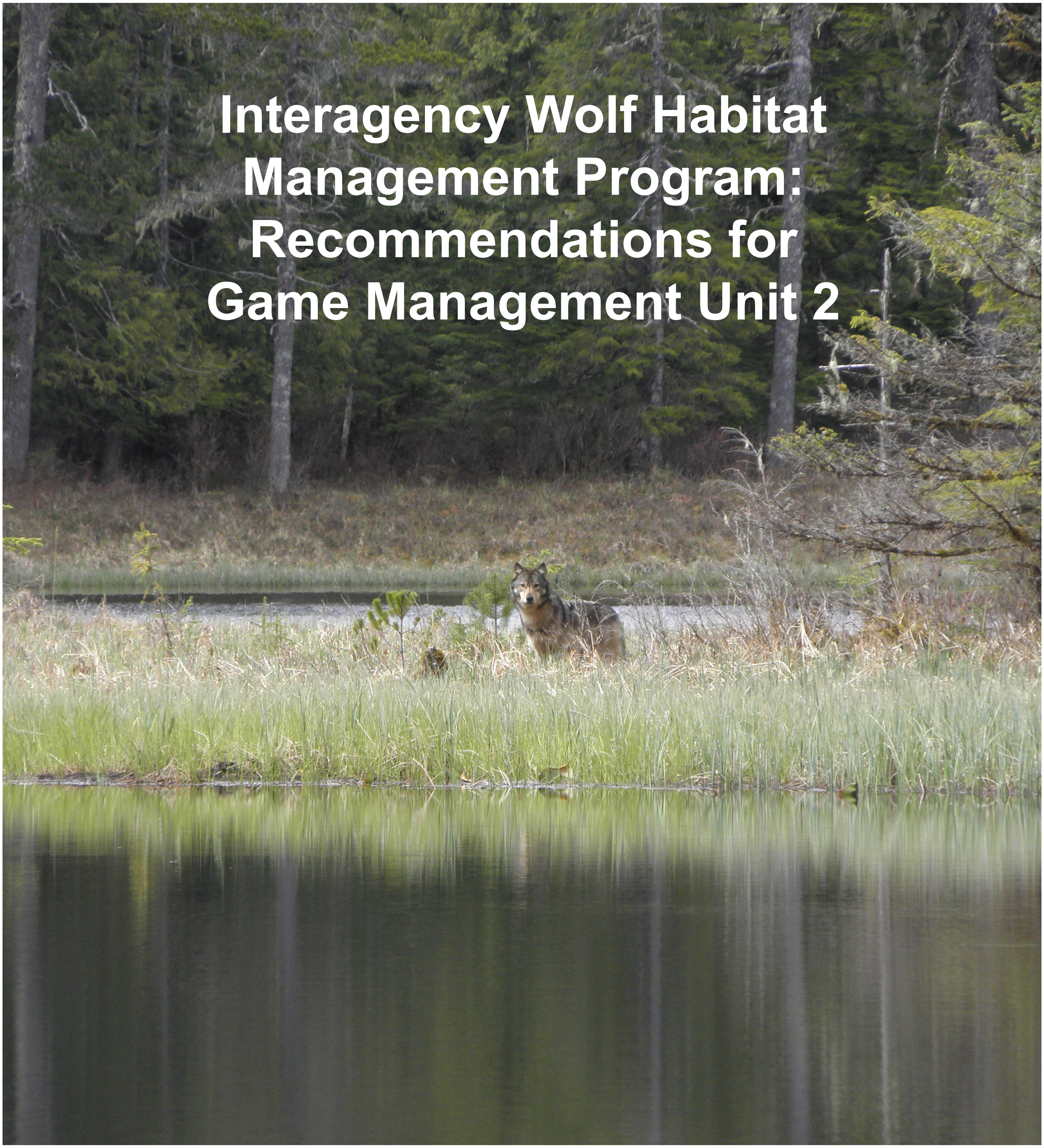
USDA

United States Department of Agriculture

Interagency Wolf Habitat Management Program: Recommendations for Game Management Unit 2



Forest Service
Alaska Region

U.S. Fish &
Wildlife Service

Alaska Department
of Fish and Game

R10-MB-822
March 2017

Suggested Citation

Wolf Technical Committee. 2017. 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.

Cover photo credit: Ray Slayton

Table of Contents

Introduction

Since 1997, the U.S. Forest Service (USFS) Tongass National Forest Land and Resource Management Plan (Forest Plan; amended 2016) has included standards and guidelines to assist in maintaining long-term, sustainable wolf populations. Among these is a standard to develop and implement an interagency Wolf Habitat Management Program in cooperation with the Alaska Department of Fish and Game (ADF&G) and U.S. Fish and Wildlife Service (USFWS), where wolf mortality concerns have been identified. Specific measures addressed in the Forest Plan include: a) working with the ADF&G and USFWS to identify probable sources of mortality and examine the relationships among wolf mortality, human access, and hunter/trapper harvest; b) incorporating interagency analyses on road access and associated human-caused mortality into travel management planning and hunting/trapping regulatory planning; and c) integrating the Wolf Habitat Management Program, including road access management, with season and harvest limit proposals.

Wolf mortality concerns have been identified several times within northcentral Prince of Wales Island (POW) and the encompassing Game Management Unit 2 (GMU 2; Unit 2 under Federal regulations), which includes POW and nearby islands (Figure 1). For example, unsustainable harvest rates have been documented in portions of the area by Person and Russell (2008) and Person and Logan (2012). The effects of these unsustainable harvests are reflected in an apparent progressively declining wolf population for GMU 2 since the mid-1990s. Based on estimates using different methods, fall wolf population densities in northcentral POW declined from an estimated 39.5 wolves/1,000 kilometers^2 (km) in 1994 (Person et al. 1996) to more recent estimates of 24.5 $\pm$ 6.8 wolves/1,000 km^2 in 2013 and 9.9 $\pm$ 3.0 wolves/1,000 km^2 in 2014 (Roffler et al. 2016a), with a slight increase to 11.9 $\pm$ 2.7 wolves/1,000 km^2 in 2015 (Roffler 2016).

Petitions to list the Alexander Archipelago wolf and the GMU 2 wolf population as threatened or endangered under the Endangered Species Act were filed with the USFWS in 1993 and 2011. Concerns listed by petitioners included high harvest followed by declining harvest, a rapidly expanding road network that allowed increased potential for harvest, and an anticipated decline in prey abundance. Although listing was found to be not warranted at the time, concerns about the sustainability of the GMU 2 wolf population were indicated (FR 32473 1/5/16, USFWS 2015). The finding considered a population model for GMU 2 that predicted additional wolf population declines of 5 to 20 percent over the next 30 years, primarily driven by predicted declines in deer habitat capability, and therefore deer abundance, due to forest management (Gilbert et al. 2015).

The 2016 amended Forest Plan facilitates a transition from harvesting old-growth forest to predominantly harvesting young-growth forest. After the USFWS decision in 2016 that listing was not warranted, and based on continued GMU 2 wolf population concerns, USFS leadership within the Tongass National Forest and Alaska Region directed staff to proceed with developing the Wolf Habitat Management Program and wolf management recommendations for GMU 2.

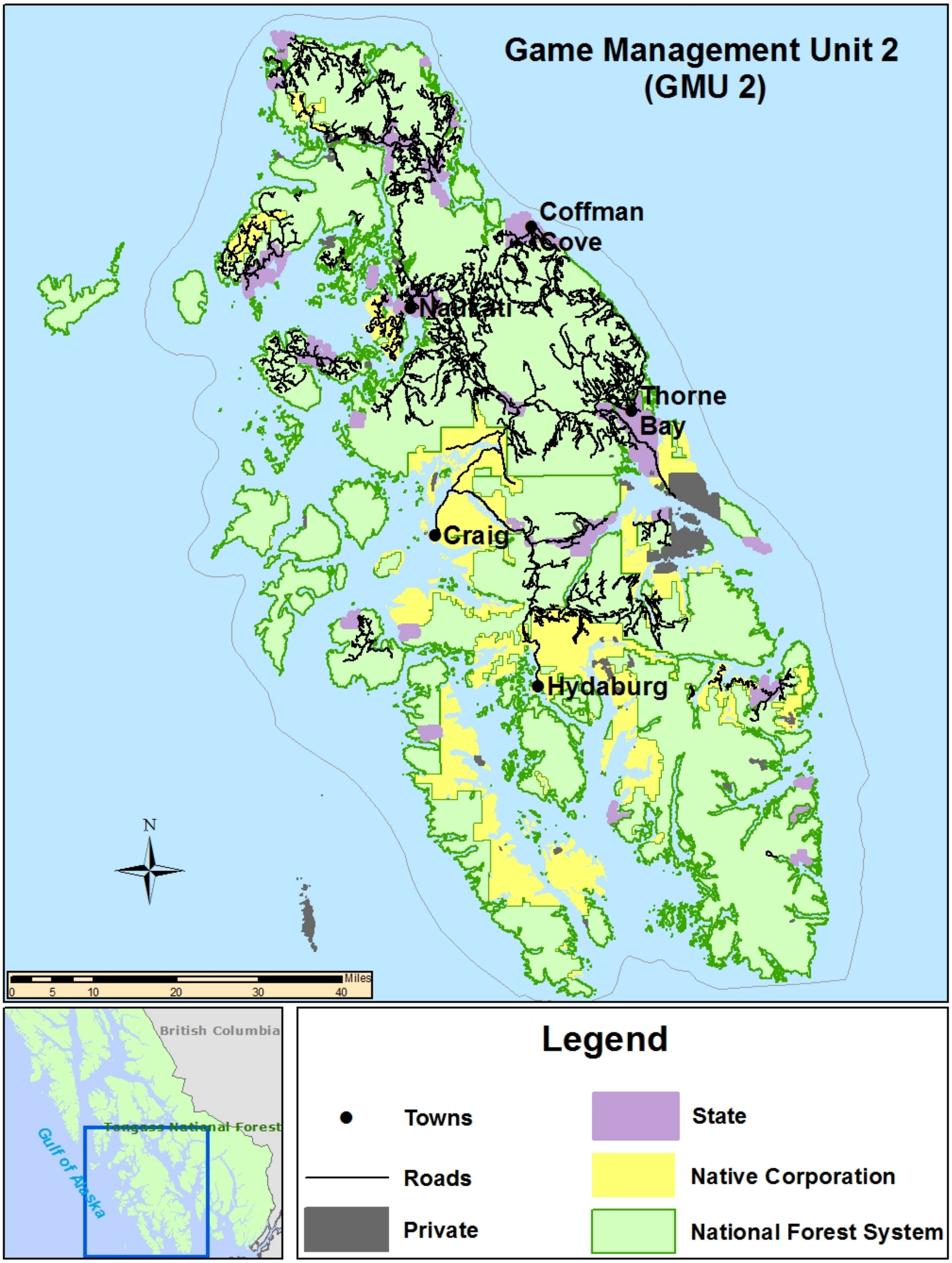


Figure 1. Game Management Unit 2 including Prince of Wales and surrounding islands.

The primary goal of these recommendations is to address wolf habitat concerns, which include Sitka black-tailed deer habitat management. The Forest Plan also requires integrating the Wolf Habitat Management Program with season and harvest limit proposals to assist in managing wolf mortality rates to within sustainable levels. Wolf harvests are managed by both the ADF&G and the USFS, under regulations adopted by the Alaska Board of Game (BOG) and Federal Subsistence Board, respectively; as described in the Wolf Management and Mortality section below. Specific population objectives have not been established for GMU 2 wolves by either management authority. However, since 1997 the BOG has set a Harvest Guideline Level (HGL) in regulation, with the intent of ensuring sustainable harvest over time. The HGL is a percentage of ADF&G's preseason population estimate for Unit 2 wolves and represents the maximum allowable harvest under State regulation. The HGL has been periodically adjusted by the BOG in response to changes in wolf abundance and new findings on harvestable surplus. The HGL was first set at 25% of the estimated wolf population in 1997, increased to 30% in 2000, and reduced to 20% in 2015. Within the HGL, the ADF&G and USFS set annual harvest quotas, usually 100%, of the HGL. However, to address an apparent decline in wolf numbers and documentation of high rates of unreported human-caused mortality (Person and Russell 2008, Roffler et al. 2016a), harvest quotas for 2015 and 2016 were reduced to 50% of the HGL.

The objective of this document is to develop science-based recommendations to meet mandatory Forest Plan standards for wolf habitat management in GMU 2. The management intent is to secure a wolf population that supports a sustainable harvest in GMU 2. Management recommendations for habitat, roads, and harvests provided in this management bulletin are intended to ensure the population is resilient to variation in prey abundance, harvest, and land management practices. Effects of implemented actions can be measured by monitoring the wolf population using the recently developed technique of noninvasive genetic mark-recapture sampling using wolf hair (Roffler et al. 2016b), followed by evaluation and adaptive management as appropriate.

These recommendations are intended to be useful in developing project measures and alternatives using public input through National Environmental Policy Act (NEPA) processes as well as in developing future State and Federal regulations. These recommendations focus on Game Management Unit 2 but may also have utility elsewhere on the Tongass National Forest.

Key Components of Wolf Management in Game Management Unit 2

Key components of wolf management in GMU 2 should address wolf population stressors that can be influenced by management, as well as other components critical to successful wolf management. Key wolf population stressors in GMU 2 include a) a predicted decline in deer, the main prey base of wolves, from severe winters and habitat loss due to changes in forest structure from past and future timber harvest, and b) high levels of human-caused mortality enabled by access roads provide and harvest regulations (Person and Russell 2008; Gilbert et al. 2015). Past and future timber-harvest and severe-winter frequency influence wolf populations indirectly by affecting deer populations and deer vulnerability. These indirect effects can be influenced via deer habitat management. Because deer are the principle prey of wolves in GMU 2, factors affecting deer habitat and deer populations are integral to wolf population dynamics in GMU 2. Therefore, key components of successful wolf habitat management in GMU 2 include managing deer habitat capability, especially in important winter deer habitats; and minimizing human-caused wolf mortality via road management and regulatory mechanisms through consultation with advisory committees, advisory councils, and the public. In addition, consideration of den management and human dimensions are critical to successful wolf management and are included as key components. Each key component of management is discussed in the following sections, with associated recommendations concluding each section.

Deer Habitat Management

Forest Plan standards and guidelines require, where possible, sufficient deer habitat capability to first maintain sustainable wolf populations, and then to consider meeting estimated human-deer harvest demands. Under State of Alaska statute and BOG regulation, deer in Unit 2 have been identified as a population important for providing high levels of harvest for human consumption use (5 AAC 92.108). The Forest Plan considers habitat capability of 18 deer/mi^2 (using habitat capability model outputs) sufficient to provide for both wolf and human harvests where deer are the primary prey of wolves, such as in GMU 2 (Forest Plan, USDA 2011). Note that Person et al. (1996) recommended using 18 deer/mi^2 for setting up reserves with high-quality deer habitat, but suggested habitat supporting a minimum of 13 deer/mi^2, where deer are the primary prey for wolves, provides for observed levels of deer harvest by hunters, trappers, and wolves. Measures require using 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 arrangement of habitat types, information from local users, and other factors also need to be considered rather than solely relying on model outputs. One supplementary tool to model comparative deer habitat conditions, the Forest Resource Evaluation System for Habitat (FRESH; Hanley et al. 2012), has recently been developed in a spatial environment. FRESH was used as part of the 2016 Forest Plan Amendment to evaluate changes in deer habitat capability in young forest conditions in the analysis of effects associated with the transition from an old-growth dominated timber program to a young-growth program.

