Moving Forward: Future Forest and Resource Management on City of Ashland Forestlands with Considerations for Climate Change

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Vulnerability Assessments and Adaptation Options

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1. Soils and Soil Productivity

Climate Change Key Vulnerabilities

1. Very erosive soils. Decomposed granitic soils are very erosive soils and dominate almost all of the City forestland ownership. Surface soil erosion can be easily exacerbated by climate changes.

2. Steep topography and increased opportunity for landslides. High percentage of ownership is on steep to very steep topography that periodically results in debris slides, especially during major storm events. Root-holding capacity of vegetation reduces that potential.

3. High severity fire (or other high severity disturbance)
   - consumption of organic matter and heating and changing the physical, chemical and biological, features in the soil; hydrophobic soils
   - large scale increase in surface soil erosion (e.g. water repellent soils) and sedimentation in hydrologic network, including Reeder Reservoir
   - elevated potential for landslide processes with significant potential impacts downstream (loss of vegetation and root holding capacity, increase in peak storm events)
   - increased potential for reburns and additional soil degradation
   - long duration fire creates most serious soil impacts (i.e. from excess amounts of snags, large woody debris); most impactful in headwall locations.
   - loss of plant:soil interactions and impacts on soil biology and biological processes at soil depth, many of which are poorly understood and rarely considered (e.g. mutualistic relationships and resource sharing, including carbon; hydraulic redistribution; etc.)

1. Soils and Soil Productivity

Adaptation Options for Management

1. **Persist in trying to prevent large scale, high severity fire or insect-related mortality (Persist)**

2. **Minimize management on slopes > 55-65% to reduce the likelihood of slope failure in storms of increasing intensity . Consider decreasing importance of fire management objectives on steeper slopes. (Persist)**

3. **Avoid long duration fire and excess high amounts of snags and LWD; manage to encourage for endemic rather than outbreak levels of insect-related mortality. Maintain adequate amounts of snags and LWD for soil health, wildlife habitat and other ecosystem level needs. Reduce excess amounts of snags and LWD when they occur; especially in more hazardous spatially explicit locations (Persist, Change)**

4. **Elevate amounts of prescribed underburning to decrease possibility of high severity fire; burn in ways that minimize potential surface soil erosion. Minimize bare soil exposure through retention of duff, litter and protective understory vegetation. Burn cool at least initially; retain unburned patches (mosaic burning). Carefully monitor (Persist, Change). Biochar?**

5. **Avoid ground-based disturbance except of gentlest of slopes; remove merchantable fuel through utilization of helicopters on steeper slopes. No new roads. (Persist)**

2. Water and Hydrologic Function

Climate Change Key Vulnerabilities

1. **Decreased seasonal municipal water supply from longer drier summers, decreased snowpack.**

2. **Changes in peak stream flows, with more extreme precipitation in winter and earlier spring snowmelt; importance of rain-on-snow events; downstream flooding of increased magnitude and effects on infrastructure.**

3. **Changes in aquatic, hydrologic and riparian functions**
   - **Increasing stream temperatures (potentially moderated by outflows from Reeder Reservoir) downstream effects- effects on water quality, fisheries**
   - **Reduced summer flow- shrinking of perennial and intermittent stream network and making them more available to upland disturbance processes (fire, insects, tree mortality, etc)**
   - **More extreme winter storms resulting in increased sedimentation, scouring, etc**

4. **Road impacts on hydrology from aging infrastructure (1960's engineering) perhaps not well-suited to handle upcoming peak storm events.**

5. **Direct effects on vegetation from longer, drier summer droughts**
   - **increased stress on vegetation affecting growth, vigor, insect and disease susceptibility, mortality**
   - **longer fire season, more starts, decreased foliar moisture, more severe fires**
   - **reduction in C uptake by trees – potentially large consequences for regional-scale carbon cycling**

2.Water and Hydrologic Function

Adaptation Options for Management

1. Continue management to decrease the likelihood of large scale, high severity fire **(PERSIST)**

2. Increase water availability to individual plants and on watershed scale
   - Ongoing stand management to pre-determined desired densities **(PERSIST)**
   - Reduce understory vegetation through prescribed underburning while maintaining for inherent values, including reduced surface soil erosion **(PERSIST, CHANGE)**
   - Manage downed wood, slash, non-tree vegetation, & soil organic matter **(PERSIST, CHANGE)**
   - Emphasize protection of complex below-ground soil biology, plant:soil relationships, importance for water delivery to plants **(CHANGE)**
   - Increase water holding capacity- manage organic matter amounts and inputs, biochar? **(CHANGE)**

3. Minimize likelihood of landslides
   - Maintain full site occupancy of vegetation and subsequent root holding capacity on steeper sites; avoid operating on steeper slopes whenever possible and minimize openings in these steeper locations **(PERSIST)**

