Morice & Lakes IFPA

Morice & Lakes Innovative Forest Practices Agreement

Vegetation Pathway Diagrams for the Morice and Lakes Innovative Forest Practices Agreement

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1.0 Introduction

This document summarises the results of two, two-day meetings to characterize the vegetation dynamics in the Morice and Lakes Innovative Forest Practices Agreement (IFPA). The workshops were both held in Houston, the first on February 21–22, 2001 and the second on May 9–10, 2001.The purpose of the meetings was to create successional pathway diagrams (SPD) which describe forest succession (under natural or managed conditions) and the impacts of natural disturbances in different ecosystem types. This document describes the SPDs that were developed at the meeting and will provide the basis for further discussion and elaboration.

Successional pathway diagrams are stratified by the BEC variants that are included in the IFPA. Each successional pathway diagram contains the following information:

- all successional classes (combination of dominant overstorey species and structural stage) typically found in the BEC;
- the transition pathways between classes in the absence of disturbance;
- the transition times between classes, defined as the number of years required to move from one class to the next;
- the probability of disturbance for each successional class (defined as average annual probability); and
- the disturbance impact, defined as the pathway to a different successional class or as change in the number of years remaining in the current class.

This document contains the SPD for the Englemann Spruce Subalpine Fir (ESSF), Sub-boreal Spruce (SBS), and Sub-boreal Pine Spruce areas within the Morice and Lakes IFPA. In each SPD, a complete description of the disturbance pathways is included as well as the results of a simulation of the SPD to equilibrium. While landscapes are not in equilibrium, simulations of this type are useful to indicate the possible consequence of some of the definitions. Thus, if the equilibrium landscape contains too much old forest, then either some disturbance agent is missing or the disturbance probabilities are too low. If there is too much young forest, then the probabilities are too high (and remember that some agents may act together rather then separately).

1.1 Background Information

Vegetation change over time can be modelled using basic successional theory (e.g., Noble and Slatyer 1977, 1980[1]), in which the forest changes from one state to another as a function of ageing, management, and natural disturbances. One

[1] **Noble, I.R. and R.O. Slatyer.** 1977. Post-fire succession of plants in Mediterranean ecosystems. In: H.A. Mooney and C.E. Conrad (eds.). Proceedings of the Symposium on the Environmental Consequences of Fire and Fuel management in Mediterranean Ecosystems. Gen. Tech. Rept. WO-3. USDA Forest Service, Washington, DC, pp. 27-36.

Noble, I.R. and R.O. Slatyer. 1980. The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances. Vegetation. 43: 5-21.

method of modelling vegetation change is to use a successional pathway diagram (SPD). Successional pathway diagrams use “successional classes,” or combinations of structural stage and cover type, to represent different the states of the forest, and they use “pathways” to describe how a forest may change from one state to another. Changes in successional class can either be due to disturbance or because growth dynamics have changed the cover type, the structural stage, or both. The time required to “grow” from one class to the next defines succession in the absence of disturbance. Transition probabilities associated with a disturbance pathway define the likelihood of different disturbances in each successional class. Note that at any point in time, a pixel or polygon is in only one of the successional classes described by one of the diagrams.

Successional pathway diagrams can be compiled using the Vegetation Dynamics Development Tool (VDDT, Beukema and Kurz 2000[2]). This tool allows users to create the successional classes, to define the succession and disturbance pathways, and to test the consequences of their assumptions in a non-spatial modelling environment. Technically, VDDT uses a semi-Markovian approach to modelling succession. It combines transition times for succession with transition probabilities for disturbances.

Inside VDDT, and in all the diagrams pictured here, successional classes are represented as a box containing information about the cover type and structural stage of the class as well as the approximate age range of the class and a letter that can be used to identify the class in discussions (Figure 1.1)

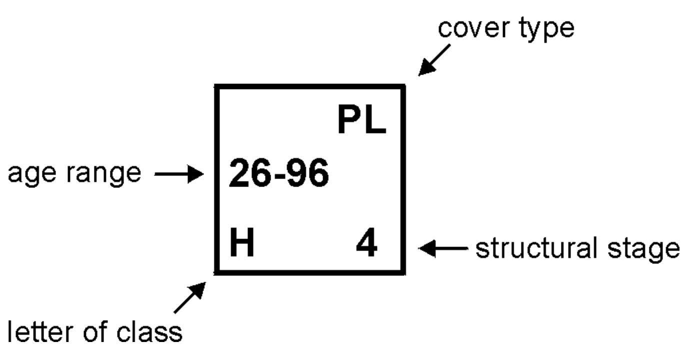

Figure 1.1: Diagram of a successional class in from an SPD diagram. For more information about structural stages see Section 1.2 or for cover types, see Section 1.3.

1.1.1 Effects of Natural Disturbances

To a large extent, the model’s structure, the large spatial scale at which the model is typically applied, and the limited amount of the forest information available to the model constrain the formulation of natural disturbance effects and require that all rules be as simple as possible. Linkages between disturbance

[2] S.J. Beukema and W.A. Kurz. 2000. Vegetation dynamics development tool user's guide. Version 4.0. Prepared by ESSA Technologies Ltd., Vancouver, BC. 117 pp. VDDT.

types can be captured either through their independent effects on forest cover and structural stage or through disturbance types which are defined as the joint action of two or more biotic or abiotic factors.

Disturbances may affect the successional path of a forest in several ways:

- moving the forest to an earlier or later class;
- prolonging the time in a class;
- increasing the rate of transition through a class; or
- changing the dominant cover type and thus the successional path of the forest.

Only those disturbances that somehow affect the rate or pattern of natural succession are defined in the successional pathway diagrams, but any type of such disturbance can be used.

The disturbance probabilities define the probability of a pixel being affected by disturbance in any given year. This probability is only a function of the current state of the pixel, and is not affected by events in previous years except to the extent that these are reflected in the current state of the pixel. Probabilities are also independent of the condition of the adjacent pixels. VDDT is a non-spatial model and is by itself, therefore, not capable of modelling events connected in space (contagion) or time (such as defoliator outbreaks).

Probabilities can be assigned to represent different assumptions about the level of forest protection efforts, external drivers (such as global warming), introduction of exotic agents (such as white bark pine blister rust) or other factors. Some examples of the types of assumptions that could be implemented are:

- historic disturbance conditions, no management;
- ecosystem management (mimic ecosystem processes);
- protection (protect all lands from the effects of natural disturbances); and
- climate change with increased natural disturbances.

Natural disturbances may have different probabilities in these different scenarios to reflect the change in conditions. For example, there may be one assumed fire cycle in ecosystem management (the “natural” cycle), a reduced fire cycle under the protection scenario, and an increased fire cycle under a climate change scenario. When probabilities are defined for each of the disturbances, they should be consistent with the appropriate scenario.

1.2 Description of Forest Structural Stages

The definitions of structural stages used in the McCully Creek watershed (Table 1.1) have been adopted for application to the Morice and Lakes IFPA. The only exception is that structural stages 2 and 3 or the open and closed stem-exclusion phases were combined into a single stage just representing the stem-exclusion phase, abbreviated “se.” At a later date, if other attributes are to be applied to the various classes, these stages may be separated again.

Table 1.1: Definitions of structural stages used in the Morice and Lakes IFPA.

Structural Stage	Definition
1. Stand Initiation	Herb, shrub, and tree complex following disturbance.
se. Stem Exclusion / Sapling Stage	Growing space is occupied and no new trees are infilling. Limitation is either light (e.g., closed canopy) or nutrients (e.g., open canopies). This is a young forest, single cohort. Note that in some areas this could be an extended (several decades) phase.
4. Understorey Reinitiation	Gaps forming and understorey emerging. Two or more cohorts are present.
5. Young Forest Multi Strata	No original cohort, short multi-age stand.
6. Old Forest Multi Strata	Multi-cohort, multi-layer stand with older trees present.

1.3 Description of Cover Types

Every SPD uses its own set of cover types. When creating the diagrams, several assumptions were made in describing what was present in each class:

- Species are only listed when they get into the overstorey. Understorey species may be present, but will not be visible until later in the row.
- The sum of all species mentioned should occupy at least 80% of the stand or polygon.
- If only one species is mentioned, it is the leading species and it occupies 80% or more of the stand or polygon;
- If two or more species are listed separated using "/", then the first is dominant over the second, and the two combined must be at least 80% of the stand or polygon. For example: Sp1/Sp2 means that Species 1 is dominant over Species 2 and that combined they both are at least 80% of the stand or polygon;
- If two or more listed species are separated using "-", then both species have equal dominance. For example, "Sp1-Sp2" means that Species 1 and Species 2 are essentially equally present in the stand, and combined makes up more than 80% of the stand or polygon.

Some exceptions to these rules may apply, but will be noted in the description of the class.

Also note that VDDT will not allow two classes to have the same cover type and structural stage designations. In order to combat this, an extra number or letter was added to the end of some of the cover type abbreviations to allow the diagram to be created.

1.4 Description of Disturbances

As discussed above, almost any type of natural disturbance, as long as it has an impact on the class, can be described. So far, all the SPD combined contain two types of fire (wildfire and ground fire), tomentosus, several different insects, and floods. The group discussed other disturbance types but did not include them because of their small-scale impacts or because they did not play a big role in changing stand structure or composition. The impact of the different disturbances and their probabilities are described more fully in each chapter.

1.5 IFPA Characteristics

The IFPA consists of two TSAs: Morice and Lakes. Combined, they contain over 2 million hectares (ha), distributed into 10 different BEC variants (Table 1.2). Most of the landscape, 71%, is in the SBS zone, and another 22% is in the ESSF zone. Therefore, the dynamics of these zones was the focus of the meetings. Although it represents only 2% of the landscape, the SBPS was also addressed because mountain pine beetle is currently quite active there. No time was spent on the CWH zone because it contains few insects or pathogens, or on the MHmm because it represented less than 1% of the landscape.

Table 1.2: Distribution of the IFPA by area and BEC variant. The “Covered?” column shows those BECs that have pathway diagrams in this document. Only two BECs have no pathway diagrams: CWHws2 and MHmm2.

Subzone or Variant	Area (ha)	Percentage	Covered?
SBSmc	1,192,122	42.1%	Yes
SBSdk	788,633	27.9%	Yes
ESSFmc	431,351	15.2%	Yes
ESSFmk	182,840	6.5%	Yes
CWHws2	63,869	2.3%	
SBPSmc	57,034	2.0%	Yes
SBSwk3	47,433	1.7%	Use SBSmc
ESSFmv3	43,615	1.5%	Use ESSFmc
MHmm2	17,001	0.6%	
ESSFmv1	7,290	0.3%	Use ESSFmc
Total	**2,831,188**	**100%**	

1.6 Next Steps

This document provides the summary information about each of the pathway diagrams that have been defined for the Morice and Lakes areas. These are preliminary diagrams and are subject to review and revision.

The suggested next steps are:

1. Review the existing successional pathway diagrams, the summary notes provided in this document, and the results of the runs to equilibrium. Particularly note classes or rows which disappear during the simulation (indicating that it would be unlikely to be found in the landscape) or which accumulate a large proportion of the area.
2. Define rules by which the current landscape can be classified into one of the classes in the document. This will identify any missing classes or unusual cases that have not yet been addressed. It will also show the need to attach site series or other classifier to each of the rows in the diagram, especially in cases for which more than one class exists with the same cover type and structural stage combination. If rules cannot be defined in order to distinguish these similar classes, the diagram should be revisited to reduce the number of classes to those that can be uniquely identified.
3. Produce graphs of the current classification of the landscape, and do runs that show how the actual landscape will change over time based on the defined pathways and probabilities.
4. Refine pathways and probabilities as needed.
5. Develop partial cutting pathways.

2.0 Englemann Spruce Subalpine Fir (ESSF)

2.1 ESSFmc Subzone

The ESSFmc occurs in about 15.2 percent of the Morice and Lakes IFPA. The pathways developed for this area will also be used for the two variants in the ESSFmv subzone.

2.1.1 Successional Pathways

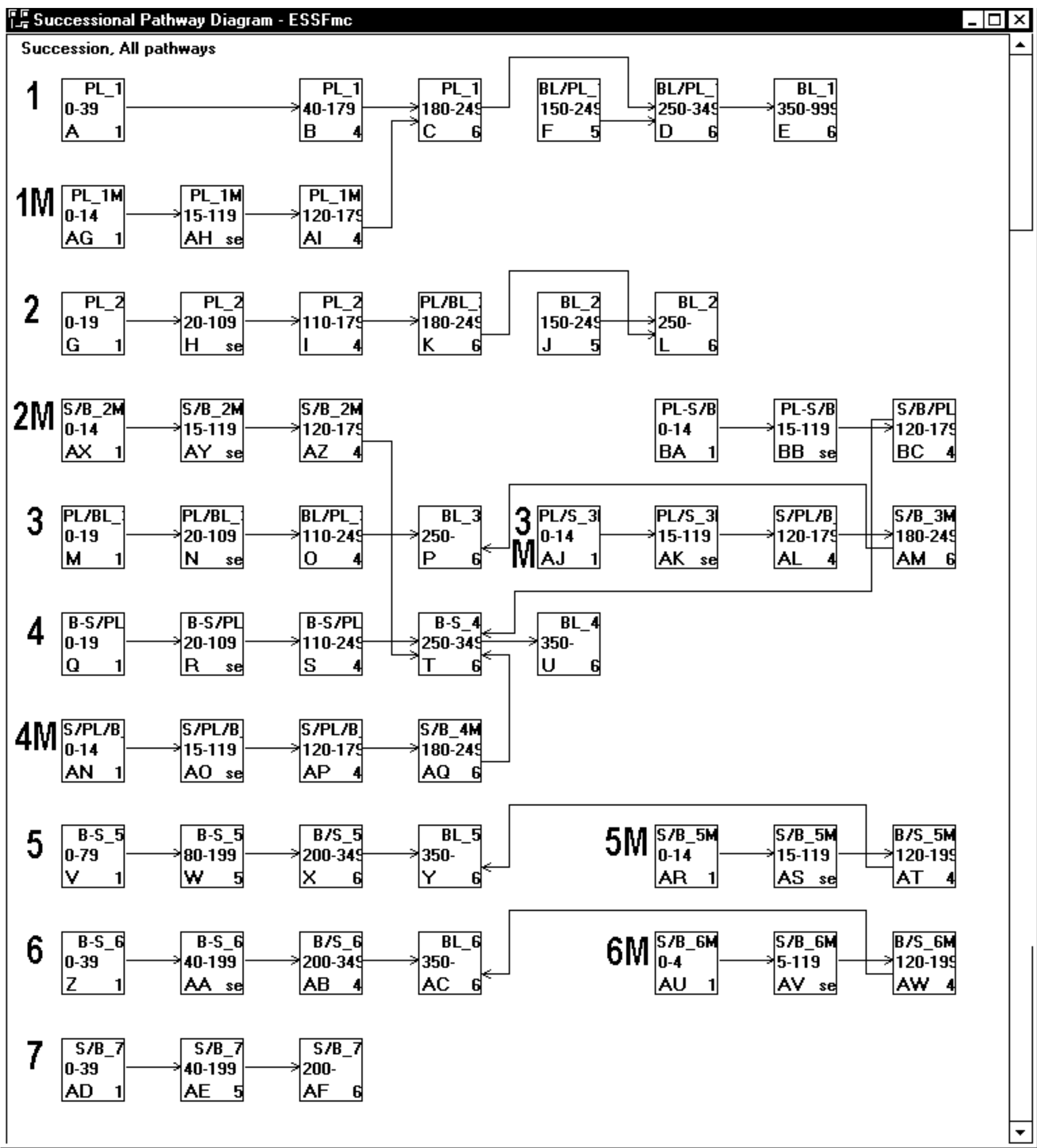

Figure 2.1: Successional pathway diagram for the ESSFmc showing the major classes and their succession pathways. If a class has no pathway leaving it, then area remains in this class until it is disturbed.

Notes about the classes

During the workshop, people mentioned some of the assumptions behind some of the different classes such as what mechanism was creating the gaps and driving succession or which species were in the understorey. Table 2.1 summarizes, in point form, some these points. Note that all classes in structural stage 6 with a cover type of Bl, may include up to 20% Sxw.

Table 2.1: Notes for the ESSFmc classes. The letters in the first column identify the different classes. Each set of classes is also grouped according to the row that it is on. These notes are only for the natural classes. Notes about the managed classes (those on rows numbered with an M) are given in the management section.

Row 1 – Pl Open	
	Site series: 02/03. Drier sites, sub-xeric, poor, rocky, open canopy. Fire return interval = 180 years.
A	Long initiation period because site is dry and poor.
B	Rocks/moisture limiting, so gaps not being created, already there, stress killing trees
C	Bl starting to co-dominate
D	Bl taking over eventually to become multiple story. Most area stays in class, but 20% will move to class E.
E	An old forest, with the Pl essentially gone.
F	Class created only from mountain pine beetle attacks in class B. These remove some of the Pl overstory, and allow the Bl to become more dominant than would otherwise occur.
Row 2 – Pl Closed	
	Site series 01 leading (02/03), mesic types, ridges. Coarser/drier soils than row 3. No S or BL seed source.
G	Initiated from stand destroying fires.
H	Gaps created by root rots, some suppressed understorey
K	Bl coming up in gaps and Pl dying
L	Conversion to Bl completed
J	Like class F above. This class is created from mountain pine beetle attacks in class I, which removes the Pl.
Row 3 – Pl/Bl	
	Site series 01/04/05. Finer soils than row 2 and generally smaller patch sizes. Mesic/sub-hygric,
M	Both Bl/Pl growing evenly together, Pl dominant, fire initiated
N	Pine death occurring due to stem rot/shading by Bl
O	Bl taking over, Pl continuing to die out
P	Bl dominant

Row 4 – Bl-Sxw/Pl	
	Site series 01/05/06. Moister sites. Rare.
Q	Matrix Bl/Sxw with Pl. Created from burn with Bl/Sxw areas adjacent providing the seed source, especially in good seed years. Thus areas that currently do not contain Bl or S can regenerate as this matrix.
Row 5 – Bl-Sxw	
	Site series: any 07 and upper 30% of ESSFmc. Mostly 05/06/08. Devil's club and gullies. 350 year fire return interval.
V	Large shrub layer
W	Stem decay removing trees
X	Bl Dominant
Row 6 – Bl-Sxw	
	Site series: any of the lower 30% of the ESSFmc that does not contain pine, with the exception of the 07 sites (which are row 5). Generally moister sites or horsetail sites.
Z	Post fire
AA	Stem decay removing trees
Row 7 – Sxw/Bl	
	Floodplains/riparian, cold air ponding.
AD	Ac in stand but <20% so not in cover type designation.
AE	Multi-story
AF	Spruce dominant, floods replace stands

2.1.2 Disturbances

A number of natural disturbances were considered for the ESSFmc. These included two types of fires: stand-replacing fire and ground fire, four types of insects: mountain pine beetle, budworms, spruce bark beetle and balsam bark beetle, root disease, flooding, windthrow, landslides/mass wasting and burls. Fire, insects and flooding were included in the diagrams, and are discussed in further detail below.

The following disturbances were not included for various reasons:

Root disease:	The ESSF is considered too cold for root disease.
Windthrow:	Generally a small event, usually around 200 square meters, and was considered below the scale of the diagrams.
Landslides and mass wasting:	Events were ignored because although the events can be very large, the probability is very small. In addition, a terrain stability data layer is required to predict where the events will occur, rather than vegetation structure or composition.

"Oogie-boogie" wood: (Burls upon burls) occurs intensively in small pockets on Bl. Not much is known about it, including how to predict what types of Bl stands will be hit.

Not all insects were included, but the exclusions will be discussed with the other insects.

Fire

The fires that were simulated in the ESSF were either ground fires or stand-replacing fires. The stand-replacing fires are often not initiated in the ESSF, but spread up from the SBS. Thus, actual fire frequencies are greater than would be expected if the ESSF were in isolation. With the exception of rows 1, 5, and 7, the diagram uses a 219-year return interval. Row 1 has a higher return interval of 180 years, and row 5 has a lower return interval of 350 years. All classes, except those in the flood plain (last row), are eligible for burning. Since the fire is assumed to be stand replacing, the fire sets the stand back to the beginning of a row. Fire pathways always take a pixel back to the beginning of the row it is currently in (Table 2.2). In some cases, pathways may also move the area to another row based on assumptions about likely seed source, fire severity, or stand adjacencies. For example, Pl usually comes back into a stand after a fire, so most classes will have at least one fire pathway that will return to a Pl-dominated class. Some classes, however, may have had Pl excluded for so long that the seed source is no longer there, so the probability of going to a Pl-leading class will be lower than for other classes.

Table 2.2: Fire pathways, and their proportions, in the ESSFmc. For rows 2-4 and row 6 the overall fire return interval is 219 years or a probability of 0.0047. Row 1 has a return interval of 180 years (probability of 0.0055), and row 5 has a return interval of 350 years (probability of 0.0029).

	Row:	**1**	**2**	**3**	**4**	**5**	**6**
	To:	**PL1**	**PL1**	**PL/BL1**	**B-S/PL1**	**B-S1**	**B-S1**
Row:	**From:**						
1	**PL1,4&6**	100					
1	**BL/PL5&6**	100					
1	**BL6**	100					
2	**PL1,se&4**		100				
2	**PL/BL6**		100				
2	**BL5**		100				
2	**BL6**		20	70	10		
3	**PL/BL1&se**		40	60			
3	**BL/PL4**		20	80			
3	**BL6**			100			
4	**B-S/PL1**		33	33	33		
4	**B-S/PLse**		20	30	50		

	Row:	1	2	3	4	5	6
	To:	PL1	PL1	PL/BL1	B-S/PL1	B-S1	B-S1
Row:	From:						
4	B-S/PL4		10	30	60		
4	BL6				90		10
4	B-S6				90		10
5	B-S1&5					100	
5	B/S6					100	
5	BL6					100	
6	B-S1						100
6	B-Sse				10		90
6	B/S4				10		90
6	BL6				10		90

Ground fires occur more frequently, on an assumed 200-year return interval. They generally kill the smaller trees and do not occur in the wet sites of the S/B classes. The rules were that fires in structural stage 1 or 6 set the stand back to itself, structural stage “se” stands become stage 4 stands, and stage 4 stands become stage 6 due to removal of understorey (Figure 2.2). In all cases, the pathway would not cause the stand to change to a different row.

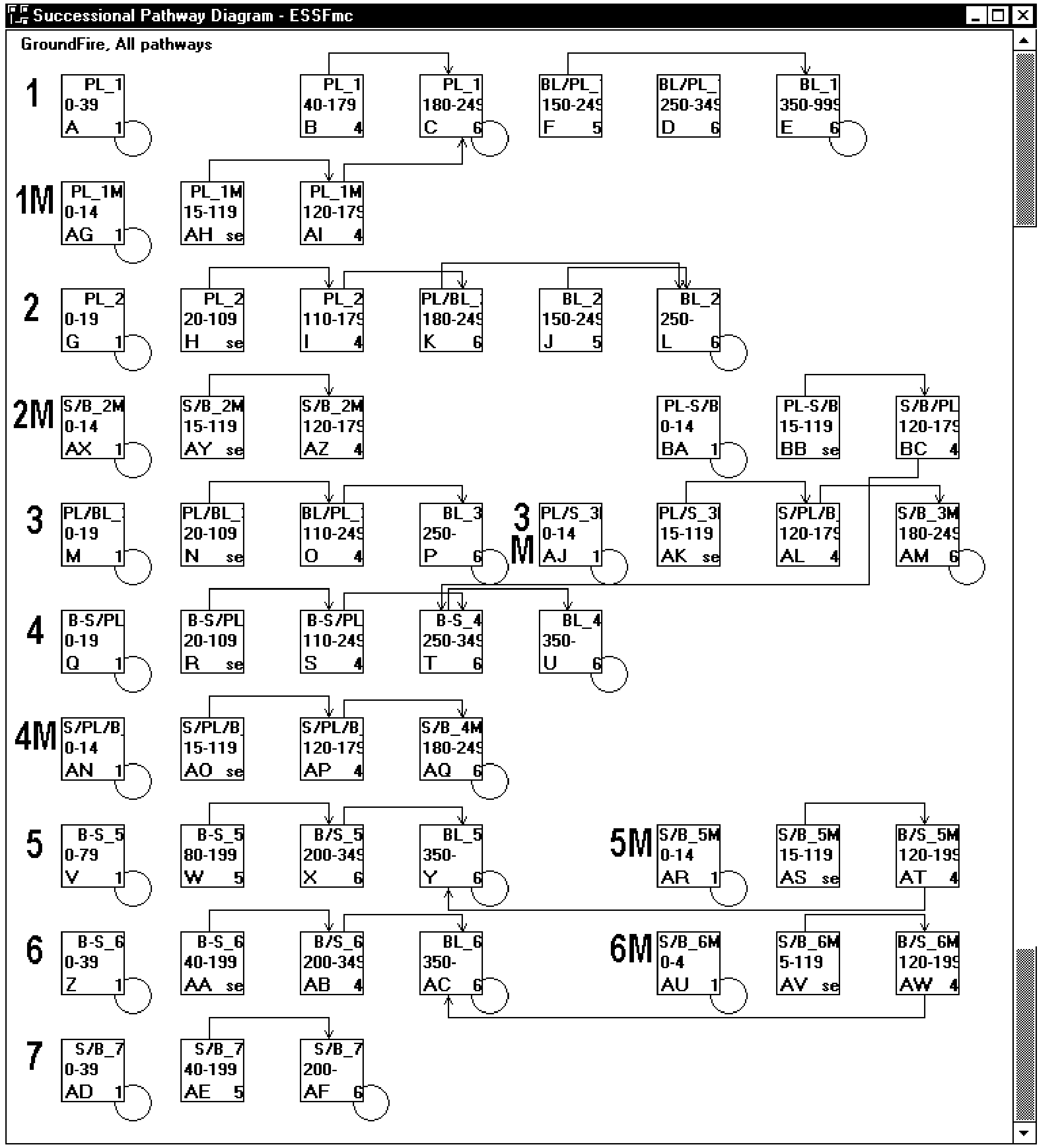

Figure 2.2: Ground fire pathways in the ESSFmc.