Healthy deer populations are integral to maintaining sustainable wolf populations in GMU 2. While data on GMU 2 deer population trends are lacking, there is strong predictive evidence that deer populations will decline in the coming decades primarily as a result of previous and ongoing forest management (Person and Brinkman 2013, The Nature Conservancy 2014). Deer populations in GMU 2 are predicted to decline by 21 to 33 percent over the next 30 years, based on various road, timber harvest, and winter severity scenarios (Gilbert et al. 2015). Of these, the most likely scenario based on current management direction is predicted to result in a 21 percent decline in deer abundance over the next 30 years. Gilbert et al. (2015) discuss a number of assumptions and associated limitations related to their deer (and wolf) model. For the purposes of this document, we acknowledge that these assumptions and limitations exist and further emphasize that model predictions should be treated as relative effects of future change rather than as forecasts of population size or viability. Causes of predicted deer declines are complicated and include severe winter frequency, wolf population dynamics, wolf and deer harvest, and road densities. One of the primary causes of decline, and also one with opportunity for managers, relates to reductions in habitat capable of supporting deer, especially during severe winters, resulting from previous and ongoing timber harvest.

Effects of Timber Management on Deer

Old-growth forests are critical to deer in providing the juxtaposition of snow interception from canopy cover (Hanley and Rose 1987) that facilitates movement and available winter forage (Hanley and McKendrick 1985). Structural characteristics of old-growth forest in southeast Alaska and in GMU 2 develop through fine-scale tree mortality and growth resulting in a rich diversity and mosaic of tree ages and structure (Schoen et al. 1988). The heterogeneous canopy structure with occasional small gaps and side-lighting translates into a forest floor mosaic that benefits deer with a rich understory of forb, shrub, and lichen forage species under a canopy that intercepts snow.

Clearcutting of old-growth forests results in vegetation development that dramatically influences deer habitat capability (Alaback 1982, 1984, Schoen et al. 1988, Gilbert et al. 2017). Early-seral, post-clearcut stages are characterized by a flush of understory shrubs that provide abundant summer forage for deer, and forage during mild winters, but do not intercept snow due to lacking canopy closure so provide little forage and hinder movement during more severe winters. The succession of young-growth forests without treatment leads to a phase of stem exclusion. The dense, even-aged canopy of the stem exclusion phase provides canopy closure and associated snow interception, which facilitates deer movement during severe winters. The dense, even-age canopy also blocks sunlight and is characterized by a forest floor devoid of understory shrubs and forbs, so lacks deer forage. The degree to which the stem exclusion phase shades out understory vegetation depends on site productivity, topography, and other conditions. Seeds and rhizomes of understory forbs and shrubs are less abundant in older young-growth stands compared to old-growth forests and clearcuts, and reestablishment in older young growth is likely dependent on distance to seed source (Tappeiner and Alaback 1989). Stem exclusion lasts multiple decades with the most productive sites, especially those that also have side-source sunlight and nearby seed sources, pushing through earliest (~age 80 years) to start developing understory shrubs and forbs again. The timing and intensity of past timber harvest has led to large areas of young-growth forest within GMU 2 (Albert and Schoen 2013) most of which are in or moving towards age classes typical of stem exclusion (USDA 2014).

The term young growth refers to forests which have re-grown after a timber harvest. Four age classes are relevant to deer habitat management. The post-clearcut age class is characterized by saplings or young tree canopies that have not yet started to connect. Young-age young growth defines early-seral stands in which tree canopies have started to connect, but that are not yet exhibiting stem exclusion. Older non-commercial young growth refers to stand ages that have reached stem exclusion, but are not yet commercially viable for timber harvest. Older commercial young growth refers to stands that have reached sizes that are commercially viable, but have not yet pushed through to developing shrubs and forbs again. Though highly dependent on site productivity and timber markets for commercial viability, the approximate age ranges for each of these stages in more productive sites is 0-15 years, 16-25 years, 26-60 years, and >60 years, respectively.

Snow depth is the primary driver of winter habitat selection by deer, with deer preference for productive old-growth forest types increasing substantially with increased snow depth (Klein 1965, Schoen and Kirchhoff 1985, Gilbert 2015, Gilbert et al. 2017). Increased snow depths also resulted in increased preference for older young-growth forests which offer little forage but intercept snow, allowing for movement (Gilbert et al. 2017). Forage improvements from young-aged thinning can persist past subsequent canopy closure, however, leading to improved forage and snow intercept in treated older young growth. Increased snow depths also resulted in decreased deer preference for recently clearcut young-growth forests due to large accumulations of snow that impede deer movements (Gilbert et al. 2017). Deer use of untreated, older young-growth forests as well as younger clearcuts can result in malnutrition due to the absence of accessible forage year-round and during winter, respectively (Farmer et al. 2006). Fawn survival and population growth (Gilbert 2015) and deer population densities (Brinkman et al. 2011) are substantially reduced by severe winters in GMU 2. Old-growth forests on south-facing slopes and lower elevations are particularly important during severe winters, when other aspects and elevations retain more snow (Schoen and Kirchhoff 1985, Doerr et al. 2005, Person et al. 2009, Gilbert et al. 2017).

Snow conditions are likely to change in southeast Alaska in the coming decades. While most models for southeast Alaska predict reductions in snow-pack, earlier snow melt, and lengthened growing season, most also predict more severe and more frequent periodic storm events (Haufler et al. 2010, Wolken et al. 2011, Shanley et al. 2015). Changes in the availability, accessibility, and longevity of summer alpine and subalpine forage important to deer that migrate to higher elevations (75% of the population in some areas; Schoen and Kirchhoff 1985) are also possible. We acknowledge that snow regimes are important and likely to change, but do not further address climate change in this document due to the complexities and uncertainties of climate change scenarios and their potential effects on deer and wolves.

Habitat Management Techniques

Habitat management has been shown to reduce the impacts of post-clearcut forest succession on deer forage (Doerr and Sandburg 1986, Zaborske et al. 2002, Hanley 2005, Alaback 2010, Cole et al. 2010, Suring 2010, Hanley et al. 2013, Harris and Barnard in prep), though population-level benefits to deer remain undocumented. Young-age thinning (often called precommercial thinning) is done on young-age young growth towards the end of the early-seral stage to delay entry into stem exclusion and shading understory forage (Doerr and Sandburg 1986, Cole et al. 2010, Hanley et al. 2013). Commercial thinning is done on older commercial young growth, resulting in timber product as well as benefits to deer forage (Zaborske et al. 2002, Hanley 2005). Small-gap creation (DeMeo et al. 1990, Knotts and Brown 1995 – cited in Suring 2010; Alaback 2010, Harris and Barnard in prep), branch pruning (Hanley et al. 2013), girdling trees (Hanley et al. 2013), elevational leave corridors (reaching from high to low elevation; The Nature Conservancy 2014), and slash treatments (Hanley et al. 2013) are other techniques used, some in combination. These techniques are discussed in more detail below. Goals of young-growth treatments include decreasing stem exclusion effects on deer forage, increasing fine-scale (within-stand) heterogeneity to provide for forage, movement (including elevational), and thermal cover needs in close proximity across young-growth landscapes, especially on deer winter range, and avoiding the inadvertent creation of a secondary conifer-recruitment flush that mimics a secondary clearcut.

Thinning of Young-Age Young-Growth Forest

Site productivity and the timing and types of treatments of young-aged young growth have important ramifications on ecological succession. The Tongass Young-Growth Management Strategy (USDA 2014) provides clarity on the wide variability of young-growth conditions as well as timings appropriate to various treatment and site types. The readiness of a stand for treatment depends on stand productivity which can be highly variable even within a stand. The ideal timing for young-aged thinning occurs when some young trees begin to express dominance and canopies begin to close. Earlier treatments are susceptible to creating a second flush of tree growth, essentially producing another effective mini-clearcut, though these concerns can be abated with good stocking prescriptions as long as the trees are at least about 10 feet tall. Earlier treatments also run the risk of removing potentially dominant trees before they have expressed dominance. Later treatments create larger quantities of slash that inhibit deer movement and take longer to break down due to larger log diameters (McClellan et al. 2014). Higher mortality of young deer by malnutrition in thinned 28-30 year-old young growth, as well as evidence of a highly variable distribution of forage in this habitat despite its overall abundance, led Farmer et al. (2006) to speculate that large amounts of slash may have hindered movements by young deer, limiting availability of food and increasing risk of death by malnutrition. Management should aim to thin before tree sizes get big enough to cause slash to persist longer than about 10 years when slash treatment is not part of the prescription.

To prolong understory productivity by delaying the stem exclusion phase, management should aim to thin all young, untreated young growth prior to about 25 years post-harvest in medium to high productive stands; older treatments are appropriate for sites of lower productivity. Many acres of untreated young growth in GMU 2 are expected to be ready for young-age thinning as shown in Figure 2 and Table 1. Using these timing projections, treatments can be prioritized as needed in landscapes likely to support deer winter range and where the need is greatest. In addition to deer winter range, this may include prioritizing landscapes with high proportions of untreated young growth (or alternatively low proportions of intact old growth), high proportions of scheduled old-growth harvest, or where understory forage is more ubiquitously devoid across the landscape due to topographic, geologic, hydrologic, and/or soil influences. The readiness of a stand for young-age thinning as discussed above is most likely to influence treatment prioritization of stands within a landscape. Other criteria for stand prioritization that favor deer needs could include understory conditions of the stand based on topographic, geologic, hydrologic, and/or soil conditions, the likelihood of improving forage (e.g., based on side lighting), and the likelihood of improving forage near elevational movement corridors, thermal cover, and winter habitat. The most important deer winter range in GMU 2 is typically defined as southerly-facing slopes (120-240^{o}, Person et al. 2009) lower than 800 foot elevation (USDA 2011). Habitat in close proximity to salt water may also be selected during severe winters (Doerr et al. 2005).

Leaving strips that provide elevational movement corridors for deer should retain high canopy cover within otherwise thinned young-age stands, thereby providing habitat heterogeneity, snow interception, and slash-free areas facilitating movement along elevational gradients. It is important to maintain or enhance connectivity between higher and lower elevations, aiming to connect the full elevational span of alpine to beach habitat. Ridgelines running from high to low elevation are typical travel corridors in undisturbed landscapes and should be considered for leave strips in the absence of on-the-ground knowledge of local deer movements. Steep V-notches containing streams would often be poor corridors that could inhibit deer mobility, especially in deep snow. Existing migration and movement routes, terrain features, and habitat connectivity that provide for deer-elevational movements are likely to be most important during severe winters. These routes and features should be identified by an interagency team and used in designing locations for leave strips on the landscape.

Distance between elevational movement corridors is also a management consideration. As stated above, the design of leave strip locations will often be determined by existing movement routes, terrain features, and habitat connectivity needs between stands. In the absence of these characteristics, management should space movement corridors within areas proposed for thinning to reduce the potential of deer getting trapped within thinned stands during heavy snowfalls and to reduce energy expenditure of young deer moving through slash because deep

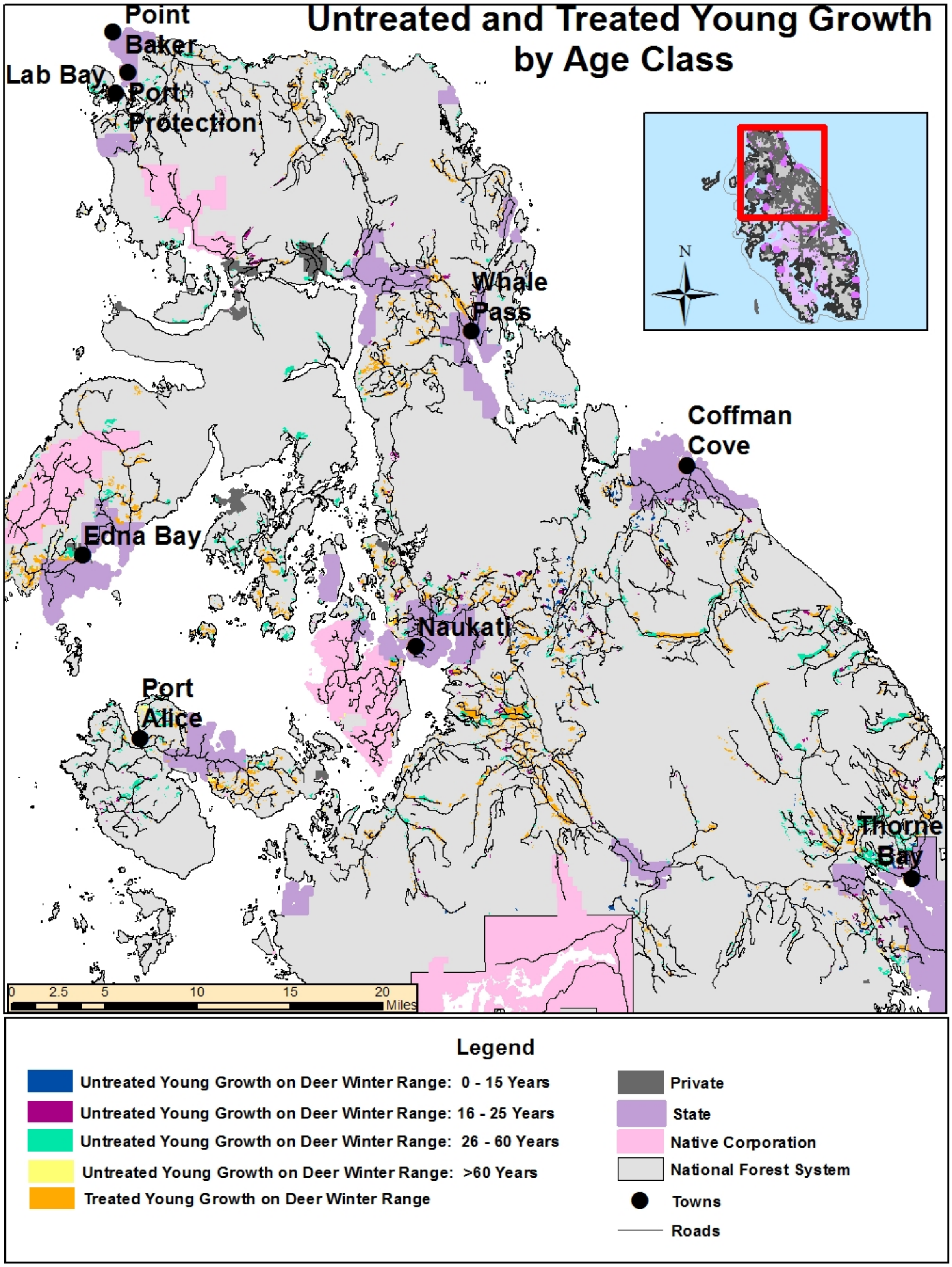


Figure 2. Untreated and treated young growth by age class (0-15, 16-25, 26-60, and >60 years) on deer winter range on Forest Service lands on the northern portion of Game Management Unit 2. Deer winter range is defined as southerly-facing slopes (120-240 degrees) lower than 800 foot elevation.

