Appendix B – Proposed Treatment Descriptions and Silviculture Summary

Treatment Type and Prescription Descriptions

Improvement Cut, Underburn - An improvement cut is an intermediate harvest that removes the less desirable trees of any species in a stand of poles or larger trees, primarily to improve the composition and quality. These treatments would generally be 'from below' to favor retaining larger trees over smaller trees, however, thinning regimes would favor retaining smaller trees of a more desirable species over larger trees of a less desirable species, and would favor keeping smaller, healthier trees over larger, damaged or diseased trees. The species preference for retention would be aspen, western larch, ponderosa pine, Douglas-fir, lodgepole pine, Engelmann spruce, and subalpine fir in descending order. Trees would be thinned to an average spacing of 20 to 40 feet (109 to 27 TPA), but spacing could vary widely. Thinning would be by hand and/or machine. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns (e.g., snag and downed large woody debris requirements) would be removed for utilization. Following thinning, the units would be underburned, which are "Prescribed burns of low intensity covering a majority of the burn unit consuming surface fuels, but not the overstory canopy."

Improvement Cut, Jackpot burn – The improvement cut would be as described previously. The thinning would be followed by a jackpot burn, which is "prescribed burning of fuels in scattered concentrations" and in addition does not cover a majority of the unit.

Precommercial Thin, Handpiling, Burn Piles – These treatments involve cutting small trees of little to no merchantable value to decrease stocking and reduce fuels. Trees would be thinned by hand or by machine. Post-thinning average tree spacing would range from 12 to 20 feet (109 to 303 TPA). Thinning debris in several units would be piled by hand and the handpiles would be burned to reduce fuels. See the fuels report for handpile and burning specifications.

Precommercial Thin – These treatments involve cutting small trees of little to no merchantable value to decrease stocking and reduce fuels. Trees would be thinned by hand or by machine. Post-thinning average tree spacing would range from 12 to 20 feet (109 to 303 TPA).

Shelterwood (Group) with Reserves, Site Prep Burn – These treatments involve removing all trees except for those needed for shelter and seed production. Leave trees would be grouped, and would be aspen, ponderosa pine, Douglas-fir, Engelmann spruce, or subalpine fir, in descending order of preference. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns may be removed for utilization. Following cutting and removal, the units would be burned to prepare sites for natural regeneration. Expected natural regeneration species are Douglas-fir and lodgepole pine. Areas may be planted with ponderosa pine and western larch to achieve the desired species composition. The leave trees would be retained following regeneration.

Low Severity Fire, Openings less than 5 acres – These treatments would involve cutting of small trees (slashing) to create fuel beds in areas less than 5 acres in size, and underburning to reduce fuels, cause additional mortality of undesirable trees, and prepare sites for natural regeneration. Desired natural regeneration species are Douglas-fir, ponderosa pine, and lodgepole pine depending upon the unit.

Low Severity Fire, Openings less than 10 acres – These treatments would involve cutting of small trees (slashing) to create fuel beds in areas less than 10 acres in size, and underburning to reduce fuels, cause additional mortality of undesirable trees, and prepare sites for natural regeneration. Desired natural regeneration species are Douglas-fir, whitebark pine, and lodgepole pine.

Seedtree with Reserves, Slashing, Handpiling, Burn Piles – These treatments involve removing all trees except for those needed for seed production. Seed trees are expected to be Douglas-fir. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be

removed for utilization. Undesirable, damaged, or diseased small trees would be cut (slashed), handpiled and burned. Leave trees would be retained following regeneration. Regeneration is expected to be Douglas-fir and lodgepole pine.

Shelterwood (Group) with Reserves, Jackpot Burn – The shelterwood treatment would be as described previously. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Following cutting and removal, concentrations of fuels involving less than a majority of the unit area would be burned. Expected regeneration would be some combination of Douglas-fir, lodgepole pine, Engelmann spruce, and aspen. Some combination of ponderosa pine, western larch, and Douglas-fir may be planted.

Seedtree with Reserves, Jackpot Burn - These treatments involve removing all trees except for those needed for seed production. Seed trees are expected to be mainly Douglas-fir with ponderosa pine, Engelmann spruce, and aspen depending on unit. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Following cutting and removal, units would be jackpot burned. In some units, ponderosa pine and Douglas-fir may be planted.

Seedtree with Reserves, Broadcast Burn - These treatments involve removing all trees except for those needed for seed production. Seed trees are expected to be Douglas-fir. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Following cutting and removal, units would be broadcast burned. Ponderosa pine and Douglas-fir may be planted.

Shelterwood with Reserves, Site Prep Burn - These treatments involve removing all trees except for those needed for shelter or seed production. Leave trees would be relatively uniformly spaced and would be Douglas-fir, western larch, ponderosa pine, and aspen at about 30-40 BA. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Following removal, the area would be prescribe burned for site preparation. Expected regeneration would be Douglas-fir and lodgepole pine.

Shelterwood (Group) with Reserves, Slashing, Handpile/Burn – The shelterwood treatment would be as described previously for group shelterwoods with reserves. Leave trees are expected to be Douglas-fir. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Following cutting and removal, undesirable small trees would be cut, handpiled and burned. Expected regeneration would be Douglas-fir and lodgepole pine.

Shelterwood (Group) with Reserves - The shelterwood treatment would be as described previously for group shelterwoods with reserves. Expected natural regeneration would be Douglas-fir and lodgepole pine. Ponderosa pine may be planted. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. These units do include some area of ponderosa pine plantation that would be thinned.

Clearcut with Reserves, Jackpot Burn – These treatments involve removing all trees except for scattered Douglas-fir and ponderosa pine. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Natural regeneration of Douglas-fir and lodgepole pine is expected. Ponderosa pine may be planted. Following cutting and removal, units would be jackpot burned.

Clearcut with Reserves, Site Preparation Burn – These treatments involve removing all trees except for scattered clumps of Douglas-fir, ponderosa pine and western larch. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Natural regeneration of Douglas-fir and lodgepole pine is expected. Ponderosa pine, Douglas-

fir, and western larch may be planted. Following cutting and removal, units would be prescribed burned to prepare sites for regeneration.

Clearcut with Reserves, Broadcast Burn - These treatments involve removing all trees except scattered clumps or individual Douglas-fir for structure. All dead and live cut trees considered merchantable, except as needed to meet other resource concerns, may be removed for utilization. Following cutting, the area would be broadcast burned for fuels reduction and site preparation. Natural regeneration of lodgepole pine is expected. Douglas-fir and western larch may be planted.

Sanitation, Slashing, Handpiling, Burn Piles – These treatments involve removing trees to improve stand health by stopping or reducing the actual or anticipated spread of insects and disease. In these units, all dead and dying trees considered merchantable would be cut and removed except as needed to meet other resource concerns. No additional live trees would be cut. Small, undesirable, damaged, or diseased trees would be cut, handpiled and burned. Following treatment, trees would average 10- to 15-foot spacing (194 to 436 TPA).

Mixed Severity Fire, Openings – These treatments would be burned with a mixed-severity fire, creating various sizes of openings depending upon forest type and site factors. Patches of trees may be cut in the units to facilitate burning as well as to enhance regeneration of whitebark pine and other species.

Proposed Treatments by Group and Unit

Table B- 1. Alternative 2 proposed treatments by group and unit

Group	Unit	Treatment Type	Prescription	Acres
1	6	Intermediate Harvest	Improvement Cut, Underburn	14
1	7	Intermediate Harvest	Improvement Cut, Underburn	17
1	8	Intermediate Harvest	Improvement Cut, Underburn	62
1	15	Intermediate Harvest	Improvement Cut, Underburn	15
1	23	Intermediate Harvest	Improvement Cut, Underburn	29
1	24	Intermediate Harvest	Improvement Cut, Underburn	5
1	26	Intermediate Harvest	Improvement Cut, Underburn	65
1	28	Intermediate Harvest	Improvement Cut, Underburn	22
1	30	Intermediate Harvest	Improvement Cut, Underburn	14
1	31	Intermediate Harvest	Improvement Cut, Underburn	16
1	32	Intermediate Harvest	Improvement Cut, Underburn	45
1	33	Intermediate Harvest	Improvement Cut, Jackpot Burn	17
1	44	Intermediate Harvest	Improvement Cut, Underburn	97
1	45	Intermediate Harvest	Improvement Cut, Underburn	38
1	46	Intermediate Harvest	Improvement Cut, Jackpot Burn	251
1	47	Intermediate Harvest	Improvement Cut, Jackpot Burn	220
1	54	Intermediate Harvest	Improvement Cut, Jackpot Burn	20
1	55	Intermediate Harvest	Improvement Cut, Underburn	29
2	3	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	37
2	14	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	11
2	16	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	3
2	18	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	21
2	21	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	6

Group	Unit	Treatment Type	Prescription	Acres
2	48	Intermediate Harvest	Precommercial Thin	141
2	49	Intermediate Harvest	Precommercial Thin	49
2	50	Intermediate Harvest	Precommercial Thin	49
2	51	Intermediate Harvest	Precommercial Thin	193
2	59	Intermediate Harvest	Precommercial Thin	16
2	60	Intermediate Harvest	Precommercial Thin	25
2	61	Intermediate Harvest	Precommercial Thin	34
2	62	Intermediate Harvest	Precommercial Thin	37
2	63	Intermediate Harvest	Precommercial Thin	17
2	64	Intermediate Harvest	Precommercial Thin	30
2	65	Intermediate Harvest	Precommercial Thin	25
2	66	Intermediate Harvest	Precommercial Thin	26
2	67	Intermediate Harvest	Precommercial Thin	20
2	68	Intermediate Harvest	Precommercial Thin	15
2	69	Intermediate Harvest	Precommercial Thin	31
2	70	Intermediate Harvest	Precommercial Thin	39
2	71	Intermediate Harvest	Precommercial Thin	40
2	72	Intermediate Harvest	Precommercial Thin	85
2	73	Intermediate Harvest	Precommercial Thin	33
2	75	Intermediate Harvest	Precommercial Thin	148
3	1	Regeneration Harvest	Shelterwood (Group) with Reserves, Site Prep Burn	96
3	2	Prescribed Fire	Low Severity Fire, Openings <5 Acres	146
3	9	Regeneration Harvest	Seedtree with Reserves, Slashing, Handpiling, Burn Piles	18
3	11	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	23
3	12	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	80
3	13	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	41
3	20	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	32
3	22	Regeneration Harvest	Shelterwood with Reserves, Site Prep Burn	30
3	25	Regeneration Harvest	Seedtree with Reserves, Broadcast Burn	29
3	29	Regeneration Harvest	Shelterwood (Group) with Reserves, Slashing, Handpile/Burn	25
3	34	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	12
3	39	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	42
3	40	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	11
3	41	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	12
3	42	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	65
3	43	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	104
3	53	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	17
3	57	Regeneration Harvest	Shelterwood (Group) with Reserves	93
3	58	Regeneration Harvest	Shelterwood (Group) with Reserves	15
4	10	Regeneration Harvest	Clearcut with Reserves, Jackpot Burn	18
4	17	Regeneration Harvest	Clearcut with Reserves, Jackpot Burn	38

Group	Unit	Treatment Type	Prescription	Acres
4	19	Regeneration Harvest	Clearcut with Reserves, Jackpot Burn	15
4	27	Regeneration Harvest	Clearcut with Reserves, Site Prep Burn	31
4	35	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	24
4	36	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	20
4	37	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	8
4	38	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	7
4	52	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	22
4	56	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	17
4	74	Regeneration Harvest	Clearcut with Reserves, Site Prep Burn	23
5	4	Intermediate Harvest	Sanitation, Slashing, Handpiling, Burn Piles	7
5	5	Intermediate Harvest	Sanitation, Slashing, Handpiling, Burn Piles	18
6	76	Prescribed Fire	Low Severity Fire, Openings <10 acres	123
6	78	Prescribed Fire	Low Severity Fire, Openings <5 acres	38
6	85	Prescribed Fire	Low Severity Fire, Openings <5 acres	143
7	80	Prescribed Fire	Mixed Severity Fire, Openings <20 acres	326
7	86	Prescribed Fire	Mixed Severity Fire, Openings <10 acres	47
7	87	Prescribed Fire	Mixed Severity Fire, Openings <5 acres	36
8	77	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	736
8	79	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	337
8	81	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	629
8	82	Prescribed Fire	Mixed Severity Fire, Openings <75 acres	776
8	83	Prescribed Fire	Mixed Severity Fire, Openings <75 acres	457
8	84	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	831
8	88	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	892

