Deschutes Collaborative Forest Project Lodgepole Pine Recommendations

Introduction

The Restoration Planning Subcommittee (RPSC) of the Deschutes Collaborative Forest Project (DCFP) has engaged in a year-long social learning process to develop restoration and management recommendations in climax lodgepole pine forests (Appendix 1). Recognizing the range of ecological, economic, and social values associated with lodgepole pine forests, the RPSC has developed recommendations and desired outcomes for each of the following areas:

- Stand Structure
- Wildlife (habitat restoration and maintenance)
- Forest products and their economics
- Forest Health (resilience and resistance to wildfire, insects, and disease)

Prior to developing these recommendations, the RPSC engaged in a thorough social learning process that included presentations and discussions on the following topics outlined in Table 1 below:

Table 1: Timeline of Social Learning Process

- Dec 2019: Overview of Lodgepole Pine Species
  Joe Bowles, Deschutes National Forest
  - Distribution and general life cycle

- Feb 2020: Framework for Understanding Lodgepole in Central Oregon Ecosystems
  Pete Caligiuri, The Nature Conservancy
  - Dry, moist, high-elevation, and wet meadow/riparian

- March 2020: Fire Disturbance Ecology in Lodgepole Pine Systems
  Andrew Merschel, Oregon State University
  - Fire disturbance regimes in lodgepole pine
  - Data from South Central Oregon

- May 2020: Insects, Disease, and Fires and Fuels Risks
  Travis Wooley, The Nature Conservancy
  Andrew Merschel, Oregon State University
  - Limitations for using prescribed fire in insect-impacted lodgepole pine within the WUI
  - WUI Treatments and trade-offs in areas surrounded by lodgepole pine climax forest types
  - Fire modeling & risk management

- June 2020: Insects, Disease, and WUI
  Robbie Flowers, Deschutes National Forest
  Alex Enna, Deschutes National Forest
  - Current and historic insect and disease cycle in lodgepole pine types
  - Role of disturbance factors in development of lodgepole pine forest types
  - Interactions between insects, disease, and fire

- <u>July 2020: Wildlife and Lodgpole Pine Forest Types</u>
  Craig Bienz, The Nature Conservancy
  Trent Seager, Sustainable Northwest
  - Identify species that use each lodgepole pine forest type
  - Impact of lodgepole pine encroachment on other potential wildlife habitat (meadows/aspen)

- <u>August 2020: Understory within Lodgepole Pine Forest Types</u>
  Gregg Reigel, Deschutes National Forest
  - Understory components in different lodgepole pine forest types
  - Linkages between understory composition, fuel loads, and fire behavior

- <u>December 2020: Economics and Operational Constraints in Lodgepole Pine</u>
  Loren Kellogg, Intermountain Wood Energy
  John Ernst, Quicksilver Contracting Company
  Chris Johnson, Shanda
  - Value, sale viability, firewood & post and pole
  - Cost of various operating systems, key economic variables & limitations

This learning process helped clarify several factors described below that challenge or complicate restoration and management in lodgepole pine forests. Important context identified through this process includes the diversity of biophysical conditions and lodgepole forest types, their disturbance ecology, the history of beetle epidemics and management, wildlife and plant species of concern, the broad geographic distribution of lodgepole, and the challenging economics of mechanical treatments and forest products. Additionally, restoration and management actions will need to consider the context of lodgepole at the stand and project scale.

We recognize that appropriate treatments may vary from stand to stand, given the context range of variables at play. In other words, there is no "one size fits all" approach to restoration in lodgepole pine forests. Treatments will be more appropriate and effective if they consider biophysical setting, past management and beetle epidemics, wildlife habitat needs, and landscape context.

Biophysical setting – Lodgepole pine has a broad ecological amplitude that allows it to develop pure or nearly pure stands in a variety of biophysical environments. This variability has been broadly summarized for distinct lodgepole types that each have a distinct disturbance ecology, productivity, distribution, and restoration opportunities across the Deschutes National Forest (Appendix 1, Figure 1). Using this lodgepole typology helps the DCFP to make recommendations that accommodate biophysical variability in lodgepole pine forests.

Disturbance ecology – In central Oregon, lodgepole pine forests historically had a diverse mixed-severity fire regime with a broad range of fire return intervals (See Appendix 1 for more details). In general the extensive dry and moist lodgepole forest types were frequently disturbed by a combination of insects, disease, and fires spreading from adjacent ponderosa pine and mixed-conifer forests. At longer time scales the combination of beetles and infrequent severe fire resulted in larger stand-replacing fire events.

History of beetle epidemics and management – Fire exclusion and past management practices have altered lodgepole ecosystems by replacing fine-scale variability in stand and age structure with larger patches of relatively homogenous forest. In some stands there are heavy accumulations of large woody fuels that built up after widespread beetle epidemics in the absence of fire, and/or densely regenerated stands with heavy disease infection (e.g. shelterwoods).

Wildlife – Historically, uneven-aged lodgepole structure at the stand level and patchiness in disturbances at landscape levels would have created a variety of structural characteristics utilized by a diversity of wildlife species. Black backed woodpecker and American marten rely on patches of standing dead and jack-straw lodgepole piles, respectively, created from localized torching and beetle kill within dense lodgepole patches. Openings created from fire and beetles also promote foraging opportunities for early-successional species such as mule deer, songbirds and pollinators. At the same time, dense patches provide hiding/thermal/travelling cover by mule deer, small mammals, and northern goshawk. Lodgepole encroachment from fire suppression has resulted in the loss of structure required by a variety of wildlife, including the loss of wet-meadows and moist aspen stands.

***Landscape Context* –** The broad ecological amplitude of this species means that lodgepole pine forests can be found in many different contexts across the Deschutes National Forest (see map in Appendix 1). This includes remote areas in wilderness at relatively high elevations in steep rugged terrain, remote areas in flat topography on the east side of the forest, and also substantial areas near popular recreation areas and in the WUI near homes and business. The location of a lodgepole forest should be used to inform appropriate restoration treatments or no treatment actions.

***Economics of treatments and forest products* –** Lodgepole pine, both green and dead, is a locally valuable tree species with a wide variety of uses, including dimensional lumber, paneling, posts, poles, chips and firewood. The value of various products depends on both supply chains and demand, while harvesting and hauling costs can be a major limiting factor for lodgepole value. The economic viability of treatments in lodgepole pine is heavily dependent on the per acre volume of merchantable logs (>2000 board feet/acre) and overall size of treatment units, with small, isolated and scattered units being most costly.

