

FINAL REPORT
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USDA ECOLOGICAL SITE DESCRIPTION
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State-and-Transition Models

Concepts and Definitions

Rangeland Ecological Processes

Ecological processes functioning within a normal range of variation will support a suite of specific plant communities. The important primary processes are (1) hydrology (the capture, storage, and redistribution of precipitation); (2) energy capture (conversion of sunlight to plant and animal matter); and (3) nutrient cycling (the cycle of nutrients through the physical and biotic components of the environment (Pellant et al. 2000, Whisenant 1999). Pellant et al. (2000) defines the functioning of an ecosystem by "the degree to which the integrity of the soil, vegetation, water, and air, as well as the ecological processes of the rangeland ecosystem, are balanced and sustained". Integrity is defined as the "maintenance of the functional attributes characteristic of a locale, including normal variability" (Pellant et al. 2000). Degradation of an ecosystem occurs when the integrity of the system is damaged or lost. Maintenance of a functional site or repair of a damaged site requires management focused on soil stability, nutrient cycling, and the capture, storage and safe release of precipitation. *Vegetation goals should be based on the concept of vegetation as a tool for maintaining or repairing damaged ecological processes rather than predefined species groups.* Monitoring of species groups may be a mechanism for evaluating or detecting change in the site's ecological processes.

State

A state is a recognizable, resistant and resilient complex of two components, the soil base and the vegetation structure. The vegetation and soil components are necessarily connected through integrated ecological processes that interact to produce a sustained equilibrium that is expressed by a specific suite of vegetative communities.

Soil Base and Vegetation Structure

The base of any rangeland ecosystem is the soil resource that has developed through time from a specific parent material, climate, landscape position, and interaction with soil and terrestrial biota. These factors are the primary determinants of the ecological site's capability. The integrity of the soil resource, as reflected by site hydrology and nutrient cycling, is directly connected to the composition and energy capture process of the above-ground vegetative component. The interaction between the soil resource and the associated vegetative community determines the functional status of the state's ecological processes.

- **Soil Base:** a component that results from the interaction of climate, abiotic soil characteristics, soil biota and topography that determines the hydrologic characteristic and biotic potential of the system.
- **Vegetation Structure:** a component resulting from above ground communities of living organisms, who competitively capture and utilize the system's available energy, water, nutrients, and space.

The interaction between the structural attributes of soil and the vegetative communities, through the processes of energy capture, hydrology and nutrient cycling defines the resilience and resistance of the state.

Resilience and Resistance

The stability of a state is defined above in terms of resilience and resistance. Resilience and resistance are inherent properties of an ecosystem that are determined by the physical components of the system and the functional capacity of the associated ecological processes. Resilience focuses on how far a system can be displaced from equilibrium before return to equilibrium is precluded. The emphasis is placed on the persistence of relationships as they affect the systems ability to adapt to change (Walker et al. 1981), therefore, resilience relates to

the functioning of the system's ecological processes. Resistance indicates the ability of a system to remain at or near its equilibrium condition by maintaining control of its ecological processes.

Thus, the strength of this control determines a system's inherent resistance to change.

Consequently, under an existing climate, stability of a state is a function of the combination of its inherent resilience and resistance.

Thresholds and Transitions

Thresholds are points in space and time at which one or more of the primary ecological processes responsible for maintaining the sustained equilibrium of the state changes beyond the point of self-repair. These processes must be actively restored before the return to the previous state is possible. In the absence of active intervention a new state, which supports a different suite of plant communities and a new threshold, is formed

- Thresholds: boundary in space and time between any and all states, or along irreversible transitions, such that one or more of the primary ecological processes has been irreversibly changed and must be actively restored before return to a previous state is possible.

Transitions are trajectories of change that are precipitated by natural events and/or management actions which alter the integrity of one or more of the states primary ecological processes.

Transitions are often composed of two separate properties that are defined by the state threshold.

The first property is reversibility and it occurs within the state. The second property is irreversibility and it occurs once a threshold has been breached. Transitions are vectors of system change that will lead to a new state without removal of the stressor(s). The primary difference between the reversible and irreversible property of a transition is defined by the systems' ability or inability to repair itself.

- Transition: a trajectory of system change away from the current state that is triggered by natural events, management actions, or both.

- Reversible Property of the Transition: trajectory of change that occurs within a state and indicates the system is moving toward a threshold. Reversal requires elimination of the stress or stresses responsible for triggering the transition or re-introduction of a removed stress (i.e., fire) involved in maintaining ecological function.
- Irreversible Property of the Transition: trajectory of change that occurs after a threshold has been breached. The system can no longer self-repair even with removal of the stressor(s). The system will not come to rest until a new equilibrium (i.e., new state) is established that supports a different suite of plant communities.

MODEL STRUCTURE

The conceptual model, illustrating the above definitions, is represented in Figure 1. States are diagrammed as the large boxes and are bordered by thresholds. Thresholds are the boundaries of any and all states, but may also occur during the transition between states. For a state change to occur a threshold must be breached. The small boxes within the state are referred to as plant community phases or seral stages and are joined by community pathways that flow in both directions. Transitions are reserved for a trajectory of change with the dashed line inside the state indicating the portion of the transition that is reversible with minimal input from management. Figure 1 illustrates the process of a state change. Once the threshold is crossed the state has lost control of its primary ecological processes, is no longer able to self-repair and will transition to a new equilibrium with a different ecological capability. The entire trajectory from a vegetation phase in State 1, across the threshold to the formation of State 2 is considered a transition and represents a change of ecological capability. The portion of the transition contained within the boundary of State 1 is reversible with removal of the stressor(s), however, once the trajectory crosses the threshold it is not reversible without active restoration including substantial energy input. Additional thresholds may occur while the system is in transition,

changing the direction of the trajectory away from State 2 towards State 3 (Fig. 1). State-and-transition modeling efforts indicate the first threshold is forced by a change in the biotic component of the system whereas additional thresholds would involve changes in the soil resource (Westoby et al. 1989, Milton et al. 1994, and Whisenant 1999).

Plant community phase changes within states, in addition to transitions of change, thresholds and multiple stable states are illustrated in Figure 1. The management and natural mechanisms responsible for community phase shifts and transition initiation must be defined in terms of ecological processes and included in the model description. For example, prolonged drought or overgrazing leads to a reduction in the perennial herbaceous understory. The decrease in perennial understory leads to a decrease in total energy capture and nutrient cycling. In addition, the plant community's ability to protect the soil from raindrop impact and potential soil erosion declines. The mechanism (or mechanisms) of disturbance have led to a change in the three primary ecological processes and a phase shift from one community within a state to another community within the same state has occurred. If the disturbance causing the plant community phase change is removed (drought ends) return to the late seral plant community phase would gradually occur. These dynamics are recognized as occurring within states and are diagrammed within the state. If for example, abusive grazing occurs along with long-term drought the vigor of the herbaceous understory may decline to a point where the community's ability to maintain control of the primary ecological processes is impacted. As the vigor of the herbaceous community declines, the site is opened up for invasion by annual species. The transition from State 1 towards State 2 has begun and will continue without release from the disturbance(s). At the point in time where annuals dominate the herbaceous understory and fire frequency intensifies, the state has crossed a threshold and is transitioning to a new state.

Although many scientists have recognized the short-comings of the quantitative climax model developed by Dyksterhuis (1949) there are ecosystems, generally of more mesic climates,

where the linear model is appropriate. It is important to realize that any modeling approach is a best-fit solution, not a perfect-fit solution. Therefore, the retrogression-succession continuum can be modeled within the states to depict the situation where plant community phases do respond linearly. However, it is also possible for linear response mechanisms to be pushed past an ecological threshold, resulting in a state change.

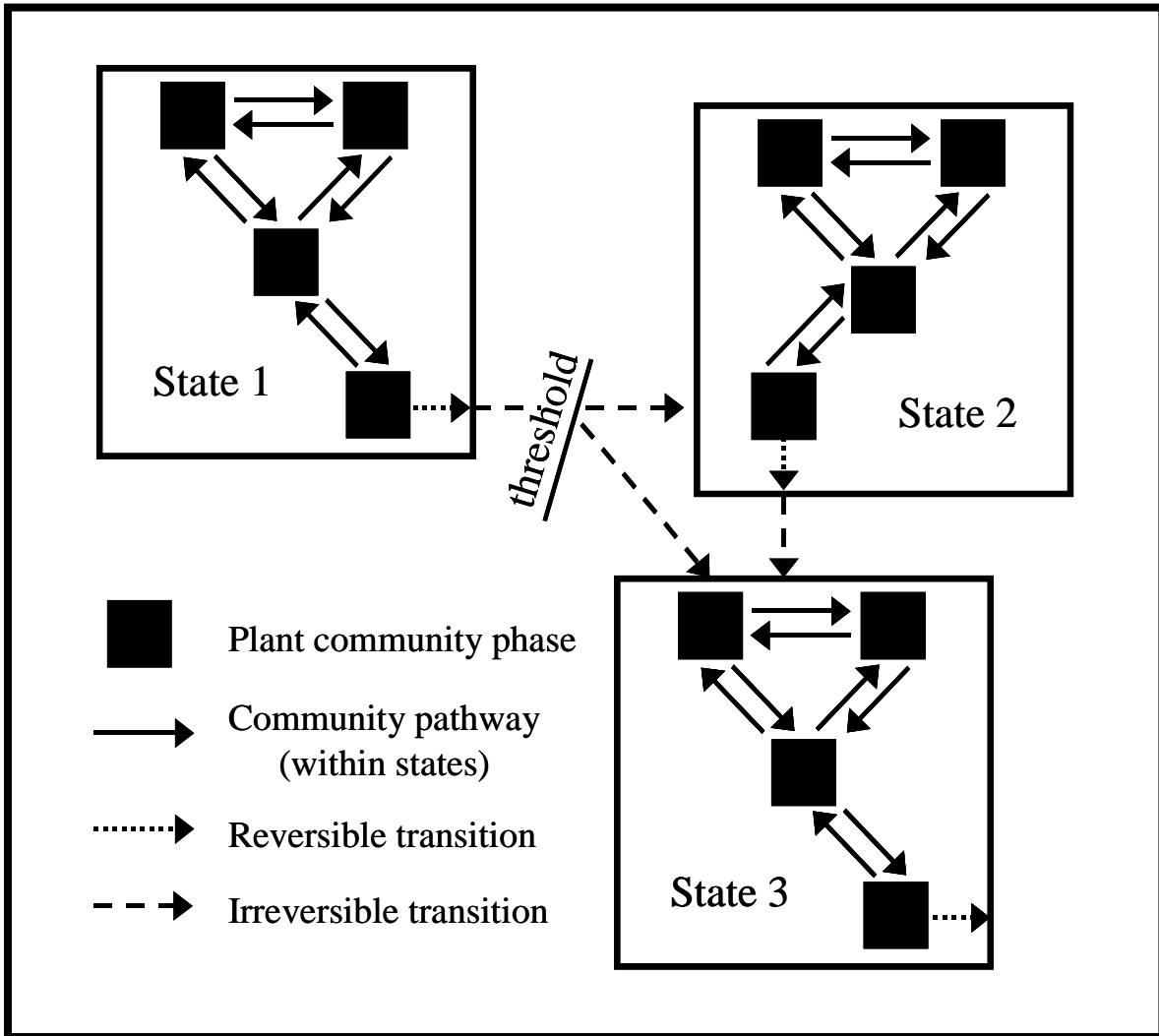


Fig. 1

Stringham, T.K., W.C. Krueger, and P.L. Shaver. 2003. State and transition modeling: An ecological process approach. *Journal of Range Management* 56:106-113

In January 2005 a workgroup consisting of Jeff Repp, NRCS State Range Conservationist, Alan Bahn NRCS Range Conservationist, CiCi Brooks NRCS Range Conservationist, Kathryn Petersen BLM, Ed Horn BLM Soil Scientist and Tom Clark NRCS Soil Scientist was convened by Dr. Tamzen Stringham of Oregon State University, Dept. of Rangeland Ecology and Management for the purpose of developing state-and-transition models for the B10, D23 and D24 major land resource areas (MLRA). The initial work focused on sorting ecological sites (ESD) within a MLRA into groups with similar soils, aspects, plant community attributes and precipitation. The second task was to develop a state-and-transition model (STM) for each similar group of ESD's. The assumption, by the work group was similar ecological sites would respond to disturbance in a similar manner while recognizing that the rate of response and the magnitude of change may vary by ecological site. The end point of change within an ESD group was assumed to be nearly the same across ecological sites justifying the use of one STM for the group.

MLRA B10

Twelve groups were initially created from the 121 approved ecological sites within the B10 major land resource area. Group 2 was eventually split into two groups and labeled Group 2A and 2B and groups representing riparian areas were eliminated from the current modeling effort. The working group decided on the following sort criteria for determining groupings:

- Precipitation
- Elevation and aspect
- Soil characteristics
 - ✓ Depth
 - ✓ Texture
 - ✓ pH
 - ✓ soil temperature (mesic/frigid break = 4000ft)

Group 1

Group 1 consists of 21 ecological sites, nine from MLRA 10B and twelve from 10C. Aspect is north or non-aspect with an elevation range of 3000 to 6200 feet and a primarily frigid soil temperature regime. Precipitation ranges from 12 to 26 inches with the most common being 12 – 16 inches. The modal ecological site soils are moderately deep and well drained. The surface layer is a silt loam to silty clay loam about 8 inches thick with the subsoil a clay loam to clay approximately 20 inches thick. Water holding capacity is about 4 to 6 inches and the potential for erosion is moderate to severe.

The historical climax plant community (HCPC) is dominated by Idaho Fescue (20 to 80% composition by weight) often with a co-dominant of bluebunch wheatgrass (5 to 50% most commonly less than 30%). Mountain big sagebrush was the dominate shrub on twelve of the sites within this group ranging from 2 – 15% composition by weight and antelope bitterbrush was dominate on six sites with composition ranging from 5 to 20 percent. Western juniper is less than 2% of the community composition. Average production for the 21 sites is 1200 lbs. The modal community (occurring most frequently) was defined as the SR Mountain Clayey 12-16 PZ ecological site.

