Millar Western Forest Products Ltd.

Silviculture Generic Establishment Regimes

2007-2016 **Detailed Forest Management Plan**

May 10, 2007

EXECUTIVE SUMMARY

This component of Millar Western's Detailed Forest Management Plan (DFMP) describes the linkages between reforestation and juvenile stand management to site quality, long-term management planning, biodiversity impact assessment and watershed modeling.

Millar Western Forest Products Ltd. is committed to reforestation of cutover areas, by corporate ethics, legal and forest certification requirements. Other than the removal of forest cover associated with forest harvesting, silviculture has the largest forest management related impact on the forest. Silviculture activity, in large part, determines the plant community that develops after harvest. This component serves several functions: 1) It provides silviculturists with guidance in DFMP expectations and in prescribing and deploying an integrated suite of treatments to meet silviculture objectives; 2) it links longer-term management planning objectives (at the yield stratum level) with opening specific silvicultural practice; and 3) it provides the Biodiversity Assessment Project (BAP) model with specific and detailed plant community structures associated with silviculture practice and site characteristics.

This component was developed around five key precepts:

1. Silviculture is most successful when treatments are integrated into a sequence (in this document – termed Generic Establishment Regimes) that applies a series of integrated "nudges" to plant community assembly, thereby, shifting it in a desired direction. Generic Establishment Regimes are not intended as a "recipe", instead they provide silviculturists an adaptive base for planning, implementing and adjusting treatments to ensure successful reforestation.

2. Site quality and previous forest composition are key determinants of future forest composition; that is, silviculture is most successful when it attempts to establish plant communities compatible with site. Treatments are used to shift site suitability rather than

attempt to "force" plant community assembly. At present, site quality information must be validated through some form of field sampling.

3. Longer-term management planning and site capability should be used in concert to set silvicultural objectives. Silviculturists are provided a set of "business rules" that guide setting silviculture objectives based on site capability and management objectives. This, in turn, helps select an appropriate Generic Establishment Regime to meet the chosen silvicultural objectives.

4. Our understanding of silvicultural outcomes is adequate to describe plant community assembly outcomes for use in predicting impacts on biodiversity using the BAP models. Plant community assembly diagrams were developed for an array of site quality by Generic Establishment Regime combinations. Site quality was described by ecosite phase, which was used as a surrogate for edatopic grid position.

5. The plant community assembly diagrams cited above may be used to estimate plant biomass development following harvest, thereby, providing input for the FORWARD watershed modeling exercise.

Table of Contents

List of Tables

List of Figures

1. Introduction

Millar Western Forest Products Ltd. (Millar Western) is committed to a reforestation process that supports the growth and yield assumptions of this Detailed Forest Management Plan (DFMP). A process has been developed to ensure this occurs. This section of the DFMP describes that process and how it will assure silviculture activities will cohere with the assumptions.

Other than harvesting, silvicultural activities have the largest impact on the forest - in terms of changes to plant communities, viewscapes, water management and habitat supply. In recognizing this, Millar Western sought to develop a process whereby silviculture activities (and more importantly the plant communities arising from harvesting and silvicultural activities) are used to project the broader array of values, which underpin sustainable management.

In essence, this component describes how silviculture has been embedded in the DFMP as a core activity. Describing the process of embedding and describing the links between silviculture and the DFMP, will demonstrate the strategic importance of, and commitment to, silviculture in this DFMP.

Attempts were made to use silviculture as part of the harvest sequencing optimization process. Unfortunately, they were not successful. Improvements in landbase productivity predictions from new information such as LIDAR (LIght Detection And Ranging - an optical remote sensing technology that measures properties of scattered light to find range and/or other information about distant targets) should improve success in the future. However, silviculture effort and the associated likelihood of success were part of the DFMP process in determining the limits of stand merchantability for harvesting.

The process focused on capturing current silvicultural practices, documenting them, and developing strategies to make systematic decisions (i.e. focus was on ensuring repeatability of silvicultural effort based on site conditions and management objective(s)). Therefore the DFMP does not propose to substantially change silviculture – instead, it makes silviculture more systematic and links silviculture to site quality, initial plant community and long-term management objectives. The focus is on clear, measurable relationships between timber supply analysis (TSA), biodiversity prediction using the BAP model, watershed management (FORWARD project) and silvicultural activities, as currently practiced. The emphasis is on providing clarity in setting management objectives at the stand level, which in turn, cues a specific silviculture regime empirically demonstrated to be capable of meeting the stand level management objective.

This exercise was intended to capture existing silvicultural processes and link their outcomes with broader scale planning, including: 1) the BAP process; 2) the FORWARD watershed study; and 3) longer-term management assumptions and plans. In some cases potential deficiencies in silvicultural process or deployment strategies were identified. In these instances, adjustments to process were developed.

2. Assembly Theory of Plant Community Development

Assembly theory of plant community development was useful in predicting how silvicultural regimes would influence plant community structure and dominance for purposes of linking operational silviculture to DFMP strategic goals. Community assembly theory attempts to explain the existence of environmentally similar sites with differing assemblages of species. It assumes that species have similar niche requirements, so that community formation is a product of random fluctuations from a common species pool. If all species are relatively equivalent ecologically, then random variation in colonization, migration and extinction drive differences in species composition between sites with comparable environmental conditions.

Assembly theory offers an alternative approach to deterministic succession in explaining plant community development over time. Drake (1990) challenges ecologists to decide "whether ecological communities are patterned structures, populations that respond individually to environmental gradients, or idiosyncratic, random collections of species …"' In an attempt to answer his own challenge Drake suggests better clarity around the definition of community and offers guidance in identifying probabilistic rules for community assembly. McCune and Allen (1984) apply assembly theory to the development of forests to answer the question "will similar forests develop on similar sites?" and answer it with the conclusion that there is not a one-to-one correspondence between site factors and stand composition in old growth forests in Montana. They conclude therefore, that forest composition is probabilistic where community-altering processes, such as low intensity fire, insect outbreaks and human mediated factors, act to shift the trajectory of plant community development. In particular they make the case that a single, climax condition for forest composition on a specific site is somewhat misleading.

Assembly theory is of particular use when assessing managed plant communities – as it provides a framework whereby the type and extent of effects of management interventions can be used to predict changes in community structure and trajectory. This is particularly important when silviculture activity is likely to extend well into the early life of the plant community (*e.g.* stand tending activities, density management regimes, protection from pests and pathogens.) In effect, assembly theory parallels Wagner (1999) in postulating shifts in plant community composition, dominance and structure in response to management activities and natural disturbances. Unfortunately no references from refereed journals describing assembly rules for boreal forest plant communities could be found.

On Millar Western's FMA the existing pattern of species distribution and forest stands demonstrates well assembly theory tenets. Forests in the area are in general a product of macro or regional factors - terrain is generally rolling without large elevation differences; the climate is continental with short wet summers and cold winters; soils originate from glacial tills, so are fine textured and nutrient rich. None of these factors have much amplitude across the FMA, so do not drive the selection of tree species on a particular site. Rather, species occurrence is a product of the particular fire history on a site. (Sites wetter than sub-hygric are an exception – successful reforestation of these sites depends on use of black spruce, tamarack or white birch.) For the most part each site has potential to regenerate any one or a combination of several species. Thus, there is flexibility in selecting crop species and species composition when making reforestation prescriptions – to better meet management objectives.

3. Silvicultural Paradigm

Part of the appeal of assembly theory as an analytic framework for linking silviculture with higher-level objectives is the similarity in process between assembly theory and current silvicultural practices at Millar Western. Millar Western uses a series of silvicultural interventions to establish and direct plant communities toward desired forest conditions – that being vegetation communities that maintain or exceed the productivity of the natural forest stands prior to harvest. In effect MWFP mirrors Wagner's description of the current silvicultural paradigm being "employing a series of strategically timed nudges to shift plant community development in a desired direction".