4. Stand management
   - Create and maintain more openings resulting in longer snow retention **(CHANGE)**
   - Encourage older forests and/or longer rotations- more summertime flow **(PERSIST)**

5. Roads
   - Stormproof road system; improve drainage systems for likely increase in peak flows; increase culvert size **(CHANGE)**
   - Disconnect roads and ditches from hydrologic network; install more engineered rolling dips **(CHANGE)**
   - More frequent and scheduled road maintenance **(CHANGE)**
   - Prepare urban environment including existing water treatment plant **(CHANGE)**
   - City road along Ashland Creek- decrease sediment delivery into creek **(CHANGE)**

Vegetation: Functional Processes and Disturbance

Climate Change Key Vulnerabilities

Main Point- The likelihood of increasing scale and severity of disturbance, particularly fire, and subsequent loss of ecological benefits associated with more frequent low severity disturbance is the most significant climate change induced vulnerability on the City of Ashland Forestlands.

1. **Rising temperature and increased length of summer dry season will produce an Increased likelihood of large scale, high severity disturbance, from multiple interacting agents and disturbances, with increasing loss of green forests. Even with all of the work completed, we are still at an elevated potential for high severity fire. We must continue to reduce that risk, even while recognizing that the risk will continue to increase as climate get s warmer and with longer drier summer fire seasons .**

2. **Increased difficulty of restoring a more frequent, low to moderate disturbance regime upon which these ecosystems were adapted to and were dependent on for millenia. (e.g.fire)**
   a. **Less opportunity to develop multi-layered, more heterogenous stand structures and associated ongoing opportunities for natural regeneration.**
   b. **Loss of systems dominated by older conifers (especially those that are more shade intolerant) that are enhanced by frequent, low severity disturbance.**
   c. **Loss of desired traits and relationships enhanced by more frequent low severity disturbance**
      - **induced defenses to insects, fire(Hood et.al 2017)**
      - **tree stability, wind resistance (height:diameter ratios)**
      - **frequent smoke and induced deterrent to forest diseases**
      - **charcoal production as a soil amendment**
      - **likely many others.**

3. **Frequent, low severity disturbance regimes have been missing from southern Oregon forests for decades and the City forestlands has, in comparison, a relatively long (i.e. 25+ years) running example of encouraging frequent low to moderate severity disturbance as an operating silvicultural framework through implementation of planned disturbances that emulate historical processes and functions.**

Vegetation: Density/Vigor

Climate Change Key Vulnerabilities

Main Point- Tree and stand vigor declining and mortality increasing from cumulative stress is a key vulnerability moving forward. Cumulative stress is already high in many areas and this will only increase with longer, warmer, drier summers .

1. **Tree decline and mortality from cumulative stress.** A host of factors are involved, but in the dry forests on the COA ownership, loss of tree vigor has primarily been associated with increased moisture stress aggravated by a host of factors. Continued projected increases in temperature and extended dry seasons with climate changf will add to cumulative stress. Lowering existing stressors and key vulnerabilities will increase the likelihood that trees and stands will best be able to withstand future increases in climate-related stressors.

2. **Density-related decline in tree and stand vigor. W**ell established in research literature and in practice, density-related decline continues unabated without disturbance, planned or otherwise. Densities are high in places on the City ownership but have been reduced significantly with management over the past 25 years on the City ownership.

3. **Insect and disease related factors in tree and stand decline and mortality**. Often, insect-related decline and mortality is closely associated with excessive density or other cumulative stressors. Well established in research literature and in practice.

4. **Drought**. Tree decline and mortality often associated with drought as a final stressor exceeding the vegetation/tree/stand abilities to overcome moisture stress; expectations for more droughty conditions with future increasing temperature and longer dry seasons.

5. **Site and species relationships.** Loss of tree vigor and subsequent mortality also has both site and species relationships (Main 2006, Main and Schmidt 2020).

6. **Increasing Vapor Pressure Deficit (VPD) and "hot drought"** . With climate warming, temperature is increasing linearly but VPD goes up exponentially. Increasing VPD has the potential to become a much more important stressor and thereby affecting possibilities for management to reduce its potential impact.

7. **Water availability decrease**. Increased total transpiration on from high stand densities on a landscape level means less water availability as an ecosystem service.

8. **Decreased foliar moisture .** Foliar moisture is a landscape level form of resistance to high severity fire. At decreasing amounts from high vegetation density, drought, and warmer, drier, extended summer seasons, very low live vegetation moisture is a significant contributor to elevated fire behavior on a landscape level.