Group 1 Ecological Sites

B10	B	R010XB028OR	JD SHRUBBY MOUNTAIN CLAYEY 12-16 PZ
B10	B	R010XB071OR	JD SHRUBBY MOUNTAIN NORTH 12-16 PZ
B10	B	R010XB078OR	JD MOUNTAIN NORTH 12-16 PZ
B10	B	R010XB079OR	JD MOUNTAIN CLAYEY 12-16 PZ
B10	B	R010XB082OR	JD SHRUBBY MOUNTAIN CLAYPAN 12-16 PZ
B10	B	R010XB083OR	SHRUBBY MOUNTAIN SHALLOW 12-16 PZ
B10	B	R010XB085OR	JD ASHY NORTH 12-16 PZ
B10	B	R010XB086OR	JD SHRUBBY SHALLOW 12-16 PZ
B10	B	R010XB088OR	JD ASHY DEEP NORTH 12-16 PZ
B10	C	R010XC019OR	SR DRY MOUNTAIN SWALE 12-16 PZ
B10	C	R010XC032OR	SR MOUNTAIN CLAYEY 12-16 PZ MODAL
B10	C	R010XC033OR	SR MOUNTAIN LOAMY 12-16 PZ
B10	C	R010XC034OR	SR SHRUBBY MOUNTAIN LOAM 16-20 PZ
B10	C	R010XC037OR	SR MOUNTAIN SHALLOW 12-16 PZ
B10	C	R010XC053OR	SR HIGH MOUNTAIN LOAM 18+ PZ
B10	C	R010XC065OR	SR MOUNTAIN NORTH 9-12 PZ
B10	C	R010XC066OR	SR MOUNTAIN NORTH 12-16 PZ
B10	C	R010XC067OR	SR SHRUBBY MOUNTAIN NORTH 16-20 PZ
B10	C	R010XC075OR	SR MOUNTAIN SHALLOW NORTH 12-16 PZ
B10	C	R010XC080OR	SR MAHOGANY MOUNTAIN LOAM 14-18 PZ
B10	C	R010XC082OR	SR DRY PINE 14-16 PZ

Disturbance Response

Overgrazing may cause a decrease in deep-rooted perennial bunchgrass, primarily Idaho fescue and bluebunch wheatgrass. Unpalatable species such as sagebrush and juniper increase and the percentage of squirreltail may also increase. As grass cover declines the potential for weed invasion and expansion of juniper increases (State 1: SS community phase to JSS community phase).

Fine fuel reduction from improper grazing and fire suppression has led to an increase in the historical fire return interval on many western rangelands. A reduction in fire frequency on these

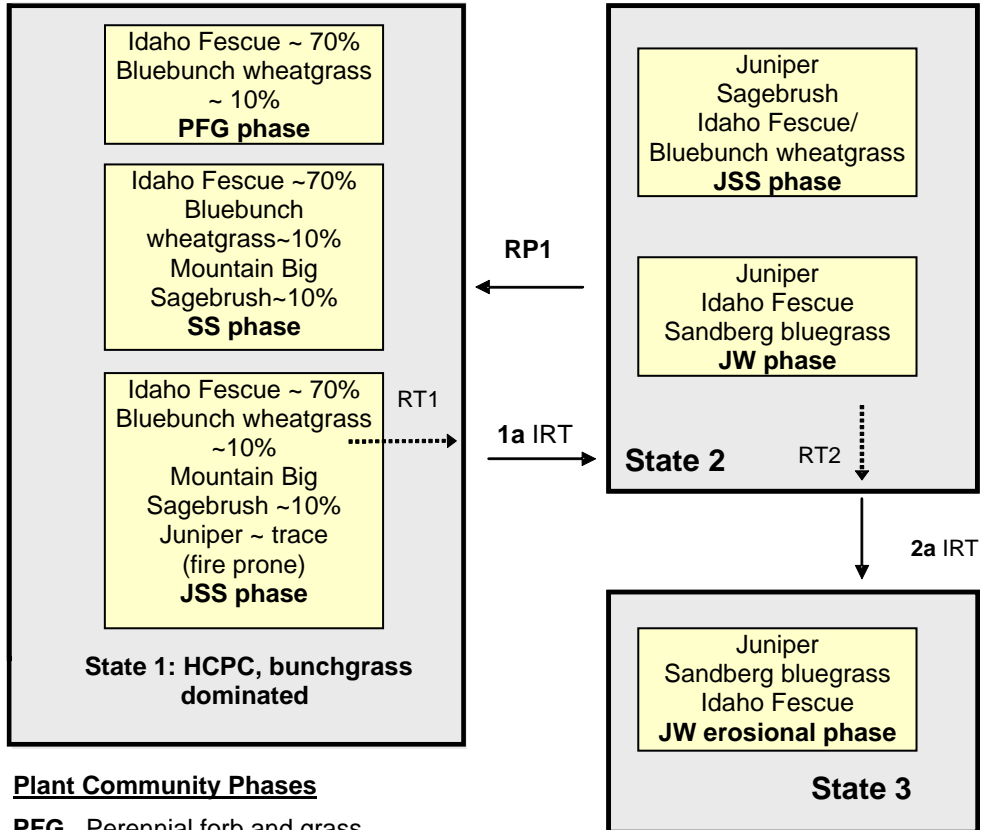
sites leads to an increase in juniper cover, a decrease in sagebrush cover followed by a decrease in herbaceous cover and understory diversity. As juniper encroaches on north facing aspects sagebrush declines with a subsequent decrease in forbs, Bluebunch wheatgrass and needlegrass (State 1: JSS community phase transitioning to State 2). Idaho fescue becomes the primary herbaceous species occurring under the canopy of the juniper trees. Sandberg's bluegrass increases in the plant community on lower elevation north slopes and warmer non-aspect sites while bare ground increases in the interspaces between trees. Bitterbrush is more resistant to juniper encroachment than sagebrush and maintains its presence in the community, however vigor and fitness (seed production) may be thwarted (State 2: JSS community phase). The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines (State 2: JW plant community phase).

The combined effect of overgrazing and juniper invasion increases the rate of decline in ecological function and the probability of crossing a threshold is high.

Treatment Response

North facing aspects respond positively to juniper removal if soil erosion is not significant. Seeding may be necessary if there is less than 1-2 bunchgrass plants per meter square in the understory. Sagebrush and forbs may also need to be seeded if adult plants are no longer present in the understory.

Group 1



Plant Community Phases

- PFG** Perennial forb and grass
- SS** Sagebrush steppe
- JSS** Juniper Sagebrush steppe
- JW** Juniper Woodland

Vectors of Change

- RT = reversible transition
- IRT = irreversible transition
- RP = repair pathway

Group 1

State 1: Community phases are maintained by fire and are not negatively affected by appropriate grazing. Inappropriate grazing, reduced fire frequency or both lead to increased juniper cover and decreased cover of understory species, however the JSS community phase is still susceptible to fire.

RT1: The JSS community in State 1 is recognized as the “at risk” community and the transition to State 2, a fire proof juniper woodland has begun.

1a: Irreversible transition has occurred and a biotic threshold has been crossed. Juniper controls site dynamics.

RP1: requires mechanical treatment of juniper and potentially seeding of native grass and shrubs.

State 2: is recognized by the need to mechanically treat the juniper woodland prior to initiating a prescribed burn. JSS phase with juniper dominance, Idaho fescue beneath tree canopies, bareground interspaces with a trace of Bluebunch wheatgrass and an increase in Sandberg’s bluegrass. Sagebrush is stressed and dying (JSS phase). As the juniper woodland matures, sagebrush and Bluebunch wheatgrass are eliminated and the potential for soil erosion increases (JW phase).

2a: Active soil erosion is evident.

State 3: The site has crossed an abiotic threshold characterized by soil loss and lack of seedbank thereby resulting in the inability to sustain the establishment of perennial plants including juniper. All ecological processes, hydrologic cycle, nutrient cycle and energy capture have been significantly changed.

Group 2

Group 2 initially consisted of 12 sites, however after consultation with professionals familiar with these sites the group was split into two groups on the basis of precipitation. Sort criteria were primarily precipitation, non-aspect landscapes and elevation near 4000 feet.

Group 2A

Group 2A represents sites on the lower end of the precipitation range (8-10pz) with the modal community designated as Pumice Flats 8-10pz. Elevation ranges from 2000 to 4000 feet with the average range of 2500 to 3700 feet. The majority of the sites are classified as non-aspect with the exception of the one north aspect site. Slope ranges from 0 to 65% with the majority of the sites occurring on slopes of less than 20%. The soils range from shallow to deep, are well drained and with sandy loam surface layers. They are generally formed in pumice ash over basalt bedrock. Soil temperatures are mesic with an xeric moisture regime. The potential native plant communities for all sites in this group have an old growth juniper component of 1-10% of composition by weight. However, the majority of sites are characterized as having up to 5% juniper cover. The understory is comprised of two species of sagebrush; Wyoming big sagebrush and Basin big sagebrush. Sagebrush cover ranges from 5 to 15% of plant community composition. The herbaceous component is dominated by either Needle-and-Thread or Bluebunch wheatgrass with the exception of the Pumice North site that is dominated by Idaho Fescue. The grass/forb component of these sites ranges in composition from 30 to 60%. Total foliar cover ranges from 40 to 70% with the grass and forb understory comprising the largest component. The modal site exhibits 70% foliar cover with 50% grass and forb, 15% tree and 5% shrub cover.

Group 2A Ecological Sites

R010XA002OR	PUMICE HILLS 8-10 PZ
R010XA003OR	DROUGHTY JUNIPER FAN 8-10 PZ
R010XA019OR	DROUGHTY 8-12 PZ
R010XA022OR	LAVA BLISTERS 8-10 PZ
R010XA024OR	PUMICE NORTH 8-10 PZ
R010XA027OR	PUMICE FLAT 8-10 PZ MODAL

Disturbance Response

Three primary disturbances were identified for this group: grazing, tree cutting and the infrequent small area fire.

Inappropriate grazing causes a reduction in Bluebunch wheatgrass (PSSPS), needle-and-thread (STCO4), Indian ricegrass (ACHY) and other understory grass species. Idaho fescue (FEID) remains in the community under the north side canopy of juniper trees and cheatgrass (BRTE), if present, will increase on all other aspects under the canopy. Interspaces are normally sparse, however with overgrazing prickly gilia (LEPU) increases and grasses decline. Squirreltail (ELEL5) may increase initially as needle-and-thread and Bluebunch wheatgrass decline, however with continued overgrazing this species will also decline. Eventually deep rooted perennial bunchgrasses (DRPBG) are eliminated. Cheatgrass becomes dominate along with grey

rabbitbrush (CHNA). Ground fire potential increases with increasing cheatgrass, however fires would be infrequent and small in area.

Cutting of juniper (JUOC) leads to an increase in grey rabbitbrush and an increase in cheatgrass with or without grazing. Idaho fescue is eliminated from areas where trees are removed due to harsh microclimate and cheatgrass replaces it. The addition of inappropriate grazing would lead to a decline in the other deep-rooted perennial bunchgrasses and an increase in annuals and prickly gilia.

Fire was extremely infrequent in the historical community and limited to single tree or small area events (Miller, R. pers. comm. 2006). With juniper cutting and/or improper grazing cheatgrass will dominate the understory and the probability of ground fire increases, however without ladder fuels the fire would be small in extent. Fire would reduce the amount of sagebrush while increasing cheatgrass and other annuals.

Group 2B

Group 2B represents similar sites to group 2A however with a higher precipitation range (10-12pz) with the modal community defined by Pumice Flat 10-12pz.

Group 2B Ecological Sites

R010XA009OR	PUMICE FLAT 10-12 PZ MODAL
R010XA021OR	SHALLOW PUMICE HILLS 10-12 PZ
R010XA023OR	LAVA BLISTERS 10-12 PZ
R010XA025OR	SHALLOW NORTH 10-12 PZ
R010XA026OR	PUMICE NORTH 10-12 PZ
R010XA083OR	SANDY NORTH 10-12 PZ