Silviculture regimes described herein are not novel or untried – instead they are the outcome of a process capture exercise with Millar Western silviculture personnel. Therefore flexibility in timing of specific treatments (in the silviculture regimes) reflects the reality of both the need for operational flexibility and responsive treatment based on monitoring plant community conditions over time.

Millar Western's silviculture practice is also underpinned by a commitment to promptness. This goes beyond simply meeting the two-year silvicultural treatment requirement stipulated in the Regional Operating Ground Rules (OGR's). Instead, promptness directs most silviculture activities. To be effective silviculture treatments must be timely – site preparation must occur the first year after harvest, planting must take place at the very latest in the second year after harvest to allow planted seedlings time to establish on site before competing vegetation begins to develop, and when the competition does arrive, tending treatments must occur quickly to prevent its establishment. Millar Western uses frequent monitoring of plant community conditions to assess whether reforested areas demonstrate a composition and condition favorable to attaining the reforestation objectives defined for that area. If not, silvicultural interventions will be prescribed. For example, if monitoring identifies lack of stocking as a potential challenge to successful regeneration, fill planting will be prescribed. Further, if the lack of stocking is due to competition-caused mortality, a competition control treatment will be prescribed prior to fill planting.

Integration of treatment effects is equally important to silvicultural success – that is, success depends on timely deployment of treatments and complementary treatment effects. For example, on poorly drained or perennially wet rich sites, experience has shown that regeneration success depends on orchestration of elevated microsite site preparation, physiologically conditioned planting stock that emphasizes root egress and development, timely tending with glyphosate to control marsh reedgrass, with potential follow-up fill plants or a second stand tending treatment is necessary. Note that this approach is not unique to rich, wet sites, but these sites simply demonstrate the importance of integration most graphically. Therefore, it was important to capture silviculture processes in a manner that reflects integration, timeliness, and their importance to success.

To that end, the concept of a Generic Establishment Regime was formulated – a Generic Establishment Regime (GER) is the integrated package of silvicultural interventions associated with a yield group and a management intensity. GERs are, in effect, guidance to silviculturists in treatment deployment and integration to meet higher level planning objectives. They also provide a vehicle for creating community assembly descriptions which can be used to link silviculture activity and effects to sustainability and biodiversity criteria.

The reforestation processes detailed in the Generic Establishment Regimes use time to integrate treatments and assure their promptness. GERs are reforestation tools that assure timely, integrated silviculture practice, linked to site (i.e. biological factors) and to management objectives. The GERs appear in Table 1.

Table 1. Generic establishment regimes.

Treatment Regime[7]	Regenerated Strata	BCG	Leave For Natural	Mechanical Site Preparation	Chemical Site Preparation	Seed	Plant[6]	Tend 1	Tend 2
MS 1	AW PB	D D	Yes	No	No	No	No	No	No
MS 2	PL SW PL_DEC SB	C C CD C	No	Year 0, variable application[1,3]	No	No	Year 1 or 2 with conifer seedlings @ 1200-2000 sph	Year 2 to 4[5]	No
MS 3	PL	C	Yes	Year 0[3]	No	From Cones or artificial seeding	Year 1 or 2 with conifer seedlings @ 800-1200 sph[2]	Year 2 to 4[5]	No
MS 3A	PL	C	Yes	Year 0, Prescribed Burn	No	From Cones or artificial seeding	Year 1 or 2 with conifer seedlings @ 800-1200 sph[2]	Year 2 to 4[4]	No
MS 4	SW PL SWSB_DEC PL_DEC	C C CD CD	No	Year 0, variable application[1,4]	Broadcast Year 1[5]	No	Year 1 or 2 with conifer seedlings @ 1400-1800 sph	Year 2 to 4[5] - hilite if CD	Year 8 to 14[5]
MS 4A	AW_SWSB AW_PL PB_CON	DC DC DC	No	Year 0, variable application[1,4]	Hilite Year 1[5]	No	Year 1 or 2 with conifer seedlings @ 1400-1800 sph	HiliteYear 3 to 4[5]	Year 8 to 14[5]
MS 4B	AW_SWSB AW_PL PB_CON	DC DC DC	No	Year 0, variable application[1,4]	Hilite Year 1[5]	No	Year 1 or 2 with conifer seedlings @ 800-1200 sph	Year 2 to 4[5] - centered on conifer	Year 8 to 11[5]
MS 5	SB	C	No	Year 0 or 1, Mound	No	No	Year 1 or 2 with conifer seedlings @ 1400-2000 sph	Year 2 to 4[5]	

1. Highlight mound any wetter ecosite inclusions
2. Plant only those areas where germination from seed is weak
3. Drag, ripper-drag, disk trench, row mound, or other method depending on slash, duff depth and access
4. Ripper plow, shear blade, disk trench, row mound, bedding plow, other method or no site preparation depending on slash, duff depth and access
5. If required, based on assessment of vegetation, as per operators Standard Operating Procedures
6. Planting densities are target densities. Actual planted density may vary due to operational constraints
7. Prescriptions may change due to operational or site conditions.

Care was taken to ensure a certain degree of interchangeability between managed stand GER's on the same or similar site types. This reflects the earlier discussion on assembly theory. It also reflects Millar Western's expectation that despite the best intentions and the most rigorous implementation of treatments, in some cases managed stands will fall short of expectation due to unforeseen circumstances, such as climatic variation, insect outbreaks or similar unavoidable constraints. Conversely, it is expected equally that some stands will exceed height and density targets due to favorable climatic effects or similar unplanned beneficial occurrence. By having some degree of interchangeability, especially in the seedling density component of the GERs, stands exceeding targets might well be eligible for swapping to another crop status. Conversely, this provides some assurance that stands failing to meet initial targets will still meet minimum provincial regulatory standards.

Note that the GERs shown are drawn from operational practice – in effect, they capture current silviculture practice at Millar Western. This has several implications for the GERs:

- First, because they arise from practice capture it is likely that they will attain the desired outcomes;

- Second, the timelines associated with the GERs are empirically supported by operational experience; and
- Third, Millar Western was able to project plant community assembly over the course of the first 15 to 20 years of community assembly based on operational, empirical understanding of plant community dynamics in current silvicultural practice.

The ability to project plant community assembly over time was a critical step in linking silviculture practice to higher level DFMP objectives and assumptions around habitat supply and biodiversity over time under Millar Western's DFMP. See Section 4 (Relationship Between Silviculture and Higher Level Plans) for more discussion.

3.1 Silviculture Treatments

Table 1, Generic Establishment Regimes, references various silvicultural treatments. The following sections provide more detail around the wide range of silviculture treatments employed by Millar Western across the FMA. Application of specific treatments is based on site conditions, with particular attention to factors limiting to seedling growth, such as soil drainage, and with regard to the management objective for the site.

3.1.1 Deciduous Leave for Natural (LFN)

Millar Western harvests approximately 900 ha of forest for deciduous fiber annually. Due to the suckering nature of aspen and generally limited success in planting aspen, this area is reforested by relying on emergence of aspen suckers – termed Leave for Natural (LFN) reforestation. This approach is the most successful means of reforesting aspen. Successful LFN is very dependent on harvest practices not impacting the aspen sucker potential. In particular, sucker potential can be compromised by soil compaction, high slash loading or bluejoint reedgrass establishment

Two primary factors ensure successful use of LFN for deciduous regeneration – first is ensuring adequate vigorous aspen is present on site to provide as a source for suckers, second is to ensure soil compaction does not occur. Soil compaction is of particular concern when operations are undertaken during the following conditions:

- On unfrozen soil; conditions at harvest render the soil susceptible to compaction.
- On fine textured soils; and
- On the above criteria, when soil moisture is at or above field capacity.