Vegetation: Density/Vigor

Adaptation Options for Management

1. Stand density reduction and continued adjustment towards more open forests in many situations. Apply as soon as possible in forests/stands that can reasonably be expected to respond (i.e. build vigor by distributing site resources, including water, onto fewer numbers of preferred stems). Thin ahead of expected drought or other cumulative stressors **(Persist).**

2. Carefully assess on-the-ground individual tree characteristics for vigor (crown ratio, crown density/color, radial growth, basal area in vicinity, etc.): watch for new developments in individual tree vigor assessment. Rely on regularly assessed , locally generated effectiveness monitoring, both qualitative and quantitative, to guide adaptive management as opposed to more generalized conceptual information designed for more regional applications. Continue to use density indices to identify potential problems and/or determine effectiveness of density reductions **(Persist)**

3. Understand and respond to density/vigor/insect relationships and implement accordingly (e.g. green slash management with pine bark beetles). Do very careful management to avoid encouraging insect population increases; understand each insect and its host relationships. **(Persist, Change)**

4. Pay very close attention to microsite variations in aspect, slope, topography, elevation, soil type and depth and other factors that influence site productivity and soil moisture availability (Main and Schmidt 2020). **(Persist).** Use risk rating system. Identify sites/stands with lower likelihood of favorable thinning response/higher likelihood of thinning-related stand decline (Main 2006, Main and Schmidt 2020) **(Change).** Monitor over time: apply adaptive management strategies.

5. Continue to encourage multi species, multi-cohort stands using principles of uneven-aged management and variable density thinning **(Persist, Change)**
   - Maintain multiple options by encouraging vigor in each crown class **(Change),** a classic strategy of uneven-aged management
   - Utilize shading (i.e. temperature controls) to minimize effects of Vapor Pressure Deficit **(Persist, Change).** May make it more difficult for large overstory trees that will most directly experience temperature increases and effects of VPD.

6. Implement density reduction in stages (i.e. more slowly over time and more similar to frequent, low to moderate disturbance regimes), especially around highly desired preferred trees/structures (i.e. particularly older legacy trees often under high stress currently) to allow staged adaptation to new conditions after 100+ years of high density. DO NOT initiate high severity disturbance in the immediate vicinity of treasured older trees. Slowly shift the operating environment of the tree, both above and below ground, to a more favorable condition. Utilize stand level thinning (Hood et.al. 2017) rather than radial thinning whenever possible to accomplish density reduction objectives. **(Persist)**

Vegetation: Species Composition

Climate Change Key Vulnerabilities

Main Point- Individual species are responding to increases in temperature and longer summer season (more moisture stress). Vegetation communities will continue to shift over time, although it's not clear how fast they will shift. This may result in new opportunities for invasive plants and/or new species combinations and associations (e.g. ponderosa pine and/or Douglas-fir with a mixed component of Pacific madrone, etc).

1. **Vulnerability strongly dependent on type, frequency and severity of disturbance.**
2. **General loss of conifers.**
3. **Vegetation community shifts, alterations and reorganizations and potential losses of forestlands to other alternate states and community types.**
4. **Individual species effects**

Vegetation: Species Composition

Adaptation Options for Management

Main Point- Restore more appropriate species mixes and vegetation communities that are 1) adapted to more frequent, low severity disturbance regimes 2) are relevant given expected climate change.

1. Plant communities are likely to move upward in elevation with changes in climate. Continue to plant trees that are more resistant to impacts from temperature increases and decreases in moisture availability (pines, oaks). Consider planting trees from lower elevation seed sources or plant communities up into the next elevation band. Consider planting more drought tolerant species and genotypes from nearby locations. **(Persist, Change)**

2. Encourage more opportunities for shade intolerant species, either natural or planted, through creation of openings, canopy gaps and generally more open forests. If natural regeneration of conifers is desired, there must be an established seed source in close proximity. **(Persist, Change)**

3. Protect and enhance older PP, SP, DF, oaks. **(Persist, as long as possible)**. Accelerate development of older trees of these species **(Persist)**

4. Implement species and stand management strategies based on individual species characteristics and likelihood to be able to adapt to climate changes **(Persist, Change)**

5. Monitor for and manage invasive species of all types, most notably understory vegetation and unusual organisms such as non-native insects and diseases (e.g. the cautionary tale of white pine blister rust). **(Persist, but expand monitoring and management)**

Vegetation: Stand Structures and Structural States

Climate Change Key Vulnerabilities

Main Point: Vegetation structures tend to be homogenous on both a stand and landscape level thereby increasing potential for high severity fire and decreasing the inherent variability that characterizes our region.

1.Structural homogeneity on both a stand and landscape level creates the following vulnerabilities:

- Fire- Fuel continuity and increased likelihood of large scale, high severity fire and further simplification of structural variability
- High stand densities elevate the potential for additional fire, insect and/or disease related mortality
- Species composition- Consistent stand structures and canopies reduce the potential for shade intolerant species;
- Wildlife- Important habitat values reduced
- Water- Potentially less water yield and changes in seasonality
- Biodiversity- Homogenous stand structures have reduced inherent biodiversity values

2. Unbalanced representation of structural states, with several underrepresented- 1) early successional 2) more open, mid seral 3) more open, late seral,

3. Older forests structures are threatened, primarily at Winburn.

Vegetation: Stand Structures and Structural States

Adaptation Options for Management

Main Point- Encourage more heterogenous stand structures and structural states on both a stand and landscape level while emphasizing protection and development of under-represented structural types.