Project-scale Recommendations (1000s of acres)

1. Restore forest conditions within the lodgepole pine forest types consistent with their historical disturbance regimes (i.e., fire, insects, and disease) and their relative effects (see stand-scale recommendations below for more refined stand-level characteristics).

2. Design and implement all components of proposed management plans so they deliver the biggest "bang for your buck". The ecological and economic efficacy of treatments and their efficiency can be improved by treating across forest types and linking treatments together so that restored areas are larger and more contiguous. Small isolated treatments (including non-commercial treatments) may have limited potential to modify wildfire behavior, allow for meaningful reintroduction of fire, and provide large functional areas of core wildlife habitat; they also increase treatment costs and inefficiencies.

3. Track, report-on (to the collaborative), and complete non-commercial components of planned restoration work including restructuring and rehabilitation of the transportation system, prescribed fire, and recruitment and maintenance of wildlife habitat.

4. Increase heterogeneity at stand and landscape scales, promote floral and faunal diversity and provide a variety of habitat resources for several priority lodgepole-associated wildlife species.

    - Managing for heterogeneity at the stand scale should consider the provisioning of habitat resources in adjacent forest types and promote (1) uneven tree size class distributions, (2) long-term snag recruitment, (3) uneven dead-wood decay distribution, (4) a variety of forage opening sizes, (5) a variety of leave-tree clump sizes and (6) downed-lodgepole piles.

    - Managing for landscape-scale heterogeneity should consider the spatial arrangement of lodgepole and non-lodgepole stands to optimize habitat for a variety of early, mid and late-seral associated species, consistent with historical conditions in each lodgepole type. Core habitat areas should be identified for prioritizing management for sensitive wildlife species (e.g., away from active roads and trails) and treatment objectives should seek to minimize disturbance during critical nesting, breeding, migration and overwintering habitats.

5. Consider management history and associated legacy effects on current forest conditions when determining the appropriate restoration pathway (e.g., no treatment, mechanical treatment, and reintroduction of fire) and scale and intensity of disturbance required to restore desired future conditions over time, given initial vegetation structure. Acknowledge that measures to minimize human-wildlife interactions (i.e., retention of larger leave-tree patches) may not be consistent with historical fire effects, but should be considered to conserve sensitive wildlife species surrounding road and trail infrastructure. Tradeoffs among wildfire risk, wildlife habitat, recreational values and forest restoration practices should be assessed for long-term adaptive management.

6. Restore forest and stand conditions across dry- and moist-lodgepole pine types such that if fires do occur, high-severity patches will be smaller (e.g. 10s of acres rather than 100s-1000s of acres).

7. Arrange treatments in dry and moist lodgepole so they facilitate the reintroduction of prescribed fire, particularly in Riparian and Wet Meadow Lodgepole and in ponderosa pine and mixed-conifer forests that are adjacent to lodgepole pine forest types.
    - Consider fire and smoke impacts on public health and safety when determining appropriate levels of prescribed fire to achieve restoration objectives in the WUI.
    - Consider spring prescribed fire impacts on wildlife in riparian and wet meadow lodgepole pile.

8. Use restoration treatments to increase habitat suitability and connectivity for key native indicator species that utilize different resources within lodgepole pine forests (e.g., black-backed woodpecker [snags], American marten [piles] mule deer [forage openings

and hiding/thermal cover]).

- Assess the selection of lodgepole stands and specific resources (e.g., foraging habitat, thermal, nesting and hiding cover) by indicator species to evaluate whether functional habitat is being recruited and maintained.
- Habitat resources should be addressed at the species level to determine the suitable density and distribution of specific resources at the stand scale (e.g., snag size and density, forage opening size, regeneration clump size) and landscape scales (e.g., cover connectivity, patch size distributions and configuration).

9. Evaluate and consider alterations to the existing transportation/recreation system (roads and trails) to optimize restoration activities, restore or improve ecological functions, meet management needs and minimize disturbance to wildlife (e.g., close, decommission, reroute, maintain and construct), while providing determined recreation access. Using the USFS Forest Fragmentation Tool, prioritize alterations that increase core habitat areas, and limit the creation of unauthorized roads and use of closed roads/trails; Improve and maintain roads critical to fire management, restoration, forest products, and determined recreation access.

10. Use restoration treatments to protect and sustain current and future economic values from the forest, including local recreation assets and commercial forest products.

11. Recognize and take into account important local values in the planning, design, and implementation stages of management activities at project- and stand-scale in the four lodgepole forest types, including:
    - Economic values (e.g., forest products industry and infrastructure, forest jobs, outdoor recreation sector)
    - Social values (e.g., recreation access, quality of life, scenic views, community wildfire protection, game and non-game wildlife, wilderness aesthetics)
    - Ecological values (e.g., natural disturbance processes, forest/soil productivity, floral and faunal diversity, wildlife and their habitat resources, wilderness aesthetics)

12. Assess carbon storage trade-offs from treating or not treating stands.

Stand-scale Recommendations (1-10s of acres)

Stand Structure

Dry Lodgepole

1. *Intention/Purpose: Recognize and work with the variability in lodgepole stands*

   Lodgepole stands have different initial structural conditions, as a result of differences in site productivity and biophysical setting (e.g. lodgepole pine type), past fire history, silvicultural history, presence of dwarf mistletoe and beetle mortality. Treatments and no treatment areas should vary among lodgepole stands.

2. <u>Intention/Purpose:</u> *Provide diversity of wildlife habitat via creating/maintaining diverse stand structure that is consistent with a moderately frequent, mixed-severity fire regime*

   Mechanical treatments should create within-stand heterogeneity in canopy cover, tree density and tree size over time. This can be accomplished by applying a combination of small diameter tree thinning and tree harvest while leaving portions of a treatment area untreated.

3. <u>Intention/Purpose:</u> *Strategically plan where to locate untreated areas within treated stands*

   Untreated areas within treated stands should be used to develop heterogeneity in forest structure, maintain existing undisturbed or minimally disturbed areas, limit and avoid expansion of the transportation (roads and trails) system, and recruit and maintain wildlife habitat. Decisions to leave small untreated areas should recognize that many project areas and parts of the landscape have large areas of untreated lodgepole. Identify no treatment areas, leave areas, and wildlife cover and corridors (permeability patches) *in the preplanning process* rather than in the implementation stage in order to better strategically locate them on the landscape.