Slash loading is another major constraint to successful use of LFN. Aspen suckering depends on relatively high soil temperatures stimulating sucker buds on the roots of stems harvested for aspen production. If the soil is insulated by slash, organic material, grass thatch or any other insulating layer, suckering will be inhibited. In many cases this does not result in complete inhibition of suckering, instead it causes spotty aspen emergence thereby compromising reforestation success for the entire opening. To prevent this, Millar Western does not de-limb aspen at the stump and ensures harvest slash and debris are piled and burned on roads and landings after harvest.

Millar Western plants coniferous seedlings on roads and landings in aspen reforestation areas because these portions of the cutover generally have aspen roots removed or damaged to the point where suckering will not occur reliably.

Another major constraint to successful LFN regeneration of deciduous is the presence of bluejoint reedgrass on the area prior to harvesting. In older stands reedgrass is abundant in the understory capitalizing on light made available by canopy break-up. After harvesting, this highly competitive grass species effectively overwhelms the site with massive reproduction from rhizomes. Particularly on moist (sub-hygric), medium to rich sites, this can result in a reedgrass disclimax where reedgrass competition effectively excludes all other plant species. Because deciduous regeneration depends on LFN for success, reedgrass management practices used to ensure coniferous regeneration (*e.g.* herbicides) can not be used; most of these treatments negatively impact deciduous regeneration. Thus deciduous regeneration areas with a high risk of reedgrass disclimax developing may need to be reforested to a mixedwood or coniferous objective simply to provide a venue for managing the reedgrass disclimax (Collins, 2001).

3.1.2 Coniferous Leave for Natural (LFN)

The lodgepole pine tree, common throughout the FMA, has evolved mechanisms to ensure its continued survival in the face of forest fires. In particular, the cones of this tree are usually serotinous. That is, the scales are stuck firmly together by a resin and the seeds are sealed within the cones. The heat generated by a forest fire causes the cones to open and release large numbers of seeds at one time.

Forest managers may take advantage of this characteristic of the cones to reforest a cutblock following harvest. Various mechanical site preparation methods (discussed below) are used to expose and mix the surface soil horizons, and to scatter the pine cones left on the ground surface following harvest. The heat from the sun is sufficient to open the serotinous cones, releasing the seed. This technique is commonly called Leave-for-Natural regeneration.

The following treatments are applied primarily to ensure or enhance success of coniferous regeneration in either coniferous or mixedwood management scenarios.

3.1.3 Site Preparation

The primary function of site preparation is to ameliorate fundamental soil and site conditions that may limit tree seedling establishment or growth. In the simplest terms, these conditions are:

- Wet soil – wet soils tend to have limited pore space for air and thus do not provide roots sufficient oxygen for optimal growth.

- Periodic flooding – may occur on wet soils or on slowly pervious (imperfectly drained or wetter) soils. Flooding can result in conifer seedlings drowning due to the roots inability to obtain oxygen. White spruce will tolerate 10 to 14 days of flooding before drowning (Lees, 1972).

- Cold soils – coniferous seedling roots require temperatures well above freezing for active growth. Slash, organic material, and particularly reedgrass thatch may be sufficient insulation as to dramatically shorten the growing season for conifers and to somewhat limit growth over the entire season.

- Inadequate soil nutrients – frequently forest soils are poorly developed with much of the soil nutrient capital tied up in foliage and bark; with the remainder trapped in un-decomposed organic matter (mor). This tie-up of nutrients can be particularly limiting to seedling growth on relatively dry (sub-mesic to xeric) medium to poor nutrient regime sites.

- Slash loading – following logging operations there can be significant accumulations of logging slash, composed of limbs and tops. The relative amount of accumulation is dependent on several factors, including the age and species composition of the original forest stand, season of operation (summer vs. winter), and type of harvest (full tree-length vs. limbing and topping at the stump). Heavy slash loads impede access to microsites for planting trees and can insulate the site, resulting in cold soil temperatures.

- Competing vegetation – as with aspen regeneration, discussed in Section 3.1.1 (Deciduous Leave for Natural (LFN)) above, establishment of coniferous regeneration for either coniferous or mixedwood management objectives is also affected by competing vegetation. Mechanical or chemical site preparation may be used to reduce the competition to coniferous seedlings from other plant species. Generally however, mechanical techniques such as mounding tend to be limited in their effectiveness against the primary competitive species on the FMA area – bluejoint reedgrass, and only provide seedlings a temporary respite from competition.

Millar Western employs several broad categories of site preparation:

- <u>Large, elevated microsite</u> – commonly referred to as mounding or excavator mounding, is used to ameliorate poor soil drainage and/or risk of flooding. As an ancillary benefit, excavator mounding will provide some measure of bluejoint reedgrass control for up to two or three growing seasons after treatment – note that duration and success of control depend on site richness with reedgrass on richer sites being generally less amenable to control.

- <u>Small elevated microsites and mixing treatments</u> – various techniques and equipment are used to enhance site conditions by creating small elevated microsites or to mix the surface humus layers with mineral soil. The purpose of this treatment is to create a microsite that is warmer, drier and better aerated than the original soil profile. Because of these optimum soil conditions seedling growth may be enhanced. Another technique is to use either ripper-drags or anchor chain drags on nutrient poor sites to blend mor humus with mineral soil to enhance both soil moisture holding capacity and nutrient availability. Note that these treatments may be used to relocate pine cones nearer the soil surface to warm, thereby stimulating cone opening and providing some propagules for pine reforestation. This will be discussed more fully in Section 3.1.4 (Propagules).

- Raking treatments – brush rakes mounted on small cats or tracked hoes are used to pile logging slash, which is then burned. Another technique uses a shear blade mounted on a large cat to windrow the slash and create very clean sites. This technique is usually followed up by secondary site preparation treatments such as mixers and mounders to create raised microsites for planting.

- Chemical Site Preparation – this technique is chosen when competition management is the primary goal of site preparation treatment. Given the prominence and importance of the bluejoint reedgrass disclimax phenomenon to reforestation, successful chemical site preparation tends to focus on reedgrass management. While not the primary reason for prescribing chemical site preparation, mixedwood compositional objectives may be less compromised by a chemical site preparation treatment than they would be by a later chemical tending treatment. Operational experience, at Millar Western and elsewhere, has shown aspen stocking and density are less negatively affected by early broadcast herbicide treatments than they have been by later treatments.

3.1.4 Propagules

Propagules is a generic term for the source of crop “seedlings” – in the case of Millar Western these include suckers (aspen only), seed (primarily lodgepole or hybrid lodgepole – jack pine), and planted seedlings (lodgepole pine, black spruce, white spruce).

As discussed in Section 3.1.1 (Deciduous Leave for Natural (LFN)), regeneration depends entirely on suckers. Suckers arise from dormant, adventitious stem buds on deciduous root systems. Sucker buds are maintained in a dormant condition by polar transport of auxins (hormones) in active stems. Therefore, when stems are cut down and polar transport of auxins is prevented, sucker buds are no longer inhibited and begin to grow, emerging from the soil as new aspen stems. Sucker regeneration usually results in large numbers of individual stems, which are dramatically reduced over time by a variety of environmental factors including:

- Herbivory – by both large (browsing by moose) and small (girdling by voles) mammals.

- Disease – particularly shepherd’s crook (*Venturia macularis*).

- Intraspecific competition – with adjacent stems.

- Insect outbreaks – including forest tent caterpillar (*Malacosma disstria*), large aspen tortrix (*Choristoneura conflictana*), and bruce spanworm (*Operophtera bruceata*).

The cumulative effect of these stressors is to reduce aspen sucker density dramatically in the period three to seven years after cutting. Termed “self-thinning” this phenomenon is critical to young aspen becoming a viable crop.