1. **Match appropriate stand management to the structure type. Implement multi-cohort, multi-species stand management where appropriate utilizing variable density thinning, thinning-from-below and other ecologically appropriate stand improvement silvicultural strategies (Persist).**

2. **Strive for a diversity of structural states and stand conditions. Promote a high contrast landscape at multiple scales of reference. Convert to a more balanced representation of structural states by managing to create more mid open and late open stand structures. Create more heterogenous stand structures with more openings, early successional habitat and open forests with improved fuel discontinuity (Persist, Change).**

3. **Continue active planned disturbance to protect and promote existing older forests (Persist)**
    - **improve vigor of larger older forest structures**
    - **rake around older pines as needed**
    - **manage snags and LWD- middle elevations most vulnerable to high severity, long duration, mass fire**

4. **Accelerate development of older forests through aggressive management of mid-seral forests (Persist, Change)**

5. **Identify refugia and prioritize for retention (Persist)**

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Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

Main Point- The likelihood of increasing scale and severity of disturbance and subsequent loss of ecological benefits and ecosystem services associated with more frequent low severity disturbance is the most significant climate change induced vulnerability on the City of Ashland Forestlands

1. **Persist in trying to minimize the potential for large scale, high severity disturbance. Most severe vulnerability on City of Ashland Forestlands**
   a. **Fire- the most important large scale, high severity disturbance to avoid/minimize (Persist! Change- do more!)**
   b. **Insects- more significant agent of disturbance than usually realized (Persist)**
   c. **Pathogens- the most underrated of the common disturbance agents, with long-term effects (Persist,Change)**

2. **Encourage frequent low severity disturbance and in the process help create a diversity of desired stand structures, densities and compositions. The City of Ashland is a great example of accomplishing objectives while re-engaging in frequent, low to moderate severity "planned disturbance" (Persist, but increase the pace and scale of treatments)**

3. **Post high severity disturbance. Options for providing for Ecosystem Services are dramatically reduced…and not easily replaced in any short or medium time frame. Persist in trying to avoid, or at least minimize, the need to address this issue by taking more aggressive management actions sooner. KEEP GREEN FORESTS AND THE ECOSYSTEM SERVICES THEY PROVIDE!**

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

1. Minimize the potential for large scale, high severity disturbance: a. Fire

a. Continue stand density reduction and slash treatment, including prescribed underburning **(Persist)**

b. Avoid development of outbreak levels of mortality and subsequent fuel accumulations; build vigor in stands that can release from thinning treatments ahead of stand decline where insects can gain a foothold and elevate mortality (**Persist, Change**)

c. Continue strategic location of fuel reduction treatments followed by ongoing maintenance. Increase size and area of fuel reduction zones to allow opportunities during more severe fire behavior **(Persist, Change)**

d. Middle elevations of Ashland Watershed (Winburn) are most at risk due to increased site productivity , a similar lack of disturbance and resulting fuel tonnages and fire prone vegetation; prioritize elevate fire management activities over time at Winburn **(Persist, Change)**

e. Begin developing plans and considerations for when landscape level conditions might allow accomplishment of fire management objectives during severe wildfire events. Further develop use of Potential Operational Delineations (PODS). Conduct fire management planning at larger scales of reference than only City ownership and with other key partners (**Persist, continue to prioritize consideration of fire management at larger scales of reference).**

f. Prioritize ongoing maintenance of areas already treated. Do not lose investment in key acres and/or treat more acres than can be maintained. These treated and maintained areas, stategically located, will continue to provide the greatest benefit, especially those close to the urban environment. Regular ongoing monitoring of the need for maintenance. (**Persist**)

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

1. Prevent large scale, high severity disturbance: b. **Insects**

a. Stand density reduction; maintain high tree vigor; thin well in advance of drought (**Persist** in favorable locations)

b. Multi-aged, multi-species (but site and stand appropriate!) management; most insects are host-specific; understand species differences **(Persist)**

c. Intensive, microsite level management (Main and Schmidt 2020); variations in elevation, topography, soils, aspect, stand condition and likely other factors **(Persist)**

d. Shift (change) species at lowest productivity sites; thinning may not always produce an immediate response (Main 2006, Main and Schmidt 2020) **(Persist, Change)**

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

1. Prevent large scale, high severity disturbance: c. **Pathogens**

a. Douglas-fir dwarfmistletoe
- retention in spatially explicit locations for owl habitat and other wildlife values; reduction elsewhere.
- individual tree management (rating, isolation, etc)
- mapping and monitoring

b. Laminated root disease
- mapping and monitoring
- opening creation is good, alternative species enhancement

c. Smoke

d. Others (ongoing monitoring)