4. <u>Intention/Purpose</u>*: Improve the future trajectory of stagnant stands by addressing conditions resulting from past management, including fire suppression and past harvest.*

   Increase individual tree growth and recruitment of large vigorous overstory lodgepole, especially in dense stagnated stands with heavy mistletoe and gall rust infection that have developed following past seed tree cuts and clear cuts. Use treatments that reduce mistletoe infection in seedlings and young trees. Consider the availability/diversity of successional stages (e.g. young – open, young-closed, mature, old multi-aged stands). Also consider increased mistletoe and susceptibility to mountain pine beetle mortality on lodgepole pine sites across a project area.

5. <u>Intention/Purpose</u>: *For fire to play a more natural role in lodgepole pine and adjacent ponderosa pine and mixed-conifer forest types (See appendix for description of the historical fire regime)*

   Prepare lodgepole forests for wildfire and prescribed fire. Use prescribed fire to maintain fine-scale heterogeneity in vegetation structure. Specifically, prescribed fire should break up the continuity and homogeneity of fuels, burn with mixed-severity, and increase heterogeneity in lodgepole forests by creating patches of with different stand and age structure. Initial mechanical treatments may be required to develop the fuel structure that facilitates reintroduction of fire. After mechanical treatments, it will take time to recover more fire resistant and heterogeneous stand structure in many treatment areas. Better outcomes during future wildfires and increased opportunities for prescribed fire may require preparing larger contiguous areas that include adjacent forest types (e.g. ponderosa pine and mixed-conifer). This does not mean that every acre needs to be treated, but treatments across a project area should prepare project areas to burn with fire effects that are consistent with historical fire regimes (e.g., low-severity in ponderosa pine, mixed-severity in lodgepole pine).

   The use of prescribed fire will not be immediately possible in many stands that have a large accumulation of heavy continuous woody fuels that have developed following beetle outbreaks and a century of fire exclusion. Consider that historical fires removed fuels much more frequently than they have in the past century and burned through a greater diversity of fuels that are present in most stands (see Travis Wooley's presentation for examples of diversity in fuels that is driven by succession in lodgepole forests). Implementation of prescribed fire may be challenging in these areas and require more resources.

6. _Intention/Purpose_: *Variability in structure should follow the underlying biophysical template and/or be consistent with historical fire effects. Increase edge habitats and spatial diversity in forest structure and microclimate.*

   To the degree possible, given initial starting conditions, tree harvest, thinning, and no treatment areas should have irregular shapes (e.g. sinuous blobs that are not round, square, or with straight edges). The pattern or mosaic of different structure patches should vary with biophysical environment (e.g. soils, forest type, and topography) and transitions between them should be gradual. When different aged patches are created in the same biophysical setting to mimic mixed-severity fire, edges should be diffuse and gradual rather than abrupt. Overall, variability in forest structure should follow the underlying biophysical template or be consistent with mixed-severity fire. Removing hard edges will occur over time in some scenarios.

Moist Lodgepole

Stand structure recommendations are consistent with dry lodgepole *except for recommendations 3-4*

3. _Intention/Purpose_: *Scale of treatments in productive lodgepole is larger in productive/moist stands than dry stands and treatments often result in denser even-aged patches.*

   Mechanical treatments should create within stand heterogeneity in canopy cover, tree density and tree size. This can be accomplished by applying a combination of small diameter tree thinning and tree harvest while leaving portions of a treatment area untreated. In comparison to dry lodgepole, treatments will produce larger patches of even-aged and relatively dense structure. In order to maintain heterogeneity and recruit overstory trees, follow-up treatments (e.g. non-commercial thinning) will likely be required for thick sapling regeneration within past and future treatments.

4. _Intention/Purpose:_ *Use fire to support aspen and meadow restoration*

   Where possible, use prescribed fire to maintain fine-scale heterogeneity in vegetation structure, restore aspen, and adjacent meadows. Understory herb, forb, and shrub diversity and vigor are a priority in this type and should be maintained using the combination of prescribed fire and mechanical treatments.

Riparian Areas and Wet Lodgepole Meadows

Intention/Purpose: *Restoration of meadow and riparian habitat*

Restoration of understory forbs, sedges and grasses, willow, and aspen via the removal of encroaching lodgepole forest is the primary management goal for "riparian and wet meadow lodgepole" (Seager 2017). Riparian and meadow sites are distinguished by marshy or flooded conditions early in the growing season and often have saturated soils until late June or July (Volland 1988). Lodgepole forest cover was not historically common on these sites/soils and forest cover today represents ingrowth as a result of fire suppression and changes in the water table.

1. Remove or girdle <u>encroaching</u> conifers while retaining, old trees, snags, and trees beneficial for wildlife (e.g., dense cover adjacent to meadows). Historically conifers occurred mostly on the edges of riparian and meadow habitats above seasonally flooded soils and sparsely occurred within them. Encroaching conifers that have formed continuous forest cover are novel (i.e. historically rare) and developed as a result of fire suppression and changes in hydrology. This does not include all conifers; conifers should be maintained at a level that supports wildlife while also allowing a vigorous meadow ecosystem (e.g. aspen, willow, forbs, tall sedges and grasses).

   Note: the Collaborative values retention of large and old trees and meadow habitat—and sometimes these are at odds with each other. Prioritizing these values should be site- and context-specific.

2. Treatments should be monitored and adapted to prevent stimulation and dense reproduction of young lodgepole.

3. Retain and enhance herbaceous vegetation, aspen, cottonwood and willow maintained at a level that supports wildlife. Build wild-ungulate exclosures (as necessary, not in general) to facilitate aspen and willow recovery. Where possible, use jackstraw and barriers of downed lodgepole to reduce ungulate browse and facilitate aspen production.

4. Where possible, use prescribed fire to stimulate hardwood recovery and kill encroaching lodgepole.

5. Restore the hydrology that supports meadow systems where it has been altered by drainage, erosion of stream banks, and grazing. Use cut trees to slow water flow, increase sediment deposition, and improve beaver habitat.

6. Relocate or decommission roads and limit driving access to protect riparian soils.

7. Treatments should be timed to occur when conditions are favorable, especially avoiding compaction and displacement of wet soils.

