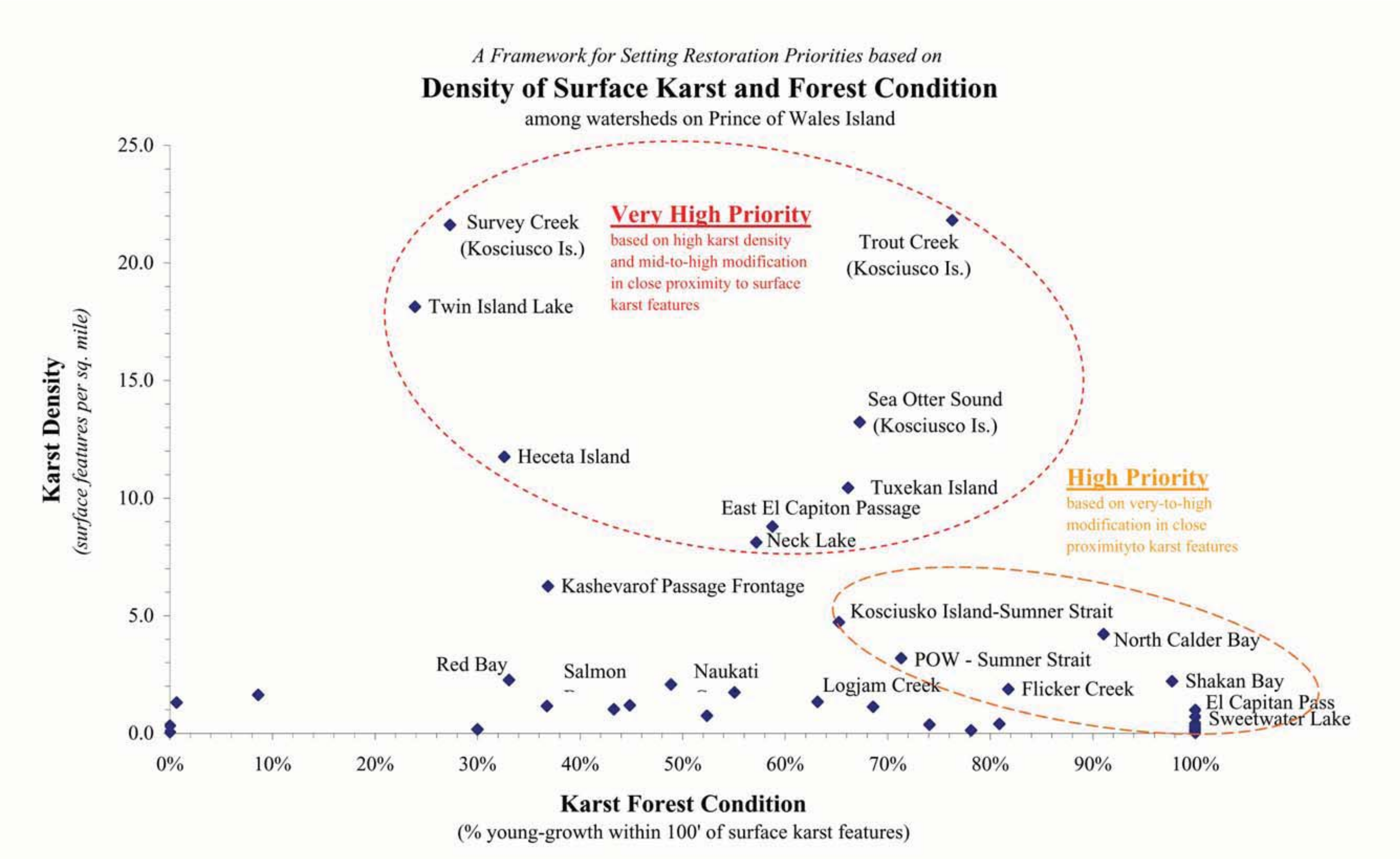

Figure 13. A framework for setting restoration priorities based karst density and forest condition among watersheds on Prince of Wales Island.

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