Table 1: Untreated young growth (acres; YG) on Forest Service lands by decade harvested. Also open and total road densities (miles/miles^2) below 1,200 feet elevation, within Wildlife Analysis Areas (WAAs) on Prince of Wales (POW) and adjacent islands in Game Management Unit 2. Open roads include all Forest Service, State, and private roads (Total Roads) minus all decommissioned and Operating Maintenance Level 1 (USDA 2005) roads. Roads data are from the National GIS Clearinghouse.

WAA	Pre-1935 YG	1936-1945 YG	1946-1955 YG	1956-1965 YG	1966-1975 YG	1976-1985 YG	1986-1995 YG	1996-2005 YG	2006-2015 YG	Total Acres YG	Open Roads mi/mi^2	Total Roads mi/mi^2
901	0	0	0	27	0	12	1022	219	507	**1788**	0.23	0.77
902	0	0	0	0	0	0	0	0	0	**0**	0.04	0.04
1003	0	23	857	493	4436	1847	1952	577	0	**10185**	0.92	2.43
1105	43	20	0	296	0	0	0	0	0	**359**	0.92	0.92
1106	0	14	0	0	0	0	0	0	0	**14**	2.88	2.88
1107	0	225	53	35	1	759	307	97	0	**1477**	1.02	1.05
1108	49	0	138	0	0	12	0	0	0	**199**	0	0
1209	0	0	0	0	0	0	0	0	0	**0**	0.03	0.03
1210	0	0	0	0	0	0	51	0	0	**51**	0.01	0.01
1211	0	0	0	191	665	65	879	496	177	**2473**	1.45	1.59
1212	0	0	0	6	58	0	0	4	0	**68**	0	0
1213	0	0	0	117	0	0	0	68	0	**185**	0.38	0.38
1214	0	51	345	1028	104	0	2847	3181	13	**7570**	1.7	2.09
1315	0	190	429	4639	2359	394	3967	2490	422	**14891**	1.83	2.35
1316	0	0	0	0	90	0	0	0	0	**90**	0.04	0.04
1317	0	0	0	4403	948	16	826	853	43	**7090**	1.04	1.9
1318	0	0	0	116	0	2749	4126	1912	184	**9088**	2.41	2.47
1319	0	0	0	817	2275	1182	3249	891	188	**8602**	0.94	1.54
1323	0	15	123	0	82	0	829	50		**1099**	0.2	0.34
1332	0	0	46	114	682	187	1004	212	74	**2320**	0.94	1.22
1420	0	0	133	3023	1463	412	2880	492	379	**8783**	1.71	2.49
1421	0	0	73	398	1182	1876	3012	109	2038	**8687**	0.95	1.48
1422	59	449	369	12	3196	2684	2987	2551	163	**12469**	1.13	2.05
1524	0	0	0	0	0	0	0	0	0	**0**	0	0
1525	0	106	388	1424	2781	590	2	97	0	**5388**	0.88	2.12
1526	0	0	0	0	1178	932	0	0	0	**2109**	0.01	0.24
1527	0	0	0	0	1639	724	1668	16	0	**4047**	1.23	1.8
1528	0	0	0	82	771	0	590	43	0	**1486**	0.23	0.64
1529	8	14	54	1005	203	1190	3438	272	0	**6184**	1.08	1.77
1530	0	5	0	746	1230	421	1512	199	194	**4307**	1.15	1.72
1531	10	251	654	401	2749	1046	1019	101	437	**6667**	0.97	1.67
Total	**169**	**1362**	**3663**	**19373**	**28089**	**17098**	**38169**	**14931**	**4821**	**127675**	**POW 0.91**	**POW 1.26**

snows are the most limiting factor of deer movements (Gilbert 2015, Gilbert et al. 2017). Shorter distances between travel corridors may also help reduce the young deer mortality observed in thinned stands presumably caused by slash impediments and high forage dispersion (Farmer et al. 2006). An appropriate distance for spacing travel corridors in young-age thinning has not been previously documented and deer movement limitations within young thinned stands are not well understood. Deer have been documented traveling up to 1,312 feet into clearcuts under conditions with generally low snow accumulation (Chang et al. 1995). Nelson et al. (2008) suggested limiting openings to 2.5 to 7.4 acres on deer winter range experiencing enough snow accumulation to restrict deer foraging and movement. Assuming a square clearcut, this suggests widths on deer winter range of about 330-568 feet (372-641 feet for a circular cut) to reduce the creation of movement impediments and facilitate deer access between travel corridors during snowy winters. Until additional data become available, we suggest using 400 feet as a guide to space travel corridors within thinning treatments in the absence of existing routes, terrain features, or habitat connectivity drivers.

There may also be opportunities during young-age thinning to favor certain tree species with forage value for deer. Though conifers typically have low forage value, during winter deer will forage on red cedar and yellow cedar, which should be favored over other conifers (Nelson et al. 2008). Another approach includes retaining, and possibly planting, red alder to keep the forest canopy open and retain understory forage longer as well as to improve nitrogen fixation and enhance growth of understory plants (Deal 1997, Hanley and Barnard 1998, Hanley 2005, Hanley et al. 2006, Nelson et al. 2008), though deer may avoid alder-dominated habitats during winter months (Miller 1968, Hines and Land 1974).

While some studies have assessed effects of young-age thinning treatments on understory response (Doerr and Sandburg 1986, DellaSala et al. 1996, Alaback 2010, Cole et al. 2010, Hanley et al. 2013; and ongoing monitoring see Suring 2010, USDA 2014), research on effects of young-age thinning on use and vital rates of deer are more limited (e.g., Doerr and Sandburg 1986, Farmer et al. 2006). To learn whether young growth treatments are having the desired effect and whether they can be improved, additional monitoring and research to evaluate population response of deer to young-growth treatments are needed. The need to treat second-growth forest presents an opportunity to experimentally test the effects of treatments on deer and other species. Some of the early efforts to treat young growth should be developed in an experimental framework to evaluate effectiveness of the treatments. Information from monitoring will assist in adaptive management and planning for subsequent treatments, and help avoid inadvertent creation of long-term impacts to deer habitat.

Treatments for Older Young-Growth Forest

Additional treatment opportunities are also present for older forest stand ages. Non-commercial, older young-growth treatments should generally be avoided to avoid heavy slash accumulation, if slash treatment is not part of the prescription. Exceptions may be sought where older young-growth forests exhibit stem exclusion across large portions of a landscape. In these areas, thinning, creating small gaps, pruning, girdling, and a combination of these treatments should be considered to provide forage for deer until the stand is old enough for commercial treatments, which do not incur slash impacts. Thinning treatments should generally favor the retention of dominant trees to maintain snow interception capacity of the overstory. Thinning treatments should also incorporate unthinned corridors to facilitate elevational movements by deer. Large accumulations of slash will reduce habitat availability and forage following thinning of older, non-commercial forest, so tradeoffs, mitigations, and other options should be carefully assessed.

Gap treatments are an option to consider for improving deer forage in older, non-commercial young-growth stands in areas where stem exclusion is ubiquitous across a landscape. One benefit of gap creation in older-age young-growth stands that does not occur with broader-scale thinning is that gaps provide deer forage within and near canopy closure, simultaneously providing for forage, thermal cover, and facilitated movement. Winter carrying capacity as measured in understory biomass available, biomass used, and deer days calculated using the FRESH model (Hanley et al. 2012) showed gap treatments as having higher winter capacity than thinning treatments, while both had lower values than old-growth habitat (Alaback 2010, Harris and Barnard in prep). However, the opposite relationship existed for summer and snow-free winters, with gaps resulting in fewer deer days than thinning treatments under these scenarios (Harris and Barnard in prep). Gaps also resulted in long-term benefits to deer forage, with increases continuing beyond 23 years (Harris and Barnard in prep). Approaches to increase growth and recruitment of understory forage in gaps could include pruning along the edges of gaps to maximize side-lighting into adjacent forest, siting gaps on remnant understory vegetation, and planting target understory forage plants (Christensen 2012). Mulching or tilling the duff and topsoil layers within gaps may also help stimulate microbial activity and release nutrients to increase understory plant growth. Measures should also be taken to reduce slash within gaps. The relative costs of gap creation are more than thinning based solely on the footprint area of treatment (e.g., 1/10th acre gap), but are likely more cost effective when considering the effective area that each gap, and multiple gaps across the landscape, improve for deer. Indeed, only a fraction of the area (<5–10%) of unproductive young-growth landscapes needs a gap treatment to increase forage productivity for deer (Alaback 2010).

Gaps should be large enough to provide canopy openings and sunlight to produce deer forage over time, but small enough to avoid creating a secondary recruitment flush of conifers (Alaback 2010, Deal and Farr 1994) and to function as a gap rather than as a stand-replacement disturbance (Ott and Juday 2002). Conifer flush did not appear to have a consistent relationship with gap size (Alaback 2010), though the young age of some of these stands at treatment (ages 13 to 41, median 23 years) may have been influential. The biomass of conifer seedlings in gaps ranging from 35 to 77 feet diameter in older young-growth stands (~58 years at treatment), was initially higher than shrub biomass, but was surpassed by shrub biomass after the first 10 years post treatment and continuing 23+ years post treatment, suggesting that these gap diameters did not produce a forage-limiting conifer flush (Harris and Barnard in prep).

A number of suggestions have been made regarding appropriate gap widths. Alaback (2010) suggested gaps < 160 foot in diameter simulate wind disturbance or small-patch tree mortality characteristic of old-growth forests in southeast Alaska (Nowacki and Kramer 1998, Ott and Juday 2002). Tappeiner and Alaback (1989) suggested creating openings 33 to 98 feet in diameter to help maintain understory forb and shrub species. Gaps designed to increase deer forage productivity ranged from 35 to 77 feet in diameter (60 foot mean; Harris and Barnard in prep). Calculations of appropriate gap diameters based on tree heights of the surrounding canopy may be more appropriate. One example is to use a diameter to canopy height ratio <1, which is supported by natural variation in this ratio in southeast Alaska of 0.08 to 0.62 (mean ratio < 0.3; Ott and Juday 2002). Derivations allowing for long, narrow gaps with a diameter to height ratio >1 but still functioning as gaps, for example an average long-access width < average total height of surrounding forest, have also been proposed (Ott and Juday 2002). The influences of opening shapes and sizes on forage and deer response over time are not well understood and we recommend evaluating these relationships further. Based on these uncertainties, as well as the gap parameters discussed above and the likelihood that wind will increase gap sizes by blowing down additional trees post treatment (Harris 1999, Ott and Juday 2002), we recommend designing gap widths to be around 70 feet in older, young growth managed for deer habitat values, until additional information becomes available. This value may be adjusted to correspond with tree heights.

Girdling, typically combined with lighter thinning prescriptions, should be explored as a way of increasing deer forage in non-commercial, older-age young-growth stands within larger areas of stem exclusion. The potential benefits of girdling include reducing and delaying the accumulation of slash, thereby reducing impacts on deer mobility. Indeed, preliminary results show 4-6 times higher deer habitat values from girdling treatments compared to untreated controls (Hanley et al. 2013). There is some evidence that girdled trees in the wet, windy, and heavy-snow conditions typical of the Tongass National Forest tend to come down quickly, many snapping off at the girdle within the first 4 years after treatment (Hanley et al. 2013). Girdling technique may have contributed significantly to this outcome, however, and these scientists suggest the need for careful contract administration to avoid deep chainsaw cuts that leave too small of an intact bole to sustain wind and snow. The relative costs of girdling are generally similar, perhaps slightly higher, than those for non-commercial thinning.

Pruning, or cutting branches along the bole of trees to a defined lift height (typically as high as 17 feet), may be the most certain way to enhance deer forage in stem exclusion. This habitat management technique increased deer habitat values by 4-6 times that of untreated controls when done in previously untreated stands at age 25-35 years and monitored 4 years after treatment (Hanley et al. 2013). Pruning is expected to produce greater benefits when applied to stands that have been previously thinned (Hanley et al. 2013). Around the edges of gaps, on steeper slopes, or adjacent to other more open areas may also be good areas to focus pruning because of advantages from increased side-lighting into the forest. Pruning results in light slash that breaks down quickly and is not likely to impede deer movement. Preliminary observations suggest no additional forage benefits from pruning 50% of the trees compared to 25% of the trees (Hanley et al. 2013), though further study is warranted, especially regarding benefits of pruning all trees (100%). Effects of lift heights on forage development have not been reported. Pruning treatments may provide additional benefits for deer by retaining canopy closure and snow interception, though effects of pruning on snow interception are not well understood.

Though pruning originated to improve wood quality for harvest, it is now typically seen as a wildlife treatment because benefits to timber have not yet been actualized. Pruning may have some benefits in reducing knots and producing more clear wood (Petruncio 1994), especially if done on all trees to reduce the need for sorting by processors. However, there is evidence that pruning causes epicormic sprouting, or sprouting of small branches along the bole, especially in spruce trees (Deal et al. 2003), though follow-up site visits indicate the branches did not persist. Pruning may also result in hemlock staining (McClellan 2005). The relative costs of pruning depend on the percent of trees pruned and lift height, and can be similar to, cheaper, and sometimes more expensive than non-commercial thinning.

Treatments intended to improve deer habitat in older non-commercial young growth should include management of slash to facilitate deer movement and improve availability of forage. Slash treatment options could include bucking, chipping, burning, trail cutting, windrowing, smashing with heavy equipment, moving/piling (e.g., out of gaps), and finding uses for the logs elsewhere. Creative uses of slash include as firewood, alternative fuel for commercial boilers and residential heating systems, and riparian and instream habitat structures. Slash treatments can be cost prohibitive and are typically done at small scales (e.g., in gaps or corridor creation).

In GMU 2, young-growth stands generally start to reach commercial viability around ages 55-70+ years, depending on site productivity and market product demand; note that we used >60 years to define and summarize these stands (Figure 2). Such stands may be commercially treated or harvested. In commercial applications, logs are removed from the site, reducing the accumulation of large-diameter slash and effects of large slash on deer movements. Land Use Designations (LUDs) and Forest Plan standards and guidelines define management conditions and objectives for all Forest Service lands within GMU 2, and in some areas set sidebars for achieving those conditions and objectives.