The primary conifer propagules employed at Millar Western are container seedlings. Planting densities specified in this DFMP were calculated based on the need for approximately 1200 relatively uniformly distributed seedlings per hectare to achieve 80 percent stocking. The number was adjusted upward to reflect mortality of planted seedlings (as measured in 10 to 14 year survival plots on the FMA area) and upward again by a factor used to account for under-sized seedlings (that is seedlings not able to meet performance survey height requirements). Seedling size and age were selected based on the likely competition they would encounter on a specific site if they were deployed according to the GER for that site type and management objective. Details of seedling densities and sizes are found in Table 2.

Table 2. Planting stock type and density targets.

Silviculture	Pl		Sw		Sb	
Regime	Stock Type	Density/ha	Stock Type	Density/ha	Stock Type	Density/ha
MS 2	410	1600	410	1600	-	-
MS 3	410	1200	-	-	410	1600
MS 3a	410	1600	-	-	410	2000
MS 4	410	1600	410	1600	-	-
MS 4a	410	1600	410	1600	-	-
MS 4b[1.]	410	1000			-	-
MS 5	-	-	-	-	410	2000

1. Plant 60% of opening area.

Note that Millar Western has conducted research on nutrient-loaded seedlings and physiologically conditioned seedlings over a 12 plus year interval. This research has shown physiologically conditioned seedlings set up to maximize root growth during the first growing season on-site are most likely to succeed in the face of severe bluejoint reedgrass competition, especially if deployed as part of GER that focuses on managing the competition between conifer tree species and bluejoint reedgrass.

Collection of seed for nursery production of conifer seedlings is the responsibility of the conifer timber operators in the FMA. Collection of seed is regulated by the provincial government. The Standards for Tree Improvement in Alberta (STIA) manual (www.srd.gov.ab.ca/forests/managing/manuals) details requirements for all aspects of seed collection, storage and deployment as seedlings. Companies within the FMA are committed to following these standards.

At present wild seed from natural stands is the mainstay for production of seedlings for planting. As of spring 2007, operators within the FMA have approximately 2,600 kilograms of seed available to grow seedlings. This seed is stored at the Alberta Tree Improvement and Seed Centre, operated by the provincial government. Table 3 below details the total seed available by species for all conifer operators, with an estimate of the number of seedlings that can be produced. Annually, operators in both W11 and W13 combined plant an average 8-9 million seedlings. At this rate the current seed inventory has sufficient seed for the next 45 years, well beyond the timelines of this management plan. Operators monitor their seed supplies regularly to ensure there is sufficient seed from across all seedzones. Collection of additional seed occurs on an ongoing basis in response to this monitoring.

In the near future invasion of lodgepole pine forests by mountain pine beetle may damage or destroy these forests throughout the FMA, greatly reducing the production of new seed for reforestation. Companies operating in the FMA are currently evaluating this threat and may be collecting more seed over the next few years to ensure a sufficient supply for future reforestation programs.

Table 3. Availability of seed by seedzone and species.

	Pl		Sw		Sb	
Seedzone	**Seed Available (kg)**	**Estimated Seedling Production**	**Seed Available (kg)**	**Estimated Seedling Production**	**Seed Available (kg)**	**Estimated Seedling Production**
CM3.2	-	-	443	79,821,000	-	-
CM3.4	0	10,000	43	7,686,000	-	-
LF1.3	373	37,290,000	548	98,640,000	32	10,744,000
LF1.4	74	7,400,000	424	76,320,000	-	-
LF1.5	5	510,000	146	26,244,000	13	4,318,000
LF2.1	191	19,070,000	130	23,400,000	2	646,000
UF1.1	225	22,500,000	4	702,000	11	3,570,000
UF1.2	18	1,810,000	-	-	-	-
UF1.4	4	430,000	-	-	-	-
Total	890	89,020,000	1,738	312,813,000	57	19,278,000

Millar Western is involved with two tree improvement breeding programs. These are the Region I White Spruce Breeding Program, and the Region L1 Black Spruce Breeding Program. Both programs are well advanced.

The Region I breeding program was initiated in 1986. The goal of the program is to provide a source of genetically improved seed, producing trees with fast growth, good health and form and undiminished wood quality. The first cone crop was collected in 2006. Though it will take several years for the orchard to reach capacity, once on-stream, this orchard is designed to have a capacity of 8.3 million seeds per year. Millar Western’s share of that program is 26%, or 1.95 million seeds, to produce 1.5 million seedlings annually. At current planting densities, this will be sufficient seedlings to plant 900 hectares annually.

The Region L1 Black Spruce Orchard was initially established in 1999. The goal of the program is to provide a secure source of Black Spruce seed within Region L1. Production of the first cone crops is forecast for 2008. This orchard is designed to have a capacity of 1.6 million seeds per year. Millar Western’s share of this program is 55%, or 900,000 seeds, to produce 500,000 seedlings annually. At current planting densities, this will be sufficient seedlings to plant 250 hectares annually.

Deployment of seedlings from these two breeding programs is expected to occur on GERs implemented on good and medium sites. Deployment limits will be as specified in the STIA manual. It is expected that surplus seed beyond the requirements of Millar Western will be available for purchase by other operators within the FMA.

Programs for genetic conservation of all species found on the FMA will be developed in conjunction with overall provincial strategy and a province-wide program for the species. This program will include maintenance and regulation of in-situ and ex-situ conservation areas.

Millar Western only deploys seed as seed released by cones left on site after harvest. This particular propagule type is only included in one GER – which is focused on reforestation of poor to medium dry sites. With potential for Mountain Pine Beetle in the FMA this GER may be used on better sites as well. This GER integrates mixing mechanical site preparation with seed from cones and monitors for the need to fill plant blocks treated with this regime should pine seedling emergence not meet expectation. This GER also depends on prompt tending of competition despite the relatively poor site quality to ensure competition does not overwhelm recently emerged seedlings.

3.1.5 Vegetation Management (Stand Tending) Treatments

Millar Western believes prompt stand tending is critical to reforestation success – whether measured biologically or as outcomes against regeneration standards. Therefore all GERs with the exception of aspen LFN prescribe some level of tending. In the mid to late 1990's Millar Western used a wide array of tending treatments, including: motor-manual, basal bark herbicide application, ground broadcast herbicide application and aerial broadcast herbicide application. The array of tending treatments was employed for two reasons:

- First, Millar Western had considerable untended older reforestation area (backlog) where conifer stocking had eroded due to competition. Tending in these circumstances had to be somewhat selective thereby allowing growing space unoccupied by coniferous species to be occupied by deciduous crop species; and

- Second, Millar Western wished to better understand the operational costs and the longer-term value of the various tending methods employed.

As a consequence of these efforts the reforestation backlog was considerably reduced in size and over time an appreciation for the value of various tending methods began to emerge. The most important understanding of tending to come from these efforts was that broadcast foliar herbicide application gave by far the greatest growth response in coniferous seedlings. Secondly, as mentioned in Section 3.1.3 (Site Preparation, Chemical Site Preparation), early broadcast herbicide treatments seem to have a somewhat less negative impact on deciduous crop species than later treatments.

Finally, and most importantly Millar Western learned that while stand tending is important, the best value from stand tending treatments is derived by integrating stand tending treatments into a time-driven silviculture process and that careful prescription and delivery of stand tending prescriptions is critical to their success.

3.1.6 Integration and Promptness in Reforestation

The current silviculture literature and operational experience at Millar Western support timeliness in all reforestation activities being the key ingredient in silvicultural success. In a broader sense effectiveness in reforestation is achieved through timeliness and integration of treatments.

