Chapter 9

Vegetation Succession Modeling for the LANDFIRE Prototype Project

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Introduction

One of the main objectives of the Landscape Fire and Resource Management Planning Tools Prototype Project, or LANDFIRE Prototype Project, was to determine departure of current vegetation conditions from the range and variation of conditions that existed during the historical era identified in the LANDFIRE guidelines as 1600-1900 A.D. (Keane and Rollins, Ch. 3). In order to approximate this range and variation, we simulated a series of historical vegetation conditions using the landscape succession model LANDSUMv4, the fourth version of the LANDSUM model, developed specifically for the LANDFIRE Project (Keane and Rollins, Ch. 3).

LANDSUMv4 deterministically simulates vegetation dynamics based on successional communities called succession classes. Succession classes are characterized by cover types, which describe the species composition of the dominant vegetation, and structural stages, which describe the height and cover of the dominant vegetation. The combination of these two descriptors captures vegetation growth and development through time. These succession classes, linked by multiple pathways, transition between seral stages after a set number of years and eventually converge in an end-point community called a potential vegetation type or PVT. Disturbances occur probabilistically within the model and alter the successional status of vegetation communities, often setting succession back a number of time-steps (Pratt and others, Ch. 10).

At the end of a user-defined reporting period, LANDSUMv4 outputs a vegetation map. Synthesis of this chronosequence of vegetation maps over the simulation period reflects the net result of these successional transitions and disturbances. The modeling process results in an estimate of the distribution of succession classes through time for a particular PVT, which may be thought of as simulated historical reference conditions. (For a detailed description of the role played by LANDSUMv4 simulations in the LANDFIRE Prototype, see Pratt and others, Ch. 10 and Holsinger and others, Ch. 11)

To parameterize LANDSUMv4, we had to define all succession pathways and their associated transition times for each PVT. We estimated transition times between succession classes based on a number of factors, such as site productivity and species adaptations to disturbance. In addition, we had to define all disturbance pathways along with the probabilities of their occurrence, requiring that we convert knowledge of historical disturbance intervals into yearly probabilities. More importantly, we had to test these inputs before they could be used for modeling purposes. To test the inputs we created for the model, we used a computer model called the Vegetation Dynamics Development Tool (VDDT) (Beukema and others 2003).

The VDDT modeling framework is almost identical to that of LANDSUMv4 (Keane and others 2002), except that in VDDT, the modeling environment is "aspatial" and uses pixels to track succession classes. These pixels are independent of adjacent pixels because VDDT does not simulate the contagion of ecosystem processes (such as wildland fire) through space or over time (Beukema

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and others 2003). This simpler approach allows for near-instantaneous model execution as well as for rapid model building and rapid testing of the model's sensitivity to a wide range of inputs.

The objective of the LANDFIRE Prototype vegetation modeling was to provide the myriad of LANDSUMv4 inputs as well as to document both the processes used to derive these inputs and the assumptions involved in constructing the succession models. The following sections describe the general process we used to create the succession models in addition to all input parameters for LANDSUMv4. This process included the initial steps of deciding which PVTs to model, which cover types should be included in each PVT, and which structural stages should be used in combination with these cover types to represent the various succession classes within each PVT. We then defined pathways for each of the succession classes in each PVT. These pathways took two forms. One set described succession and the associated number of time-steps required to transition from one succession class to another without disturbance. The other set described disturbance, both in terms of the succession class that is the result of that disturbance and the associated probability of that disturbance occurring for that particular succession class. Also included are general descriptions of all of the models built as input into LANDSUMv4 along with recommendations for modifying this process in the context of national implementation.

Methods

The LANDFIRE Prototype Project involved many sequential steps, intermediate products, and interdependent processes. Please see appendix 2-A in Rollins and others, Ch. 2 for a detailed outline of the procedures followed to create the entire suite of LANDFIRE Prototype products. This chapter focuses specifically on the procedure followed in developing the models of vegetation dynamics (including disturbance probabilities and transition times) which were an important precursor to the modeling of historical vegetation conditions and fire regimes.

PVTs and Succession Classes

Succession classes for each PVT were represented by combinations of cover types and structural stages (Zhu and others, Ch. 8). An example of a succession class in the Spruce – Fir/Blue Spruce PVT would be "Douglas-fir, High Cover, High Height Forest," each succession class being described by a combination of one cover type and one structural stage. Thus, for each PVT, we first decided which cover types and which structural stages would be used to represent the various stages of succession for that PVT. The list of these PVTs developed for LANDFIRE mapping purposes, shown in tables 1 and 2, contains the PVTs used for succession modeling purposes. The cover type list (tables 3 and 4), which describes dominant species, and the structural stage list (table 5), which describes dominant vegetation cover and height, were used to limit the number of succession classes that could occur within a PVT. (For detailed information on the cover types, potential vegetation types, and structural stages mapped for the LANDFIRE Prototype, see Long and others, Ch. 6.) Tabular summaries from the LANDFIRE reference

Table 1—Potential vegetation types (PVTs) used for succession modeling in Zone 16.

PVT#	Potential vegetation type
1601	Spruce – Fir / Blue Spruce
1602	Spruce – Fir / Blue Spruce / Lodgepole Pine
1603	Spruce – Fir / Spruce – Fir
1604	Spruce – Fir / Spruce – Fir / Lodgepole Pine
1611	Grand Fir – White Fir
1612	Grand Fir – White Fir / Maple
1621	Douglas-fir / Timberline Pine
1622	Douglas-fir / Douglas-fir
1623	Douglas-fir / Lodgepole Pine
1631	Timberline Pine
1632	Ponderosa Pine
1633	Lodgepole Pine
1634	Aspen
1641	Pinyon – Juniper / Mountain Big Sagebrush / North
1642	Pinyon – Juniper / Mountain Big Sagebrush / South
1643	Pinyon – Juniper / Wyoming – Basin Big Sagebrush / North
1644	Pinyon – Juniper / Wyoming – Basin Big Sagebrush / South
1645	Pinyon – Juniper / Mountain Mahogany
1646	Pinyon – Juniper / Gambel Oak
1651	Blackbrush
1652	Salt Desert Shrub
1653	Warm Herbaceous
1654	Cool Herbaceous
1661	Dwarf Sagebrush
1662	Wyoming – Basin Big Sagebrush
1663	Mountain Big Sagebrush
1671	Riparian Hardwood
1672	Riparian Shrub
1673	Wetland Herbaceous
1680	Alpine

database (Caratti and others, Ch. 4) provided a list of the cover types and structural stages that, based on plot data, occurred in each PVT. This list provided the building blocks for constructing the various succession models used to simulate historical reference conditions for the LANDFIRE Prototype.

Potential vegetation types represent specific biophysical environments and associated suites of successionally dominant species or species complexes (Keane and Rollins, Ch. 3; Long and others, Ch. 6) and, as such, are very similar in concept to "habitat types" (Daubenmire 1968). A number of habitat type classifications were available for the two prototype mapping zones, and we used data from these classifications to refine the lists of cover types that could exist in each PVT. For forest vegetation, habitat classifications for Zone 16 included those by Mauk and Henderson 1984; Muegler and Campbell 1986; Padgett and others 1989; Pfister 1972; Steele and others 1981; Youngblood and Mauk 1985; and Youngblood and others 1985. Habitat type classifications for Zone 19 included those by Hansen and others 1987; Hansen and others 1988; Pierce 1986; and Pfister and others 1977.

Table 2 — Potential vegetation types (PVTs) used for succession modeling in Zone 19.

PVT#	Potential vegetation type
1902	Western Redcedar
1914	Grand Fir – White Fir
1920	Spruce – Fir / Montane / Western Larch
1921	Spruce – Fir / Montane / Douglas-fir
1922	Spruce – Fir / Timberline
1924	Spruce – Fir / Subalpine
1930	Douglas-fir / Ponderosa Pine / Western Larch
1931	Douglas-fir / Ponderosa Pine / Douglas-fir
1932	Douglas-fir / Lodgepole Pine
1934	Douglas-fir / Timberline Pine
1936	Douglas-fir / Douglas-fir
1940	Lodgepole Pine
1942	Ponderosa Pine
1944	Timberline Pine / Limber Pine
1946	Timberline Pine / Whitebark Pine
1950	Rocky Mountain Juniper
1952	Riparian Hardwood
1960	Riparian Shrub
1962	Mountain Mahogany
1964	Dry Shrub
1965	Dry Shrub / Conifer
1970	Dwarf Sagebrush Complex
1971	Dwarf Sagebrush Complex / Conifer
1972	Mountain Big Sagebrush Complex
1973	Mountain Big Sagebrush Complex / Conifer
1974	Threetip Sagebrush
1975	Threetip Sagebrush / Conifer
1976	Wyoming – Basin Big Sagebrush Complex
1977	Wyoming – Basin Big Sagebrush Complex / Conifer
1980	Wetland Herbaceous
1982	Alpine
1984	Fescue Grasslands
1985	Fescue Grasslands / Conifer
1986	Bluebunch Wheatgrass
1987	Bluebunch Wheatgrass / Conifer

Table 3—Cover types (CTs) used for succession modeling in Zone 16.

CT#	Cover type
1401	Riparian Hardwood
1405	Aspen – Birch
1201	[Interior] Ponderosa Pine
1204	Lodgepole Pine
1205	Douglas-fir
1206	Grand Fir – White Fir
1211	Spruce – Fir
1801	Timberline Pines
2201	Pinyon – Juniper
2202	Juniper
3704	Mountain Deciduous Shrub
3402	Riparian Shrub
3403	Exotic Riparian Shrub
3101	Mountain Big Sagebrush Complex
3102	Wyoming – Basin Big Sagebrush Complex
3103	Dwarf Sagebrush Complex
3104	Sand Sagebrush
3105	Blackbrush
3106	Rabbitbrush
3107	Chaparral
3301	Montane Evergreen Shrubs
3701	Salt Desert Shrub
3702	Desert Shrub
3703	Dry Deciduous Shrub
4101	Warm Season Grasses
4102	Cool Season Grasses
4201	Native Forbs
4202	Exotic Forbs
4301	Wetland Herbaceous
4302	Alpine
4401	Annual Grasslands

Table 4—Cover types (CTs) used for succession modeling in Zone 19.

CT#	Cover type
1201	Cedar
1202	Douglas-fir
1203	Grand Fir
1204	Hemlock
1205	Lodgepole Pine
1206	Juniper
1207	Ponderosa Pine
1208	Spruce – Fir
1209	Limber Pine
1212	White Pine
1401	Aspen – Birch
1402	Riparian Hardwood
1403	Western Larch
1801	Timberline Forest
2101	Upland Broadleaf Dwarf Shrubland
2102	Upland Broadleaf Medium Shrubland
2103	Upland Broadleaf Tall Shrubland
2202	Upland Microphyllous Medium Shrubland
2211	Dwarf Sage
2212	Shrubby Cinquefoil
2213	Threetip Sage
2218	Mountain Big Sage
2219	Wyoming – Basin Big Sage
2220	Rabbitbrush
2222	Greasewood
2223	Mountain Mahogany
2300	Upland Needleleaf Shrubland
2400	Upland Sclerophyllous Shrubland
2600	Riparian Broadleaf Shrubland
3110	Annual Forb
3120	Annual Graminoid
3130	Perennial Forb
3141	Perennial Exotic Bunch Gramminoid
3142	Perennial Native Bunch Gramminoid
3151	Perennial Exotic Rhizomatous Gramminoid
3152	Perennial Native Rhizomatous Gramminoid
3200	Wetland Herbaceous

Table 5—Structural stages used for succession modeling in zones 16 and 19.

Structural stage #	Structural stage name	Structural stage abbreviation
Zone 16		
11	Low Cover, Low Height Forest	LLF
12	High Cover, Low Height Forest	HLF
13	High Cover, High Height Forest	HHF
14	Low Cover, High Height Forest	LHF
21	Low Cover, Low Height Woodland	LLW
22	High Cover, Low Height Woodland	HLW
23	High Cover, High Height Woodland	HHW
24	Low Cover, High Height Woodland	LHW
31	Low Cover, Low Height Shrubland	LLS
32	High Cover, Low Height Shrubland	HLS
33	High Cover, High Height Shrubland	HHS
34	Low Cover, High Height Shrubland	LHS
51	Low Cover, Low Height Herbaceous	LLH
52	High Cover, Low Height Herbaceous	HLH
53	High Cover, High Height Herbaceous	HHH
54	Low Cover, High Height Herbaceous	LHH
Zone 19		
10	Low Cover, Low Height Trees	LLT
11	Low Cover, Low -Mod Height Trees	LLMT
12	High Cover, Low - Mod Height Trees	HLMT
13	Low Cover, Mod Height Trees	LMT
14	High Cover, Mod Height Trees	HMT
15	Low Cover, High Height Trees	LHT
16	High Cover, High Height Trees	HHT
21	Low Cover, Low Height Shrubs	LLS
22	High Cover, Low Height Shrubs	HLS
23	Low Cover, Mod Height Shrubs	LMS
24	High Cover, Mod Height Shrubs	HMS
25	Low Cover, High Height Shrubs	LHS
26	High Cover, High Height Shrubs	HHS
31	Low Cover, Low Height Herbs	LLH
32	High Cover, Low Height Herbs	HLH
35	Low Cover, High Height Herbs	LHH
36	High Cover, High Height Herbs	HHH

In cases where several habitat types from a particular classification – each having different species compositions – were associated with one PVT, we used a weighting process to predict the average cover type composition. We assigned weights based on the number of plots recorded for each habitat type. If a cover type was listed as a major seral or climax species in a particular habitat type, we assumed that it could dominate the site and should therefore be included in the succession model. Using the weights assigned from data describing each habitat type within a PVT, we developed a list of cover types and associated expected percent composition for each PVT.

Regarding rangeland vegetation, we found no existing habitat type classifications for Zone 16. This lack of previously established rangeland habitat classifications led us to rely almost entirely on tabular summaries from the LANDFIRE reference database (Caratti and others, Ch. 4) for the assignment of cover types to rangeland PVTs. In Zone 16, the plot data were well distributed across PVTs and there were enough data to effectively describe the cover types within each PVT. Habitat types as defined by Mueggler and Stewart (1980) served as the source for nearly all the information used to describe cover types found in specific PVTs in Zone 19.

Once all possible cover types had been assigned to each PVT, we began defining structural stages for each cover type for each PVT. For forest PVTs, each cover type was represented by a standard set of structural stages (Long and others, Ch. 6). These structural stages consisted of one or more shrub or herbaceous cover types (used to describe early seral conditions), which generally result from a stand-replacing disturbance. Four structural stages, defined by two categories of tree height and two categories of crown cover, were used to describe each forest succession class. Modeled succession for each PVT began in the various early seral types and then flowed through the three structural stages for that particular cover type: "Low Cover, Low Height Forest," "High Cover, Low Height Forest," and "High Cover, High Height Forest." A fourth structural stage, "Low Cover, High Height Forest," was used to represent stands that resulted only from mixed-severity, non-stand-replacing disturbances (see Pratt and others, Ch. 10 for details on the fire regime classification used in the LANDFIRE Prototype).

The development of rangeland pathways was predicated on the theory that rangeland vegetation exhibits multiple states and transitions (Stringham and others 2003). The changes in structural stages generally represented transitions from a grass-dominated state (generally resulting from a stand-replacing disturbance, such as fire) to a shrub state or, depending on the PVT, a forest state. In addition, to capture more subtle transitions between these states, we included additional succession classes by incorporating two and sometimes three cover and height breaks for each cover type.

Succession and Disturbance Modeling

For forest PVTs, we estimated transition times between succession classes by forest cover type using site index data from a number of sources. Site index is a measure often used to describe the height of a free-growing tree after a certain number of years, generally between 50 to 100 years. We then interpolated these data to the height classes defined in the structural stages. Transition times for rangeland PVTs were gleaned from a wide variety of rangeland vegetation studies. Information from these studies often characterized the response of rangeland plant communities to fire and other stand-replacing disturbances and was applied on a case-by-case basis to the appropriate PVT.