Table B- 2. Alternative 3 proposed treatments by group and unit

Group	Unit	Treatment Type	Prescription	Acres
1	15	Intermediate Harvest	Improvement Cut, Underburn	15
1	23	Intermediate Harvest	Improvement Cut, Underburn	29
1	24	Intermediate Harvest	Improvement Cut, Underburn	5
1	28	Intermediate Harvest	Improvement Cut, Underburn	22
1	46b	Intermediate Harvest	Improvement Cut, Jackpot Burn, Handpiling, Burn Piles	27
1	47b	Intermediate Harvest	Improvement Cut, Jackpot Burn, Handpiling, Burn Piles	9
1	47c	Intermediate Harvest	Improvement Cut, Jackpot Burn, Handpiling, Burn Piles	31
1	6	Intermediate Harvest	Improvement Cut, Underburn	14
1	7	Intermediate Harvest	Improvement Cut, Underburn	17
1	8	Intermediate Harvest	Improvement Cut, Underburn	62
2	14	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	11
2	16	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	3
2	3	Intermediate Harvest	Precommercial Thin, Handpiling, Burn Piles	37

Group	Unit	Treatment Type	Prescription	Acres
2	48	Intermediate Harvest	Precommercial Thin, Underburn	141
2	50	Intermediate Harvest	Precommercial Thin	49
2	51	Intermediate Harvest	Precommercial Thin, Underburn or Slash Treatment along PVT	193
2	59	Intermediate Harvest	Precommercial Thin	16
2	61a	Intermediate Harvest	Precommercial Thin, Handpile Underburn	9
2	62	Intermediate Harvest	Precommercial Thin	37
2	63	Intermediate Harvest	Precommercial Thin	17
2	66	Intermediate Harvest	Precommercial Thin	26
2	67	Intermediate Harvest	Precommercial Thin	20
2	68	Intermediate Harvest	Precommercial Thin	15
2	69	Intermediate Harvest	Precommercial Thin	31
2	70	Intermediate Harvest	Precommercial Thin	39
2	71	Intermediate Harvest	Precommercial Thin	40
2	72	Intermediate Harvest	Precommercial Thin	85
2	73	Intermediate Harvest	Precommercial Thin	33
2	75b	Intermediate Harvest	Precommercial Thin, Jackpot Burn, Handpiling, Burn Piles	20
3	1	Regeneration Harvest	Shelterwood (Group) with Reserves, Site Prep Burn	96
3	11	Regeneration Harvest	Shelterwood (Group) with Reserves, Underburn	23
3	12	Regeneration Harvest	Shelterwood (Group) with Reserves, Underburn	80
3	13	Regeneration Harvest	Seedtree with Reserves, Jackpot Burn	41
3	22a	Regeneration Harvest	Shelterwood with Reserves, Site Prep Burn	22
3	25	Regeneration Harvest	Seedtree with Reserves, Broadcast Burn	29
3	34	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	12
3	39	Regeneration Harvest	Seedtree with Reserves, Underburn	26
3	40	Regeneration Harvest	Seedtree with Reserves, Underburn	11
3	41	Regeneration Harvest	Shelterwood (Group) with Reserves, Underburn	12
3	42	Regeneration Harvest	Seedtree with Reserves, Underburn	65
3	43	Regeneration Harvest	Seedtree with Reserves, Underburn	104
3	53	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	17
3	57	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	93
3	58	Regeneration Harvest	Shelterwood (Group) with Reserves, Jackpot Burn	15
3	9	Regeneration Harvest	Seedtree with Reserves, Slashing, Handpiling, Burn Piles	18
4	10	Regeneration Harvest	Clearcut with Reserves, Underburn	18
4	27	Regeneration Harvest	Clearcut with Reserves, Site Prep Burn	31
4	35	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	24
4	36	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	20
4	37	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	8
4	38	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	7
4	52	Regeneration Harvest	Clearcut with Reserves, Broadcast Burn	22

Group	Unit	Treatment Type	Prescription	Acres
4	74	Regeneration Harvest	Clearcut with Reserves, Site Prep Burn	23
5	4	Intermediate Harvest	Sanitation, Slashing, Handpiling, Burn Piles	7
5	5	Intermediate Harvest	Sanitation, Slashing, Handpiling, Burn Piles	18
6	2	Prescribed Fire	Low Severity Fire, Openings <5 acres	146
6	78	Prescribed Fire	Low Severity Fire, Openings <5 acres	38
6	85	Prescribed Fire	Low Severity Fire, Openings <5 acres	143
7	87	Prescribed Fire	Mixed Severity Fire, Openings <5 acres	36
8	79	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	337
8	82	Prescribed Fire	Mixed Severity Fire, Openings <75 acres	776
8	83	Prescribed Fire	Mixed Severity Fire, Openings <75 acres	457
8	84	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	831
8	88	Prescribed Fire	Mixed Severity Fire, Openings <30 acres	865
9	17a	Prescribed Fire	Underburn	38
9	19a	Prescribed Fire	Underburn	15
9	20a	Prescribed Fire	Underburn	24
9	29a	Prescribed Fire	Underburn	25
9	30a	Prescribed Fire	Underburn	14
9	31a	Prescribed Fire	Underburn	16
9	32a	Prescribed Fire	Underburn	45
9	44a	Prescribed Fire	Underburn	97
9	45a	Prescribed Fire	Underburn	38
9	80a	Prescribed Fire	Jackpot Burn	326
10	46a	Intermediate Harvest	Improvement Cut, Jackpot Burn, Handpiling, Burn Piles	223
10	47a	Intermediate Harvest	Improvement Cut, Jackpot Burn, Handpiling, Burn Piles	180

Table B- 3. Treatment unit management area acreages

Unit	MA	Acres	Unit	MA	Acres	Unit	MA	Acres
1	T4	96	37	T3	8	63	T3	17
2	T4	146	38	T3	7	64	T3	30
3	T4	37	39	T3	42	65	T3	25
4	T4	7	40	T3	11	66	T3	26
5	T4	18	41	T3	11	67	T3	20
6	T4	14	42	T2	39	68	T3	15
7	T4	17	42	T3	26	69	T3	31
8	T4	62	43	T2	104	70	T3	39
9	T4	18	44	T1	93	71	T3	40
10	T1	1	44	T3	4	72	T2	85
10	T3	5	45	T1	26	73	T4	33
10	T4	12	45	T3	12	74	T3	23

Unit	MA	Acres	Unit	MA	Acres	Unit	MA	Acres
11	T1	22	46	T2	248	75	T2	148
12	T1	80	46	T3	3	76	T3	99
13	T1	7	47	M1	2	76	W1	24
13	T3	34	47	T2	218	77	T1	90
14	T1	10	48	M1	56	77	T3	619
15	T1	15	48	T2	85	78	T1	38
16	T1	3	49	M1	13	79	M1	267
17	T1	38	49	T2	37	79	T1	59
18	T1	21	50	M1	48	79	T3	7
19	T1	15	51	M1	19	79	W1	3
20	T1	32	51	T1	173	80	M1	318
21	T1	6	52	T3	22	80	W1	8
22	T3	30	53	T3	17	81	M1	583
23	T3	29	54	T3	20	81	T1	6
24	T3	5	55	T3	29	81	W1	40
25	T3	29	56	T3	17	82	M1	13
26	T3	65	57	T1	92	82	W1	763
27	T3	31	58	M1	6	83	M1	201
28	T3	17	58	T1	9	83	W1	256
28	T4	5	59	T3	16	84	M1	795
29	T4	25	60	T1	1	84	T1	28
30	T4	14	60	T3	22	84	T2	7
31	T4	16	60	T4	2	85	M1	143
32	T4	45	61	T3	21	86	M1	47
33	T3	17	61	T4	12	87	M1	25
34	T3	12	62	T3	21	87	T1	12
35	T3	24	62	T4	16	88	M1	740
36	T3	20				88	W1	124

Fuels Treatments

The MRFC discusses Forest Types and Fire Regimes and is quoted below:

The following briefly describes major forest ecotypes in Montana and ascribes to each an approximate historical fire regime and a very general picture of historical stand structure. Because there is overlap between each ecotype and no black and white distinctions in historical fire regimes or stand structures, these elements should be considered in the planning and design of restoration projects.

Restoration by Forest Type

Low-to-mid elevation ponderosa pine, Douglas-fir, and western larch forests typify the low- and mixed-severity fire regime with average fire return intervals of 5 to 30 years.

- Pure ponderosa pine experienced frequent, low-severity fires and primarily exhibited an open stand structure across the landscape.
- Mixed ponderosa pine/Douglas-fir/western Larch (in all combinations) forests exhibited less frequent fire, more variable stand structures across the landscape, and variable fire intensity and severity.
- Historically, these low elevation forests were subject to the greatest amount of timber management and fire suppression activities and thus are likely the furthest from their natural range of variability.
- These forest types are the most likely and appropriate candidates for restoration activities to re-establish natural fire return intervals, but especially in the case of mid-elevation mixed-fire severity forests, restoration activities should be taken on a case-by-case basis.

Mid-elevation lodgepole pine, Douglas-fir, and subalpine fir forests exhibit dense stand structures and historically experienced mixed and stand replacing fire regimes.

- Mixed fire regimes may be more widespread than stand replacement regimes in the Inland Northwest and have fire intervals averaging between 30 and 100 years. Stand replacement regimes have average natural return intervals of about 100 – 200 years.
- Mixed severity forest types were likely historically dominant and may not require any specific management activity to allow them to maintain function within their historic range of variability, but again they would have to be considered on a case by case basis.

High-elevation subalpine fir, lodgepole pine and Engelmann spruce forests historically experienced fire on a 200- to 300- year fire return interval where subalpine forests of whitebark pine historically experienced fire on a mean fire return interval of 50 – 300 years. These forest ecotypes are likely the closest to their natural range of variability and likely require minimal restoration efforts.

The treatment groups include both timber management and fuels management treatments. Treatment descriptions for the fuels management treatments are as follows:

Low-Severity Fire- is applied to meet fuel reduction objectives and reintroduce fire to the landscape. Low severity fire would topkill some of the understory vegetation, effects to soils would be minimal. Some over story canopy openings of less than 5 acres may be created with this treatment. Small diameter trees may be cut in areas to create a continuous fuel bed to carry the fire (included in treatment groups 6 and 9).

Mixed Severity Fire- is applied to meet fuel reduction objectives and reintroduce fire to the landscape. Mixed severity fire would exhibit a wide range of effects on the vegetation. Some areas would result in low severity fire effects; other areas would exhibit moderate fire severity with some over story mortality but not complete replacement; and yet other areas would result in higher severity fire resulting in

complete over story mortality. Overstory canopy openings of various sizes would be created with this treatment. Small diameter trees may be cut in areas to create a continuous fuel bed to carry the fire (included in treatment group 8).

Hand pile/pile burning—fuels would be piled by hand and piles would be burned when burning conditions are favorable (included in treatment groups 2, 3, 5, 9, and 10).

Jackpot Burning—burning of concentrations of fuels within the unit. These concentrations occur from harvest operations, insect and disease activity or natural forest succession. This does not include burning of hand and machine piles included in treatment groups 1, 3, 4, 9, and 10).

Machine pile/pile burning—natural and residual activity generated fuels are piled using equipment to reduce fuel accumulations and prepare sites for planting (where necessary). Piles are generally burned during the fall/winter when burning conditions are favorable and risk of escape is low. Sufficient down woody material is retained onsite to meet objectives for soil nutrient and habitat needs included in treatment groups 2, 3, and 5).

Prescribed Under Burning- consists of controlled burning with flame lengths generally 3 feet or less and would be utilized as a stand-alone treatment or following thinning. Underburning would be used to reduce natural and activity fuels and shrubs and prepare sites for planting. Cutting and piling of ladder fuels may occur to reduce potential fire behavior and scorch to residual trees (included in treatment groups 1, 3, 4, and 9).

Site Prep Burn – Following harvest activity designated units would be under burned prior to tree planting (included in treatment groups 3 and 4).

Slashing—Cutting of small diameter conifers (less than 6 inches d.b.h.) using chainsaws. The treatment is conducted prior to burning to ensure there are sufficient surface fuels to carry the fire (included in treatment groups 3, 6, 7, and 8).

Silviculture Summary

Compliance with Forest Plan and Other Relevant Laws, Regulations, Policies and Plans

Alternative 1

Compliance of alternative 1 (no action) with Forest Plan forestwide standards pertinent to this discussion is displayed in Table B- 4. Note that forestwide standard statements refer to appendices in the Forest Plan and not of this document.