8. Considering planting riparian vegetation such as hardwoods where they are absent or in low abundance.

9. Locate treatments in places where there is the best opportunity for the retention of wildlife habitat and regeneration of historical aspen stands

10. Wildlife and aquatic values are high and there is relatively little data regarding restoration of these habitats. Prescriptions and results should be continuously be monitored and assessed by wildlife and aquatics staff, with adaptive management guiding future management needs and actions, using a cautionary approach.

High-Elevation Lodgepole

High-elevation lodgepole forests are typically found in wilderness areas or remote parts of the DNF and therefore natural dynamics related to an infrequent mixed-severity fire regime should be emphasized and wilderness character should be retained. For fire prevention purposes and to manage hazard trees, exceptions for treatments could be made for post-beetle mortality salvage harvests in areas within or immediately adjacent to high-value infrastructure (e.g. campgrounds, developed recreation areas snow parks, resorts, frequently-used roads, etc.) and adjacent to private development.

Beetle salvage harvests are *not* fire salvage harvests or clearcuts. The goal of beetle salvage harvest is to remove recently killed trees at a level that reduces the risk of crown fire in order to prevent the spread of crown fire from these areas to developed areas during the highly flammable red stage, which occurs 1-10 years after heavy beetle mortality (Hickey et al. 2012, Harvey et al. 2014).

Wildlife

Dry Lodgepole

1. Use retained trees and mortality from insects and pathogens to recruit and retain a variety of snag size classes, with a focus on mechanically creating larger snags for cavity-nesting and foraging birds where they are not being recruited. Snags should occur in different forest structural types (e.g. dense lodgepole, gaps/openings, and thinned lodgepole). Where possible, snags should be created via topping to avoid premature blowdown and maintain standing wood, although girdling can be considered to promote near-term recruitment of downed-logs. Endemic levels of beetle mortality should be maintained to promote habitat for indicator species, such as black-backed woodpecker.

2. Use retained trees and mortality from insects and pathogens for recruiting and maintaining a variety of decay classes of both snags and downed logs to promote the suitability of stands by a variety of wildlife species.

3. When lodgepole piles that are intended to be retained are created, they should be purposefully constructed. Piles should be approximately 10x10 to 30x30 ft in size, with cross-hatched lodgepole boles for the base, and finer branches for the top covering to promote hiding, denning and nesting cover for a variety of species, including small mammals, porcupine, American marten, and songbirds. Disperse piles at approximately 1 pile/acre where large downed logs are present and 2 piles/acre where they are missing from units to facilitate connectivity for coarse wood associated species. Avoid the disturbance and removal of existing downed-wood within units when constructing piles. Attempt to remove fine fuels and dig handlines around lodgepole piles to mitigate combustion during prescribed fire operations. Piles should be created in both openings and thinned areas, but should not occur where they create ladder fuels into a contiguous forest canopy. Retention of piles should be coordinated with fire personnel.

4. Maintain and recruit a range of forest opening sizes, consistent with historical conditions to promote pumice moonwort, bitterbrush, foraging habitat for mule deer, elk, pollinators and small mammals, and nesting habitat for early-successional associated songbirds. If possible,

attempt to create openings approximately 300 meters away from roads and motorized trails and 100 meters away from non-motorized trails to minimize human interaction while utilizing dense lodgepole patches as cover screens adjacent to road and trail systems.

5. Retain a range of dense cover patch sizes – from 0.2 to 5 acres in size – to provide hiding and thermal cover for rodents, lagomorphs and mule deer. Dense patches should be located adjacent to forage openings to promote mule deer escape and hiding cover, especially where roads and trails are present. Assess potential tradeoffs and conflicts among fire risk, wildlife, recreation opportunities and restoration objectives when prioritizing locations of leave-tree patches.

Moist Lodgepole - wildlife recommendations are consistent with dry lodgepole *except* for the following recommendations.

1. Recruit and maintain a range of forest openings consistent with both group torching and stand-replacing patches of fire to promote foraging habitat for deer, elk, and small mammals, and nesting habitat for early-successional associated songbirds. Moist lodgepole has the potential to provide greater forage production than dry lodgepole, while small openings have the greatest potential to regenerate as dense lodgepole. Larger openings would provide greater value as foraging habitat for mule deer and elk and increase the spatial availability of habitat resources for territorial songbird species. Openings in this type may also provide greater floristic and pollinator diversity, although the use of prescribed fire and follow-up mechanical treatments will be needed to reduce dense lodgepole regeneration, especially in small openings. Where possible, create openings 300 meters away from roads and motorized trails and 100 meters from hiking and biking trails to minimize human interaction and utilize dense lodgepole patches as cover screens where needed. Identify understory vegetation in deciding opening placement to optimize post-disturbance floristic development and diversity.

2. Moist lodgepole has a greater capacity to be maintained in relatively densely-grown patches with less competition-induced stress and may therefore promote better long-term forest cover and snag recruitment. Maintain greater patch sizes of dense-lodgepole to maintain cover habitat for dense-forest associated species (e.g., northern goshawk, American marten).

3. Corridors (linear patches) of lodgepole pine should be maintained to facilitate the movement (landscape permeability) of canopy-sensitive species along seasonal migratory routes (e.g., mule deer) and where connectivity will facilitate the dispersal of dense-forest associated species across the landscape (e.g., northern goshawk).

4. Where aspen is present, remove lodgepole within and adjacent to mature and spouting aspen stems.

Riparian Areas and Wet Lodgepole Meadows

1. Retain and create downed wood along edges of meadows and create snags in both edges and dispersed throughout the interior of meadows. Plan for future recruitment of snags along the edges of openings by retaining large trees in diffuse-treatment edges.

2. Retain lodgepole edges in meadow systems where they minimize line-of-sight and human disturbance from roadways, trails and campgrounds.

3. Utilize cut lodgepole to create piles within meadows and adjacent stands for small mammals, forest carnivores, and songbirds.

4. Utilize prescribed fire to maintain herbaceous cover and promote floristic diversity.

5. Within riparian zones, utilize cut lodgepole for in-stream wood habitat.

Prioritize this type for promoting meadow-dependent species and pollinator diversity.

Forest Products

Dry, Moist, Riparian and Meadow Lodgepole

1. Incorporate and utilize the existing transportation infrastructure and consider topography in treatment designs to limit logistical challenges and costs.