For Zone 16, we obtained site index data from Alexander 1966; Brickell 1966; Mauk and Henderson 1984; Mueggler and Stewart 1980; Padgett and others 1989; Pfister 1972; Youngblood and Mauk 1985; Youngblood and others 1985; and, for adjacent areas, from studies by Pfister and others 1977 and Steele and others 1975. We based the expected longevity of various tree species on Alexander 1974; Burns and Honkala 1990; Jones 1974; and McCaughey and Schmidt 1982.

For Zone 19, we obtained site index data from Brickell 1966; Burns and Honkala 1990; Pfister and others 1977; and Seidel 1982. We based the expected longevity of various tree species on Burns and Honkala 1990 and Ferguson and others 1986. We then adjusted the life expectancy to reflect the environmental conditions found in the PVT.

We used an extensive literature search to define disturbance pathways for each PVT. Disturbance pathway parameters were based primarily on the way each succession class responds to disturbance. These parameters were generally based on vegetation studies that addressed an individual species' response to fire. We supplemented the results of the literature search with information provided by local scientists as well as with online sources of information on plant communities' responses to fire, including the Fire Effects Information System (FEIS) database (USDA Forest Service 2005) and the National Resource Conservation Service and its associated descriptions of rangeland ecological site data (USDA NRCS 2005).

For Zone 16, information pertinent to defining disturbance pathways was gleaned from studies by Bradley and others 1992; Brown and Debyle 1989; and Yanish 2002. For Zone 19, these data were taken from studies by Fisher and Bradley 1987; Zlatnik and others 1999; Arno and Gruell 1983, 1986; Fiedler (no date); Ferguson and others 1986; and Oliver 1979.

We obtained information on fire intervals from literature searches and from personal communication with local scientists, as well as from online sources of information on plant communities' responses to fire, including the FEIS database (USDA Forest Service 2005) and the National Resource Conservation Service and its associated descriptions of rangeland ecological site data (USDA NRCS 2005).

For Zone 19, historical fire intervals for each succession class were derived from Arno 1976; Arno and others 2000; Barrett 1988, 1995, 2002; Losensky 1989, 1992, 1993, and 1995; and Pierce 1982.

Model Evaluation

We ran each of our models for a 1000-year simulation period and examined the distribution of succession classes for each PVT. We assumed that the proportion of succession classes at the end of the simulation period

would represent the natural conditions found on the landscape at the time of Euro-American settlement. These values were largely dependent on the assignment of pixels to various succession classes as they moved from initiation communities to tree-dominated communities. In addition, changes in succession class could result from wildland fire. Evaluation of the proportion of succession classes associated with each PVT is highly important in the parameterization of each model. We reviewed the models to determine if the proportion of succession classes within a PVT, the modeled fire intervals, and the modeled severities were similar to findings in the literature or as expected according to the known information about the plant communities.

Model Descriptions

The next two sections describe VDDT succession modeling results. These results relate to groups of PVTs with similar succession dynamics and similar fire return intervals. The objective of the discussion is to highlight the important succession and disturbance regimes of each PVT and connect them to the resulting succession class distributions. Detailed results from the simulations are presented in appendices 9-A through 9-P and include summaries of transition times between succession classes, fire return intervals, and succession class distributions -- by succession class for each PVT. (Note: PVT legends and descriptions can be found in Long and others, Ch. 6: appendices 6-F and 6-G.)

Zone 16 Models

Spruce – Fir Forests—Spruce – Fir forests in Zone 16 were represented by the Spruce – Fir/Blue Spruce and Spruce – Fir/Spruce Fir PVTs in Zone 16 (appendix 9-A). Two variants were modeled for both of these PVTs to reflect the distribution of the Lodgepole Pine cover type in the northern sections of Zone 16 and the lack of the Lodgepole Pine cover type in the southern part of Zone 16 (table 1). All PVTs had fairly long fire return intervals between stand-replacing fires and moderately long intervals between mixed-severity fires and non-lethal fires (appendix 9-A: table 2). Dominant cover types were Douglas-fir, Spruce – Fir, Lodgepole Pine (restricted to northern portions of the zone) and Aspen – Birch. Each cover type was consistently dominated by late seral structural stages, with a slightly higher proportion of the open cover class. Spruce – Fir was the successional endpoint in all of these models, but Douglas-fir is a long-lived seral dominant.

White Fir/Douglas-fir Forests—White Fir/Douglas-fir forests in Zone 16 were represented by one Grand Fir/White Fir PVT and three Douglas-fir PVTs (appendix 9-B). All of these PVTs support the Douglas-fir, Ponderosa Pine, and Aspen – Birch cover types but differ from each other in the unique combinations of other seral species they also support. Non-lethal fires with short return intervals characterize nearly all of this group's PVTs (appendix 9-B: table 2). Late seral Douglas-fir cover types dominate nearly all PVTs in this group, with the exception of late seral Ponderosa Pine cover types in the Grand Fir/White Fir PVT (appendix 9-B: table 3).

Pine Forests—Pine forests in Zone 16 were represented by three PVTs, each of which occupies a fairly distinct landscape setting that generally favored the dominance of a single cover type (appendix 9-C). The Lodgepole Pine PVT occurred primarily in an upper montane and subalpine setting, while the Ponderosa Pine PVT occupied a lower montane setting. The Timberline Pine PVT occupied unique sites where species composition was purely limber pine or bristlecone pine. Fire intervals were modeled to be moderately long or very long for stand-replacing and mixed-severity fires, but short to moderate for non-lethal fires (appendix 9-C: table 2). Modeling results under these fire intervals produced a mixture of all structural stages of the dominant cover type, except where the Aspen – Birch cover type co-dominates with the Lodgepole Pine cover type in the Lodgepole Pine PVT.

Broadleaf Forests—Broadleaf forest PVTs in Zone 16 were represented with the Riparian Hardwood PVT and the Aspen PVT (appendix 9-D). The Juniper cover type played a mid-seral role in the Riparian Hardwood PVT and eventually succeeded to the Riparian Hardwood cover type, which is dominated mostly by cottonwood, the endpoint of succession for this PVT (appendix 9-D: table 3). The fire regime of this PVT was stand-replacing fires with moderate to long return intervals (appendix 9-D: table 2). The Aspen PVT occurred on sites where the Aspen – Birch cover type, dominated by aspen, is the "stable" climax community. The fire regime of this PVT was stand-replacing fires with moderate to long return intervals as well (appendix 9-D: table 2).

Pinyon – Juniper Woodlands—Pinyon – Juniper woodlands in Zone 16 were composed of the Pinyon – Juniper/Mountain Big Sagebrush PVT and the Pinyon – Juniper/Wyoming – Basin Big Sagebrush PVT (appendix 9-E). The Pinyon – Juniper/Mountain Big Sagebrush PVT was divided into two succession models: a northern variant

and a southern variant. Fires were always stand-replacing and had fairly short intervals (appendix 9-E: table 2). The major differences between the northern and southern succession models were associated with the amount of Juniper cover type on the landscape. The Juniper cover type is dominant in the northern model, whereas the Pinyon – Juniper cover type is dominant in the southern model.

The Pinyon – Juniper/Wyoming – Basin Big Sagebrush PVT was also divided geographically into two succession models (northern and southern). They are identical with the exception of the time spent in the Cool Season Grasses cover type, which reflects site productivity differences across the PVT. We varied the fire intervals in this PVT from 40 to 60 years, depending on the succession class (appendix 9-E: table 2). This range in fire frequency reflected the biophysical variation in this PVT, with dryer sites of the PVT having a longer fire return interval. The resulting distribution of succession classes varied between the northern and southern zones. The Pinyon – Juniper cover type dominates more in the south, while the Wyoming – Basin Big Sagebrush cover type has a much larger component in the north.

Mountain Shrublands—Mountain shrubland PVTs in Zone 16 consisted of the Pinyon – Juniper/Mountain Mahogany PVT, the Pinyon – Juniper/Gambel Oak PVT, and the Grand Fir – White Fir/Maple PVT (appendix 9-F). The Mountain Mahogany PVT has a moderate fire return interval, which allowed Mountain Mahogany to escape fires and form relatively mature stands of tree-like shrubs. The Pinyon – Juniper/Gambel Oak PVT was designed to have two successional endpoints: one in the Pinyon – Juniper cover type and one in the Mountain Deciduous Shrub cover type, which is dominated by Gambel oak. On somewhat drier sites in this PVT, the successional endpoint leads to the Pinyon – Juniper cover type; however, on more mesic sites, dominance of pure Gambel oak is more common, and the successional endpoint is the Mountain Deciduous Shrub cover type. Stand-replacing fires with fairly short return intervals were modeled in this PVT (appendix 9-F: table 2). We considered the Bigtooth Maple PVT to be a moister, northern variant of the Pinyon – Juniper/Gambel Oak PVT. This PVT was found in northern parts of Zone 16 where bigtooth maple, contained within the Riparian Hardwood cover type, occurred in relatively pure stands. The results of the VDDT modeling show a fairly significant component of white fir sharing dominance with bigtooth maple (appendix 9-F: table 3). Moderately short fire return intervals were modeled in the Bigtooth Maple PVT (appendix 9-F: table 2).

Sagebrush Shrublands—We modeled three individual sagebrush PVTs for Zone 16 (appendix 9-G). The Mountain Big Sagebrush PVT represented the upper elevation ranges that support big sagebrush. Fire intervals in the Mountain Big Sagebrush PVT were fairly short (appendix 9-G: table 2). This fire regime resulted in the dominance of Low Cover, Low Height Shrubland structural stages of the Mountain Big Sagebrush cover type. The Dwarf Sage PVT represented lower elevations with drier, warmer conditions and nearly pure stands of "low sagebrush" species or mixtures of low sagebrush and black sagebrush. This PVT was modeled with a moderately long fire return interval (appendix 9-G: table 2). High Cover, Low Height Shrubland structural stages of the Dwarf Sagebrush Complex cover type almost completely dominated the landscape (appendix 9-G: table 3). More mesic sites at lower elevations with deeper soils were represented by the Wyoming – Basin Big Sagebrush PVT. Moderately short fire return intervals were used in this PVT (appendix 9-G: table 2), resulting in a mixture of High Cover, Low Height and Low Cover, Low Height Shrubland structural stages of the Wyoming – Basin Big Sagebrush cover type and a substantial component of the Cool Season Grasses cover type (appendix 9-G: table 3).

Desert Shrublands—The Blackbrush PVT and the Salt Desert Shrub PVT were modeled to represent desert shrubland conditions in Zone 16 (appendix 9-H). The Blackbrush PVT had low productivity, and fire intervals were modeled to be fairly low (appendix 9-H: table 2). Much of the landscape in the Blackbrush PVT was dominated by the High Cover, High Height Shrublands structural stage of the Blackbrush cover type along with a significant component of both High Cover, Low Height Shrubland and Low Cover, Low Height Shrubland structural stages of the Desert Shrub cover type. (appendix 9-H: table 3). The Salt Desert Shrub PVT had a limited distribution in Zone 16. Moderately low fire return intervals were modeled for this PVT (appendix 9-H: table 2). The Wyoming – Basin Big Sagebrush cover type dominated much of this PVT -- both as a High Cover, Low Height Shrubland and Low Cover, Low Height Shrubland -- along with a significant proportion of the Salt Desert Shrub cover type.

Zone 19 Models

Western Redcedar and Grand Fir Forests—Cedar and Grand Fir forest PVTs in Zone 19 were comprised of the Western Redcedar PVT and the Grand Fir/White Fir PVT (appendix 9-I). We used a diverse array of

succession classes for each of these two PVTs (appendix 9-I: table 1). We modeled very long fire intervals for most stand-replacing fires in the Western Redcedar PVT and moderate to long intervals for the Grand Fir/White Fir PVT (appendix 9-I: table 2). Intervals for mixed-severity fires were generally moderate for both types, and non-lethal fires were also modeled at moderate intervals. For both PVTs, the results of the modeling (appendix 9-I: table 3) featured the dominance of long-lived seral species including the Douglas-fir cover type and the Western Larch cover type, in addition to smaller amounts of the White Pine cover type. The main difference between the two PVTs is the substantial amounts of the Cedar, Hemlock, and Spruce – Fir cover types in the Western Redcedar PVT.

Spruce – Fir Forests—Spruce – Fir forests in Zone 19 (appendix 9-J) were divided into two groups: those that occurred in a montane or mid-elevation landscape setting and those occurring in a higher elevation, subalpine or timberline landscape setting. Montane settings were represented by the Spruce – Fir/Montane PVT, which had the most floristically diverse succession classes (appendix 9-J: table 1). The Spruce – Fir/Subalpine PVT and Spruce – Fir/Timberline PVT were less productive PVTs and were modeled with fewer cover types (appendix 9-J: table 1). Moderately long return interval, mixed-severity fires played a significant role in the Spruce – Fir/Subalpine PVT, whereas stand-replacing fires occurred in these systems infrequently (appendix 9-J: table 2). VDDT modeling results (appendix 9-J: table 3) show that, with the exception of the Douglas-fir cover type in the Spruce – Fir/Montane PVT, the Spruce – Fir cover type dominated these sites historically. Lodgepole Pine was the next most dominant cover type in the Spruce – Fir/Subalpine PVT, while Timberline Forest, which consisted of whitebark pine, was the next most dominant cover type in the Spruce – Fir/Timberline PVT.

Douglas-fir Forests—A wide array of Douglas-fir PVTs was modeled to represent the historical dynamics of Douglas-fir forests in Zone 19 (appendix 9-K). Succession classes for each PVT are shown in appendix 9-K: table 1. The Western larch cover type was modeled in the Douglas-fir/Ponderosa Pine PVT and played minor roles in the Douglas-fir/Douglas-fir PVT and in the higher, colder Douglas-fir/Lodgepole Pine PVT. In all cases, the cover type was restricted to the northwest corner of the zone. The Ponderosa pine cover type played a major role in the Douglas-fir/Ponderosa Pine PVT and a minor role in the Douglas-fir/Douglas-fir PVT. Both PVTs had the Lodgepole Pine cover type as well. The driest of the Douglas-fir forests was the Douglas-fir/Timberline PVT. This PVT had a distinctive array of cover types, including the Limber Pine and Juniper cover types, in addition to the Douglas-fir cover type. Many of the succession classes in these PVTs historically had short to moderately short fire intervals in mixed-severity and non-lethal regimes (appendix 9-K: table 2). Stand-replacing fires were rare, except in younger age classes for all of these PVTs. With the exception of the Douglas-fir/Ponderosa Pine PVT, which was dominated by the Ponderosa Pine cover type, cover types were dominated by Douglas-fir in nearly all of these PVTs (appendix 9-K: table 3).

Pine Forests—Pine forest PVTs represented areas generally out of the range of distribution of either the Spruce – Fir cover type or the Douglas-fir cover type. These PVTs included the Ponderosa Pine PVT, the Timberline Pine/Limber Pine PVT, the Lodgepole Pine PVT, and the Timberline Pine/Whitebark Pine PVT (appendix 9-L). The Ponderosa Pine PVT occurred at the lowest elevations and was characterized by very short fire return intervals (appendix 9-L: table 2). This regime maintained both High Cover, High Height and Low Cover, High Height Forest structural stages of the Ponderosa Pine cover type in high proportions (appendix 9-L: table 3). The remaining PVTs were characterized by fairly long fire return intervals, which maintained a variety of structural stages in each of the cover types that were modeled in the PVT.

Broadleaf Forests—Broadleaf forests were represented by the Riparian Hardwood PVT, which was the only PVT where broadleaf trees were the chief component (appendix 9-M). Appendix 9-M: table 1 shows the list of succession classes used for the VDDT modeling of the Riparian Hardwood PVT. This PVT had a mix of fire regimes but tended to be dominated by stand-replacing fire with a long return interval (although, unlike other PVTs, the influence of surrounding PVTs' fire regimes seemed to affect this PVT more than its own). The result of this PVT's fire regime was dominance of the Riparian Hardwood cover type, dominated by cottonwood, with small and dispersed amounts of the Aspen – Birch cover type (appendix 9-M: table 3).