Table B- 4. Alternative 1 compliance with Forest Plan forestwide standards

FORESTWIDE STANDARDS		COMPLIANCE
Timber	1. Silvicultural examinations and prescriptions will be required before any timber manipulation or silvicultural treatment takes place. Exceptions include cutting of trees that block vision along roads, cutting hazard trees, clearing right-of-way, clearing for mineral development, minor and incidental amounts of free use, and cutting personal firewood. Final determination of what silvicultural system will be used for a particular project will be made by	No timber manipulation or silvicultural treatment other than ongoing activities would take place under this alternative.

FORESTWIDE STANDARDS		COMPLIANCE
	a certified silviculturist after an on-the-ground site analysis. This site-specific analysis will determine the appropriate even or uneven age silvicultural system that best meets the goals and objectives of the management area. Standards for applying all silvicultural systems, as well as supporting research references are in the Northern Region guide (June 10, 1983). In addition, broad guidelines are found in Appendix H and M. Even aged management methods will be used only where it is determined to be appropriate to meet objectives. Clearcutting will be used only where it is the optimum method.	
	2. Tree improvement will be conducted in accordance with the current Regional and Forest level tree improvement plans.	No tree improvement activities would be conducted under this alternative.
	4. Timber stand openings created by even-aged silvicultural systems will normally be 40 acres or less. Creation of larger openings will require a 60-day public review and Regional Forester approval. Exceptions are listed in the Northern Regional Guide.	No timber stand openings would be created by even-aged silvicultural systems under this alternative.
Protection Insect and Disease	1. Silvicultural systems will be the primary tool for preventative pest management. Use silvicultural systems to: (1) improve species diversity, growth, and vigor for stands and (2) increase the size diversity and class diversity between stands.	No silvicultural systems would be proposed under this alternative.
	2. During ongoing infestations, control insects and disease through silvicultural and biological practices. Chemical controls will be limited to high value areas or used on a broader scale only when all other measures have failed and other resource values can be protected. Emphasize cooperative control measures between Federal, State, and private landowners.	No activities would be proposed under this alternative.
	3. Biological practices will be considered in controlling insect and disease infestations.	No activities would be proposed under this alternative.
	4. If possible, harvest stands which are a high risk for mountain pine beetle attack before harvesting moderate or low risk stands.	No activities would be proposed under this alternative.
Wildfire	2. Locate timber sales, or cutting units within a sale, to break-up contiguous natural fuel.	No timber sales would be proposed under this alternative.
Wildlife/Snags	Larch, ponderosa pine, Douglas-fir, spruce, and subalpine fir, in that priority, are the preferred species for snags and replacement trees (live trees left to replace existing snags).	Tree mortality and potential snag tree species would continue as is under this alternative.

Compliance of alternative 1 (no action) with Forest Plan management area standards pertinent to this discussion are displayed in Table B- 5.

Table B- 5. Alternative 1 compliance with management area standards

MANAGEMENT AREA STANDARDS		COMPLIANCE
M-1	**Timber** - Timber harvest, such as salvage and firewood removal, may occur where access exists. Slash created by any management practice will be disposed of in a manner consistent with the management area goals. Forested lands are classified as unsuitable for timber management.	No timber harvest is proposed.
	Protection - Salvage of dead, dying, or high-hazard trees is permitted to prevent disease and insect population build-up. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Prescribed fire with unplanned ignitions may be used in this management area, for the enhancement and maintenance of resources, when within pre-established prescribed fire criteria. These criteria are stated in the Fire Management Direction in Appendix R. -Evaluate areas periodically for significant insect and disease problems. Endemic levels will be accepted as normal. If epidemic levels develop and control is necessary, the control method should minimize impacts on watershed and other resource values.	No actions are taken to prevent disease and insect population build-up. No prescribed fire is proposed for the enhancement and maintenance of resources. No areas are evaluated for insect and disease problems.
T-1	**Timber** - This management area is suitable for timber management activities. - Timber harvest practices include clearcut, group selection, and shelterwood harvest, depending on habitat group, physical site conditions, and silvicultural objectives. Precommercial thinning and intermediate harvest may occur where needed as determined by silvicultural objectives and project planning. (Appendices H and M of the Forest Plan provide broad guidelines for various habitat groups.) - As a minimum, a cutover area will not be considered an opening when: (1) a new forest stand is established and certified as stocked, and (2) vegetative conditions reach the point where harvest of additional timber can occur and the combined area can still meet watershed management objectives. - Prescribed burning or other techniques may be used for slash disposal, site preparation, silvicultural, and livestock objectives. In habitat groups where fire is not a useful treatment tool, lopping and scattering, yarding unmerchantable material (YUM), or other methods will be used to reduce fuel accumulations and prepare sites for regeneration. - Project level planning will provide for stand regeneration within five years of final harvest. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H.	No timber harvest activities are proposed.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling.	No forest protection measures are proposed.

MANAGEMENT AREA STANDARDS		COMPLIANCE
T-2	**Timber** - This management area is suitable for timber management activities. - Timber harvest methods and volumes will be adjusted as necessary to meet big game winter range needs. Even- or uneven-aged silvicultural systems may be used. (Appendix M provides guidance for vegetative management practices by habitat groups.) - Openings created by timber harvest should meet hiding cover requirements of big game before adjacent areas can be harvested. - Schedule sale activities outside winter periods (December 1 to May 15). - No more than 25 percent of the timber-perimeter around natural or artificial parks should be nonthermal cover at one time. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H.	No timber harvest activities are proposed.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	No forest protection measures are proposed.
T-3	**Timber** - This management area is suitable for timber management activities. - Timber harvest methods and volumes may be modified as necessary to achieve the management area goals. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include salvage or sanitation harvest and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H. Appendix M provides guidance for various vegetative management practices by habitat group. - Stocking control may be maintained through precommercial and commercial thinnings. The timing and planning of thinning operations will be coordinated with a wildlife biologist. - Vegetative diversity will be encouraged. - Openings created by timber harvest will be reforested to the extent necessary to meet the hiding cover requirements of big game before harvesting adjacent areas.	No timber harvest activities are proposed.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	No forest protection measures are proposed.
T-4	**Timber** - This management area is suitable for timber management activities. - Even-aged stands may be scheduled for final regeneration harvest when	No timber harvest activities are proposed.

MANAGEMENT AREA STANDARDS		COMPLIANCE
	they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H. - Timber harvest practices include clearcutting, group selection, and shelterwood harvest, depending on habitat group, physical site conditions, and visual quality objectives. Precommercial thinnings and intermediate harvest will occur where needed as determined by silvicultural objectives, project planning, and visual quality objective. (Appendices H and M provide broad guidelines for various habitat groups.) - Openings created by timber harvest will be reforested to the point where harvest of adjacent timber can occur and the combined area can still meet the VQOs of the area. - Use timber harvest to rehabilitate existing harvest units, to improve the VQO. - Prescribed burning will be used to accomplish slash disposal, site preparation, and silvicultural objectives. In habitat groups where fire is not a useful treatment tool, loping and scattering, YUM yarding, or other methods will be used to reduce fuel accumulations and prepare sites for regeneration provided the area goals are met.	
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions will be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	No forest protection measures are proposed.
W-1	**Timber** - Timber will be harvested only if it can be used as a tool to maintain or enhance wildlife habitat values. Productive forest land is classified as unsuitable for timber management	No timber harvest activities are proposed.
	Protection - Areas will be evaluated periodically for significant insect and disease problems. Endemic levels will be accepted as normal. If epidemic levels develop and control is necessary, the control method should minimize impacts on big game and other wildlife values. - Prescribed fire with planned ignitions will be used in this management area, for the enhancement and maintenance of resources. - Prescribed fire with unplanned ignitions may be used in this management area, for the enhancement and maintenance of resources, when within pre-established prescribed fire criteria. These criteria are detailed in the Fire Management Direction in Forest Plan Appendix R. - Prescribed fire may be used as a tool to reduce natural fuels and improve quantity and quality of wildlife forage.	No forest protection measures are proposed.

Table B- 6 below displays this alternatives compliance with Forest Service management direction for regeneration harvest.

Table B- 6. Alternative 1 compliance with other Forest Service management direction

Management Direction	Compliance
Suitability for timber production. No timber harvest, other than salvage sales or sales to protect other multiple-use values, shall occur on lands not suited for timber production (16	No timber harvests are proposed.

Management Direction	Compliance
USC 1604 (k)).	
Prior to regeneration harvest, stands of trees must have generally reached CMAI of growth (FSH 1909.12, ch. 60; 16 U.S.C. 1604 (m)(1); FSM 1921.12f).	No regeneration harvest is proposed.
The size of harvest openings created by even-aged silviculture in the Northern Region will be normally 40 acres or less with some exceptions. Creation of large openings will require 60-day public review and Regional Forester approval, with several exceptions including: "Where natural catastrophic events such as fire, windstorms, or insect and disease attacks have occurred" (FSM 1900-2006-2; FSM R1 Supplement 2400-2001-2).	No regeneration harvest is proposed.
Clearcutting and Even-aged Management 916 USC 1604(g)(3)(F)): Insure that clearcutting ... and other cuts designed to regenerate an even-aged stand of timber will be used as a cutting method on National Forest System lands only where for clearcutting, it is determined to be the optimum method ... to meet the objectives and requirements of the relevant land management plan." "Clearcutting will be used only where it is the optimum method" (Helena Forest Plan, USDA Forest Service 1986).	No regeneration harvest is proposed.

Alternative 2

Compliance of alternative 2 with Forest Plan Forest-wide standards pertinent to this discussion are displayed in Table B- 7. Note that the forestwide standard statements refer to appendices in the Forest Plan and not in this document.

Table B- 7. Alternative 2 compliance with Forest Plan forestwide standards

Forestwide Standards		Compliance
Timber	1. Silvicultural examinations and prescriptions will be required before any timber manipulation or silvicultural treatment takes place. Exceptions include cutting of trees that block vision along roads, cutting hazard trees, clearing right-of-way, clearing for mineral development, minor and incidental amounts of free use, and cutting personal firewood. Final determination of what silvicultural system will be used for a particular project will be made by a certified silviculturist after an on-the-ground site analysis. This site-specific analysis will determine the appropriate even or uneven-age silvicultural system that best meets the goals and objectives of the management area. Standards for applying all silvicultural systems, as well as supporting research references are in the Northern Region guide (June 10, 1983). In addition, broad guidelines are found in Appendix H and M. Even-aged management methods will be used only where it is determined to be appropriate to meet objectives. Clearcutting will be used only where it is the optimum method.	Silvicultural exams and prescriptions would have been done and approved by a certified silviculturist. Site-specific analysis has been done to determine the optimum method of treatment. Clearcutting is being used where it is the optimum method. See project records.
	2. Tree improvement will be conducted in accordance with the current Regional and Forest level tree improvement plans.	Tree improvement would be conducted following the applicable Regional and Forest direction.
	4. Timber stand openings created by even-aged silvicultural systems will normally be 40 acres or less. Creation of larger openings will require a 60-day public review and Regional Forester approval. Exceptions are listed in the Northern Regional Guide.	Proposed regeneration harvest units exceed 40 acres in seven units (appendix L). All of the units have been severely impacted by recent mountain pine beetle mortality and can be excepted from 60-day review and Regional Forester approval. The

Forestwide Standards		Compliance
		Stonewall Vegetation Project EIS process serves to notify the public and document the need for the unit size.
Protection Insect and Disease	1. Silvicultural systems will be the primary tool for preventative pest management. Use silvicultural systems to: (1) improve species diversity, growth, and vigor for stands and (2) increase the size diversity and class diversity between stands.	Silvicultural systems are proposed in this alternative to meet the project purpose and need which includes species diversity, growth, and vigor for stands and size diversity and class diversity between stands.
	2. During ongoing infestations, control insects and disease through silvicultural and biological practices. Chemical controls will be limited to high value areas or used on a broader scale only when all other measures have failed and other resource values can be protected. Emphasize cooperative control measures between Federal, State, and private landowners.	Silvicultural practices are proposed to address recent past, ongoing, and future insect and disease concerns. No insect and disease chemical controls are proposed.
	3. Biological practices will be considered in controlling insect and disease infestations.	No biological practices are being considered beyond vegetation management.
	4. If possible, harvest stands which are a high risk for mountain pine beetle attack before harvesting moderate or low risk stands.	Proposed timber harvests addressed recently impacted and high risk stands as well as those where treatment was considered necessary to meet the purpose and need for the project.
Wildfire	2. Locate timber sales, or cutting units within a sale, to break-up contiguous natural fuel.	Cutting units were located to reduce current and potential fuels created as a result of the MPB epidemic and modify fuels to meet the purpose and need to modify fire behavior for community protection and to allow for the reestablishment of fire as a natural process on the landscape
Wildlife/Snags	Larch, ponderosa pine, Douglas-fir, spruce, and subalpine fir, in that priority, are the preferred species for snags and replacement trees (live trees left to replace existing snags).	Treatment design includes artificial and natural regeneration of ponderosa pine and western larch as well as retaining these species over several others in thinning operations. Larch and ponderosa pine would increase due to the treatments.