Insects

Only two different insects were included: mountain pine beetle and balsam bark beetle. Spruce beetle was not included because it has a relatively low probability in the ESSF, and there is little area affected by it. Two-year cycle budworm was excluded because although it is common, there is a low probability that it will affect the stands enough to change the structure and composition in these diagrams.

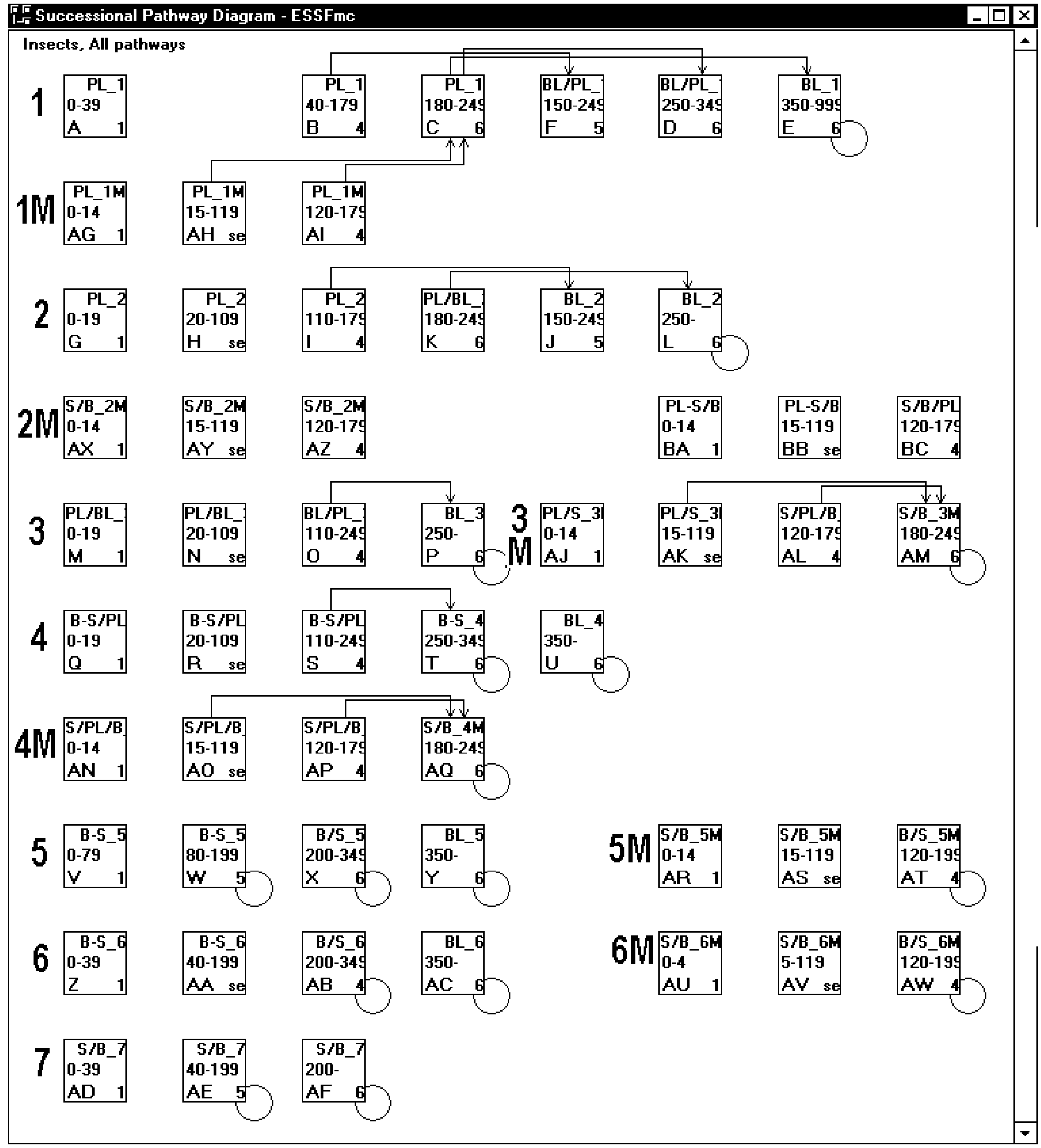

Figure 2.3: Insect pathways in the ESSFmc. Mountain pine beetle pathways are those that attack and change the class of Pl leading stands in the first four rows. Balsam bark beetle pathways are those that cycle within a class and attack either balsam-leading stands or the spruce-balsam stands in the flood plains.

Mountain pine beetle attacks structural stages 4 and 6 of pine-leading stands older than 100 years (Figure 2.3). In no case, did we assume a stand-replacing beetle event, since all classes contained Bl in the understorey. In this diagram, it is found only in the first four rows. The beetle removes or reduces the amount of Pl in the stand, and hastens the infill of Bl. Mountain pine beetle is not as severe in the ESSF as in the SBS or SBPS because the ESSF is colder. Also, attacks in the ESSF tend to be more isolated and less likely to spread. The probabilities in the diagrams are about 0.008 in pure pine stands and 0.006 in mixed species stands.

Balsam bark beetle attacks stands where the BL is over 120 years and contains mature or large diameter trees. In many of these, the stand age may be older than that if the Bl was not part of the originating stand. The beetle acts as an endemic maintaining agent in all classes in which it occurred (Figure 2.3) because it removes the big old stems and forms more gaps in the stand which will be filled by other Bl stems. The assumption in the diagram is that 40% of eligible stands will be hit in 100 years, giving a probability of 0.004. The same probability was used for all pathways.

Table 2.3: Insect pathway definitions (classes, probabilities and age change) for the ESSFmc.

Insect	Row	From	To	Probability	Age Change
Mountain Pine Beetle	1	PL4	BL/PL5	0.003	
	1	PL6		0.0067 (total)	
			BL/PL6	15%	
			BL6	85%	
	1M	PLse	PL6	0.004	
	1M	PL4	PL6	0.004	
	2	PL4	BL5	0.0057	
	2	PL/BL6	BL6	0.0057	
	3	BL/PL4	BL6	0.0036	
	3M	PL/Sse	S/B6	0.003	
	3M	S/PL/B4	S/B6	0.003	
	4	B-S/PL4	B-S6	0.002	
	4M	S/PL/Bse	S/B6	0.003	
	4M	S/PL/B4	S/B6	0.003	
Balsam Bark Beetle	1, 2, 3, 4, 5, 6	BL6 (all)	BL6 (to self)	0.004	-50
	3, 4M, 7	S/B6 (all)	S/B6 (to self)	0.004	-50
	4	B-S6	B-S6	0.004	-50
	5	B-S5	B-S5	0.004	-50
	5	B/S6	B/S6 (row 6)	0.004	-50
	5M, 6, 6M	B/S4 (all)	B/S4 (to self)	0.004	-50
	7	S/B5	S/B5 (row 7)	0.004	-50

Flooding

Flooding occurs only in the S/B row (the last row), with a 300-year return interval. All floods are stand initiating and do not cause a change in row.

2.1.3 Sample Results

Both succession and disturbance pathways and disturbance probabilities have been defined for the ESSF, making it possible to assess the consequences of these assumptions in terms of the distribution of successional classes. In order to see the consequences of these assumptions, VDDT was run for 1000 years using the defined information until the landscape was near equilibrium. Note, however, that real landscapes are not in equilibrium because disturbance frequencies can change over time. Actual distributions of classes in the landscape will differ because the current landscape has different amounts of each row and/or cover type. The run was done starting with an equal amount of area in each "natural" class. Those classes in rows coming from management (those designated with an M) were not included, and management was not simulated.

The first, fifth, and seventh rows are self-contained. This means that all area that started in these rows will remain in it, and that no additional area will move to those stands. Row 7, the flood plains represented by the last three bars on the graph, contains two-thirds of its area in the oldest S/B6 class. 1/9 of the area is in the youngest class, and 2/9 in the middle-aged class. This is consistent with the 300-year return interval for flooding that was assumed. Increasing the rate will decrease the amount of old and increase the area in the other two classes.

The first row shows that the majority of the area is in the Pl4 and the climax Bl6 stands. The class Bl/Pl5 (F) contains very little area because area only enters this class following the low-level MPB attacks on class Pl4 (B).

The fifth row (B-S_5, B/S56, BL56 in the graph) has about half of its area evenly distributed among the younger three classes, and the other half of its area in the oldest class. A large area appears in the oldest age class because of the low fire-return interval, and because this class represents the largest amount of area.

The remaining rows exchange area during a run, entirely through the fire pathways (see Table 2.2). Row 2 gets area from rows 3 and 4, and area moves from class L (BL6) back to rows 3 and 4. Row 3 receives area from rows 2 and 4, and sends area to row 2. Row 4 sends area to rows 2, 3, and 6, and gets area from rows 2 and 6. Finally row 6 exchanges area with row 4. The graphs show that the exchanges are balanced enough that all rows will maintain area. Area is moving slowly towards row 3, away from rows 4 and 6. If this is a problem, slight adjustments in the allocation between different fire pathways can be made.

2.1.4 Management

The managed pathways each represent a different site series. Stands will choose the appropriate managed pathway based on their site series.

In all cases, the stand-initiation stage is shorter for planted trees than the unmanaged rows. Planted trees are older than those growing from seed, and the planters try to maximize the potential of the site by not leaving big gaps in the stand. The stem-exclusion phase is generally longer than in the unmanaged rows because operators are generally doing management that maintains the stand so that it doesn't break up. Most stands will be harvested when they are in this stage. Older classes, such as those in the reinitiation stages, are added to account for stands that were not optimally harvested for whatever reason.

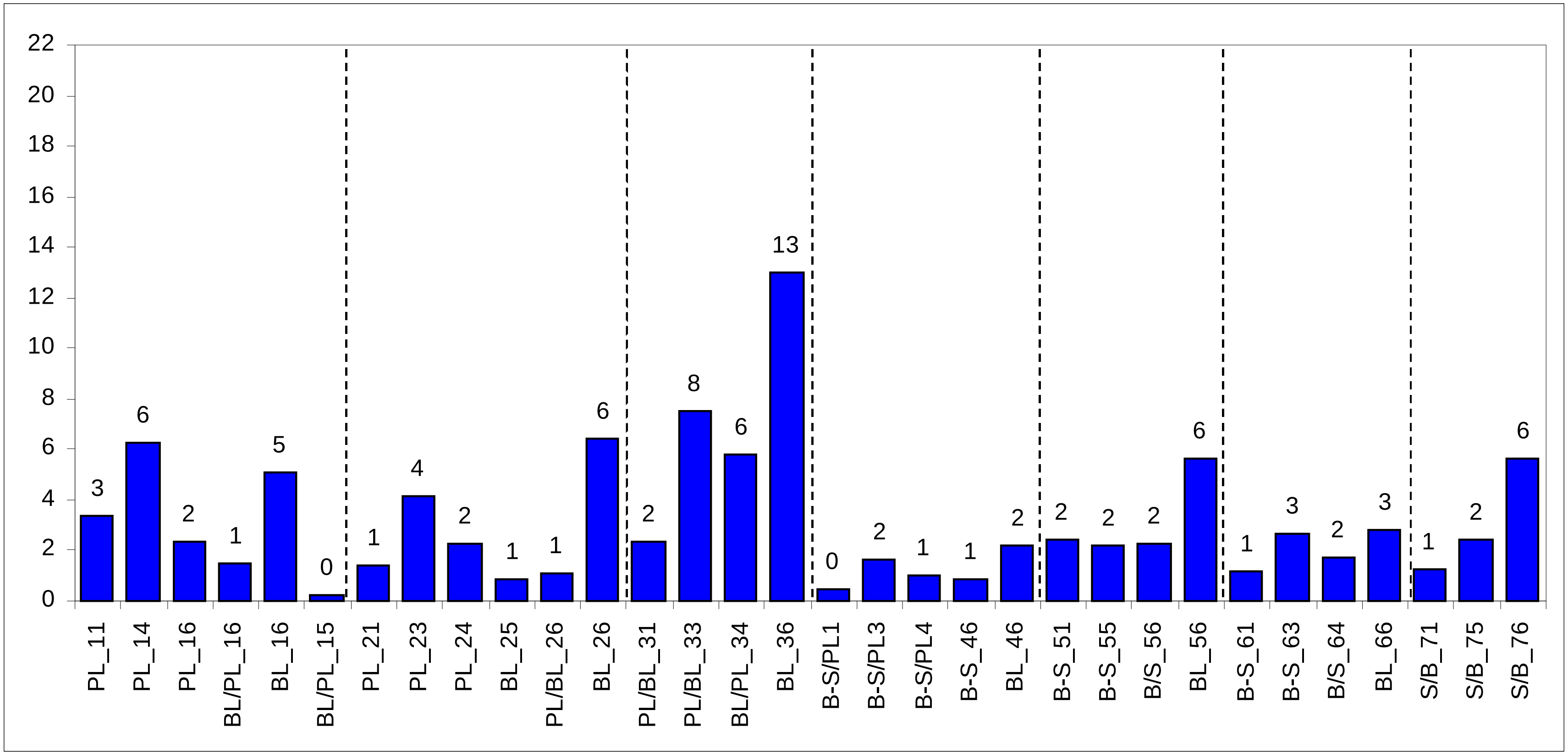

Figure2.4: Distribution of area in the ESSFmc after VDDT was run to near equilibrium. The lines delineate each row in Figure 2.1. Note that none of the management pathways are included in this graph or in these calculations.

Any stand in the stem exclusion phase and older can be managed. The result of the management depends on the site series of the stand. In some cases, separate management pathways were defined for the Morice and the Lakes to capture slightly different harvest practices.

Row 1M - Site series 02/03	
	No harvest normally on row 1, but if it occurs, then plant 100% Pl.
Row 2M - Site series 01	
Morice	(BA-BC) Plant 50% Pl, 50% Sx. Bl comes in naturally later.
Lakes	(AX-AZ) Plant 60% Sx, 30% Pl.
Row 3 M - Site series: 04	
	Plant 80% Pl, 20% Sx. Bl comes in naturally.
Row 4M – site series 05/o6/09	
Morice	Plant in summer: 80% Sx, 20% Bl and in winter, plant 60% Sx, 20% Bl, 20% Pl
Lakes	Plant 80% Sx, 20% Pl. No planting of Bl, because it shows up naturally in the early stages.
Row 5 M - Site series: 07/08	
	Plant 60% Sx, 40% Bl.
Row 6 M - site series 10	
	Plant 60% Sx, 40% Bl. Basically the same as row 5M except that the earliest stage is much faster.
Row 7- floodplain	
	No management

2.2 ESSFmk Subzone

The ESSFmk occurs in about 6.5 percent of the Morice and Lakes IFPA.

2.2.1 Successional Pathways

This diagram was originally based on the ESSFmc, and as such the classes and pathways are very similar (see Section 2.1.1). The main changes are the addition of PA, and the addition of another row at the end of the diagram representing balsam/hemlock stands.

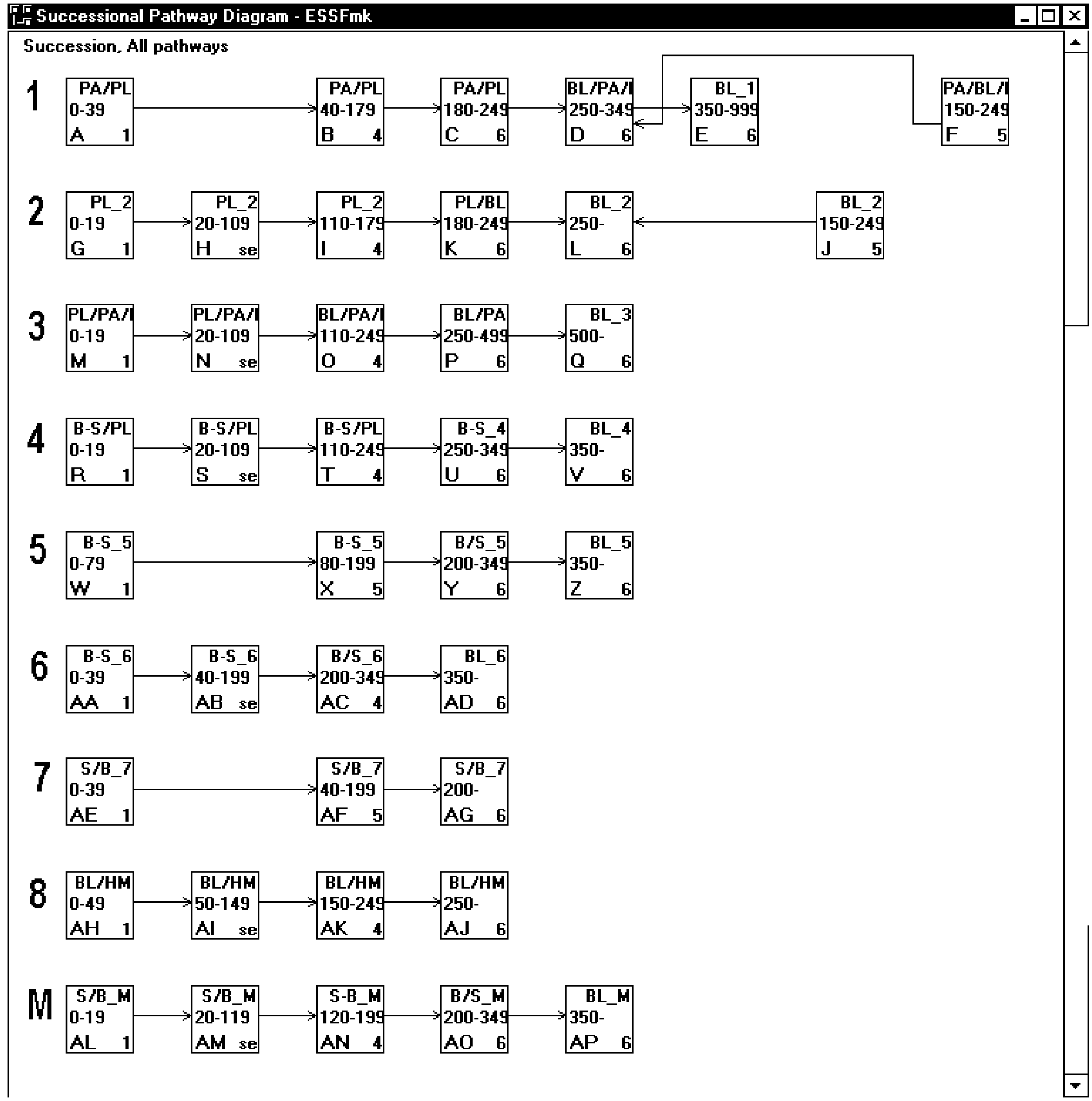

Figure 2.5: Successional pathway diagram for the ESSFmk showing the major classes and their succession pathways.

Notes about the classes

Details about the classes in the ESSFmk are very similar to those for the ESSFmc. Thus, Table 2.4 only describes the exceptions and additions. Rows 1 and 3 both have Pa in addition to the Pl. A new row 8 contains Bl and Hm.

Table 2.4: The exceptions and additions of the ESSFmk subzone pathways compared with the ESSFmc pathways (Table 2.1). These notes are only for the natural classes. Notes about the managed classes (those on rows numbered with an M) are given in the management section.

Row 1 – Pa/Pl Open	
	Site series 02. Lower fire return interval (300 years)
A	Drier sites, sub-xeric, poor, rocky, open canopy
E	Eventually Pl & Pa die out due to rust & mountain pine beetle
F	From mountain pine beetle, which kills the Pl, leaves the older Pa and lets the Bl become more dominant.
Row 2 - Pl	
	Site series 01/04. Similar to row 2 in the ESSFmc.
Row 3 – Pl/Pa/Bl	
	Site series 03(01). Morainal/mesic, not necessarily dry; valley bottom; cold air ponding.
M	Some Hm, extensive Pa
P	The Bl stand still has some of the Pa from left from the original stand. This is no longer the climax class
AG	The new climax, Bl class. It may contain some Hm component (stunted), and some Pa understorey can be 200 years old.
Row 4 – Bl-Sxw/Pl	
	Site series 04/01 (moister)
Row 5 – Bl-Sxw	
	Site series 07 and upper 30% of ESSFmk - use the same rules as for row 5 in the ESSFmc.
Row 6 – Bl-Sxx	
	Site series 06/07 - remaining 70% of any other site using the same rules as for row 6 in the ESSFmc.
Row 7 – Sxw/Bl	
	Floodplain.
Row 8 – Bl/Hm	
	Site series 01/06 with Hm and Bl/Ba in polygon.
AH	Mesic/sub-hygric
AI - AJ	Persistent Bl/Hm with Bl and Hm filling in gaps as they occur, Hm is present as a stressed understorey/sub-canopy layer

2.2.2 Disturbances

The natural disturbances considered for the ESSFmk are the same as ESSFmc (see Section 2.1.2 - Disturbances). A few pathways and probabilities are different, however, and these are discussed below.

Fire

The ESSFmk receives more snow in the winter and has a drier summer than the ESSFmc. At the first workshop, it was thought that that would lead to an increased frequency of fire. Information received after that workshop, however, showed that the stand-replacing fire return interval should be 650 years. As in the ESSFmc, all classes except those in the wet floodplains are eligible for stand-replacing fire, and all pathways lead back to a structural stage 1 at the beginning of some row. The pathways are described in Table 2.5.

Table 2.5: Fire pathways, and their proportions, in the ESSFmk. The overall fire return interval is 650 years or a probability of 0.0015.

	Row: **To:**	**1** **PA/PL1**	**2** **PL1**	**3** **PL/PA/BL1**	**4** **B-S/PL1**	**5** **B-S1**	**6** **B-S1**	**8** **BL/HM1**
Row:	**From:**							
1	**PA/PL1,se&6**	100						
1	**PA/BL/PL5**	100						
1	**BL/PA/PL6**	100						
1	**BL6**	100						
2	**PL1,se&4**		100					
2	**BL5**		100					
2	**BL6**		20	70	10			
2	**PL/BL6**		100					
3	**PL/PA/BL1&se**			100				
3	**BL/PA/PL4**		40	60				
3	**BL/PA6**		20	80				
3	**BL6**			100				
4	**B-S/PL1**		33	33	33			
4	**B-S/PLse**		20	30	50			
4	**B-S/PL4**		10	30	60			
4	**B-S6**				90		10	
4	**BL6**				90		10	
5	**B-S1&5**					100		
5	**B/S6**					100		
5	**BL6**					100		
6	**B-S1**						100	
6	**B-Sse**				10		90	
6	**B/S4**				10		90	
6	**BL6**				10		90	
8	**BL/HM1,se,4&6**							100

The rules and return interval (200 years) for ground fire was the same as for the ESSFmc (Figure 2.2).

Insects

The rules and probabilities for mountain pine beetle and balsam bark beetle were the same as in the ESSFmc. The pathways are shown in Figure 2.6.

