Appendix A: State and Transition Model of Vegetation Succession

Prior to the early 1990's, the accepted theory of secondary succession within arid and semi-arid vegetation communities was based on variations of a Clemensian-based model. These models suggested that rangeland systems are best described by a predictable linear succession of plant communities, sequentially changing in orderly response to control variables like defoliation (grazing), fire, precipitation, and competition. Disturbances, other than those natural disturbances which lead to a flux in composition defined as the potential natural condition, lead to a replacement of late seral species with more weedy and annual species. Similarly, following removal of disturbances which lead to an increase in early seral and weedy species and a retrogression in vegetation condition classification, a passive and predictable linear sequence of species replacement would occur through time to restore the vegetation composition to the climax or potential natural vegetation community for the site. A traditional Clemensian-based model of vegetation dynamics in sagebrush grassland steppe is presented in figure 1 (from Allen-Diaz and Bartolome, 1998).

Classical Model *Seral stages*	Range Condition Model *Classes*
Pseudoroegneria spicata >50% cover *Artemisia tridentate* <50% cover	EXCELLENT (Potential Natural Condition) 75-100% potential native plant community by weight
↓ ↑	----------
Artemisia tridentate >50% cover *Pseudoroegneria spicata* <50% cover	GOOD (Late) 50-75% potential native plant community by weight ----------
↓ ↑	FAIR (Middle) 25-50% potential native plant community by weight
Artemisia tridentate and/or *Bromus tectorum/Poa secunda* dominant	---------- -
↓ ↑	
Mustard and other annual forbs, *Artemisia* present	POOR (Early) <25% potential native plant community by weight
↓ ↑	
Thistles or other annual weeds on bare soil, Perennials absent	

Figure 1: Seral stages and transitions for the classical linear succession and range condition models in the sagebrush-grass type of southeastern Oregon. Where seeded, *Agropyron cristatum* or other nonnative perennial grasses substitute for *Pseudoroegneria spicata*.

Dissatisfaction with the ability of Clemensian-based models to predict vegetation recovery following removal of disturbances, such as inappropriate livestock management practices, resulted in alternate theories of rangeland vegetation dynamics, especially in western North America. State-and-transition models were specifically developed to overcome these limitations for evaluation of vegetation dynamics in variable rangeland environments (Allen-Diaz and Bartolome, 1998; Briske et al, 2003; Bestelmeyer et al, 2003). The vegetation types in this model are called “states” and the processes that cause states to change from one to another are called “transitions”. Although predictable and passive transition from one state to another more diverse state may be possible, consistent with Clemensian-based models, more often a number of transitions dependent on the timing and intensity of inputs may lead to variable states. While some transitions may require little management input, other than removal of a disturbance, other transitions

may require such significant inputs that it is unlikely that such transitions would occur within acceptable time-frames. A state and transition model of vegetation dynamics for a sagebrush-grass rangeland in southeastern Oregon is presented in figure 2 (Allen-Diaz and Bartolome, 1998). The authors identified T1, T2, T5 and T8 occurring over a 10 year period with no management action, whereas transitions T3, T4, T6, T7 and T9 resulted from plowing, spraying and/or seeding to remove competition by one species or group of species. Since this is a simplistic model of observed states and transitions, it is not intended to display the complexity of factors which contributed to currently inventoried vegetation composition and multiple pathways to desired future conditions. Nor does it depict the thresholds which may preclude attaining desired conditions within reasonable funding and time constraints. It does depict the multiple pathways to declining conditions which do not meet management objectives and suggests implementation of appropriate actions to avoid exceeding thresholds which may even more preclude future opportunities for resource use or loss of resource values.

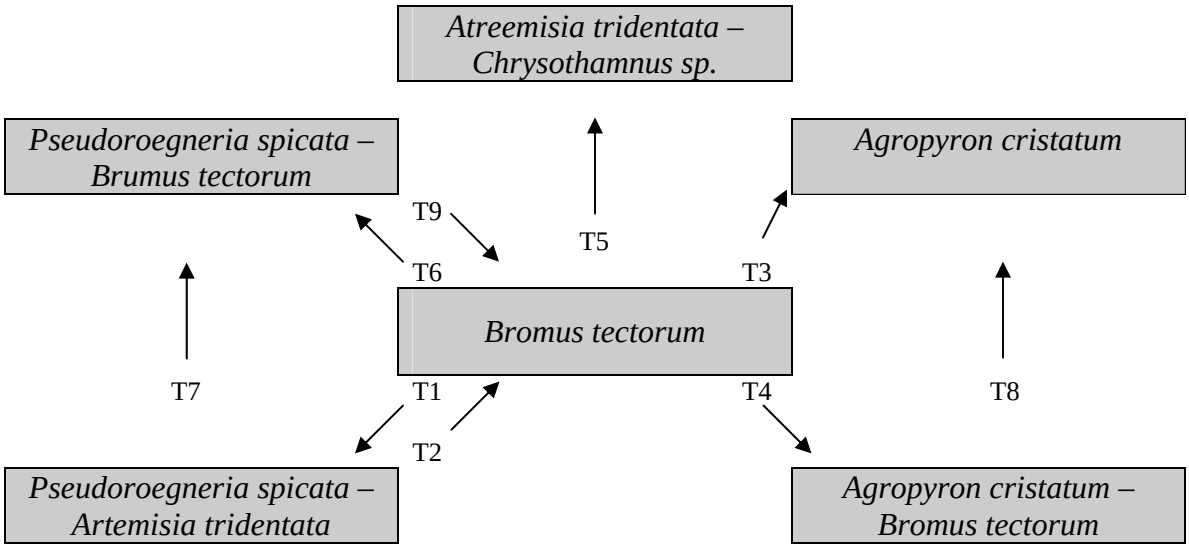

Figure 2: State – Transition model for sagebrush-grass rangeland in southeastern Oregon. Boxes represent states. Arrows represent transitions observed between states at least twice (Allen-Diaz and Bartolome, 1998).

The National Research Council, as others, has suggested that past thinking related to vegetation succession and rangeland health be reconsidered when identifying objectives for management of rangeland resources for desired products and amenities (National Research Council, 1994). As a result, management objectives to improve ecological condition in pastures of Dry Creek Geographic Management Area may need to be considered in light of current thinking and modified as appropriate.

The National Range and Pasture Handbook, assembled by the United States Department of Agriculture Natural Resource Conservation Service, is a source of additional information about ecological sites and state-and-transition models.

Allen-Diaz, B., and J.W. Bartolome. 1998. Sagebrush-grass vegetation dynamics: Comparing classical and state-transition models. Ecological Applications. Volume 8(3): 795-804.

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National Research Council. 1994. Rangeland Health: New Methods to Classify, Inventory, and Monitor Rangelands. National Academy Press. Washington D.C. 173 p.