Woodlands—Woodland vegetation in Zone 19 was represented by the Rocky Mountain Juniper PVT and the Mountain Mahogany PVT (appendix 9-N). The Rocky Mountain Juniper PVT featured the Juniper cover type – with Rocky Mountain juniper as the dominant

species – in addition to a significant component of the Perennial Native Bunch Graminoids cover type (appendix 9-N: table 3). Fire intervals used in the VDDT modeling process were fairly long (appendix 9-N: table 2). The Mountain Mahogany PVT represented somewhat rare sites around the zone that were located adjacent to ridge tops and on rock outcrops that support the Mountain Mahogany cover type. Our succession model used fairly long fire return intervals (appendix 9-N: table 2), resulting in the dominance of the Mountain Mahogany cover type and a wide array of structural stages, along with lesser amounts of the Wyoming – Basin Big Sagebrush cover type.

Sagebrush and Other Dry Shrublands—Sagebrush and other shrub types in Zone 19 were represented by four different PVTs (appendix 9-O). All of these PVTs featured a model including conifer succession classes and a model excluding conifer succession. Models with conifer succession classes represented areas generally adjacent to conifer PVTs where conifer encroachment is most likely to occur due to proximity to seed source and site conditions. The Mountain Big Sagebrush PVT and the Threetip Sagebrush PVT were modeled with fairly short fire return intervals (appendix 9-O: table 2). In both cases, a substantial proportion of the PVT was maintained in the Perennial Native Bunch Graminoid cover type (appendix 9-O: table 3). The remainder of the PVT was dominated by each respective sagebrush species cover type. The Wyoming – Basin Big Sagebrush PVT had somewhat longer fire return intervals and was maintained historically in a higher proportion of the Wyoming – Basin Big Sagebrush cover type; however, this PVT also had a significant proportion of the Perennial Native Bunch Graminoid cover type (appendix 9-O: table 3). The Dwarf Sagebrush PVT was modeled to represent fairly dry and less productive sites. With an available seed source, conifer encroachment will occur without fire; however, the encroachment will be very slow as these sites have soils with high salinity, or a caliche layer exists. Fire return intervals were moderately long (appendix 9-O: table 2), and most of the PVT was dominated by various structural stages of the Dwarf Sagebrush cover type (appendix 9-O: table 3).

The Dry Shrub PVT was modeled to represent a wide variety of shrub cover types found across a number of landscape settings (appendix 9-O: table 4). These cover types were relatively common in Zone 19 but did not necessarily grow adjacent to each other. Similar to the sagebrushes, this PVT had two succession pathway models, one associated with conifer encroachment and one not. We assumed a long fire return interval for this PVT and, like the sagebrushes, results showed a substantial proportion of the PVT dominated by the Perennial Native Bunch Graminoid cover type (appendix 9-O: table 6). The dominant shrub cover was the Shrubby Cinquefoil cover type.

Grasslands—Grassland PVTs for Zone 19 consisted of the Fescue Grassland PVT and the Bluebunch Wheatgrass PVT (appendix 9-P). The Fescue Grassland PVT was represented by Idaho fescue and rough fescue. We modeled two fescue grasslands that differ only in inclusion of a conifer component. Conifers, predominantly Douglas-fir, are often adjacent to fescue grassland PVTs, and if a seed source is available, conifer encroachment will occur over time without fire. We modeled these types of sites with the Fescue Grassland/Conifer PVT. On sites where grasses are competitive, especially on finer-textured soils, large areas of the landscape presently show very little conifer encroachment. These types of sites were modeled with a moderately short fire return interval (appendix 9-P: table 2) which, over time, maintained the PVT with an even distribution of the Perennial Native Bunch Graminoid and shrub cover types (appendix 9-P: table 3).

The Bluebunch Wheatgrass PVT represents some of the drier grasslands in Zone 19, and conifer invasion occurred slowly. The potential and degree of conifer invasion depended on the soils, surrounding landscape, and past disturbances. In the southern portion of the zone, Utah juniper and Rocky Mountain juniper were the conifer species most likely to encroach into these grasslands. In the central and northern parts of Zone 19, Rocky Mountain juniper was common, as were Douglas-fir, limber pine and ponderosa pine. Fire intervals in this PVT were fairly short (appendix 9-P: table 2). A large proportion of the PVT was maintained in the Perennial Native Bunch Graminoid cover type, attesting to the drier nature of these sites.

Recommendations for National Implementation

PVT Classification

The PVT classification formed the foundation for all succession modeling in the two prototype areas (Long and others, Ch. 6). A number of existing western U.S. habitat type classifications, which could be linked directly to the LANDFIRE PVT classification, proved to be immensely helpful. The modeling of succession and the effects of disturbance would have been, at best, conjectural without these baseline, floristically detailed

classifications embedded within the PVT classification. This classification provided the framework for understanding the interactions between the succession classes found within each PVT. As noted, much of the western U.S. has existing habitat classifications in place, at least for forest vegetation; however, in other portions of the country, such classifications do not exist. Furthermore, the development of a climax vegetation-based PVT classification and subsequent succession modeling become problematic due to the historical land use of these non-western areas and the more subtle and complicated species interactions therein. The modeling of vegetation response in the Midwest and East should therefore be based on concepts other than the climax vegetation theory to properly evaluate succession and disturbance processes.

Cover Type Classification

The vegetation models were generally designed to simulate vegetation dynamics at the mid-level, but small inclusions of other PVTs or cover types were often evident in the plot data. These inclusions resulted in a number of illogical cover type combinations for some PVTs. Unfortunately, there was no process in place to address this issue, and, in some cases, these combinations were carried forward into the succession modeling process. Similarly, we encountered situations where, within a zone, a cover type occurred in only a particular geographic region of the PVT. In these situations, it became necessary to develop rules by which to subdivide the mapping zone and apply different succession models to these geographic variants. We recommend developing succession classes based on a more generalized and robust characterization of cover types so these situations can be avoided.

In addition, because there is a wide diversity of understory vegetation that may dominate during the early seral stages of forest development, we had to use a number of cover types to represent these stages of many PVTs. We used four succession classes to describe the early seral stages of forest development in Zone 16 PVTs and, on average, over seven succession classes to describe the early seral stages of forest development in Zone 19. At any given time, these early stages represented l0 percent or less of the total amount of all succession classes. Consequently, at any point in time in the modeling, a particular succession class in these early seral stages may have represented less than one percent of the vegetation. For this reason, we recommend that the number of cover types used to describe early seral stages of forest development be kept to a minimum and represent broad categories of vegetation.

For Zone 19, we employed a cover type classification that relied more on physiognomic characteristics in an attempt to provide a more systematic methodology to the classification process (Long and others, Ch. 6). However, this classification resulted in a number of cover types that were difficult to use for succession modeling purposes. For example, the Upland Broadleaf Medium Shrubland cover type included both mountain snowberry and menziesia shrubs. In one case, the cover type occurs in very dry conditions while, in the other case, it occurs in a moist, cool environment. This resulted in two very different fire intervals for the same cover type. We recommend using a cover type classification more closely aligned with the classification employed for Zone 16, which categorizes the cover types based on their response to environmental conditions and fire intervals, rather than on a physiognomic classification (Long and others, Ch. 6). It should be noted that the development of such a classification requires the input of expert opinion.

Structural Stage Classification

Structural stages, as defined by the LANDFIRE structural stage classification, served as the main characteristic to describe forest development in the modeling process. It was assumed that as forests age, they become taller and denser. In addition, it was assumed that the height and cover classes would represent meaningful differences in seral stages and effectively describe early, mid, and late seral communities associated with the forest development process. The structural stage classification was built around four combinations of two height and two cover classes for each life form, and these classes were defined prior to the model building process. Thresholds used to define low height and high height as well as low cover and high cover had a great bearing on the modelers' ability to describe the forest development process.

For many of the cover types, the height thresholds used to define low height structural stages created succession classes that existed for too short of a time period and did not capture the entire age range of the mid-seral stage of forest development. This caused these classes to be insensitive to changes made in many of the model parameters, and they consequently had very little effect on the final results of the model. Conversely, height thresholds used define high height structural stages created succession classes that existed for too long of a time period and subsequently affected the model results greatly. We recommend defining structural stage

categories that use height breaks that more concisely bracket age ranges within the succession classes and tier more to early, mid, and late seral stage concepts.

Disturbance Modeling

The overall disturbance modeling process became somewhat problematic because of the inherent differences between the ways VDDT and LANDSUMv4 model disturbance. The VDDT model is designed to treat each pixel independently of its neighbors, whereas LANDSUMv4 models fire spread across landscapes, incorporating landscape context into mapped model output. In other words, a simulated fire will spread to adjacent pixels in the LANDSUMv4 model, whereas pixels are modeled independently in the VDDT model. Thus fire intervals modeled in LANDSUMv4 for particular places on the landscape may not match those modeled in VDDT. We recommend use of LANDSUMv4 to test and verify the succession model input parameters. There may also be value in allowing the modelers to review the LANDSUMv4 output as a final assessment of the input parameters used in the modeling process and to evaluate the spatial aspects that LANDSUMv4 uses in the disturbance simulation process.

Another issue related to disturbance modeling encountered in the LANDFIRE Prototype Project involved species that followed stand-replacing disturbances. No preference was given to cover types that aggressively colonize following a fire event, such as Lodgepole Pine. Similarly, no advantage was given to cover types better-adapted to regeneration under the tree canopy conditions that usually develop after moderate disturbances, in types such as Grand Fir – White Fir. This approach may have underestimated the amount of Lodgepole Pine cover type resulting from stand-replacing fire as well as the amount of Grand Fir – White Fir cover type resulting from an insect outbreak. This situation should be evaluated in future modeling efforts. We recommend that, when estimating proportions of these outcomes, fire adapted species and their inherent survival strategies be considered in this process with less reliance on proportions from habitat type classifications.

One of the most difficult tasks in the vegetation modeling for the LANDFIRE Prototype was estimating the fire intervals and fire severities for the various succession classes within each PVT. Although estimates were available in the literature for the average fire return interval and fire severity of a particular cover type, little information was available regarding the ways return intervals or severities varied with the age of the cover type. In addition, there is very little information available regarding the return intervals of post-disturbance early seral stages of many cover types. We recommend that a wider array of experts, who specialize in a wide array of ecological conditions found around the country, develop such estimates for use in future modeling efforts.

Although we adjusted fire intervals by the structural stage of the cover type, no attempt was made to adjust fire intervals following events in the life of a stand that affect fuel loading or fuel conditions. One example of such an event would be an outbreak of mountain pine beetle in a lodgepole pine stand, which generally increases the risk of stand-replacing fire. We recommend that these types of interactions be explored in future modeling studies.

Model Evaluation

Historical vegetation studies may be used as guidelines to evaluate the results of each model; however, conclusive evaluation of the results from the various succession models is uncertain at best. Even in areas with good fire history studies, the model evaluation is subjective. In areas with limited data available on natural fire frequencies, the process will be even more difficult. We recommend developing guidelines, according to expert opinion, prior to model development to determine which criteria will be used to evaluate model results.

Conclusion

We executed each of our models for a 1000-year simulation period and assumed that the proportion of succession classes for each PVT at the end of the period would represent the historical conditions found on the landscape at the time of Euro-American settlement. In the succession model development process, we made every effort to simulate the historical succession and disturbance processes for each PVT. However, the variation and complexity of these processes is such that we should not imply that these results are the only representation of historical conditions for each PVT. The models reflect only our best understanding of these historical processes. The results of these models should be thought of as portraying a range of conditions, with a great deal of variation from one time period to the next.

For further project information, please visit the LANDFIRE website at www.landfire.gov.

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Appendix 9-A—Spruce – Fir Forest PVTs

Appendix 9-A: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Spruce – Fir PVTs.

Succession class	Spruce – Fir/Blue Spruce	Spruce – Fir/Spruce – Fir
Cool Season Grasses	15	15
Dry Deciduous Shrub	15	15
Montane Evergreen Shrubs	15	15
Mountain Deciduous Shrub		15
Native Forbs	10	10
Wetland Herbaceous	15	17
Aspen – Birch-HHF*	115	120
Aspen – Birch-HLF	25	22
Aspen – Birch-LHF	40	35
Aspen – Birch-LLF	10	8
Douglas-fir-HHF	255	260
Douglas-fir-HLF	30	27
Douglas-fir-LHF	45	45
Douglas-fir-LLF	15	13
Grand Fir – White Fir-HHF	250	
Grand Fir – White Fir-HLF	35	
Grand Fir – White Fir-LHF	50	
Grand Fir – White Fir-LLF	15	
Lodgepole Pine-HHF	170	175
Lodgepole Pine-HLF	15	13
Lodgepole Pine-LHF	35	30
Lodgepole Pine-LLF	15	12
Ponderosa Pine-HHF	470	
Ponderosa Pine-HLF	17	
Ponderosa Pine-LHF	35	
Ponderosa Pine-LLF	13	
Spruce – Fir-HHF	395	400
Spruce – Fir-HLF	30	30
Spruce – Fir-LHF	55	50
Spruce – Fir-LLF	25	20
Timberline Pine-HHF	225	
Timberline Pine-HLF	45	
Timberline Pine-LHF	45	
Timberline Pine-LLF	30	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-A: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 16 Spruce – Fir PVTs.

Succession class	Spruce – Fir/Blue Spruce			Spruce – Fir/Spruce – Fir		
	SR*	MS	NL	SR	MS	NL
Cool Season Perennial Grass	200			200		
Native Forb	350			345		
Wetland Herbaceous	750			750		
Mountain Deciduous Shrub				600		
Dry Deciduous Shrub	300			400		
Montane Evergreen Shrub	250			300		
Aspen – Birch-LLF**	250			300		
Aspen – Birch-HLF	200			200		
Aspen – Birch-LHF	150		50	150		50
Aspen – Birch-HHF	125	85	60	125	100	60
Douglas-fir-LLF	75			100		
Douglas-fir-HLF	150		50	75		
Douglas-fir-LHF	300	100	40	400	100	40
Douglas-fir-HHF	200	100	50	300	100	50
Ponderosa Pine-LLF	75					
Ponderosa Pine-HLF	150		50			
Ponderosa Pine-LHF	250	150	30			
Ponderosa Pine-HHF	200	125	35			
Lodgepole Pine-LLF	300			300		
Lodgepole Pine-HLF	150			150		
Lodgepole Pine-LHF	200	125	80	200	150	80
Lodgepole Pine-HHF	175	100	75	175	125	80
Timberline Pine-LLF	300					
Timberline Pine-HLF	300					
Timberline Pine-LHF	300		100			
Timberline Pine-HHF	300	200	75			
Spruce – Fir-LLF	400			400		
Spruce – Fir-HLF	300			300		
Spruce – Fir-LHF	400	200	75	400	200	75
Spruce – Fir-HHF	300	200	75	300	200	100
Grand Fir – White Fir-LLF	100					
Grand Fir – White Fir-HLF	150		50			
Grand Fir – White Fir-LHF	300	125	40			
Grand Fir – White Fir-HHF	200	125	50			

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire

** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-A: Table 3—Succession modeling results in percent composition of each of the Zone 16 Spruce – Fir PVTs.