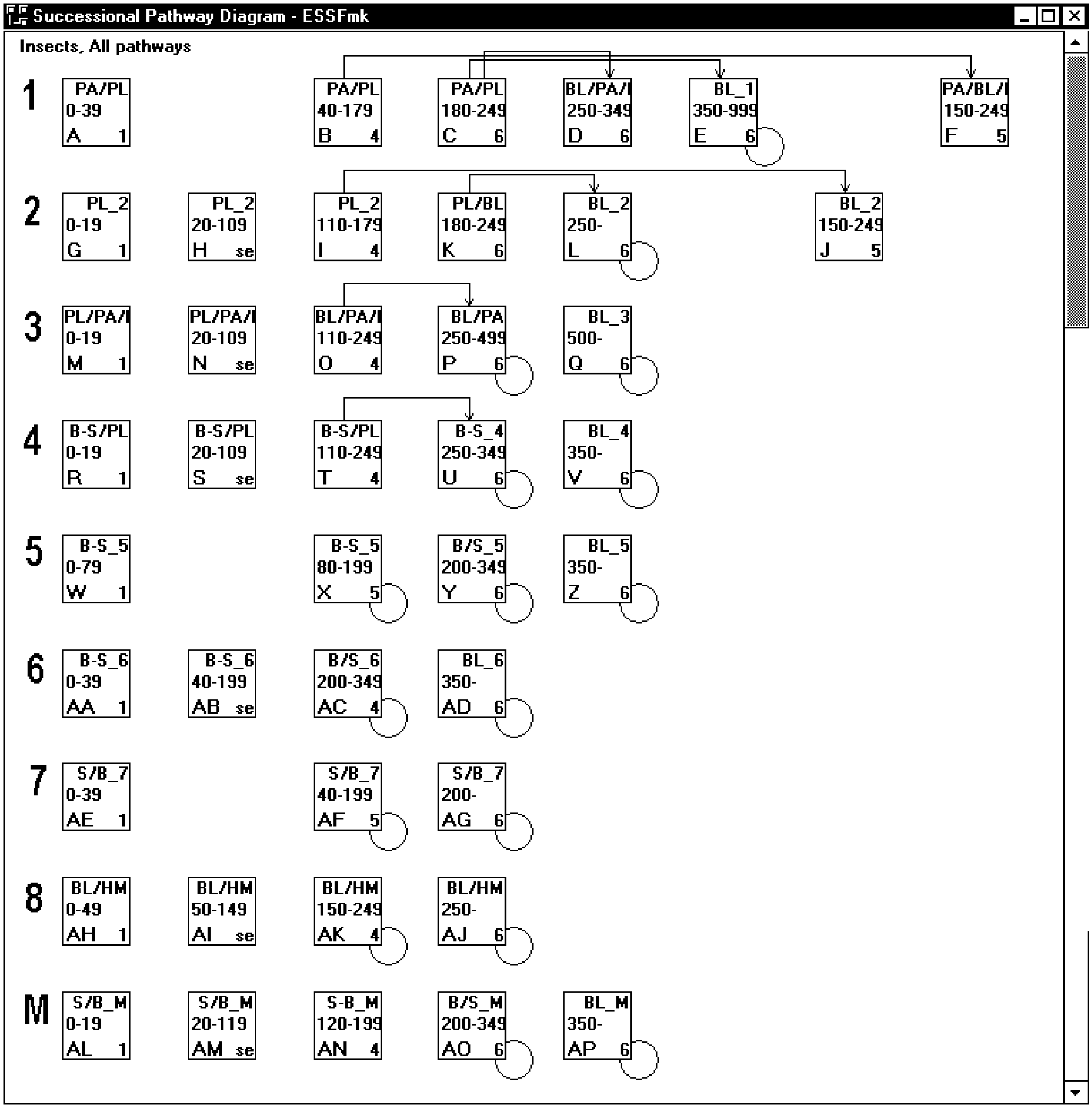

Figure 2.6: Insect pathways in the ESSFmk. Mountain pine beetle pathways start in classes with Pl leading (or class O or S) and move to another class, while balsam bark beetle pathways start in classes with BL leading (or the S/B stands) and remain in the same class.

Table 2.6: Insect pathway definitions (classes, probabilities and age change) for the ESSFmk.

Insect	Row	From	To	Probability	Age Change
Mountain Pine Beetle	1	PA/PL4	PA/BL/PL5	0.003	
	1	PA/PL6		0.0067 (total)	
			BL/PA/PL6	15%	
			BL6	85%	
	2	PL4	BL5	0.0057	
	2	PL/BL6	BL6	0.0057	
	3	BL/PA/PL4	BL/PA6	0.0036	
	4	B-S/PL4	B-S6	0.002	
Balsam Bark Beetle	1, 2, 3, 4, 5, 6, M	BL6 (all)	BL6 (to self)	0.004	-50
	3	BL/PA6	BL/PA6	0.004	-50
	4	B-S6	B-S6	0.004	-50
	5	B-S5	B-S5	0.004	-50
	5, M	B/S6 (all)	B/S6 (to self)	0.004	-50
	6	B/S4	B/S4	0.004	-50
	7	S/B5	S/B5	0.004	-50
	7	S/B6	S/B6	0.004	-50
	8	BL/HM4	BL/HM4	0.004	-50
	8	BL/HM6	BL/HM6	0.004	-50

2.2.3 Sample Results

The results show that the ESSFmk landscape would be on average much older than the ESSFmc. Approximately 65% percent of the landscape would be in the climax vegetation state, which in most cases is pure Bl. Another 10% of the landscape would be in non-climax structural stage 6 stands. The old state of the landscape occurs because of the long fire return interval.

Four rows, rows 1, 5, 7, and 8, are self-contained, while rows 2, 3, 4, and 6 exchange area through fire (see Table 2.5). While Row 2 now has area both entering and leaving it, it is still slowly disappearing from the landscape. Part of this is due to the infrequency of fires. Area mostly enters row 2 from the early stages of row 4, and it mostly leaves row 2 from the last class (BL6). Because of the long fire return interval, the landscape is old with more area in the old classes (which sends area away from row 2) than in the younger classes (which send area to row 2).

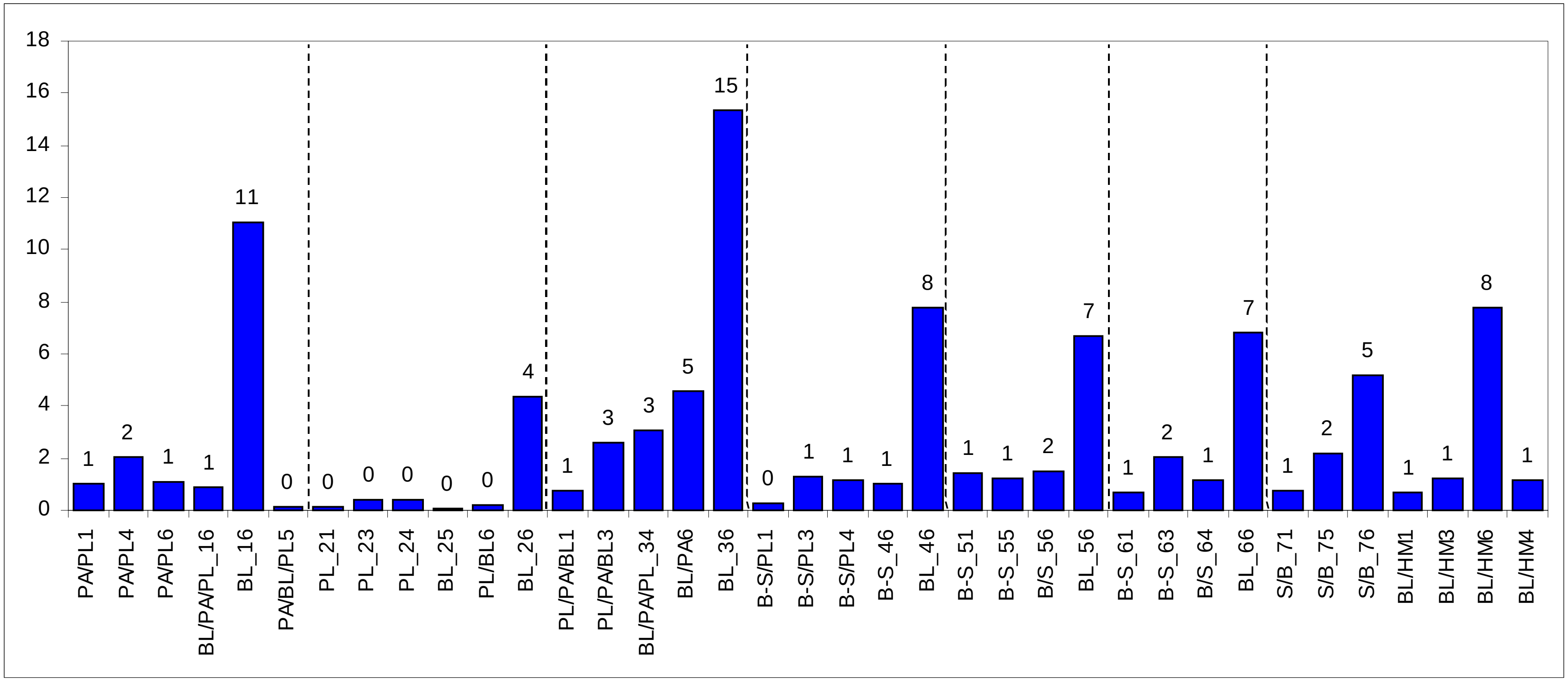

Figure 2.7: Distribution of area in the ESSFmk after VDDT was run to near equilibrium. The lines delineate each row in Figure 2.5. Note that none of the management pathways are included in this graph or in these calculations.

2.2.4 Management

Unlike the other subzones, the ESSFmk has only one management pathway (Row M). All classes that get managed go to this pathway after management. If the stand originally contained Hm and/or Pa/Pl then these may still be present, but will not show up on the label because they will make up less than 20% of the stand.

Not all rows or classes get managed. Rows 1 and 7 are not managed and any stands that are Pa-leading will also not get harvested.

3.0 Sub-boreal Spruce Zone (SBS)

The Sub-boreal Spruce (SBS) zone includes SBSdk, SBSmc and SBSwk3, which together comprise 71% of the Morice and Lakes IFPA area, mostly in the first two of the subzones. This section describes pathway diagrams for the SBSmc and the SBSdk. The SBSwk can use the pathway diagram from the SBSmc.

3.1 SBSmc Subzone

3.1.1 Succession Pathways

Notes about the diagram

Table 3.1: Notes about the SBSmc pathways and classes. These notes are only for the natural classes. Notes about the managed classes (those on rows numbered with an M) are given in the management section.

Row 1 - S/Pl Open	
	Site series: 02. Created from tomentosus in class A, row 2.
Row 2 – Pl Open	
	Site series 02. Rocky/poor site, xeric/sub-xeric, outwash terraces
	Drier/poor, open canopy, rusts a problem and rusts are driving succession.
Row 3– Pl Closed	
	Site series 01. Mesic/sub-mesic, Sxw in stand slowly growing
Row 4– Pl/Bl/Sxw	
	Site series: 01/05/06. Mesic/rich sites
P	Sxw has stem rots, creates gaps when topples and exposes mineral soil, Sxw persists due to mineral (approx. 30% probability)
Row 5– Bl-Sxw/Pl	
	Site series 05/06, wetter. Mesic/rich sites
Row 6– Bl-Sxw	
	Site series 06/09. Post-fire, circum-mesic sites, cold aspects.
Row 7– Sxw/Bl	
	Site series 10. Riparian/floodplain sites, fluvial.
Row 8– Sxw/Bl	
	Site series 09. Upland type, moist/rich, big trees.
AD	Root and stem rots occurring to create the gaps to move to next class (AE)
AF	Some spruce remains in stand (<20%)
BW	Created from spruce beetle attacks in AE

Table 3.1 is continued on page 29.

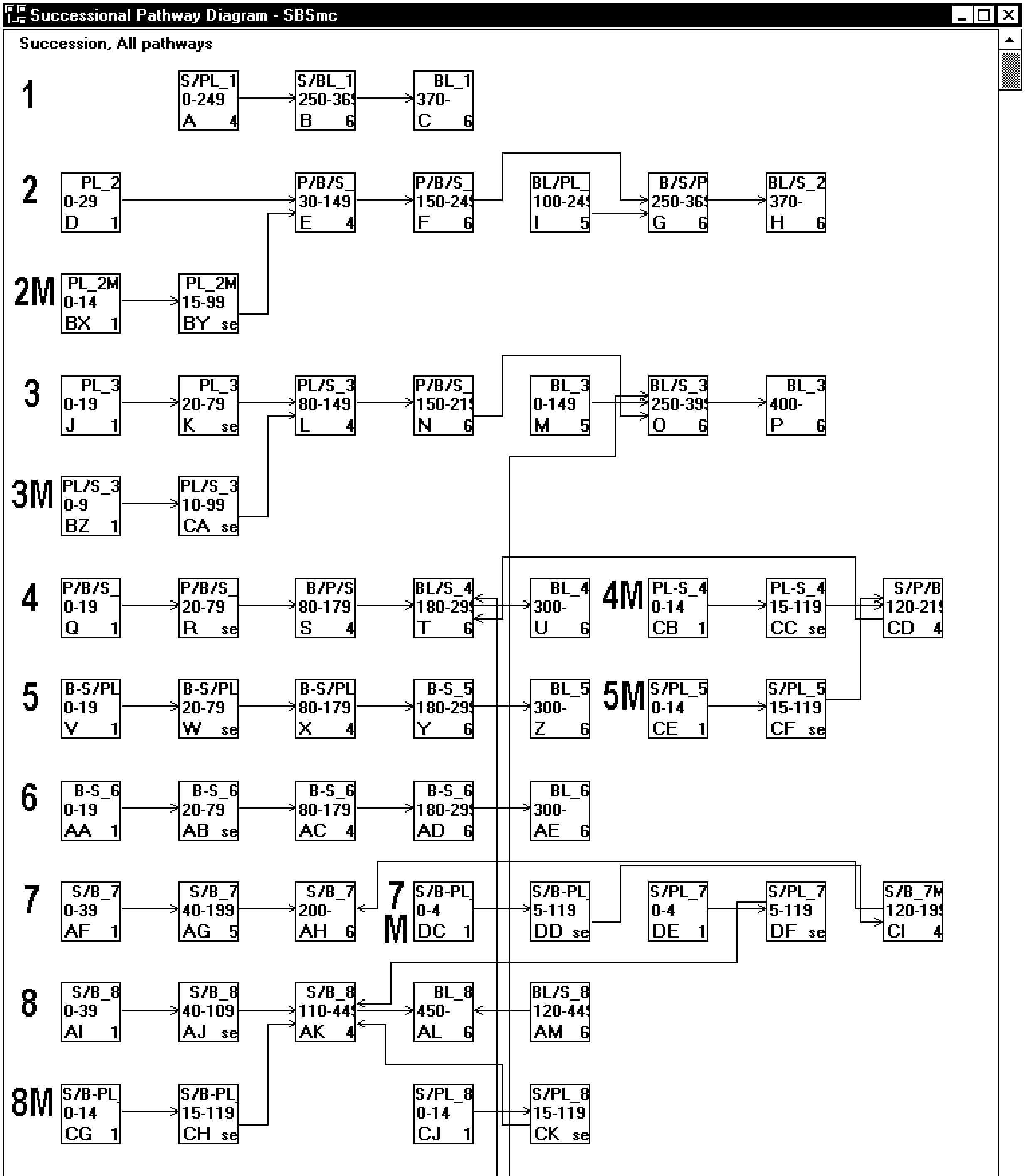

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Figure 3.1: Successional pathway diagram for the SBSmc showing the major classes and their succession pathways.

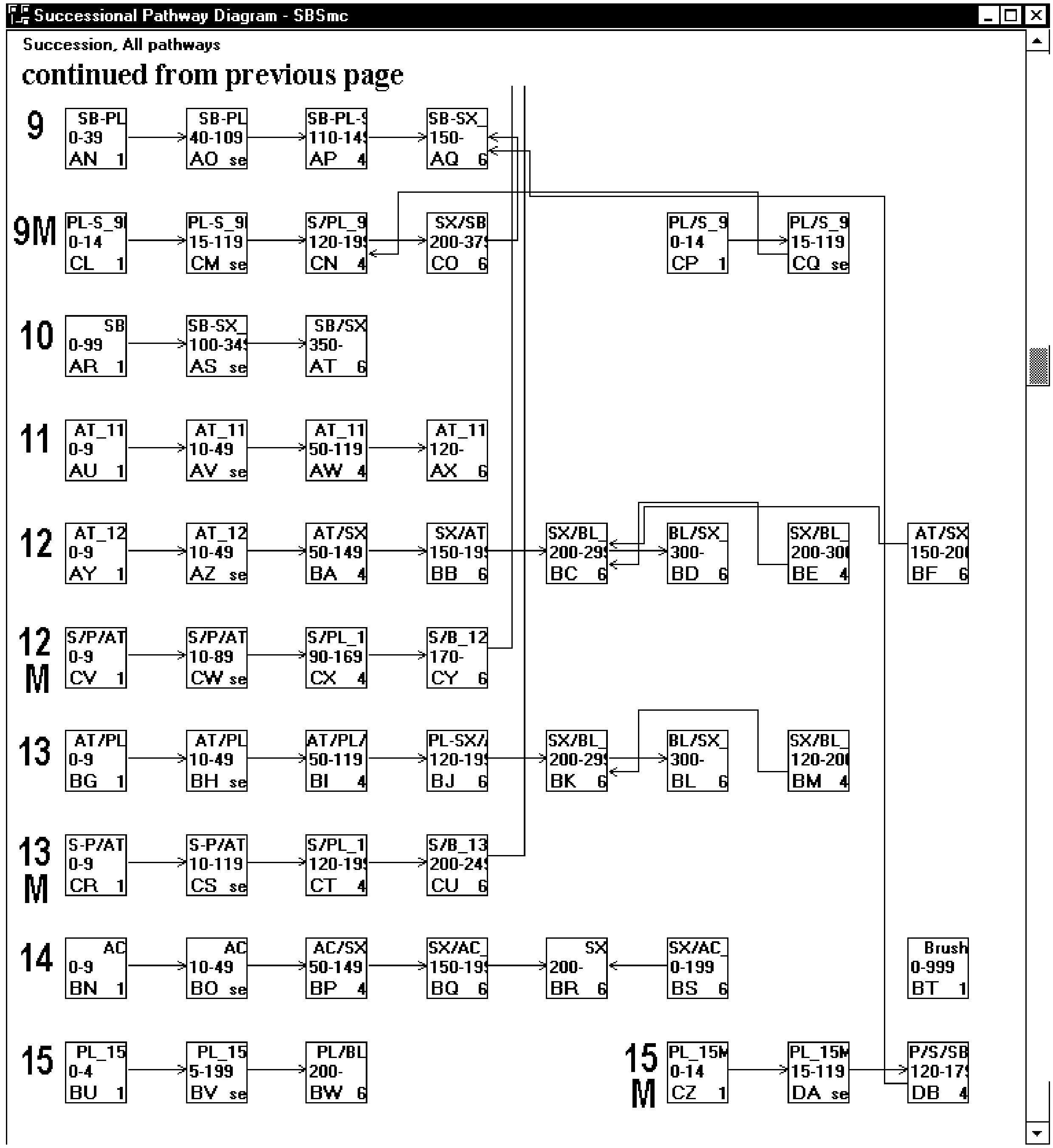
Successional Pathway Diagram - SBSmc
Succession, All pathways
continued from previous page
9
SB-PL 0-39 AN 1
SB-PL 40-109 AO se
SB-PL-S 110-14 AP 4
SB-SX_ 150- AQ 6
9M
PL-S_9 0-14 CL 1
PL-S_9 15-119 CM se
S/PL_9 120-19 CN 4
SX/SB 200-37 CO 6
PL/S_9 0-14 CP 1
PL/S_9 15-119 CQ se
10
SB 0-99 AR 1
SB-SX_ 100-34 AS se
SB/SX 350- AT 6
11
AT_11 0-9 AU 1
AT_11 10-49 AV se
AT_11 50-119 AW 4
AT_11 120- AX 6
12
AT_12 0-9 AY 1
AT_12 10-49 AZ se
AT/SX 50-149 BA 4
SX/AT 150-19 BB 6
SX/BL_ 200-29 BC 6
BL/SX_ 300- BD 6
SX/BL_ 200-30 BE 4
AT/SX 150-20 BF 6
12 M
S/P/AT 0-9 CV 1
S/P/AT 10-89 CW se
S/PL_1 90-169 CX 4
S/B_12 170- CY 6
13
AT/PL 0-9 BG 1
AT/PL 10-49 BH se
AT/PL/ 50-119 BI 4
PL-SX/ 120-19 BJ 6
SX/BL_ 200-29 BK 6
BL/SX_ 300- BL 6
SX/BL_ 120-20 BM 4
13 M
S-P/AT 0-9 CR 1
S-P/AT 10-119 CS se
S/PL_1 120-19 CT 4
S/B_13 200-24 CU 6
14
AC 0-9 BN 1
AC 10-49 BO se
AC/SX 50-149 BP 4
SX/AC_ 150-19 BQ 6
SX 200- BR 6
SX/AC_ 0-199 BS 6
Brush 0-999 BT 1
15
PL_15 0-4 BU 1
PL_15 5-199 BV se
PL/BL 200- BW 6
15 M
PL_15M 0-14 CZ 1
PL_15M 15-119 DA se
P/S/SB 120-17 DB 4

Table 3.1 continued:

Row 9 – Sb-Pl	
	Site series 07/03. New site series, glow moss.
AG	Equal Sb and Pl, cold air drainage, poor soils
AH	Sb and Pl keep regenerating due to open canopy
AI	Pl starts to die off due to stem rots
AJ	Persists as this complex
Row 10– Sb	
	Site series 12. Sb wetland forest, with Sx coming in later
AL	Possibly some Pl (<20%)
Row 11 – At	
	Site series 01/05
AN	Pure At, no conifer due to high herbaceous component (cow parsnip, coltsfoot)
AO	Reduced stocking
AQ	Persists without disturbance in this state due to high herbaceous not allowing conifer growth, some Scouler's willow present
Row 12- At	
	Site series 05 leading
AR	Mesic/rich site, Sxw in understorey
AS	Sxw in understorey
AT	Sxw co-dominant, Bl coming up in understorey
AU	At still in canopy
AV	Sxw and Bl take over canopy
AW	Sxw drops out due to stem rots, Bl becomes dominant
BQ	Created from budworm attacks in classes AV or AW.
BR	Created from spruce beetle attacks in class AU. Aspen suckering.
Row 13- At/Pl	
	Site series 01 drier, south facing upper slopes. Mesic/sub-mesic
AY	Sxw in understorey
BA	Sx now in canopy, At starting to drop out
BB	Both Pl and At have dropped out, Bl becoming more dominant
BV	Created from budworm or balsam bark beetle attacks, which remove the mature trees in the overstorey and release the understorey.
Row 14 – Ac	
	Site series 08 from dk. Floodplains/low bench riparian
BD	Sxw in understorey
BE	Sxw in sub-canopy
BH	Sxw will persist due to periodic flooding, Ac in canopy but <20%,
BP	Brushfield created from severe spruce beetle outbreaks. Once created, these will only regenerate after a flood.

Row 15 – Pl Dogs-hair	
	Site series 01 (03)
BM	Mesic/sub-mesic stands, fast initiation, very dense
BN	Stand suppressed for long period, rusts key in opening gaps
BO	Eventually Bl overtakes

3.1.2 Disturbances

A number of natural disturbances were considered for the SBSmc. These included two types of fires: stand-replacing fire and ground fire, five types of insects: mountain pine beetle, budworms, spruce bark beetle, tent caterpillars and balsam bark beetle, and other disturbances such as flooding, windthrow, and landslides/mass wasting. Windthrow and landslides were not addressed in this pathway diagram for the same reasons that are given in the ESSFmc (Section 2.1.2). Fire, insects, and flooding are discussed in further detail below.

Fire

For stand-replacing fire, we assumed a 133-year return interval with the following exceptions – a 200-return interval was assumed for row 8 (starting with cover type S/B, class AC) and 300-year return interval for row 10 (cover type SB, class AK). The fire return interval was kept at 133 for row 2 because although the stands are drier, they are also high and are not less likely to burn. In these diagrams, all classes except those on the flood plain are eligible for burning. While fires occur on flood plains in the real world, the probability is low and is not being modelled (rows 7 and 14).

After a burn, all stands except the At-leading stands, could re-initiate as Pl-leading, with some potential for a small proportion of the stands to become a high-density dog-hair pine stand. Existing high-density stands are more likely than other stands to become the high-density stands, but will have some chance of becoming a lower-density stand as well. Because the amount of high-density Pl stands remains about constant on the landbase, the group decided to have the high- density stands stay high density after a fire, and no other stands to become high density (Table 3.2). This will not capture the fact that these dog-hair stands change location in the landscape, but it will mean that the amount stays about right. At-leading or mixed stands will not reinitiate as Pl-leading, but will reinitiate with an At component.

Ground fires occur on an assumed 200-year return interval. The rules for the pathways are the same as for the ESSFmc. Fires in structural stage 1 or 6 set the stand back to itself, structural stage “se” stands become stage 4 stands, and stage 4 stands become stage 6 due to removal of understorey (Figure 3.2). In all cases, the pathway would not cause the stand to change to a different row.