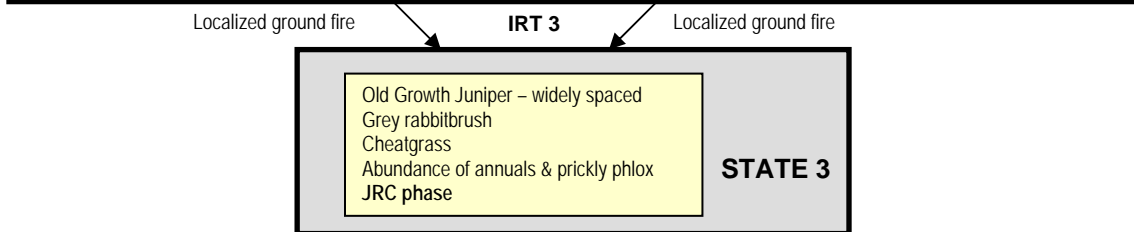
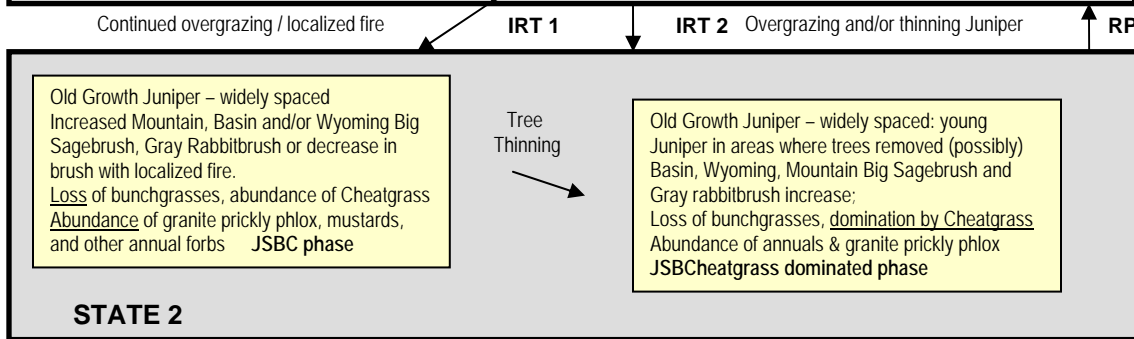
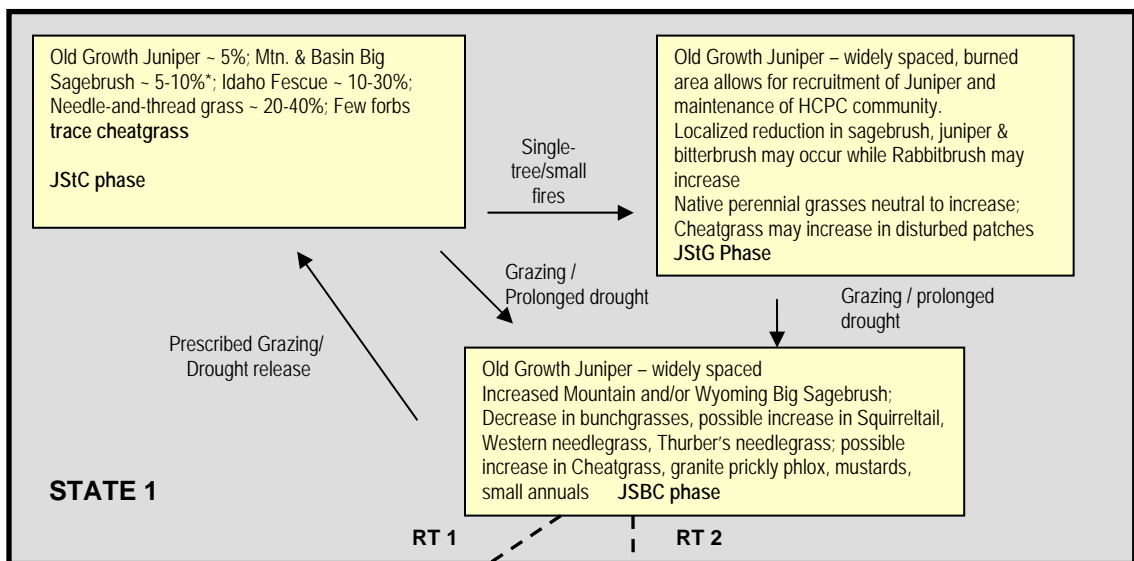
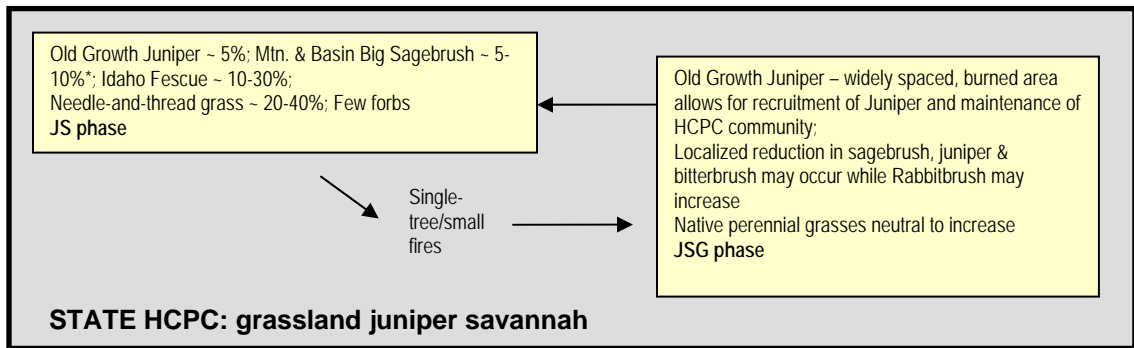
Disturbance and Treatment Response

Disturbance and treatment response is similar therefore the state-and-transition model developed for Group 2A applies to Group 2B with a few exceptions:

1. Tree recruitment is considerably greater in the 10-12 PZ sites.
2. Fire played a larger role due to increased fine fuels and was responsible for the maintenance of a grass or shrub steppe savanna. With the reduction in fire frequency trees invade rapidly reducing the understory shrub community.
3. Inappropriate grazing, juniper thinning and fire can lead to an increase in cheatgrass particularly on the south side of the juniper canopies.

GROUP 2A & 2B

**8 to 10" PZ – pumice/juniper sites
10 to 12" PZ – pumice/juniper sites**



Legend:

Plant Community Phases

- JS** Juniper Savannah
- JSG** Juniper Savannah Grassland
- JStC** Juniper Savannah trace Cheatgrass
- JSBC** Juniper Savannah Brush & Cheatgrass
- JRC** Juniper Rabbitbrush Cheatgrass

Vectors of change

- RT** reversible transition
- IRT** irreversible transition
- RP** repair pathway

Group 2

State HCPC: Community phase changes are rare, spatially dispersed and precipitated by small or single tree fires. The existence of the HCPC community today is rare or not at all, therefore it is presented in this model as a reminder of what once was.

State 1: Compositionally similar to the HCPC state with the addition of a trace of cheatgrass. Ecological function has not changed, however the resiliency of the state has been reduced by the presence of cheatgrass. Management of State 1 must include provisions for preventing cheatgrass expansion.

RT1 and 2: The JSBC phase in State 1 is recognized as the “at risk” community and the possible transition to State 2, a cheatgrass dominated state, is high. This potential transition can be managed by curtailing inappropriate grazing practices and/or mechanical tree thinning.

IRT1 and 2: Irreversible transition has occurred and a biotic threshold has been crossed. Brush species and cheatgrass control site dynamics. Deep rooted perennial bunchgrasses are gone.

RP1: requires treatment of cheatgrass and possibly brush species along with seeding of deep-rooted perennial grasses and potentially shrubs. Prescribed grazing after establishment of native species and management to prevent cheatgrass expansion.

State 2: JSBC phase is recognized by cheatgrass abundance and a significant reduction/total loss of Idaho fescue and needle-and-thread grass along with an increase in sagebrush and rabbitbrush. Localized mechanical tree removal leads to potential increases in young juniper and/or domination of cheatgrass within disturbed areas (JSBCheatgrass dominated). Spatial and temporal energy capture and nutrient cycling has been truncated. Changes in infiltration may occur with changes in plant cover and organic matter inputs.

IRT3: Increased fire frequency leads to a cheatgrass, rabbitbrush dominated site. Potential for wind and water redistribution of soil increases with loss of bunchgrasses and deep-rooted perennial shrubs.

State 3: The site has crossed an abiotic threshold characterized by soil redistribution and/or loss along with the loss of perennial bunchgrass and sagebrush seedbanks thereby resulting in the inability to sustain the establishment of perennial plants. In the long term juniper may even drop out of the community due to lack of recruitment and frequent fire. All ecological processes, hydrologic cycle, nutrient cycle and energy capture have been significantly altered.

Group 3

Group 3 consists of 7 ecological sites, two from MLRA 10B and five from 10C. Aspect is south facing with an elevation range of 3200 to 6000 feet and an average elevation range of 3629 to 5843 feet. The majority of the sites exhibit frigid soil temperatures while three sites are classified as mesic/frigid. Four of the sites within this group exhibit precipitation ranges from 12 to 16 inches including the modal community SR Mountain Shallow South 12-16 PZ. The remaining three sites are higher elevation sites with precipitation in the 16 to 20 inch range. All sites are classified as south aspect with slopes ranging from 12 to 80%. The average slope range is 12.5 to 64.0%. The soils of the modal site are typically shallow and well drained with a loamy, silt loam or clay loam surface layer about 6 inches thick. The subsoil is a clay or extremely gravelly clay loam on average about 11 inches. Depth to bedrock or an indurated pan is 10 to 20 inches. Soil temperatures are mesic to frigid with an xeric moisture regime. The historical climax plant community (HCPC) exhibits a co-dominance of mountain big sagebrush and antelope bitterbrush (3-10% composition by weight) with an understory strongly dominated by bluebunch wheatgrass (50-70% composition by weight). Several important sub-dominant species include Idaho fescue, Thurber's needlegrass and Sandberg's bluegrass. Approximate ground cover on the modal site is 40-60%. Fire, drought and herbivory were the historical disturbances responsible for maintenance of the three plant community phases contained within the HCPC state. SR Mountain Shallow South 12-16 PZ was defined as the modal community. Average production for this ecological site is 400 to 900 lbs/ac.

Group 3 Ecological Sites

R010XB046OR	JD SHRUBBY MOUNTAIN SOUTH 12-16 PZ
R010XB089OR	JD ASHY SOUTH 12-16 PZ
R010XC047OR	SR MOUNTAIN SOUTH 12-16 PZ
R010XC049OR	SR SHRUBBY MOUNTAIN SOUTH 16-20 PZ
R010XC051OR	SR HIGH MOUNTAIN SOUTH 16-20 PZ
R010XC054OR	SR MOUNTAIN SHALLOW SOUTH 12-16 PZ MODAL
R010XC055OR	SR MOUNTAIN SHALLOW SOUTH 16-20 PZ

Disturbance Response

Overgrazing may cause a decrease in bluebunch wheatgrass, the preferred perennial bunchgrass on this group of ecological sites. As bluebunch wheatgrass declines, Sandberg's bluegrass increases along with unpalatable species such as sagebrush and juniper. The potential for cheatgrass invasion is increased as the site deteriorates (State 1; JSS phase). The JSS phase within State 1 is recognized as the "at risk" plant community. If fire is suppressed juniper will continue to expand and out compete both the bunchgrass and sagebrush understory. When fine fuels are reduced to the point where fire no longer will carry the site has crossed a threshold and transitioned (IRT 1) to State 2; JSS phase (fire proof). Maturation of the juniper community leads to a juniper woodland with no more than a trace amount of sagebrush and deep-rooted perennial bunchgrasses. Juniper controls nutrient cycling, energy capture and water use (State 2: JW phase). The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines. The risk of a transition (IRT 2) over an abiotic threshold to the JW erosional phase of State 4 increases with increasing slope and increasing bare ground.

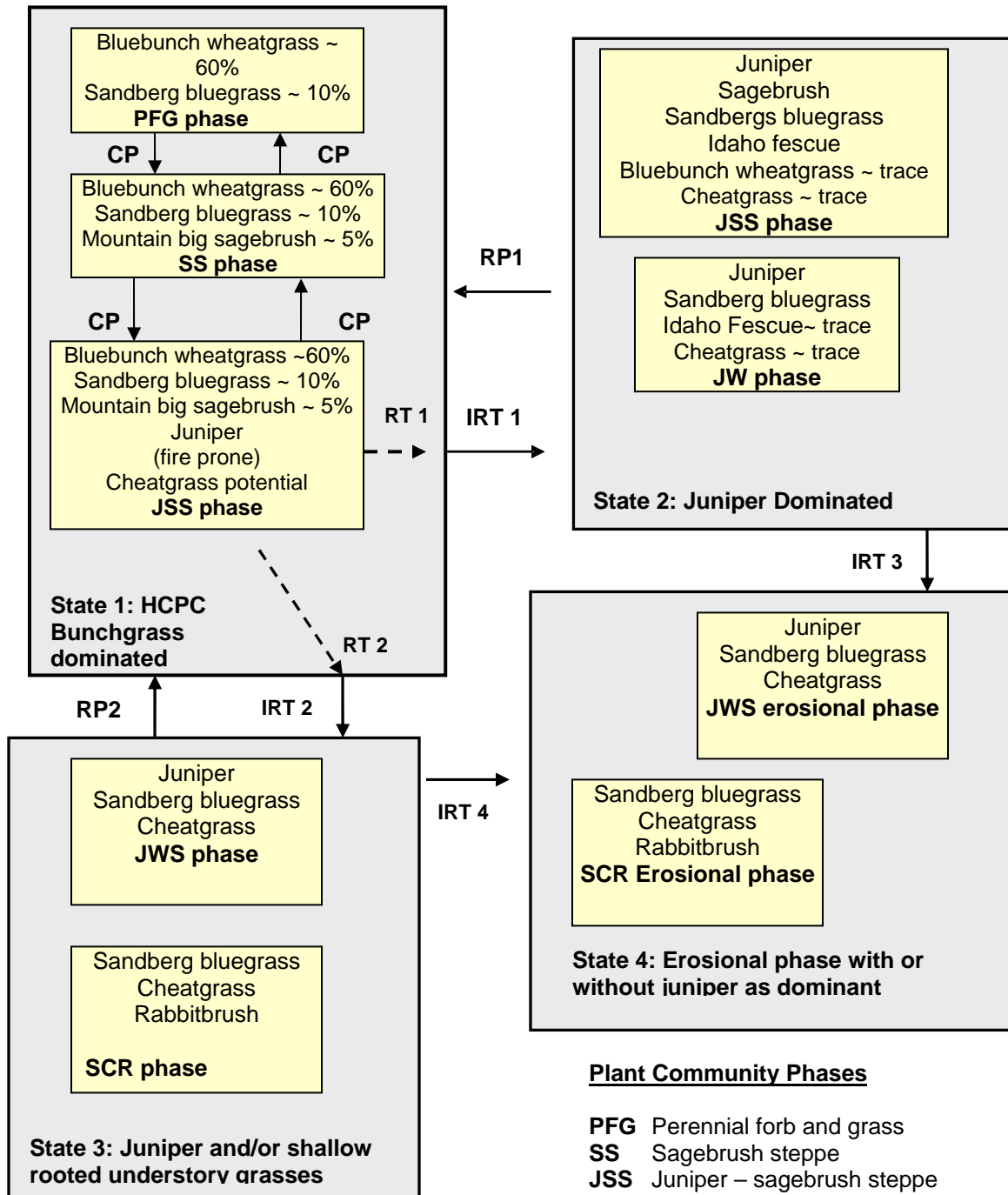
A second pathway of change from State 1: JSS phase to State 3: SCR phase exists under grazing management and/or drought that causes a loss of deep-rooted perennial bunchgrasses in combination with an increase in cheatgrass abundance. Fire within this “at-risk” community phase leads to an irreversible transition (IRT 3) to SCR phase. Alternatively, severe overgrazing in combination with lack of fire creates potential for an irreversible transition to the State 3: JWS phase characterized by juniper dominance and an understory of shallow-rooted perennial and annual grasses. The JWS phase exhibits extreme risk for fire due to the abundance of cheatgrass leading potentially to the State 3:SCR phase. The primary difference between State 2 and 3 is the amount of cheatgrass in the system and the issue of what ecosystem component is controlling site function. In State 2 juniper is the controlling agent whereas in State 3 juniper and cheatgrass play co-roles in the JWS phase while cheatgrass alone dominates site function in the SCR phase.

A third pathway of change from State 3: JWS phase to State 4: JWS erosional or SCR erosional phase exists. Severe overgrazing in combination with lack of fire creates potential for an irreversible transition (IRT 4) to the JWS erosional phase within State 4. The SCR phase within State 3 may transition to State 4 with continued abusive grazing or fire frequencies that work to increase bare ground thus facilitating both wind and water erosion of soil. The abundance of cheatgrass within State 4:JWS phase increases the likelihood of fire promoting a community pathway occurrence from the JWS erosional phase to the SCR erosional phase. Both phases are modeled within State 4 because the abiotic component of soil loss is driving ecological processes. Treatment of juniper or cheatgrass will not allow reestablishment of the HCPC state ecological function due to soil loss.