Treatments in Stands with Dual Management Objectives

Under the 2016 amended Forest Plan, commercial young-growth treatments within Old-Growth Habitat LUDs, the beach and estuary fringe within Development and Old-Growth Habitat LUDs, and Riparian Management Areas outside of Tongass Timber Reform Act buffers within Development and Old-Growth Habitat LUDS will be designed to meet dual management objectives defined under desired conditions and management approaches. Desired conditions in these areas include progressing stands towards old-growth conditions while also obtaining commercially viable products. We recommend careful consideration be put into prescriptions in these areas. Treatments should be designed to benefit deer in the long-term. Opportunities also exist in these areas to design treatments that improve habitat for deer in the near-term by increasing understory forage development without compromising continued succession towards old-growth conditions that support long-term habitat for deer. Treatments that might be used to meet the dual desired conditions of these areas and help deer include variable-density thinning, thinning to favor retention of dominant trees, and creating small gaps and narrow openings. Some of these treatments may be combined with pruning, especially in areas with prior young-age thinning and/or adjacent to gaps to further forage development. While the 2016 Forest Plan standards require that cuts not exceed 10 acres within these areas, smaller openings are more typical across the southeast Alaska landscape (Ott and Juday 2002). Smaller openings are also allowed under these standards, would help maintain consistency with the desired management condition of progressing stands toward old-growth conditions, and would likely promote short- and long-term deer habitat value in these stands. All gaps in these areas should be narrow, designed with an approximate width of 70 feet - see discussion of gap diameters above - with increases in length and sinuosity (maintaining width) as they get bigger. Commercial opportunities should aim to be economically viable, while avoiding compromising succession towards old-growth conditions within these areas.

Habitat Treatments in Development LUDs

Commercial-age young-growth treatments in Timber Production, Modified Landscape, and Scenic Viewshed LUDs (Development LUDs) also offer opportunities for deer habitat improvement. Given that timber production is a high priority within these LUDs, deer habitat improvement may be prioritized as needed in areas with high potential for important deer winter range, such as on low-elevation, southerly-facing slopes. The overall goal would be to provide stand heterogeneity, providing deer forage in close proximity to high canopy cover (to provide thermal cover, snow interception, and travel corridors) through time, across the landscape. Deer like edges (Chang et al. 1995) and treatments that create many openings can break up large expanses of young-growth stands, improving deer habitat. Therefore, more small treatments as opposed to fewer large treatments, spread across larger or contiguous even-aged stands, can improve deer habitat value of the area. Staggering treatments in time (cutting only a small percentage of a large stand each decade, for example) can reduce fluctuations in deer habitat quality and help stabilize deer numbers. Slopes are also a consideration (The Nature

Conservancy 2014). Due to higher predation of deer on flatter slopes, especially during snowy winters (Farmer et al. 2006), there may be benefits to designing treatments that are smaller and more dispersed on flatter terrain (The Nature Conservancy 2014).

Harris (1984) developed a strategy for maximizing edge effects through successive rotations by systematically placing new cuts adjacent to stands of mid-rotation age. His concept of "long rotation islands" relies on skips between successive, wedge-shaped cuts, arranged in a circular pattern similar to a pie, with all but a permanently-protected reserve in the center harvested over successive rotations (Figure 3). This system could be conceptually adapted to low-gradient sites where deer habitat is a consideration. For example, a large young-growth stand or set of stands (e.g., a valley bottom) could be divided into 9 wedges, with one wedge treated each decade, in an order similar to that shown in Figure 3. As a guideline for wedge size, Nelson et al. (2008) suggested limiting openings to 2.5 to 7.4 acres on deer winter range that experience enough snow accumulation to restrict deer foraging and movement. This conceptual design would maintain early-succession stands (in the shrub stage) adjacent to stands at least 40 to 50 years old, throughout the entire (and successive) rotation(s). Additional ecological benefits would likely result from retention of mature or old forest in the center of the treatment "pie."

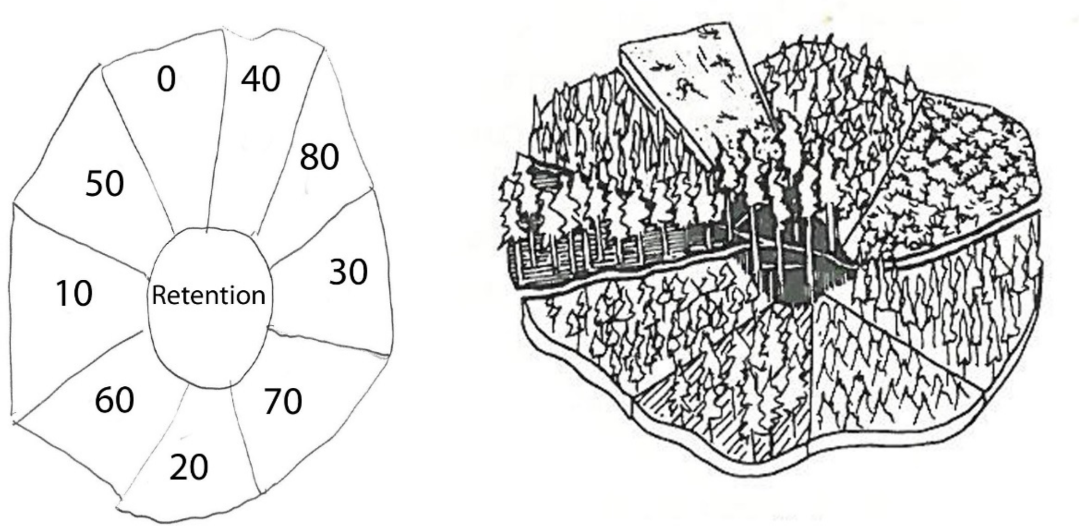


Figure 3. An example rotation island concept to provide heterogeneity and edges through successive timber rotations. Left is a schematic of 9 wedge-shaped harvest units, with the year each unit is cut through a 90-year rotation. Alternate wedges are cut 10 years apart, leaving intervening units to provide snow interception and hiding cover between recently cut units. After 90 years, the rotation island might resemble the diagram on the right; with the stand that was cut in year 0 harvested a second time. This system is recommended for low-gradient, low-elevation, young-growth sites (e.g., valley bottoms) where improvements in deer wintering habitat are desired (Adapted from Harris 1984).

A variation of Harris's (1984) long rotation island that could be adapted for use on south-facing slopes with existing roads to provide deer habitat through the full timber rotation would use blocks of 9 or more parallel strip cuts and oriented with their long axes running from high to low elevation along a south-facing slope (Figure 4). This "strip rotation block" arrangement would also rely on skips between cuts, with successive cuts done approximately every10 years. Closed canopy forest (either old growth or young growth, as available) should be retained along ridgelines or other elevational corridors to provide snow interception throughout the rotation (Figure 4).

Both systems would produce a relatively stable ratio of shrub to older stand edges once the first few cuts were established. We note that these systems would provide a slower but perhaps more stable flow of timber from existing young-growth stands, with entries every 10 years. Managers may choose to experiment with a variety of treatments, such as gaps, variable retention thinning, pruning, or other techniques to create additional heterogeneity in the strips and wedges over time (The Nature Conservancy 2014, Harris 1984, Aubry et al. 1999).

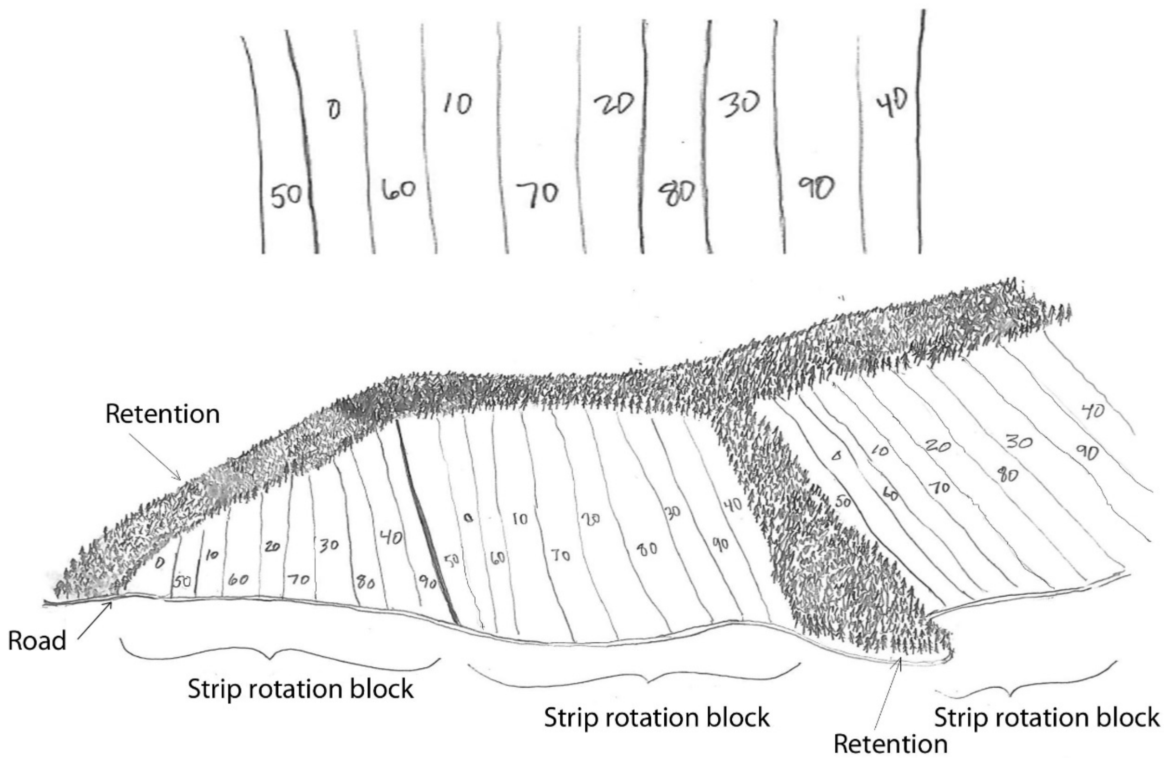


Figure 4. An example of strip rotation blocks using skips between successive cuts, to provide improved deer habitat on slopes in a landscape dominated by even-aged young growth. At the top is a schematic showing the year that each strip in a block is cut, with skips between successive strip cuts. Below is an example of how 3 strip rotation blocks might be scheduled to provide a stable supply of edges through successive, 100-year rotations, with leave strips along ridgelines to provide elevational migration corridors.

While vertical strip rotations would be useful for deer on slopes to address their elevational movement needs, smaller treatments (including Harris's long rotation islands) may be useful on flatter terrain, especially if dispersed across the landscape (The Nature Conservancy 2014).

Rotational timber harvest would not be appropriate for areas where succession towards old-growth conditions is identified as a primary or dual objective, or where stipulations would limit treatments to a single entry.

There are also opportunities to steer old-growth harvest in ways that promote deer habitat needs. For example, when conditions are suitable, old growth needed to bridge timber transition to primarily young-growth management could be obtained from northerly-facing, higher elevation slopes that constitute less important deer winter habitat. It would also be helpful to use uneven-age management or retention system techniques instead of even-aged management in old-growth harvesting where feasible to promote deer habitat needs. Further, retention of residual old-growth patches in young-growth forest can provide important landscape and stand diversity needed by deer (Chang et al. 1995, Alaback 2013).

Concepts for Deer Habitat Management Recommendations

- Prioritize habitat improvement and maintenance as needed on deer winter range.
- Achieve the following deer habitat management objectives:
    - ♦ Improve retention, recruitment, and growth of deer forage in young-growth forests.
    - ♦ Facilitate deer movements in treated young-growth forests by promoting small patches and corridors with higher canopy cover that intercepts snow, and by minimizing and mitigating accumulations of slash.
    - ♦ Provide travel corridors with high canopy cover and little slash to promote seasonal elevational movements of deer.
    - ♦ Provide a mix of habitat patches that offer forage, shelter, and movement in close proximity to each other.
    - ♦ Manage for long-term deer habitat consisting of a rich understory of forb, shrub, and lichen forage species, under or in immediate proximity to areas with high canopy cover that intercept snow, resulting from heterogeneously-structured, fine-scale canopy mosaics with small gaps and side-lighting.
    - ♦ Plan for stable ratios (see text) of openings (and other treatments that provide forage) to closed canopy forest over the long term within each watershed to minimize substantial habitat-induced fluctuations in deer populations within young-growth dominated landscapes in Development LUDs.
    - ♦ Quantitatively document effects of habitat management on deer forage, use of treated stands by deer, and the deer population.

Recommendations

Young-Age Young Growth in All Areas:

- Aim to treat all young-aged young growth, prioritizing as needed based on text and Table 1, prior to the onset of stem exclusion to offset the effects of stem exclusion on deer forage (Table 1).
- Emphasize multiple smaller treatments spread across even-age landscapes and staggered in time, to provide a variety of stand and patch ages.

- Incorporate leave strips that provide elevational movement corridors for deer. Maintain or enhance connectivity between higher and lower elevations, aiming to connect the full elevational span of alpine to beach habitat.
- Evaluate current and historic migration and movement routes and identify terrain features and habitat connectivity, possibly with interagency involvement, that are most likely to allow elevational movements by deer during severe winters, and prioritize leave strips in these areas. In absence of more definitive information, establish leave strips at about 400 foot spacing.
- Consider a variety of treatment combinations including variable-spaced thinning, girdling, pruning, small-gap creation, and slash treatments, with the goal of creating deer forage and movement corridors in close proximity, increasing heterogeneity of habitat to address needs of deer across young-growth landscapes, and avoiding the creation of a secondary conifer-recruitment flush.
- Encourage additional monitoring and research in conjunction with examination of currently available information to evaluate effectiveness of young-growth treatments on deer response.
- Strongly consider investigating population-level effects of stand treatments on deer using an experimental framework.
- Favor yellow cedar and red cedar for retention over hemlock and spruce that have no winter forage value for deer. Retain, and consider planting, red alder to allow longer retention of understory forage.

Older Non-Commercial Young Growth in All Areas:

- To avoid effects of heavy slash accumulations on deer mobility, generally avoid treating older young growth non-commercially except where older young-growth forests are exhibiting stem exclusion across large portions of the landscape. In these areas, consider thinning, creating small gaps, pruning, girdling, and a combination of these treatments to provide forage for deer on a sustainable basis through time and elevational movement corridors across the landscape.
- Thinning treatments should favor dominant trees to maintain snow interception capacity of the overstory, and incorporate unthinned travel corridors to facilitate elevational movements by deer.
- For gap treatments, encourage understory recruitment and growth by considering a) pruning along the edges of gaps to maximize side-lighting into adjacent forest, b) siting gaps on remnant understory vegetation, c) mixing (mulching or tilling) the duff and topsoil layers to stimulate microbial activity and help release nutrients, d) planting target understory forage plants, and e) designing gap sizes to about 70 feet diameter, with slight variation from this depending on tree sizes, to avoid creating a secondary recruitment flush of conifers that would shade out understory forage and to help the openings function as gaps.
- Older stands thinned or gapped non-commercially should include treatments to reduce or abate effects of slash on deer mobility. Slash treatment options could include bucking, chipping, burning, trail cutting, windrowing, smashing with heavy equipment, moving/piling (e.g., out of gaps), and looking for creative ways to use the logs elsewhere.