Compliance of alternative 2 with Forest Plan Management Area standards pertinent to this discussion are displayed in Table B- 8.

Table B- 8. Alternative 2 compliance with management area standards

Management Area Standards		Compliance
M-1	**Timber** - Timber harvest, such as salvage and firewood removal, may occur where access exists. Slash created by any management practice will be disposed of in a manner consistent with the management area goals. Forested lands are classified as unsuitable for timber management.	Six acres of Unit 58 is proposed for a regeneration harvest due to high mortality. Slash would be treated through jackpot burning.

Management Area Standards		Compliance
	Protection - Salvage of dead, dying, or high-hazard trees is permitted to prevent disease and insect population build-up. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Prescribed fire with unplanned ignitions may be used in this management area, for the enhancement and maintenance of resources, when within pre-established prescribed fire criteria. These criteria are stated in the Fire Management Direction in Appendix R. -Evaluate areas periodically for significant insect and disease problems. Endemic levels will be accepted as normal. If epidemic levels develop and control is necessary, the control method should minimize impacts on watershed and other resource values.	The proposed regeneration harvest and jackpot burning is consistent with the removal of dead, dying or high-hazard trees and prescribed burning.
T-1	**Timber** - This management area is suitable for timber management activities. - Timber harvest practices include clearcut, group selection, and shelterwood harvest, depending on habitat group, physical site conditions, and silvicultural objectives. Precommercial thinning and intermediate harvest may occur where needed as determined by silvicultural objectives and project planning. (Appendices H and M of the Forest Plan provide broad guidelines for various habitat groups.) - As a minimum, a cutover area will not be considered an opening when: (1) a new forest stand is established and certified as stocked, and (2) vegetative conditions reach the point where harvest of additional timber can occur and the combined area can still meet watershed management objectives. - Prescribed burning or other techniques may be used for slash disposal, site preparation, silvicultural, and livestock objectives. In habitat groups where fire is not a useful treatment tool, lopping and scattering, yarding unmerchantable material (YUM), or other methods will be used to reduce fuel accumulations and prepare sites for regeneration. - Project level planning will provide for stand regeneration within five years of final harvest. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H.	Proposed treatments are consistent with timber harvest practices, are determined by silvicultural objectives and project planning to meet the purpose and need. Prescribed burning is proposed where necessary for fuels reduction and site preparation. See table 25 below for regeneration and CMAI consistency.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling.	The project purpose and need and proposed treatments address creating a landscape that is diverse, resilient and sustainable to wildfire and insects.
T-2	**Timber** - This management area is suitable for timber management activities. - Timber harvest methods and volumes will be adjusted as necessary to meet big game winter range needs. Even- or uneven-aged silvicultural systems may be used. (Appendix M provides guidance for vegetative management practices by habitat groups.) - Openings created by timber harvest should meet hiding cover requirements of big game before adjacent areas can be harvested.	Treatments would be adjusted to meet wildlife needs see wildlife design criteria (appendix P), and wildlife report.

Management Area Standards		Compliance
	- Schedule sale activities outside winter periods (December 1 to May 15). - No more than 25 percent of the timber-perimeter around natural or artificial parks should be nonthermal cover at one time. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H.	
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. -- Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	See T-1 above.
T-3	**Timber** - This management area is suitable for timber management activities. - Timber harvest methods and volumes may be modified as necessary to achieve the management area goals. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include salvage or sanitation harvest and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H of the Forest Plan. Forest Plan Appendix M provides guidance for various vegetative management practices by habitat group. - Stocking control may be maintained through precommercial and commercial thinnings. The timing and planning of thinning operations will be coordinated with a wildlife biologist. - Vegetative diversity will be encouraged. - Openings created by timber harvest will be reforested to the extent necessary to meet the hiding cover requirements of big game before harvesting adjacent areas.	Proposed treatments are modified to meet wildlife needs. See the see wildlife design criteria (appendix P), and wildlife report. The project purpose and need and proposed treatments address increasing vegetative diversity. See below for CMAI consistency.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	See T-1 above.
T-4	**Timber** - This management area is suitable for timber management activities. - Even-aged stands may be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Forest Plan Appendix H. - Timber harvest practices include clearcutting, group selection, and	Proposed treatments are consistent with timber harvest practices, are determined by silvicultural objectives and project planning to meet the purpose and

Management Area Standards		Compliance
	shelterwood harvest, depending on habitat group, physical site conditions, and visual quality objectives. Precommercial thinnings and intermediate harvest will occur where needed as determined by silvicultural objectives, project planning, and visual quality objective. (Forest Plan Appendices H and M provide broad guidelines for various habitat groups.) - Openings created by timber harvest will be reforested to the point where harvest of adjacent timber can occur and the combined area can still meet the VQOs of the area. - Use timber harvest to rehabilitate existing harvest units, to improve the VQO. - Prescribed burning will be used to accomplish slash disposal, site preparation, and silvicultural objectives. In habitat groups where fire is not a useful treatment tool, loping and scattering, YUM yarding, or other methods will be used to reduce fuel accumulations and prepare sites for regeneration provided the area goals are met.	need. Prescribed burning is proposed where necessary for fuels reduction and site preparation.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions will be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	See T-1 above.
W-1	**Timber** - Timber will be harvested only if it can be used as a tool to maintain or enhance wildlife habitat values. Productive forest land is classified as unsuitable for timber management	No timber harvest is proposed in W-1.
	Protection - Areas will be evaluated periodically for significant insect and disease problems. Endemic levels will be accepted as normal. If epidemic levels develop and control is necessary, the control method should minimize impacts on big game and other wildlife values. - Prescribed fire with planned ignitions will be used in this management area, for the enhancement and maintenance of resources. - Prescribed fire with unplanned ignitions may be used in this management area, for the enhancement and maintenance of resources, when within pre-established prescribed fire criteria. These criteria are detailed in the Fire Management Direction in Forest Plan Appendix R. - Prescribed fire may be used as a tool to reduce natural fuels and improve quantity and quality of wildlife forage.	Prescribed fire is proposed to meet purpose and need to increase species and structural diversity and landscape resilience to wildfire and insects. See wildlife design criteria in table 9, chapter 2 for additional information.

Table B- 9 that follows displays compliance with Forest Service management direction for regeneration harvest for alternative 2.

Table B- 9. Alternative 2 compliance with Forest Service regeneration harvest direction

Management Direction	Compliance
Suitability for timber production. No timber harvest, other than salvage sales or sales to protect other multiple-use values, shall occur on lands not suited for timber production (16 USC 1604 (k)).	All timber harvest would take place in land classified as suitable for timber harvest under the Helena Forest Plan (MA T-1, T-2, T-3, T-4) with the exception of six acres in Unit 58 which is in MA M-1 (appendix J). All proposed treatments involving timber harvest are designed to meet the project purpose and need (stated above) and are not designed for timber production other than salvage. Timber

Management Direction	Compliance
	harvest may occur in M-1 where access exists.
Prior to regeneration harvest, stands of trees must have generally reached CMAI of growth (FSH 1909.12, ch. 60; 16 U.S.C. 1604 (m)(1); FSM 1921.12f).	Average CMAI for forests in the area ranges from 100 to 120 years (USDA Forest Service 1986 appendix H). Trees in most of the suitable units are of an age where they probably had reached CMAI (appendix K) however, the question of culmination of mean annual increment of growth in these units has been rendered moot by the severe levels of mortality. The units are not proposed for treatment for timber production purposes, but to restore the forests, modify fire behavior, and capture economic value of timber and so the CMAI growth requirement would not apply as stated above.
The size of harvest openings created by even-aged silviculture in the Northern Region will be normally 40 acres or less with some exceptions. Creation of large openings will require 60-day public review and Regional Forester approval, with several exceptions including: “Where natural catastrophic events such as fire, windstorms, or insect and disease attacks have occurred” (FSM 1900-2006-2; FSM R1 Supplement 2400-2001-2).	Proposed regeneration harvest units exceed 40 acres in seven units (appendix L). All of the units have been severely impacted by recent mountain pine beetle mortality and are exempt from 60-day review and Regional Forester approval as described in FSM 1900-2006-2. FSM R1 Supplement 2400-2001-2. The Stonewall Vegetation Project EIS 45-day comment period serves to notify the public and is sufficient in documenting the need for the unit size.
Clearcutting and Even-aged Management 916 USC 1604(g)(3)(F)): Insure that clearcutting ... and other cuts designed to regenerate an even-aged stand of timber will be used as a cutting method on National Forest System lands only where for clearcutting, it is determined to be the optimum method ... to meet the objectives and requirements of the relevant land management plan.” “Clearcutting will be used only where it is the optimum method” (Helena Forest Plan, USDA Forest Service 1986).	Proposed regeneration treatments utilize clearcutting with reserve trees in 11 units with severe mortality and few remaining live trees. Clearcutting has been determined to be the optimal method for regenerating these units to the desired seral species in order to meet the project purpose and need as documented in project records.
There is assurance that the lands can be adequately restocked within five years after final regeneration harvest (16 USC 1604(g)(3)(E)(ii); FSM 1921.12g).	Each regeneration harvest treatment area has been field reviewed by a certified silviculturist and treatment designed to ensure that the stands can be adequately stocked following final harvest. Restocking would be through natural and artificial methods to levels established for each unit. As displayed in appendix G table 35, 3,842 acres regeneration harvest are recorded to have taken place in the project area. Examination of these past regeneration harvest units shows that regeneration success in the project area is very good. Stocking criteria would be established for each unit based upon site conditions, treatment objectives, and Forest Plan direction and would be documented in silvicultural prescriptions developed for the project. Regeneration treatments would be monitored (FSM 2472.4) to access treatment success and schedule additional corrective work if the units are not adequately proceeding toward desired stocking guidelines.

Compliance of alternative 3 with Forest Plan Forestwide standards pertinent to this discussion is displayed in Table B- 10.

Table B- 10. Alternative 3 compliance with Forest Plan forestwide standards

Forestwide Standards		Compliance
Timber	1. Silvicultural examinations and prescriptions will be required before any timber manipulation	Silvicultural exams and prescriptions would have been done and approved

Forestwide Standards		Compliance
	or silvicultural treatment takes place. Exceptions include cutting of trees that block vision along roads, cutting hazard trees, clearing right-of-way, clearing for mineral development, minor and incidental amounts of free use, and cutting personal firewood. Final determination of what silvicultural system will be used for a particular project will be made by a certified silviculturist after an on-the-ground site analysis. This site-specific analysis will determine the appropriate even or uneven-age silvicultural system that best meets the goals and objectives of the management area. Standards for applying all silvicultural systems, as well as supporting research references are in the Northern Region guide (June 10, 1983). In addition, broad guidelines are found in Appendix H and M. Even-aged management methods will be used only where it is determined to be appropriate to meet objectives. Clearcutting will be used only where it is the optimum method.	by a certified silviculturist. Site-specific analysis has been done to determine the optimum method of treatment. Clearcutting is being used where it is the optimum method. See project records.
	2. Tree improvement will be conducted in accordance with the current Regional and Forest level tree improvement plans.	Tree improvement would be conducted following the applicable Regional and Forest direction.
	4. Timber stand openings created by even-aged silvicultural systems will normally be 40 acres or less. Creation of larger openings will require a 60-day public review and Regional Forester approval. Exceptions are listed in the Northern Regional Guide.	Proposed regeneration harvest units exceed 40 acres in six units (appendix M). All of the units have been severely impacted by recent mountain pine beetle mortality and can be excepted from 60-day review and Regional Forester approval. The Stonewall Vegetation Project EIS process serves to notify the public and document the need for the unit size.
Protection Insect and Disease	1. Silvicultural systems will be the primary tool for preventative pest management. Use silvicultural systems to: (1) improve species diversity, growth, and vigor for stands and (2) increase the size diversity and class diversity between stands.	Silvicultural systems are proposed in this alternative to meet the project purpose and need which includes species diversity, growth, and vigor for stands and size diversity and class diversity between stands.
	2. During ongoing infestations, control insects and disease through silvicultural and biological practices. Chemical controls will be limited to high value areas or used on a broader scale only when all other measures have failed and other resource values can be protected. Emphasize cooperative control measures between Federal, State, and private landowners.	Silvicultural practices are proposed to address recent past, ongoing, and future insect and disease concerns. No insect and disease chemical controls are proposed.
	3. Biological practices will be considered in controlling insect and disease infestations.	No biological practices are being considered beyond vegetation management.
	4. If possible, harvest stands which are a high risk for mountain pine beetle attack before harvesting moderate or low risk stands.	Proposed timber harvests addressed recently impacted and high risk stands as well as those where treatment was considered necessary to meet the purpose and need for the project.
Wildfire	2. Locate timber sales, or cutting units within a	Cutting units were located to reduce

Forestwide Standards		Compliance
	sale, to break-up contiguous natural fuel.	current and potential fuels created as a result of the MPB epidemic and modify fuels to meet the purpose and need to modify fire behavior for community protection and to allow for the reestablishment of fire as a natural process on the landscape
Wildlife/Snags	Larch, ponderosa pine, Douglas-fir, spruce, and subalpine fir, in that priority, are the preferred species for snags and replacement trees (live trees left to replace existing snags).	Treatment design includes artificial and natural regeneration of ponderosa pine and western larch as well as retaining these species over several others in thinning operations. Larch and ponderosa pine would increase due to the treatments.