Succession class	Spruce – Fir/ Blue Spruce	Spruce – Fir/ Spruce – Fir
Dry Deciduous Shrub	1.4	1.4
Mountain Deciduous Shrub		0.9
Montane Evergreen Shrub	1.5	0.1
Riparian Shrub		
Cool Season Perennial Grass	0.9	0.4
Native Forb	0.9	1.5
Wetland Herbaceous	0.1	0.4
Douglas-fir-LLF*	1	1.2
Douglas-fir-HLF	1	1.3
Douglas-fir-LHF	9.6	10.2
Douglas-fir-HHF	14.8	16.1
Ponderosa Pine-LLF	0.2	
Ponderosa Pine-HLF	0.3	
Ponderosa Pine-LHF	1	
Ponderosa Pine-HHF	2.1	
Grand Fir – White Fir-LLF	0.4	
Grand Fir – White Fir-HLF	0.6	
Grand Fir – White Fir-LHF	1.3	
Grand Fir – White Fir-HHF	1.3	
Lodgepole Pine-LLF	0.4	1
Lodgepole Pine-HLF	0.4	0.4
Lodgepole Pine-LHF	6.2	4.8
Lodgepole Pine-HHF	3.7	6.5
Spruce – Fir-LLF	1.1	2.8
Spruce – Fir-HLF	2	3.1
Spruce – Fir-LHF	9.6	11.3
Spruce – Fir-HHF	10.3	14.7
Aspen – Birch-LLF	2.1	1.6
Aspen – Birch-HLF	4.1	5.5
Aspen – Birch-LHF	7.7	5.3
Aspen – Birch-HHF	7.6	9.4
Timberline Pine-LLF	1.4	
Timberline Pine-HLF	0.5	
Timberline Pine-LHF	0.5	
Timberline Pine-HHF	3.9	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-B—White Fir / Douglas-fir Forest PVTs

Appendix 9-B: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 White Fir / Douglas-fir PVTs.

Succession class	Grand Fir – White Fir	Douglas-fir/ Timberline Pine	Douglas-fir/ Douglas-fir	Douglas-fir/ Lodgepole Pine
Cool Season Grasses-HLH*			19	
Dry Deciduous Shrub-HLS	12		17	
Montane Evergreen Shrub-LLS	14			14
Mountain Deciduous Shrub-LHS	14	24	19	14
Native Forb-HLH				11
Aspen – Birch-HHF	110	125	110	110
Aspen – Birch-HLF	30	35	30	30
Aspen – Birch-LHF	45	50	45	45
Aspen – Birch-LLF	12	15	12	12
Douglas-fir-HHF	255	300	305	305
Douglas-fir-HLF	25	20	25	25
Douglas-fir-LHF	45	60	45	45
Douglas-fir-LLF	20	30	20	20
Grand Fir – White Fir-HHF	250			
Grand Fir – White Fir-HLF	30			
Grand Fir – White Fir-LHF	50			
Grand Fir – White Fir-LLF	20			
Juniper-HHF		310	310	
Juniper-HLF		150	150	
Juniper-LHF		75	75	
Juniper-LLF		40	40	
Lodgepole Pine-HHF				175
Lodgepole Pine-HLF				13
Lodgepole Pine-LHF				30
Lodgepole Pine-LLF				12
Pinyon – Juniper-HHF		225		
Pinyon – Juniper-HLF		35		
Pinyon – Juniper-LHF		75		
Pinyon – Juniper-LLF		40		
Ponderosa Pine-HHF	470	460	460	270
Ponderosa Pine-HLF	15	20	20	15
Ponderosa Pine-LHF	35	45	45	35
Ponderosa Pine-LLF	15	20	20	15
Timberline Pine-HHF	225	225		
Timberline Pine-HLF	45	35		
Timberline Pine-LHF	50	75		
Timberline Pine-LLF	30	40		

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-B: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 16 White Fir and Douglas-fir PVTs.

	Grand Fir – White Fir			Douglas-fi/Lodgepole Pine		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Cool Season Grasses-HLH**						
Dry Deciduous Shrub-HLS	500			200		
Montane Evergreen Shrub-LLS	200			200		
Mountain Deciduous Shrub-LHS	150					
Native Forb-HLH				300		
Aspen – Birch-HHF	125	75	50	125	75	50
Aspen – Birch-HLF	150			150		
Aspen – Birch-LHF	200		50	175		50
Aspen – Birch-LLF	200			200		
Douglas-fir-HHF	200	125	40	150	125	75
Douglas-fir-HLF	150		40	100		60
Douglas-fir-LHF	300	100	40	300	75	50
Douglas-fir-LLF	50			75		
Grand Fir – White Fir-HHF	200	125	40			
Grand Fir – White Fir-HLF	150		40			
Grand Fir – White Fir-LHF	300	150	40			
Grand Fir – White Fir-LLF	75					
Lodgepole Pine-HHF				150	75	45
Lodgepole Pine-HLF				100		
Lodgepole Pine-LHF				200	150	50
Lodgepole Pine-LLF				300		
Ponderosa Pine-HHF	250	100	35	300	100	35
Ponderosa Pine-HLF	150		50	150		50
Ponderosa Pine-LHF	250	150	30	300	150	30
Ponderosa Pine-LLF	75			75		
Timberline Pine-HHF	300	200	75			
Timberline Pine-HLF	250					
Timberline Pine-LHF	300		100			
Timberline Pine-LLF	250					

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-B: Table 3—Fire frequencies, in years and by severity type, used in succession modeling for Zone 16 White Fir and Douglas-fir PVTs.

	Douglas-fir/Timberline Pine			Douglas-fir/Douglas-fir		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Cool Season Grasses-HLH**				100		
Dry Deciduous Shrub-HLS				400		
Montane Evergreen Shrub-LLS						
Mountain Deciduous Shrub-LHS	50			150		
Native Forb-HLH						
Aspen – Birch-HHF	125	85	59	125	85	50
Aspen – Birch-HLF	150			150		
Aspen – Birch-LHF	175		75	175		50
Aspen – Birch-LLF	200			200		
Douglas-fir-HHF	300	150	59	150	100	35
Douglas-fir-HLF	150		59	125		35
Douglas-fir-LHF	350		50	250	100	35
Douglas-fir-LLF	100			50		
Juniper-HHF	300	200		250	250	
Juniper-HLF	200			125		
Juniper-LHF	300	200		200	150	
Juniper-LLF	200			75		
Lodgepole Pine-HHF		75	45			
Lodgepole Pine-HLF						
Lodgepole Pine-LHF		150	50			
Lodgepole Pine-LLF						
Pinyon – Juniper-HHF	250	150	100			
Pinyon – Juniper-HLF	200		100			
Pinyon – Juniper-LHF	250	150	75			
Pinyon – Juniper-LLF	200			300	200	15
Ponderosa Pine-HHF	300		25	100		25
Ponderosa Pine-HLF	150		30	400	200	15
Ponderosa Pine-LHF	400	150	20	40		
Ponderosa Pine-LLF	50					
Timberline Pine-HHF	300	200	100			
Timberline Pine-HLF	100					
Timberline Pine-LHF	300		75			
Timberline Pine-LLF	200					

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-B: Table 4—Succession modeling results in percent composition of each of the Zone 16 White Fir / Douglas-fir PVTs.

Succession class	Grand Fir – White Fir	Douglas-fir/ Timberline Pine	Douglas-fir/ Douglas-fir	Douglas-fir/ Lodgepole Pine
Cool Season Grasses-HLH*			0.2	
Dry Deciduous Shrub-HLS	5.1	10.3	1	3.4
Montane Evergreen Shrub-LLS	0.8			1.1
Mountain Deciduous Shrub-LHS	0.7		7.8	
Native Forb-HLH				2.8
Aspen – Birch-HHF	4.1	1.8	9.8	3.7
Aspen – Birch-HLF	4	1.3	5.6	2.8
Aspen – Birch-LHF	3.1	2.2	11.1	3.5
Aspen – Birch-LLF	1.8	1.1	2.7	1.2
Douglas-fir-HHF	19.3	30	21.5	38.7
Douglas-fir-HLF	1.3	1.8	3.2	2.3
Douglas-fir-LHF	11.3	15.6	15.6	17.7
Douglas-fir-LLF	2.1	2.9	4.7	4.2
Grand Fir – White Fir-HHF	4.4			
Grand Fir – White Fir-HLF	0.8			
Grand Fir – White Fir-LHF	4.7			
Grand Fir – White Fir-LLF	2.8			
Juniper-HHF		1.8	1.2	
Juniper-HLF		1.3	2.2	
Juniper-LHF		1.3	0.1	
Juniper-LLF		0.8	1.1	
Lodgepole Pine-HHF				3.2
Lodgepole Pine-HLF				0.5
Lodgepole Pine-LHF				2.8
Lodgepole Pine-LLF				1.3
Pinyon – Juniper-HHF		2		
Pinyon – Juniper-HLF		0.4		
Pinyon – Juniper-LHF		1.5		
Pinyon – Juniper-LLF		1		
Ponderosa Pine-HHF	14.1	7.6	7	7
Ponderosa Pine-HLF	1.1	0.4	0.9	0.7
Ponderosa Pine-LHF	6.8	4	3.7	2.4
Ponderosa Pine-LLF	1.3	0.5	0.5	0.6
Timberline Pine-HHF	4.8	5.5		
Timberline Pine-HLF	1.2	1.2		
Timberline Pine-LHF	0.9	1.9		
Timberline Pine-LLF	0.4	1.7		

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-C—Pine Forest PVTs

Appendix 9-C: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Pine PVTs.

Succession class	Lodgepole Pine	Ponderosa Pine	Timberline Pine
Cool Season Grasses-HLH*	12	25	
Mountain Deciduous Shrub-LHS	12	30	50
Montane Evergreen Shrub-LLS	12	25	
Native Forb-HLH	10		
Wetland Herbaceous-LHH	15		
Aspen – Birch-HHF	110	100	
Aspen – Birch-HLF	30	35	
Aspen – Birch-LHF	45	50	
Aspen – Birch-LLF	12	15	
Juniper-HHF		310	
Juniper-HLF		150	
Juniper-LHF		75	
Juniper-LLF		40	
Lodgepole Pine-HHF	270		
Lodgepole Pine-HLF	18		
Lodgepole Pine-LHF	35		
Lodgepole Pine-LLF	12		
Pinyon – Juniper-HHF		225	
Pinyon – Juniper-HLF		35	
Pinyon – Juniper-LHF		75	
Pinyon – Juniper-LLF		40	
Ponderosa Pine-HHF		460	
Ponderosa Pine-HLF		20	
Ponderosa Pine-LHF		45	
Ponderosa Pine-LLF		20	
Timberline Pine-HHF			925
Timberline Pine-HLF			35
Timberline Pine-LHF			75
Timberline Pine-LLF			40

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-C: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 16 Pine PVTs.

	Lodgepole Pine			Ponderosa Pine			Timberline Pine		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**	**SR**	**MS**	**NL**
Cool Season Grasses-HLH**	150								
Mountain Deciduous Shrub-LHS	200			50			200		
Montane Evergreen Shrub-LLS	200			75					
Native Forb-HLH	300								
Wetland Herbaceous-LHH	500								
Aspen – Birch-HHF	150	100	60	100	75	40			
Aspen – Birch-HLF	150			75					
Aspen – Birch-LHF	175		60	125		45			
Aspen – Birch-LLF	300			100					
Juniper-HHF				200	100	40			
Juniper-HLF				100		40			
Juniper-LHF				300	200	35			
Juniper-LLF				50					
Lodgepole Pine-HHF	150		45						
Lodgepole Pine-HLF	100								
Lodgepole Pine-LHF	200	100	60						
Lodgepole Pine-LLF	300								
Pinyon – Juniper-HHF				200	100	30			
Pinyon – Juniper-HLF				100		30			
Pinyon – Juniper-LHF				300	200	25			
Pinyon – Juniper-LLF				40					
Ponderosa Pine-HHF				300	100	15			
Ponderosa Pine-HLF				100		25			
Ponderosa Pine-LHF				400	200	10			
Ponderosa Pine-LLF				40					
Timberline Pine-HHF							300	200	100
Timberline Pine-HLF							100		
Timberline Pine-LHF							350		75
Timberline Pine-LLF							200		

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-C: Table 3—Succession modeling results in percent composition of each of the Zone 16 Pine PVTs.

Succession class	Lodgepole Pine	Ponderosa Pine	Timberline Pine
Cool Season Grasses-HLH*	0.4	3.8	
Mountain Deciduous Shrub-LHS	1.7	6.8	17.1
Montane Evergreen Shrub-LLS	0.8	2.5	
Native Forb-HLH	0.2		
Wetland Herbaceous-LHH	0.6		
Aspen – Birch-HHF	17.7	2.7	
Aspen – Birch-HLF	9.5	3	
Aspen – Birch-LHF	16.6	2.8	
Aspen – Birch-LLF	4.5	1	
Juniper-HHF		0.5	
Juniper-HLF		1.3	
Juniper-LHF		0.1	
Juniper-LLF		0.9	
Lodgepole Pine-HHF	19.7		
Lodgepole Pine-HLF	5.7		
Lodgepole Pine-LHF	16.6		
Lodgepole Pine-LLF	5.9		
Pinyon – Juniper-HHF		0.8	
Pinyon – Juniper-HLF		0.5	
Pinyon – Juniper-LHF		0.2	
Pinyon – Juniper-LLF		0.5	
Ponderosa Pine-HHF		38.7	
Ponderosa Pine-HLF		1.8	
Ponderosa Pine-LHF		28	
Ponderosa Pine-LLF		4	
Timberline Pine-HHF			49.3
Timberline Pine-HLF			7.2
Timberline Pine-LHF			16
Timberline Pine-LLF			10.4

* For complete structural stage names, refer to table 5: *Structural stages used for succession modeling in zones 16 and 19.*

Appendix 9-D—Broadleaf Forest PVTs

Appendix 9-D: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Broadleaf PVTs.

Succession class	Riparian Hardwood	Aspen
Cool Season Grasses-HLH*	10	10
Dry Deciduous Shrub-HLS	15	12
Montane Evergreen Shrub-LLS		12
Mountain Deciduous Shrub-LHS	15	
Native Forb-HLH		8
Wetland Herbaceous-LHH		10
Aspen – Birch-HHF		120
Aspen – Birch-HLF		22
Aspen – Birch-LHF		35
Aspen – Birch-LLF		8
Juniper-HHF	100	
Juniper-HLF	70	
Juniper-LHF	50	
Juniper-LLF	30	
Mountain Deciduous Shrub -HHF	80	
Mountain Deciduous Shrub -HLF	10	
Mountain Deciduous Shrub -LHF	25	
Mountain Deciduous Shrub -LLF	10	
Riparian Hardwood-HHF	200	
Riparian Hardwood-HLF	22	
Riparian Hardwood-LHF	50	
Riparian Hardwood-LLF	8	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-D: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 16 Broadleaf PVTs.

	Riparian Hardwood			Aspen		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Cool Season Grasses-HLH**	250			200		
Dry Deciduous Shrub-HLS	300			300		
Montane Evergreen Shrub-LLS				300		
Mountain Deciduous Shrub-LHS	400					
Native Forb-HLH				350		
Wetland Herbaceous-LHH				750		
Aspen – Birch-HHF				100		75
Aspen – Birch-HLF				150		
Aspen – Birch-LHF				200		50
Aspen – Birch-LLF				200		
Juniper-HHF 150	100	75				
Juniper-HLF 150		75				
Juniper-LHF 150	100	75				
Juniper-LLF 200						
Mountain Deciduous Shrub-HHF	150		75			
Mountain Deciduous Shrub-HLF	200					
Mountain Deciduous Shrub-LHF	150		60			
Mountain Deciduous Shrub-LLF	200					
Riparian Hardwood-HHF	200		100			
Riparian Hardwood-HLF	200					
Riparian Hardwood-LHF	200		100			
Riparian Hardwood-LLF	200					

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire

* *For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-D: Table 3—Succession modeling results in percent composition of each of the Zone 16 Broadleaf PVTs.