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

2. Promote frequent, low to moderate severity disturbance regime

a. Emulate the historic more frequent low to moderate disturbance regime that organisms have adjusted to over millenia in ways we are only beginning to understand. Recognize that historic frequent, low to moderate severity fire resulted in a diversity of stand structures , compositions and densities – a desired direction for planned management today and in the future. Both thinning and prescribed underburning have advantages and disadvantages; utilize either/both as appropriate. **(Persist)**

b. Avoid necessarily having to reach some idealized stand condition in a single entry but rather trend towards more open, less dense stand conditions in most situations. Ease stands out of severe stagnation that has occurred with 100+ years in the absence of disturbance; utilize staged thinning and other moderate stand modifications when necessary.

c. Utilize more frequent low to moderate disturbance as part of multi species, multi cohort management regime that retains desired structures of vegetation including maintenance of canopies and sufficient stand densities to continue to retard understory development of ladder fuels. Simultaneously, variable density thinning including retention of clumps and gaps/openings should be part of stand management prescriptions when appropriate. Prescribed burning will likely also occur in a range of low to moderate severities, but should be done to avoid high severity disturbance at any but the smallest scales; creating small openings should be desired, although less likely to be controlled by location than in stand density reduction by thinning. **(Persist,Change)**

d. Assess the ability of a stand/unit to release following treatment (Main 2006, Main and Schmidt 2020), especially in lower elevations and/or moisture limited sites and stand conditions. The decreased potential for release will move up in elevation over time with increasing cumulative stress associated with projected warming temperatures and longer droughtier summers **(Persist, Change)**

e. Regularly respond and adjust to emerging increases in other stressors (drought, insects, pathogens, etc). Thin well in advance of drought. A wide range of densities are acceptable and should be determined for each individual site/stand. **(Persist, Change)**

f. Develop desired snag and LWD amounts to be retained by site, varying with the need to 1) provide for important ecological attributes and functions; 2) adjust to meet fire management objectives . Avoid higher undesirable amounts by regular monitoring and treatment of emerging excessive fuels (snags, large woody debris, etc) that exceed desired targets. **(Persist, Change)**

g. Start newly initiated stands early with frequent, low severity disturbance (e.g. Units LW-C1,2). Allow desired seedlings to gain sufficient size to survive first prescribed underburn; in these situations, utilize manual low to moderate severity thinning treatments until prescribed underburning can be applied without excessive damage to developing seedlings. **(Persist)**

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

3. Be prepared for post high severity disturbance

a. **Do everything possible to keep green forests, but acknowledge that we no longer can insure that we can keep wildfire from impacting for communities, property and lives and forest ecosystems (Change).**

b. **Acknowledge that ecosystem services are much more limited following large scale, high severity disturbance and considerable time will be needed for ecological integrity to be restored even while accepting that some areas may return to a new permanent altered state. We cannot necessarily change these outcomes with post-fire rehabilitation practices. (Change)**

c. **Not only will climate change increase the likelihood and severity of fire in forest ecosystems but it will accentuate the cumulative degree of disturbance over time in ways that are hard to predict but likely will be even more impactful (Change).**

d. **Possibilities for natural regeneration of conifers decreases with increasing scale of high severity fire. Strong increases are expecetd in species that prefer infrequent, high severity fire, such as stump-sprouting species like Pacific madrone. (Change)**

e. **Through management actions, strive to continue to reduce percentage amount of high severity fire when (not if) fire occurs (Persist, Change).**

f. **Use the disturbance to establish desired species moving forward more well-adapted to future climate change. (Change)**

4. Wildlife, Habitat Management and Biodiversity Conservation

Climate Change Key Vulnerabilities

1. Homogeneity of habitats over time- decreased structural diversity limits wildlife habitat now, increased potential for high severity fire and continued homogenization limits wildlife habitat in the future.

2. Loss of refugia as areas to reduce thermal stress particularly for species specialized for cooler habitats.

3. Important older forest habitat values are threatened, especially at middle elevation sites (e.g. Winburn).
- **fire**
- **loss of big tree structures likely to continue to occur**

4. Lack of Mid and Late Open Structural states and associated habitats

5. Specific wildlife species
- **Northern Spotted Owl**
- **Fisher**

4. Early to mid seral shrubfields, oak woodlands and grasslands vulnerable due to proximity to Ashland
- **unique wildlife population assemblages, including pollinator habitat**
- **conflict with fire management goals**

5. Specific habitat features. Numerous other specific impacts with climate change (Mawdsley 2009)

6. Human influence on wildlife habitat values close to and within COA
- **Trails- increasing human use; fragmentation.**
- **Dogs**