Treatment Response

South facing aspects lack resiliency and typically respond poorly to juniper removal due to shallow soils and heat. One repair pathway (RP1) located between State 1 and 2 indicates potential for rehabilitation of the juniper controlled plant community exists. The potential for success is less than that of Group 1 due primarily to aspect and soils. Treatment of juniper should incorporate lopping of limbs to provide microsites for seedling establishment along with seeding of bluebunch wheatgrass, forbs and sagebrush. Fire is not a recommended tool of rehabilitation due to the increased risk presented by cheatgrass presence. Repair pathway (RP2) is located between States 1 and 3. Treatment of the SCR phase would require chemical control of the Rabbitbrush and cheatgrass along with seeding. Treatment of the JWS phase would also require control on the cheatgrass while removing juniper and seeding desirable species. The potential for failure of rehabilitation projects within Group 3 is high. Every effort should be made to prevent threshold forcing events from occurring.

Group 3



Vectors of Change

CP = community pathway

RT = reversible transition

IRT = irreversible transition

RP = repair pathway

Plant Community Phases

PFG Perennial forb and grass

SS Sagebrush steppe

JSS Juniper – sagebrush steppe

JW Juniper woodland

JWS Juniper woodland shallow rooted grasses

SCR Sandberg bluegrass, cheatgrass & rabbitbrush

Group 3

State 1: Community phases are maintained by fire and are not negatively affected by appropriate grazing. Inappropriate grazing, reduced fire frequency or both lead to increased juniper cover and decreased cover of understory species, however the JSS community phase is still susceptible to fire. In addition due to the south facing aspect and shallow soil typical of this group of ecological sites the risk of cheatgrass invasion with inappropriate grazing is significant.

RT1: The JSS community in State 1 is recognized as the “at risk” community and the transition to State 2, a fire proof juniper woodland has begun. Reintroduction of fire is required to reverse this transition therefore grazing must be managed to promote fine fuels.

IRT 1: Irreversible transition has occurred and a biotic threshold has been crossed. Juniper controls site dynamics.

RP1: Requires mechanical treatment of juniper and potentially seeding of native grass and shrubs.

State 2: Recognized by the need to mechanically treat the juniper woodland prior to initiating a prescribed burn. JSS phase with juniper dominance, Idaho fescue beneath tree canopies, bareground interspaces with a trace of Bluebunch wheatgrass and an increase in Sandberg's bluegrass. Sagebrush is stressed and dying (JSS phase). As the juniper woodland matures, sagebrush and Bluebunch wheatgrass are eliminated and the potential for soil erosion increases (JW phase).

IRT3: Bareground areas are large and connected. The potential for soil erosion is high. Soil erosion is evident and widespread.

State 4: JW erosional phase. The site has crossed an abiotic threshold characterized by soil loss and lack of seedbank thereby resulting in the inability to sustain the establishment of perennial plants including juniper. All ecological processes, hydrologic cycle, nutrient cycle and energy capture have been significantly changed.

RT 2: Severe overgrazing and/or drought cause a significant reduction in deep rooted perennial bunchgrasses facilitating cheatgrass invasion and the potential for juniper dominance. Prescribed grazing may reverse this transition.

IRT 2: Continued abusive grazing eliminates bunchgrasses, facilitates cheatgrass as the dominant understory and juniper as the dominate overstory. Juniper out competes sagebrush creating the JWS community phase. Continued abusive grazing with fire eliminates bunchgrasses, cheatgrass dominates understory with an overstory of rabbitbrush.

State 3: Recognized by the lack of bunchgrasses and sagebrush along with an understory dominated by cheatgrass with an overstory of either juniper or rabbitbrush.

IRT 4: Severe overgrazing in combination with lack of fire creates potential for an irreversible transition to the JWS erosional phase within State 4. Abusive grazing and/or severe drought increases bareground facilitating wind and water erosion of soil. The SCR phase will transition to State 4 with similar disturbances or with frequent fire return intervals.

State 4: Recognized by wind and water erosion and redistribution of soil. Dominated by annuals and shallow rooted grasses. Juniper or rabbitbrush may be the dominate overstory. Abiotic factors control site resources and ecological function. Rehabilitation of this state may not be practical nor possible.

Group 4

Group 4 consists of 13 sites with a precipitation range of 8-12 inches. There are six non-aspect sites, six south aspect sites and one north aspect site. The slope ranges from a minimum of 0% to a maximum of 90% with the average slope ranging between 8.5 and 45%. Elevation ranges from 1000 to 4000 feet with an average elevation range between 1531 and 3146 feet. Soil temperature is mesic, including that of the modal site. The ecological sites within this group exhibit xeric to aridic moisture regimes. This site generally has soils 30 to 60 inches deep with a surface texture of stony clay loam, silty clay loam, or stony loam approximately 5 inches thick. The subsurface texture is a cobbly clay loam about 20 inches thick. This soil is moderately well drained with a slow permeability class. Five of the sites in this group exhibit a 2-10% dry weight component of old growth juniper in the potential native plant communities; Bluebunch wheatgrass and Thurber's needlegrass dominate the herbaceous communities. The shrub communities on these five sites are composed of 2-25% dry weight Basin or Wyoming Big Sagebrush. The remaining eight sites are dominated by an herbaceous understory of Bluebunch wheatgrass, Thurber's needlegrass and Needle-and-thread. Basin Big Sagebrush is the primary overstory species, making up 3-10% of the shrub cover. Ground cover is 50-60% and average production of all 13 sites ranges from 500-1000 lbs.

The working group struggled on whether or not to combine groups 4 and 5 as both groups can become dominated by juniper with the suppression of fire, however Group 4 is drier and may have multiple pathways of response including transitioning to a state dominated by annuals without juniper present. For the purpose of this document I have maintained the two groups as separate entities.

Group 4 Ecological Sites

R010XA001OR	DROUGHTY LOAM 8-10 PZ
R010XA005OR	DROUGHTY SOUTH 9-11 PZ
R010XA007OR	SOUTH 10-12 PZ
R010XA014OR	CINDERY HILLS 10-12 PZ
R010XB022OR	JD CLAYEY 9-12 PZ MODAL
R010XB023OR	JD SHALLOW 9-12 PZ
R010XB025OR	JD SANDY LOAM 9-12 PZ
R010XB035OR	JD SHALLOW NORTH 9-12 PZ
R010XB041OR	JD CLAYEY SOUTH 9-12 PZ
R010XB044OR	JD DROUGHTY SOUTH 9-12 PZ
R010XB051OR	JD SHALLOW SOUTH 9-12 PZ
R010XB052OR	JD DROUGHTY SHALLOW SOUTH 9-12 PZ
R010XA018OR	LOAMY 10-12 PZ

Disturbance Response

Overgrazing may cause a decrease in bluebunch wheatgrass, the preferred perennial bunchgrass on this group of ecological sites. As bluebunch wheatgrass declines, Sandberg's bluegrass increases along with unpalatable species such as sagebrush and juniper. The potential for cheatgrass invasion is increased as the site deteriorates (State 1; JSS or SD phase). The JSS and SD phases within State 1 are recognized as the "at risk" plant communities.

Multiple pathways of change from State 1: JSS phase exist. Depending on the particular ecological site if fire is suppressed juniper will continue to expand and out-compete both the bunchgrass and sagebrush understory. When fine fuels are reduced to the point where fire no longer will carry the site has crossed a threshold and transitioned (IRT 1a) to State 2; JSS phase (fire proof). Cheatgrass can invade these ecological sites and with inappropriate grazing will likely be found under the juniper canopy. The JSS phase within State 2 has the potential to transition (IRT 2) to State 3 with a canopy fire. Maturation of the juniper community within State 2 leads to a juniper woodland with no more than a trace amount of sagebrush and deep-rooted perennial bunchgrasses. Juniper controls nutrient cycling, energy capture and water use (State 2: JW phase). The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines. The risk of a transition (IRT 3) over an abiotic threshold to the JW erosional phase of State 4 increases with increasing slope and increasing bare ground.

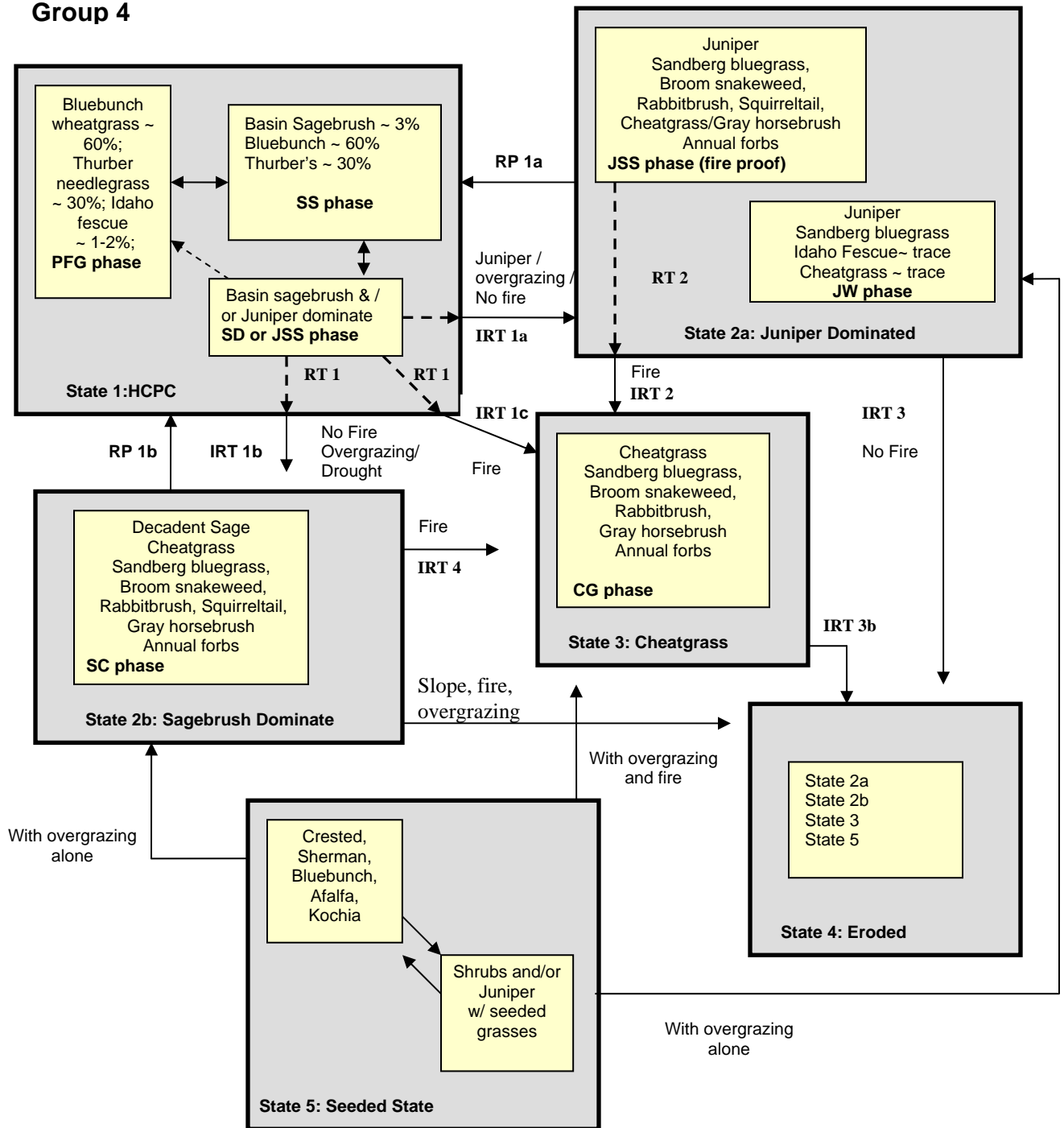
With no fire, overgrazing and or severe drought within State 1: JSS phase the perennial bunchgrasses will continue to decline while cheatgrass abundance increases and sagebrush matures further facilitating the decline in bunchgrass. This feedback continues until sagebrush and cheatgrass control stand dynamics (State 2b). Fire within this community can trigger an irreversible transition (IRT 4) to State 3. The potential for soil erosion increases as the sagebrush community matures and the understory plant community cover declines. The risk of a transition (IRT 3) over an abiotic threshold to the erosional phase of State 4 increases with increasing slope and increasing bare ground.

Many of the ecological sites within this group have been seeded to non-native grass and forb communities. Abusive grazing can cause the seeded State 5 to transition either to a decadent sagebrush cover type or a juniper dominated system. With abusive grazing and fire the seeded rangeland has the potential to convert to State 3.

Treatment Response

This group of ecological sites lack resiliency to disturbance primarily due to the characteristic annual precipitation of less than 12 inches along with south exposure and droughty soils. One repair pathway (RP1a) located between State 1 and 2a indicates potential for rehabilitation of the juniper controlled plant community exists. The potential for success is less than that of Group 1 or Group 3 due primarily to precipitation, aspect and soils and the presence of cheatgrass. Treatment of juniper should incorporate methods to provide soil cover to facilitate microsites for seedling establishment along with seeding of bluebunch wheatgrass, forbs and sagebrush. Fire is not a recommended tool of rehabilitation due to the increased risk presented by cheatgrass presence. Repair pathway (RP1b) is located between States 1 and 2b. Treatment of the SC phase would require chemical or mechanical control of the sagebrush and cheatgrass along with seeding. The potential for failure of rehabilitation projects within Group 4 is high. Every effort should be made to prevent threshold forcing events from occurring.

Group 4



Legend:

Plant Community Phases

PFG	Perennial Forb Grass
SS	Sagebrush Steppe
SD	Sagebrush Dominate
JSS	Juniper Shrub Steppe
SC	Sagebrush & Cheatgrass
CG	Cheatgrass
E	Eroded

Vectors of change

RT	reversible transition
IRT	irreversible transition
RP	repair pathway

Group 4

State 1: Community phases are maintained by fire and are not negatively affected by appropriate grazing. Inappropriate grazing, reduced fire frequency or both lead to increased sagebrush and/or juniper cover and decreased cover of understory species, however the SD or JSS community phase is still susceptible to fire. In addition due to the south facing aspect and/or shallow soil typical of this group of ecological sites the risk of cheatgrass invasion with inappropriate grazing is significant. Sites exhibit low resiliency to disturbance.