Note that all rules and probabilities are assumed to be pre-fire suppression. With fire suppression in effect, the probabilities would be lower, and we would expect to have an older landscape with more pine.

Table 3.2: Fire pathways in the SBSmc. The overall fire return interval is 133 years (probability of 0.0075) for all rows except row 8 (200 years, probability 0.005) and row 10 (300 years, probability 0.0033). Rows 7 and 14 are not included, since they do not burn.

Row:	**Row: To: From:**	**2 PL1**	**3 PL1**	**4 P/B/S1**	**5 B-S/PL1**	**6 B-S1**	**8 S/B1**	**9 SB-PL1**	**10 SB1**	**11 AT1**	**12 AT1**	**13 AT/PL1**	**15 PL1**
1	**S/PL4**	100											
1	**S/BL4**	100											
1	**BL6**	100											
2	**PL1**	100											
2	**P/B/S4&6**	100											
2	**BL/PL5**	100											
2	**B/S/P6**	100											
2	**BL/S6**	100											
3	**PL1&se**		100										
3	**PL/S4**		100										
3	**BL5&6**		10	45	45								
3	**BL/S6**		10	45	45								
3	**P/B/S6**		100										
4	**P/B/S1&se**		80	20									
4	**B/P/S4**		60	30	10								
4	**BL/S6**		10	40	40	10							
4	**BL6**		10	40	40	10							
5	**B-S/PL1,se&4**		60	20	20								
5	**BL6**		10	40	40	10							
5	**B-S6**		10	40	40	10							
6	**B-S1,se,4&6**			20	60	20							
6	**BL6**			20	60	20							
8	**S/B1,se&4**						100						
8	**BL/S6**						100						
8	**BL6**						100						
9	**SB-PL1&se**							100					
9	**SB-PL-SX4**							100					
9	**SB-SX6**							100					

Row:	Row: To: From:	2 PL1	3 PL1	4 P/B/S1	5 B-S/PL1	6 B-S1	8 S/B1	9 SB-PL1	10 SB1	11 AT1	12 AT1	13 AT/PL1	15 PL1
10	**SB1**								100				
10	**SB-SXse**								100				
10	**SB/SX6**								100				
11	**AT1,se&4**									100			
11	**AT6**									60	20	20	
12	**AT1&se**										100		
12	**SX/BL4&6**			10	10						70	10	
12	**BL/SX6**			10	10						70	10	
12	**SX/AT6**									40	50	10	
12	**AT/SX4&6**									60	30	10	
13	**AT/PL1&se**											100	
13	**AT/PL/SX4**											100	
13	**SX/BL4**			10	10						20	60	
13	**BL/SX6**			10	10						20	60	
13	**SX/BL6**			10	10						40	40	
13	**PL-SX/AT6**											100	
15	**PL1&se**												100
15	**PL/BL6**												100

Insects

Four insects were included: spruce beetle, balsam bark beetle, budworm, and mountain pine beetle. Tent caterpillars attacking At were discussed but were not included. They have a low probability of changing the structure of a stand, and have only a slight impact on the rate of succession.

Mountain pine beetle attacks structural stages 4 and 6 of stands that are pine-leading or that have a significant component of mature pine (Figure 3.3). The only exception is that they do not attack the very dense pine stands because the trees in those stands, while old enough, are usually too small. In the forest, the beetles generally kill trees older than 80 years, except during epidemics in which they may kill younger trees. In the diagrams, MPB started attacking at age 100, and we assumed that there was a 60% probability that Pl older than 100 years would be hit within 100 years. Additional MPB pathways and probabilities were added to account for outbreak conditions. The pathways were generally the same as the existing ones and additional pathways were added to younger pine-containing stands to represent the fact that MPB attacks younger stands during outbreaks. The probabilities in the outbreak pathways were also much higher to represent that during an outbreak, 70% of the older stands would be hit in 10 years, and 30% of the younger stands.

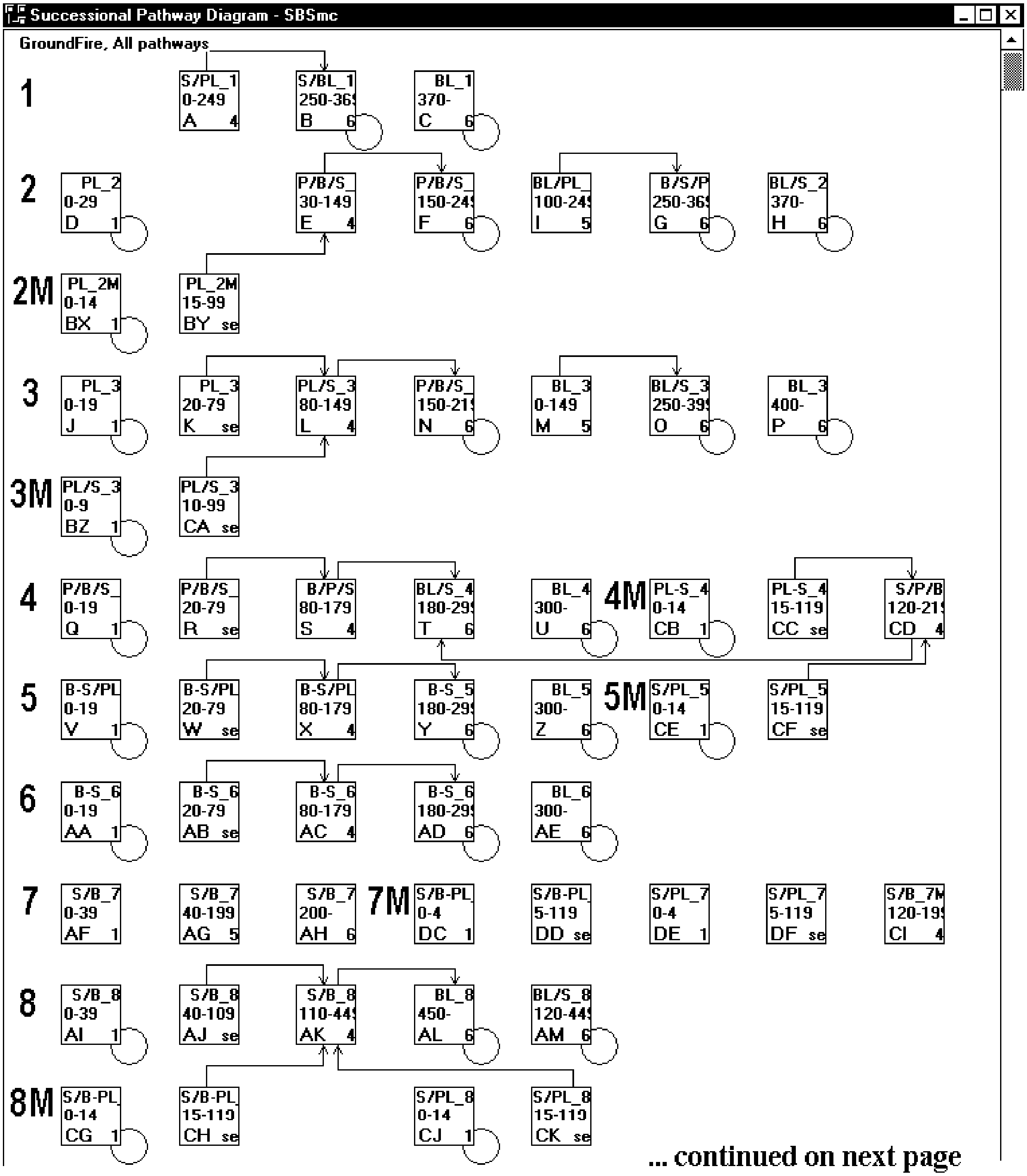

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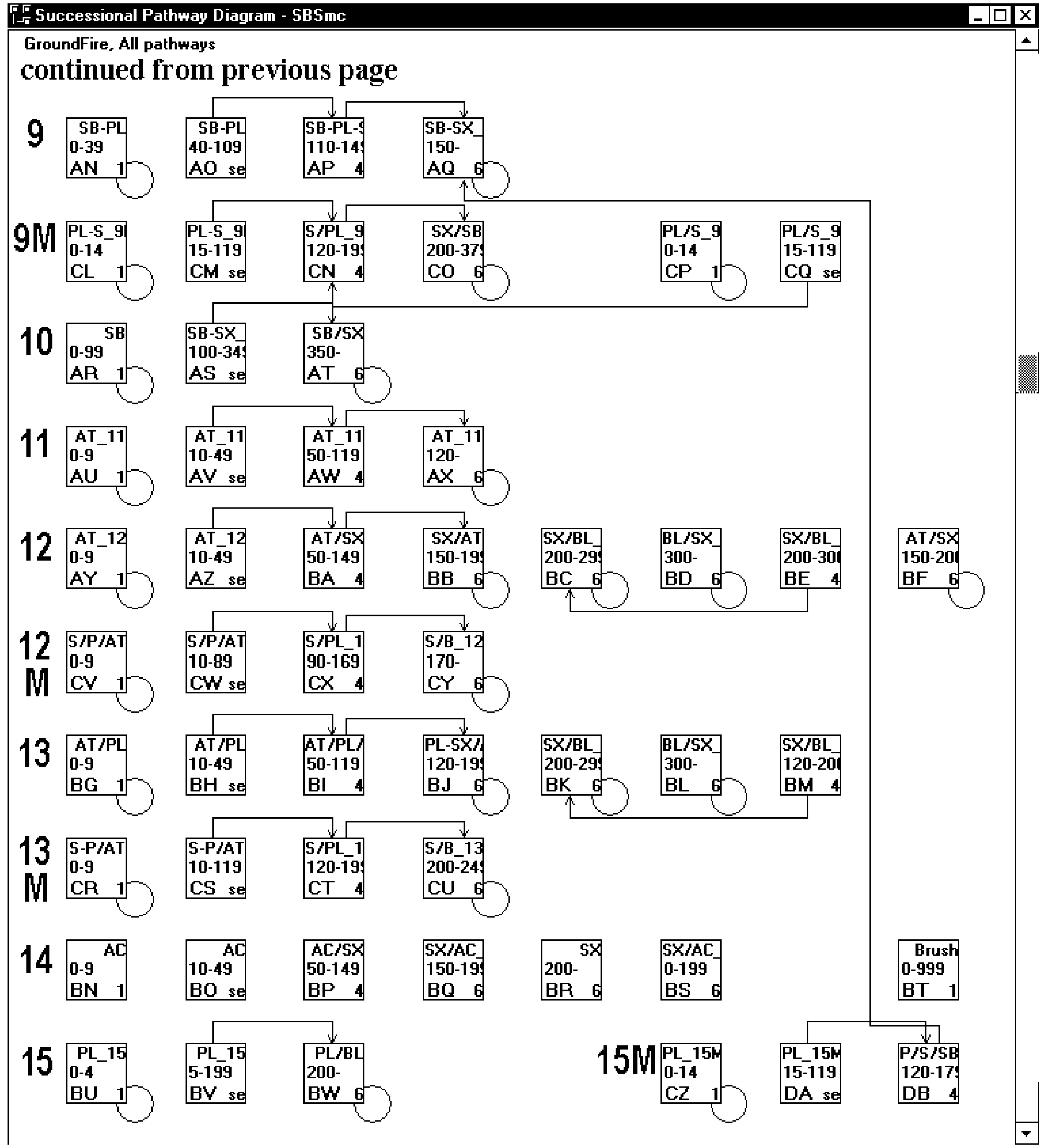
Figure 3.2: Ground fire pathways in the SBSmc. No fires occur in the flood plains (rows 7 and 14).



Balsam bark beetle primarily attacks mature balsam stands in which Bl older than 120 years is present. The beetle, like other insects, can be present at endemic or epidemic levels. At endemic levels, it is one of the drivers of succession, and is not explicitly modelled. At epidemic levels, the beetle removes some mature Bl from the stand, releasing the understorey. Thus, when it attacks structural stage 4 stands, it speeds the process to a stage 6 stand by creating more gaps (Figure 3.3). In most cases however, the beetle is only present in structural stage 6 stands, and it just causes area to cycle within the class. The beetle is less severe in the SBS than in the ESSF, and uses a probability of 0.004.

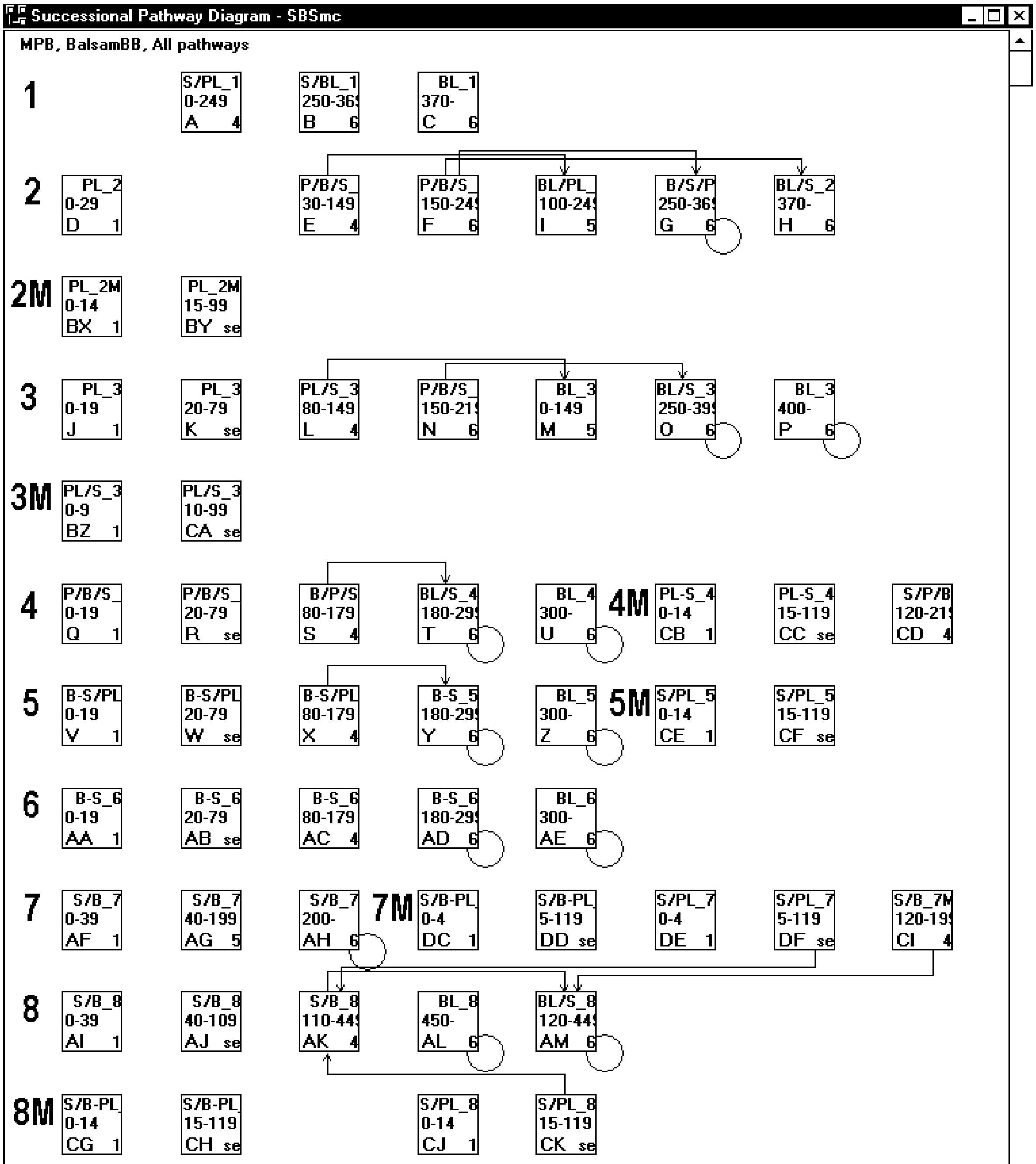


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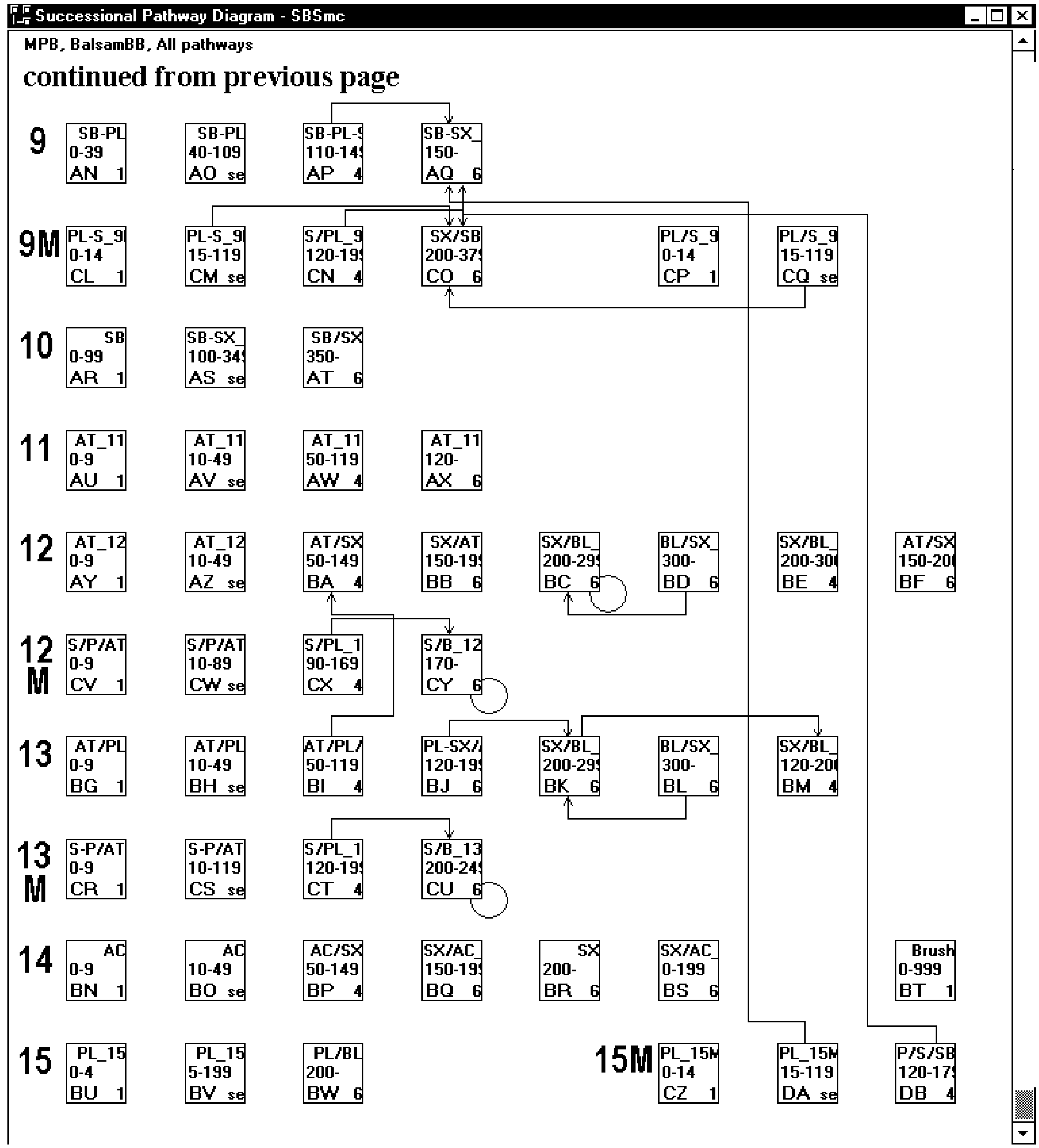
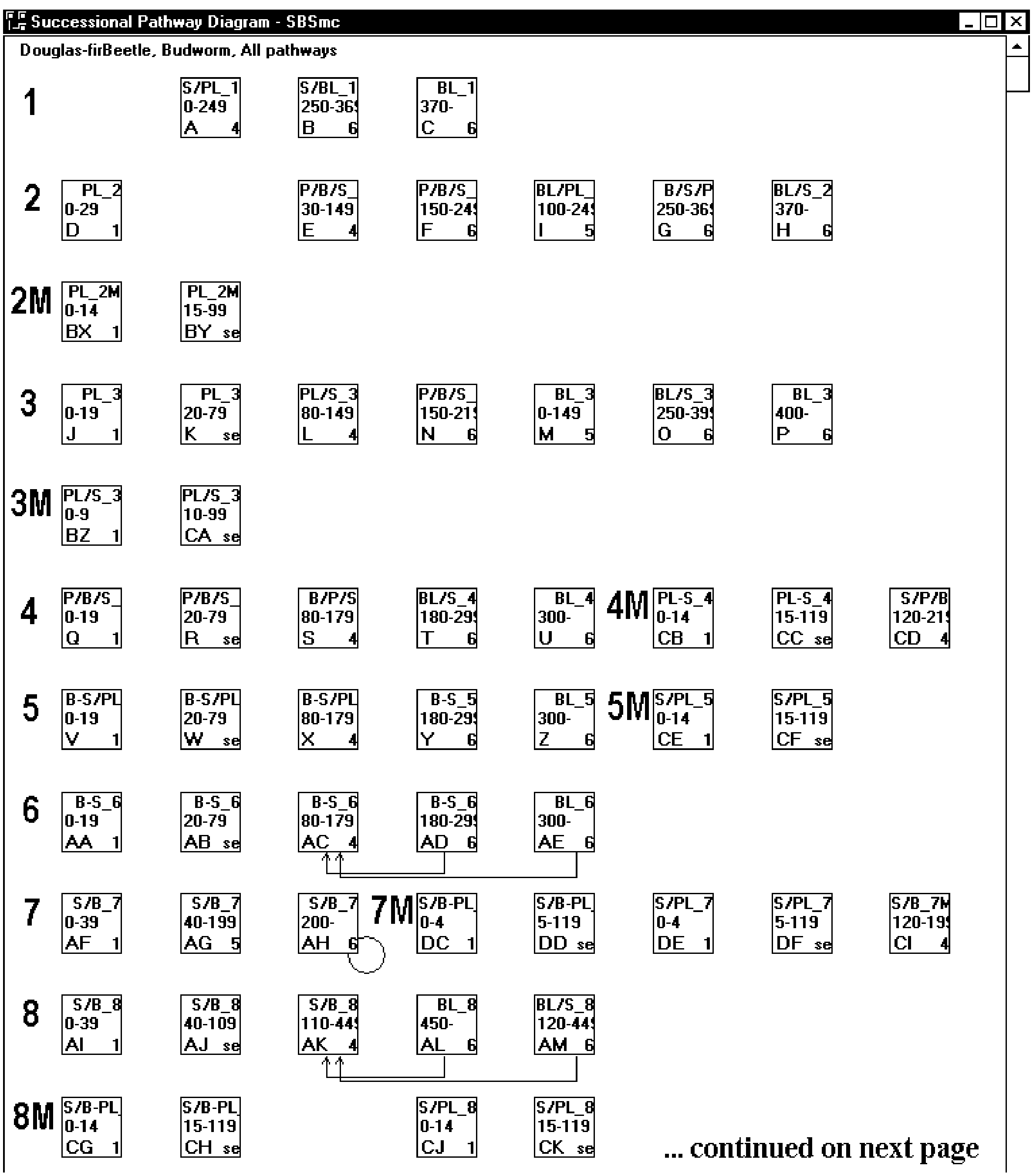
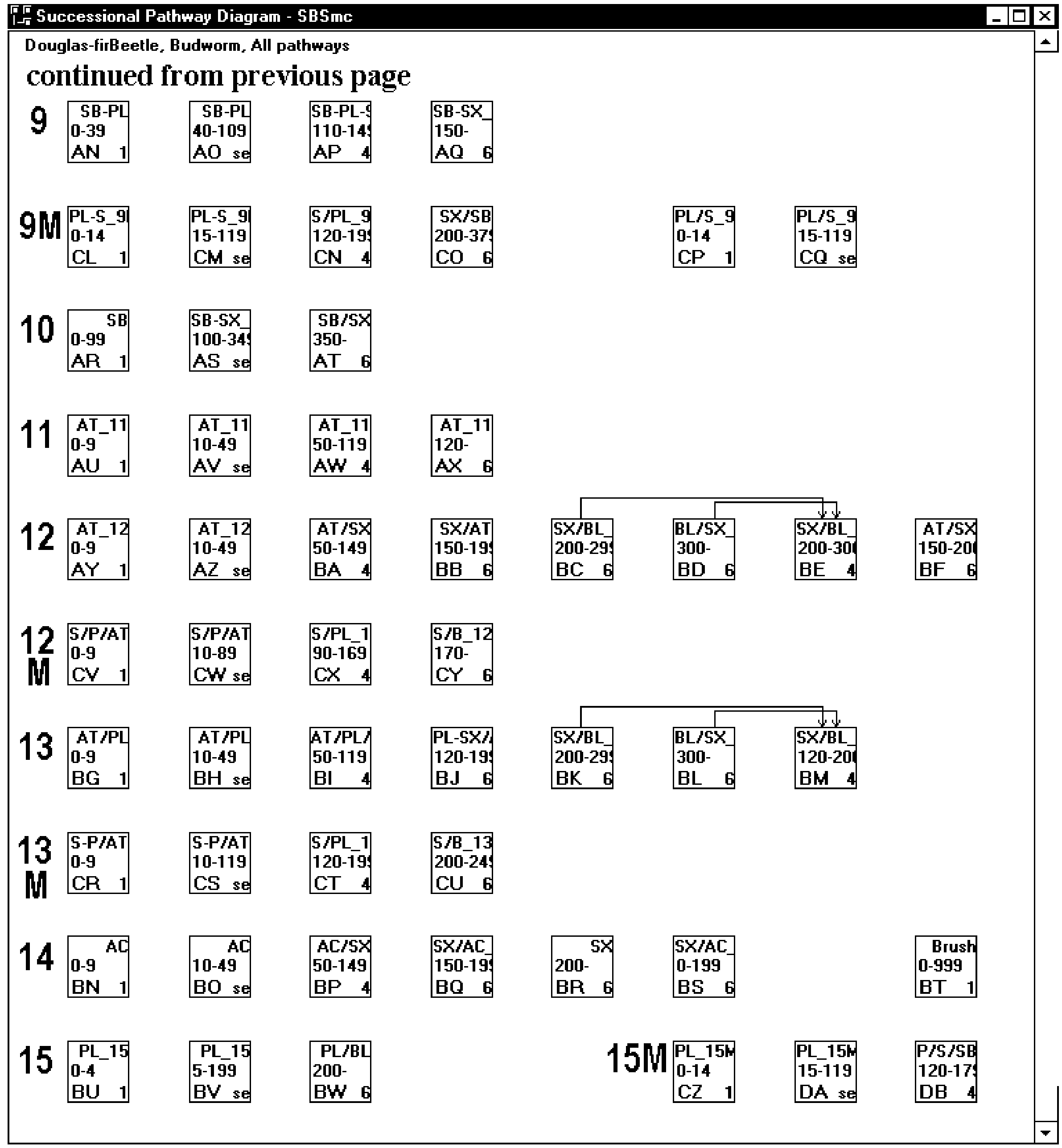
Figure 3.3: Mountain pine beetle and balsam bark beetle pathways in the SBSmc. Mountain pine beetles are the pathways from stands with a significant pine component, while balsam bark beetle pathways are in stands with the balsam component.