Compliance of alternative 3 with Forest Plan management area standards pertinent to this discussion are displayed in Table B- 11.

Table B- 11. Alternative 3 compliance with management area standards

Management Area Standards		Compliance
M-1	**Timber** - Timber harvest, such as salvage and firewood removal, may occur where access exists. Slash created by any management practice will be disposed of in a manner consistent with the management area goals. Forested lands are classified as unsuitable for timber management.	Six acres of Unit 58 is proposed for a regeneration harvest due to high mortality. Slash would be treated through jackpot burning.
	Protection - Salvage of dead, dying, or high-hazard trees is permitted to prevent disease and insect population build-up. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Prescribed fire with unplanned ignitions may be used in this management area, for the enhancement and maintenance of resources, when within pre-established prescribed fire criteria. These criteria are stated in the Fire Management Direction in Appendix R. -Evaluate areas periodically for significant insect and disease problems. Endemic levels will be accepted as normal. If epidemic levels develop and control is necessary, the control method should minimize impacts on watershed and other resource values.	The proposed regeneration harvest and jackpot burning is consistent with the removal of dead, dying or high-hazard trees and prescribed burning.
T-1	**Timber** - This management area is suitable for timber management activities. - Timber harvest practices include clearcut, group selection, and shelterwood harvest, depending on habitat group, physical site conditions, and silvicultural objectives. Precommercial thinning and intermediate harvest may occur where needed as determined by silvicultural objectives and project planning. (Appendices H and M of the Forest Plan provide broad guidelines for various habitat groups.) - As a minimum, a cutover area will not be considered an opening when: (1) a new forest stand is established and certified as stocked, and (2) vegetative conditions reach the point where harvest of additional timber can occur and the combined area can still meet watershed management objectives. - Prescribed burning or other techniques may be used for slash disposal, site preparation, silvicultural, and livestock objectives. In habitat groups	Proposed treatments are consistent with timber harvest practices, are determined by silvicultural objectives and project planning to meet the purpose and need. Prescribed burning is proposed where necessary for fuels reduction

Management Area Standards		Compliance
	where fire is not a useful treatment tool, lopping and scattering, yarding unmerchantable material (YUM), or other methods will be used to reduce fuel accumulations and prepare sites for regeneration. - Project level planning will provide for stand regeneration within five years of final harvest. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H.	and site preparation.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling.	The project purpose and need and proposed treatments address creating a landscape that is diverse, resilient and sustainable to wildfire and insects.
T-2	**Timber** - This management area is suitable for timber management activities. - Timber harvest methods and volumes will be adjusted as necessary to meet big game winter range needs. Even- or uneven-aged silvicultural systems may be used. (Appendix M provides guidance for vegetative management practices by habitat groups.) - Openings created by timber harvest should meet hiding cover requirements of big game before adjacent areas can be harvested. - Schedule sale activities outside winter periods (December 1 to May 15). - No more than 25 percent of the timber-perimeter around natural or artificial parks should be nonthermal cover at one time. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Forest Plan Appendix H.	Treatments would be adjusted to meet wildlife needs see wildlife design criteria in table 9, chapter 2.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. -- Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	See T-1 above.
T-3	**Timber** - This management area is suitable for timber management activities. - Timber harvest methods and volumes may be modified as necessary to achieve the management area goals. - Even-aged stands will be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include salvage or sanitation harvest and management for experimental or research purposes and to meet other	Proposed treatments are modified to meet wildlife needs. See the see wildlife design criteria in table 9, chapter 2. The

Management Area Standards		Compliance
	resource objectives. CMAI for primary species on the Helena National Forest is shown in Appendix H of the Forest Plan. Forest Plan Appendix M provides guidance for various vegetative management practices by habitat group. - Stocking control may be maintained through precommercial and commercial thinnings. The timing and planning of thinning operations will be coordinated with a wildlife biologist. - Vegetative diversity will be encouraged. - Openings created by timber harvest will be reforested to the extent necessary to meet the hiding cover requirements of big game before harvesting adjacent areas.	project purpose and need and proposed treatments address increasing vegetative diversity. See below for CMAI consistency.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions may be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	See T-1 above.
T-4	**Timber** - This management area is suitable for timber management activities. - Even-aged stands may be scheduled for final regeneration harvest when they generally have reached the culmination of mean annual increment (CMAI) of growth. Exceptions include thinning or other stand improvement measures, salvage or sanitation harvest, and management for experimental or research purposes and to meet other resource objectives. CMAI for primary species on the Helena National Forest is shown in Forest Plan Appendix H. - Timber harvest practices include clearcutting, group selection, and shelterwood harvest, depending on habitat group, physical site conditions, and visual quality objectives. Precommercial thinnings and intermediate harvest will occur where needed as determined by silvicultural objectives, project planning, and visual quality objective. (Forest Plan Appendices H and M provide broad guidelines for various habitat groups.) - Openings created by timber harvest will be reforested to the point where harvest of adjacent timber can occur and the combined area can still meet the VQOs of the area. - Use timber harvest to rehabilitate existing harvest units, to improve the VQO. - Prescribed burning will be used to accomplish slash disposal, site preparation, and silvicultural objectives. In habitat groups where fire is not a useful treatment tool, loping and scattering, YUM yarding, or other methods will be used to reduce fuel accumulations and prepare sites for regeneration provided the area goals are met.	Proposed treatments are consistent with timber harvest practices, are determined by silvicultural objectives and project planning to meet the purpose and need. Prescribed burning is proposed where necessary for fuels reduction and site preparation.
	Protection - Insect and disease control should emphasize reduction and prevention through timber harvest and timber stand improvement. The use of other approved integrated pest management techniques may be necessary at times. - Prescribed fire with planned ignitions will be used in this management area, for the enhancement and maintenance of resources. - Fuel reduction methods for activity created fuels include burning, removing residue, or rearranging, such as dozer trampling. Disposal activities will meet visual quality objectives.	See T-1 above.
W-1	**Timber** - Timber will be harvested only if it can be used as a tool to maintain or enhance wildlife habitat values. Productive forest land is classified as unsuitable for timber management	No timber harvest is proposed in W-1.

Management Area Standards		Compliance
	Protection - Areas will be evaluated periodically for significant insect and disease problems. Endemic levels will be accepted as normal. If epidemic levels develop and control is necessary, the control method should minimize impacts on big game and other wildlife values. - Prescribed fire with planned ignitions will be used in this management area, for the enhancement and maintenance of resources. - Prescribed fire with unplanned ignitions may be used in this management area, for the enhancement and maintenance of resources, when within pre-established prescribed fire criteria. These criteria are detailed in the Fire Management Direction in Forest Plan Appendix R. - Prescribed fire may be used as a tool to reduce natural fuels and improve quantity and quality of wildlife forage.	Prescribed fire is proposed to meet purpose and need to increase species and structural diversity and landscape resilience to wildfire and insects. See wildlife design criteria in table 9, chapter 2 for additional information.

Table B- 12 below displays compliance with Forest Service management direction for regeneration harvest for alternative 3.

Table B- 12. Alternative 3 compliance with Forest Service regeneration harvest direction

Management Direction	Compliance
Suitability for timber production. No timber harvest, other than salvage sales or sales to protect other multiple-use values, shall occur on lands not suited for timber production (16 USC 1604 (k)).	All timber harvest would take place in land classified as suitable for timber harvest under the Helena Forest Plan (MA T-1, T-2, T-3, T-4) with the exception of six acres in Unit 58 which is in MA M-1 (appendix J). All proposed treatments involving timber harvest are designed to meet the project purpose and need (stated above) and are not designed for timber production other than salvage. Timber harvest may occur in M-1 where access exists.
Prior to regeneration harvest, stands of trees must have generally reached CMAI of growth (FSH 1909.12, ch. 60; 16 U.S.C. 1604 (m)(1); FSM 1921.12f).	Average CMAI for forests in the area ranges from 100 to 120 years (USDA Forest Service 1986 appendix H). Trees in most of the suitable units are of an age where they probably had reached CMAI (appendix K) however, the question of culmination of mean annual increment of growth in these units has been rendered moot by the severe levels of mortality. The units are not proposed for treatment for timber production purposes, but to restore the forests, modify fire behavior, and capture economic value of timber and so the CMAI growth requirement would not apply as stated above.
The size of harvest openings created by even-aged silviculture in the Northern Region will normally be 40 acres or less with some exceptions. Creation of large openings will require 60-day public review and Regional Forester approval, with several exceptions including: “Where natural catastrophic events such as fire, windstorms, or insect and disease attacks have occurred” (FSM 1900-2006-2; FSM R1 Supplement 2400-2001-2).	Proposed regeneration harvest units exceed 40 acres in seven units. All of the units have been severely impacted by recent mountain pine beetle mortality and are exempt from 60-day review and Regional Forester approval as described in FSM 1900-2006-2. FSM R1 Supplement 2400-2001-2. The Stonewall Vegetation Project EIS 45-day comment period serves to notify the public and is suffice in documenting the need for the unit size.
Clearcutting and Even-aged Management 916 USC 1604(g)(3)(F)): Insure that clearcutting ... and other cuts designed to regenerate an even-aged stand of timber will be used as a cutting method on National Forest System lands only where for clearcutting, it is determined to be the	Proposed regeneration treatments utilize clearcutting with reserve trees in 8 units with severe mortality and few remaining live trees. Clearcutting has been determined to be the optimal method for regenerating these units to the desired seral species in order to meet the project purpose and need as documented in project records.

Management Direction	Compliance
optimum method ... to meet the objectives and requirements of the relevant land management plan." "Clearcutting will be used only where it is the optimum method" (Helena Forest Plan, USDA Forest Service 1986).	
There is assurance that the lands can be adequately restocked within five years after final regeneration harvest (16 USC 1604(g)(3)(E)(ii); FSM 1921.12g).	Each regeneration harvest treatment area has been field reviewed by a certified silviculturist and treatment designed to ensure that the stands can be adequately stocked following final harvest. Restocking would be through natural and artificial methods to levels established for each unit. As displayed, 3,842 acres of regeneration harvest is recorded to have taken place in the project area. Examination of these past regeneration harvest units shows that regeneration success in the project area is very good. Stocking criteria would be established for each unit based upon site conditions, treatment objectives, and Forest Plan direction and would be documented in silvicultural prescriptions developed for the project. Regeneration treatments would be monitored (FSM 2472.4) to access treatment success and schedule additional corrective work if the units are not adequately proceeding toward desired stocking guidelines

Data Sources

The following are short discussions of data sources used for this analysis.

Aerial Insect and Disease Detection Survey (ADS)

Aerial Insect and Disease Detection Survey (ADS) data for Region 1 is collected annually by the USDA Forest Service Region 1 and 4 Forest Health Protection Aviation Program (USDA Forest Service 2011). The purpose of the ADS program is to:

Detect new outbreaks or identify previously undetected outbreaks of forest pests

- Monitor existing outbreaks
- Provide timely information for management planning
- Provide information for forest health assessments and project plans.

The surveys are conducted primarily using fixed-wing aircraft that fly patterns over survey areas beginning in the first part of July and continue through the end of September and often into October. During the flights, personnel sketches the observed insect and disease damage and mortality spatial locations and estimates the degree of the damage (trees per acre affected), the insect or disease causing the damage or mortality, and the tree species being affected.

The ADS is conducted according to well-established and documented survey standards (USDA Forest Service 1999). The results of the survey are digitized into GIS layers following established procedures (USDA Forest Service 2005). The GIS layers produced from the surveys are used in this analysis.

Because the ADS data relies on ocularly estimated insect and disease damaging agent, degree of damage or mortality, and spatial location, the information is useful for detecting, describing and analyzing insect and disease damage and establishing trends on a landscape over time. However, due to limitations in the ocular estimation process, care should be taken in applying the ADS at a stand, or smaller, degree of resolution.