RT1: The SD or JSS community in State 1 is recognized as the “at risk” community and the transition to State 2a or 2b, a fire proof juniper woodland or decadent sagebrush / cheatgrass community has begun. If fire occurs with cheatgrass present State 1 has a high risk of transitioning to State 3.

IRT 1a: Irreversible transition has occurred and a biotic threshold has been crossed. Juniper controls site dynamics.

IRT 1b: Irreversible transition has occurred and a biotic threshold has been crossed. Sagebrush and cheatgrass controls site dynamics.

IRT 1c: Irreversible transition has occurred and a biotic threshold has been crossed. Cheatgrass controls site dynamics.

RP1a: Requires mechanical treatment of juniper and potentially seeding of native grass and shrubs. If cheatgrass is present herbicide or other treatment may be necessary.

RP1b: Requires mechanical or chemical treatment of sagebrush and treatment of cheatgrass. Desired grasses and forbs may need to be seeded.

State 2a: Recognized by the need to mechanically treat the juniper woodland. The presence of cheatgrass and site characteristics indicate prescribed burning as an extreme risk. JSS phase with juniper dominance, bareground interspaces with a trace of Bluebunch wheatgrass under tree canopies and an increase in Sandberg’s bluegrass. Sagebrush is stressed and dying (JSS phase). As the juniper woodland matures, sagebrush and Bluebunch wheatgrass are eliminated and the potential for soil erosion increases (JW phase).

State 2b: Recognized by the need to mechanically or chemically treat the sagebrush. The presence of cheatgrass and site characteristics indicate prescribed burning as an extreme risk. SC phase with sagebrush dominance, bareground interspaces with a trace of Bluebunch wheatgrass under brush canopies and an increase in Sandberg’s bluegrass, broom snakeweed and Rabbitbrush.

IRT 2: Canopy fire leading to cheatgrass domination.

IRT 3: Soil erosion is evident and widespread.

IRT 4: Canopy fire leading to cheatgrass domination.

State 3: Cheatgrass dominated state maintained through frequent fire.

State 4: erosional phase of State 2a, 2b, or 3. The site has crossed an abiotic threshold characterized by soil loss and lack of seedbank thereby resulting in the inability to sustain the establishment of perennial plants including juniper. All ecological processes, hydrologic cycle, nutrient cycle and energy capture have been significantly changed.

State 5: Seeded. State 5 is a common occurrence on many of these ecological sites therefore it has been included in the model. Overgrazing of the seeded rangeland can cause a reduction in deep rooted perennial grasses in favor of Sandberg’s bluegrass, cheatgrass, sagebrush and or juniper. State 5 can transition to any of the other states with inappropriate grazing, fire or both.

Group 5

Group 5 appears to be a mixed bag of sites with aspects ranging from non-aspect, through both north and south facing slopes. However, the south facing aspects all occur in 12-16 inch precipitation zones and the north facing aspects within the 9-12 inch precipitation zone with the exception of JD North 12-16 PZ which exhibits a xeric soil moisture regime. The differences in climate, aspect and soil smooth out the dissimilarities and allow similar response to similar disturbances across sites thus justifying the grouping.

Of the 13 sites in Group 5, four sites exhibit a north aspect, three have south aspects and six are non-aspects. The slopes range from 0-70% with an average range of 8.0 to 45.0%. Soil temperature is primarily mesic to mesic-frigid. The moisture regimes are generally xeric. Elevation ranges from 1300 to 4800 feet with an average elevation range of 2046-3692 feet. Two modal sites were identified for this group: JD Clayey 12-16 PZ and Loamy 9-12 PZ. The JD Clayey 12-16 PZ modal site typically has moderately deep to deep soils which are moderately well drained. The surface layer consists of clay loam or silty clay loam approximately 8 inches thick. The subsurface texture group is clayey, often a cobbly clay loam about 25 inches thick. The JD Loamy 9-12 PZ modal site expresses soils with depths of 16-62 inches, fairly deep with some shallow pockets. The soil originated from basalt parent material formed from alluvium, colluvium, and loess. The surface texture consists of stony, gravelly and ashy loam with a loamy subsurface texture group. The soil is well drained and has moderately slow to slow permeability with a mesic soil temperature and xeric moisture regime. Juniper occurs as a 1-5% dry weight component of old growth on five sites while a 2-10% dry weight component of Basin Big Sagebrush is the primary overstory species on the remaining eight sites. However, on modal site JD Clayey 12-16, Antelope bitterbrush holds a dominating presence within the shrub community. Bluebunch wheatgrass strongly dominates the understory on eight sites and is also a component of the community on the remaining five sites that are dominated by Idaho Fescue or Thurber's needlegrass.

Group 5 Ecological Sites

R010XB013OR	JD SHRUBBY LOAM 12-16 PZ
R010XB030OR	JD LOAMY 12-16 PZ MODAL
R010XB031OR	JD SHALLOW 12-16 PZ
R010XB033OR	JD SHALLOW NORTH 12-16 PZ
R010XB034OR	JD LOAMY 9-12 PZ MODAL
R010XB045OR	JD CLAYEY SOUTH 12-16 PZ
R010XB047OR	JD SHALLOW SOUTH 12-16 PZ
R010XB048OR	JD LOAMY SOUTH 12-16 PZ
R010XB053OR	JD DROUGHTY FAN 9-12 PZ
R010XB063OR	JD NORTH 9-12 PZ
R010XB064OR	JD DROUGHTY NORTH 9-12 PZ
R010XB070OR	JD NORTH 12-16 PZ
R010XB027OR	JD CLAYEY 12-16 PZ

Disturbance Response

Overgrazing may cause a decrease in bluebunch wheatgrass and Idaho fescue while Sandberg bluegrass increases. If deterioration continues Sandberg bluegrass may decline with an increase in annual weeds and invasive brush species. Cheatgrass, Medusahead, snakeweed, gray Rabbitbrush and juniper often invade. The potential for cheatgrass or Medusahead invasion is increased as the site deteriorates (State 1; JSS or SD phase). The JSS and SD phases within State 1 are recognized as the “at risk” plant communities.

The primary difference between Group 4 and 5 is the rate of change and difficulty in restoration. Group 4 is drier and the rate of change with disturbance is expected to be quicker while restoration is much more difficult. The model and pathways described are mirror images of group 4 with the exception of the presence of Medusahead potential within group 5.

Multiple pathways of change from State 1: JSS phase exist. Depending on the particular ecological site if fire is suppressed juniper will continue to expand and out-compete both the bunchgrass and sagebrush understory. When fine fuels are reduced to the point where fire no longer will carry the site has crossed a threshold and transitioned (IRT 1a) to State 2; JSS phase (fire proof). Cheatgrass and / or Medusahead can invade these ecological sites and with inappropriate grazing will likely be found under the juniper canopy. The JSS phase within State 2 has the potential to transition (IRT 2) to State 3 with a canopy fire. Maturation of the juniper community within State 2 leads to a juniper woodland with no more than a trace amount of sagebrush and deep-rooted perennial bunchgrasses. Juniper controls nutrient cycling, energy capture and water use (State 2: JW phase). The potential for soil erosion increases as the juniper woodland matures and the understory plant community cover declines. The risk of a transition (IRT 3) over an abiotic threshold to the JW erosional phase of State 4 increases with increasing slope and increasing bare ground.

With no fire, overgrazing and or severe drought within State 1: JSS phase the perennial bunchgrasses will continue to decline while cheatgrass and / or Medusahead abundance increases and sagebrush matures further facilitating the decline in bunchgrass. This feedback continues until sagebrush and annual grasses control stand dynamics (State 2b). Fire within this community can trigger an irreversible transition (IRT 4) to State 3. The potential for soil erosion increases as the sagebrush community matures and the understory plant community cover declines. The risk of a transition (IRT 3) over an abiotic threshold to the erosional phase of State 4 increases with increasing slope and increasing bare ground.

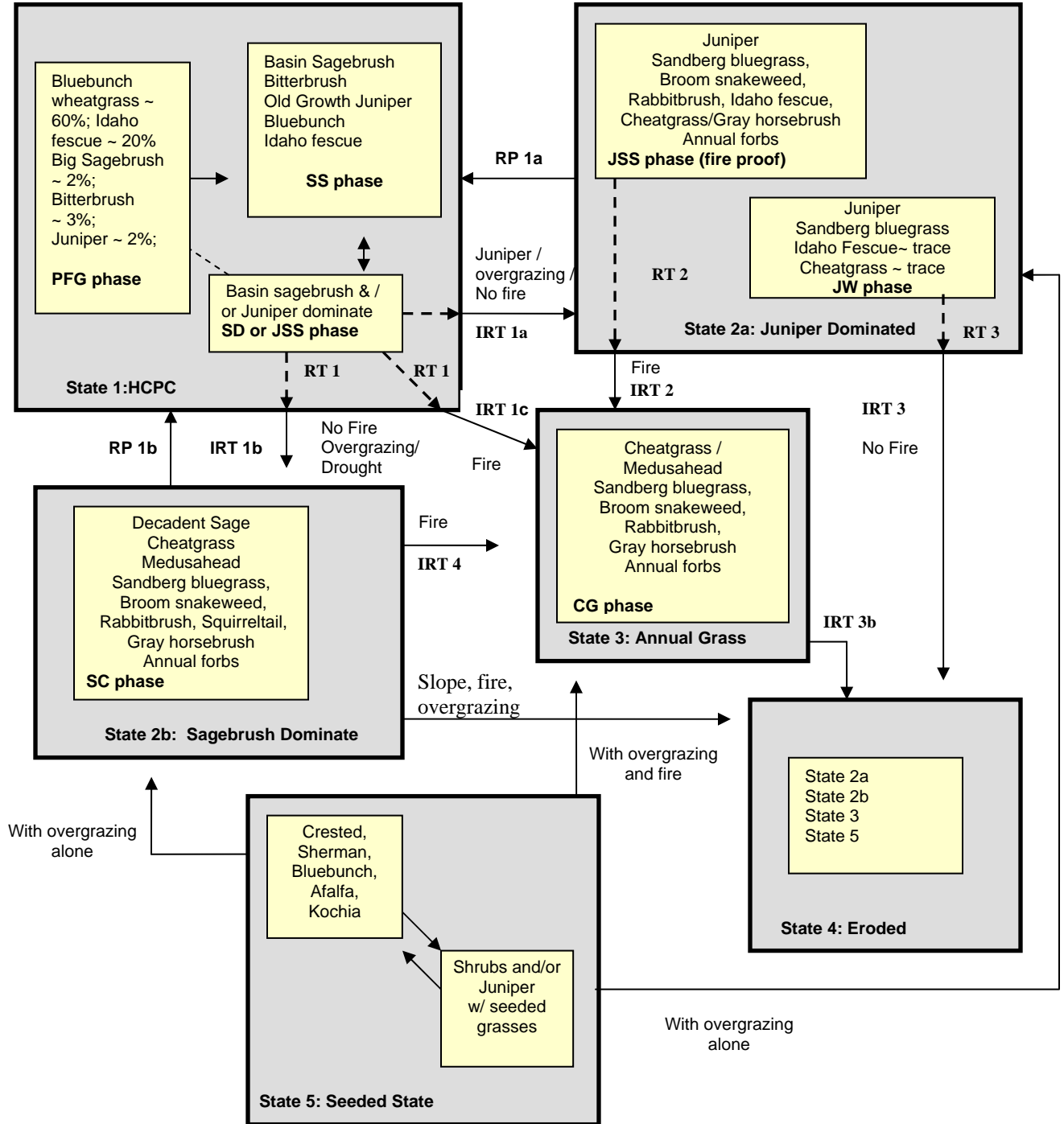
Many of the ecological sites within this group have been seeded to non-native grass and forb communities. Abusive grazing can cause the seeded State 5 to transition either to a decadent sagebrush cover type or a juniper dominated system. With abusive grazing and fire the seeded rangeland has the potential to convert to State 3.

Treatment Response

This group of ecological sites is slightly more resilient to disturbance primarily due to the characteristic annual precipitation of greater than 12 inches or less than 12 inches combined with a north aspect. One repair pathway (RP1a) located between State 1 and 2a indicates potential for rehabilitation of the juniper controlled plant community exists. The potential for success is greater than that of Group 4; however Medusahead could cause long term issues requiring

continuous treatment. Treatment of juniper should incorporate methods to provide soil cover to facilitate microsites for seedling establishment along with seeding of bluebunch wheatgrass, Idaho fescue and forbs and sagebrush. Fire is not a recommended tool of rehabilitation due to the increased risk presented by the presence of annual grasses. Repair pathway (RP1b) is located between States 1 and 2b. Treatment of the SC phase would require chemical or mechanical control of the sagebrush and annual grass along with seeding. The potential for failure of rehabilitation projects within Group 5 increases with the presence of Medusahead. Every effort should be made to prevent annual grass establishment.

Group 5



Legend:

Plant Community Phases

PFG	Perennial Forb Grass
SS	Sagebrush Steppe
SD	Sagebrush Dominate
JSS	Juniper Shrub Steppe
SC	Sagebrush & Cheatgrass
CG	Cheatgrass
E	Eroded

Vectors of change

RT	reversible transition
IRT	irreversible transition
RP	repair pathway

Group 5

State 1: Community phases are maintained by fire and are not negatively affected by appropriate grazing. Inappropriate grazing, reduced fire frequency or both lead to increased sagebrush and/or juniper cover and decreased cover of understory species, however the SD or JSS community phase is still susceptible to fire. In addition due to the south facing aspect and/or shallow soil typical of this group of ecological sites the risk of cheatgrass invasion with inappropriate grazing is significant. Sites exhibit low resiliency to disturbance.

RT1: The SD or JSS community in State 1 is recognized as the “at risk” community and the transition to State 2a or 2b, a fire proof juniper woodland or decadent sagebrush / cheatgrass / medusahead community has begun. If fire occurs with annual grasses present State 1 has a high risk of transitioning to State 3. Reduction in grazing pressure may reverse this transition.

IRT 1a: Irreversible transition has occurred and a biotic threshold has been crossed. Juniper controls site dynamics.

IRT 1b: Irreversible transition has occurred and a biotic threshold has been crossed. Sagebrush and annual grass controls site dynamics.