7. Biodiversity and Landscape Connectivity

4. Wildlife, Habitat Management and Biodiversity Conservation

Adaptation Options for Management

1. Manage and restore ecosystem function rather than solely focusing on specific components (species or assemblages) **(Persist, Change)**
    a. Continue to reduce potentials for high severity fire; coordinate on larger landscape levels, particularly with USFS
    b Address forest health concerns
        -density/vigor continued implementation of frequent low to moderate severity disturbance regime using stand density reduction and prescribed fire;
        -more open forests but retain refugia (3,6,riparian)
        - continue to monitor and manage insect and disease disturbances, including spatially explicit management of dwarfmistletoe lam root disease in DF
        - legacy tree management through stand level thinning
        - manage LWD; reduce where possible particularly in strategically important fire management areas (1,4,5) but maintain for important habitat values

2. Continue to strive for vegetation and structural diversity at multiple scales of reference; manage for a high contrast landscape **(Persist, Change)**

3. Manage to retain important features and structural types for rare species- northern spotted owl, Pacific fisher **(Persist)**

4. Winburn- example
    - Structurally diverse older closed canopy forest may become more rare (high severity fire); really important to maintain if at all possible
    - Managing for mid and late open structural states and associated habitat values
    - Retain thermal refugia (steep northerly aspects above major streams)
    - Fire management objectives and large woody debris; determine on a site-by-site basis
    - NSO potential habitat- spatially explicit retention of Douglas-fir dwarfmistletoe
    - Functional perennial stream and associated values
    - Accelerate development of replacement older forest values

5. Retention of oak woodlands, shrubfields **(Persist, Change)**
    - may be difficult except perhaps in locations somewhat removed from urban and semi-urban environment (e.g. Siskiyou Mountain Park) due to high fire danger)
    - inventory shrub fields and locations for firesafe retention; retain small patches
    - maintain patches of more open, less fire prone white oak oak woodland, white oak savannah, pine/oak woodlands
    -plan for white oak woodland and pine/oak woodland expansion up in elevation with climate change, particularly on more southerly aspects

6. Reduce pressures on wildlife species from sources other than climate change **(Change)**
    -Expanding human use has trade-offs with effects on wildlife habitat**.** Expect continued increased demand and seasonal shifts with temperature increases. Consider the concept of carrying capacity

7. Landscape level connectivity (larger scope than City ownership) (**Persist)**
    -Maintain protected areas network , protect movement corridors, important refugia; maintain landscape permeability to species movement throughout ownership/watershed and consider effects of trails, dogs, etc initiated on City ownership

5. Riparian

1. The Ashland Forest Plan (2016) has a good description of streams and riparian habitat on the City ownership.

2. The riparian network on the City ownership is characterized by the primary mainstem fish-bearing Ashland Creek, several smaller stretches of perennial creeks and a large network of intermittent/ephemeral drainages.

3. The mainstem of Ashland Creek is highly altered from Reeder Reservoir below and through the city down through Lithia Park (1.45 miles and 34.42 acres, Ashland Forest Plan 2016, and includes the water treatment plant). Flows are adjusted through outlet from Reeder Reservoir and are primarily designed to meet municipal City water supply needs. Fish passage is blocked at the upper end of Lithia Park by the "swimming hole"- an old historic dam and reservoir. Standard riparian management strategies such as retention/promotion of large structural features (logs, rocks etc) are minimized in this stream location in deference to flood stage control (e.g. 1997). The viability of this stretch as a functional riparian habitat and aquatic ecosystem are reduced as a result. The potential for active restoration and/or improvement of riparian habitat values must be considered within the context of this highly altered aquatic/riparian environment. Very little active management within this area has occurred in the last 25 years.

4. The stream systems on the Winburn parcel, as part of West Fork Ashland Creek watershed, are much more functional riparian and aquatic ecosystems, with slightly over 1 mile and about 22 acres (Ashland Forest Plan) of riparian management area. No active management within this area has occurred within the last 25 years.

5. The steep topography and decomposed granitic base make for quick transition out of perennial stream conditions into drier uplands and more ephemeral riparian conditions, many of which have limited or no associated riparian vegetation. These areas generally interact with disturbance (e.g. fire) in a similar fashion to the adjacent uplands. Many of these ephemeral/intermittent channels are influenced by periodic debris slide processes that occur during major storm events (on adjacent US Forest Service lands they are often described and mapped as Landslide Hazard Zones (LHZ's).