Commercial-Age Young Growth in Areas where Succession towards Old-Growth Conditions is Identified as a Dual Objective (i.e., Old-Growth Habitat LUDs, and Beach and Estuary Fringe and Riparian Management Areas outside of Tongass Timber Reform Act Buffers that are within Development and Old-Growth Habitat LUDs):

- Design treatments that progress stands towards old-growth conditions to benefit deer in the long-term. The long-term habitat objective for deer includes a rich understory of forb, shrub, and lichen forage species combined with snow interception, from a heterogeneously-structured canopy mosaic with occasional small gaps and side-lighting.
- Design treatments that provide understory deer forage and reduce effects of stem exclusion and slash to foster short-term habitat for deer, when such treatments can be done without compromising continued succession towards old-growth conditions that support long-term habitat for deer. Treatments could include variable-density thinning, thinning to favor dominant trees, creating small gaps and narrow openings, and pruning in areas with prior young-age thinning or adjacent to gaps.
- Avoid creating gaps and opening widths that are likely to result in a subsequent flush of conifer recruits and lose gap function that promotes understory forage; design gaps to be about 70 feet wide, adjusting as appropriate based on canopy height.
- Incorporate leave strips of intact canopy, especially along ridgelines, to promote elevational movements during severe winters and minimize distance between deer movement and foraging opportunities across the landscape.

Commercial-Age Young Growth in Development (Timber Harvest) LUDs:

- In areas with high potential for important deer winter range, as an alternative to traditional clearcutting of young growth, rotate cutting of smaller units through time (e.g., Figures 3 and 4), to accomplish the following:
    - ♦ Sustained deer forage yield throughout rotations adjacent to intact canopy that provides snow interception and facilitates elevational movements by deer. The goal is to provide heterogeneity and provide deer foraging adjacent to movement corridors and thermal cover across the landscape through time.
    - ♦ Plan rotations to provide a relatively constant supply of edges (or ecotones) between the most advanced young growth available (i.e., approaching or beyond economic maturity) and harvested stand in the shrub/forb stage of regeneration.
    - ♦ Consider vulnerability to predation when designing sizes and shapes of multi-age-class-rotational configurations, decreasing deer vulnerability on flatter slopes by creating smaller and more dispersed treatments.

Old-Growth in Development (Timber Harvest) LUDs:

- Obtain old growth needed to transition to primarily young-growth management from north-facing, higher-elevation slopes because they have lower habitat value for deer.
- Use uneven-aged management instead of even-aged management where feasible.
- Retain residual old-growth patches in young-growth forest.

Road Management

Since the late 1970s when only about 150 miles (mi) of logging roads existed on POW (USDOT undated), approximately 2,800 mi of roads have been built (USDOT 2011), resulting in current road densities as shown in Table 1. High road densities and the access and human-caused mortality they facilitate have been identified as the key driver of wolf mortality in GMU 2 (Person and Russell 2008, Person and Logan 2012, Gilbert et al. 2015). This relationship results from increased hunter and trapper access and associated increases in sighting probability and harvest opportunity and success. Forest Plan guidelines suggest that road densities of 0.7 to 1.0 mi/mi^2 or less may be necessary to reduce wolf-harvest vulnerability where interagency analysis concluded that road access contributes to locally unsustainable wolf mortality. Indeed, Person et al. (1996) reported that wolf harvest increased twofold when total road density below 1,200 feet elevation exceeded 0.66 mi/mi^2 in GMUs 2 and 3, threefold when densities exceeded 1.19 mi/mi^2, and fourfold when densities exceeded 1.63 mi/mi^2. Further, Person and Logan (2012) found positive associations between road densities and chronic unsustainable harvest; increases of 0.3 mi/mi^2 resulted in 167% increases in predicted risk of chronic unsustainable harvest. However, note that Person and Russell (2008) found that road densities $\geq$ 1.5 mi/mi^2 had little additional effect on harvest rates, possibly because hunters and trappers are unable to make more effective use of higher road densities and due to depressed wolf numbers in these areas.

Given strong correlations between road densities and wolf harvest rates, management should aim to avoid increasing road densities where they exceed 0.7 mi/mi^2. Consider using open road densities rather than total road densities only when road closures are effective (see below). Temporary roads and reconstructed roads needed for young-growth harvest should be included in total road density calculations and effectively closed or obliterated when their need has been met.

There are several challenges related to road management for wolves in GMU 2. One is that road closures are not always effective at reducing motorized access, either because they do not include physical barriers or existing physical barriers have become ineffective. Some closed or stored roads in GMU 2 do not have physical closures, but are closed only administratively via omission from Motorized Vehicle Use Maps as per the Access and Travel Management Plan (ATM) covering GMU 2. Many of these administratively closed roads continue to be fully accessible to trappers and hunters using highway vehicles. Some physical closures (e.g., tank traps, culvert removals, and gates) can become ineffective or are vandalized to allow vehicular passage (Person et al. 1996). Physical barriers and road obliterations are also costly to implement.

A second challenge to road management is that residents, tourists, recreationists, hunters, trappers, and most other forest users tend to like the access provided by roads and prefer keeping roads open. Because of strong public interests in roads, local managers receive pressure to avoid road closures, even when roads have been identified for closure as part of the ATM or other NEPA actions.

A third challenge is that road closures in GMU 2 may not reduce access to landscapes commensurate with the proportion of roads closed (Person and Logan 2012). Though modeled road closures reduced wolf harvest rates by an average of 17% among Wildlife Analysis Areas in GMU 2, reductions were less than expected based on the substantial road closures modeled (Person and Logan 2012). Their explanation was that road closures did not confer proportional reductions in access because portions of closed roads near open roads were still effectively open to hunting and trapping by foot. The authors included a road distance of 0.62 mi from open road junctions as effectively open, based on reported distances traveled on foot by deer hunters.

Another complication is that over half of the wolf harvest in GMU 2 occurs by boat access (57%, Person and Russell 2008; 59% Person and Logan 2012).

The road density-wolf harvest relationship and associated management are also complicated because of behavioral modifications and adaptations of wolves with respect to roads. Wolves tend to select low-use roads over non-roaded habitat due to benefits in movement, speed, and prey encounter and kill rates (Whittington et al. 2005, 2011, Gurarie et al. 2011, Zimmerman et al. 2014, Dickie et al. 2016). Selection for roads has been documented to decrease with increasing road densities (Houle et al. 2010), decrease during the day/increase during night under increasing road densities (Zimmerman et al. 2014, Benson et al. 2015) with commensurate increases in survival associated with this behavior (Benson et al. 2015), and occur primarily during nomadic periods in the fall and early winter (Houle et al. 2010, Lesmerises et al. 2013), which overlaps with the hunting and trapping seasons in GMU 2. Other studies showed that prey availability was the driving factor for habitat selection irrespective of road densities (Lesmerises et al. 2012, Dellinger et al. 2013), but that increased human densities decreased selection for roads (Dellinger et al. 2013). Almost all of these relationships also depend on trapping pressures, with increased trapping pressures increasing risks of roads and road densities on wolves. The complexities of wolf behavior and habitat selection with respect to roads further contribute to challenges in road management for wolves.

Despite these challenges, given the importance of roads and road densities to wolf harvest and population concerns within the northcentral portion of POW, road management opportunities need to be addressed. Some opportunities exist to better manage roads already closed under the current ATM. One is installing physical barriers (e.g., culvert removal, tank trap, or locked gate) on all roads identified for closure or storage. It is worth considering using adjacent terrain features in placement of new physical barriers to help make physical barriers more effective at blocking access to all-terrain vehicles (ATVs) throughout the year. There are also clear benefits from monitoring and maintaining physical barriers to ensure they remain effective.

Other opportunities exist for managing future road closures in GMU 2. Person and Logan (2012) emphasized the importance of providing core wolf habitats of low road density. The Conservation Strategy of the Forest Plan includes a reserve network incorporating all non-development LUDs and a system of small, medium, and large old-growth reserves. It would be of value to identify core wolf habitat in GMU 2, perhaps using the designated reserve network in the Conservation Strategy, current and past pack activity centers, productive habitats for deer, elevation and habitat preferences, and focused seasonal use areas such as salmon streams. This core wolf habitat could then be managed for low road densities, for example by limiting road construction and reconstruction, and prioritizing this habitat for future road closures. We do not have enough information to provide a map of these areas at this time, but see value in this approach.

Prioritizing roads for future closure can be based on characteristics that influence wolf harvest risk. Person and Russell (2008) identified muskegs, where they intersect roads at localized scales, as a predictor of mortality risk, though at larger landscape-level scales muskeg negatively correlated with road densities so the opposite relationship was observed (Person and Logan 2012). Harvest risk may also be influenced by alpine habitat (i.e., mountainous topography) that concentrates wolf activity in narrow valley bottoms and in beach fringe habitats (Person and Russell 2008). Person and Logan (2012) also found correlations between harvest risk and land distance from towns and villages. A combination of factors affecting wolf-harvest vulnerability could be used to prioritize road closures. Future road closures should also be prioritized in areas where benefits to wolves are most likely to be realized, where effective road access can be reduced to levels that minimize wolf mortality (e.g., to 0.7 mi/mi^2 or lower), and where a closed road has the most benefit in reducing hunter/trapper access to wolves (e.g., within pack activity areas during harvest seasons).

There is additional opportunity for regulatory closure of roads to wolf hunting and trapping, especially in Wildlife Analysis Areas where wolf harvest is unsustainable (see Person and Logan 2012). Person and Russell (2008) recommended a combination of large roadless reserves and conservative harvest regulations as the most effective means of conserving wolves where risks from human-caused mortality are high. See the Wolf Management and Mortality section for additional discussion and regulatory recommendations related to road management.

Recommendations

- Avoid increasing road densities where total road densities (including temporary roads) exceed 0.7 miles per square mile within GMU 2 Wildlife Analysis Areas.
- Effectively close all roads that are currently administratively closed by omission from, meaning they are no longer included on, Motor Vehicle Use Maps covering GMU 2.
    - ♦ Identify roads that have been administratively closed, but are not physically closed.
    - ♦ Install physical barriers (e.g., culvert removal, tank trap, or locked gate) on roads identified for closure to prevent vehicle access (allowing for ATVs where specified).
    - ♦ Consider coordinating adjacent terrain features in placing new physical barriers to help make them more effective.
    - ♦ Monitor and maintain physical closures to ensure they remain effective.
- Effectively close roads that have been identified as temporary when the purposes of those roads have been met.
- Prioritize roads for closure based on wolf harvest vulnerabilities in future ATMs or other NEPA planning processes using interagency and public input. Focus closures in areas where benefits to wolves are most likely to be realized.

Wolf Management and Mortality

Wolf harvest in GMU 2 is managed by both the ADF&G and USFS through implementation of regulations set by the BOG and the Federal Subsistence Board. These agencies work collaboratively to manage the wolf population and harvest, with public input from State-designated Advisory Committees and the federally-designated Southeast Alaska Subsistence Regional Advisory Council. State regulations governing wolf harvest in GMU 2 are more restrictive than elsewhere in Alaska, including both a specific HGL for the population and a 14-day sealing requirement for trappers. The current HGL set by the BOG limits harvest to 20% of ADF&G's preseason population estimate and the 14-day sealing requirement for trappers, typically 30 days elsewhere, is the shortest in the state. The short sealing period was set to help managers monitor harvest during the trapping season. Managers may set a harvest quota that is less than the number of wolves potentially allocated for harvest under the HGL percentage. State hunting and trapping seasons open on December 1 and close on March 31. However, most land in GMU 2 is Federally managed and most hunters and trappers are Federally qualified subsistence users, so wolf harvest is effectively managed under the longer Federal hunting (Sept.

1-Mar. 31) and trapping (Nov. 15-Mar. 31) seasons. State and Federal managers may close seasons early by ADF&G emergency order and Federal special action. Neither State nor Federal regulations include a personal bag limit for trappers, but the bag limit for hunters is 5 wolves (Table 2).

Since 1997 the trend in managing GMU 2 wolf harvest has generally been one of successively restricting harvest to address apparent and then documented declines in the population. The State and Federal wolf hunting and trapping seasons in GMU 2 were closed early by emergency order in 1999, 2013, 2014, and 2015. To address high and potentially unsustainable harvest during the early to mid-1990s, in 1997 the BOG established an HGL for GMU 2 wolves of 25% of the most recent population estimate. At that time the most recent estimate was 250-350 wolves (Person et al. 1996), so ADF&G set the harvest quota at 90 wolves. In 2000 an analysis by ADF&G found that intraspecific mortality among GMU 2 wolves was lower than elsewhere and that the population could sustain a 30% harvest rate (Larsen 1997). Based on that finding the BOG raised the HGL to 30% of the population estimate, but ADF&G kept the harvest quota at 90 wolves. To address concerns over an apparent decline in wolf numbers, in 2010 ADF&G reduced the harvest quota to 60 wolves, and in response to a 2013 population estimate (221 wolves, 95% confidence interval = 130-378, Roffler et al. 2016a) suggesting a continued decline, ADF&G reduced the harvest quota for 2014 to 25 wolves. Another population estimate in 2014 (89 wolves, 95% confidence interval 50-159, Roffler et al. 2016a) indicated the population continued to decline, so the BOG reduced the HGL to 20% of the most recent population estimate. To encourage recovery of the population while providing harvest opportunity to hunt and trap wolves, ADF&G and USFS managers reduced the quota under the HGL by 50% in 2015 and 2016.

Table 2. Current hunting and trapping regulations for wolves within Game Management Unit 2. These regulations are implemented by the State of Alaska and U.S. Forest Service (authority delegated by the Federal Subsistence Board).

	Federal Hunting	Federal Trapping	State Hunting	State Trapping
Season	Sept. 1–Mar. 31	Nov.15–Mar. 31	Dec. 1–Mar. 31	Dec. 1–Mar. 31
Individual Harvest Limit	5 wolves	No Limit	5 wolves	No Limit
Sealing Requirement	Within 14 days of harvest	Within 14 days of harvest	Within 30 days of harvest	Within 14 days of harvest
Trap / Snare Identification	Not Applicable	Required	Not Applicable	Not Required
Quota	Season may be closed when the combined (joint) Federal-State quota is reached.	Season may be closed when the combined (joint) Federal-State quota is reached.	Quota will not exceed 20% of the most recent unit-wide pre-season (fall) population estimate.	Quota will not exceed 20% of the most recent unit-wide pre-season (fall) population estimate.