IRT 1c: Irreversible transition has occurred and a biotic threshold has been crossed. Cheatgrass and / or Medusahead controls site dynamics.

RP1a: Requires mechanical treatment of juniper and potentially seeding of native grass and shrubs. If annual grass is present herbicide or other treatment may be necessary.

RP1b: Requires mechanical or chemical treatment of sagebrush and treatment of cheatgrass and / or medusahead. Desired grasses and forbs may need to be seeded.

State 2a: Recognized by the need to mechanically treat the juniper woodland. The presence of annual grass and site characteristics indicate prescribed burning as an extreme risk. JSS phase with juniper dominance, bareground interspaces with a trace of Bluebunch wheatgrass under tree canopies and an increase in Sandberg’s bluegrass. Sagebrush is stressed and dying (JSS phase). As the juniper woodland matures, sagebrush and Bluebunch wheatgrass are eliminated and the potential for soil erosion increases (JW phase). Idaho fescue holds on under trees on north facing aspects.

State 2b: Recognized by the need to mechanically or chemically treat the sagebrush. The presence of annual grass and site characteristics indicate prescribed burning as an extreme risk. SC phase with sagebrush dominance, bareground interspaces with a trace of Bluebunch wheatgrass under brush canopies and an increase in Sandberg’s bluegrass, broom snakeweed and Rabbitbrush.

IRT 2: Canopy fire leading to annual grass domination.

IRT 3: Soil erosion is evident and widespread.

IRT 4: Canopy fire leading to annual grass domination.

State 3: Annual grass dominated state maintained through frequent fire.

State 4: erosional phase of State 2a, 2b, or 3. The site has crossed an abiotic threshold characterized by soil loss and lack of seedbank thereby resulting in the inability to sustain the establishment of perennial plants including juniper. All ecological processes, hydrologic cycle, nutrient cycle and energy capture have been significantly changed.

State 5: Seeded. State 5 is a common occurrence on many of these ecological sites therefore it has been included in the model. Overgrazing of the seeded rangeland can caused a reduction in deep rooted perennial grasses in favor of sandberg’s bluegrass, cheatgrass, sagebrush and or juniper. State 5 can transition to any of the other states with inappropriate grazing, fire or both.

Group 6

Group 6 consists of thirteen sites, 3 with frigid soil temperatures and 3 with mesic. Initially the workgroup discussed splitting this group into two on the basis of soil temperature, however the soil scientists within the team indicated the three sites with frigid soil temperatures may be inaccurately described. Frigid soil temperatures are indicated with elevation in the 4000 to 4500 foot range. The three sites classified with frigid soil regimes exhibit elevation ranges of 2700 to 4400 feet therefore the working group decided to maintain these ecological sites within Group 6.

The 13 sites in this group have a precipitation range of 9-12 inches. The majority of the sites are non-aspect with four south aspect sites and one north aspect site. Elevation ranges from 1300 to 4400 feet with an average range of 2108 to 3800 feet. The SR Clayey 9-12 PZ modal site has soils ranging from shallow to deep, with the deeper soils exhibiting a duripan or cemented hardpan between 20 and 30 inches. The soil is well-drained soil with a surface layer of loam or silt loam material approximately 8 inches thick followed by subsoil of clay, clay loam or silty clay loam. Permeability is moderate to very slow while the potential for erosion is moderate to severe. Soil temperature is mesic and the moisture regime is aridic to xeric.

The SR Mountain Clayey 9-12 PZ modal site has a well drained, moderately deep soil of 20 to 40 inches with an indurated pan or bedrock feature between 20 to 40 inches. The surface layer is a silt loam to silty clay loam about 8 inches thick followed by a subsurface of clay loam to clay. The soils have a mesic soil temperature and a predominately xeric soil moisture regime. Permeability is moderate and potential for erosion is moderate to severe. All sites are characterized by a shrub overstory, consisting primarily of Wyoming and Basin big sagebrush with an herbaceous understory dominated by Bluebunch wheatgrass or Idaho fescue. Western juniper is not a part of the historical plant community.

Group 6 Ecological Sites

R010XB019OR	JD GUMBO 9-12 PZ
R010XC018OR	SR ADOBELAND 9-12 PZ
R010XC020OR	SR LOAMY 9-12 PZ
R010XC021OR	SR CLAYEY 9-12 PZ MODAL
R010XC030OR	SR MOUNTAIN LOAMY 9-12 PZ
R010XC031OR	SR MOUNTAIN CLAYEY 9-12 PZ MODAL
R010XC035OR	SR SHALLOW 9-12 PZ
R010XC036OR	SR MOUNTAIN SHALLOW 9-12 PZ
R010XC043OR	SR CLAYEY SOUTH 9-12 PZ
R010XC044OR	SR SOUTH SCHIST 9-12 PZ
R010XC050OR	SR SHALLOW SOUTH 9-12 PZ
R010XC052OR	SR SHALLOW SOUTH SCHIST 9-12 PZ
R010XC064OR	SR NORTH 9-12 PZ

Disturbance Response

Overgrazing may cause a decrease in bluebunch wheatgrass and Idaho fescue while Sandberg bluegrass, bottlebrush squirreltail and sagebrush increase. If deterioration continues Sandberg bluegrass may decline with an increase in cheatgrass, medusahead, gray rabbitbrush and sagebrush. The potential for cheatgrass or medusahead invasion is increased as the site

deteriorates (State 1: SD phase). The SD phase within State 1 is recognized as the “at risk” plant community phase.

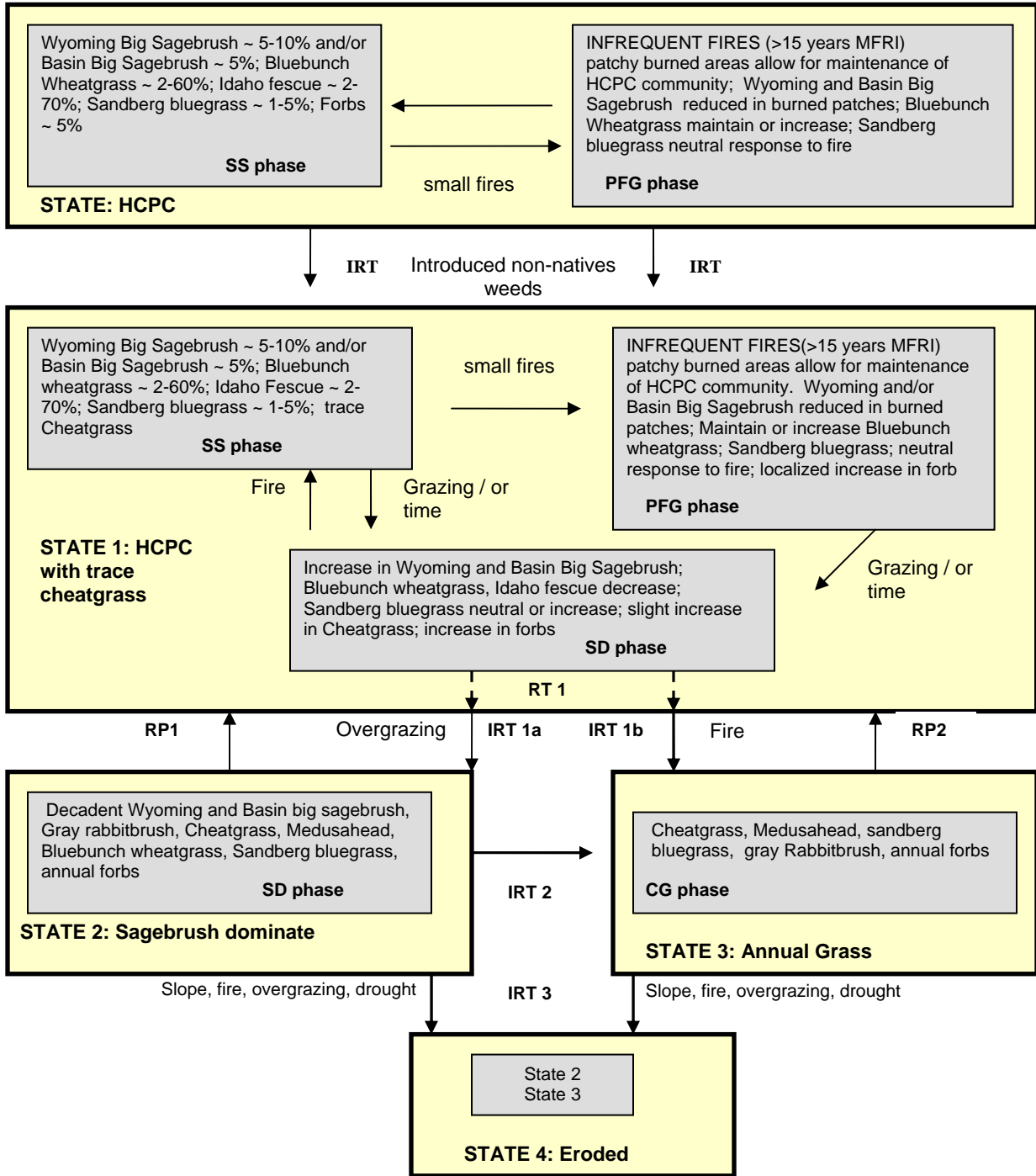
Thickening and aging of the sagebrush overstory increases competition for resources with the herbaceous understory causing a decline in deep-rooted perennial grasses an increase in bare ground and a reduction in fine fuels necessary to carry fire. If inappropriate grazing occurs the SD phase of State 1 can transition to State 2 (IRT 1a) where decadent sagebrush control site function and the potential for fire is greatly reduced. In the event of a stand replacing fire within the SD phase of State 2 the community will cross a threshold and transition (IRT 2) to State 3, an annual grass dominated community. The SD phase of State 1 can also experience a stand replacing fire causing an irreversible transition (IRT 1b) to the annual grassland dominated State 3. The potential for soil erosion increases as the sagebrush matures and the understory plant community cover declines. The risk of an irreversible transition (IRT 3) over an abiotic threshold to the erosional phase of State 4 increases with increasing slope and increasing bare ground. Both State 2 and State 3 are at risk of transitioning to an eroded phase with continued overgrazing and/or fire.

Treatment Response

One repair pathway (RP1) located between State 1 and 2 indicates potential for rehabilitation of the decadent sagebrush plant community. Rehabilitation of State 2 will require mechanical or chemical treatment of sagebrush along with seeding of the desired plant community. Cheatgrass or medusahead could cause long term issues requiring continuous treatment. Fire is not a recommended tool of rehabilitation due to the increased risk presented by the presence of annual grasses. Repair pathway (RP2) is located between States 1 and 3. Treatment of the CG phase would require chemical or mechanical control of the annual grasses along with seeding of desired species. The risk of failure is high and it may be wise to pursue a pathway of assisted succession, i.e., planting an aggressive perennial grass such as Crested wheatgrass followed years later with the reintroduction of native grasses and forbs. Every effort should be made to prevent annual grass establishment.

Group 6

**9-16" PZ – mesic (frigid near mesic), typically clay subsoils;
production <1000 #**



Legend:

Plant Community Phases

- PFG** Perennial Forb Grass
- SS** Sagebrush Steppe
- SD** Sagebrush Dominate
- JSS** Juniper Shrub Steppe
- SC** Sagebrush & Cheatgrass
- CG** Cheatgrass
- E** Eroded

Vectors of change

- RT** reversible transition
- IRT** irreversible transition
- RP** repair pathway

Group 6

State 1: Community phases are maintained by fire and are not negatively affected by appropriate grazing. Inappropriate grazing, reduced fire frequency or both lead to increased sagebrush decreased cover of understory species, however the SD community phase is still susceptible to fire. In addition the risk of cheatgrass invasion with inappropriate grazing is significant on these ecological sites. Sites exhibit low resiliency to disturbance.

RT1: The SD in State 1 is recognized as the “at risk” community and the transition to State 2a or 2b, a fire proof juniper woodland or decadent sagebrush / cheatgrass / medusahead community has begun. If fire occurs with annual grasses present State 1 has a high risk of transitioning to State 3. Reduction in grazing pressure may reverse this transition.

IRT 1a: Irreversible transition has occurred and a biotic threshold has been crossed. Sagebrush controls site dynamics.

IRT 1b: Irreversible transition has occurred and a biotic threshold has been crossed. Annual grass controls site dynamics.

RP1: Requires mechanical or chemical treatment of sagebrush and treatment of cheatgrass and / or medusahead. Desired grasses and forbs may need to be seeded.

RP2: Requires mechanical and / or chemical treatment of annual grasses along with seeding of perennial grass and shrubs.

State 2: Recognized by the need to mechanically or chemically treat the sagebrush. The presence of annual grass and site characteristics indicate prescribed burning as an extreme risk. SC phase with sagebrush dominance, bareground interspaces with a trace of Bluebunch wheatgrass under brush canopies and an increase in Sandberg’s bluegrass, and rabbitbrush.

IRT 2: Canopy fire leading to annual grass domination.

IRT 3: Soil erosion is evident and widespread.

State 3: Annual grass dominated state maintained through frequent fire.

State 4: erosional phase of State 2 or 3. The site has crossed an abiotic threshold characterized by soil loss and lack of seedbank thereby resulting in the inability to sustain the establishment of perennial plants. All ecological processes, hydrologic cycle, nutrient cycle and energy capture have been significantly changed.

Group 7

Group 7 includes all sites where low sage is the dominant shrub on the site. The two low sages are low sagebrush and scabland or stiff sagebrush. Production ranges on average from 300 to 800 lbs. per acre with the average at just under 550 pounds.