Northern Region Vegetation Map (R1 VMap)

Region 1, Northern Region Vegetation Map (R1 VMap) data is derived from satellite imagery, and provides consistent and continuous data at several levels of accuracy and utility as part of the R1 Multi-level Vegetation Classification, Mapping, Inventory, and Analysis System (R1-CMIA, Berglund et al. 2009). The R1-CMIA data collection program meets the requirements of the Existing Vegetation Classification and Mapping Technical Guide, which describes agency data needs, vegetation classification standards, and mapping standards (Brohman and Bryant 2005). Levels of accuracy in the VMap data include: (1) broad-level data used for forest, multi-forest, and regional-level assessments, (2) mid-level data which is intended to support forest and district integrated vegetation treatment plans, and (3) base-level data which is meant to be used for stand-level analysis purposes (Berglund et al. 2009). The VMap data used in the Stone-Dry EWAS (Milburn et al. 2006) and the Stonewall project is mid-level data that has been edited in 2010 and 2011 to reflect changes in vegetation attributes due to (1) recent wildfires, (2) site- and stand-specific data, and (3) the recent bark beetle epidemic (USDA Forest Service 2011). Attributes in the VMap data used in this analysis includes tree dominance type, tree canopy cover class, tree size class.

National Agriculture Imagery Program (NAIP)

The National Agriculture Imagery Program (NAIP) acquires aerial imagery during the agricultural growing seasons in the continental U.S. NAIP imagery used in the Stonewall Vegetation Project was acquired in 2009, and is 1-meter resolution available in color or infrared.

Fire Regime Condition Class (FRCC)

Fire Regime Condition Class (FRCC) is an interagency, standardized tool for determining the degree of departure from reference condition vegetation, fuels and disturbance regimes (FRCC 2005). Helena NF personnel classified vegetation and analyzed FRCC for the Stone Dry EWAS (Milburn et al. 2006, 2009). VMap data served as the spatial database for the FRCC analysis. The spatial data and FRCC analysis was updated for the Stonewall project analysis (Olsen 2010). For the Stonewall Vegetation Project, we used attributes from the updated FRCC analysis spatial data for biophysical setting.

Stand Data and Silvicultural Diagnoses

Individual stand attributes and detailed silvicultural diagnoses were done in the field in 2008, and updated in 2009 for proposed treatment units. Information collected for each includes: tree species composition, tree stocking levels, understory species compositions and coverage, insect activity, disease presence, vigor, mortality, past harvest, snag availability, and other pertinent information. Personnel measured and recorded selected stand attributes in informal plots (non-statistical). The Forest silviculturist performed most diagnoses in person, although several were done by another certified silviculturist and a forester, under the direction of the Forest silviculturist. Diagnoses represent the most current on-the-ground assessment of all proposed units.

Forest Inventory and Analysis (FIA) and FIA Intensification Plots

The Forest Inventory and Analysis (FIA) Program of the USDA Forest Service serves as the Nation's continuous forest census (USDA Forest Service 2011b). The program has established a set of permanent plots on a national grid that can be measured to characterize changes in forest attributes over time. Forest Inventory and Analysis plots are used at the Forest and landscape scales to set the context for forest conditions and effects, and assessments of insect hazard. Forest Inventory and Analysis plots are maintained at the National level on a periodic remeasurement schedule. In Region 1, FIA plots have been used to estimate the amount of old growth forest and snag density (Czaplewski 2004). The R1 Summary Database, using the NRIS Access Tool, was used to summarize Forest and landscape FIA and grid intensification data. This database is continually updated and was used to derive estimates of snags, old

growth habitat types, and insect hazard ratings and forest structure characteristics. The use and limitations of this database is documented (USDA Forest Service 2008).

Models and Assumptions

Forest Vegetative Simulator

The Forest Vegetation Simulator (FVS) was developed in the early 1970's as the "Prognosis" model (Stage 1973). Since that time, FVS has undergone continual and continuing research and development efforts to expand FVS's range and capabilities, validate, update, and modify FVS's predictions, and increase the FVS program's usefulness and usability. Over the last three decades, the USDA Forest Service has invested a substantial amount annually on research and development of FVS, and are continuing to do so within the Forest Service and through partnerships with educational institutions, other government agencies, and other countries (USDA 2011c).

Currently, the FVS is used almost exclusively by the USDA Forest Service, and is used heavily by other US government agencies such as the Bureau of Land Management, Bureau of Indian Affairs, National Park Service, Natural Resource Conservation Service, Army Corps of Engineers, Fish and Wildlife Service, Department of Defense, and Department of Energy. At least five state forestry agencies utilize FVS and it is heavily used in the private forestry sector. Most major university forestry programs in the US teach the use of FVS.

International use of FVS includes use in the Canadian provinces of British Columbia, Ontario, Alberta and Nova Scotia. FVS is also being used, or variants are being developed for use in Russia, China, Austria, South Korea, Japan, Costa Rica, Portugal, Indonesia, and the United Kingdom as well as other European countries.

Over the last several decades, the Forest Vegetation Simulator has become the most used forest vegetation modeling program in the United States and the world.

The Forest Vegetation Simulator is the product of hundreds of contributors over the past three decades (Dixon 2010). It is not a single growth and yield "model" but consists of a number in integrated models including those for predicting large-tree height and diameter increment, small-tree height and diameter increment, tree mortality, crown change, tree regeneration establishment, shrub development, shrub and tree vertical canopy distribution, mountain pine beetle risk, Douglas-fir tussock moth hazard and impacts, economic analysis, western spruce budworm hazard and impacts, western root disease impacts, dwarf mistletoe impacts, white pine blister rust impacts, and fire effects.

The Forest Vegetation Simulator has expanded its range of applicability from its original Northwest US roots through the creation of "geographic variants" that utilize research from various geographic regions of the US to tailor equations such as those for tree growth, mortality and volume to those regions. There are currently over 20 variants representing forests within the US. In developing some the variants, the Forest Vegetation Simulator has evolved from a growth and yield model into a framework supporting regional models such as TWIGS (Miner et al. 1988) and GENGYM (Edminster et al.1991) further incorporating the extensive research undertaken in developing these models into FVS.

Since FVS uses stand exam data, geographical variant equations for growth are further calibrated using the stand data. This calibration process, coupled with the use of site variables such as slope, aspect, elevation, habitat type, plant association or ecoclass code, location (nearest National Forest, and in some cases Ranger District), site index, and stand density index maximums or basal area maximums, and tree measurements such as species, diameter-at-breast-height, total tree height, tree height to a dead or broken top, diameter increment, age, crown ratio, and damages or diseases, enables FVS to make very accurate individual tree and stand-level growth and yield predictions.
Dixon (2010) describes FVS as "a semi-distant-independent individual tree growth and yield model". He considers it semi-distant-independent because certain parts of FVS localize competition and site variables

to a plot (or point) basis within a stand where other parts do not. Because FVS uses stand exam data, it keeps track of the plot on which trees are located enabling the user to simulate group selection or differentially treat a stand based on density within a stand. One must realize when one is modeling treatment simulations based upon plots that although the plots may be modeled independently in FVS, the FVS outputs will still be showing the *average of all trees on all plots.* Portions of the FVS that do not model on a plot basis are the VSS classification module and the Fire and Fuels Extension.

Fire Fuels Extension

Fire behavior and effects are modeled in FVS through the Fire and Fuels Extension (FFE) which simulates fuel dynamics and potential fire behavior over time in the context of stand development and management (Reinhardt and Crookston 2003). The Fire and Fuels Extension models changes to surface and crown fuels over time due to treatments. Surface fuels attributes include tons-per-acre of fuels by fuels size class. Crown fuels attributes modeled include crown bulk density (CBD) and canopy base height (CBH). The FFE uses existing fire fuel models for fire behavior and effects and adds new submodels for snag and fuel dynamics. The FFE uses Rothermel's (1972) fire behavior model as implemented by Albini (1976) in FIREMOD and subsequently by Andrews (1986) in Behave to predict fire intensity, approaches developed by Van Wagner (1973, 1977) and Scott and Reinhardt (2001) to predict the onset of crowning, and methods from FOFEM (Reinhardt et al. 1997) for predicting tree mortality, fuel consumption and smoke production.

Limitations of the Models

"It should be noted a model is a simplification or approximation of reality and hence will not reflect all of reality" (Stratton 2006). The use of models such as FVS depends upon sample data, validity of the model itself and assumptions made by the modeler. All three affect the results. The use of FVS in this analysis is to generally characterize and display existing conditions and the nature and magnitude of treatment effects to inform decisions to be made. The modeling results are not to be taken as reality.

Historic Stand Conditions

Historic stand structures and species compositions were shaped by a number of factors including climate/weather, site conditions, and the historic fire regime. These factors determined whether any one fire, whether naturally or artificially ignited, would burn any particular forested patch and how severe the fire would be when it burned the patch. Dryer sites such as south-facing slopes tended to burn more frequently which resulted in lower downed woody fuel loads, a higher occurrence of herbaceous understory vegetation, and forests dominated by trees that are relatively resistant to fire, such as ponderosa pine and larger Douglas-fir (Wright and Bailey 1982, Agee 1993, Arno 2000, Beaty and Taylor 2001, Beaty and Taylor 2007). Moister sites tended to burn less frequently in what can be called "mixed-severity" fire regimes which may consist of a combination of understory and stand-replacement fires such as the seral ponderosa pine-western larch forests in western Montana that were burned with stand-replacement fires at long intervals (150+ years) with nonlethal fires at short intervals (20 to 30 years average (Arno 2000) or mixed-severity fire regimes could consist of fires that tended to burn with a fine-grained pattern, killing a large portion of the fire-susceptible species but sparing many of the fire-resistant trees (Arno 2000). The coolest and moistest sites tended to burn with stand-replacing fire regimes.

A number of studies have displayed stand structures and species compositions in terms of diameter distribution charts. Available studies include:

- In western Montana, Arno et al. (1995) found that most old growth ponderosa pine/Douglas-fir plots sampled had burned with frequent (13 to 50 year intervals) non-lethal underburns prior to 1900. They attributed the fire regime to having maintained open, nearly all-aged stands (Arno et al. 1995). Tree species composition and diameter distribution charts for these plots show mixed-species stands

dominated by ponderosa pine with western larch and Douglas-fir as a co-dominant in lesser and varying presence, and lodgepole as a minor species with stand diameter distributions being very flat except for the smaller size classes which displayed increased tree numbers due to fire exclusion. They did find one plot containing even-aged ponderosa pine and western larch which they related to a pre-1900 fire history characterized by patchy stand-replacing events at intervals of 150 or more years. Tree species composition and diameter distribution chart for this plot shows a mixed-species stand dominated by ponderosa pine with western larch and Douglas-fir as co-dominants, and lodgepole as a minor species with a diameter distributions having a prominent "peak" at 16-18 inches d.b.h., characteristic of an even-aged stand. Arno et al. (1995) in their western Montana study found that in recent years, all stands had developed an understory of Douglas-fir which they related to fire exclusion.

- Holden et al. (2007) in studying tree density, diameter-class distribution, and stocking levels among areas that had burned under two different fire frequencies since 1972 in New Mexico stands found that more frequent burns resulted in more open stands with fewer small trees. They display tree diameter distributions that are almost flat compared to the unburned control stand diameter distributions in which TPA increases greatly with decreasing tree diameter.
- Fulé and Covington (1997) studied fires regimes and forest structures in the Sierra Madre occidental and displayed diameter distributions showing almost flat distributions for burned sites as opposed to increasing numbers of small trees and increases in fire-susceptible species at unburned sites.
- Minnich et al. (2000) displays diameter distributions for six forest types in the Sierra San Pedro Martir under un-managed fire regimes, showing flat diameter distributions for all forest types and dominance by fire-resistant species.
- Minnich et al. (1995) studied forest stem densities from data collected on plots in 1932 and 1992 and displayed diameter distributions for the historic measurements to be relatively flat and from the 1992 measurements to have substantial numbers of small trees, which he attributed to forest densification due to fire exclusion. They also displayed increases in understory shade tolerant and fire-susceptible trees over time.

As the studies above indicate, for any combination of fire-resistant and fire-susceptible tree species, frequent fire regimes will result in stands that tend to be uneven-aged, multi-story with open understories and slightly sloping to flat diameter distributions.

Bark Beetles and Fires

Work in a variety of forest systems has generally shown that measures of fire intensity and severity are positively associated with tree susceptibility to bark beetle attack (Ryan and Amman 1996, Bradley and Tueller 2001, Sullivan et al. 2003, McHugh et al 2003, Wallin et al. 2003, Six and Skov 2009). Factors most mentioned in these studies include: crown scorch volume, cambial damage (bole char), root damage, stocking level, and tree size.