5. Riparian

Climate Change Key Vulnerabilities

1. **Increased peak flows during winter**

2. **Decreased flows and longer summers of higher temperatures alter riparian vegetation and function.**

3. **Decrease in extent of riparian zone**
   - Intermittent reaches of riparian network may become more ephemeral and greater percentage of riparian network will more closely reflect adjacent upland vegetation conditions with associated increased availability for fire-related impacts

4. **Increased frequency, scale and severity of insect and fire-related disturbances**
   - Historically, fire severity tended to be reduced in riparian areas, particularly as compared to adjacent uplands, and riparian areas tended to act as firebreaks in many situations
   - With fire exclusion, riparian vegetation has become denser and, coupled with climate-change related increasing temperatures and lower summer precipitation/streamflow, possibilities for higher severity fire in riparian zones is increased

5. **Combined effect results in a potentially significant loss in ecosystem services.**

5. Riparian

Adaptation Options for Management

1. Use adaptive management and monitor thoroughly over time. The combination of projected drier extended summers and winters with larger storm events and higher peak flows presents a difficult conundrum for appropriate management responses in riparian areas. **(Change)**
2. Recognize that the riparian area below Reeder Reservoir will like continue to be an extremely altered riparian/aquatic environment with major concerns for potential flood stage impacts. Riparian management will likely have to continue to be considered within this unique context where limiting damage from floods in the highest priority. **(Persist)**
3. Thinning in riparian areas to increase tree size and function and improve tree vigor, especially in more upland areas higher in riparian network in intermittent and ephemeral portions. Promote more shade intolerant species. **(Persist, Change)**
4. Allow more frequent, low severity disturbance including from insects and disease such as occurring at Winburn with laminated root disease. Create low density stand conditions that may retard advancement of high severity fire within the riparian network while still retaining important riparian and aquatic function. **(Change)**
5. Break up fuel continuity in uplands close to major riparian areas (especially along Ashland Creek) to discourage opportunity for high severity disturbance advancing into riparian areas. Particularly target protection of important refugia to be retained at higher densities. **(Change)**
6. Develop a team of experts to specifically look at adaptation options for management in the riparian forestlands on the City of Ashland ownership. **(Change)**

6. Recreation

Climate Change Key Vulnerabilities

1. **Increased population and expansion of outdoor recreational needs will impact natural areas and resource values and likely require increasing monitoring and oversight.**

2. **Extreme wildfire, projected to increase, may reduce recreational demand because of degraded site desirability, impaired air quality from smoke, and limited site access caused by fire management activities. Expect social and economic impacts**

3. **With longer summer season, increased days where minimum temperature encourage outdoor recreation use, particularly in shoulder seasons. Greater use and subsequent impacts on recreational facilities (e.g. trails) and higher maintenance costs to maintain the same level of ecological impact.**

4. **Larger peak storm events in winter – greater impact from trails, pirate trails, erosion and sedimentation, etc**

5. **Potentially greater impacts on cooler locations in summer, especially aquatic/riparian habitats (e.g. thermal refugia) , with impacts on water, wildlife, etc.**

6. **Impacts on wildlife generally- spatially complex relationships between wildlife and their habitats**
   - **-Alteration in complex spatial arrangement of habitat needs often subtle but important; impact is aggravated as vegetation changes with climate change**
   - **-Trails**
   - **-Dogs- anti-predator response, flight initiation distance, fragmentation**
   - **-More open forests, less hiding cover**
   - **-Decrease in landscape permeability**
   - **-Pacific fisher presence in lower watershed that has becomeincreasingly used for outdoor recreation**

7. **Increased potential for introduction of unwanted invasive species**

8. **Increased likelihood of outdoor recreationalists interaction with fire in a wildfire event. Evacuation?**

6. Recreation

Adaptation Options for Management

1. Recreational use in wildlands is different than in more urban or semi-urban City parks and requires a different set of constraints and oversight. Identify current and future impacts on ecological values and forest resources on City forestlands from expected expanding human recreational use. Consider individual categories of use/impacts and tools for managing those impacts. Determine a recreational carrying capacity while looking at all impacts and values by location and vegetation/habitat type. (Change)

2. Plan for increased demand for recreational use of City lands in the future with temperature increases, especially cooler locations along riparian networks. Spatially arrange for that use, avoiding areas through recreation engineering that have other important values that may be in conflict with increasing recreational use (e.g. refugia important from a wildlife perspective, etc). In particular, consider habitat connectivity to facilitate animal movement and range shifts with climate change, especially along riparian corridors. (Change)

3. Plan for increased maintenance of trail, parking and other recreational infrastructure, both from increased shoulder-season use and greater storm-related impacts in winter. Consider a more regulated plan for trail use including evacuation of trail users in an emerging wildfire event. (Change)

4. Separate considerations for and importance of human from pet use of recreational facilities. (Change)

5. Closely monitor and remove (if possible) unwanted invasive species (Persist, Change e.g. more monitoring and removal along all trails (including “pirate” trails) or other high use areas).

7. Carbon

Carbon sequestration is the long-term process of removing carbon from the atmosphere through photosynthesis and storing it in forest biomass and soils

Carbon storage is the actual amount of carbon stored in forest and in the products produced by forests.