Succession class	Riparian Hardwood	Aspen
Cool Season Grasses-HLH*	2.5	0.5
Dry Deciduous Shrub-HLS	2.3	2.5
Montane Evergreen Shrub-LLS		0.9
Mountain Deciduous Shrub-LHS	1.2	
Native Forb-HLH		0.8
Wetland Herbaceous-LHH		0
Aspen – Birch-HHF		55.4
Aspen – Birch-HLF		14.8
Aspen – Birch-LHF		17.7
Aspen – Birch-LLF		7.4
Juniper-HHF	2.3	
Juniper-HLF	2.4	
Juniper-LHF	3.9	
Juniper-LLF	2.9	
Mountain Deciduous Shrub -HHF	3.8	
Mountain Deciduous Shrub -HLF	0.8	
Mountain Deciduous Shrub -LHF	0.9	
Mountain Deciduous Shrub -LLF	0.6	
Riparian Hardwood-HHF	39.7	
Riparian Hardwood-HLF	8.7	
Riparian Hardwood-LHF	23.3	
Riparian Hardwood-LLF	3.8	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-E—Pinyon – Juniper Woodland PVTs

Appendix 9-E: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Pinyon – Juniper PVTs.

	Pinyon – Juniper/Wyoming – Basin Big Sagebrush		Pinyon – Juniper/ Mountain Big Sagebrush	
Succession class	Northern variant	Southern variant	Northern variant	Southern variant
Cool Season Grasses-LHH*	20		5	10
Cool Season Grasses-LLH	25	25		
Desert Shrub-LHS	25	25		
Desert Shrub-LLS	20	20		
Dry Deciduous Shrub-LHS	25		25	25
Dry Deciduous Shrub-LLS	20		20	20
Dwarf Sagebrush Complex-LHS	25	25		
Dwarf Sagebrush Complex-LLS	20	20		
Juniper-HHW	250	250	300	300
Juniper-LHW	100	100	100	100
Juniper-LLW	50	50	50	5
Mountain Big Sagebrush Complex-HLS			30	30
Mountain Big Sagebrush Complex-LLS			10	15
Mountain Deciduous Shrub-LHS			25	25
Mountain Deciduous Shrub-LLS			20	20
Pinyon – Juniper HHW	250	250	300	300
Pinyon – Juniper-LHW	100	100	100	100
Pinyon – Juniper-LLW	50	50	50	50
Wyoming – Basin Big Sagebrush Complex-HLS	50	50		
Wyoming – Basin Big Sagebrush Complex-LLS	25	25		

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-E: Table 2—Fire frequencies, in years, used in succession modeling for Zone 16 Pinyon – Juniper PVTs. All fires were modeled as stand-replacing.

	Pinyon – Juniper/Wyoming – Basin Big Sagebrush		Pinyon – Juniper/ Mountain Big Sagebrush	
Succession class	Northern variant	Southern variant	Northern variant	Southern variant
Cool Season Grasses-LHH*	50	50	30	30
Cool Sseason Grasses-LLH	50	50	30	30
Desert Shrub-HLS	60	60		
Desert Shrub-LLS	60	60		
Dry Deciduous Shrub-HLS	40	40		
Dry Deciduous Shrub-LLS	50	50		
Dwarf Sagebrush Complex-HLS	60	60		
Dwarf Sagebrush Complex-LLS	60	60		
Juniper-HHW	60	60	30	30
Juniper-HLW	50	50	30	30
Mountain Big Sagebrush Complex –LLS			30	30
Mountain Big Sagebrush Complex-HLS			30	30
Mountain Deciduous Shrub-HLS			30	30
Mountain Deciduous Shrub-LLS			30	30
Pinyon – Juniper-HHW	50	50	30	30
Pinyon – Juniper-HLW	60	60	30	30
Wyoming – Basin Big Sagebrush Complex-HLS	50	50		
Wyoming – Basin Big Sagebrush Complex–LLS	50	50		

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-E: Table 3—Succession modeling results in percent composition of each of the Zone 16 Pinyon – Juniper PVTs. PVTs. All fires were modeled as stand-replacing.

	Pinyon – Juniper/Wyoming – Basin Big Sagebrush		Pinyon – Juniper/ Mountain Big Sagebrush	
Succession class	Northern variant	Southern variant	Northern variant	Southern variant
Cool Season Grasses-LHH*			5	
Cool Season Grasses-LLH	2	1	4	3
Desert Shrub-LHS	2	2		
Desert Shrub-LLS	2	2		
Dry Deciduous Shrub-LHS	2			
Dry Deciduous Shrub-LLS	3		1	
Dwarf Sagebrush Complex-LHS		1		
Dwarf Sagebrush Complex-LLS		2		
Juniper-HHW			1	
Juniper-LHW			15	
Juniper-LLW			46	
Mountain Big Sagebrush Complex-HLS			8	7
Mountain Big Sagebrush Complex-LLS			19	18
Mountain Deciduous Shrub-LHS				9
Mountain Deciduous ShrubLLS				1
Pinyon – Juniper High-HHW	5	10		
Pinyon – Juniper-LHW	24	35		16
Pinyon – Juniper-LLW	33	32		44
Wyoming – Basin Big Sagebrush Complex-HLS	4	1		
Wyoming – Basin Big Sagebrush Complex-LLS	23	2		

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-F—Mountain Shrubland PVTs

Appendix 9-F: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Mountain PVTs.

Succession class	Pinyon – Juniper/ Mountain Mahogany	Pinyon – Juniper/ Gambel Oak	Grand Fir – White Fir/Maple
Cool Season Grasses-HLH*			2
Cool Season Grasses-LLH	10	3	1
Dry Deciduous Shrub-LHS	25	15	
Dry Deciduous Shrub-LLS	25	12	
Grand Fir – White Fir-HHF			50
Grand Fir – White Fir-LHF			50
Mountain Deciduous Shrub-HLW	20	20	14
Mountain Deciduous Shrub-LHW		150	
Mountain Deciduous Shrub-LLW	16	27	14
Mountain Mahogany-HHW	35		
Mountain Mahogany-LHW	255		
Pinyon – Juniper -LHW	65	100	
Pinyon – Juniper-HHW	100	100	
Pinyon – Juniper-LLW	25	50	
Riparian Hardwood-HHF			100
Riparian Hardwood-LHF			65
Riparian Hardwood-LLF			30

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-F: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 16 Mountain PVTs.

Succession class	Pinyon – Juniper/ Mountain Mahogany	Pinyon – Juniper/ Gambel Oak	Grand Fir – White Fir/Maple
Cool season perennial grass-HLH*			35
Cool season perennial grass-LLH	60	50	100
Dry Deciduous Shrub-LHS	50	40	
Dry Deciduous Shrub_LLS	60	50	
Grand Fir – White Fir-HHF			35
Grand Fir – White Fir-LHF			50
Mountain Deciduous Shrub-HLW	50		35
Mountain Deciduous Shrub-LHW	50		50
Mountain Deciduous Shrub-LLW		40	
Mountain Deciduous Shrub-HHW		40	
Mountain Mahogany-HHW	60		
Mountain Mahogany-LHW	60		
Pinyon – Juniper-HHW	60	35	
Pinyon – Juniper-LLW	60	35	
Riparian Hardwood-HHF			
Riparian Hardwood-LHF			50
Riparian Hardwood-LLF			50

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-F: Table 3—Succession modeling results in percent composition of each of the Zone 16 Mountain PVTs.

Succession class	Pinyon – Juniper/ Mountain Mahogany	Pinyon – Juniper/ Gambel Oak	Grand Fir – White Fir/Maple
Cool season perennial grass-HLH*			3
Cool season perennial grass-LLH	2	4	1
Dry Deciduous Shrub-LHS	8	13	
Dry Deciduous Shrub-LLS	3	11	
Grand Fir – White Fir-HHF			49
Grand Fir – White Fir-LHF			19
Mountain Deciduous Shrub-HLW		23	13
Mountain Deciduous Shrub-LHW		0	
Mountain Deciduous Shrub-LLW		2	11
Mountain Mahogany-HHW	33		
Mountain Mahogany-LHW	54		
Pinyon – Juniper-HHW		2	
Pinyon – Juniper-HLW	1	14	
Pinyon – Juniper-LLW		31	
Riparian Hardwood-HHF			0
Riparian Hardwood-LHF			4
Riparian Hardwood-LLF			0

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-G—Sagebrush Shrubland PVTs

Appendix 9-G: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Sagebrush PVTs.

Succession class	Dwarf Sagebrush Complex	Wyoming – Basin Big Sagebrush Complex	Mountain Big Sagebrush Complex
Cool Season Grasses-HLH*		42	15
Cool Season Grasses-LLH	20	3	
Dry Deciduous Shrub-HLS		30	30
Dry Deciduous Shrub-LLS		12	11
Dwarf Sagebrush Complex-HLS	150		
Dwarf Sagebrush Complex-LLS	30		
Mountain Deciduous Shrub-HHS		12	30
Mountain Deciduous Shrub-LHS		185	13
Mountain Big Sagebrush Complex-HLS			56
Mountain Big Sagebrush Complex-LLS			30
Rabbitbrush-HLS	30	12	13
Rabbitbrush-LLS	17	30	30
Salt Desert Shrub-HLS	180	175	
Salt Desert Shrub-LLS	17	22	
Wyoming – Basin Big Sagebrush-HLS	100	100	
Wyoming – Basin Big Sagebrush-LLS	50	55	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-G: Table 2—Fire frequencies, in years, used in succession modeling for Zone 16 Sagebrush PVTs. All fires were modeled as stand-replacing.

Succession class	Dwarf Sagebrush Complex	Wyoming – Basin Big Sagebrush Complex	Mountain Big Sagebrush Complex
Cool Season Grasses-HLH*		80	20
Cool Season Grasses-LLH	80	100	20
Dry Deciduous Shrub-HLS		60	20
Dry Deciduous Shrub-LLS		80	20
Dwarf Sagebrush Complex-HLS	100		
Dwarf Sagebrush Complex-LLS	100		
Mountain Deciduous Shrub-HHS		60	20
Mountain Deciduous Shrub-LHS		80	20
Mountain Big Sagebrush Complex-HLS			20
Mountain Big Sagebrush Complex-LLS			20
Rabbitbrush-HLS	60	60	20
Rabbitbrush-LLS	80	80	20
Salt Desert Shrub-HLS	100	100	
Salt Desert Shrub-LLS	120	100	
Wyoming – Basin Big Sagebrush-HLS	80	80	
Wyoming – Basin Big Sagebrush-LLS	80	80	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-G: Table 3—Succession modeling results in percent composition of each of the Zone 16 Sagebrush PVTs.

Succession class	Dwarf Sagebrush Complex	Wyoming – Basin Big Sagebrush Complex	Mountain Big Sagebrush Complex
Cool Season Grasses-HLH*		23	5
Cool Season Grasses-LLH	3	2	
Dry Deciduous Shrub-HLS		3	7
Dry Deciduous Shrub-LLS		3	6
Dwarf Sagebrush Complex-HLS	80		
Dwarf Sagebrush Complex-LLS			
Mountain Deciduous Shrub-HHS		1	6
Mountain Deciduous Shrub-LHS		7	8
Mountain Big Sagebrush Complex-HLS			22
Mountain Big Sagebrush Complex-LLS			47
Rabbitbrush-HLS		4	
Rabbitbrush-LLS	5	2	
Salt Desert Shrub-HLS	1		
Salt Desert Shrub-LLS	10		
Wyoming – Basin Big Sagebrush-HLS		27	
Wyoming – Basin Big Sagebrush-LLS	1	28	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-H—Desert Shrubland PVTs

Appendix 9-H: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 16 Desert PVTs.

Succession class	Blackbrush	Salt Desert Shrub
Blackbrush-HLS* 100		
Cool Season Grasses-LLH		15
Warm Season Grasses-LLH	3	
Desert Shrub-HLS	27	185
Desert Shrub-LLS	71	12
Rabbitbrush-LLS		12
Salt Desert Shrub-HLS		150
Salt Desert Shrub-LLS		35
Wyoming – Basin Big Sagebrush Complex-HLS		100

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-H: Table 2—Fire frequencies, in years, used in succession modeling for Zone 16 Desert PVTs. All fires were modeled as stand-replacing.

Succession class	Blackbrush	Salt Desert Shrub
Blackbrush-HLS*	200	
Cool Season Grasses-LLH		150
Warm Season Grasses-LLH	200	
Desert Shrub-HLS	200	100
Desert Shrub-LLS	200	150
Rabbitbrush-LLS		100
Salt Desert Shrub-HLS		100
Salt Desert Shrub-LLS		150
Wyoming – Basin Big Sagebrush Complex-HLS		85

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-H: Table 3—Succession modeling results in percent composition of each of the Zone 16 Desert PVTs.

Succession class	Blackbrush	Salt Desert Shrub
Blackbrush-HLS*	61	
Cool Season Grasses-LLH		1
Warm Season Grasses-LLH	1	
Desert Shrub-HLS	13	0
Desert Shrub-LLS	25	0
Rabbitbrush-LLS		3
Salt Desert Shrub-HLS		32
Salt Desert Shrub-LLS		4
Wyoming – Basin Big Sagebrush Complex-HLS		29

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-I—Western Redcedar and Grand Fir Forest PVTs

Appendix 9-I: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Western Redcedar and Grand Fir PVTs.

Succession class	Western Redcedar	Grand Fir
Aspen – Birch-HHT*		120
Aspen – Birch-HLMT		18
Aspen – Birch-LHT		35
Aspen – Birch-LLMT		12
Cedar-HHT	550	
Cedar-HLMT	20	
Cedar-LHT	55	
Cedar-LLMT	30	
Douglas-fir-HHT	375	375
Douglas-fir-HLMT	10	10
Douglas-fir-LHT	30	30
Douglas-fir-LLMT	15	15
Grand fir-HHT	265	945
Grand fir-HLMT	15	15
Grand fir-LHT	40	40
Grand fir-LLMT	20	20
Hemlock-HHT	460	
Hemlock-HLMT	15	
Hemlock-LHT	45	
Hemlock-LLMT	25	
Larch-HHT	330	480
Larch-HLMT	8	10
Larch-LHT	25	30
Larch-LLMT	12	12
Lodgepole Pine-HHT	125	175
Lodgepole Pine-HLMT	10	10
Lodgepole Pine-LHT	30	30
Lodgepole Pine-LLMT	15	15
Ponderosa Pine-HHT		420
Ponderosa Pine-HLMT		15
Ponderosa Pine-LHT		35
Ponderosa Pine-LLMT		15
Spruce – Fir-HHT	365	310
Spruce – Fir-HLMT	15	15
Spruce – Fir-LHT	40	45
Spruce – Fir-LLMT	20	25
White Pine-HHT	420	370
White Pine-HLMT	13	15
White Pine-LHT	35	35
White Pine-LLMT	15	15
Perennial Forb-HLHB	9	11
Perennial Native Bunch Gramminoid-HHHB	11	
Perennial Native Rhizomatous Gramminoid-HLHB	9	11
Riparian Broadleaf Shrubland-HHSH	14	
Upland Broadleaf Dwarf Shrubland-HLSH		14
Upland Broadleaf Medium Shrubland-HMSH	11	14
Upland Broadleaf Tall Shrubland-HHSH	14	17
Wetland Herbaceous-HHHB	11	14

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-I: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Western Redcedar and Grand Fir PVTs.