Spruce bark beetle plays a significant role in changing stand structure or composition in the SBS. It hits big spruce in stands over 100 years old that contain Sxw (Figure 3.4). The only exception is that the Sxw in row 10 is not attacked because of the presence of Sb. During an attack, the beetle can take out most of the mature layer of the trees almost causing a stand-replacing event. In the floodplains, heavy infestations of the beetle can cause the stand to reinitiate as an herbaceous brushfield. In many classes, the impact of the spruce beetle varies considerably depending on the level of infestation that is assumed. Thus, many classes have more than one spruce beetle pathway, which are allocated with different weights (Table 2.3). The beetle has a return interval of approximately 20 years in the landscape. In these diagrams, we assumed that every 20 years, it would only attack about 10% of the stands, giving a probability of 0.005 for spruce beetle in any eligible class.





Budworms have a lesser impact on the stand. They remove understorey Bl or Sxw, as well as some overstorey. They move stands from stage 6 (multi-layer) to stage 4 (understorey reinitiation). They have the same probability as spruce beetle.

Table 3.3: Insect pathway definitions (classes, probabilities and age change) for the SBSmc.

Insect	Row	From	To	Probability	Age Change
Mountain Pine Beetle	2	PL/S4	PL5	0.006	
	2	PL/S6		0.006 (total)	
			S/PL6	15%	
			S6	85%	
	3	PL/S4	PL/S6	0.006	
	3	PL/S6	S6	0.006	
	4	S/PL4	S6	0.006	
	5	S/PL4	S6	0.006	
	7M	S/PL4	S6 (row 7)	0.003	
	8M	S/PL4	S-SB6	0.003	
	10M	S-P/ATse	S6 (row 4)	0.003	
	10M	S/PL4	S6 (row 4)	0.003	
	11	AT/PL/SX4	AT/SX4	0.006	
	11	PL-SX/AT6	SX6	0.006	
	11M	S/PL4	S6 (row 4)	0.003	
	15	Fd/S/PL6	Fd/S6	0.006	
Spruce Bark Beetle	5	S/PL4	S6	0.005	
	5	S6	S6	0.005	-50
	6	S6	S5	0.005	
	6M	S4	S6 (row 6)	0.005	
	7	S4		0.005 (total)	
			S6 (row 5)	70%	
			S6 (row 7)	30%	-50
	7	S6	S6	0.005	-50
	7M	S/PL4	S6 (row 7)	0.005	
	8M	S/PL4	S-SB6	0.005	
	8M	S-SB6	S-SB6	0.005	-50
	10	AT/SX4	AT/SX4	0.005	-50
	10	SX/AT6	AT/SX6	0.005	
	10	SX6	SX6	0.005	-50
	10	AT/SX6	AT6	0.005	
	10M	S/PL4	S6 (row 4)	0.005	
	11	PL-SX/AT6	AT/PL/SX4	0.005	
	11	SX6	SX4	0.005	
	11	SX4	SX4	0.005	-50
	11M	S/PL4	S6 (row 4)	0.005	
	12	AC/SX4		0.005 (total)	
			AC/SX4	40%	-50
			Brush	60%	
	12	SX/AC6		0.005 (total)	
			SX/AC6	40%	-50
			Brush	60%	
	12	SX6		0.005 (total)	
			SX6	80%	-50
			Brush	20%	
	14	S6		0.005 (total)	

Insect	Row	From	To	Probability	Age Change
			EpAt/S	80%	
			S/EpAt	20%	
	15	Fd/S/PL6	Fd6	0.005	
	15	S6	Fd/S6	0.005	
	15	Fd/S6	Fd6	0.005	
Budworm	6	S6	S6	0.005	-50
	7	S6	S4	0.005	
	10	SX6	SX4	0.005	
	11	SX6	SX6	0.005	-50
Douglas Fir Beetle	15	Fd/S/PL6	Fd/S/PL6	0.005	-50
	15	Fd/S6		0.005 (total)	
			Fd/S6	80%	-50
			S_76	20%	
	15	Fd6	Fd6	0.005	-50

Flooding

Flooding occurs in the two rows that represent flood plains: row 7 (S/B), and row 14 (AC). In both cases, we assumed that the floods occurred with a 300-year return interval, and that all floods were stand initiating and did not cause a change in row. When class BP, the brushfield floods, the stands will regenerate as AC stands.

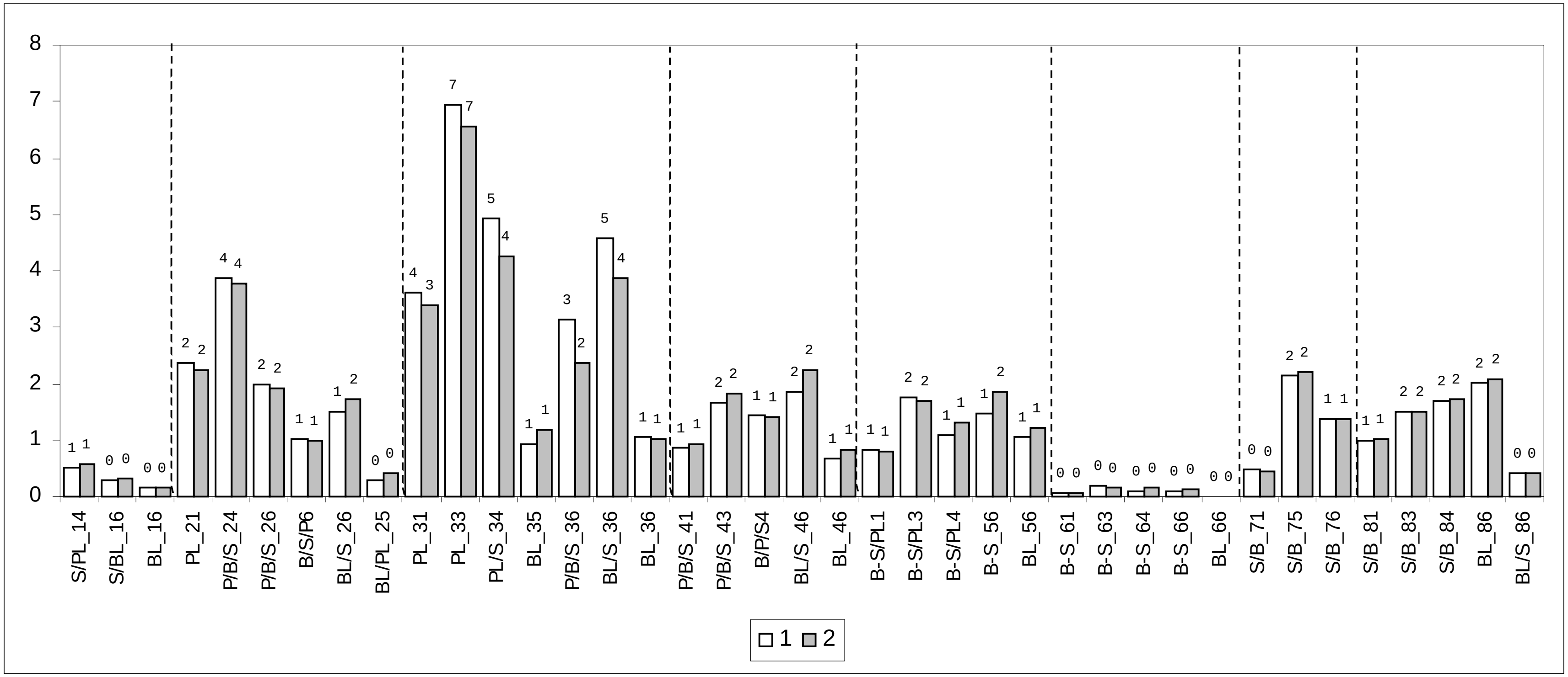
3.1.3 Sample Results

All the natural disturbance pathway and probability information thus far described for the SBSmc was used to simulate a sample landscape for 1000 years. Management pathways were not used. In the run, each of the 74 natural classes was started with about 1.3% of the area. Classes arising from management (all those with a letter greater than “BT”) were not included in this run. In the results, classes with less than 1% on the graph have more pathways that cause areas to leave the class than enter the class, and classes with more than 1% have more area entering the class than leaving the class.

Two runs were done. In one run, just the basic pathways and constant disturbance probabilities were used. This run is similar to those used in all the other regions. In the other run, additional MPB pathways were added (those pathways listed as “MPB Outbreak”) and these were turned on for about 10 years approximately every 260 years apart. These pathways have much higher probabilities, and affect a wider range of ages of pine. Figure 3.5 shows the results of both runs.

The run shows that in both cases the defined pathways and probabilities keep a mixture of all stages in the landscape, especially the middle age stem-exclusion or understorey-reinitiation stands (Structural stages se and 4). Few older stands exist.

Area is retained in most rows and classes in the landscape, even if at extremely low levels for some rows. For example, row 6 (B-S) continues to exist but at a very low level because there is very little area that enters this row. The oldest class in this row will be eliminated because the fire pathways and probabilities ensure that no area will make it that far.


8
7
6
5
4
3
2
1
0
S/PL_14
S/BL_16
BL_16
PL_21
P/B/S_24
P/B/S_26
B/S/P6
BL/S_26
BL/PL_25
PL_31
PL_33
PL/S_34
BL_35
P/B/S_36
BL/S_36
BL_36
P/B/S_41
P/B/S_43
B/P/S4
BL/S_46
BL_46
B-S/PL1
B-S/PL3
B-S/PL4
B-S_56
BL_56
B-S_61
B-S_63
B-S_64
B-S_66
BL_66
S/B_71
S/B_75
S/B_76
S/B_81
S/B_83
S/B_84
BL_86
BL/S_86
1
2

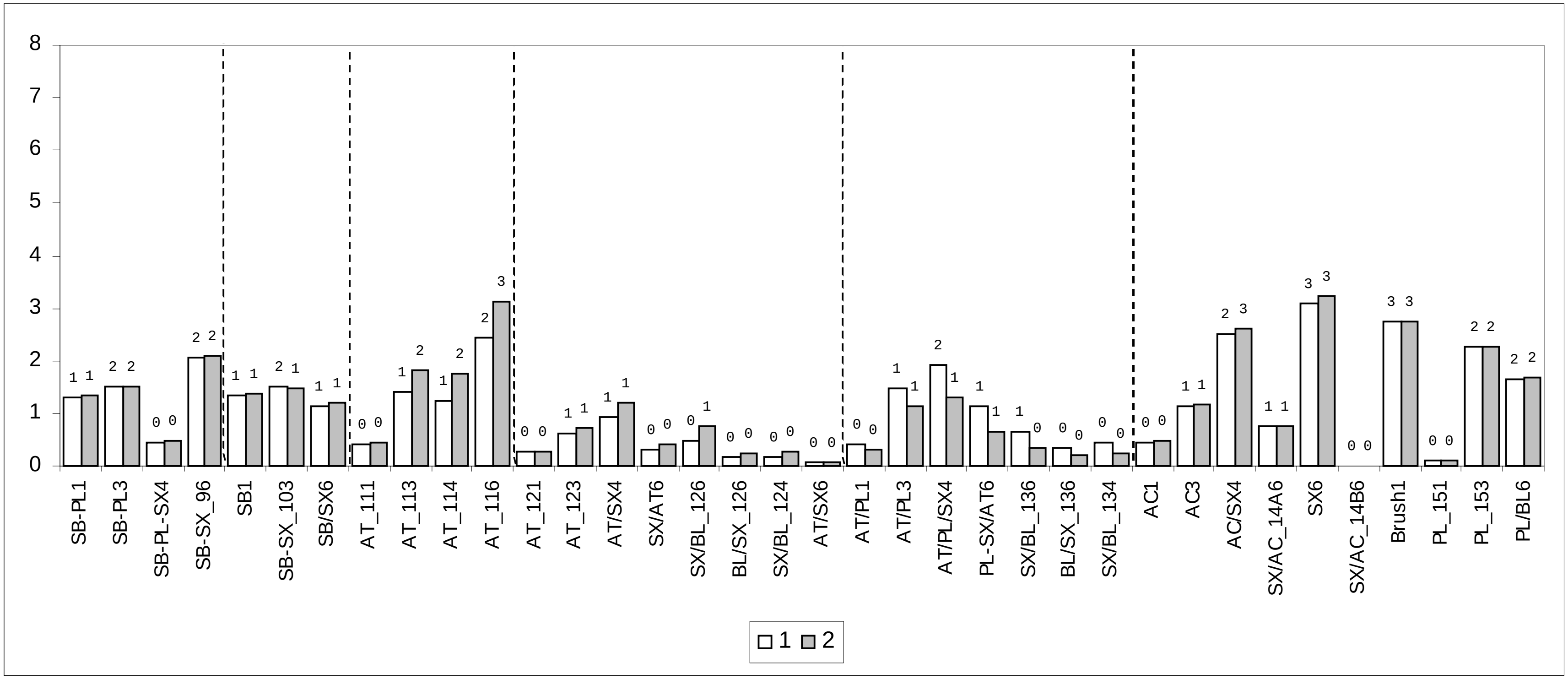


Figure 3.5: Distribution of area (percent) in the SBSmc when VDDT is run for 1000 years under two different scenarios. The left bar (scenario 1) in each pair represents the basic case, while the right bar (scenario 2) represents the case with periodicity. The dotted lines delineate each row in Figure 3.1. Note that none of the management pathways are included in this graph or in these calculations. The first graph shows rows 1-8, while the second graph shows rows 9-15.

Area slowly builds up in the Pl-dominated row 3, drawing mostly from rows 4 and 5, and indirectly from row 6. In the run with periodicity, less area is in row 3 and more in row 4. More structural stage 5 stands exist, in these rows (2-5) because of the beetle activity. The beetle plays a role in the aspen stands. Area is moved from the At/Pl stands into At/Sx or At stands. Any differences between the results in rows 7 to 10 and rows 114 and 15 are purely random.

Note that if the outbreaks had occurred in a different time period relative to when the graph was prepared, the allocation into different classes may be somewhat different than shown here. There is relatively little pine on the overall diagram, and that may explain why differences between runs are smaller than may be expected based on experience with pine-dominated areas of the landscape.

3.1.4 Management

In all cases, the stand-initiation stage is shorter than the unmanaged rows because the trees are planted. When planted, the trees are older than those growing from seed, and the planters try to maximize the potential of the site by not leaving big gaps in the stand. The stem-exclusion phase is generally longer than in the unmanaged rows because operators are generally doing management that maintains the stand so that it doesn't break up. Most stands will be harvested when they are in this stage. Older classes, such as those in the reinitiation stages, are added to account for stands that were not optimally harvested for whatever reason.

When management occurs, any stand in the stem exclusion phase and older can be managed. The result of the management depends on the site series of the stand.

Row 2M - Site series 02	
	No harvest normally, but if it occurs, then plant 100% Pl.
Row 3M - Site series 01	
	Planted 70/30 Pl/Sx.
Row 4/5 M - Site series: 05/06	
Morice	(classes CB, CC) Plant 50% Pl and 50% S
Lakes	(classes CE, CF) Plant 70% S and 30% Pl
CB/CE	Stand initiation phase longer than in row 3M because of the slower growing Spruce
CC/CF	Stem exclusion phase is faster because the sites are richer
Row 6/8M - Site series 09.	
	Good Sx growing sites. Lower density planting to capture advanced regeneration Bl.
Morice	(CG, CH) Plant 60% Sx 20% Bl 20%Pl
Lakes	(CJ, CK) Plant 70% Sx 30% Pl. to get S/B-P from Bl regeneration.

Row 7– Site series 10	
	Same as site series 09 above, but stand initiation is only five years instead of fifteen.
Row 9 – site series 07	
Morice	(CL, CM) Plant 50% Pl, 50% S
Lakes	(CP, CQ) Plant 70% Pl, 30% S
	Initially there is little Sb because there are few site available (given that most sites were planted). If the stand remains unharvested for long enough, the Sb can come in as the Pl falls out.
Row 10– site series 12	
	No management
Row 12 M - site series 05	
	Plant 70% Sx, 30% Pl
	Aspen in stand but will drop out faster than in the 01 site (row 13M) because this is a richer site and it is out-competed sooner by the Sx.
Row 13 M - site series 01	
	Plant 50% Sx, 50% Pl
	Some At will be in stand but in two cohorts. The older cohort (that was left after stand management) starts dropping out at 50+, but the new aspen lasts until 120 years.
Row 14 – site series 08	
	Management is possible but will be ignored because of low value of these stands.
Row 15 M - site series 03	
	If managing an 01 stand of this type, it will be managed as in row 3 M.
	Plant 100% Pl and rehabilitate the site.
CZ	The site is nutrient poor, so a longer time is spent in initiation phase than in other managed rows.

3.2 SBSdk Subzone

3.2.1 Succession Pathways

Notes on the Diagram

The SBSdk was based upon SBSmc2 pathways. The main difference is that there is no Bl in any of the classes. Other notes and differences are described in Table 3.4.

Table 3.4: Notes for the SBSdk where the diagram or classes differ from the SBSmc (Table 3.1). These notes are only for the natural classes. Notes about the managed classes (those on rows numbered with an M) are given in the management section.

Row 2 – Pl Rocky	
	Site series 02/03. Rocky/poor site, xeric/sub-xeric, outwash terraces.
Row 3 – Pl Open	
	Site series 03/01. Sub-xeric/mesic, open canopy
Row 4 – Pl/Sxw	
	Site series 01/05. Mesic
Row 5 – Sxw/Pl	
	Site series 06/01. Mesic/sub-hygric.
P	Stand suppressed for long period, rusts key in opening gaps
Row 6 –Sxw	
	Site series 07b. Non-floodplain, swamp edges. Fine textured soils.
Row7 – Sxw	
	Site series 06 or 07a. Upland type, moist/rich, big trees.
Row8 – Sb	
	Site series 10/09.
Row9 – At	
	Site series 01 seral.
Row10 – At	
	Site series 01/06 seral.
Row11 – At/Pl	
	Site series 01/05 seral.
Row 12 – Ac	
	Site series 08. Floodplains/low bench riparian.
AC	Sxw in understorey
AW	Sxw in sub-canopy
AZ	Ac in canopy but <20%

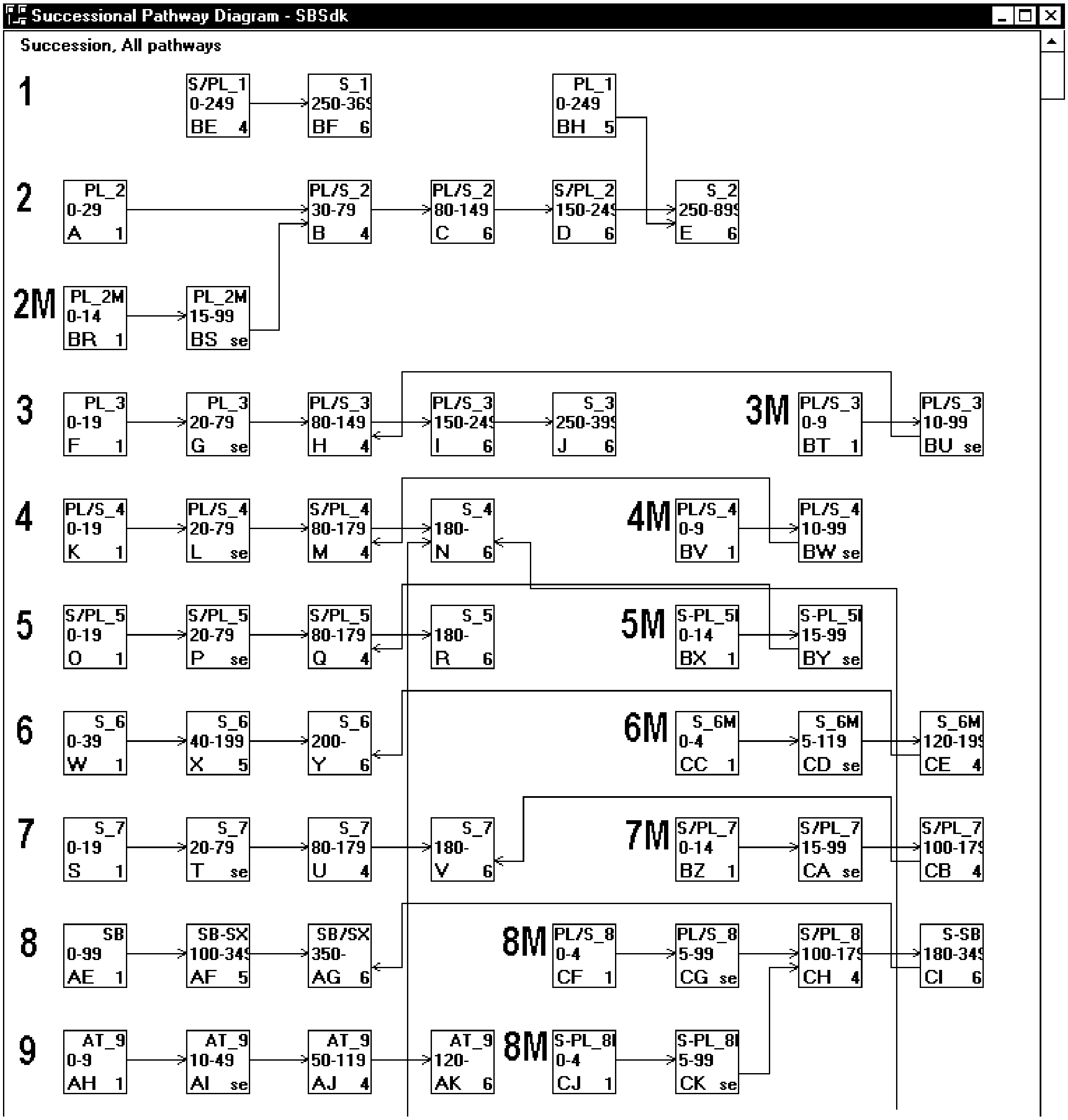


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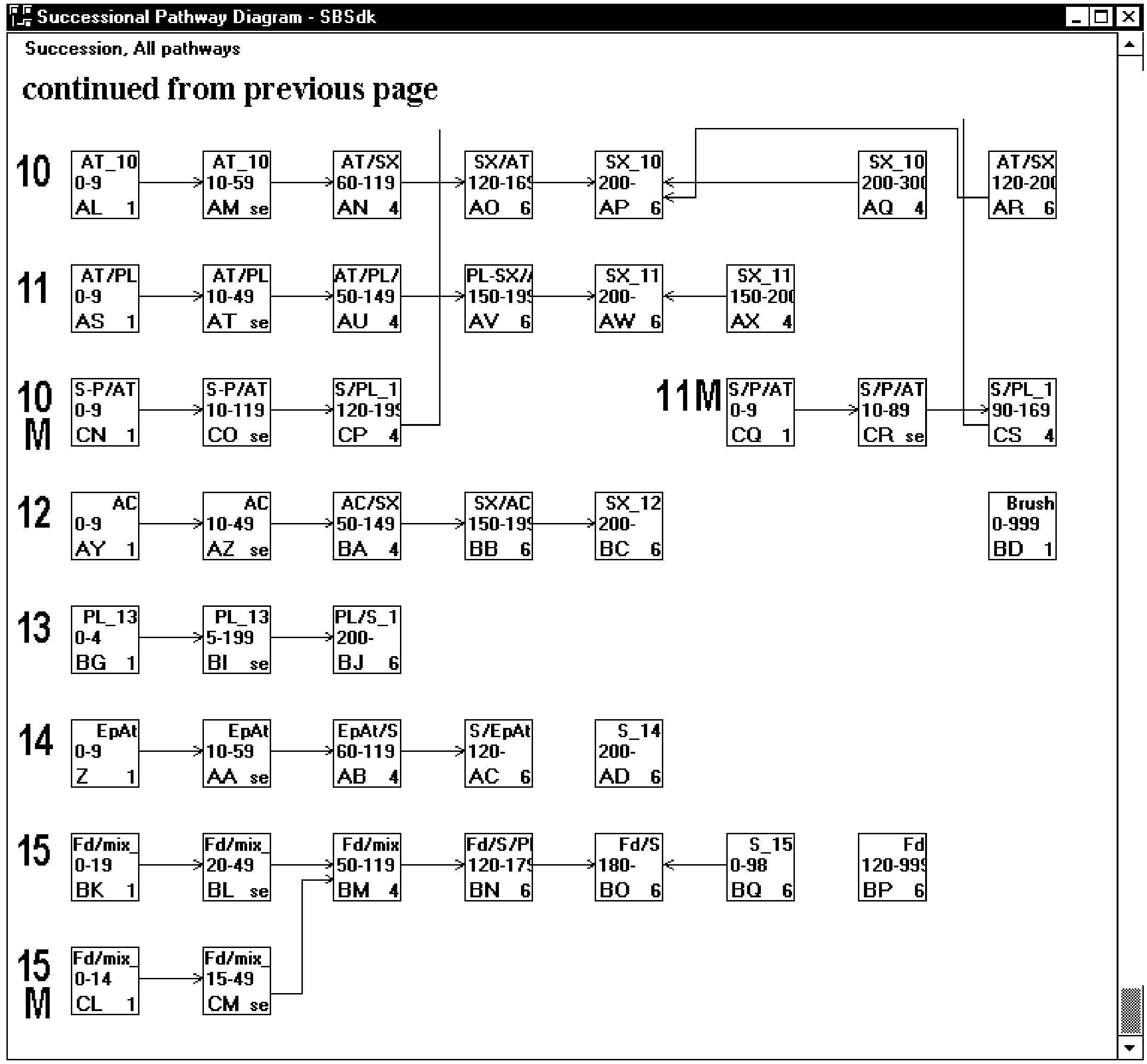
Figure 3.6: Successional pathway diagram for the SBSdk showing the major classes and their succession pathways.