Fire damage to trees is determined by characteristics of the fire and of the trees. The height of crown scorch is determined by fire-line intensity, wind speed, and air temperature (Van Wagner 1973) as well as tree characteristics such as needle size, bud mass, and crown volume. Tree bole cambial and root damage by fires is related to the intensity and duration of heat on tree bases and roots and tree bark thickness and root depth (Ryan and Reinhardt 1988). Tree characteristics tend to be linked, with shallow-rooted conifers tending to have thin bark and conversely deeper-rooted trees tending to have thicker bark. Younger trees tend to have both thinner bark, and lower crowns. Young Douglas-fir tend to have relatively thin bark and small thin needles with compact crowns that are heated quickly and so are less fire-tolerant than small ponderosa pine with their thicker, platy bark, thicker, linger needles and open crown structures. Larger Douglas-fir are relatively fire resistant with thick bark.

In this discussion, we will address the effects of burning by wildfires and controlled prescribed burns on Douglas-fir beetle (DFB) and mountain pine beetle (MPB) mortality.

Mountain Pine Beetle

Elkin and Reid (2004) studied attack and reproductive success of MPB in fire-damaged lodgepole pines and found that beetle attack preference or reproductive success was not affected by fire damage. They suggested that fire damage only affects mountain pine beetle reproduction and population growth in areas where attack densities are low otherwise fire damage will have negligible effects on beetle attack and reproductive success.

In western Montana, Six and Skov (2009) studied the response of bark beetles and their natural enemies to prescribed burning-only, thinning-only, and thinning-and-prescribed-burning treatments in mixed-conifer forests in western Montana. They observed no increase in MPB due to the treatments. They attributed that to mountain pine beetles preference for relatively vigorous trees and its ability to maintain outbreaks in such, reflected in avoidance of burned trees

Douglas-fir Beetle

The link between fire damage and Douglas-fir beetle attack has been identified for many years, and there are a number of studies concerning DFB increases following wildfires but the number concerning DFB increases following low-intensity and severity prescribed burns is limited.

Furniss (1965) examined the susceptibility of fire-injured Douglas-fir to bark beetle attack in Southern Idaho following the Poverty Flat Fire (920 acres). The Poverty Flat Fire burned as a relatively intense fire during dry weather on steep slopes. He found that 70 percent of the trees in his plots had been attacked by the Douglas-fir beetle one year after the fire. Even small or lightly burned trees were being attacked and the incidence of attack increased with the size of tree and severity of crown and cambium fire injury. He mentioned that due to the nature of the burn the number attractive, fire-damaged trees were plentiful.

Ryan and Amman (1996) found that the relationship between bark beetle attack and tree damage in areas affected by the 1988 Yellowstone Fire indicated that stress resulting from fire injury led to increased bark beetle activity. They observed that bark beetle populations appeared to have increased in fire-injured trees and then infested uninjured trees. The 1988 Yellowstone fire was a fall wildfire that burned under relatively severe fire conditions, the result being a large fire and an abundance of fire-injured trees. They also suggested that droughty conditions prior to the fire had resulted in relatively stressed trees and high Douglas-fir populations prior to the fire which contributed to the post-fire population increases.

Cunningham et al. (2005) studied Douglas-fir beetle attack on a range of fire-injured Douglas-fir and found that one year after the fire event the DFB selected and attacked large-diameter Douglas-fir with 60-80 percent bole char and 60-80 percent crown volume scorch. The following year beetle preference shifted to smaller trees with lighter fire injury because most of the larger trees had already been colonized the previous year. In the third year host selection shifted to green trees along the burn perimeter but beetle populations did not reach outbreak levels. The burn was an August wildfire.

Hood and Bentz (2007) found in their study of post-fire Douglas-fir beetle attacks and tree mortality that beetles attacked trees with greater crown scorch, but that beetle attack and mortality was also related to cambium damage and stand stocking. They noted that trees within their Yellowstone data set that died within 4 years after the Yellowstone wildfire had greater crown scorch (52 percent versus 22 percent) and cambium damage (2.9 versus 2.2 tree base quadrants damaged) than live trees.

Hood and Bentz (2007) also included in their study data from a prescribed fire in Western Montana. In that data they found that dead trees had greater crown scorch (68 percent versus 15 percent) and cambium

injury (2.9 versus 0.5 quadrants damaged). They also noted that only 2 percent of the trees in the prescribed burn were attacked by Douglas-fir beetles.

In western Montana, Six and Skov (2009) studied the response of bark beetles and their natural enemies to prescribed-burning-only, thinning-only, and thinning-and-prescribed-burning treatments in mixed-conifer forests. They describe their burns as being in late spring with relative humidities of 20-48 percent and flame lengths of 0.2 to 1.2 m (0.7-3.9 feet) in the burn-only treatment and 0.2 to 2.7 m (0.7-8.9 feet) in the thin-and-burn treatment. Their fires were relatively patchy with some areas burning fairly hot resulting in considerable mortality of small diameter trees, while other areas remained relatively untouched. The thin-and-burn treatments were less patchy in nature than the burn-only treatment. They observed that Douglas-fir beetle activity increased following the treatments but decreased the following year. During the four years studied, they recorded that 20 percent of the trees attacked in the thin-and-burn treatment were attacked successfully and 6 percent of the attacked trees in the burn-only treatment were attacked successfully. They observed that mean crown scorch height, percent circumference charred, ground charring, and d.b.h. were higher in the attacked trees than in the un-attacked trees. They concluded that the increase in Douglas-fir beetle was short lived, and occurred on fire-weakened trees with the beetle unable to successfully move to residual green trees. They stated a mean crown scorch height of 11.59 m in the thin-and-burn treatment and a mean flame length of 7.98 in the burn-only treatment.

In Oregon, Youngblood et al. (2009) studied delayed mortality in ponderosa pine and Douglas-fir following thinning, thinning and burning and burning only treatments. They found that bark beetle mortality was low overall with only 0.03 percent across all species, but was higher in the treatments involving prescribed burning.

Summary

Of the two bark beetles we are concerned with and addressing in this report, we can conclude that prescribed burning in the project area would not increase MPB, would likely increase DFB to a small degree for a short time, and would decrease the potential for wildfires in the future to cause an increase in DFB.

Mountain pine beetle risk is now low in the project due to the recent outbreak, and damage by fires does not appear to substantially increase MPB activity.

Douglas-fir beetle can increase following fires, with the beetles initially targeting the largest, moderately to highly damaged Douglas-fir, and when they are depleted would turn toward smaller diameter trees, trees with light damage, and eventually green trees. The impacts from DFB following wildfires can be substantial. The impacts from DFB following prescribed burning would be much lower because of the substantially lower tree crown, bole, and root damage caused by the prescribed burn.

Thinning Effects on Bark Beetle Risk

Bark beetles are characterized by foresters as primary and secondary. Aggressive bark beetles thought of as primary killers of trees are those that attack and kill apparently healthy trees. These primary killers include Douglas-fir beetle (*Dendroctonus pseudotsugae*), mountain pine beetle (*Dendroctonus ponderosae*), western pine beetle (*Dendroctonus brevicomis*), pinyon engraver (*Ips confusus*), roundheaded pine beetle (*Dendroctonus adjunctus*), spruce beetle (*Dendroctonus rufipennis*), and fir engraver (*Scolytus ventralis*). Secondary bark beetles infest severely stressed, dying, or freshly dead trees as well as stressed tree tops and branches. Pine engraver (*Ips pini*), red turpentine beetle (*Dendroctonus valens*) and striped ambrosia beetle (*Trypodendron lineatum*) are mostly considered secondary bark beetles. Depending upon stand conditions and beetle population levels, some bark beetles that typically act in a secondary role can act as a primary killer of trees. Pine engraver, for example, normally reproduces in logging slash, wind-blown trees, broken limbs, and severely stressed trees like other

secondary bark beetles, but when populations increase due to an abundance of host material, it frequently invades and kills small live trees or the tops of larger trees. Bark beetle risk concerns in the project area involve primary bark beetles, not secondary, and the following discussion addresses only those listed above as primary bark beetles.

Researchers began to recognize the importance of tree stocking control to reduce bark beetle activity in about 1941 (Eaton 1941). In 1953, Clements recognized the relationship between stand density and mountain pine beetle activity in sugar pine in 1953 (Clements 1953 in Oliver 1995). Since then, Sartwell and Stevens (1975) worked to further establish the links between tree stocking levels and bark beetle activity. Based upon the works of Sartwell and others, Oliver (1995) investigated the relationship between the stand density index (SDI) threshold of self-thinning mortality due to competition and SDI thresholds for mortality due to bark beetles. Oliver (1995) concluded that stand density for ponderosa pine stands was limited by *Dendroctonus* bark beetles to lower levels than the level of self-thinning. He found that there appears to be a "limiting stand density index" of 365, and stands approaching that limiting SDI usually suffered large losses from bark beetle epidemics that equal or exceed periodic growth for the stands experiencing the bark beetle mortality. He suggests that endemic levels of bark beetle mortality could start in stands when they reached an SDI of 230. The 230 SDI level could be considered a "zone of imminent bark beetle mortality."

Within the last several decades, a number of studies examined the relationships between tree thinning to reduce bark beetle activity and risk. Many of the studies observed decreased bark beetle activity with decreased tree stocking levels. These studies include: (1) observations of low bark beetle activity within thinned stands during long term stocking studies (Cochran and Barrett 1995, Cochran and Barrett 1999a, Cochran and Barrett 1999b, Cochran and Dahms 2000), (2) control studies measuring bark beetle mortality within pine stands thinned to various stocking levels and un-thinned areas (Amman 1988a, Amman 1988b, Amman et al. 1988a, Amman et al. 1988b, Cole and McGregor 1985, Cole et al. 1983, Fiedler and Morgan 2002, Fiddler et al. 1995, McGregor et al. 1987, Mitchell et al. 1983, Safranyik et al. 2004, Schmid and Mata 2005, Whitehead and Russo 2005) and (3) control studies measuring bark beetle activity as a function of the number of beetles trapped in stands thinned to various stocking levels as well as unthinned stands (Bartos and Booth 1994, Sanchez-Martinez and Wagner 2001, Schmitz et al. 1981, Zausen et al. 2005). Of the mortality studies, only Mitchell et al. (1983) did not demonstrate a difference in mortality between lightly thinned stands and unthinned controls, but they did observe that the heavily thinned stands had no mortality. Only one trapping study, Sanchez-Martinez and Wagner (2001), did not observe fewer trapped beetles in thinned stands compared to unthinned. Sanchez-Martinez and Wagner's (2001) measurements found no significant difference between bark beetles trapped in thinned and unthinned ponderosa pine stands on the Coconino plateau in Arizona. However, their data was collected during low levels of bark beetle activity (endemic) in the area and they observed that the average tree size within the unthinned stands was very small, (22.2 cm) making the trees undesirable habitat for the most aggressive bark beetles found in the area--western pine beetle and mountain pine beetle. Given the results all studies mentioned above, we conclude that available research provides overwhelming evidence for the utility of thinning to reduce tree stocking and therefore the level of bark beetle mortality and the risk of epidemic levels of mortality.

Restoration

Whitebark Pine Restoration

Whitebark pine (*Pinus albicaulis*) is a subalpine conifer that is relatively slow growing, intolerant of shade, and tolerant of poor soils, steep slopes, windy exposures, and cold environments (Arno and Hoff 1990). Whitebark pine cones are indehiscent, that is, they do not open sufficiently to release the seeds when ripe but they may be shed from the tree and decay on the ground, releasing the seeds (Arno and Hoff 1990, Owens et al. 2008). Seeds are large and wingless. The combination of indehiscent cones and

large wingless seeds limits unaided dispersal of seeds. The major mechanisms for dispersing whitebark pine seed depends primarily upon the seed-harvesting and caching behavior of Clark's nutcracker (*Nucifraga columbiana*) (Tomback 1982, Hutchins and Lanner 1982), although a number of other birds and small mammals take the seeds for eating and for storage as winter food. Wildlife species that eat whitebark pine seeds include woodpeckers, jays, ravens, chickadees, nuthatches, finches, chipmunks, ground squirrels, bears and probably mice (Hutchins and Lanner 1982, Tomback 2001). Pine squirrels (*Tamiasciurus* spp.) harvest and cache whitebark pine cones in middens (Hutchins and Lanner 1982, Kendall 1983). Whitebark pine seeds serve as an important food source for grizzly bears (*Ursus arctos*) and black bears (*U. americanus*) which raid the middens (Kendall 1983).