	Western Redcedar			Grand Fir		
Succession class	**SR***	**MS**	**NF**	**SR**	**MS**	**NL**
Aspen – Birch-HHT**				200	95	
Aspen – Birch-HLMT				150		
Aspen – Birch-LHT				200		65
Aspen – Birch-LLMT				200		
Cedar-HHT	350	350				
Cedar-HLMT	350					
Cedar-LHT	400	300	200			
Cedar-LLMT	350					
Douglas-fir-HHT	350	250	200	300	125	90
Douglas-fir-HLMT	300			50		
Douglas-fir-LHT	400	200	170	350	150	65
Douglas-fir-LLMT	300			75		
Grand Fir-HHT	300	125		250	100	150
Grand Fir-HLMT	300			75		
Grand Fir-LHT	400	200	170	300	125	90
Grand Fir-LLMT	300			75		
Hemlock-HHT	350	350				
Hemlock-HLMT	350					
Hemlock-LHT	400	300	200			
Hemlock-LLMT	350					
Larch-HHT	200	100		150	75	
Larch-HLMT	250			75		
Larch-LHT	300	200	85	200	100	100
Larch-LLMT	350			200		
Lodgepole Pine-HHT				300	150	54
Lodgepole Pine-HLMT				100	100	
Lodgepole Pine-LHT				350	250	38
Lodgepole Pine-LLMT				75		
Ponderosa Pine-HHT	350	350		250	110	
Ponderosa Pine-HLMT	350			200		
Ponderosa Pine-LHT	400	300	250	300	150	100
Ponderosa Pine-LLMT	350			250		
Spruce – Fir-HHT	300	200	135	300	200	60
Spruce – Fir-HLMT	500	500		100	100	
Spruce – Fir-LHT	350	200	100	350	200	48
Spruce – Fir-LLMT	250			75		
White Pine-HHT	350	150	400	300	200	200
White Pine-HLMT	350			100		
White Pine-LHT	400	250	150	300	250	155
White Pine-LLMT	350			150		
Perennial Forb-HLHB	350					
Perennial Native Bunch Gramminoid-HHHB	200			150		
Perennial Native Rhizomatous Gramminoid-HLHB	225			400		
Riparian Broadleaf Shrubland-HHSH				150		
Upland Broadleaf Dwarf Shrubland-HLSH	250			150		
Upland Broadleaf Medium Shrubland-HMSH	250			150		
Upland Broadleaf Tall Shrubland-HHSH	450			150		
Wetland Herbaceous-HHHB	500					

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-I: Table 3—Succession modeling results in percent composition of each of the Zone 19 Western Redcedar and Grand Fir PVTs.

Succession class	Western Redcedar	Grand Fir
Aspen – Birch-HHT*		0.9
Aspen – Birch-HLMT		0.7
Aspen – Birch-LHT		0.3
Aspen – Birch-LLMT		0.4
Cedar-HHT	15.8	
Cedar-HLMT	0.9	
Cedar-LHT	0.9	
Cedar-LLMT	1.2	
Douglas-fir-HHT	20.3	20.7
Douglas-fir-HLMT	0.5	0.4
Douglas-fir-LHT	4.5	9.8
Douglas-fir-LLMT	1.7	2.7
Grand Fir-HHT	0.7	5.8
Grand Fir-HLMT	0.2	0.5
Grand Fir-LHT	0.1	3.7
Grand Fir-LLMT	0.5	1.7
Hemlock-HHT	9.2	
Hemlock-HLMT	0.5	
Hemlock-LHT	0	
Hemlock-LLMT	1.2	
Larch-HHT	0.9	0.6
Larch-HLMT	0.1	0.5
Larch-LHT	0	0.6
Larch-LLMT	0.3	0.7
Lodgepole Pine-HHT		1.5
Lodgepole Pine-HLMT		0.1
Lodgepole Pine-LHT		1.1
Lodgepole Pine-LLMT		0.1
Ponderosa Pine-HHT	7.1	3.9
Ponderosa Pine-HLMT	0.4	0.5
Ponderosa Pine-LHT	0.9	1.2
Ponderosa Pine-LLMT	0.9	1.2
Spruce – Fir-HHT	16.6	21.6
Spruce – Fir-HLMT	0.5	0.4
Spruce – Fir-LHT	1.6	8.7
Spruce – Fir-LLMT	1	0.7
White Pine-HHT	5.5	2.5
White Pine-HLMT	0.1	0.1
White Pine-LHT	2.1	0.4
White Pine-LLMT	0	0.2
Perennial Forb-HLHB	1.5	1.4
Perennial Native Bunch Gramminoid-HHHB	0.3	
Perennial Native Rhizomatous Gramminoid-HLHB	0	0.4
Riparian Broadleaf Shrubland-HHSH		0.5
Upland Broadleaf Dwarf Shrubland-HLSH	0.7	2.5
Upland Broadleaf Medium Shrubland-HMSH	0.6	0.5
Upland Broadleaf Tall Shrubland-HHSH	0.6	
Wetland Herbaceous-HHHB	0	0.5

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-J—Spruce – Fir Forest PVTs

Appendix 9-J: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Spruce – Fir PVTs.

Succession class	Spruce – Fir/ Montane	Spruce – Fir/ Subalpine	Spruce – Fir/ Timberline
Douglas-fir-HHTR*	370		
Douglas-fir-HLMT	15		
Douglas-fir-LHT	35		
Douglas-fir-LLMT	15		
Lodgepole Pine-HHT	175	220	300
Lodgepole Pine-HLMT	10	12	20
Lodgepole Pine-LHT	30	35	55
Lodgepole Pine-LLMT	15	16	30
Spruce – Fir-HHT	302	300	290
Spruce – Fir-HLMT	20	20	20
Spruce – Fir-LHT	55	55	65
Spruce – Fir-LLMT	28	30	40
Timberline Forest-HHT			310
Timberline Forest-HLMT			40
Timberline Forest-LHT			100
Timberline Forest-LLMT			50
Western Larch-HHT	325		
Western Larch-HLMT	10		
Western Larch-LHT	30		
Western Larch-LLMT	16		
Perennial Forb-HLHB	12	15	35
Perennial Native Bunch Gramminoid-HHHB	15	15	50
Perennial Native Rhizomatous Gramminoid-HLHB	12	15	45
Riparian Broadleaf Shrub-HHSH	18	20	
Shrubby Cinquefoil-HMSH			40
Upland Broadleaf Dwarf Shrub-HLSH	15	15	40
Upland Broadleaf Medium Shrub-HMSH	15	12	40
Upland Broadleaf Tall Shrub-HHSH	18	20	
Upland Needleleaf Shrub-LLSH	18		
Upland Sclerophyllous Shrub-HLSH	15	15	
Wetland Herbaceous-HHHB	15	15	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-J: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Spruce – Fir PVTs.

	Spruce – Fir/ Montane			Spruce – Fir/ Subalpine			Spruce – Fir/ Timberline		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**	**SR**	**MS**	**NL**
Douglas-fir-HHTR**	300	200	100						
Douglas-fir-HLMT	200								
Douglas-fir-LHT	400	200	75						
Douglas-fir-LLMT	250								
Lodgepole Pine-HHT	250	100		300	200		300	300	
Lodgepole Pine-HLMT	100			300			250		
Lodgepole Pine-LHT	300	150	150	300		100	400		200
Lodgepole Pine-LLMT	300			350			300		
Spruce – Fir-HHT	250	270		350	350		300	400	
Spruce – Fir-HLMT	300			400			350		
Spruce – Fir-LHT	350	180	70	400	400		400	300	
Spruce – Fir-LLMT	300			400			350		
Timberline Forest-HHT							300	300	
Timberline Forest-HLMT							400		
Timberline Forest-LHT							400	400	
Timberline Forest-LLMT							400		
Western Larch-HHT	300	200	75						
Western Larch-HLMT	400	400							
Western Larch-LHT	500		45						
Western Larch-LLMT	250								
Perennial Forb-HLHB	300			350			400		
Perennial Native Bunch Gramminoid-HHHB	175			150			200		
Perennial Native Rhizomatous Gramminoid-HLHB	200			200			300		
Riparian Broadleaf Shrub-HHSH	400			400					
Shrubby Cinquefoil-HMSH							300		
Upland Broadleaf Dwarf Shrub-HLSH	200			175			300		
Upland Broadleaf Medium Shrub-HMSH	200			250			200		
Upland Broadleaf Tall Shrub-HHSH	150			300					
Upland Needleleaf Shrub-LLSH	150								
Upland Ssclerophyllous Shrub-HLSH	250			200					
Wetland Herbaceous-HHHB				500					

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
**For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-J: Table 3—Succession modeling results in percent composition of each of the Zone 19 Spruce – Fir PVTs.

Succession class	Spruce – Fir/ Montane	Spruce – Fir/ Subalpine	Spruce – Fir/ Timberline
Douglas-fir-HHTR*	24.1		
Douglas-fir-HLMT	1.1		
Douglas-fir-LHT	7.7		
Douglas-fir-LLMT	1.9		
Lodgepole Pine-HHT	6.1	11.1	3.8
Lodgepole Pine-HLMT	0.7	0.8	0.8
Lodgepole Pine-LHT	3.2	6.1	0.7
Lodgepole Pine-LLMT	1.5	1.6	1.2
Spruce – Fir-HHT	21.3	50.2	38.3
Spruce – Fir-HLMT	2.2	4.6	2.8
Spruce – Fir-LHT	6.7	14.2	10.5
Spruce – Fir-LLMT	3.9	6.5	5.1
Timberline Forest-HHT			10.6
Timberline Forest-HLMT			3
Timberline Forest-LHT			7.2
Timberline Forest-LLMT			4.5
Western Larch-HHT	9.5		
Western Larch-HLMT	0.5		
Western Larch-LHT	4.3		
Western Larch-LLMT	0.6		
Perennial Forb-HLHB	1.3	1.4	3.6
Perennial Native Bunch Gramminoid-HHHB	0.1	0.3	1.2
Perennial Native Rhizomatous Gramminoid-HLHB	0.3	0.3	0.4
Riparian Broadleaf Shrub-HHSH	0.1	0.3	
Shrubby Cinquefoil-HMSH			0.4
Upland Broadleaf Dwarf Shrub-HLSH	0.5	0.6	4.7
Upland Broadleaf Medium Shrub-HMSH	1.6	0.1	1.2
Upland Broadleaf Tall Shrub-HHSH	0.2	0	
Upland Needleleaf Shrub-LLSH	0.1		
Upland Sclerophyllous Shrub-HLSH	0.2	0.8	
Wetland Herbaceous-HHHB	0.2	1	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-K—Douglas-fir Forest PVTs

Appendix 9-K: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Douglas-fir PVTs.

Succession class	Douglas-fir/ Timber-line Pine	Douglas-fir/ Ponderosa Pine	Douglas-fir/ Douglas-fir	Douglas-fir/ Lodge-pole Pine
Douglas-fir-HHT*	350	415	375	365
Douglas-fir-HLMT	20	15	10	15
Douglas-fir-LHT	60	40	30	40
Douglas-fir-LLMT	30	20	15	20
Juniper-HHT	250			
Juniper-HLMT	40			
Juniper-LHT	110			
Juniper-LLMT	60			
Limber Pine-HHT	620			
Limber Pine-HLMT	30			
Limber Pine-LHT	90			
Limber Pine-LLMT	50			
Lodgepole Pine-HHT		175	170	170
Lodgepole Pine-HLMT		12	12	12
Lodgepole Pine-LHT		35	35	35
Lodgepole Pine-LLMT		15	16	16
Ponderosa Pine-HHT		470	420	
Ponderosa Pine-HLMT		15	13	
Ponderosa Pine-LHT		35	35	
Ponderosa Pine-LLMT		17	16	
Western Larch-HHT		475	430	420
Western Larch-HLMT		12	10	13
Western Larch-LHT		35	30	35
Western Larch-LLMT		15	13	17
Mountain Big Sage-HMSH	45		35	
Perennial Forb-HLHB	35	20	15	15
Perennial Native Bunch Gramminoid-HHHB	50	25	20	20
Perennial Native Rhizomatous Gramminoid-HLHB		25	20	18
Upland Broadleaf Dwarf Shrub-HLSH			18	15
Upland Broadleaf Medium Shrub-HMSH	40	20	18	15
Upland Broadleaf Tall Shrub-HHSH			20	
Upland Needleleaf Shrub-LMSH	50			20
Upland Sclerophyllous Shrub-HLSH	40	20		15
Wyoming – Basin Big Sage-HMSH	45	30	35	25

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-K: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Douglas-fir / Timberline Pine and Douglas-fir / Ponderosa Pine PVTs.

	Douglas-fir/Timberline Pine			Douglas-fir/Ponderosa Pine		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Douglas-fir-HHT**	200	150	120	150	75	50
Douglas-fir-HLMT	75			40		
Douglas-fir-LHT	200		58	300	150	25
Douglas-fir-LLMT	75			45		
Juniper-HHT200	150					
Juniper-HLMT	200					
Juniper-LHT300		75				
Juniper-LLMT200						
Limber Pine-HHT	200	150				
Limber Pine-HLMT	200					
Limber Pine-LHT	300		75			
Limber Pine-LLMT	200					
Lodgepole Pine-HHT				150	75	115
Lodgepole Pine-HLMT				30		
Lodgepole Pine-LHT				200	125	50
Lodgepole Pine-LLMT				50		
Ponderosa Pine-HHT				400	150	25
Ponderosa Pine-HLMT				70	70	
Ponderosa Pine-LHT				400	400	16
Ponderosa Pine-LLMT				40		
Western Larch-HHT				450	150	32
Western Larch-HLMT				80	60	
Western Larch-LHT				500	250	23
Western Larch-LLMT				40		
Mountain Big Sage-HMSH	60					
Perennial Forb-HLHB	75			50		
Perennial Native Bunch Gramminoid-HHHB	30			20		
Perennial Native Rhizomatous Gramminoid-HLHB				30		
Upland Broadleaf Dwarf Shrub-HLSH						
Upland Broadleaf Medium Shrub-HMSH	150			60		
Upland Broadleaf Tall Shrub-HHSH						
Upland Needleleaf Shrub-LMSH	60					
Upland Sclerophyllous Shrub-HLSH	50			50		
Wyoming – Basin Big Sage-HMSH	60			25		

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
**For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-K: Table 3—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Douglas-fir / Lodgepole Pine and Douglas-fir / Douglas-fir PVTs.

	Douglas-fir/Lodgepole Pine			Douglas-fir/Douglas-fir		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Douglas-fir-HHT**	250	125	93	300	100	120
Douglas-fir-HLMT	50			50		
Douglas-fir-LHT	300	200	55	350	100	60
Douglas-fir-LLMT	75			75		
Lodgepole Pine-HHT	150	65		150	125	125
Lodgepole Pine-HLMT	50			50		
Lodgepole Pine-LHT	200	150	75	200	150	75
Lodgepole Pine-LLMT	75			75		
Ponderosa Pine-HHT				300	150	50
Ponderosa Pine-HLMT				67	200	
Ponderosa Pine-LHT				350		32
Ponderosa Pine-LLMT				75		
Western Larch-HHT	400	175	75	300	200	50
Western Larch-HLMT	100	100		100	100	
Western Larch-LHT	500		38	350		35
Western Larch-LLMT	75			75		
Mountain Big Sage-HMSH				35		
Perennial Forb-HLHB	100			75		
Perennial Native Bunch Gramminoid-HHHB	50			40		
Perennial Native Rhizomatous Gramminoid-HLHB	75			75		
Upland Broadleaf Dwarf Shrub-HLSH	100			100		
Upland Broadleaf Medium Shrub-HMSH	75			75		
Upland Broadleaf Tall Shrub-HHSH				100		
Upland Needleleaf Shrub-LMSH	75					
Upland Sclerophyllous Shrub-HLSH	100					
Wyoming – Basin Big Sage-HMSH	40			35		

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
**For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-K: Table 4—Succession modeling results in percent composition of each of the Zone 19 Douglas-fir PVTs.