Carbon cycles through forest ecosystems in an ever evolving process: 1) Uptake through photosynthesis and subsequent growth; 2) Release through respiration , decomposition and forest disturbances.

Forests in the United States are currently a carbon sink, sequestering and storing more carbon than they are releasing, although there are large differences amongst regions. This is an important ecosystem service.

Carbon taken up by forests is approximately 12-19% of total carbon dioxide emissions (Ryan et.al 2010) . They are the largest terrestrial carbon sink in the nation.

Carbon is stored in different amounts in different reservoirs in the forest – above ground, below ground, understory, standing dead, downed dead, forest floor, soil organic carbon .

The actual numbers in each of these important metrics can vary considerably in the published literature (i.e. the devil is in the details, in the assumptions and in the inherent amount of uncertainty in the subject in general).

7. Carbon

Climate Change Key Vulnerabilities

1. Loss of forest in general from high severity disturbance and/or climate change over time- potential loss of both stored carbon and potential for ongoing sequestration; shift to alternate vegetation types that don't store or sequester as much carbon.

2. Loss of carbon storage in older forests and large trees as they decline

3. Declining vigor in future forest from climate change will reduce vegetation growth and carbon sequestration

4. Potential impacts to carbon stored in forest soils from high severity fire or poor land management practices

7. Carbon

Adaptation Options for Management

1. Emphasize ecosystem function and resilience, with carbon one of multiple ecosystem services and values to be integrated into forest management decisionmaking. (**Persist)**

2. Utilize full-cost carbon accounting that recognizes the value of management actions that reduce the risk of carbon loss through stand replacing fire. **(Persist)**

3. Continue to utilize fuel treatments to minimize scale and severity of disturbance; avoid high severity disturbance that impacts so many important ecosystem services and values in this situation. Utilize prescribed underburning recognizing the trade-off: while prescribed fires obviously release carbon into the atmosphere, it is at significantly lower levels than that released during higher severity wildfires (Hurteau and North 2009) . Manual thinning and slash treatment to achieve fire management objectives releases even less carbon into the atmosphere. KEEP GREEN FORESTS THAT BOTH STORE AND SEQUESTER CARBON! **(Persist)**

4. Strive to maintain large trees and older forests for as long as possible **(Persist)**

5. Manage for less intensive harvests and longer rotations, which can be common outgrowths of implementation of frequent, low severity “planned disturbances” and multi-cohort, multi-species management. (**Persist)**

6. Tree mortality management. Maintain stand densities, structures and species compositions that minimize the likelihood of outbreak levels of mortality, and adjust over time to respond to expected changes in climate variables Carefully evaluate tree mortality and strive for improved ways to measure tree vigor. Determine appropriate levels of snags, downed wood and fuels that can be maintained to provide important ecosystem services while continuing to maintain an acceptable risk from a fire management perspective. **(Persist)**

7. Use best management practices to avoid soil impacts and protect forest soil carbon. Continue to use helicopters when necessary to avoid soil impacts. If using ground-based harvest systems, best management practices are very important to minimize soils impacts **(Persist)**

Summary of Carbon Adaptation Strategies

1. **Major disruptions to intact disturbance regimes (e.g. high severity fire, clearcutting) can cause significantly alter carbon stocks, particularly if they ultimately produce type conversions accelerated by climate change.**

2. Treatments such as thinning and prescribed underburning may produce short-term carbon losses but can be quickly regained by forest recovery in healthy forests. Frequent, low to moderate severity disturbance can be employed without major carbon losses over time, with extended rotations well-recognized as a plus for carbon retention. The City of Ashland is in the somewhat unique position to already have employed frequent low severity planned disturbance for 25+ years in it's dry forests.

3. Treatments may result in short-term carbon losses but significant other co-benefits related to carbon storage and sequestration may occur in the immediate years to come:

- **increased growth and vigor of retained trees**
- **increased retention and vigor of big trees and older forests that store the most carbon**
- **reduced likelihood of high severity wildfire with high emissions, loss of ecosystem services and potential for type conversions**
- **long-term carbon storage can occur in wood products if utilized**

4. Treatments to reduce fire danger in dry forests that have evolved with frequent, low to moderate severity forests for millenia, such as on the City of Ashland forestlands, are much more important to consider when analyzing strategies for carbon retention and management.

There is likely nowhere in southern Oregon where the ecosystem values and services are higher than in the Ashland Watershed. There is also already a very high carbon density and considerable carbon storage in the Ashland Watershed that is threatened by potential high severity disturbance- a potential which will only increase with climate change. Given these realities, management designed to protect and maintain these values/services and the ecological functions that have produced these values/services over time is especially prudent, although this does not maximize carbon accounting in the short term.

Persist in appropriate management to reduce the potential for large scale, high severity fire. The expected increases in that potential with climate change suggests an even greater urgency to continue, if not accelerate, that management.

If not now, when?

If not here, where?