Wolf researchers (Fuller 1989, Gasaway et al. 1983, Keith 1983, and Peterson et al. 1984) found that populations decline when total wolf mortality exceeded 25-40%. Person et al. (1996) also emphasized that wolves occupying islands, like those in GMU 2, are likely more vulnerable to overexploitation because they cannot be readily augmented by immigration from adjacent areas. Mortality results from human (legal harvest, wounding loss, collisions with vehicles, and illegal killing) and natural (starvation, accidents, disease, and fighting) causes. Natural mortality accounts for about 4% of annual mortality (Person and Russell 2008), and ideally human-caused mortality can be regulated by managers. However, management of wolves in GMU 2 has been complicated by an apparently high level of unreported human-caused mortality and until recently, the challenge of obtaining a reliable estimate of abundance. Using the fates of radio collared wolves, Person and Russell (2008) estimated that unreported human-caused mortality accounted for nearly 50% of mortality in GMU 2. Although limited, more recent data suggest that 40%-50% of GMU 2 wolf mortality still results from unreported human causes. By setting 2015 and 2016 harvest quotas at 50% of HGL, managers attempted to compensate for high levels of unreported human-caused mortality.

Wolves in GMU 2 are currently managed to provide a sustainable harvest (Alaska Constitution, Article VIII, Section 4). However, no quantitative population or harvest objectives for wolves exist. Unit 2 wolves are presently managed as a population that fluctuates in response to prey abundance, environmental conditions, and human harvest. Establishing science-based population and harvest objectives for GMU 2 wolves through an inclusive public process would help guide habitat management and regulatory planning, while incorporating social concerns related to deer and wolf abundance and reducing the likelihood of future litigation related to wolves. Ideally, a management plan would include a harvest strategy that maintains the population within a desired range.

We recommend that the population objective be expressed as a range (e.g., 150 to 300 wolves) rather than a single number (e.g., 200 wolves) to promote regulatory stability through wolf population fluctuations that are expected to be sustainable and acceptable. A population objective range could also allow for consideration and recognition of the precision or statistical confidence of population estimates.

Confirming that population objectives are being met will require periodic estimates of wolf abundance with more frequent (perhaps annual) estimates when the population is low. Failure to meet objectives could trigger regulatory actions such as conservative harvest caps or shortened harvest seasons.

Additional consideration needs to be given to the interval for population estimates needed to effectively manage wolves in GMU 2. Annual abundance estimates are currently produced through a temporary research project. Each estimate requires at least 10 weeks of staff time and substantial funding. Consideration must also be given to producing estimates that more closely reflect abundance at the beginning of hunting and trapping seasons, rather than during the fall of the previous year. Managers should consider whether estimates of mortality and reproduction during the preceding winter and summer can be incorporated into fall wolf abundance estimates.

The most recent data on sustainable wolf harvest rates are reported in the USFWS's Species Status Assessment for the Alexander Archipelago Wolf (2015). Mortality of wolves due to human harvest may be compensated for via increases in survival, reproduction, or immigration (i.e., compensatory mortality) or harvest mortality may be additive, causing overall survival rates and population growth to decline. Most studies demonstrate that high rates of reproduction and immigration can compensate for human-caused mortality rates of 17–48% (±8%; Fuller et al. 2003, pp. 184–185; Adams et al. 2008 [29%], p. 22; Creel and Rotella 2010 [22%], p. 5; Sparkman et al. 2011 [28%], p. 5; Gude et al. 2012 [25%], pp. 113–116). However, results of other studies suggest that harvest of wolves by humans are at least partially additive (Murray et al. 2010, pp. 2519–2520), and therefore, sustainable mortality rates may be lower than expected (~22–25%; Creel and Rotella 2010, p. 5). Sustainable rates of human-caused mortality within a wolf population vary considerably based on population characteristics such as age and sex structure, but typically depend on productivity and immigration (Fuller et al. 2003, p. 185). In this regard, each population (or group of populations) is different and a universal human-caused mortality rate does not exist.

Unreported human-caused mortality has been documented in GMU 2 at rates of 38% (Roffler et al. 2016a) and 47% (Person and Russell 2008) of collared wolves killed by humans (3 of 8 and 16 of 34 wolves, respectively). Causes of death in these unreported instances included gun shot, snare, and trap wounds, though it is important to recognize that data from most of these cases do not speak to intent. Some of these animals may have been injured during attempted lawful harvest but escaped, and so were not successfully recovered and therefore went unreported. Regardless, unreported human-caused mortality exists at fairly high levels in GMU 2. Harvest quotas should continue to account for this.

Beyond incorporating unreported human-caused mortality rates into quota development, there are challenges in effectively regulating unreported human-caused mortality. Accidental escapes from otherwise lawful harvest would be difficult to further regulate because they occur accidentally and sometimes unknowingly. Purposeful unreported harvest would be difficult to further regulate in GMU 2 because of the expanse of the island and its road system and paucity of enforcement officers. Increasing the number of enforcement personnel on the ground, and prioritizing wolf trapping season patrols in GMU 2 may help. Prioritizing and increasing enforcement in the beginning of the season as well as pre-season may help more generally to help ensure the quota is not surpassed, especially when the quota is low.

Wolf trappers in GMU 2 are not currently required to identify their traps or trap-lines with a trap label or sign indicating their name and address or permanent identification number under State regulations, but trap marking is required under Federal regulations. The lack of trap marking requirements under State regulations reduces the ability of law enforcement personnel to identify owners of traps set outside open seasons. Regulations that require identification of trap ownership can help encourage responsible and ethical trapping. Recommendations to mark traps must be vetted through public processes involving advisory committees and advisory councils. In addition, law enforcement agencies must be able to articulate the need and effectiveness of proposed enforcement-related regulatory actions. Therefore, we recommend that USFS and ADF&G staff work with advisory groups and law enforcement to determine need and effectiveness of wolf trap marking requirements for GMU 2 in both State and Federal regulations.

Given the importance of monitoring wolf mortality relative to varying annual harvest quotas and the two-week period between when a wolf is harvested and when it is required to be sealed, it is worth continuing to look for creative ways to encourage timely reporting of wolf harvests and to minimize and enforce against unreported human-caused mortality. Previous considerations included implementation of mandatory trap checks and limiting the number of traps per trapper, but these recommendations were rejected because we expected little or no population-level benefits from these actions. Peer pressure from lawful hunters and trappers may have influence in GMU 2, so continuing to foster good relationships between agency personnel and hunter and trapper communities will be important (also see Human Dimensions section). Additionally, management agencies must engage with advisory committees and advisory councils to determine social desires for wolves, deer, and harvest opportunities.

Because salmon are an important seasonal component of wolf diets in southeast Alaska (Szepanski et al. 1999, Darimont et al. 2008), wolves may be vulnerable to hunters at salmon spawning areas from the beginning of the Federal hunting season, Sept 1, through the end of the spawning period. Historically, however, early season harvest has been low (<5%, September-November; R. Scott, personal communication) with peak harvests occurring during the period December to February. Even during regulatory years 2011-2015, which had lower quotas, early-season wolf take in GMU 2 along salmon streams constituted <2% of total harvest (B. Porter, personal communication). We do not consider harvest along salmon streams a biological concern at this time. Delaying the Federal wolf hunting season until after most spawning has ended (typically in October), or closing wolf hunting along roads at productive salmon streams could be options for reducing early mortality if this becomes an issue in the future.

Given the strong correlation between road densities and wolf harvest, and the challenges with road closures, there may be opportunities to manage road closures with regulations. Person and Logan (2012) suggested considering the roaded portion of central and northcentral POW for a regulatory regime separate from the rest of GMU 2, thereby facilitating regulatory changes specific to this area. One example is to establish a controlled use area within the roaded portion of central and northcentral POW, within which a motorized vehicle cannot be used to assist with wolf hunting or trapping. Another example is to consider regulatory closure to wolf hunting and trapping along roads within this roaded area or in Wildlife Analysis Areas where wolf harvest is unsustainable (see Person and Logan 2012).

Recommendations

- We recommend ADF&G and USFS biologists establish a science-based management strategy with population objectives for wolves in GMU 2, using input from affected and concerned stakeholders.
- Maintain flexibility in quota management to alter quotas on a yearly basis to ensure wolf population and harvest sustainability.
- Continue to incorporate unreported human-caused mortality rates in developing wolf harvest quotas using best available data.
- Monitor the wolf population to help evaluate program effectiveness.
- Prioritize and increase enforcement in pre-season and beginning of season, increase enforcement capabilities, and prioritize wolf trapping season patrols in GMU 2.
- Work with advisory groups and law enforcement agencies to determine need and effectiveness of wolf trap marking requirements for GMU 2 in both State and Federal regulations.
- Continue to consider additional ways to minimize unreported human-caused mortality of wolves in GMU 2.
- Consider the roaded portion of central and northcentral POW for a regulatory regime (e.g., controlled use area) separate from the rest of GMU 2 to facilitate regulatory changes specific to this area.

Den Management

The Forest Plan includes standards and guidelines addressing wolf den management. Measures include designing management activities to avoid abandonment of wolf dens, maintaining a 1,200 foot forested buffer, where available, around known active wolf dens, discouraging road construction within this buffer and identifying alternative routes where feasible, and permitting no road construction within 600 feet of a den unless site-specific analysis indicates that local landform or other factors will alleviate potential adverse disturbance. Further, if a den is monitored for 2 consecutive years and found to be inactive, these buffers are no longer required, though each known inactive den site is to be checked to see if it is active in the spring, prior to implementing on-the-ground management activities (e.g., timber harvest or road construction).

Aspects of these standards and guidelines may be insufficient to adequately protect wolf dens. Of particular concern are guidelines allowing den buffers to be dropped after 2 years of den inactivity, and the buffer distances for road construction and other potentially disturbing management activities. Wolf den sites are frequently used in multiple consecutive years and intermittently over long periods (Mech and Packard 1990), suggesting both high den-site fidelity and the importance and perhaps rarity of suitable den sites on the landscape. Within GMU 2, dens are typically located in loose, dry soils, under root-wad cavities of large living or dead trees, within dense canopies of old-growth forest, near freshwater, often on peninsulas or islands, on gentle, low-elevation slopes, and farther from logged stands and roads than random sites (Person and Russell 2009). Large proportions of the GMU 2 landscape are considered unsuitable for den sites due to logging and topography, and availability of the combined characteristics that provide quality den sites may be limited (Person and Russell 2009). Therefore, management should aim to protect den sites, as well as sufficient foraging habitat to successfully rear pups at each den in perpetuity. We specifically recommend: a) perpetually protecting all documented wolf dens (active and inactive) with noncircular polygons of not yet determined size to ensure the specific den sites remain attractive and b) protecting some not yet determined proportion of old-growth foraging habitat within core foraging areas utilized by wolves during denning to ensure the dens remain a viable place to rear pups. Additional evaluation of core use areas around den sites is necessary to identify appropriate buffers for dens (discussed in more detail below).These protected denning areas and foraging habitat should be generally centered around the dens, determined by interagency biologists (ADF&G, USFS, and USFWS), and based on wolf core use areas (i.e., den sites and core foraging areas) during denning, or habitat features that model core use during denning, as per impending ADF&G analyses. We encourage young-growth management within the protected denning areas that promotes development of habitat values for wolf denning. Therefore, we recommend young growth management in these areas be in accordance with Forest Plan direction for areas where succession towards old growth conditions is a dual management objective with providing commercial timber byproducts (see detailed definitions and recommendations for deer habitat specific to these areas in Deer Habitat Management section above).

To preserve key denning habitat and additional den-site options for wolves, Person and Russell (2009) recommended retaining roadless, forested buffers >330 feet wide around low elevation major lakes and streams in extensively logged watersheds. This recommendation may be fine-tuned a bit using slope characteristics of den sites in GMU 2; dens were observed on gradual slopes ranging up to 13.7 degrees (Person and Russell 2009). In addition, wolves selected den sites with coarse canopy old growth (Person and Russell 2009). Therefore, retaining roadless, gently sloping (< 14 degrees) old-growth forest within 330-foot buffers of major lakes and streams in extensively logged watersheds would be of value. Major lakes are defined here to include class I lakes (lakes with anadromous fish or with high value resident fisheries) and class II lakes (lakes with lower value resident fisheries) that are $\geq$ 3 acres. Major streams are defined here to include class I (streams with anadromous or adfluvial fish or fish habitat, or high quality resident fish or habitat) and class II (streams with resident fish or fish habitat that do not meet class I). Extensively logged watersheds are defined here to include value comparison units

(VCUs) that have had concentrated past timber harvest activity and are at risk for not providing the full range of functions (see Forest Plan Wild1 IV D, pages 4-86 and 4-87).

Avoiding abandonment of active dens and associated movement of pups to another den site (hereafter called den relocation) from human disturbance is another consideration for management. A number of studies have documented den relocations as a result of human disturbance (Chapman 1979, Thiel et al. 1998, Frame et al. 2007, Habib and Kumar 2007, Argue et al. 2008, Beck et al. 2009, Person and Russell 2009). Wolf dens may be relocated to other nearby den sites several hundred feet away and up to several miles away (up to 4.7 miles, Habib and Kumar 2007). Though some studies have found no negative effects on pup survival from human-caused den relocations (Frame et al. 2007, Habib and Kumar 2007), loss of pups can occur during (Smith 1998, river crossing) or after den relocations (Argue et al. 2008, drowned in new den site), so a conservative approach to management is warranted. Because nearby freshwater is a selection factor for GMU 2 den sites and sites are often situated on peninsulas and islands (Person and Russell 2009), the potential for a disturbance-caused relocation requiring negotiation of water crossings by small pups also warrants caution. Other negative effects on long-term pup growth and survival could occur if the alternate site is of lesser quality, is in an area with lower prey density, or the relocation results in fewer pack helpers (Habib and Kumar 2007).

Wolf pup age is key in determining the likelihood of disturbance causing den relocation and the success of a relocation effort, and therefore is most influential in determining an appropriate window for seasonal restrictions of management activities near dens. Dens with young pups ≤ 3 weeks of age did not relocate with a single human walk-through and brief stay at the den site, while those with pups >6 weeks of age always relocated (Frame et al. 2007). Dens with intermediate pup ages of 4-6 weeks varied in response, with some relocating, some attempting to relocate, but moving back to the natal den due to poor pup mobility and adult difficulties with carrying small pups, and others not attempting to relocate (Frame et al. 2007). However, even dens with young pups (1-3 weeks) were relocated under scenarios with more intense human disturbance, such as entries into dens to count pups (7/8 dens relocated) and pup handling (3/4 dens relocated; Beck et al. 2009).

Even though wolves are more likely to relocate their dens after pups are > 6 weeks of age, the most vulnerable period for disturbance is in the early to intermediate denning period (< 6 weeks), when the pups are less mobile or immobile and must be carried. After 6 weeks, pups are mobile enough to move to rendezvous sites or alternate den sites and these behaviors occur naturally without disturbance. The period of about 4 weeks before the pups are born is also thought to be important, as disturbance during this period may affect den selection and occupancy (Chapman 1979). Within GMU 2, natal dens were occupied from April 21 to July 15 (Person and Russell 2009). An appropriate window for seasonal management activity restrictions around active dens that encompasses these dates, as well as about 4 weeks prior to avoid negatively influencing selection of quality den sites, is 15 March-15 July.