Succession class	Douglas-fir/ Timber-line Pine	Douglas-fir/ Ponderosa Pine	Douglas-fir/ Douglas-fir	Douglas-fir/ Lodge-pole Pine
Douglas-fir-HHT*	25.2	8.6	43.7	32.9
Douglas-fir-HLMT	4	1.9	1.7	2.1
Douglas-fir-LHT	13.2	10.4	17.7	19.4
Douglas-fir-LLMT	9.2	3.3	6	5
Juniper-HHT	1			
Juniper-HLMT	0.4			
Juniper-LHT	0.7			
Juniper-LLMT	0.4			
Limber Pine-HHT	10.1			
Limber Pine-HLMT	2.5			
Limber Pine-LHT	4.9			
Limber Pine-LLMT	4.9			
Lodgepole Pine-HHT		0.5	1.9	10.1
Lodgepole Pine-HLMT		0.1	0.4	2.1
Lodgepole Pine-LHT		0.3	0.7	6.7
Lodgepole Pine-LLMT		0.1	0.2	4.4
Ponderosa Pine-HHT		24.7	2.7	
Ponderosa Pine-HLMT		1.4	0	
Ponderosa Pine-LHT		25.7	1.6	
Ponderosa Pine-LLMT		3	0.1	
Western Larch-HHT		4.7	11.2	5
Western Larch-HLMT		0	0.2	0.1
Western Larch-LHT		3	2.8	0.7
Western Larch-LLMT		0	0.1	0.6
Mountain Big Sage-HMSH	0.1		0.2	
Perennial Forb-HLHB	6.5	1.5	1	1.6
Perennial Native Bunch Gramminoid-HHHB	12.5	3.6	1.4	0.3
Perennial Native Rhizomatous Gramminoid-HLHB		3.8	1.9	4.4
Upland Broadleaf Dwarf Shrub-HLSH			0	1.8
Upland Broadleaf Medium Shrub-HMSH	1.6	1.4	3.7	1
Upland Broadleaf Tall Shrub-HHSH			0.2	
Upland Needleleaf Shrub-LMSH	1.6			1.1
Upland Sclerophyllous Shrub-HLSH	0.3	1.5		0.1
Wyoming – Basin Big Sage-HMSH	0.8	0.4	0.6	0.6

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-L—Pine Forest PVTs

Appendix 9-L: Table1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Pine PVTs.

Succession class	Lodgepole Pine	Whitebark Pine	Limber Pine	Ponderosa Pine
Douglas-fir-HHT*	365		875	
Douglas-fir-HLMT	15		25	
Douglas-fir-LHT	40		70	
Douglas-fir-LLMT	20		40	
Juniper-HLT			45	35
Juniper-HMT			245	275
Juniper-LHT			115	80
Juniper-LLT			60	40
Juniper-LMT			100	50
Limber pine-HLT			40	
Limber pine-HMT			610	
Limber pine-LHT			100	
Limber pine-LLT			50	
Limber pine-LMT			50	
Lodgepole Pine-HHT	320			
Lodgepole Pine-HLMT	10			
Lodgepole Pine-LHT	35			
Lodgepole Pine-LLMT	20			
Ponderosa Pine-HHT				555
Ponderosa Pine-HLMT				25
Ponderosa Pine-LHT				50
Ponderosa Pine-LLMT				20
Spruce – Fir-HHT	930	850		
Spruce – Fir-HLMT	15	40		
Spruce – Fir-LHT	50	100		
Spruce – Fir-LLMT	30	50		
Timberline forest-HHT		540		
Timberline forest-HLMT		50		
Timberline forest-LHT		115		
Timberline forest-LLMT		60		
Mountain Big Sage-HMSH	24	54		
Upland Broadleaf Dwarf Shrubland-HLSH	11	44		
Upland Broadleaf Medium Shrubland-HMSH	11			29
Upland Broadleaf Tall Shrubland-LHSH				29
Upland Microphyllous Medium Shrubland-HMSH				34
Upland Needle-leaf Shrubland-LMSH		59	54	
Upland Sclerophyllous Shrubland-HLSH	14			
Upland Sclerophyllous Shrubland-LLSH			44	
Wyoming-Basin Big Sage-HMSH			59	39
Perennial Frb-HLHB	9	49		24
Perennial Forb-LLHB			39	
Perennial Native Bunch Gramminoid-HHHB	14	59	54	34
Perennial Native Rhizomatous Gramminoid-HLHB	11	54	49	
Wetland Herbaceous-HHHB	19			

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-L: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Ponderosa Pine and Timberline Pine PVTs.

	Ponderosa Pine			Limber Pine		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Douglas-fir-HHT**			278	244		
Douglas-fir-HLMT			150			
Douglas-fir-LHT			300		200	
Douglas-fir-LLMT			300			
Juniper-HLT	50			300	200	
Juniper-HLMT	400	100	40	300		
Juniper-LLT	50			400		135
Juniper-LLMT	300	150	25	300		
Limber Pine-HLT			350		350	
Limber Pine-HMT			300			
Limber Pine-LLT			400		240	
Limber Pine-LMT			300			
Lodgepole Pine-HHT						
Lodgepole Pine-HLMT						
Lodgepole Pine-LHT						
Lodgepole Pine-LLMT						
Ponderosa Pine-HHT	300	100	19			
Ponderosa Pine-HLMT	100	25				
Ponderosa Pine-LHT	400	200	10			
Ponderosa Pine-LLMT	30					
Mountain Big Sage-HMSH						
Upland Broadleaf Dwarf Shrub-HLSH						
Upland Broadleaf Medium Shrub-HMSH	30					
Upland Broadleaf Tall Shrub-LHSH	30					
Upland Microphyllous Medium Shrub-LMSH	30					
Upland Needleleaf Shrub-LMSH			300			
Upland Sclerophyllous Shrub-LLSH			400			
Wyoming – Basin Big Sage-HMSH	25			100		
Perennial Forb-HLHB	50			400		
Perennial Native Bunch Graminoid-HHHB	20			150		
Perennial Native Rhizomatous Graminoid-HLHB				200		
Wetland Herbaceous-HHHB						

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-L: Table 3—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Lodgepole Pine and Whitebark Pine PVTs.

	Lodgepole Pine			Whitebark Pine		
Succession class	**SR***	**MS**	**NL**	**SR**	**MS**	**NL**
Douglas-fir-HHT**	200	125	95			
Douglas-fir-HLMT	75					
Douglas-fir-LHT	300	200	60			
Douglas-fir-LLMT	200					
Lodgepole Pine-HHT	150	75				
Lodgepole Pine-HLMT	75					
Lodgepole Pine-LHT	200	150	100			
Lodgepole Pine-LLMT	200					
Spruce – Fir-HHT	150	150		150	350	
Spruce – Fir-HLMT	150			400		
Spruce – Fir-LHT	300	200	150	200	400	
Spruce – Fir-LLMT	300			400		
Timberline Forest-HHT				300	300	
Timberline Forest-HLMT				400		
Timberline Forest-LHT				400		400
Timberline Forest-LLMT				400		
Mountain Big Sage-HMSH	100			300		
Upland Broadleaf Dwarf Shrub-HLSH	150			300		
Upland Broadleaf Medium Shrub-HMSH	200					
Upland Needleleaf Shrub-HLSH				300		
Upland Sclerophyllous Shrub-HLSH	200					
Perennial Forb-HLHB	200			400		
Perennial Native Bunch Graminoid-HHHB	100			300		
Perennial Native Rhizomatous Graminoid-HLHB	200			300		
Wetland Herbaceous-HHHB	500					

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
** For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-L: Table 4—Succession modeling results in percent composition of each of the Zone 19 Pine PVTs.

Succession class	Ponderosa Pine	Timberline Pine	Lodgepole Pine	Whitebark Pine
Douglas-fir-HHT*		0.9	0.7	
Douglas-fir-HLMT		0	0.3	
Douglas-fir-LHT		0.1	0.9	
Douglas-fir-LLMT		0.4	0.3	
Juniper-HHT	0.3	5.4		
Juniper-HLMT	0.4	1.3		
Juniper-LHT	0.2	2.1		
Juniper-LLMT	0.7	2.8		
Limber Pine-HHT		31.5		
Limber Pine-HLMT		8.6		
Limber Pine-LHT		19		
Limber Pine-LLMT		10.4		
Lodgepole Pine-HHT			30.8	
Lodgepole Pine-HLMT			6.9	
Lodgepole Pine-LHT			19	
Lodgepole Pine-LLMT			14.9	
Ponderosa Pine-HHT	40.6			
Ponderosa Pine-HLMT	3.3			
Ponderosa Pine-LHT	31.3			
Ponderosa Pine-LLMT	7			
Spruce – Fir-HHT			11.1	8
Spruce – Fir-HLMT			2.5	2.6
Spruce – Fir-LHT			1	7.2
Spruce – Fir-LLMT			4.5	2.7
Timberline Forest-HHT				25.2
Timberline Forest-HLMT				8.8
Timberline Forest-LHT				17.4
Timberline Forest-LLMT				13.1
Mountain Big Sage-HMSH			0	1.2
Upland Broadleaf Dwarf Shrub-HLSH			3.8	3.3
Upland Broadleaf Medium Shrub-HMSH	1.6		0.2	
Upland Broadleaf Tall Shrub-LHSH	1.2			
Upland Microphyllous Medium Shrub-HMSH	1.7			
Upland Needleleaf shrub-LMSH		5.7		3.6
Upland Sclerophyllous shrub-LMSH		0.9	0.5	
Wyoming – Basin Big Sage-HMSH	0.6	1.6		
Perennial Forb-HLHB	1.8	0.8	0.4	2.7
Perennial Native Bunch Graminoid-HHHB	9.3	7.5	0.9	3.7
Perennial Native Rhizomatous Graminoid-HLHB		1	0.8	0.5
Wetland Herbaceous-HHHB			0.5	

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-M—Broadleaf Forest PVTs

Appendix 9-M: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Broadleaf PVTs.

Succession class	Riparian Hardwood
Aspen – Birch-HHT*	135
Aspen – Birch-HLMT	7
Aspen – Birch-LHT	20
Aspen – Birch-LLMT	8
Douglas-fir-HHT	365
Douglas-fir-HLMT	15
Douglas-fir-LHT	40
Douglas-fir-LLMT	20
Lodgepole Pine-HLMT	12
Lodgepole Pine-LHT	35
Lodgepole Pine-LHT	175
Lodgepole Pine-LLMT	15
Ponderosa Pine-HHT	420
Ponderosa Pine-HLMT	15
Ponderosa Pine-LHT	35
Ponderosa Pine-LLMT	15
Riparian Hardwood-HHT	190
Riparian Hardwood-HLMT	5
Riparian Hardwood-LHT	15
Riparian Hardwood-LLMT	5
Perennial Forb	10
Perennial Native Bunch Gramminoid	15
Perennial Native Rhizomatous Gramminoid	12
Riparian Broadleaf Shrub	15
Upland Broadleaf Medium Shrub	10
Upland Broadleaf Tall Shrub	15
Upland Needleleaf Shrub	15
Wetland Herbaceous	10

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-M: Table 2—Fire frequencies, in years and by severity, used in succession modeling for zone 19 Broadleaf PVTs.

	Riparian Hardwood		
Succession class	**SR***	**MS**	**NL**
Aspen – Birch-HHT**	250	150	
Aspen – Birch-HLMT	250		
Aspen – Birch-LHT	300		200
Aspen – Birch-LLMT	350		
Douglas-fir-HHT	300	175	60
Douglas-fir-HLMT	75		
Douglas-fir-LHT	300	250	50
Douglas-fir-LLMT	75		
Lodgepole Pine-HHT	250	140	
Lodgepole Pine-HLMT	150		
Lodgepole Pine-LHT	300		100
Lodgepole Pine-LLMT	250		
Ponderosa Pine-HHT	300	150	40
Ponderosa Pine-HLMT	67	200	
Ponderosa Pine-LHT	300	200	30
Ponderosa Pine-LLMT	75		
Riparian Hardwood-HHT	250	250	500
Riparian Hardwood-HLMT	250		
Riparian Hardwood-LHT	200		150
Riparian Hardwood-LLMT	300		
Perennial Forb	350		
Perennial Native Bunch Gramminoid	200		
Perennial Native Rhizomatous Gramminoid	225		
Riparian Broadleaf Shrub	450		
Upland Broadleaf Medium Shrub	250		
Upland Broadleaf Tall Shrub	250		
Upland Needleleaf Shrub	250		
Wetland Herbaceous	500		

*SR = stand-replacing fire
MS = mixed-severity fire
NL = non-lethal fire
**For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-M: Table 3—Succession modeling results in percent composition of each of the Zone 19 Broadleaf PVTs.

Succession class	Riparian Hardwood
Aspen – Birch-HHT*	12.3
Aspen – Birch-HLMT	0.9
Aspen – Birch-LHT	1.2
Aspen – Birch-LLMT	1.2
Douglas-fir-HHT	6
Douglas-fir-HLMT	0.1
Douglas-fir-LHT	4.4
Douglas-fir-LLMT	0.2
Lodgepole Pine-HHT	0.5
Lodgepole Pine-HLMT	0.1
Lodgepole Pine-LHT	0
Lodgepole Pine-LLMT	0.3
Ponderosa Pine-HHT	5
Ponderosa Pine-HLMT	0.4
Ponderosa Pine-LHT	5.5
Ponderosa Pine-LLMT	0.6
Riparian Hardwood-HHT	49.2
Riparian Hardwood-HLMT	1.9
Riparian Hardwood-LHT	3.8
Riparian Hardwood-LLMT	1.5
Perennial Forb	1.3
Perennial Native Bunch Gramminoid	0.1
Perennial Native Rhizomatous Gramminoid	0.2
Riparian Broadleaf Shrub	1.6
Upland Broadleaf Medium Shrub	0.2
Upland Broadleaf Tall Shrub	1
Upland Needleleaf Shrub	0.3
Wetland Herbaceous	0.1

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-N—Woodland PVTs

Appendix 9-N: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Woodland PVTs.

Succession class	Rocky Mountain Juniper	Mountain Mahogany
Douglas-fir-HHT*		99
Douglas-fir-LHT		84
Douglas-fir-LLT		29
Douglas-fir-LMT		39
Mountain Mahogany-HHS		255
Mountain Mahogany-HMS		14
Mountain Mahogany-LHS		14
Mountain Mahogany-LLS		12
Mountain Mahogany-LMT		14
Mountain Big Sage-HMS	14	14
Mountain Big Sage-LLS	12	12
Mountain Big Sage-LMS	14	14
Perennial Native Bunch Graminoid-HHH	14	29
Perennial Native Bunch Graminoid-HLH	14	14
Perennial Native Bunch Graminoid-LHH	12	12
Perennial Native Bunch Graminoid-LLH	2	14
Perennial Forb-LHH	29	
Perennial Forb-LLH	12	12
Rabbitbrush-LLH	12	12
Rabbitbrush-LMH	29	29
Juniper-HHH	200	
Juniper-LHH	200	
Juniper-LLH	14	
Juniper-LMH	54	
Upland Microphyllous Medium Shrubland-HMS	14	14
Upland Microphyllous Medium Shrubland-LLS	12	12
Upland Microphyllous Medium Shrubland-LMS	14	14
Wyoming – Basin Big Sage-HMS	200	200
Wyoming – Basin Big Sage-LLS	14	14
Wyoming – Basin Big Sage-LMS	54	54

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-N: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Woodland PVTs.

Succession class	Rocky Mountain Juniper	Mountain Mahogany
Douglas-fir-HHT*		
Douglas-fir-LHT		
Douglas-fir-LLT		
Douglas-fir- LMT		
Mountain Mahogany-HHS		33
Mountain Mahogany-HMS		40
Mountain Mahogany-LHS		50
Mountain Mahogany-LLS		50
Mountain Mahogany-LMT		40
Mountain Big Sage-HMS	22	22
Mountain Big Sage-LLS	29	29
Mountain Big Sage-LMS	25	25
Perennial Native Bunch Graminoid-HHH	25	25
Perennial Native Bunch Graminoid-HLH	50	50
Perennial Native Bunch Graminoid-LHH	40	40
Perennial Native Bunch Graminoid-LLH	50	50
Perennial Forb-LHH	29	
Perennial Forb-LLH	29	40
Rabbitbrush-LLH	33	33
Rabbitbrush-LMH	29	29
Juniper-HHH	25	
Juniper-LHH	33[1]	
Juniper-LLH	295	
Juniper-LMH	25	
Upland Microphyllous Medium Shrubland-HMS	25	29
Upland Microphyllous Medium Shrubland-LLS	33	40
Upland Microphyllous Medium Shrubland-LMS	29	34
Wyoming – Basin Big Sage-HMS	29	33
Wyoming – Basin Big Sage-LLS	40	40
Wyoming – Basin Big Sage-LMS	33	50

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.
[1] In this class, approximately 20 percent of fires were estimated as mixed stand-replacing fires.

Appendix 9-N: Table 3—Succession modeling results in percent composition of each of the Zone 19 Woodland PVTs.