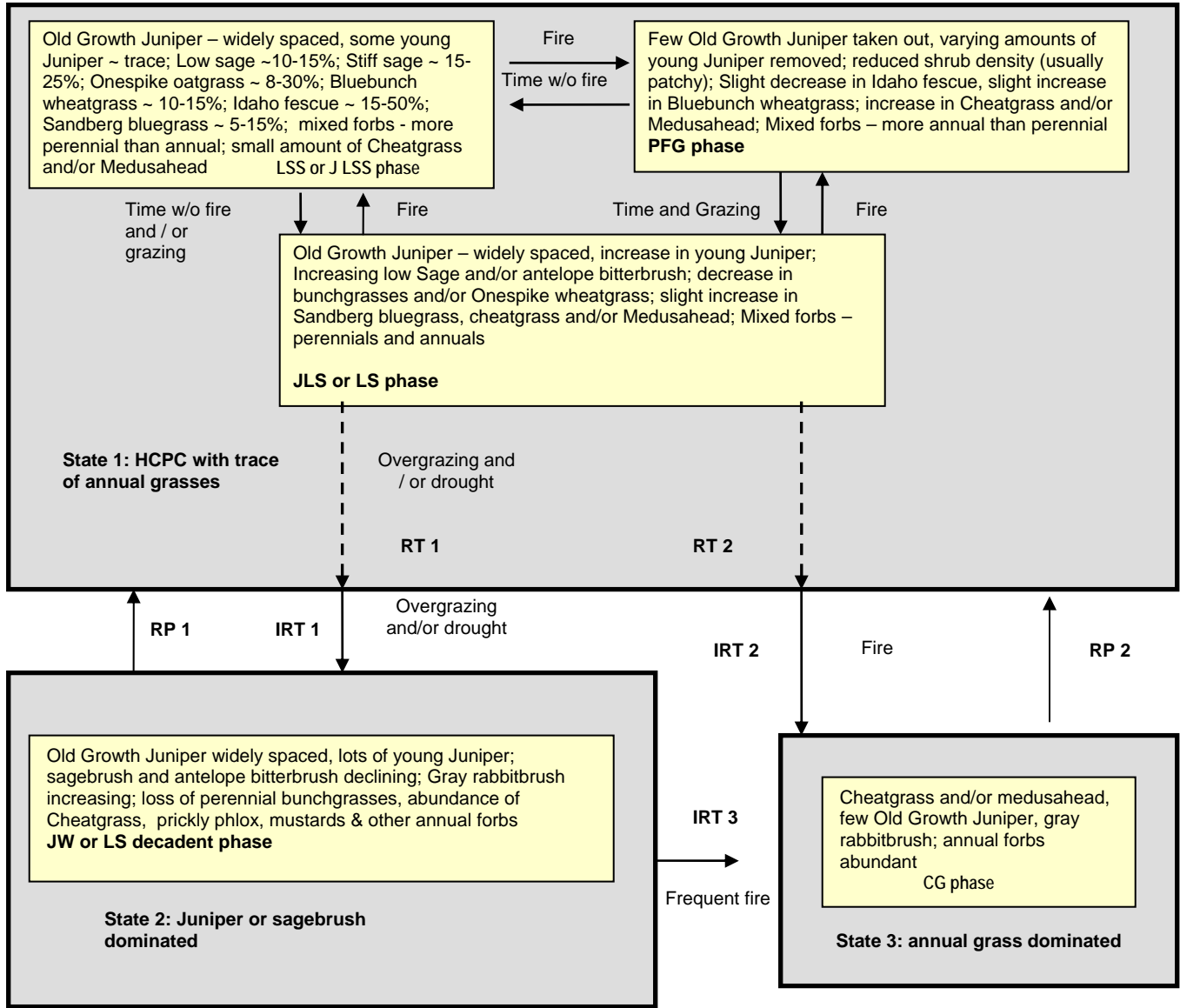
The precipitation range for 13 ecological sites contained within Group 7 ranges from 9-20 inches. Elevation ranges from 1500-6000 feet and the average elevation range from 3469-4977 feet. Slope ranges from flat to 60% and the average slope is 5-28%. Two sites have north aspects, one site has a south aspect, and the rest are non-aspect sites. The SR Mountain Very Shallow 12-16 PZ modal site has soils that are typically well drained and very shallow. The soil temperature is frigid to near frigid with a xeric moisture regime. The surface layer is a loam, very cobbly loam, or very stony loam 3-6 inches thick. The subsoil is a heavy loam, very cobbly loam or very cobbly silty clay loam over very cobbly clay from 6-11 inches thick. Depth to an indurated pan or dense subsoil is less than 10 inches. The potential for erosion is moderate to severe. The JD Mountain Claypan 12-16 PZ modal site has shallow soils with a strongly developed claypan over alluvium or bedrock. The surface layer varies between loam and clay loam 5 to 10 inches thick. Variable amounts of coarse fragments are present. There is an abrupt boundary where the surface layer meets the subsoil; the subsoil is clay. The soil temperature is frigid with a xeric or aridic moisture regime. Permeability is moderate in the surface layer but slow in the subsoil due to texture type. Available water holding capacity is 2-4 inches and the potential for erosion is moderate to severe. Juniper trees are present on seven of the sites and comprise 1-15% of the dry weight composition of the overstory tree community. Low sagebrush is dominant on eight of the sites, covering 8-15% of dry weight composition of those shrub communities. On six of these eight sites, Idaho Fescue dominates the herbaceous community. Bluebunch wheatgrass is dominant on the other two sites. Scabland sagebrush is dominant on four sites. On the scabland sagebrush dominated sites, Bluebunch wheatgrass, Sandberg's bluegrass, and one-spike oatgrass occupy the herbaceous understory. The Buckwheat Scabland 9-12 PZ ecological site does not have significant shrubs present; juniper and Sandberg's bluegrass dominate.

Group 7

JD DROUGHTY CLAYPAN 9-12 PZ
JD CLAYPAN 9-12 PZ
JD VERY SHALLOW 12-16 PZ
JD MOUNTAIN CLAYPAN 12-16 PZ **MODAL**
JD MOUNTAIN CLAYPAN NORTH 12-16 PZ
JD MOUNTAIN VERY SHALLOW SLOPES 12-16 PZ
JUNIPER CLAYPAN NORTH 9-12 PZ
JD ASHY CLAYPAN 9-12 PZ
JUNIPER CLAYPAN SOUTH 10-14 PZ
SR VERY SHALLOW 9-12 PZ
SR MOUNTAIN VERY SHALLOW 12-16 PZ **MODAL**
SR MOUNTAIN VERY SHALLOW 16-20 PZ
BUCKWHEAT SCABLAND 9-12 PZ

Group 7

Low Sage/ Stiff Sage Juniper Sites



LEGEND

Plant Community Phases

- PFG Perennial forb and grass
- LSS Low sagebrush steppe
- JLSS Juniper low sagebrush steppe
- JLS Juniper & low sagebrush
- LS Low sagebrush
- JW Juniper woodland
- CG Cheatgrass (annual grass)

Vectors of Change

- RT = reversible transition
- IRT = irreversible transition
- RP = repair pathway

Group 7

State 1: Represents the historical plant community with the potential addition of a trace amount of cheatgrass or Medusahead. Sites are either dominated with low sagebrush or stiff sagebrush some with a small percentage of old growth juniper. Infrequent fire maintained site dynamics. Grazing and / or time between fire can lead to an increase in juniper and / or sage cover with a corresponding decrease in bunchgrasses. If annual grasses are present they may increase with grazing pressure. Sites exhibit high resiliency to disturbance.

RT1: The JLS or LS phase in State 1 is recognized as the “at risk” community and the transition to State 2 or 3, a juniper woodland or decadent sagebrush / cheatgrass / medusahead community has begun. Fire occurrence is rare however if fire occurs with annual grasses present State 1 has a high risk of transitioning to State 3. Reduction in grazing pressure may result in a reversal in this transition.

IRT 1: Irreversible transition has occurred and a biotic threshold has been crossed. Sagebrush or juniper controls site dynamics.

IRT 2: Irreversible transition has occurred and a biotic threshold has been crossed. Annual grass controls site dynamics.

RP1: Requires mechanical or chemical treatment of sagebrush or mechanical treatment of juniper along with treatment of cheatgrass and / or medusahead. Desired grasses and forbs may need to be seeded.

RP2: Requires mechanical and / or chemical treatment of annual grasses along with seeding of perennial grass and shrubs.

State 2: Recognized by the need to mechanically or chemically treat the sagebrush or juniper. The presence of annual grass and site characteristics indicate prescribed burning as an extreme risk. JW phase is described by juniper dominance, reduced sagebrush and bitterbrush, increased bareground with a trace of Bluebunch wheatgrass or Idaho fescue under brush canopies and an increase in Sandberg's bluegrass, annual grasses and rabbitbrush. The LS phase exhibits decadent sagebrush and a similar understory to the JW phase. State 2 is highly resilient to change, however if a crown fire should occur an irreversible transition to State 3 is a significant risk.

IRT 3: Canopy fire leading to annual grass domination.

Group 8

These six sites are characterized by rockland and escarpment features. Precipitation ranges from 9-24 inches with the majority of the sites in the 9-12 inch range. Elevation ranges from 1300 to 6000 feet and soil temperatures are mesic to mesic-frigid. Four of the sites are non-aspect and two sites are south aspect. Slopes range from 2-100% and the average slope ranges from 14 to 75%. The primary physical features driving plant community dynamics are the rockland and escarpment site characteristics. Two modal sites were identified for this group: JD Mahogany Rockland 9-12 PZ ecological site and the JD Mahogany Rockland 12-16 PZ. Both sites typically have very shallow soils (\leq 10 inches) over fractured basalt bedrock. The soils are well drained with areas of rock outcroppings. Texture is a gravelly, stony, or cobbly loam typically less than 10 inches deep to an indurated pan or bedrock. Water holding capacity is low (2 inches) and permeability is moderate. These soils have little structural development and therefore have severe erosion potential.

The potential native plant community on four of the six sites is dominated by Curl leaf mountain mahogany with antelope bitterbrush as a sub-dominant. The other two sites are Antelope bitterbrush or Wyoming big sagebrush dominated. The bitterbrush composes 35-45% of the dry weight of the shrub community on the SR Terrace Escarpment site and Wyoming big sagebrush makes up 5-10% dry weight of the shrub composition on the SR Shallow Escarpment site. The herbaceous community on five sites is dominated by Bluebunch wheatgrass. Needle and thread grass dominates on the SR Terrace Escarpment site. Old growth juniper is present on three sites.

Group 8

R010XB057OR	JD MAHOGANY ROCKLAND 9-12 PZ	MODAL
R010XB058OR	JD MAHOGANY ROCKLAND 12-16 PZ	MODAL
R010XC056OR	SR TERRACE ESCARPMENT 9-12 PZ	
R010XC057OR	SR SHALLOW ESCARPMENT 9-12 PZ	
R010XC058OR	SR GREASEBUSH-MAHOGANY ROCKLAND 9-12 PZ	
R010XC059OR	SR MAHOGANY ROCKLAND 12+ PZ	

Disturbance Response

Infrequent and typically small area fires were the historical disturbance that maintained the historical plant community. State 1 describes the community composition of the mahogany dominated ecological sites however the antelope bitterbrush or Wyoming sagebrush sites within the rockland type can be described by this model. State 1 represents the historical plant community with the addition of a trace of cheatgrass. State 1 will maintain its ecological integrity under appropriate grazing management and fire sufficient to suppress juniper expansion or shrub decadence. If grazing and/or prolonged drought is intense enough to cause a significant decline in fine fuels and a reduction in the frequency of fire, juniper expansion will occur. Once the community is fire proof an irreversible transition (IRT 1) has occurred and State 2 plant community phase JMM develops. If abusive grazing and/or prolonged drought continue the deep rooted perennial bunchgrasses will disappear and either Sandbergs bluegrass or cheatgrass will be dominate in the understory (JW phase). The potential for fire is greatly reduced however if a crown fire should occur the next irreversible transition (IRT 2) could occur with cheatgrass becoming the driver of ecological function (State 3). A secondary irreversible transition (IRT 3) from State 2 to State 4 could occur with continued abusive grazing and/or drought. Deep rooted

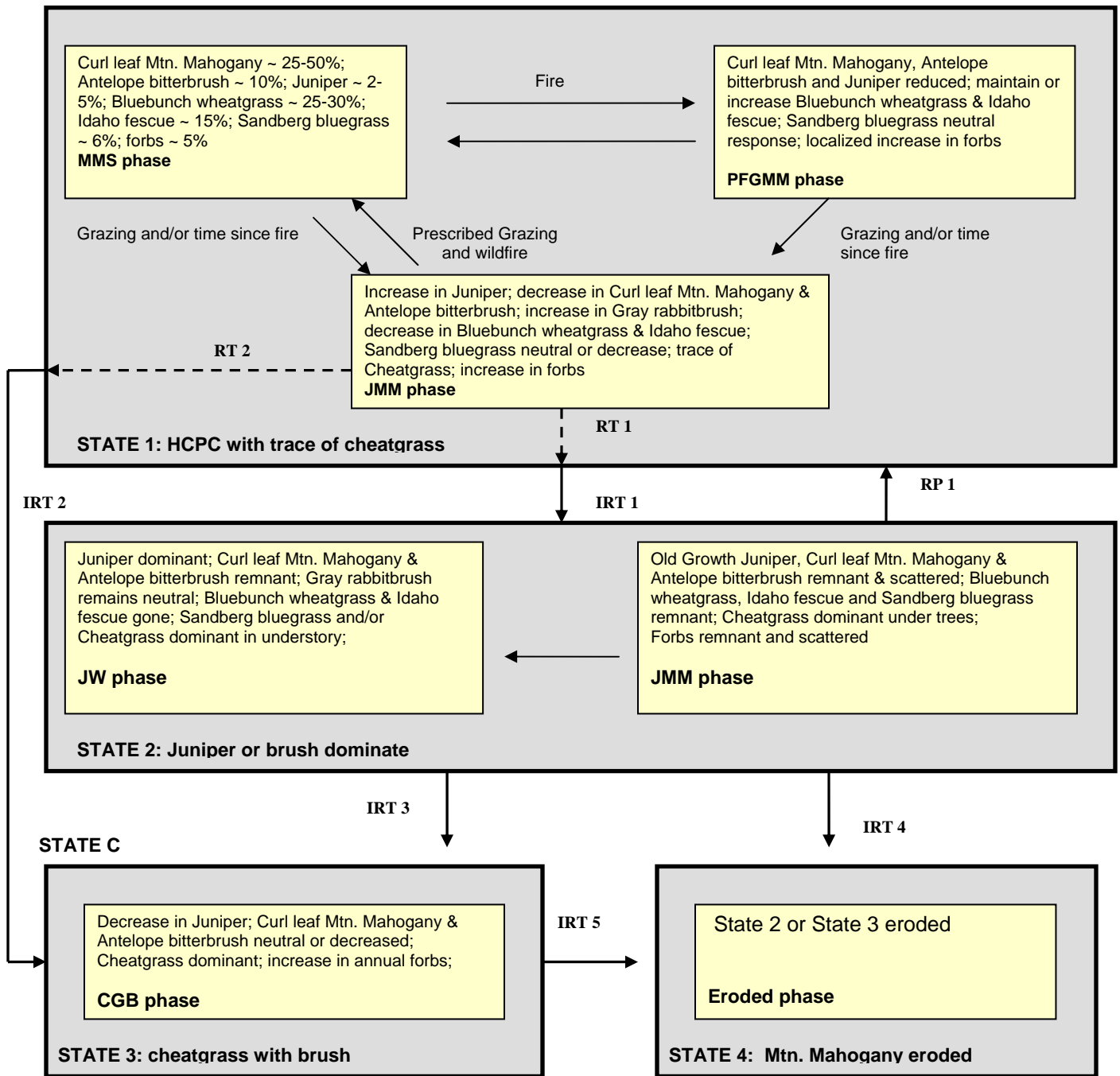
perennial grasses are eliminated, fire does not occur, bare ground increases and soil erosion occurs. State 4 is an eroded phase of either State 2 or 3 and ecological processes are controlled by physical factors. State 3 with continued fire could transition (IRT 4) across an abiotic threshold to the eroded State 4.