Row 13 – Pl Dogs-hair	
	Site series 10/05/03. Mesic/sub-mesic stands.
BC	Fast initiation, very dense
BD	Stand suppressed for long period, rusts key in opening gaps
Row14 - At-Ep – Not in the SBSmc	
	New book site series, probably 06/01 seral. Mixed, Sxw in understorey, circum-mesic, Ac possible (up to 20%) on sub-hygric
Row 15 - Fd/Mixed - Not in the SBSmc	
	Site series 04. Mixed Fd conifer/deciduous (At, Pl, Fd possible)
BN	Deciduous gone

3.2.2 Disturbances

The natural disturbances considered for the SBSdk are similar to the SBSmc (see Section 3.1.2 - Disturbances). This section simply discusses the differences between the two subzones.

Fire

Stand replacing fires occur more frequently than in the SBSmc. The model assumes a 93-year return interval with the exception of row 8 (starting with cover type SB, class AD) with a 250-year return interval. The pathways for the fires are essentially the same as in the SBSmc (Table 3.5). Fires in the new rows containing Ep and Fd, simply return to the beginning of the row.

Table 3.5: Fire pathway definitions for the SBSdk. The overall fire return interval is 93 years, which gives a probability of 0.0108.The only exception, is row 8, which has a 250 year return interval (probability of 0.004).

Row:	Row: To: From:	2 PL1	3 PL1	4 PL/S1	5 S/PL1	6 S1	7 S1	8 SB1	9 AT1	10 AT1	11 AT/PL1	13 PL1	14 EpAt1	15 Fd/mix1
1	**S/PL4**	100												
1	**S6**	100												
2	**PL1**	100												
2	**PL/S4&6**	100												
2	**S/PL6**	100												
2	**S6**	100												
3	**PL1&se**		100											
3	**PL/S4**		80	10	10									
3	**PL/S6**		60	20	20									
3	**S6**		20	40	40									
4	**PL/S1&se**		80	20										
4	**S/PL4**		60	30	10									
4	**S6**		10	45	45									
5	**S/PL1,se&4**		60	20	20									
5	**S6**		10	40	40	10								
6	**S1,5&6**				80	20								
7	**S1,se,4&6**				80		20							
8	**SB1**							100						
8	**SB-SX5&6**							100						
9	**AT1,se&4**								100					
9	**AT6**								60	20	20			
10	**AT1&se**									100				
10	**AT/SX4&6**								60	30	10			
10	**SX4**			10	10					70	10			
10	**SX/AT6**								40	50	10			
10	**SX6**			10	10					70	10			
11	**AT/PL1&se**										100			
11	**AT/PL/SX4**										100			
11	**SX4**										100			
11	**PL-SX/AT6**										100			

	Row:	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**14**	**15**
Row:	**To:**	**PL1**	**PL1**	**PL/S1**	**S/PL1**	**S1**	**S1**	**SB1**	**AT1**	**AT1**	**AT/PL1**	**PL1**	**EpAt1**	**Fd/mix1**
	From:													
11	**SX6**			10	10					20	60			
13	**PL1&se**											100		
13	**PL/S6**											100		
14	**EpAt1&se**												100	
14	**EpAt/S4**												100	
14	**S/EpAt6**												100	
14	**S6**												100	
15	**Fd/mix1,se&4**													100
15	**Fd/S/PL6**													100
15	**Fd/S6**													100
15	**Fd6**													100

Insects

Since there is no balsam in the SBSdk, balsam bark beetle will not occur. Budworm pathways (Figure 3.8) are the same as in the SBSmc. Spruce beetle and mountain pine beetle pathways are also the same, but the two new rows are also affected because they contain some spruce and pine.

The presence of Douglas-fir in the SBSdk leads to the addition of Douglas-fir beetle as a player in the landscape. The beetle is very similar to spruce beetle with but targets mature Fd over 100 years old rather than spruce. It can cause cycling in structural stage 6 stands because the Fd in the understorey comes up to replace the mature Fd that was killed by the beetle (Figure 3.7). In some cases, its effect is severe enough that the Fd is removed and stands become spruce dominant.

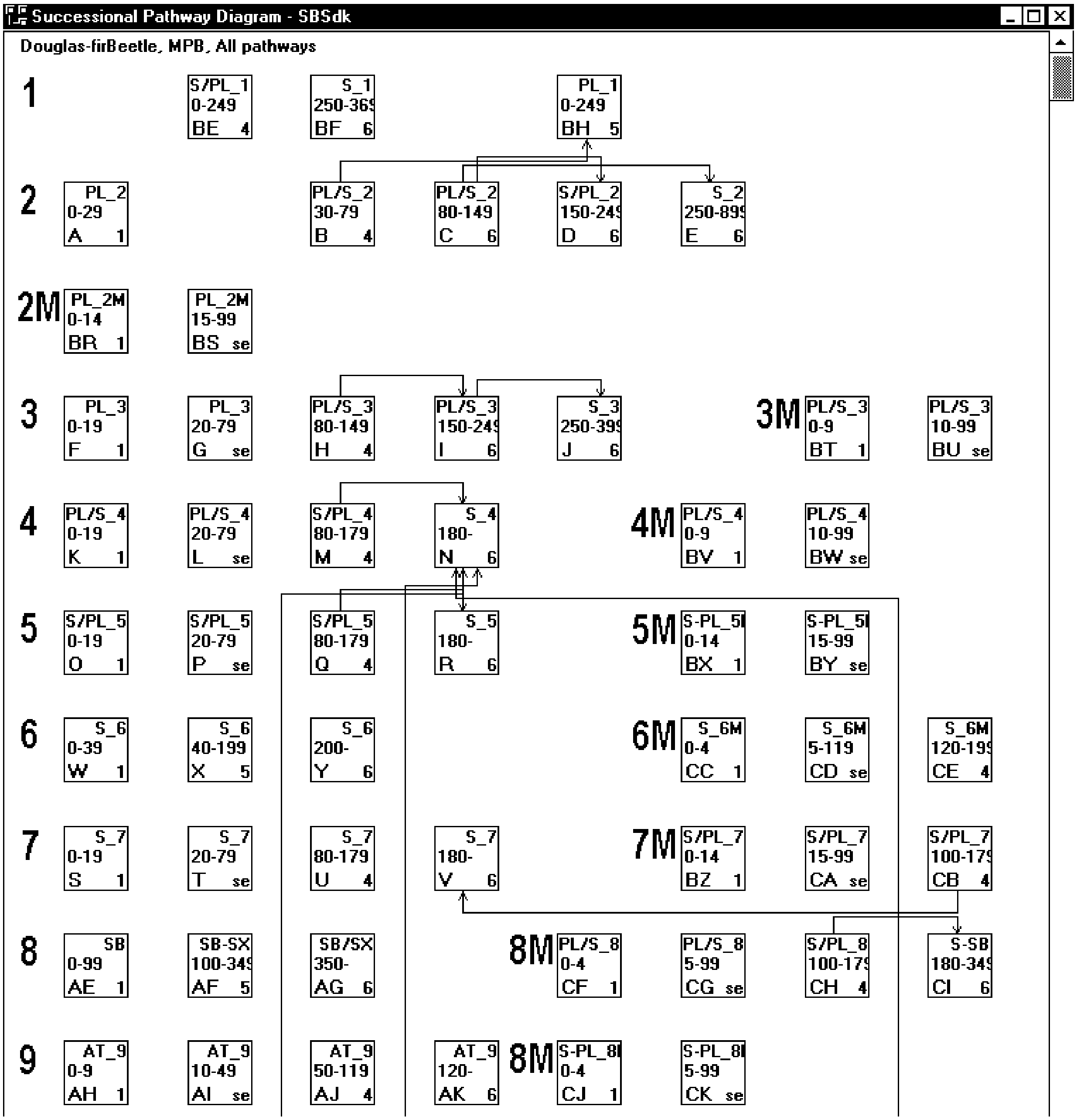


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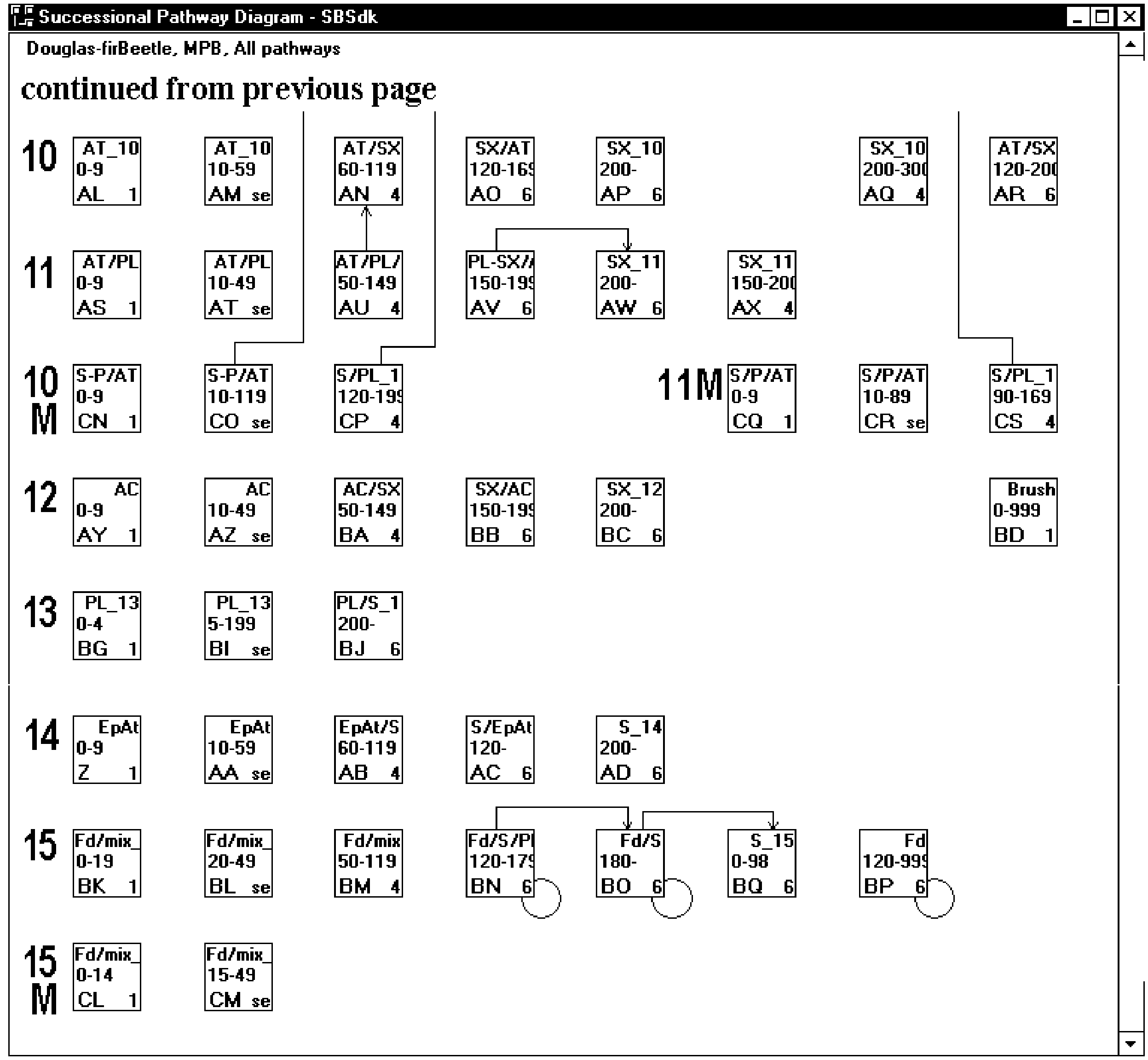
Figure 3.7: Mountain pine beetle and Douglas-fir beetle pathways in the SBSdk. Douglas-fir beetle pathways are those in the last two rows of classes that contain Fd.


Successional Pathway Diagram - SBSdk
Douglas-firBeetle, MPB, All pathways
continued from previous page
10
AT_10 0-9 AL 1
AT_10 10-59 AM se
AT/SX 60-119 AN 4
SX/AT 120-169 AO 6
SX_10 200- AP 6
SX_10 200-300 AQ 4
AT/SX 120-200 AR 6
11
AT/PL 0-9 AS 1
AT/PL 10-49 AT se
AT/PL/ 50-149 AU 4
PL-SX/ 150-199 AV 6
SX_11 200- AW 6
SX_11 150-200 AX 4
10 M
S-P/AT 0-9 CN 1
S-P/AT 10-119 CO se
S/PL_1 120-199 CP 4
11M
S/P/AT 0-9 CQ 1
S/P/AT 10-89 CR se
S/PL_1 90-169 CS 4
12
AC 0-9 AY 1
AC 10-49 AZ se
AC/SX 50-149 BA 4
SX/AC 150-199 BB 6
SX_12 200- BC 6
Brush 0-999 BD 1
13
PL_13 0-4 BG 1
PL_13 5-199 BI se
PL/S_1 200- BJ 6
14
EpAt 0-9 Z 1
EpAt 10-59 AA se
EpAt/S 60-119 AB 4
S/EpAt 120- AC 6
S_14 200- AD 6
15
Fd/mix_ 0-19 BK 1
Fd/mix_ 20-49 BL se
Fd/mix 50-119 BM 4
Fd/S/Pl 120-179 BN 6
Fd/S 180- BO 6
S_15 0-98 BQ 6
Fd 120-999 BP 6
15 M
Fd/mix_ 0-14 CL 1
Fd/mix_ 15-49 CM se

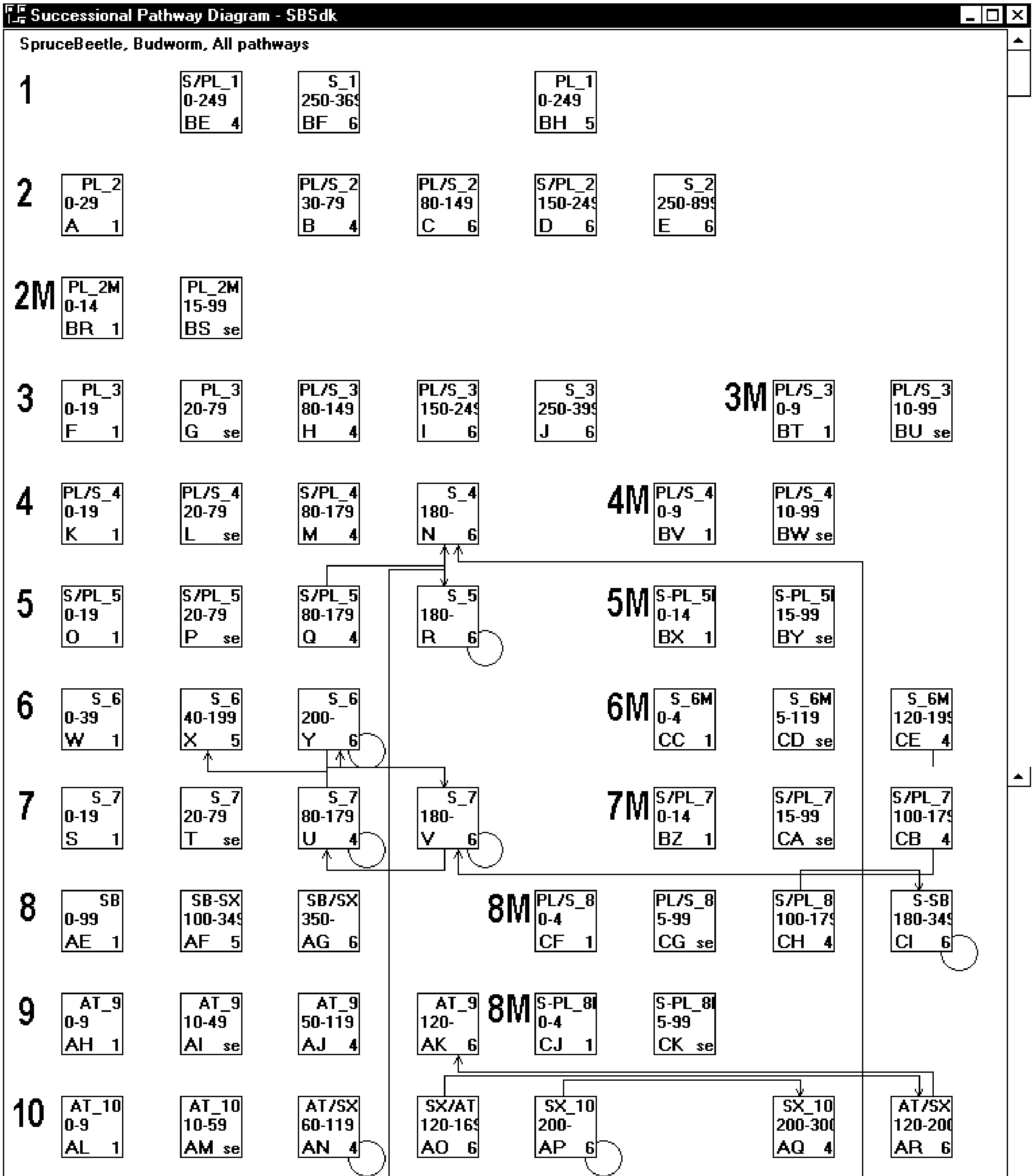


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Figure 3.8: Spruce beetle and budworm pathways in the SBSdk.

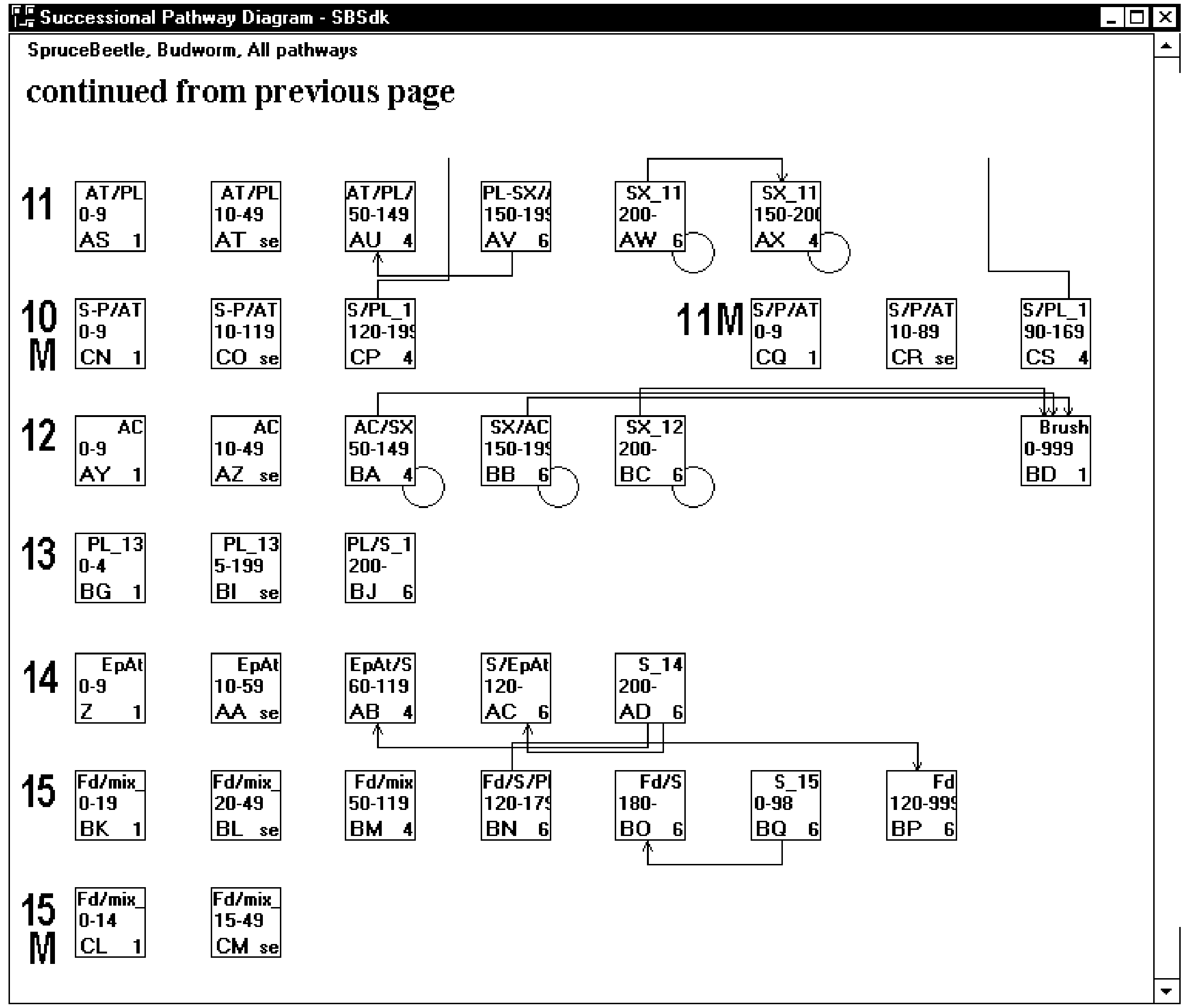
Successional Pathway Diagram - SBSdk
SpruceBeetle, Budworm, All pathways
continued from previous page
11
AT/PL 0-9 AS 1
AT/PL 10-49 AT se
AT/PL/ 50-149 AU 4
PL-SX/ 150-19 AV 6
SX_11 200- AW 6
SX_11 150-20 AX 4
10 M
S-P/AT 0-9 CN 1
S-P/AT 10-119 CO se
S/PL_1 120-19 CP 4
11M
S/P/AT 0-9 CQ 1
S/P/AT 10-89 CR se
S/PL_1 90-169 CS 4
12
AC 0-9 AY 1
AC 10-49 AZ se
AC/SX 50-149 BA 4
SX/AC 150-19 BB 6
SX_12 200- BC 6
Brush 0-999 BD 1
13
PL_13 0-4 BG 1
PL_13 5-199 BI se
PL/S_1 200- BJ 6
14
EpAt 0-9 Z 1
EpAt 10-59 AA se
EpAt/S 60-119 AB 4
S/EpAt 120- AC 6
S_14 200- AD 6
15
Fd/mix_ 0-19 BK 1
Fd/mix_ 20-49 BL se
Fd/mix 50-119 BM 4
Fd/S/P 120-17 BN 6
Fd/S 180- BO 6
S_15 0-98 BQ 6
Fd 120-99 BP 6
15 M
Fd/mix_ 0-14 CL 1
Fd/mix_ 15-49 CM se

Table 3.6: Douglas-fir beetle, rust, and the new mountain pine beetle and spruce beetle pathway definitions (classes, probabilities and age change) for the SBSdk. See Table 3.1 for all other pathways.