2. Complete non-commercial and commercial restoration and mechanical treatments across an area and its variety of forest types before moving substantial distances to another treatment area. In other words, don't create small and isolated treatment areas that
    - Increase costs
    - Have limited ability to restore resistance to disturbances and are inconsistent with historical fire regimes
    - Exclude or limit reintroduction of prescribed fire
    - Do not provide meaningful opportunities to restructure and rehabilitate the transportation system.

3. Combine treatments in lodgepole forests that aren't economically viable (e.g. < 2,000 BF/acre) with higher volume treatments in adjacent stands. For example, treatments in marginal dry lodgepole stands might be paired with restoration of aspen in adjacent moist lodgepole and riparian and meadow systems in wet lodgepole.

4. Identify no treatment areas, leave areas, and wildlife corridors (permeability patches) in the preplanning process rather than in the implementation stage.

5. Adapt a long term perspective to restoring historical conditions and dynamics and their variability among lodgepole types by emphasizing retention and recruitment of healthy and vigorous trees, while increasing heterogeneity in tree size and age structure within stands and across the landscape over time.

Forest Health

Dry and Moist Lodgepole

1. Reduce mistletoe infection to historic endemic levels among young trees
    a. When overstory lodgepole are retained, favor retention of uninfected or lightly infected trees and remove or girdle heavily infected trees where possible.

b. Create gaps or group openings that remove understory trees and regeneration around heavily infected overstory trees and retain maturing and understory trees that are both non-infected and >50 ft away from infected trees.

c. Design treatment units to take advantage of man-made or natural barriers that prevent re-invasion from adjacent infested stands.

d. Use prescribed burning to reduce dwarf mistletoe by killing some infected trees and by scorch-pruning infected branches while recognizing that prescribed fire does not typically eliminate dwarf mistletoe populations

2. Reduce the risk of widespread severe mountain pine beetle mortality
    a. Increase uneven-aged structure within and among stands where appropriate. Create a mix of age classes across the landscape to reduce the risk of outbreaks all at once.

    b. Maintain low-levels of infestation where spread is limited (see wildlife recommendations re: black backed and 3-toed woodpeckers); applicable where large-scale infestation is mitigated by stand structure, but pockets of high-susceptibility remain.

3. Consider tradeoff between uneven-aged management to reduce pine beetle mortality and potential for mistletoe infection and spread.

Riparian Areas and Wet Lodgepole Meadows

1. Remove trees infected with mistletoe and western gall rust, but retain mistletoe infected trees to meet wildlife habitat needs.

Appendix 1 – Ecology of lodgepole pine forest types that helped develop recommendations

Lodgepole pine (*Pinus contorta var. murryanna*) occurs in a variety of different forest types in central Oregon due to its adaptability to a broad range of edaphic conditions and tolerance to temperature extremes (Geist and Cochran 1991, Simpson 2007). Lodgepole pine recommendations apply only to climax lodgepole pine forests (hereafter lodgepole forests), where lodgepole is the predominant species in all phases of stand development. Lodgepole forests do not include stands where lodgepole pine is seral to true fir, (*Abies spp*) and mountain hemlock (*Tsuga mertensiana*), or where it is found in a mixture with ponderosa pine (*Pinus ponderosa*). Small amounts of other conifers may occur in lodgepole forests where they spatially transition to ponderosa pine, mixed-conifer, and mountain hemlock forests types.

Climax lodgepole forests occur on ~650,000 acres on the Deschutes National Forest (DNF) across a diverse set of landscape positions and environmental settings (Appendix 2). As a result, the DCFP's recommendations for lodgepole forests vary in relation to productivity, response to management, existing and historical conditions, and historical (pre 1910) fire regimes. To accommodate this variability in a practical way, we describe four major lodgepole pine types based on productivity, historical variation in fire and forest dynamics, and response to management. This typology is informed by plant association guides (Volland 1998, Simpson 2007) and historical forest dynamics and fire regimes in lodgepole forests (Geisler et al. 1980, Gara et al. 1985, Stuart et al. 1989, Heyerdahl et al. 2014, Hagmann et al. 2019, and Merschel 2021 *in prep*). Appendix 2 describes the distribution of lodgepole types used in these recommendations across the Deschutes National Forest. Appendix 3 provides a cross walk of plant association groups from Volland 1998 and DCFP lodgepole types.

We describe the four main lodgepole forest types as follows:

Dry Lodgepole

- Identification: Slow-growing, relatively unproductive sites, with an understory dominated by bitterbrush which is not aggregated in clumps or under lodgepole crowns. Mature stands have trees in multiple size and age classes. Snags and logs are often abundant due to beetle mortality and also occur in a variety of size and decay classes.
- Historical fire regime and dynamics: Frequent to moderately frequent fire (15-50 years) with fine-scale mixed-severity mortality effects. Bitterbrush and beetle-killed trees provided a network of dried logs and dry leaf litter that supported patchy, discontinuous, and gradual "log to log" burning (Agee 1993), under all but the most extreme weather conditions (Heyerdahl et al. 2014). A mosaic of unburned, lightly burned, and severely burned patches where shrub fuels were connected to canopy fuels resulted from most fires. Fine scale variation in fire severity is the result of variation in fuel structure, abundance, and continuity due to low productivity or surface fuels, past insect and disease disturbance Geiszler et al. 1980), and past fires that frequently burned into lodgepole forests from adjacent ponderosa pine and mixed-conifer forests (Hagmann et al. 2019.
- Historical stand structure (scale - 10s of acres): Post-fire retention of individual trees and clumps, and episodic beetle mortality promoted patchy, fine-scale regeneration, leading to multi-aged stands. Older stands would contain greater age class diversity and heterogeneity in structure (clumps, individuals, and openings), while these characteristics would be increasing over time with disturbance from fire, insects, and root pathogens in younger stands (Gara et al. 1985). The tree canopy included openings with dense tree regeneration where trees had been killed by beetles or fire, but also had treeless openings with more robust understory and bitterbrush cover were predominant (Heyerdahl et al. 2014).