The buffer distance necessary to avoid den relocations due to management activities depends primarily on the intensity and frequency of the disturbance activity, but also on other factors. Habitat is important, with open tundra requiring greater buffer distances to avoid disturbance than forested habitats (Chapman 1979). Intervening terrain features are also likely to have an effect on noise-disturbance levels from activities. The primary management activities in GMU 2 that may disturb wolf dens involve logging operations, including sawing, using large machinery, hauling, helicopter logging and associated overflights, and road construction or maintenance.

Based on our experience and personal communications the 1,200 foot buffer in the Forest Plan seems to be sufficient in preventing den relocations related to ground-based activities like sawing, machinery, and hauling activities, but not with activities causing greater noise disturbance, such as helicopter activity. A buffer of 600-feet for road construction is not likely to be sufficient to avoid relocation of a den. Person and Ingle (1995) reported a den relocation shortly after the start of road building activity nearby, though they acknowledged that this may have occurred at the normal time that wolves depart their dens (July). These authors also observed reduced year-round activity in the area thereafter and use of a poorer quality site 7 miles away the following year, suggesting wide-scale displacement from road construction affecting the use area of this pack. Other scientists showed avoidance of major roads with increasing human disturbance (e.g., traffic and construction activities) during the denning season (Lesmerises et al. 2013). One study in tundra habitat recommended a distance of 1.5 miles to avoid human disturbance, but the necessary buffer distance is expected to be smaller in forested habitats (Chapman 1979). We recommend using a ½ mile buffer for loud disturbance activities (e.g., helicopter logging or overflights, blasting, road construction) during the denning season.

Recommendations

- Perpetually protect the integrity of all documented wolf dens (active and inactive) with noncircular polygons of not yet determined size, generally centered around the dens, as determined by interagency biologists (ADF&G, USFS, and USFWS). The goal is to ensure each den remains attractive to wolves by protecting habitat to maintain a degree of isolation from development and human activity. The size and shape of these relatively small protected areas should be based on a pending analysis by ADF&G. Whenever possible, landscape features (hills, ridges, etc.) should be used to provide isolation.
    - ♦ Encourage young-growth management within these areas in accordance with Forest Plan direction for areas identified with dual objectives (see text) to promote development of wolf denning habitat values.
- Retain a not yet determined proportion of old growth habitat within core wolf foraging areas utilized during denning to ensure den sites remain viable for rearing pups. Protected old growth foraging habitat shall be generally centered around the dens (active and inactive), determined by interagency biologists (ADF&G, USFS, and USFWS), and based on wolf core foraging areas during denning, or habitat features that model core foraging areas during denning, as per impending ADF&G analyses.
- Retain roadless, gently sloping (< 14 degrees) old-growth forest within 330 foot buffers of major lakes and streams in extensively logged watersheds to preserve key denning habitat and den-site options for wolves.
- Implement timing restrictions during March 15 through July 15 to reduce the likelihood of active dens relocating due to disturbance:
    - ♦ Permit no disturbance within 1,200 feet of active dens that could result in den relocation.
    - ♦ Permit no loud disturbance activities (e.g., blasting, helicopter logging and overflights for Forest-Service activities, road construction) within ½ mile of active dens.
    - ♦ If status of a den is uncertain, then assume it is active.

Human Dimensions

Human dimensions are among the most elusive, challenging, and important aspects of a successful wolf management program. Human dimensions cover social aspects of wildlife management, including stakeholder input processes and public attitudes toward wolves and wolf management. Wolves are an important subsistence resource for fur sewing, handicrafts, sale of fur and other direct uses. Within GMU 2, another aspect of human-wolf interactions derives from the subsistence nature of the remote villages on the islands and the importance of deer as the primary human food source, along with fish, and supplemented by other hunted, gathered, and purchased food items. As a result, wolves are seen as a direct competitor for an important food source. Other aspects of human-wolf interactions in GMU 2 include hunting of wolves and deer, tourism, trapping and selling wolf furs, wildlife viewing and tourism, human and pet safety concerns, and the importance of wolves in maintaining ecological integrity and sustainability that supports other human consumptive and non-consumptive uses of animals and their habitats on the island.

Opportunities to improve human dimensions in GMU 2 include continued community involvement and shared learning in wolf and deer habitat and regulatory management and monitoring. Outlets include public meetings, informational brochures, internet and social media, and working with schools and community groups. As mentioned in the Wolf Management and Mortality section, continued fostering of good relationships between interagency personnel and hunter and trapper communities is critical. Management of wolf harvests by both the State of Alaska and the Federal Subsistence Board should be informed by public meetings and other solicitations from stakeholders, including regular briefings between the primary managers.

The Forest Plan encourages young-growth treatments that provide for areas important and accessible to human hunting of wildlife, including deer (WILD2 I A 1 c, page 4-93). The level of access to preferred hunting habitat has been shown to be just as important as deer densities in determining hunter efficiency (Brinkman et al. 2009). Therefore, improving forage production within young-growth stands that are accessible to, and in areas preferred for human hunting of deer, may help alleviate human-wolf-deer tensions in GMU 2.

Recommendations

- Continue community involvement and shared learning in public meetings, informational brochures, internet and social media outlets, working with the schools, and community groups.
- Foster good relationships between interagency personnel and hunter and trapper communities.
- Inform the Southeast Alaska Subsistence Regional Advisory Council, local advisory committees, Federal Subsistence Board and the State of Alaska Board of Game on an annual or more frequent basis of current wolf research and management efforts.
- Hold public meetings or solicit public input and information sharing when setting wolf harvest management quotas.
- Consider young-growth treatments that provide for areas important and accessible to human subsistence hunting of deer.

Monitoring and Research Needs

Below is a list of monitoring and research needs identified during development of this document. This is not an exhaustive list, but may have utility in guiding monitoring and research priorities.

- GMU 2 wolf population monitoring
- GMU 2 deer population monitoring
- Climate change effects on snow levels, deer population fluctuations, and alpine forage
- Effects of young-growth treatments on deer use, vital rates, and population dynamics
- Effects of pruning on snow interception
- Effects of pruning different proportions of trees (e.g., 25% vs 100%) on deer forage
- Influences of gap opening sizes and shapes on forage and deer response
- Assessment and inventory of GMU 2 existing deer movement routes, terrain features, and habitat connectivity needs
- Optimal spacing in thinning treatments of elevational travel corridors for deer in the absence of existing routes, terrain features, or habitat connectivity drivers
- Closure effectiveness inventory and monitoring of closed roads in GMU 2
- Assessment and identification of focal areas/roads where benefits to wolves would most likely be realized by road closures
- Assessment of area needed around dens to protect den sites
- Assessment of proportion of old growth habitat within core wolf foraging areas during denning needed to keep den sites viable for rearing pups
- Assessment of noise disturbance buffer distances needed to avoid den relocations, and terrain influences

Literature Cited

Adams, L. G., R. O. Stephenson, B. W. Dale, R. T. Ahgook, and D. J. Demma. 2008. Population dynamics and harvest characteristics of wolves in the Central Brooks Range, Alaska. Wildlife Monographs 170. 25 pp.

Alaback, P. B. 1982. Dynamics of understory biomass in Sitka spruce-western hemlock forests of southeast Alaska. Ecology 63:1932-1948.

Alaback, P. B. 1984. Plant succession following logging in the Sitka spruce-western hemlock forests of southeast Alaska: implications for management. General Technical Report PNW-173, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service. 26 pp.

Alaback, P. 2010. An evaluation of canopy gaps in restoring wildlife habitat in second-growth forests of southeastern Alaska. Final Report, The Nature Conservancy, USDA Forest Service, and Prince of Wales Tribal Enterprise Consortium. 32 pp.

Alaback, P. 2013. Opportunities for restoring second growth ecosystems in Staney Creek: scientific principles. PowerPoint, June 2013, Staney Creek Community Forestry Project. http://www.staneycreek.org/documents-and-papers/

Albert, D. M. and J. W. Schoen. 2013. Use of historical logging patterns to identify disproportionately logged ecosystems within temperate rainforests of southeastern Alaska. Conservation Biology 27:774–784.

Argue, A. M., K. J. Mills, and B. R. Patterson. 2008. Behavioural response of eastern wolves (*Canis lycaon*) to disturbance at homesites and its effects on pup survival. Canadian Journal of Zoology 86:400-406.

Aubry, K. B., M. P. Amaranthus, C. B. Halpern, J. D. White, B. L. Woodard, C. E. Peterson, C. A. Lagoudakis, and A. J. Horton. 1999. Evaluating the effects of varying levels and patterns of green-tree retention: experimental design of the DEMO study. Northwest Science 73:12-26.

Beck, K. B., C. F. Lucash, and M. K. Stoskopf. 2009. Lack of impact of den interference on neonatal red wolves. Southeastern Naturalist 8:631-638.

Benson, J. F., P. J. Mahoney, and B. R. Patterson. 2015. Spatiotemporal variation in selection of roads influences mortality risk for canids in an unprotected landscape. Oikos 124:1664-1673.

Brinkman, T. J., D. K. Person, F. S. Chapin, III, W. Smith, and K. J. Hundertmark. 2011. Estimating abundance of Sitka black-tailed deer using DNA from fecal pellets. Journal of Wildlife Management 75:232-242.

Brinkman, T. J., F. S. Chapin, III, G. Kofinas, and D. K. Person. 2009. Linking hunter knowledge with forest change to understand changing deer harvest opportunities in intensively logged landscapes. Ecology and Society 14:36 (online). http//www.ecologyandsociety.org/vol14/iss1/art36/

Chang, K.-T., D. L. Verbyla, and J. J. Yeo. 1995. Spatial analysis of habitat selection by Sitka black-tailed deer in southeast Alaska, USA. Environmental Management 19:579-589.

Chapman, R. C. 1979. Human disturbance at wolf dens–a management problem. Pages 323-328 *in* R. M. Linn, editor. Proceedings of the First Conference on Scientific Research in National Parks. Volume 1, USDI National Park Service Transactions and Proceedings Series, Number 5.

Christensen, B. 2012. Forest restoration in the Tongass: why, how and where. The Wilderness Society and Southeast Alaska Wilderness Exploration, Analysis and Discovery. 64 pp.

Cole, E. C., T. A. Hanley, and M. Newton. 2010. Influence of precommercial thinning on understory vegetation of young-growth Sitka spruce forests in southeastern Alaska. Canadian Journal of Forest Research 40:619-628.

Creel, S. and J. J. Rotella. 2010. Meta-analysis of relationships between human offtake, total mortality and population dynamics of gray wolves (*Canis lupus*). PLoS ONE 5(9): e12918. doi:10.1371/journal.pone.0012918

Darimont, C. T., P. C. Paquet, and T. E. Reimchen. 2008. Spawning salmon disrupt trophic coupling between wolves and ungulate prey in coastal British Columbia. BMC Ecology 8:14 (12 pp). http://www.biomedcentral.com/1472-6785/8/14

Deal, R. L. 1997. Understory plant diversity in riparian alder-conifer stands after logging in southeast Alaska. Research Note PNW-RN-523, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 8 pp.

Deal, R. L. and W. A. Farr. 1994. Composition and development of conifer regeneration in thinned and unthinned natural stands of western hemlock and Sitka spruce in southeast Alaska. Canadian Journal of Forest Research 24:976-984.

Deal, R. L., R. J. Barbour, M. H. McClellan, and D. L. Parry. 2003. Development of epicormic sprouts in Sitka spruce following thinning and pruning in south-east Alaska. Forestry 76:401-412.

DellaSala, D. A., J. C. Hagar, K. A. Engel, W. C. McComb, R. L. Fairbanks, and E. G. Campbell. 1996. Effects of silvicultural modifications of temperate rainforest on breeding and wintering bird communities, Prince of Wales Island, southeast Alaska. Condor 98:706-721.

DeMeo, T., D. Johnson, and C. Crocker-Bedford. 1990. Short-term vegetation response and deer use of artificial canopy gaps in southeast Alaska. USDA Forest Service Tongass National Forest, Ketchikan, Alaska, USA.

Dellinger, J. A., C. Proctor, T. D. Steury, M. J. Kelly, and M. R. Vaughan. 2013. Habitat selection of a large carnivore, the red wolf, in a human-altered landscape. Biological Conservation 157:324-330.

Dickie M., R. Serrouya, R. S. McNay, and S. Boutin. 2016. Faster and farther: Wolf movement on linear features. Journal of Applied Ecology. Online early view, 11 pp.

Doerr, J. G. and N. H. Sandburg. 1986. Effects of precommercial thinning on understory vegetation and deer habitat utilization on Big Level Island in southeast Alaska. Forest Science 32:1092-1095.

Doerr, J. G., E. J. Degayner, and G. Ith. 2005. Winter habitat selection by Sitka black-tailed deer. Journal of Wildlife Management 69:322-331.

Farmer, C. J., D. K. Person, and R. T. Bowyer. 2006. Risk factors and mortality of black-tailed deer in a managed forest landscape. Journal of Wildlife Management 70:1403-1415.

Frame, P. F., H. D. Cluff, and D. S. Hik. 2007. Response of wolves to experimental disturbance at homesites. Journal of Wildlife Management 71:316-320.

Fuller, T. 1989. Population dynamics of wolves in north-central Minnesota. Wildlife Monographs 105. 41 pp.

Fuller, T. K., L. D. Mech, and J. F. Cochrane. 2003. Wolf population dynamics. Pages 161-191 *in* Mech, L. D. and L. Boitani, editors. Wolves, behavior, ecology, and conservation. University of Chicago Press, Chicago and London.

Gasaway, W. C., R. O. Stephenson, J. L. Davis, P.E.K. Shepherd, and O.E. Burris. 1983. Interrelationships of wolves, prey, and man in interior Alaska. Wildlife Monographs 84. 50 pp.

Gilbert, S L. 2015. Environmental drivers of deer population dynamics and spatial selection in Southeast Alaska. Dissertation, University of Alaska Fairbanks. 161 pp.

Gilbert, S. L., K. J. Hundertmark, D. K. Person, M. S. Lindberg, and M. S. Boyce. 2017. Behavioral plasticity in a variable environment: snow depth and habitat interactions drive deer movement in winter. Journal of Mammalogy 98:246-259.

Gilbert, S. L., T. Haynes, M. S. Lindberg, D. Albert, and M. L. Kissling. 2015. Future population trends and drivers of change for Alexander Archipelago wolves on and near Prince of Wales Island, Alaska. Draft report, University of Alaska Fairbanks, Department of Biology and Wildlife and Institute of Arctic Biology.

Gude, J. A., M. S. Mitchell, R. E. Russell, C. A. Sime, E. E. Bangs, L. D. Mech, and R. R. Ream. 2012. Wolf population dynamics in the U.S. North Rocky Mountains are affected by recruitment and human-caused mortality. Journal of Wildlife Management 76:108-118.