Succession class	Rocky Mountain Juniper	Mountain Mahogany
Douglas-fir-HHT*		0
Douglas-fir-LHT		0
Douglas-fir-LLT		0
Douglas-fir- LMT		0
Mountain Mahogany-HHS		3
Mountain Mahogany-HMS		4
Mountain Mahogany-LHS		14
Mountain Mahogany-LLS		12
Mountain Mahogany-LMT		9
Mountain Big Sage-HMS	4	0
Mountain Big Sage-LLS	3	7
Mountain Big Sage-LMS	1	0
Perennial Native Bunch Graminoid-HHH	13	2
Perennial Native Bunch Graminoid-HLH	1	9
Perennial Native Bunch Graminoid-LHH	18	5
Perennial Native Bunch Graminoid-LLH	4	2
Perennial Forb-LHH	2	
Perennial Forb-LLH	2	0
Rabbitbrush-LLH	3	0
Rabbitbrush-LMH	2	0
Juniper-HHH	0	
Juniper-LHH	3	
Juniper-LLH	10	
Juniper-LMH	20	
Upland Microphyllous Medium Shrubland-HMS	2	0
Upland Microphyllous Medium Shrubland-LLS	5	0
Upland Microphyllous Medium Shrubland-LMS	3	0
Wyoming – Basin Big Sage-HMS	2	6
Wyoming – Basin Big Sage-LLS	0	9
Wyoming – Basin Big Sage-LMS	2	18

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-O—Sagebrush and Other Dry Shrubland PVTs

Appendix 9-O: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Sagebrush and Other Dry Shrubland PVTs.

Succession class	Dwarf Sage	Mountain Big Sage	Threetip Sage	Wyoming Sage
Douglas-fir-HHT*	200	200	200	200
Douglas-fir-LHT	69	84	84	79
Douglas-fir-LLT	34	29	29	29
Douglas-fir-LMT	49	39	39	39
Dwarf Sage-HMS	270			
Dwarf Sage-LLS	12			
Dwarf Sage-LMS	14			
Mountain Big Sage-HMS	19	19	19	24
Mountain Big Sage-LLS	12	8	8	12
Mountain Big Sage-LMS	14	14	14	9
Perennial Forb-HHH				9
Perennial Forb-LHH		34	34	12
Perennial Forb-LLH		8	8	
Perennial Native Bunch Graminoid-HHH		34	34	12
Perennial Native Bunch Graminoid-HLH		14	14	
Perennial Native Bunch Graminoid-LHH	27	8	8	12
Perennial Native Bunch Graminoid-LLH	1	1	1	1
Rabbitbrush-HMH	19		15	25
Rabbitbrush-LLH	12	8	8	12
Rabbitbrush-LMH	14	14	14	19
Three-tip Sage-HMS	19	19	275	
Three-tip Sage-LLS	12	8	8	
Three-tip Sage-LMS	14	14	14	
Upland Microphyllous Medium Shrubland-HMS		19	19	
Upland Microphyllous Medium Shrubland-LLS		8	8	18
Upland Microphyllous Medium Shrubland-LMS		14	14	19
Wyoming – Basin Big Sage-HHS				199
Wyoming – Basin Big Sage-HMS	125	200	200	250
Wyoming – Basin Big Sage-LHS				49
Wyoming – Basin Big Sage-LLS	19	19	19	9
Wyoming – Basin Big Sage-LMS	24	54	54	14

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-O: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Sagebrush and Other Dry Shrubland PVTs. All fires are stand-replacing unless otherwise noted.

Succession class	Dwarf Sage	Mountain Big Sage	Threetip Sage	Wyoming Sage
Douglas-fir-HHT*	25	20	20	40
Douglas-fir-LHT	401	291	291	50[1]
Douglas-fir-LLT	40	25	25	40
Douglas-fir-LMT	33	22	22	40
Dwarf Sage-HMS	100			
Dwarf Sage-LLS	149			
Dwarf Sage-LMS	125			
Mountain Big Sage-HMS	25	20	20	25
Mountain Big Sage-LLS	33	29	29	40
Mountain Big Sage-LMS	29	25	25	29
Perennial Forb-HHH		40		50
Perennial Forb-LHH		40	40	60
Perennial Forb-LLH		50	50	
Perennial Native Bunch Graminoid-HHH		29	29	50
Perennial Native Bunch Graminoid-HLH		50	50	
Perennial Native Bunch Graminoid-LHH	75	40	40	60
Perennial Native Bunch Graminoid-LLH	149	50	50	100
Rabbitbrush-HMH	40			
Rabbitbrush-LLH	60	40	40	60
Rabbitbrush-LMH	50	34	34	40
Three-tip Sage-HMS	29	22	22	
Three-tip Sage-LLS	60	295	29	
Three-tip Sage-LMS	33	25	25	
Upland Microphyllous Medium Shrubland-HMS		33	50	
Upland Microphyllous Medium Shrubland-LLS		40	50	60
Upland Microphyllous Medium Shrubland-LMS		40	40	50
Wyoming – Basin Big Sage-HHS				40
Wyoming – Basin Big Sage-HMS	50	33	33	50
Wyoming – Basin Big Sage-LHS				50
Wyoming – Basin Big Sage-LLS	60	40	40	50
Wyoming – Basin Big Sage-LMS	50	40	40	50

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.
[1]In this class, approximately 20 percent of fires were estimated as mixed stand-replacing fires.

Appendix 9-O: Table 3—Succession modeling results in percent composition of each of the Zone 19 Sagebrush and Other Dry Shrubland PVTs.

Succession class	Dwarf Sage	Mountain Big Sage	Threetip Sage	Wyoming Sage
Douglas-fir-HHT*	0	0	0	1
Douglas-fir-LHT	2	1	1	2
Douglas-fir-LLT	1	2	2	1
Douglas-fir-LMT	2	1	2	2
Dwarf Sage-HMS	34			
Dwarf Sage-LLS	7			
Dwarf Sage-LMS	18			
Mountain Big Sage-HMS	1	0		0
Mountain Big Sage-LLS	1	62		0
Mountain Big Sage-LMS	2	0		0
Perennial Forb-HHH		0	0	3
Perennial Forb-LHH		0	0	1
Perennial Forb-LLH		0	0	2
Perennial Native Bunch Graminoid-HHH		29	29	10
Perennial Native Bunch Graminoid-HLH	10	0	0	1
Perennial Native Bunch Graminoid-LHH		0	0	13
Perennial Native Bunch Graminoid-LLH	1	5	4	1
Rabbitbrush-HMH	1	0	0	2
Rabbitbrush-LLH	2	0	0	1
Rabbitbrush-LMH	1	0	0	1
Three-tip Sage-HMS	2	0	17	
Three-tip Sage-LLS	2	0	31	
Three-tip Sage-LMS	2	0	14	
Upland Microphyllous Medium Shrubland-HMS		0	0	2
Upland Microphyllous Medium Shrubland-LLS		0	0	2
Upland Microphyllous Medium Shrubland-LMS		0	0	1
Wyoming – Basin Big Sage-HHS				0
Wyoming – Basin Big Sage-HMS	4	0	0	34
Wyoming – Basin Big Sage-LHS				1
Wyoming – Basin Big Sage-LLS	4	0	0	8
Wyoming – Basin Big Sage-LMS	3	0	0	11

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-O: Table 4—Transition times between succession classes, in years, used in succession modeling for the Zone 19 Sagebrush and Other Dry Shrubland PVTs.

Succession class	Dry shrub
Douglas-fir-HHT*	299
Douglas-fir-LHT	84
Douglas-fir-LLT	29
Douglas-fir-LMT	39
Mountain Big Sage-HMS	14
Mountain Big Sage-LLS	14
Mountain Big Sage-LMS	14
Perennial Forb-LHH	14
Perennial Forb-LLH	12
Perennial Naive Bunch Graminoid-HHH	42
Perennial Native Bunch Graminoid-HLH	27
Perennial Native Bunch Graminoid-LLH	2
Shrubby cinquefoil-HMS	14
Shrubby cinquefoil-LLS	12
Shrubby cinquefoil-LMS	14
Upland Broadleaf Medium Shrubland-LLS	12
Upland Broadleaf Medium Shrubland-LMS	14
Upland Microphyllous Medium Shrubland-HMS	14
Upland Microphyllous Medium Shrubland-LLS	12
Upland Microphyllous Medium Shrubland-LMS	14
Upland Needleleaf Shrubland–LLS	12
Wyoming – Basin Big Sage-HMS	199
Wyoming – Basin Big Sage-LLS	14
Wyoming – Basin Big Sage-LMS	54

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-O: Table 5—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Sagebrush and Other Dry Shrubland PVTs.

Succession class	Dry shrub
Douglas-fir-HHT*	20
Douglas-fir-LHT	25[1]
Douglas-fir-LLT	29
Douglas-fir-LMT	29
Mountain Big Sage-HMS	25
Mountain Big Sage-LLS	33
Mountain Big Sage-LMS	29
Perennial Forb-LHH	33
Perennial Forb-LLH	40
Perennial Naive Bunch Graminoid-HHH	25
Perennial Native Bunch Graminoid-HLH	29
Perennial Native Bunch Graminoid-LLH	40
Shrubby cinquefoil-HMS	25
Shrubby cinquefoil-LLS	25
Shrubby cinquefoil-LMS	29
Upland Broadleaf Medium Shrubland-LLS	33
Upland Broadleaf Medium Shrubland-LMS	29
Upland Microphyllous Medium Shrubland-HMS	25
Upland Microphyllous Medium Shrubland-LLS	33
Upland Microphyllous Medium Shrubland-LMS	29
Upland Needleleaf Shrubland–LLS	33
Wyoming – Basin Big Sage-HMS	50
Wyoming – Basin Big Sage-LLS	50
Wyoming – Basin Big Sage-LMS	40

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.
[1] In this class, approximately 20 percent of fires were estimated as mixed stand-replacing fires.

Appendix 9-O: Table 6—Succession modeling results in percent composition of each of the Zone 19 Sagebrush and Other Dry Shrubland PVTs.

Succession class	Dry shrub
Douglas-fir-HHT*	0
Douglas-fir-LHT	0
Douglas-fir-LLT	0
Douglas-fir-LMT	0
Mountain Big Sage-HMS	1
Mountain Big Sage-LLS	2
Mountain Big Sage-LMS	2
Perennial Forb-LHH	2
Perennial Forb-LLH	2
Perennial Naive Bunch Graminoid-HHH	13
Perennial Native Bunch Graminoid-HLH	14
Perennial Native Bunch Graminoid-LLH	3
Shrubby cinquefoil-HMS	5
Shrubby cinquefoil-LLS	7
Shrubby cinquefoil-LMS	36
Upland Broadleaf Medium Shrubland-LLS	0
Upland Broadleaf Medium Shrubland-LMS	1
Upland Microphyllous Medium Shrubland-HMS	0
Upland Microphyllous Medium Shrubland-LLS	1
Upland Microphyllous Medium Shrubland-LMS	1
Upland Needleleaf Shrubland–LLS	1
Wyoming – Basin Big Sage-HMS	4
Wyoming – Basin Big Sage-LLS	2
Wyoming – Basin Big Sage-LMS	1

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-P—Grassland PVTs

Appendix 9-P: Table 1—Transition times between succession classes, in years, used in succession modeling for Zone 19 Grassland PVTs.

Succession class	Fescue Grassland	Bluebunch Wheatgrass
Douglas-fir-HHT*	300	400
Douglas-fir-LHT	84	59
Douglas-fir-LLT	29	14
Douglas-fir-LMT	39	14
Juniper-HHT		200
Juniper-LHT		220
Juniper-LLT		14
Juniper-LMT		49
Mountain Big Sage-HMS	14	64
Mountain Big Sage-LLS	12	13
Mountain Big Sage-LMS	14	20
Perennial Forb-LHH		9
Perennial Forb-LLH		8
Perennial Native Bunch Graminoid-HHH	43	8
Perennial Native Bunch Graminoid-LHH	28	8
Perennial Native Bunch Graminoid-LLH	1	1
Rabbitbrush-LLS		8
Rabbitbrush-LMS		9
Shrubby Cinquefoil-HMS	14	
Shrubby Cinquefoil-LLS	14	
Shrubby Cinquefoil-LMS	12	
Upland Broadleaf Medium Shrubland-HLS	12	8
Upland Broadleaf Medium Shrubland-HMS	14	59
Upland Broadleaf Medium Shrubland-LMS	14	9
Upland Microphyllous Medium Shrubland-LLS		8
Upland Microphyllous Medium Shrubland-LMS		9
Wyoming – Basin Big Sage-HMS	200	59
Wyoming – Basin Big Sage-LLS	14	14
Wyoming – Basin Big Sage-LMS	54	14

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.

Appendix 9-P: Table 2—Fire frequencies, in years and by severity type, used in succession modeling for Zone 19 Grassland PVTs.

Succession class	Fescue Grassland	Bluebunch Wheatgrass
Douglas-fir-HHT*	20	20
Douglas-fir-LHT	331	25[1]
Douglas-fir-LLT	20	29
Douglas-fir-LMT	20	29
Juniper-HHT		22
Juniper-LHT		25[1]
Juniper-LLT		29
Juniper-LMT		29
Mountain Big Sage-HMS	50	20
Mountain Big Sage-LLS	29	29
Mountain Big Sage-LMS	29	29
Perennial Forb-LHH		33
Perennial Forb-LLH		40
Perennial Native Bunch Graminoid-HHH	33	25
Perennial Native Bunch Graminoid-LHH	33	29
Perennial Native Bunch Graminoid-LLH	40	40
Rabbitbrush-LLS		25
Rabbitbrush-LMS		22
Shrubby Cinquefoil-HMS	25	
Shrubby Cinquefoil-LLS	22	
Shrubby Cinquefoil-LMS	25	
Upland Broadleaf Medium Shrubland-HLS	100	33
Upland Broadleaf Medium Shrubland-HMS	25	25
Upland Broadleaf Medium Shrubland-LMS	33	29
Upland Microphyllous Medium Shrubland-LLS		33
Upland Microphyllous Medium Shrubland-LMS		25
Wyoming – Basin Big Sage-HMS	50	50
Wyoming – Basin Big Sage-LLS	50	50
Wyoming – Basin Big Sage-LMS	40	40

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.
[1]Frequency of mixed-severity fire.

Appendix 9-P: Table 3—Succession modeling results in percent composition of each of the Zone 19 Grassland PVTs.

Succession class	Fescue Grassland	Bluebunch Wheatgrass
Douglas-fir-HHT*	1	0
Douglas-fir-LHT	8	0
Douglas-fir-LLT	15	0
Douglas-fir-LMT	8	0
Juniper-HHT		0
Juniper-LHT		0
Juniper-LLT		0
Juniper-LMT		1
Mountain Big Sage-HMS	0	2
Mountain Big Sage-LLS	1	4
Mountain Big Sage-LMS	1	6
Perennial Forb-LHH		0
Perennial Forb-LLH		0
Perennial Native Bunch Graminoid-HHH	6	5
Perennial Native Bunch Graminoid-LHH	16	48
Perennial Native Bunch Graminoid-LLH	2	2
Rabbitbrush-LLS		0
Rabbitbrush-LMS		0
Shrubby Cinquefoil-HMS	3	
Shrubby Cinquefoil-LLS	17	
Shrubby Cinquefoil-LMS	19	
Upland Broadleaf Medium Shrubland-HLS	1	1
Upland Broadleaf Medium Shrubland-HMS	1	1
Upland Broadleaf Medium Shrubland-LMS	0	1
Upland Microphyllous Medium Shrubland-LLS		2
Upland Microphyllous Medium Shrubland-LMS		2
Wyoming – Basin Big Sage-HMS	1	14
Wyoming – Basin Big Sage-LLS	0	6
Wyoming – Basin Big Sage-LMS	0	5

* For complete structural stage names, refer to table 5: Structural stages used for succession modeling in zones 16 and 19.