- Landscape scale or project scale structure (100s to 1000s of acres): A frequent mixed-severity disturbance regimes leads a mosaic of multi-aged stands with different origin dates, relating to temporal and spatial variation in high-severity fire. In other words, landscapes would contain a mixture of stands with different origin dates and maximum tree ages. Diversity in stand and age structure across a landscape provides resilience to large-scale high-severity fire and beetle mortality, and allows for relatively continuous recruitment of snags and logs, and early, mid, and late development stages across the landscape.

Moist Lodgepole

- Identification: Sites that are more moist and productive than dry lodgepole, with more rapid and abundant tree and understory regeneration/response to fire, insect epidemics, and mechanical treatments. Tree composition is dominated by lodgepole pine but may include quaking aspen (*Populous tremuloides*). Unlike dry lodgepole pine, bitterbrush is absent or subordinate to other shrubs, grasses, and herbs. Understory cover of grasses and herbs is also greater and species composition is more diverse in comparison to dry lodgepole stands.
- Historical fire regime and dynamics: Frequent fire (15-50 years) with mixed-severity effects. In comparison to dry lodgepole, higher productivity and fuels supported larger patches of tree torching and high-severity mortality effects, but low and moderate severity fire and beetle mortality also formed stands with multiple cohorts and uneven aged-structure.
- Stand structure (10s of acres): A mixture of forest structures and age classes, including even-aged, two-aged, and multi-aged stands. In comparison to Dry lodgepole, Moist lodgepole forests had larger patches with consistent structure and development history and even-aged cohorts were more common.
- Landscape Structure (100s to 1000s of acres): A frequent mixed-severity disturbance regimes leads a mosaic of even-aged and multi-aged stands with different origin dates relating to temporal and spatial variation in high-severity fire. In comparison to dry lodgepole, stands or forest patches with similar development history are larger and more distinct. Diversity in stand and age structure provides resilience to extensive high-severity fire and beetle mortality across the landscape.

Riparian and Wet Meadow Lodgepole

- Identification: Standing water occurs early in the growing season and soils are generally saturated through July. These sites are found in flat to concave depressions and drainages. Understories are diverse and productive and include tall sedges and grasses, huckleberry, honeysuckles, spirea, aspen, and willow, where a perched water table persists into the fall. Most of these sites were grazed and many have altered hydrology from intentional drainage and road system development.
- Historical fire regime and dynamics: Fire was frequent in these riparian areas and meadows, fueled by cured, tall sedges and grasses in August and September (Hagmann et al. 2019).
- Stand structure (10s of acres): Lodgepole forest structure was rare on these sites historically. Instead flooding early in the growing season, combined with fire burning through cured grasses and sedges in the fall, historically maintained open meadows with scattered lodgepole, groves of aspen, and open meadows. The contiguous forest cover that is currently common in these areas is the result of lodgepole encroachment over the past century (Seager 2010, Seager 2017). The encroachment of lodgepole into these systems is likely due to historical grazing (Belsky JA and Blumenthal DM 1996), declines in water tables, and fire suppression.

High-Elevation Lodgepole

- Identification: High elevation lodgepole pine forests occur in cold, wet environments at high elevations along the western edge of the DNF and on Paulina peak. High-elevation lodgepole pine occurs above the mixed-conifer zone and is often intermingled with mountain hemlock and subalpine fir stands, whereas the Dry, Moist, and Riparian and Wet Meadow lodgepole types are found in low elevation flat basins surrounded by ponderosa pine and dry mixed-conifer forests.
- Historical fire regime and dynamics: Less is known about historical disturbance regimes, but these habitats likely had a less frequent moderate- to high-severity fire regime (Forrestel et al. 2017, Agee 1993). These forests have more even-aged structure that reflects a history of relatively large infrequent patches of stand-replacement fire.

<u>References for further information on the ecology of lodgepole pine forests in central Oregon</u>

Most of these references are available at this weblink:
https://oregonstate.box.com/s/9wilj3mbb7vib73wjq7134oyd8x6qhag