Timeliness means deploying silvicultural treatments before the condition they are intended to address has had an opportunity to negatively impact seedling growth. For example, timely planting means ensuring cutovers are planted before competing vegetation is fully established. This provides conifer seedlings an opportunity to establish in a somewhat less competitive environment. Further, conifer seedlings are afforded an opportunity to capitalize on the Assart effect (that is, they benefit from the flush of nutrients released by decomposing vegetative material immediately after forest harvesting.)

Integration means using a sequence of complementary treatments that work together to achieve the longer-term reforestation objective. In particular, integration means treatments are chosen as a package or process that is internally coherent and works effectively to achieve the prescribed outcome for the opening being reforested. Much of the integration in Millar Western's GERs arises from the overwhelming challenge to reforestation success posed by bluejoint reedgrass. In the face of such a pernicious and persistent competitor, silviculture regimes are used to modify the site to favor conifer seedlings over reedgrass using various site preparation techniques. Next, seedlings are set up to compete with reedgrass in the most important context, which – given that reedgrass is a rhizome reproducing species – is below ground. Finally seedlings must be tended prior to their being fully encroached on by bluejoint reedgrass – again reflecting the importance of below ground competition to the seedlings chances for success.

The temporal nature of Table 1 facilitates using it as a planning tool. This table, in combination with Table 2 and the Vegetation Management Strategy, provide an integrated suite of silviculture practices focused on site-based silviculture tactics and on meeting management objectives. Most components of the GER's are fixed by site and management objective – these include site preparation, species selection, and propagule choice (and density, if planting.) Vegetation management activity with herbicides is more closely regulated than other silviculture activities and therefore will require discrete prescription prior to deployment. The Vegetation Management Strategy (VMS) – to be developed under this DFMP – will guide prescription and implementation of vegetation management activities. It will also guide revision of the Vegetation Management Manual currently in use at Millar Western to ensure coherence with this DFMP and the silviculture process described here.

No matter the GER or the target strata being regenerated, the objective at all times is to establish a vigorous young stand of trees that quickly capture the site resources, developing into a fully stocked stand that maintains the productivity of the natural forest stand, and meets the yield projections as defined in the TSA for each strata.

3.1.7 Incidental Species Regeneration

Sustainability of the Annual Allowable Cut requires that within pure conifer and deciduous strata, maintenance of incidental species is required.

In the 1997 DFMP the provincial government mandated a formula for conversion of deciduous landbase to conifer landbase within the W11 management unit. At that time, the conversion formula specified that for each 2.2 hectares of pure deciduous landbase harvested, that 1 hectare be reforested to pure coniferous landbase. The Timber Supply Analysis conducted under this DFMP has calculated a new conversion formula. Details around this can be found in Chapter 5 (Forecasting).

On remaining deciduous landbase harvested in the FMA the company commits to the following activities to maintain the incidental conifer volume:

- Planting of conifer seedlings on all in-block roads and NSR areas
- Avoidance and planned protection of coniferous understorey during logging operations.

On coniferous landbase harvested in the FMA the company will commit to the following activity to maintain the incidental deciduous volume:

- Protection of some of the deciduous component in regenerating stands when conducting stand tending activities on coniferous harvest areas.

4. Relationship between Silviculture and Higher Level Plans

Millar Western's 1997 DFMP developed a process of using the Biodiversity Assessment Program (BAP) models to link harvesting and silviculture outcomes to biodiversity goals. A revised process is being applied in the 2007 DFMP, and is discussed more fully in the DFMP Appendix X (Biodiversity Analysis of the PFMS) and Chapter 5 (Forecasting).

The BAP modeling process uses Special Habitat Element (SHE) models; each model describing the habitat requirements for a specific indicator species. One important description of habitat is the assemblage of plant communities and how those communities change over time. The mechanism used to link silviculture practices with the BAP model was the construction of graphic diagrams (examples are given in Figure 1) that describe plant community assembly over the first 10 years following harvest (details of all plant community assemblages and their development are given in Appendix 1). Each Community Assembly Diagram predicts the expected response of the plant vegetation communities on a particular site to the implementation of silviculture activities as described by each Generic Establishment Regime.

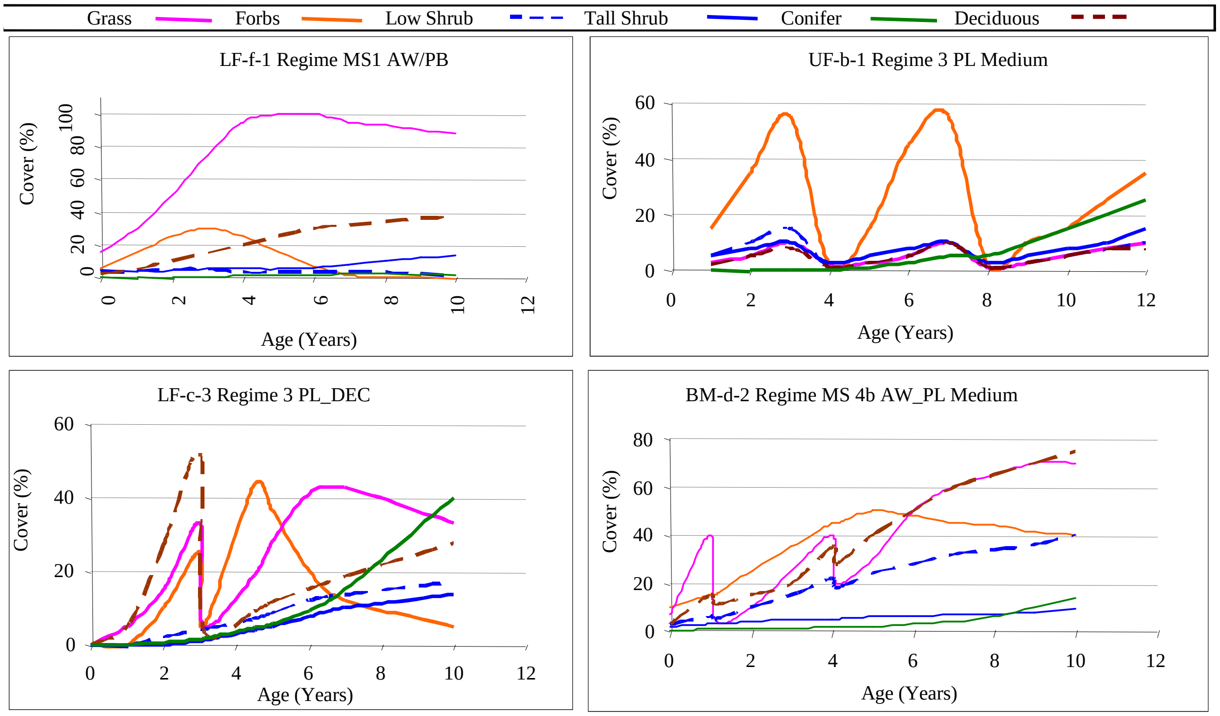

Figure 1. Example of plant community assembly diagram.

The vegetation community diagrams were used to adjust the SHE models, particularly the prediction of SHE values in the first 10 years following harvest, and the trend for predicting SHE value in later years.

Given Millar Western's emphasis on managing bluejoint reedgrass competition and the development of the GERs, developing plant community assembly descriptions for a variety of GERs by site combinations was recognized as having considerable potential value in terms of describing plant community assembly at a much finer temporal and plant community compositional resolution than was used in the 1997 DFMP. We are convinced that this finer resolution provides a stronger link between operational practice and biodiversity maintenance objectives.

The results of the BAP modeling determines whether harvesting and reforestation practices are sustainable in terms of providing suitable habitat to maintain populations of chosen indicator species over long periods of time. The BAP models thus become a limiting factor in setting the level of harvesting that can occur. The timber supply analysis that set the annual allowable cut for the 2007 DFMP has been constrained by the BAP modeling.