Insect	Row	From	To	Probability	Age Change
Mountain Pine Beetle	2	P/B/S4	BL/PL5	0.006	
	2	P/B/S6		0.006 (total)	
			B/S/P6	15%	
			BL/PL5	85%	
	3	PL/S4	BL5	0.006	
	3	P/B/S6	BL/S6	0.006	
	4	B/P/S4	BL/S6	0.006	
	5	B-S/PL4	B-S6	0.006	
	7M	S/PLse	S/B4	0.003	
	8M	S/PLse	S/B4	0.003	
	9	SB-PL-SX4	SB-SX6	0.006	
	9M	PL-Sse	SX/SB6	0.003	
	9M	S/PL4	SX/SB6	0.003	
	9M	PL/Sse	SX/SB6	0.003	
	12M	S/PL4	S/B6	0.003	
	13	AT/PL/SX4	AT/SX4	0.006	
	13	PL-SX/AT6	SX/BL6	0.006	
	13M	S/PL4	S/B6	0.003	
	15M	PLse	SB-SX6 (row 9)	0.004	
	15M	P/S/SB4	SB-SX6 (row 9)	0.004	
Mountain Pine Beetle Outbreak	2	P/B/S4	BL/PL5	0.03 (60-100 years) 0.07 (>100 years)	
	2	P/B/S6		0.07 (total)	
			B/S/P6	15%	
			BL/PL5	85%	
	3	PL/S4	BL5	0.03 (60-100 years) 0.07 (>100 years)	
	3	P/B/S6	BL/S6	0.07	
	4	B/P/S4	BL/S6	0.03 (60-100 years) 0.07 (>100 years)	
	5	B-S/PL4	B-S6	0.03 (60-100 years) 0.07 (>100 years)	
	7M	S/PLse	S/B4	0.03 (60-100 years) 0.07 (>100 years)	
	8M	S/PLse	S/B4	0.03 (60-100 years) 0.07 (>100 years)	
	9	SB-PL-SX4	SB-SX6	0.07	
	9M	PL-Sse	PL-S1	0.03 (60-100 years) 0.07 (>100 years)	
	9M	S/PL4	SX/SB6	0.07	
	9M	PL/Sse	PL/S1	0.03 (60-100 years) 0.07 (>100 years)	
	12M	S/PL4	S/B6	0.03 (60-100 years) 0.07 (>100 years)	
	13	AT/PL/SX4	AT/SX4	0.03 (60-100 years) 0.07 (>100 years)	

Insect	Row	From	To	Probability	Age Change
	13	PL-SX/AT6	SX/BL6	0.07	
	13M	S/PL4	S/B6	0.07	
	15M	PLse	SB-SX6 (row 9)	0.03 (60-100 years) 0.07 (>100 years)	
	15M	P/S/SB4	SB-SX6 (row 9)	0.07	
Balsam Bark Beetle	2	B/S/P6	B/S/P6	0.004	-50
	3	BL/S6	BL/S6	0.004	-50
	3, 4, 5, 6, 8	BL6 (all)	BL6 (to self)	0.004	-50
	4, 8	BL/S6 (all)	BL/S6 (to self)	0.004	-50
	5, 6	B-S6 (all)	B-S6 (to self)	0.004	-50
	7, 12M, 13M	S/B6 (all)	S/B6 (to self)	0.004	-50
	7	S/B4	BL/S6	0.004	
	8	S/B4	BL/S6	0.004	
	12, 13	SX/BL (all)	SX/BL6 (to self)	0.004	-50
	12, 13	BL/SX6 (all)	SX/BL6 (to self)	0.004	
Spruce Bark Beetle	5	B-S/PL4		0.005 (total)	
			B-S6	70%	
			BL6	30%	
	5	B-S_46		0.005 (total)	
			B-S6	60%	-50
			BL6	40%	
	6	B-S4		0.005 (total)	
			B-S6	70%	
			BL6 (row 14)	30%	
	6	B-S6		0.005 (total)	
			BL6	40%	
			B-S6	60%	-50
	7	S/B6	S/B5	0.005	
	8	S/B4	BL6	0.005	
	8	BL/S6	BL6	0.005	
	9M	SX/SB6	SX/SB6	0.005	-50
	12	AT/SX4	AT/SX4	0.005	-50
	12	SX/AT6	AT/SX6	0.005	
	12	SX/BL6	BL/SX6	0.005	
	12	BL/SX6	BL/SX6	0.005	-50
	13	PL-SX/AT6	AT/PL/SX4	0.005	
	13	SX/BL6	BL/SX6	0.005	
	13	BL/SX6	BL/SX6	0.005	-50
	14	AC/SX4		0.005 (total)	
			AC/SX4	40%	-50
			Brush	60%	
	14	SX/AC6		0.005 (total)	
			SX/AC6	40%	-50
			Brush	60%	
	14	SX6		0.005 (total)	
			SX6	80%	-50

Insect	Row	From	To	Probability	Age Change
			Brush	20%	
Budworm	6	B-S6	B-S4	0.005	
	6	BL6	B-S4	0.005	
	7	S/B6	S/B6	0.005	-50
	8	BL6	S/B4	0.005	
	8	BL/S6	S/B4	0.005	
	12	SX/BL6	SX/BL4	0.005	
	12	BL/SX6	SX/BL4	0.005	
	13	SX/BL6	SX/BL4	0.005	
	13	BL/SX6	SX/BL4	0.005	

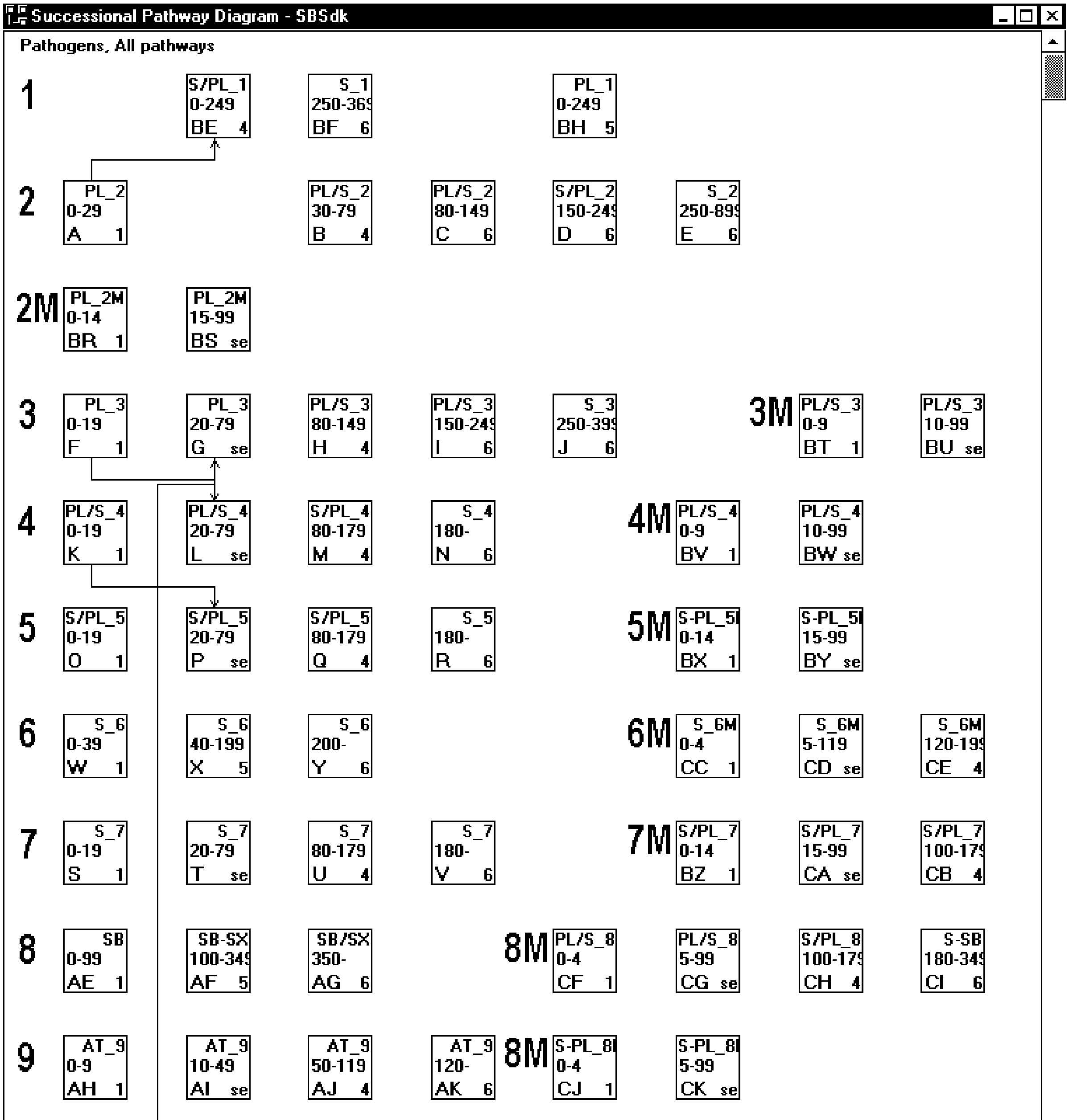

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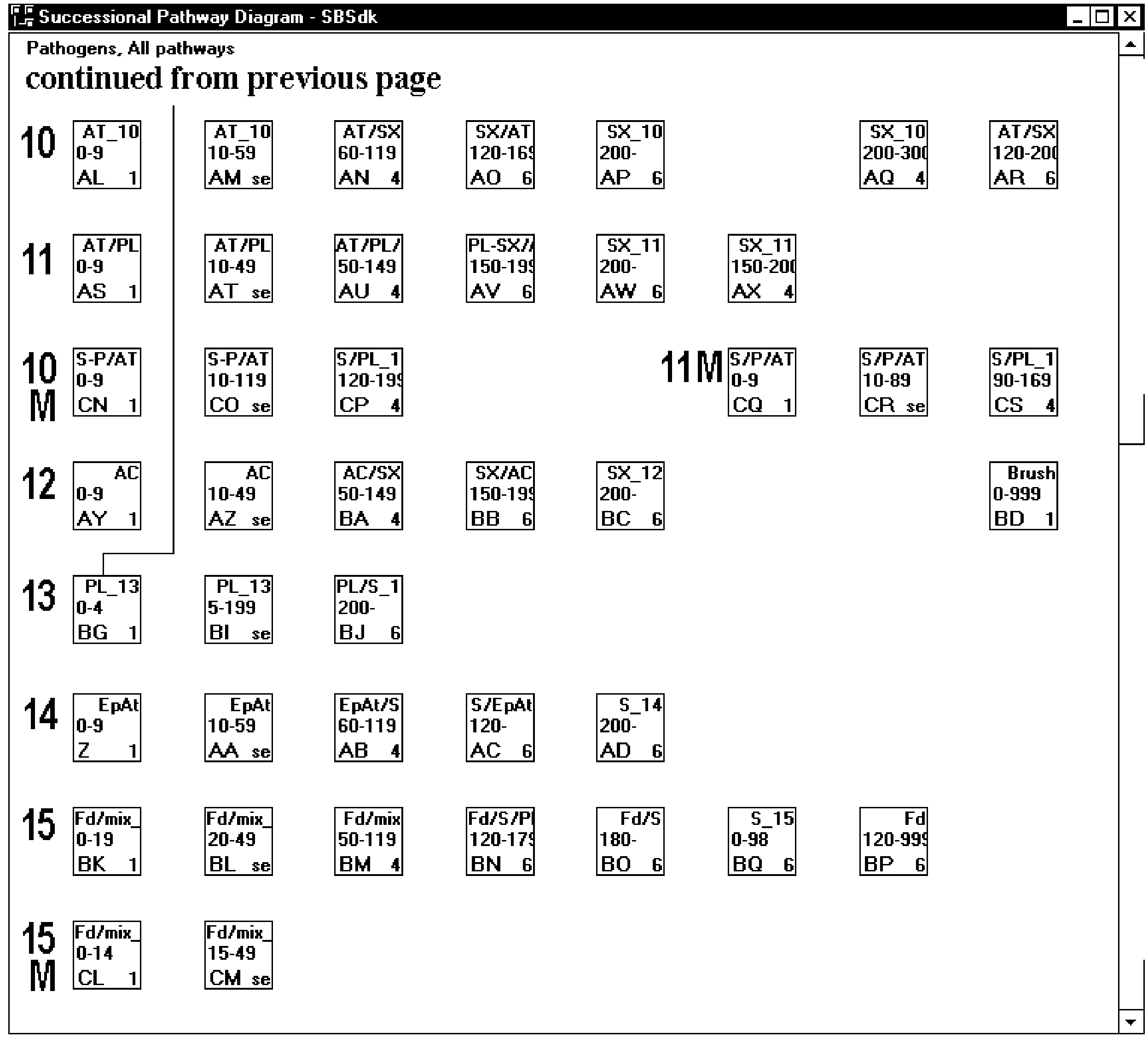
Figure 3.9: Rust pathway diagram. Remember that row 13 is the dense lodgepole pine, and the rusts are thinning the stands.



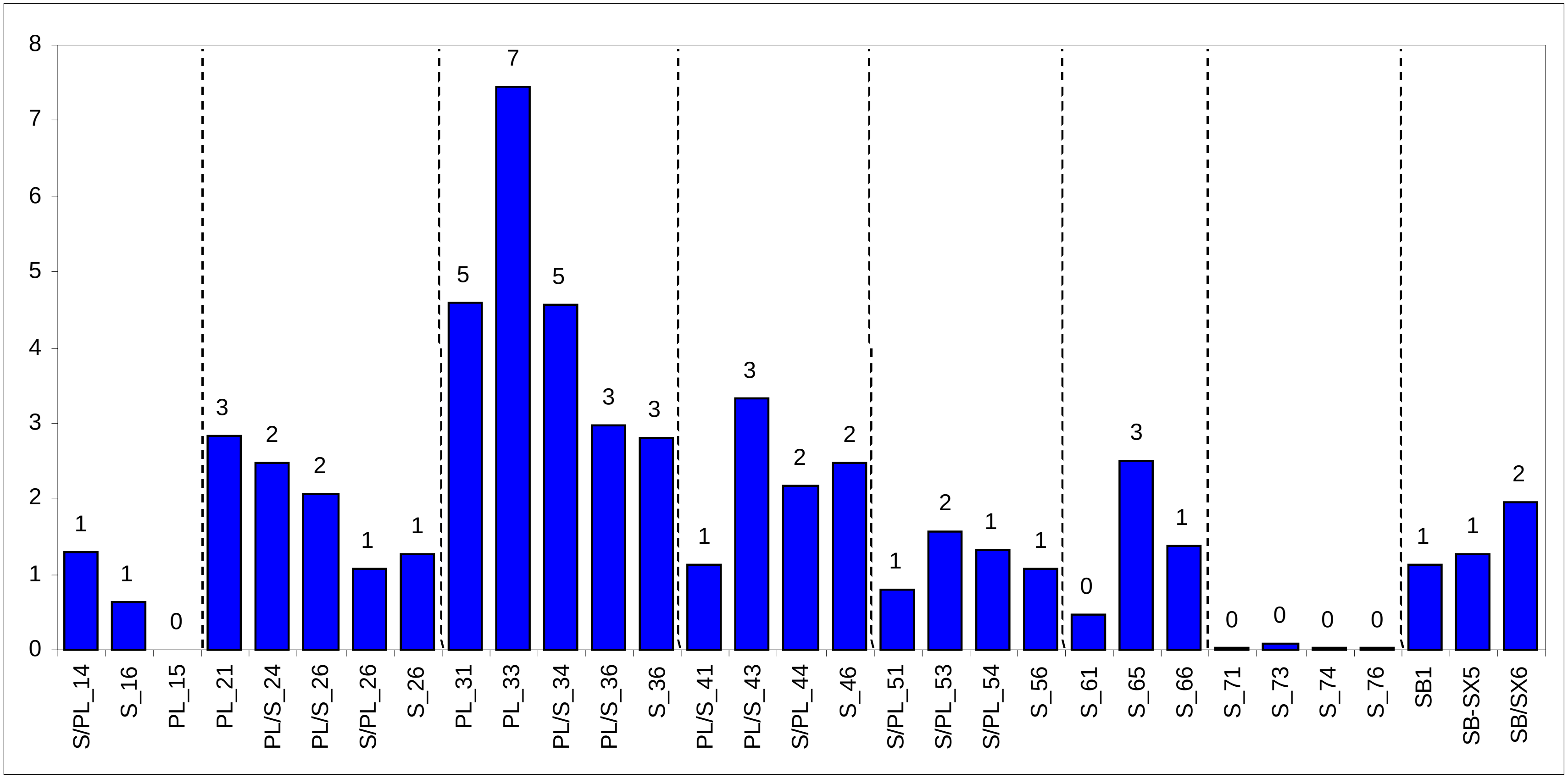
Rust

Rusts have been present in some other diagrams but at low levels, and thus were accounted for in the definitions of the rate of succession. Rusts affect young pine in dry and mesic pine-dominated sites. They reduce the density of pine, and speed up succession to a stem-exclusion phase (Figure 3.9).

3.2.3 Sample Results

All the natural disturbance pathway and probability information thus far described for the SBSdk was used to simulate a sample landscape to near equilibrium. Management pathways were not included in these simulations. The run started with 1.6% of the area in each of the classes except the management-based classes, which were not used. Changes from that value in each class indicate where the flow into a class is greater than the flow out, or vice versa. Classes are not expected to be in equilibrium with their starting condition, but the direction of flow can help interpret results.

The run shows that the defined pathways and probabilities keep a mixture of all stages in the landscape, especially middle-age stands in a structural stage 4 (reinitiation). Rows 1, 2, 6, 8, 13, 14, and 15, are all self-contained.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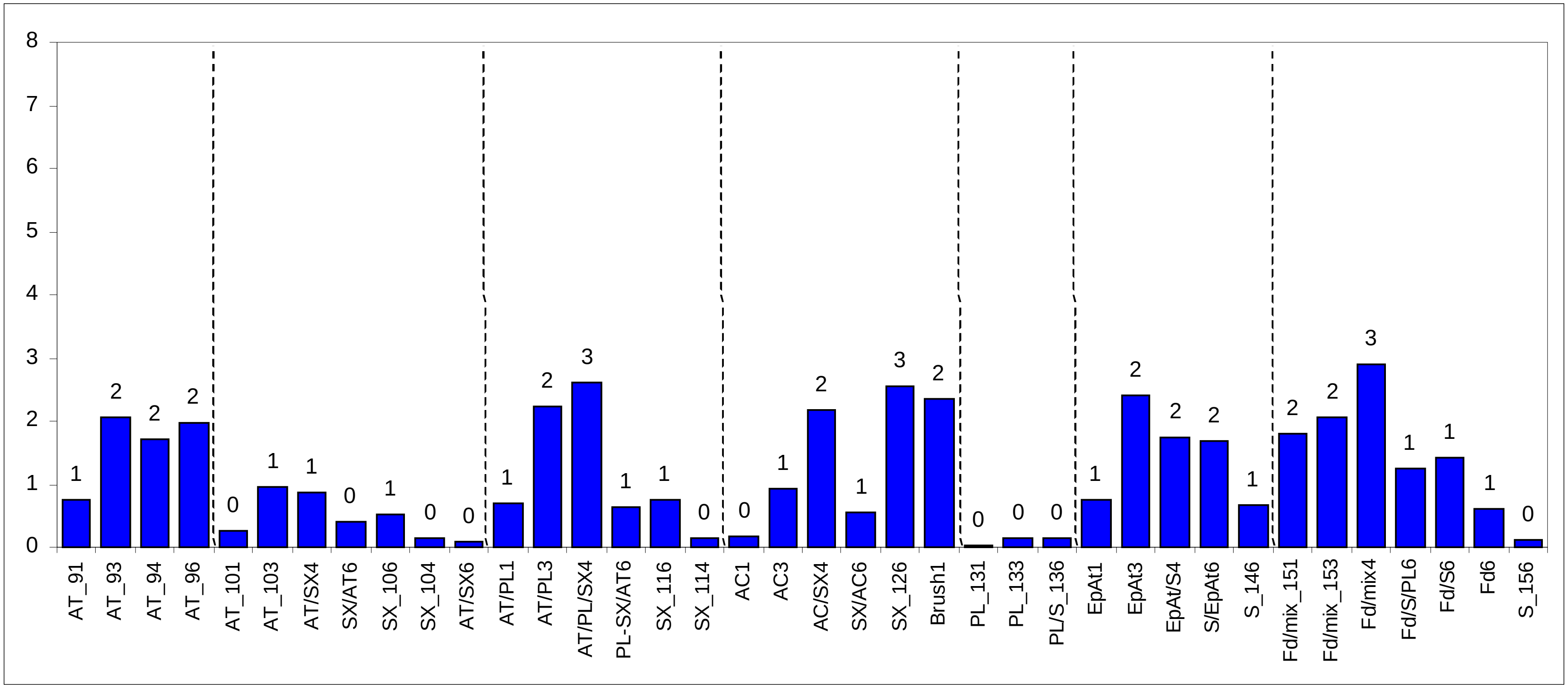


Figure 3.10: Distribution of area (percent) in the SBSdk when VDDT is run to near equilibrium. The lines delineate the rows in Figure 3.6. Note that none of the management pathways are included in this graph or in these calculations. The first graph shows rows 1-8, while the second graph shows rows 9-15.

The amount of At on the landscape very gradually disappears over time. In the At pathways (rows 9, 10, and 11), when the older stands burn, some small proportion of them will regenerate in a pathway without At because the burning stands have lost their At component. None of the stands from the pathways without At will contain At after a burn.

Some classes gradually disappear from the landscape. For example, the dense lodgepole pine stands (row 13, lower graph), will eventually disappear from the landscape. No stands become the dense pine, but rust removes 4% of the young stands. Even if a fire pathway were added to one of the other rows to create the dog-hair pine stands, the area would still decrease because the fire would not be occurring frequently enough to counteract the effect of the rust. The pure spruce row will also disappear, even though there is area both in and out of the row. Area leaves the row from all its classes, simulating the influx of pine from surrounding areas.

3.2.4 Management

The rules and pathways for the SBSdk are very similar to those for the SBSmc.

Row 2M - Site series 02/03	
	No harvest normally on rows 1 and 2, but if it occurs, then plant 100% Pl..
Row 3M - Site series 03/01	
Morice	Plant 20% Sx, 80% Pl
Lakes	Plant 30% Sx, 80% Pl
Row 4 M - Site series: 05	
	Plant 80% Pl, 20% Sx
	Rust is a concern in these sites.
Row 5 M - Site series: 06	
	Plant 50% Sx, 50% Pl.
	Richer sites, so more Sx is planted.
Row 6 M - site series 07b	
	Brushy sites, but rich so fast growing.
	Plant 60% Sx, 40% Pl
Row 7– Site series 07a	
	Same as site series 07a above, but stand initiation is 15 years.
Row 8M – site series 09 (CF-CI)	
	Plant 70% Pl 30% Sx
	Site is occupied due to mounding.
Row 8M – site series 10 (CJ-CK)	
	Plant 50% Sx 50% Pl
	Wet sites limit growing sties.

Row 10 M & row 11M - site series 01/05	
	Same as rows 12M and 13M in the SBSmc with the exception that Bl does not move in. Management plants combinations of spruce and pine, but the aspen still remains until the older ages.
Row 12 - site series 08	
	No harvesting or management because it is the Ac floodplain
Row 15 M - site series 04	
	The harvest is through partial cutting with the Fd left.. After the cut, the stand initiation phase will be faster.