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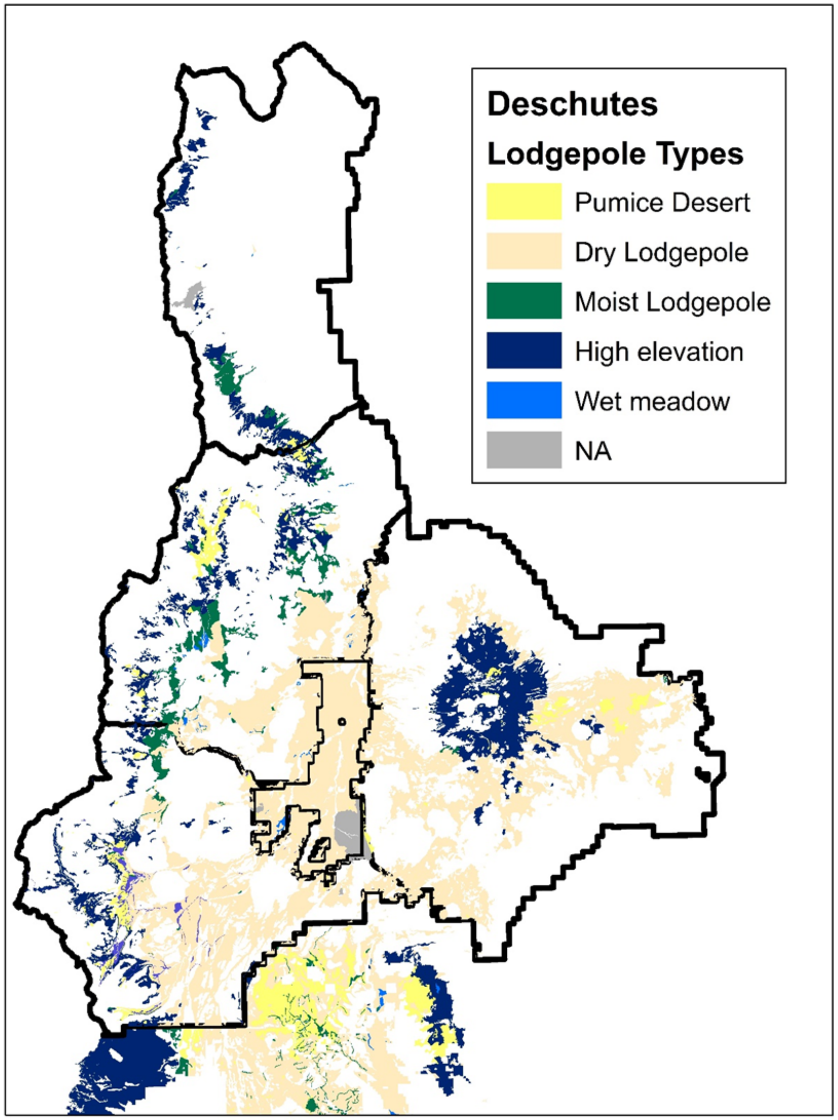
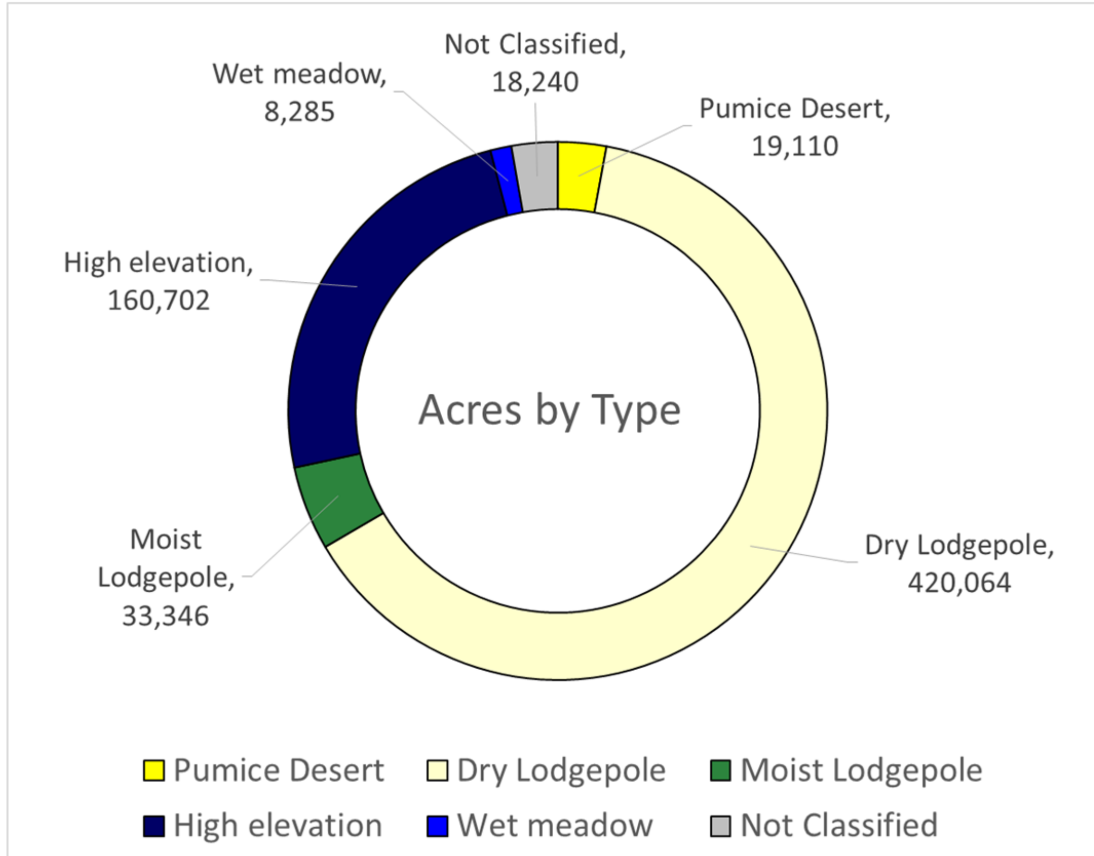
Appendix 2: Distribution (A) and abundance of lodgepole pine forest types across the Deschutes National Forest





Appendix 3: Crosswalk of Volland Plant Association Groups for climax lodgepole forests with DCFP lodgepole pine types

PAS_LABEL	Plant Association Group Description	Volland Plant Code	Volland Name	DCFP Lodgepole Type	Hall grouping
CLS111	LODGEPOLE PINE DRY	CLS1-11	Lodgepole/sagebrush/fescue	Dry Lodgepole	Warm-xeric
CLS112	LODGEPOLE PINE DRY	CLS1-12	Lodgepole/sagebrush (rhyolite)	Dry Lodgepole	Warm-xeric
CLS211	LODGEPOLE PINE DRY	CLS2-11	Lodgepole/bitterbrush/needlegrass	Dry Lodgepole	Warm-xeric
CLS214	LODGEPOLE PINE DRY	CLS2-14	Lodgepole/bitterbrush/fescue	Dry Lodgepole	Warm-xeric
CLS216	LODGEPOLE PINE DRY	CLS2-16	Lodgepole/bitterbrush (rhyolite)	Dry Lodgepole	Warm-xeric
CLM411	LODGEPOLE PINE WET	CLM4-11	Lodgepole/beargrass	High elevation	xeric
CLS215	LODGEPOLE PINE DRY	CLS2-15	Lodgepole/currant-bitterbrush/needlegrass	Dry Lodgepole	Warm-xeric
CLS311	LODGEPOLE PINE DRY	CLS3-11	Lodgepole/manzanita	High elevation	Cool-xeric
CLS412	LODGEPOLE PINE DRY	CLS4-12	Lodgepole/grouse huckleberry	High elevation	Cool-xeric
CLS911	LODGEPOLE PINE DRY	CLS9-11	Lodgepole/snowbrush-manzanita	High elevation	NA
CLG313	LODGEPOLE PINE DRY	CLG3-13	Lodgepole/needlegrass-lupine-linanthastrum	High elevation	NA
CLG314	LODGEPOLE PINE DRY	CLG3-14	Lodgepole/needlegrass-lupine	High elevation	NA
CLG411	LODGEPOLE PINE WET	CLG4-11	Lodgepole/sedge-lupine	High elevation	xeric
CLM211	LODGEPOLE PINE DRY	CLM2-11	Lodgepole/bearberry	Moist Lodgepole	Moist
CLS212	LODGEPOLE PINE WET	CLS2-12	Lodgepole/bitterbrush/sedge	Moist Lodgepole	Warm-xeric
CLS213	LODGEPOLE PINE DRY	CLS2-13	Lodgepole/bitterbrush/forb	Moist Lodgepole	Moist
CLG412	LODGEPOLE PINE WET	CLG4-12	Lodgepole/sedge-lupine-penstemon	Moist Lodgepole	xeric
CLG312	LODGEPOLE PINE DRY	CLG3-12	Lodgepole/ low huckleberry	NA	Cool-xeric
CLGXXX	LODGEPOLE PINE DRY	CLGX-XX	Not In Volland	NA	NA
CLSXXX	LODGEPOLE PINE DRY	CLSX-XX	Not in Volland	NA	NA