One of the outcomes of the timber supply analysis is generation of tables that defines the expectations for regenerating specific strata on the FMA over the course of the DFMP. Regenerated strata tables for W11 and W13 are included in DFMP chapters 5 (Forecasting) and 6 (Commitments). The assumption that these strata will be regenerated to these targets is integral to the Timber Supply Analysis. That is, failing to meet these regenerated strata targets in a significant way, has implications for the validity of the timber supply analysis, and by inference to the validity of the BAP modelling.

Thus, the exercise of linking the Generic Establishment Regimes to their impact on early vegetation communities, through the plant community assembly diagrams, influences the results from the BAP modeling. In turn, this becomes a limiting factor on the final harvest level for the DFMP as determined by timber supply analysis. The timber supply is explicit in the expectations for regenerating specific yield strata. A tight link exists between silviculture activities, the final harvest level, and the demonstrated sustainability of that harvest over time. Refer to Chapter 5 (Forecasting) and DFMP Appendix X (Biodiversity Analysis of the PFMS). The strata relationships between government regeneration standards (at the Broad Cover Group level), timber supply analysis yields (species strata) and BAP modeling (BAP strata) are presented in Table 4. GER's were developed for species strata and/or BAP strata as appropriate.

Table 4. SRD, TSA and BAP strata relationship.

Broad Cover Group	Species Strata	BAP Strata	Description
D	AW	AW	Apen
		PB	Poplar
	BW	BW	Birch
DC	AP	AW_PL	Aspen leading pine mixedwood
	AS	AS_SWSB	Aspen leading spruce mixedwood
		PB_CON	Poplar leading mixedwood
CD	PA	PL_DEC	Pine leading mixedwood
	SA	SWSB_DEC	Spruce leading mixedwood
C	LT	LT	Larch
	PL	PL	Pine
	SB	SB_UP	Upland black spruce
		SB_LOW	Lowland black spruce
	SW	SW	White Spruce

The plant community assembly diagrams were also used to estimate biomass development after harvesting, as input to the FORWARD watershed model currently under development. FORWARD models the impact of forest harvesting and regeneration upon water runoff (quality and quantity). The lesser vegetation (shrubs, forbs, grasses, etc.) have significant effects on this runoff. Results from FORWARD modeling were also used as constraints against the timber supply analysis and subsequent final harvest level. Refer to Chapter 5 (Forecasting) and DFMP Appendix XIV (FORWARD Contributions).

5. Implementation of Generic Establishment Regimes

By including the GERs in Millar Western's DFMP, the company is committing to use them to guide silvicultural activity to meet forest renewal and sustainability commitments. It is expected that all other forest operators having tenure within the FMA are committed to using these GERs as well.

Selection of a specific GER to implement on an opening will be based on a combination of site quality (as described by edatopic grid position) and management objective.

The edatopic grid describes ecosystems in terms of gradients of soil moisture regime and soil nutrient regime. Ecosites are characterized in terms of their position and extents within a two-dimensional grid. Figure 2 shows the edatopic location of managed stands. Species locales and structure of the edatopic grid are drawn from Beckingham *et al*, 1996 – Field Guide to Ecosites of West-Central Alberta.

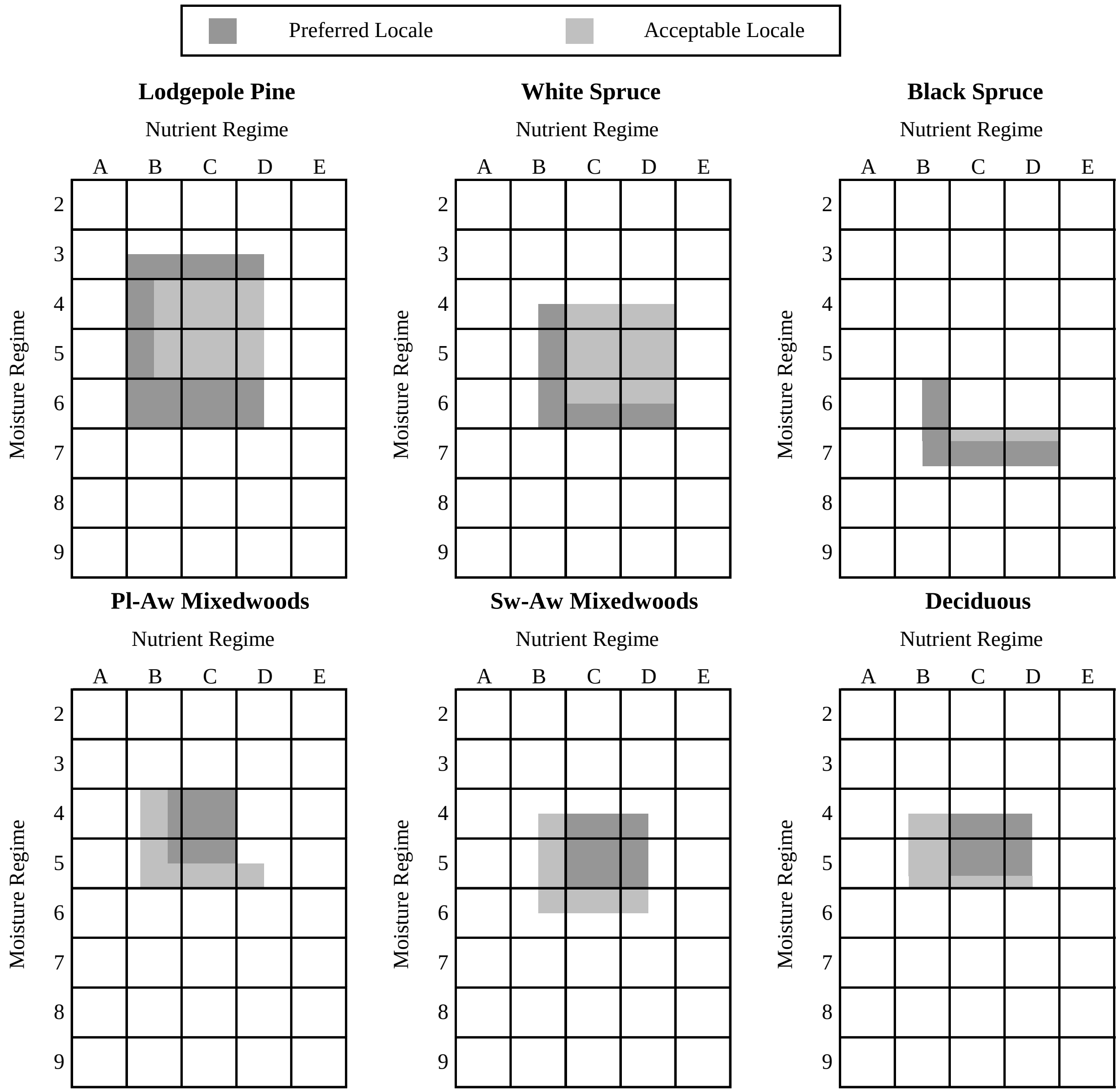

Figure 2. Preferred and Acceptable Edatopic Grid Location for Silvicultural Deployment of Tree Species.

The “edasite” layer in Millar Western’s GIS system provides an estimate of edatope based on a translation of ecosite phase and site productivity (derived from tree productivity rating or site index.) In conjunction with the judgement of experienced silviculturists and knowledge of the original (pre-harvest) forest cover-type, this information is sufficient for classifying an approximate edatopic grid position and making operational silvicultural prescriptions during an on-site visit.

Table 5 associates edatopic grid position (as described by moisture regime (2-9) and nutrient regime (A – E)) with silviculture regimes. Note that any specific edatopic grid position has several potential silviculture regimes associated with it.

Table 5. Silviculture regimes by edatopic grid position.