Gurarie, E., J. Suutarinen, I. Kojola, and O. Ovaskainen. 2011. Summer movements, predation and habitat use of wolves in human modified boreal forests. Oecologia 165:891-903.

Habib, B. and S. Kumar. 2007. Den shifting by wolves in semi-wild landscapes in the Deccan Plateau, Maharashtra, India. Journal of Zoology 272:259-265.

Hanley, T. A. 2005. Potential management of young-growth stands for understory vegetation and wildlife habitat in southeastern Alaska. Landscape and Urban Planning 72:95-112.

Hanley, T. A. and C. L. Rose. 1987. Influence of overstory on snow depth and density in hemlock-spruce stands: implications for management of deer habitat in southeastern Alaska. Research Note PNW-RN-459, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 11 pp.

Hanley, T. A. and J. C. Barnard. 1998. Red alder, *Alnus rubra*, as a potential mitigating factor for wildlife habitat following clearcut logging in southeastern Alaska. Canadian Field-Naturalist 112:647-652.

Hanley, T. A. and J. D. McKendrick. 1985. Potential nutritional limitations for black-tailed deer in a spruce-hemlock forest, southeastern Alaska. Journal of Wildlife Management 49:103-114.

Hanley, T. A., D. E. Spalinger, K. J. Mock, O. L. Weaver, and G. M. Harris. 2012. Forage resource evaluation system for habitat–deer: an interactive deer habitat model. General Technical Report 858, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 64 pp.

Hanley, T. A., M. C. McClellan, J. C. Barnard, and M. A. Friberg. 2013. Precommercial thinning: implications of early results from the Tongass-wide young-growth studies experiments for deer habitat in southeast Alaska. Research Paper PNW- RP- 593, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 64 pp.

Hanley, T. A., R. L. Deal, and E. H. Orlikowska. 2006. Relations between red alder composition and understory vegetation in young mixed forests of southeast Alaska. Canadian Journal of Forest Research 36:738-748.

Harris, L. D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago IL. 165 pp.

Harris, A. S. 1999. Wind in the forests of southeast Alaska and guides for reducing damage. General Technical Report PNW-GTR-244, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 63 pp.

Harris, S. H. and J. C. Barnard. In Prep. Understory plant development in artificial canopy gaps in an 81 year old forest stand on Chichagof Island, southeast Alaska. Research Paper in prep, Pacific Northwest Research Station, USDA Forest Service, Portland, OR.

Haufler, J. B., C. A. Mehl, and S. Yeats. 2010. Climate change: anticipated effects on ecosystem services and potential actions by the Alaska Region, U.S. Forest Service. Ecosystem Management Research Institute, Seeley Lake, Montana, USA. 53 pp.

Hines, W. W. and C. E. Land. 1974. Black-tailed deer and Douglas-fir regeneration in the Coast Range of Oregon. Pages 121-132 *in* Black, H. C., editor. Wildlife and forest management in the Pacific Northwest: Proceedings of a symposium September 11-12, 1973. Oregon State University, Corvallis, OR.

Houle M., D. Fortin, C. Dussault, R. Courtois, J. P. Ouellet. 2010. Cumulative effects of forestry on habitat use by gray wolf (*Canis lupus*) in the boreal forest. Landscape Ecology 25:419–433.

Keith, L. B. 1983. Population dynamics of wolves. Pages 66-77 *in* Carbyn, L., editor. Wolves in Canada and Alaska: their status, biology, and management. Canadian Wildlife Service Report 45.

Klein, D. R. 1965. Ecology of deer range in Alaska. Ecological Monographs 35:259-284.

Knotts, L. and M. Brown. 1995. Short-term vegetation response in artificial canopy gaps on the Craig Ranger District, Tongass National Forest. USDA Forest Service Tongass National Forest, Ketchikan, Alaska, USA.

Larsen, D. 1997. Unit 2 wolf population estimate. Alaska Department of Fish and Game memo from Ketchikan Area Management Wildlife Biologist Doug Larsen to Regional Supervisor Kim Titus, December 24, 1997.

Lesmerises F., C. Dussault, and M. H. St-Laurent. 2012. Wolf habitat selection is shaped by human activities in a highly managed boreal forest. Forest Ecology and Management 276:125-131.

Lesmerises F., C. Dussault, and M. H. St-Laurent. 2013. Major roadwork impacts the space use behaviour of gray wolf. Landscape and Urban Planning 112:18–25.

McClellan, M. H. 2005. Recent research on the management of hemlock-spruce forests in southeast Alaska for multiple values. Landscape and Urban Planning 72:65-78.

McClellan, M. H., P. E. Hennon, P. Heuer, and K. W. Coffin. 2014. Condition and deterioration rate of precommercial thinning slash at False Island, Alaska. Research Paper PNW-RP-594, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 29 pp.

Mech, L. D. and J. M. Packard. 1990. Possible use of a wolf, *Canis lupus*, den over several centuries. Canadian Field-Naturalist 104:484-485.

Miller, F. L. 1968. Observed Use of Forage and Plant Communities by Black-Tailed Deer. Journal of Wildlife Management 32:142-148.

Murray, D., D. W. Smith, E. E. Bangs, C. Mack, J. K. Oakleaf, J. Fontaine, D. Boyd, M. Jiminez, C. Niemeyer, T. Meier, D. Stahler, J. Holyan, and V. Asher. 2010. Death from anthropogenic causes is partially compensatory in recovering wolf populations. Biological Conservation 143:2514–2524.

Nelson, J., D. Cottam, E. W. Holman, D. J. Lancaster, S. McCorquodale, and D. K. Person. 2008. Habitat guidelines for black-tailed deer: coastal rainforest ecoregion. Mule Deer Working Group, Western Association of Fish and Wildlife Agencies. 48 pp.

Norwacki, G. J. and M. G. Kramer. 1998. The effects of wind disturbance on temperate rain forest structure and dynamics of southeast Alaska. General Technical Report PNW-GTR-421, Pacific Northwest Research Station, USDA Forest Service, Portland, OR. 25 pp. (Shaw, C. G., III, tech. coordinator; Conservation and resource assessments for the Tongass Land Management Plan revision).

Ott, R. A. and G. P. Juday. 2002. Canopy gap characteristics and their implications for management in the temperate rainforests of southeast Alaska. Forest Ecology and Management 159:271-291.

Person, D. K. and A. L. Russell. 2008. Correlates of Mortality in an Exploited Wolf Population. Journal of Wildlife Management 72:1540-1549.

Person, D. K. and A. L. Russell. 2009. Reproduction and den site selection by wolves in a disturbed landscape. Northwest Science 83:211-224.

Person, D. K. and B. D. Logan. 2012. A spatial analysis of wolf harvest and harvest risk on Prince of Wales and associated islands, Southeast Alaska. Final Wildlife Research Report, ADF&G/DWC/WRR-2012-06. 29 pp.

Person, D. K. and M. A. Ingle. 1995. Ecology of the Alexander Archipelago wolf and responses to habitat change. Progress Report No. 3, Alaska Department of Fish and Game, Juneau, Alaska. 39 pp.

Person, D. K. and T. J. Brinkman. 2013. Succession debt and roads: short and long-term effects of timber harvest on a large-mammal predator-prey community in Southeast Alaska. Pages 143-167 *in* Orians, G. and J. Schoen, editors. North Pacific temperate rainforests: ecology and conservation. University of Washington Press, Seattle, WA.

Person, D., C. Farmer, P. O'Connor, and J. Doerr. 2009. Habitat use and survivorship of Sitka black-tailed deer in Southeast Alaska: a regional meta-analysis and synthesis. Federal Aid Annual Research Final Performance Report, Alaska Department of Fish and Game. 13 pp.

Person, D. K., M. Kirchhoff, V. Van Ballenberghe, G. C. Iverson, and E. Grossman. 1996. The Alexander Archipelago wolf: a conservation assessment. General Technical Report PNW-GTR-384. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 42 pp. (Shaw, C. G., III, tech. coordinator; Conservation and resource assessments for the Tongass Land Management Plan revision).

Peterson, R. O., J. D. Woolington, and T. N. Bailey. 1984. Wolves of the Kenai Peninsula, Alaska. Wildlife Monographs 88. 52 pp.

Petruncio, M. D. 1994. Effects of pruning on growth of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong) Carr.) in southeast Alaska. Ph.D. Dissertation, University of Washington, Seattle, WA. 154 pp.

Roffler, G. 2016. Alaska Department of Fish and Game Fall 2015 Survey Memorandum for Game Management Unit 2 Wolf Population Estimate. 6 pp.

Roffler G. H., J. N. Waite, R. W. Flynn, K. R. Larson. 2016b. Estimation of wolf population density using spatial capture-recapture: refining methods for monitoring cryptic species. PeerJ Preprints 4:e1946v1 https://doi.org/10.7287/peerj.preprints.1946v1

Roffler, G. H., J. N. Waite, R. W. Flynn, K. R. Larson, and B. D. Logan. 2016a. Wolf population estimation on Prince of Wales Island, Southeast Alaska: a comparison of methods. Alaska Department of Fish and Game, Final Wildlife Research Report ADF&G/DWC/WRR-2016-1, Juneau, Alaska. 58 pp.

Schoen, J. W. and M. D. Kirchhoff. 1985. Seasonal distribution and home-range patterns of Sitka black-tailed deer on Admiralty Island, southeast Alaska. Journal of Wildlife Management 49:96-103.

Schoen, J. W., M. D. Kirchhoff, and J. H. Hughes. 1988. Wildlife and old-growth forests in southeastern Alaska. Natural Areas Journal 8:138-145.

Shanley, C. S., S. Pyare, M. I. Goldstein, P. B. Alaback, D. M. Albert, C. M. Beier, T. J. Brinkman, R. T. Edwards, E. Hood, A. MacKinnon, M. V. McPhee, T. M. Patterson, L. H. Suring, D. A. Tallmon, and M. S. Wipfli. 2015. Climate change implications in the northern coastal temperate rainforest of North America. Climate Change 130:155-170.

Smith, D.W. 1998. Yellowstone wolf project: annual report, 1997. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-NR-98-2. 20 pp.

Sparkman, A. M., L. P. Waits, and D. L. Murray. 2011. Social and demographic effects of anthropogenic mortality: a test of the compensatory mortality hypothesis in the red wolf. PLoS ONE 6(6): e20868. doi:10.1371/journal.pone.0020868

Suring, L. H. 2010. Summary of relevant past and ongoing monitoring of young-growth forests that pertains to wildlife on the Tongass National Forest. Final Report, Northern Ecologic L.L.C. Technical Bulletin 2010-4. 11 pp.

Szepanski, M. M., M. Ben-David, and V. Van Ballenberghe. 1999. Assessment of anadromous salmon resources in the diet of the Alexander Archipelago wolf using stable isotope analysis. Oecologia 120:327-335.

Tappeiner, J. C. II and P. B. Alaback. 1989. Early establishment and vegetative growth of understory species in the western hemlock-Sitka spruce forests of southeast Alaska. Canadian Journal of Botany 67:318-326.

The Nature Conservancy. 2014. Restoring ecological function in young-growth stands on the Tongass National Forest: an exploration of landscape alternatives for ecological and economic sustainability. Draft Report for Review 11-14-2014.

Thiel, R. P., S. Merrill, and L. D. Mech. 1998. Tolerance by denning wolves, *Canis lupus*, to human disturbance. Canadian Field-Naturalist 112:340-342.

USDA. 2005. Guidelines for road maintenance levels. USDA Forest Service Technology and Development Program Report 7700-Transportation Management 0577 1205-SDTDC. 54 pp.

USDA. 2011. 2011 Direction for Project-level Deer, Wolf, and Subsistence Analysis. USDA Forest Service interagency deer model. 7 pp.

USDA. 2014. Tongass Young-Growth Management Strategy. 2014 Report USDA Forest Service. 133 pp.

USDOT. Undated. The Prince of Wales Island road system: from logging roads to State Scenic Byway, compiled from email and interviews, 2008-2010. Federal Highway Administration, Department of Transportation Article 37 online (5 pp). https://flh.fhwa.dot.gov/about/history/documents/article-37.pdf

USDOT. 2011. Tribal Transportation: Prince of Wales Island. U.S. Department of Transportation, Federal Highway Administration, website, last updated April 5, 2011. http://www.fhwa.dot.gov/tribal/tribalprgm/govts/pow.htm

USFWS. 2015. Species status assessment for the Alexander Archipelago wolf (*Canis lupus ligoni*). Version 1.0, December 2015. Alaska Region, Anchorage, Alaska. 162 pp.

Whittington J., C. C. S. Clair, and G. Mercer. 2005. Spatial responses of wolves to roads and trails in mountain valleys. Ecological Applications 15:543-553.

Whittington J., M. Hebblewhite, N. J. DeCesare, and M. Musiani. 2011. Caribou encounters with wolves increase near roads and trails: a time-to-event approach. Journal of Applied Ecology 48:1535-1542.

Wolken, J. M., T. N. Hollingsworth, T. S. Rupp, F. S. Chapin III, S. F. Trainor, T. M. Barrett, P. F. Sullivan, A. D. McGuire, E. S. Euskirchen, P. E. Hennon, E. A. Beever, J. S. Conn, L. K. Crone, D. V. D'Amore, N. Fresco, T. A. Hanley, K. Keilland, J. J. Kruse, T. Patterson, E. A. G. Schuur, D. L. Verbyla, and J. Yarie. 2011. Evidence and implications of recent and projected climate change in Alaska's forest ecosystems. Ecosphere 2:124. www.esajournals.org

Zaborske, R. R., R. N. Hauver, M. H. McClellan, and T. A. Hanley. 2002. Understory vegetation development following commercial thinning in southeast Alaska: preliminary results from the Second-Growth Management Area Demonstration Project. Pages 74-82 *in* Parker, S. and S. S. Hummel, editors. Beyond 2000: a silvicultural odyssey of sustaining terrestrial and aquatic ecosystems. Proceedings of the 2001 National

Silviculture Workshop. General Technical Report PNW-GTR-546, Pacific Northwest Research Station, USDA Forest Service, Portland, OR.

Zimmermann, B., L. Nelson, P. Wabakken, H. Sand, and O. Liberg. 2014. Behavioral responses of wolves to roads: Scale-dependent ambivalence. Behavioral Ecology 25:1353-1364.

Wolf Technical Committee

(alphabetical by last name)

Bonnie Bennetsen, USDA Forest Service
Steve Brockmann, U.S. Fish and Wildlife Service
Anthony Crupi, Alaska Department of Fish and Game
Brie Darr, USDA Forest Service
Luke Decker, USDA Forest Service
Rodney Flynn, Alaska Department of Fish and Game
Don Martin, USDA Forest Service
Ryan Scott, Alaska Department of Fish and Game
Tom Schumacher, Alaska Department of Fish and Game