CLXXXX	LODGEPOLE PINE DRY	CLXX-XX	Not in Volland	NA	NA
CLG311	LODGEPOLE PINE DRY	CLG3-11	Lodgepole/needlegrass basins	Pumice Desert	xeric
CLG413	LODGEPOLE PINE DRY	CLG4-13	Lodgepole/sedge-needlegrass basins	Pumice Desert	xeric
CLM111	LODGEPOLE PINE WET	CLM1-11	Lodgepole/sedge-grass wetland	Wet meadow	wet
CLM112	LODGEPOLE PINE WET	CLM1-12	Lodgepole/ sedge	Wet meadow	wet
CLM113	LODGEPOLE PINE WET	CLM1-13	Lodgepole/ widefruit sedge	Wet meadow	wet
CLM311	LODGEPOLE PINE WET	CLM3-11	Lodgepole/blueberry/forb wetland	Wet meadow	Moist
CLM312	LODGEPOLE PINE WET	CLM3-12	Lodgepole/ bog huckleberry/widefruit sedge	Wet meadow	wet
CLM313	LODGEPOLE PINE WET	CLM3-13	Lodgepole/douglas spirea-forb	Wet meadow	Cool-xeric
CLM314	LODGEPOLE PINE WET	CLM3-14	Lodgepole/douglas spirea/widefruit sedge	Wet meadow	Moist
CLM9XX	LODGEPOLE PINE WET	CLM9-XX	Lodgepole-spruce/few flowered spikerush	Wet meadow	Moist
CLMXXX	LODGEPOLE PINE WET	CLMX-XX	Not in Volland	Wet meadow	Moist

Appendix 4: Overview of insects and diseases of lodgepole pine in Central Oregon.

Type	Insects and Disease	Management Implications
Dry *Moist*	***Note: differences in insect and disease impacts to dry and wet lodgepole systems is affected by stand density and frequency of fire*** ● **Mountain Pine Beetle** ○ MPB has historically been the major insect disturbance in lodgepole pine ○ While naturally occurring, outbreaks are more likely in locations where stand-replacing fires and previous management activities have led to large-areas of homogeneous age structure. Changing climate and weather patterns also play a role ○ Variability of species composition and structure increase resilience of lodgepole forests to the large-scale disturbances compared to other regions. *Interactions with Fire* ● MPB outbreaks affect fuels in lodgepole habitats with the scale of the impact dependent on the size and severity of the outbreak (link to stand density). ● **Pine Engraver** ○ Impacts lodgepole pine in drier sites and more drought-prone areas.	***Note: Management strategies must be addressed at both the planning stage and the silviculture/prescription stage and followed through the life of the stand. It is also critical to address other forest health concerns in areas where infestations occur.*** ○ Prevent outbreaks through management practices that reintroduce natural disturbance regimes to the landscape ○ Use silviculture and other management techniques to restore lodgepole pine habitats to the historic mosaic of uneven-aged structure and species composition under which they are most resilient ○ Use prevention, sanitation, maintain low, and salvage strategies (see below) as needed to reduce tree mortality in high-value areas or accelerate regeneration of affected areas ○ Prevent large-scale infestations through landscape-scale forest management by creating mosaics of age structure and species that are unfavorable to MPB epidemics ○ Treat the most susceptible areas ○ Use sanitation treatments, which involve detection and removal of infested trees in strategic areas of high resource value ○ Maintain low-levels of infestation in chronically infested stands where spread is limited; applicable when large-scale epidemics have collapsed but pockets of high-susceptibility remain ○ Use salvage to promote regeneration in areas where other efforts have failed ○ Take no action where it is clear that management actions are likely to have little to no impact.

	● **Dwarf Mistletoe** o A mosaic of infection levels was present but historically, infestations levels were lower than today o No occurrence or low incidence of mistletoe in sites where high-severity fire occurred in the recent past ○ Levels are higher and the pathogen is more widely distributed than historically due to lack of fire and increase in multi-story stands ○ Moderate-to-high density, pure lodgepole pine stands can increase the spread ○ Stress from drought can increase damage and growth losses in severely infected trees *<u>Interactions with wildlife</u>* ○ "Witches brooms" from mistletoe infestations are used by wildlife and an abundance of brooms are present on the landscape due to mistletoe being widespread *<u>Interactions with fire</u>* ○ Infestations can lead to lower canopy base height, alter ladder fuels, and change the fuel profiles and fire behavior.	○ Uneven-aged management in pure lodgepole pine habitats supports conditions for dwarf mistletoe intensification ○ If retaining overstory lodgepole pine infested by dwarf mistletoe, favor retention of uninfected trees and trees with lower levels of mistletoe; heavily infected trees should be removed when possible ○ Retain younger uninfected or lightly infected lodgepole pine where they are ≥ 50 ft away from infected overstory trees as increased spacing has been shown to slow-the-spread of dwarf mistletoe ○ Shelterwood or seed tree treatments can be used to support regeneration of healthy lodgepole pine in areas where the residual overstory trees are heavily infested if infested trees are removed post-treatment before the naturally regenerated lodgepole pine reaches ~1 m in height ○ Create group openings to reduce the source of inoculum ○ Remove infested regeneration in openings and where appropriate, plant other tree species around infected overstory lodgepole pines ○ Girdle infected overstory lodgepole pine to reduce the chances of overstory-to-understory spread ○ Design treatment units to take advantage of man-made or natural barriers that prevent re-invasion from adjacent infested stands. ○ Use prescribed burning to reduce dwarf mistletoe by killing some infected trees and by scorch-pruning that kills infected branches, recognizing that prescribed fire does not typically eliminate dwarf mistletoe populations ○ Prune mistletoe brooms and infected branches in the lower crowns of lodgepole pine where appropriate.
Meadows/ Riparian	● Higher abundance of western gall rust than historically	● Remove lodgepole pine with western gall rust cankers on the stem ● Reduce the overall abundance of lodgepole pine and trees infected with these diseases.