Moisture Regime	Nutrient Regime	Managed Stand Locales SW	PL	SB	SWSB_DEC AW_SWSB PB_CON	PL_DEC AW_PL PB_CON	AW PB
3	B		MS2				
	C	MS2	MS3/3A			MS2	
	D		MS3/3A			MS4/4A/4B	
4	B		MS3/3A/4		MS4/4A/4B	MS4/4A/4B	
	C	MS4	MS3/3A/4		MS4/4A/4B	MS4/4A/4B	MS1
	D	MS4	MS4		MS4/4A/4B	MS4/4a/4b	MS1
5	B	MS4					MS1
	C	MS4					MS1
	D	MS4					
6	B	MS4		MS2			
	C	MS4					
	D	MS4					
7	B			MS5			
	C			MS5			
	D			MS5			

The overlap of silviculture regimes across edatopes is consistent with natural forests where a variety of species compositions are found on similar sites. The overlap necessitates silviculturists having guidance in setting reforestation objectives on a site-specific basis.

Specific management objectives are determined as a result of the Timber Supply Analysis that determines the annual allowable harvest. To support the annual allowable harvest, timber supply modeling assigns each harvested cutblock to a regenerated yield strata. Refer to 2007 DFMP Chapter 5 (Forecasting) and Chapter 6 (Commitments) for the regenerated strata target tables.

With the site quality estimate, knowledge of the pre-harvest cover type, and direction from the DFMP as to management objective, final assignment of a GER can occur during a field assessment of each cutblock immediately following harvest.

Sites will be assigned GERs intended to replace the harvested stand composition by use of the most effective managed stand GER for the site, and with regard to the DFMP Regeneration Strata targets.

To implement the DFMP a DFA Silviculture Committee has been convened, with membership from all timber operators, including FRIAA and SRD. The purpose of this group is to ensure DFMP implementation. One of the main tasks of this group will be to allocate regeneration strata between operators and to review and report on progress relative to the Regeneration Strata targets. DFMP annual and stewardship reporting are another key task. The Terms of Reference for the DFA Silviculture Committee (2007 DFMP Appendix XVII) details the specific tasks of this group.

6. References

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7. Appendix 1 – Development of Plant Community Assembly Diagrams

Plant community assembly diagrams for harvested and managed forest lands are not unique. Sullivan *et al* (1998) presented several in their paper describing the influence of herbicide stand tending treatments on forest plant community development. This provided a template for developing the diagrams used in this DFMP. In effect the diagrams show percent cover of six major vegetation lifeforms – forbs, grasses (particularly bluejoint reedgrass), low shrubs, tall shrubs, deciduous trees and coniferous trees over ten years post harvest. Plant community assembly is demonstrated through temporal changes in cover by vegetation types. Dominance is shown through differences in cover by vegetation types at a single temporal interval.

Unfortunately, there is little published literature on empirical changes in plant community assembly following herbicide treatment. The best example is the previous work by Sullivan *et al*, 1999. Given the dearth of data and operational understanding that plant community assembly varied substantially with site and silviculture regime, Millar Western decided to develop plant community assembly curves specific to the GERs.

In the absence of literature Millar Western chose to employ a panel of experts to develop plant community assembly diagrams. Ted Gooding (The Forestry Corp.) facilitated a meeting in Whitecourt on April 9, 2005. Participants in developing the diagrams were: Milo Mihajlovich (Incremental Forest Technologies Ltd.), Brian McDonald (Silviculture Forester – Blue Ridge Lumber), Leslie Proudfoot (Silviculture Forester – Canadian Forest Products), Mark Dewey (Strategic Wood Supply Forester – Blue Ridge Lumber), Peggy Pike (Silviculture Technician – Millar Western) and Paul Godin (Silviculture Technician – Millar Western). Katrina Froese (Forest Analyst - The Forestry Corp.) and Doug MacDonald (Modeler - FORWARD Project) observed the meeting and took detailed notes of meeting process and outcomes.

Participants were chosen based on several characteristics:

- A minimum of five years (and preferably 10 years) silviculture experience – with an interest in plant community development. Note that in Mark Dewey's case his undergraduate thesis focused on changes in plant community assembly on the Blue Ridge Lumber FMA area following glyphosate herbicide applications for stand tending and site preparation.

- Familiarity with silviculture practices included in Millar Western's GER's.

- Interest in the process of linking silviculture and the larger scale objectives associated with DFMP's.

The group developed the following framework for plant community assembly diagrams:

- Use of percent cover to describe vegetation type abundance. FORWARD depends on vegetation biomass to predict watershed function, however, members of the "expert panel" were not comfortable attempting to predict or discuss vegetation biomass directly, but were very comfortable predicting and discussing percent cover, by vegetation type.

- Use of Millar Western's GER's with time of 0 years set as the start of the GER to describe silvicultural treatments over time.

- Assessing percent cover as a "rolled up" variable that considered treatment effects and missed treatment areas to reflect overall operational silviculture impact on plant community assembly.

- Stratification of silvicultural activity by ecoregion (*i.e.* Lower Foothills, Upper Foothills, Dry Mixedwood.)

- Use of edatopic grid position (represented by ecosite phase) as the basis for site in developing the plant community assembly diagrams. Note that this reinforced the use of edatopic grid position as a basis for developing the GERs.

- A temporal "X" axis for the graphic community assembly diagrams of 10 years where year 0 was the year where site preparation occurred.

- Agreement on how to scale percent cover on the "Y" axis of the graphic plant community assembly diagrams.

The framework defining a plant community assembly diagram is described in Figure 3.

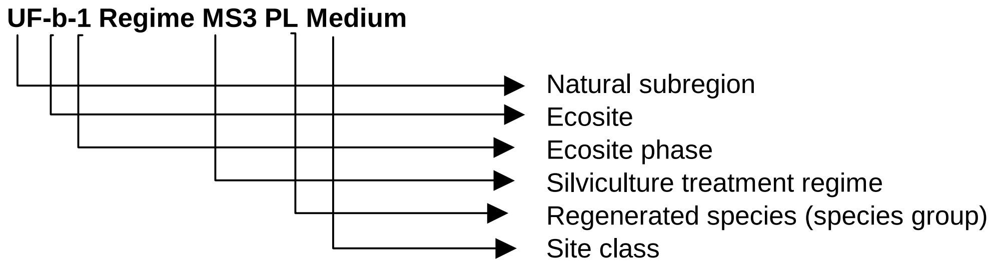

Figure 3. Identification code for the plant community assembly.

As discussed previously the plant community assembly diagram is graphic representation of six vegetation types (forbs, grasses, low shrubs, tall shrubs, deciduous trees, and coniferous trees) over the first 10 years of community assembly (with the year of site preparation set as year zero, NOT harvesting). A standardized grid for graph construction was given to all teams. Community assembly diagrams were to be constructed on this standardized graph then transfer to overhead transparencies to facilitate comparisons between graphs. Further, numeric predictions of cover used to construct the community assembly diagrams were collected by Katrina Froese and entered into a spreadsheet. (Note that ecosite/ecosite phase was used as a surrogate for edatope).

As a calibration exercise all three teams participated in developing a single diagram - ***UF-b-1 Regime MS3 PL Medium***

Each team then developed plant community assembly diagrams for 3 to 4 hierarchical positions (See Figure 4, Figure 5 and Figure 6 for the Upper Foothills, Figure 7 and Figure 8 for the Lower Foothills and Figure 9 for the Boreal Mixedwood natural subregions). Prior to the workshop ending, the entire panel reviewed all plant community assembly diagrams and came to consensus on each plant community assembly diagram.