Treatment Response

These sites are slow to change and highly resistant to disturbance. In order to restore State 2 to State 1 mechanical and/or chemical treatment of the controlling brush species is required along with treatment of cheatgrass. Seeding of desired species and prescribed grazing may also be required. The ability to rehabilitate State 3 or State 4 is not known and therefore not discussed.

GROUP 8

**9-16" PZ Mountain Mahogany/Bitterbrush sites
mesic & frigid shallow soils; production <900 #**



Legend

Plant Community Phases

- MMS Mtn. Mahogany steppe
- PFGMM Perennial forb and grass Mtn. Mahogany
- JMM Juniper Mtn. Mahogany
- JW Juniper woodland
- CGB Cheatgrass and brush

Vectors of Change

- RT = reversible transition
- IRT = irreversible transition
- RP = repair pathway

Group 8

State 1: Represents the historical plant community with the potential addition of a trace amount of cheatgrass. Sites are either dominated with mountain mahogany, antelope bitterbrush or Wyoming sagebrush. Some communities exhibit a small percentage of old growth juniper. Infrequent fire maintained site dynamics. Grazing and/or time between fire can lead to an increase in juniper and/or brush cover with a corresponding decrease in bunchgrasses. If annual grasses are present they may increase with grazing pressure. Sites exhibit high resiliency to disturbance.

RT1: The JMM phase in State 1 is recognized as the “at risk” community and the transition to State 2, a juniper woodland or decadent sagebrush / cheatgrass community has begun. Reduction in grazing pressure may result in a reversal in this transition by allowing fire to occur.

IRT 1: Irreversible transition has occurred and a biotic threshold has been crossed. Sagebrush or juniper controls site dynamics.

RT 2: Fire occurrence is rare however if fire occurs with annual grasses present State 1 has a high risk of transitioning to State 3. Grazing management to reduce cheatgrass expansion may prevent this transition.

IRT 2: Irreversible transition has occurred and a biotic threshold has been crossed. Annual grass controls site dynamics.

RP1: Requires mechanical or chemical treatment of controlling brush or mechanical treatment of juniper along with treatment of cheatgrass. Desired grasses and forbs may need to be seeded.

State 2: Recognized by the need to mechanically or chemically treat the brush or juniper. The presence of annual grass and site characteristics indicate prescribed burning as an extreme risk. JMM phase is described by juniper dominance, reduced mountain mahogany, sagebrush and bitterbrush, increased bare ground with a trace of Bluebunch wheatgrass or Idaho fescue under brush canopies and an increase in Sandberg’s bluegrass, cheatgrass, and rabbitbrush. The JW phase indicates maturation of the juniper woodland and/or brush community accompanied by a loss in deep rooted perennial bunchgrasses. Cheatgrass dominates the understory and bare ground is high. State 2 is highly resilient to change if slope is relatively flat. However with increasing the slope the risk of erosion increases with the possibility of an irreversible transition to State 4. In addition, if a crown fire should occur an irreversible transition to State 3 is a significant risk.

IRT 3: Canopy fire leading to annual grass domination.

IRT 4: Significant bare ground and soil loss leading to State 4.

State 3: Recognized by dominance of cheatgrass with a trace of old growth juniper and or brush species. Cheatgrass controls site processes and fire frequency has increased. If sites are located on slopes the potential for an irreversible transition to State 4 exists.

IRT 5: Significant bare ground and soil loss leading to State 4.

State 4: Eroded phase characterized by extreme bare ground, exposed bedrock and limited plant cover.

Appendix A: Riparian, Bottomland and Shadscale Ecological Sites (not modeled)

Group A

Group 9 is a riparian grouping and will not be modeled in this effort but the group is included for future modeling efforts.

R010XY001OR	WET MOUNTAIN MEADOW MODAL
R010XY002OR	MOUNTAIN MEADOW MODAL
R010XY003OR	WET MEADOW
R010XY004OR	MEADOW
R010XY010OR	WILLOW RIPARIAN (COYOTE WILLOW)
R010XY011OR	COTTONWOOD WILLOW RIPARIAN MODAL
R010XY012OR	WILLOW RIPARIAN (BOOTH-YELLOW WILLOW) MODAL
R010XY013OR	WILLOW RIPARIAN (BOOTH-GEYER WILLOW)

Group B (see Group 2 in D23-D24)

Bottom / Swale / Fan

Higher ppt: Juniper encroachment

Lower ppt: Artr encroachment

R010XB016OR	JD SWALE 12-16 PZ MODAL
R010XC013OR	SR SWALE 9-12 PZ MODAL
R010XC014OR	SR MOUNTAIN SWALE 9-12 PZ
R010XC017OR	SR MOUNTAIN SWALE 12-16 PZ
R010XC025OR	SR GRAVELLY FAN 12-16 PZ
R010XY005OR	LOAMY BOTTOM MODAL
R010XY006OR	MOUNTAIN LOAMY BOTTOM
R010XY009OR	SANDY BOTTOM
R010XY014OR	CLAYEY BOTTOM

Group C

See Group 1 D23-D24.

R010XB026OR	JD SODIC FAN 9-12 PZ
R010XY007OR	SODIC BOTTOM MODAL
R010XY008OR	SODIC MEADOW

Group D

Group 8 consists of three sites dominated by shadscale. (See Group 3 in D23-D24.)

R010XB021OR	JD DROUGHTY CLAYEY FAN 9-12 PZ
R010XB043OR	JD DROUGHTY CLAYEY SOUTH 9-12 PZ MODAL
R010XB065OR	JD DROUGHTY CLAYEY NORTH 9-12 PZ

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Appendix B

Major Land Resource Area's: D23 and D24 Ecological Site Response Groups

Group 1

R024XY001OR SODIC FLAT MODAL
R024XY002OR SODIC MEADOW
R024XY003OR SODIC BOTTOM MODAL
R024XY114OR SODIC LAKE TERRACE
R024XY614OR SALINE MEADOW 8-10 PZ
R024XY626OR COOL SODIC FLAT 8-10 PZ
R024XY642OR COOL SODIC BOTTOM 8-10 PZ
JD SODIC FAN 9-12 PZ (From Group11 in B10)

Group 2

R023XY070OR ALKALINE BOTTOM 8-10 PZ (N/A)
R023XY104OR LOAMY BOTTOM
R023XY202OR SWALE 10-14 PZ
R023XY406OR SWALE 12-16 PZ
R023XY609OR DROUGHTY BOTTOM 8-10 PZ (N/A)
R023XY618OR DRY FLOODPLAIN
R024XY004OR DRY FLOODPLAIN MODAL
R024XY009OR DRY BASIN 8-10 PZ MODAL
R010XB016OR JD SWALE 12-16 PZ MODAL (from Group 10, B10)
R010XC013OR SR SWALE 9-12 PZ MODAL (from Group 10, B10)
R010XC014OR SR MOUNTAIN SWALE 9-12 PZ (from Group 10, B10)
R010XC017OR SR MOUNTAIN SWALE 12-16 PZ (from Group 10, B10)
R010XC025OR SR GRAVELLY FAN 12-16 PZ (from Group 10, B10)
R010XY005OR LOAMY BOTTOM MODAL (from Group 10, B10)
R010XY006OR MOUNTAIN LOAMY BOTTOM (from Group 10, B10)
R010XY009OR SANDY BOTTOM (from Group 10, B10)
R010XY014OR CLAYEY BOTTOM (from Group 10, B10)

Group 3

R023XY628OR SODIC LAKE BASIN 8-10 PZ (N/A)
R024XY005OR SODIC DUNES 6-10 PZ
R024XY013OR LOW SODIC DUNES 6-10 PZ
R024XY014OR SODIC TERRACE 6-10 PZ
R024XY112OR DRY SODIC FLOODPLAIN
R024XY113OR SODIC FAN 6-10 PZ
R024XY120OR SILTY LOW SODIC TERRACE 6-10 PZ
R024XY121OR SILTY SODIC TERRACE 6-10 PZ
R024XY617OR SODIC DUNES 8-10 PZ
R024XY622OR COOL SODIC TERRACE
R024XY625OR ALKALINE BASIN 8-10 PZ
R024XY015OR DESERT LOAM 6-10 PZ MODAL

Group 3 cont.

R010XB021OR JD DROUGHTY CLAYEY FAN 9-12 PZ (Group 8, B10)
R010XB043OR JD DROUGHTY CLAYEY SOUTH 9-12 PZ MODAL (Group 8, B10)
R010XB065OR JD DROUGHTY CLAYEY NORTH 9-12 PZ (Group 8, B10)

Group 4

R023XY650OR DRY PONDED CLAY 6-10 PZ (N/A)
R024XY007OR DRY PONDED CLAY 6-10 PZ MODAL
R024XY632OR FLOODED TERRACE 6-10 PZ (N/A)
R023XY624OR SILTY BASIN 8-10 PZ (N/A)
R024XY006OR LAKE TERRACE MODAL

Group 5

R024XY011OR SILTY 6-10 PZ MODAL
DRY LAKEBED 6-10 PZ (N/A)

Group 6

R023XY019OR SILT LOAM TERRACE 10-12 PZ
R023XY212OR LOAMY 10-12 PZ MODAL
R023XY220OR CLAYEY 10-12 PZ
R023XY222OR SHALLOW LAVA 10-12 PZ
R023XY300OR SOUTH SLOPES 8-12 PZ
R023XY301OR DROUGHTY SOUTH SLOPES 11-13 PZ
R023XY308OR NORTH SLOPES 10-12 PZ
R023XY602OR ARID NORTH 8-10 PZ (N/A)
R023XY604OR ARID PLAINS 8-11 PZ (N/A)
R023XY636OR SHALLOW LOAM 8-10 PZ (N/A)
R023XY638OR DROUGHTY SOUTH 8-10 PZ (N/A)
R024XY008OR CLAYEY PLAYETTE 8-10 PZ
R024XY016OR LOAMY 8-10 PZ MODAL
R024XY017OR SHALLOW LOAM 8-10 PZ
R024XY020OR SHRUBBY LOAM 8-10 PZ
R024XY030OR SHALLOW LOAMY SLOPES 6-10 PZ
R024XY032OR SOUTH SLOPES 6-10 PZ
R024XY033ORNORTH SLOPES 6-10 PZ

Group 7

R023XY213OR SANDY LOAM 10-12 PZ MODAL
R023XY221OR GRAVELLY TERRACE 10-12 PZ
R023XY303OR SANDY SLOPES 10-12 PZ
R023XY619OR DRY SANDY LOAM 8-10 PZ (N/A)
R023XY649OR DROUGHTY SANDY SLOPES 10-12 PZ (N/A)
R023XY653OR ARID FAN 8-10 PZ (N/A)
R023XY670OR STIPA FESCUE BASIN 8-11 PZ (N/A)
R024XY012OR SANDY 6-10 PZ
R024XY018OR SANDY LOAM 8-10 PZ MODAL
R024XY110OR DUNES 8-10 PZ

Group 8

R023XY302OR SOUTH SLOPES 12-16 PZ
R023XY310OR NORTH SLOPES 12-16 PZ
R023XY314OR GRAVELLY NORTH SLOPES 12-16 PZ
R023XY316OR DROUGHTY LOAM 11-13 PZ
R023XY318OR LOAMY 12-16 PZ MODAL
R023XY320OR JUNIPER SOUTH SLOPES 12-16 PZ
R023XY321OR DEEP LOAMY 12-16 PZ
R023XY404OR DEEP NORTH 12-18 PZ
R023XY516OR STONY LOAM 10-12 PZ
R023XY612OR PUMICE SOUTH SLOPES 10-14 PZ (N/A)
R023XY613OR PUMICE NORTH SLOPES 10-12 PZ (N/A)

Group 9

R023XY214OR CLAYPAN 10-12 PZ MODAL
R023XY215OR SHALLOW GRAVELLY LOAM 10-12 PZ
R023XY218OR THIN SURFACE CLAYPAN 10-16 PZ
R023XY324OR SHALLOW SWALE 10-14 PZ
R023XY600OR CLAYPAN SOUTH 8-12 PZ (N/A)
R023XY601OR THIN SURFACE 8-14 PZ (N/A)
R024XY021OR THIN SURFACE 8-14 PZ MODAL
R024XY647OR DROUGHTY SODIC HILLS (N/A)

Group 10

R023XY211OR PUMICE CLAYPAN 10-12 PZ
R023XY216OR CLAYPAN 12-16 PZ MODAL
R023XY217OR JUNIPER TABLELANDS (LAVA BENCHES) 10-14 PZ
R023XY312OR SHALLOW NORTH 12-16 PZ
R023XY410OR GRAVELLY RIDGE 12-16 PZ
R023XY412OR GRAVELLY RIDGE 16+ PZ
R023XY507OR CLAYPAN 16-25 PZ MODAL
R023XY511OR JUNIPER LAVA BENCHES 9-12 PZ (N/A)

Group 11

R023XY501OR LOAMY 16-25 PZ MODAL
R023XY502OR LOAMY 25-35 PZ MODAL
R023XY503OR OPEN SLOPES 25-35 PZ
R023XY504OR SUBALPINE LOAMY 35-40 PZ MODAL
R023XY505OR SUBALPINE THIN SURFACE 35-40 PZ
R023XY509OR SUBALPINE SLOPES 16-35 PZ