4.0 Sub-boreal Pine Spruce Zone

The SBPS zone comprises only 2% of the Morice and Lakes IFPA area but diagrams were created for it because of the important role of mountain pine beetle.

4.1 Succession Pathways

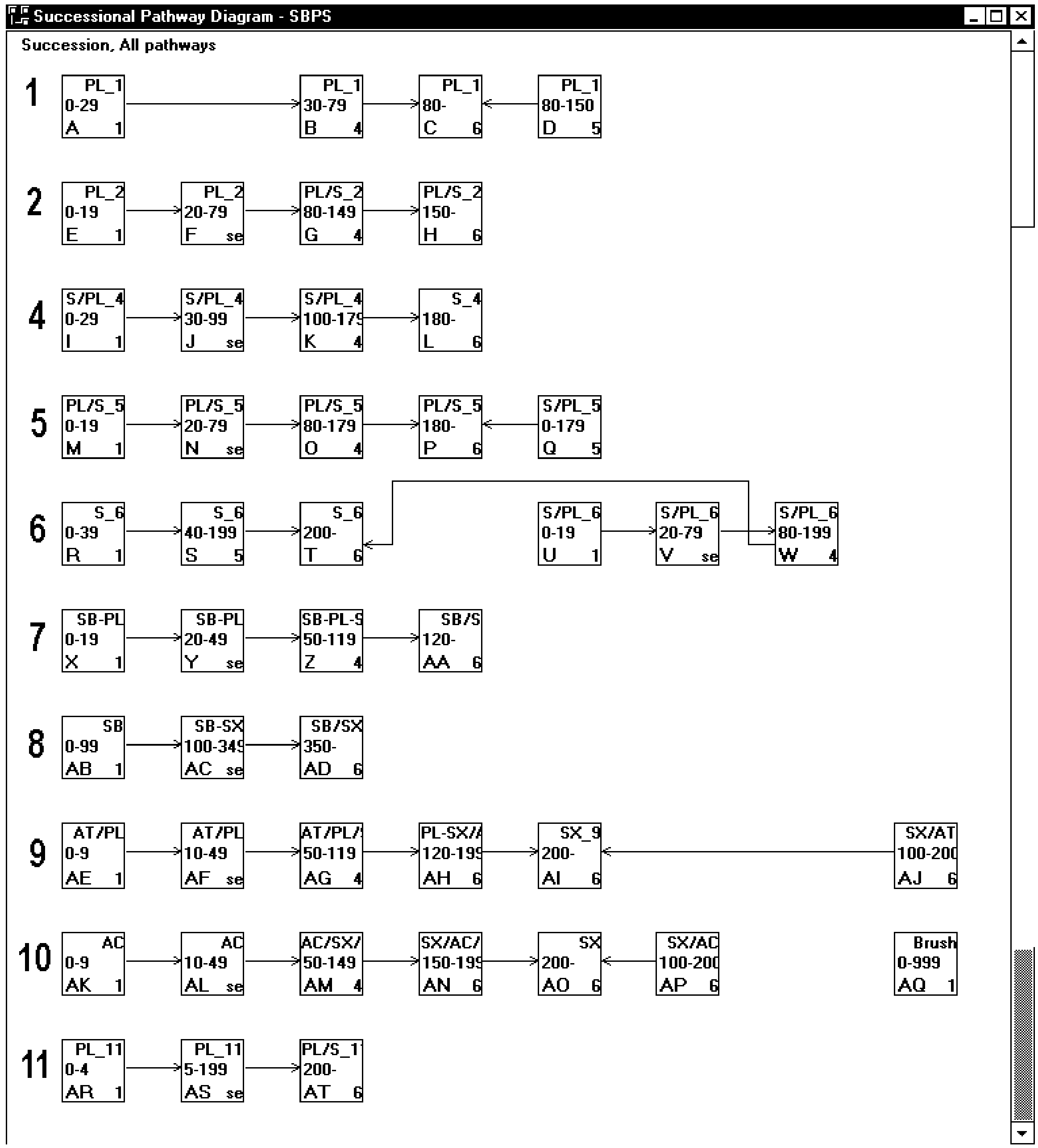


Figure 4.1: Successional pathway diagram for the SBPS showing the major classes and their succession pathways.

Notes on the diagram

The pathways are very similar to the SBSdk. As in the SBSdk, there is no balsam. The pathways with birch or Douglas-fir are not present.

Table 4.1: SBPS subzone pathways built upon SBSdk pathways (Table 3.4).

Row 1 – Pl Open	
A	Site series 02. Dry/poor site, xeric/sub-xeric, lichen site.
Row 2 - Pl Closed	
	Site series 01.
Row 4 – Sxw/Pl	
	Site series 06, glow moss. Wetland spruces, widely spaced, hygric/sub-hygric.
J	Stand suppressed for long period, rusts key in opening gaps
Row 5 – Pl	
	Site series 01. Mesic
AV	Created from MPB
Row 6 – Sxw	
	Site series 05. Riparian/floodplain sites, fluvial.
Row 7 – Sb/Pl	
	Site series 03/07/04. Submesic or subhygic, cold sites, outwash terraces, near wetlands
Row 8 – Sb	
	Site series 07. Bi-modal - either the poor dry sites or the very wet sites.
Row 9 - At/Pl	
	New book seral site series, probably like 01 or 05. Sub-mesic
Row 10 – Ac	
	Site series 05. Floodplains/low bench riparian.
AK	Sxw in understorey.
AL	Sxw in sub-canopy
AO	Ac in canopy but <20%
Row 11 – Pl Dogs-hair	
	Site series 01, from seral association. Dog-hair pine, mesic/sub-xeric

4.2 Disturbances

Fire

For stand-replacing fire, we assumed a 91-year return interval with the exception of row 4 (starting with cover type S/PL, class H) with a 150-year return interval. Ground fires occur less frequently, on an assumed 200-year return interval. All stand replacing fire pathways go back to the beginning of the row that the class is on. Exceptions are noted in Table 4.2.

Table 4.2: Pathways for stand replacing fires in the SBPS. All pathways that burn have a 91-year return interval (probability=0.011) except row 4 which has a 150-year return interval (probability=0.0067).

Row:	Row: / To: / From:	1 PL1	2 PL1	4 S/PL1	5 PL/S1	6 S1	6 S/PL1	7 SB-PL1	8 SB1	9 AT/PL1	11 PL1
1	PL1,4,5&6	100									
2	PL1&se		100								
2	PL/S4&6		100								
4	S/PL1,se&4			100							
4	S6			100							
5	PL/S1,se,4&6				100						
5	S/PL5				100						
6	S1,5&6					40	60				
6	S/PL1,se&4						100				
7	SB-PL1&se							100			
7	SB-PL-S4							100			
7	SB/S6							100			
8	SB1								100		
8	SB-SXse								100		
8	SB/SX6								100		
9	AT/PL1&se									100	
9	AT/PL/SX4									100	
9	PL-SX/AT6									100	
9	SX/AT6									100	
9	SX6									100	
11	PL1&se										100
11	PL/S6										100

Ground fires occur with a 200-year return interval and use the same rules as for all other pathway diagrams (Figure 4.2). No ground fires occur in rows 6 or 10.

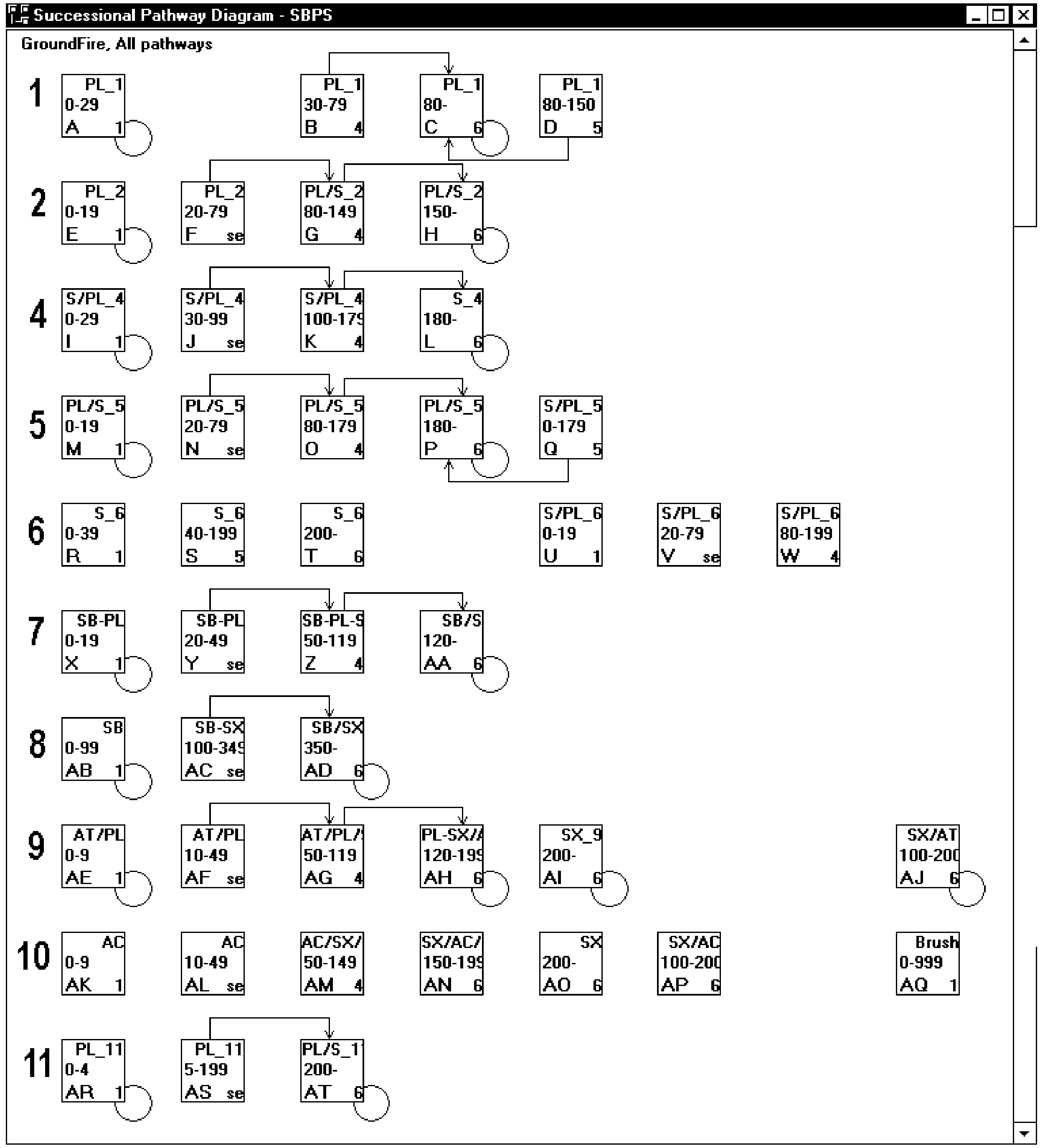


Figure 4.2: Ground fire pathways in the SBPS.

Insects

Mountain pine beetle is the only insect that is currently modelled in the SPBS. It attacks stands greater than 100 years old with large mature lodgepole pine. The diagrams use a probability of 0.008 in pure Pl, and 0.006 in mixed Pl classes.

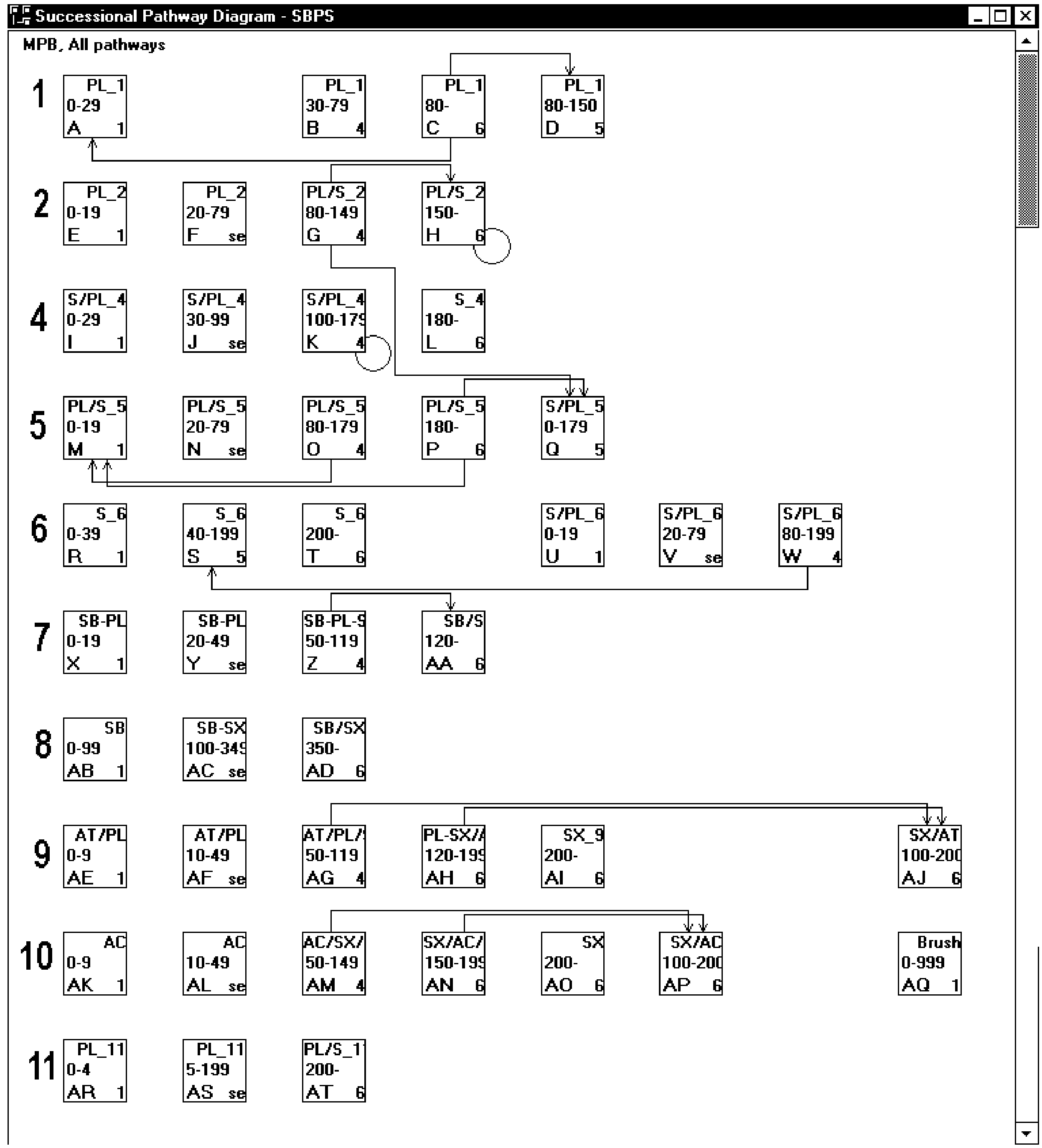


Figure 4.2: Mountain pine beetle pathways in the SBPS. The pathway destination and its probability are all in Table 4.3.

Table 4.3: Mountain pine beetle pathway definitions (classes, probabilities and age change) for the SBPS.

Insect	Row	From	To	Probability	Age Change
Mountain Pine Beetle	1	PL6		0.008 (total)	
			PL1	50%	
			PL5	50%	
	1	PL/S4		0.006 (total)	
			PL/S6	50%	
			S/PL5	50%	
	2	PL/S6	PL/S6	0.006	-50
	4	S/PL4	S/PL4	0.006	-50
	5	PL/S4	PL/S1	0.006	
	5	PL/S6		0.006 (total)	
			S/PL5	70%	
			PL/S1	30%	
	6	S/PL4	S5	0.006	
	7	SB-PL-S4	SB/S6	0.006	
	9	AT/PL/SX4	SX/AT6	0.006	
	9	PL-SX/AT6	SX/AT6	0.006	
	10	AC/SX/PL4	SX/AC6	0.006	
	10	SX/AC/PL6	SX/AC6	0.006	

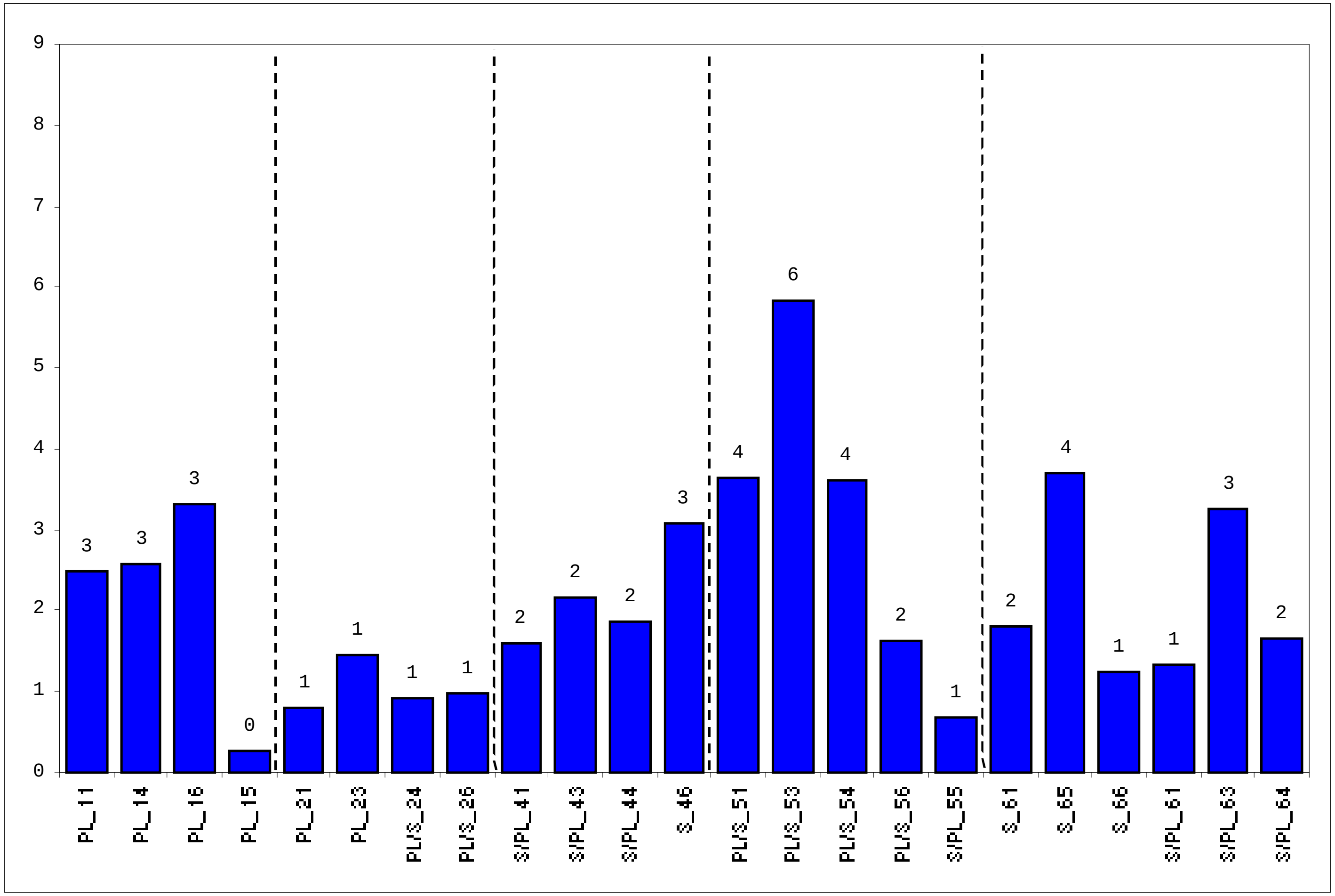
4.3 Sample Results

All the pathway and probability information thus far described for the SBPS was used to simulate a sample landscape to near equilibrium. This diagram is quite different from the others in that all of the rows are self-contained with respect to fire. In this diagram, however, there is some crossover from row 2 to row 5 due to MPB. All other rows are completely self-contained.

The high fire frequency means that only about one third of the area is in the structural stage 6 stands. The youngest stands are also relatively infrequent, making up less than a quarter of the area. Some classes only occur through MPB attacks, and are thus rare on the landscape (e.g., Row 1 PL5, Row 5 S/PL5). The brush class also disappears because there is at this time no mechanism for entering that class. In the SBS diagrams, this class resulted from severe insect outbreaks that do not occur here. The build-up of area in the Sx6 class of row 10 occurs because there are no fires in that row and floods, which occur at a lower frequency, are the only stand-replacing disturbance type.

4.4 Management

No management pathways were added to the SBPS because it is not generally managed, and because it represents a very small proportion of the Morice and Lakes IFPA.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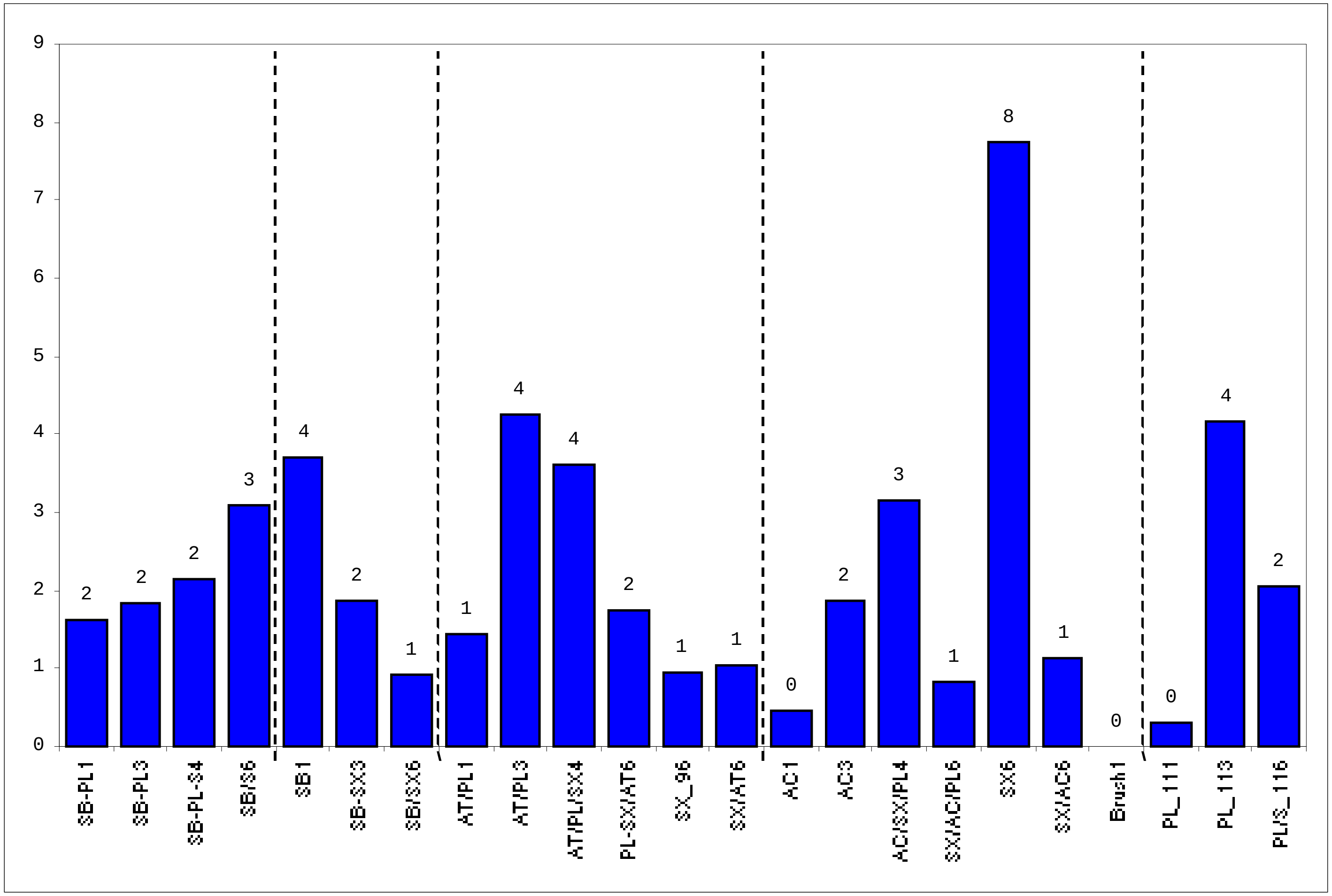

Figure 4.3: Distribution of area in the SBPS when VDDT is run to near equilibrium. The lines delineate the rows in Figure 4.1. Note that none of the management pathways are included in this graph or in these calculations. Rows 1-6 are on the first graph, with the remaining rows on the second graph.