Whitebark pine grows in a wide range of plant communities. It can be found in pure stands as the climax species on the coldest and driest sites where harsh growing conditions keep out the less hardy species (Pfister et al. 1977). At the highest elevations, it can be found growing as small stands of short, shrublike trees (krummholz) mixed in with alpine herblands; but on less harsh sites, it achieves larger size and straighter form. Whitebark pine grows as a co-climax species on sites capable of supporting shade-tolerant tree species such as subalpine fir, but on which they are unable to grow vigorously enough to replace the whitebark pine. These are described as whitebark pine-subalpine fir (*Abies lasiocarpa*) habitat types (Pfister et al. 1977) and whitebark pine phases of subalpine fir habitat types (Steele et al. 1983). On moister subalpine fir habitat types within the analysis area, whitebark pine can be present as a major seral species stand component, and on dryer subalpine fir habitat types as a minor seral species stand component.

Whitebark pine's presence as a seral species in subalpine fir habitat types is maintained by disturbances, mainly fires (Arno 2001). Prior to 1900, fires burned through whitebark pine forests at average intervals ranging from about 30 to and 400 years, usually with mixed-severity (Arno and Peterson 1983, Morgan and Bunting 1990, Barrett 1994, Brown et al. 1994, Keane et al. 1994, Tomback et al. 2001, Murray 2008, Larson et al. 2009), although the longest fire return intervals were associated with a stand-replacing fire regime (Romme 1982). Some of the seral whitebark pine stands have been perpetuated by low-intensity fires that kill understory fir and spruce (Arno 1986, Arno 1976, Fisher and Bradley 1987, Arno and Hoff 1990, Bradley et al. 1992). Severely burned patches within mixed-severity fires create openings that are used by nutcrackers for caching seeds, resulting in even-aged, whitebark pine stands.

Whitebark pine has been declining throughout major portions of its range for the last 50 years due to the effects of diseases, insects, and succession (Kendall and Keane 2001) with a rapid decline since the 1960s (Keane et al. 1996). White pine blister rust (*Cronartium ribicola*) has led to the most rapid and precipitous decline in whitebark pine. Impacts from the disease have been highest in the more mesic parts of whitebark pine range, but although the coldest and driest whitebark pine stands have been impacted to a lesser degree, all whitebark pine can be considered at risk. White pine blister rust (WPBR) enters trees through tree needles and grows from the infected needles through branches to the main stem. Smaller trees die more quickly than larger trees. Although larger trees take longer to die, the ends of branches can be killed long before the tree dies, which reduces or eliminates cone production since whitebark pine cones are produced at the ends of branches in the upper portion of the tree crown.

During the last 100 years, the area of whitebark pine cover type in the interior Columbia River Basin and the Bob Marshall Wilderness Complex in Montana is estimated to have declined 45 percent with the whitebark pine in areas where it is a major seral species declining by 98 percent (Keane et al. 1996). In a disease study of white pines (*Pinus albicaulis* and *P. flexilis*) of the Intermountain West, Smith and Hoffman (2000) found the incidence (present within the sampled stands) of WPBR to be 55 percent in the middle Rocky Mountains. In the Bob Marshall Wilderness Complex of Montana, Keane et al. (1994) reported an 83 percent infection intensity (percentage of live trees infected) with a 33 percent average crown kill in 1990. They found that snags were common, ranging from 0 to 123 trees/ha and attributed

most of the whitebark pine mortality to blister rust because they found no evidence of extensive bark beetle mortality. South of the project area in the Grand Teton National Park, Kendall et al. (1996a) found an average of 7 percent dead (ranging from 0 to 50 percent), and in Yellowstone National Park found an average of 7 percent dead (ranging from 0 to 64 percent). Kendall et al. (1996b) on the Gallatin National Forest found 10 percent dead (ranging from 0 to 43 percent). These mortality values have almost certainly increased within the last 15 years due to additional WPBR-related mortality and due to the recent mountain pine beetle epidemic. Blister rust surveys of whitebark pine in two stands south of the Stonewall project area on the Helena National Forest done in 2007 and 2009 found 74 and 97 percent WPBR infection levels (see WBP Survey_granite.xls and WBP Survey_redmtn6253.xls in project records).

Whitebark pine in the Northern Rocky Mountains depends upon fire to maintain its dominance or presence on sites where it is a successional species (Arno 2001, Keane 2001, Kendall and Keane 2001, Morgan and Murray 2001). It often can survive low-severity fires that kill its competitors. Many fires can kill most fir, spruce, and young whitebark pine, but few larger whitebark pines. Fire frequency has decreased in many whitebark pine forests since the late 1880s, with the greatest change in the last 60 years (Brown 1994, Murray et al. 1998, Rollins et al. 2000). This fire exclusion has allowed an increase in competition from shade-tolerant and fire-intolerant species and advanced the age of whitebark pine stands (Arno 1986, Kendall and Keane 2001, Keane et al. 1994) making whitebark pine trees more susceptible to WPBR and mountain pine beetle. Keane et al. (1994) reported that in the Bob Marshall Wilderness Complex, their sampled stands typically consisted of an overstory of old whitebark pine and spruce with an understory of almost exclusively subalpine fir (8 to 1500+ trees/ha, 30 to 250 years of age). They found whitebark pine regeneration in only about 9 percent of their sample plots. The number and size of forest openings suitable for nutcracker caching and whitebark seedling growth has declined. Increases in fuel loads as stands transition to dominance by subalpine fir and Engelmann spruce has led to increases in fire-severity, which threatens the survival of even the largest and most fire resistant whitebark pine trees (Morgan and Bunting 1990).

Mountain pine beetle attacks whitebark pine in addition to lodgepole pine. Increases in stand age, average tree size, and competition, increases whitebark pine tree and stand susceptibility to attack from mountain pine beetle as it does with lodgepole pine. White pine blister rust infection also stresses whitebark pine trees, making them more attractive or susceptible to mountain pine beetles (Keane et al. 1994). The recent mountain pine beetle epidemic has killed whitebark pine, along with lodgepole and ponderosa pine.

Restoring whitebark pine must address the major factors causing its decline; competition, succession and white pine blister rust (Tomback et al. 2001). To be successful in the long term, restoration should emphasize the return of ecosystem processes rather than simply historic stand conditions (Keane and Arno 2001). The primary ecosystem process that should be returned is fire.

Techniques that can be used to restore whitebark pine (Keane and Arno 1996, Keane and Arno 2001, Tomback et al. 2001) include:

- Planting rust-resistant whitebark pine seedlings
- Release cuttings
- Thinning
- Tree understory removal
- Selective tree removal
- Cutting small openings (50 m diameter) for caching by Clark's nutcracker
- Natural stand-replacement fire
- Prescribed stand-replacement fire with or without cutting for fuel enhancement

- Variable intensity prescribed burning in natural fuels
- Variable intensity prescribed burning with cutting for fuel enhancement
- Underburning

Keane and Parsons (2010a) describe the results of a study to restore white pine ecosystems using treatments that emulate the historic fire regime—primarily combinations of prescribed fire, silvicultural cuttings, and fuel enhancement cuttings. They found that all treatments that included prescribed burning created suitable nutcracker caching habitat, and many birds were observed caching seeds in the burned areas. After 5 years, however, they had not found a significant increase in regeneration of whitebark pine. They attributed the lack of regeneration to the high level of blister rust in the surrounding area that had reduced available seed and forced the nutcrackers to reclaim most of the cached seed, as well as site severity, a lack of plant cover, and a relatively short time since disturbance. Keane and Parsons (2010b) recommended that an evaluation of natural regeneration in the treatments must be made at least a decade after burning. In four of the five study sites, they recorded 88 to 95 percent mortality from blister rust, with less than 1 percent mortality on the fifth study site. Based upon their findings, their recommendations included:

- Emulating historical fire regimes
- Using prescribed burning and augmenting fuelbeds by cutting trees where necessary
- Letting wildland fires burn under acceptable conditions
- Planting potentially rust-resistant trees where whitebark pine blister rust-caused mortality was above 20 percent, rust infection levels were above 50 percent, or bark beetle mortality levels were high

Treatment Groups 7 and 8 in the Stonewall project would be prescribe burned with mixed-severity fires. The treatments in Group 7 would create mortality patches less than 5, 10, or 20 acres depending upon the unit and in Group 8 would create mortality patches less than 30 or 75 acres depending upon the unit. Where necessary, the treatments would involve cutting trees with chainsaws prior to burning to enhance increase surface fuel loadings. During cutting operations, individuals and patches of whitebark pine would be thinned around where available to reduce competition and to protect them from the prescribed burn. The result of the treatments would be to create a mosaic of lightly burned timbered areas and more severely burned patches. The patches would provide areas for nutcracker caching and for whitebark pine to establish and grow. These practices are consistent with recommendations stated above by Keane and Parsons (2010a), Keane and Arno (1996), Keane and Arno (2001), and Tomback et al. (2001) to emulate historical fire regimes, use variable intensity prescribed burning, augmenting fuels where necessary, thin to release whitebark pine trees, remove understories, and create small openings.

Aspen Restoration

Quaking aspen (*Populus tremuloides*) is the most widely distributed tree in North America (Perala 2004). It is a fast-growing, short-lived, deciduous tree that reproduces by seed and vegetatively. Although aspen can produce an abundance of highly viable seeds, few aspen seedlings survive in nature due to the short period of seed viability (2-4 weeks following maturity under favorable conditions and perhaps much less under unfavorable), unfavorable moisture during seed dispersal, high soil surface temperatures, fungi, adverse diurnal temperature fluctuations during initial seedling growth, and the unfavorable chemical balance of some seedbeds (Maini and Cayford 1968, Meyer and Fechner 1980). Aspen forms clones, which are aggregations of stems mainly produced asexually from a single sexually produced individual through root suckers, although some root collar and stump sprouts can be produced (Perala 2004). Aspen clones typically produce root suckers in response to a disturbance, for example fires, that affect the clone and produce changes in the production of growth regulators (i.e. auxin and cytokinin) soil temperatures, and available moisture. In general, the greater the disturbance the greater the number of suckers produced due to increases in cytokinin-to-auxin ratios in the root systems, increases in soil temperatures, and increases in available site resources such as water and light. Root system carbohydrate reserves are also

involved. Carbohydrate reserves provide the suckers with energy until they can provide their own through photosynthesis, and so the density of aspen regeneration following disturbance depends upon the level of those reserves. Although aspen stems are short-lived relative to other trees, aspen can reproduce through suckering following disturbance and so aspen clones can be quite old.

Aspen can grow on site conditions that preclude the establishment of conifers but which have adequate subsurface moisture for a long-lived aspen clone to survive (Jones and DeByle 1985, Mueggler 1988). These self-perpetuating clones can be considered "stable" and "climax" and are not seral to a conifer species (Pfister et al. 1977). Most, if not all, of the aspen clones within the Stonewall Project area are growing within conifer stands and can be considered a seral species to a conifer species, either subalpine fir or Douglas-fir. They are usually small and have apparently been perpetuated by periodic wildfires (Pfister et al. 1977). As a seral species, without disturbance, over time the aspen can be expected to be overtopped by taller conifers and outcompeted for site resources.

Thinning within and around aspen clones has been shown to be an effective treatment for increasing aspen regeneration and restoring aspen (Arikian et al. 1999, Huffman et al. 1999, Shepperd 2001, Prévost and Pothier 2002, Jones et al. 2005, Groot et al. 2009, Lennie et al. 2009). The heavier the thinning, the greater the number of aspen suckers produced (Huffman et al 1999, Prévost and Pothier 2002) and removing all competing trees from within and around aspen has been shown to produce the greatest increase in aspen suckering (Stone et al. 2001, Groot et al. 2009, Lennie et al. 2009, Prévost and Pothier 2002).Prescribed burning has also been shown effective at promoting aspen regeneration (Brown and DeByle 1987, Bartos et al. 1991, Kay 2001, Shepperd 2001, Durham 2008, Paragi and Haggstrom 2007). The effects of prescribed burning on aspen vary because fuels and flammability vary considerably within the aspen and mixed aspen-conifer overstory types (Brown and Simmerman 1986, Brown and DeByle 1987). In general, the fuel types in order from high potential fire intensity and rate of spread to low are: mixed conifer-aspen/shrub, aspen/shrub, mixed conifer-aspen/forb, aspen tall forb, and aspen low forb (Brown and Simmerman 1986). Brown and Simmerman (1986) rate the probability of successfully applying prescribed fire to aspen forests as moderate to high in the aspen/shrub, aspen/tall forb and mixed aspen-conifer fuel types. The aspen within the Stonewall area is present in mixed aspen-conifer fuel type.