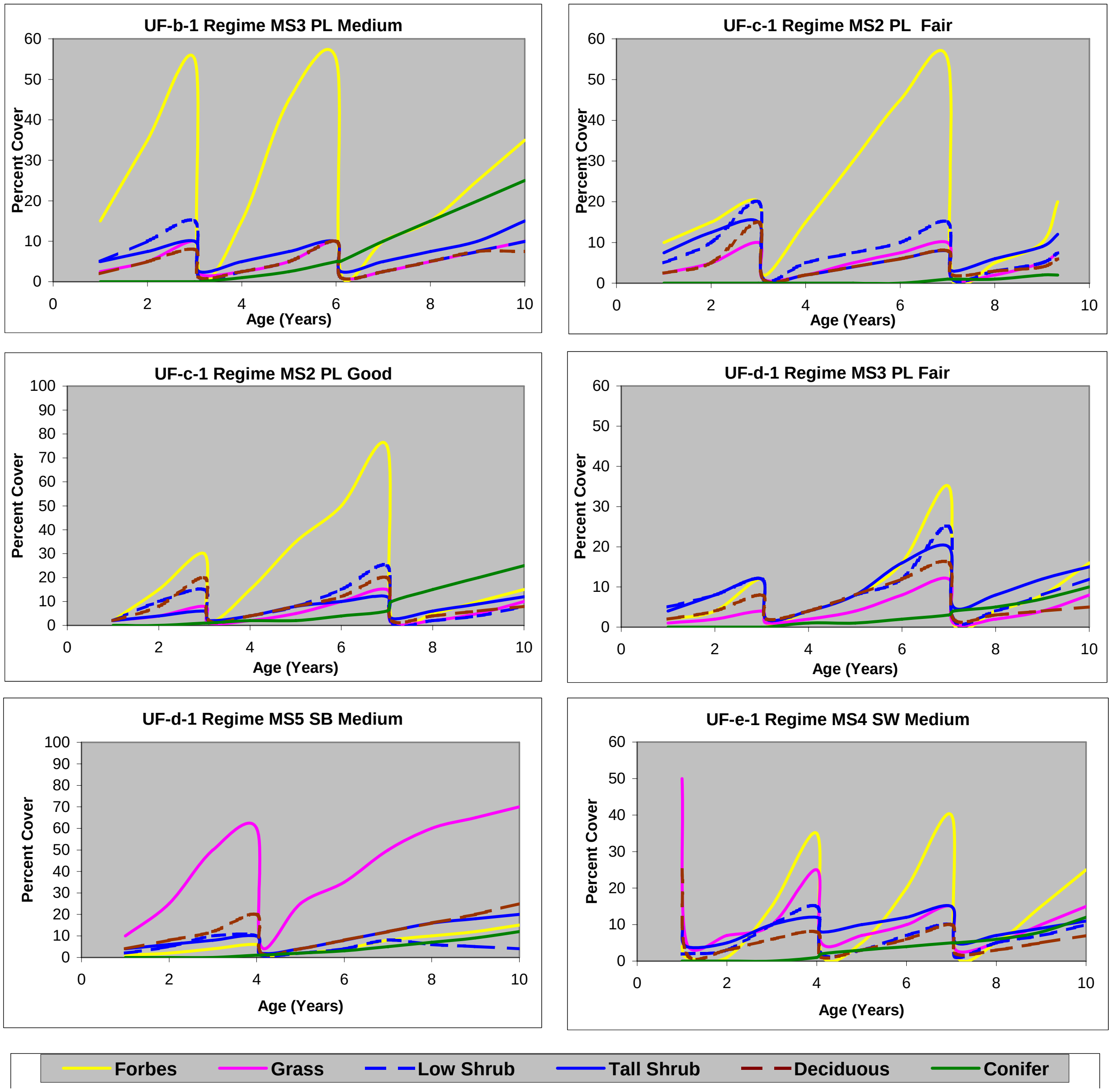

Figure 4. Upper Foothills plant community assembly diagrams.

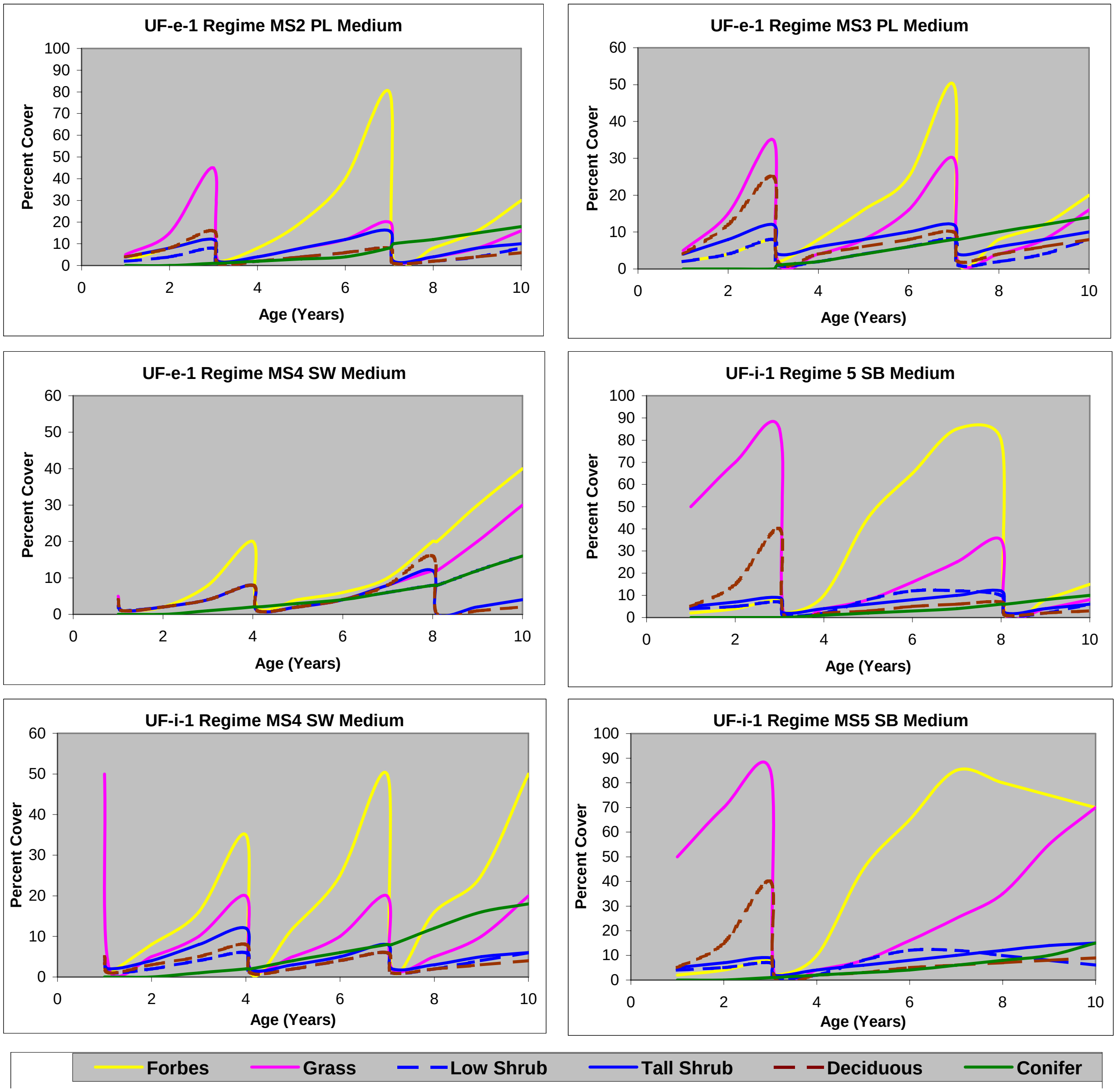

Figure 5. Upper Foothills plant community assembly diagrams - Continued.

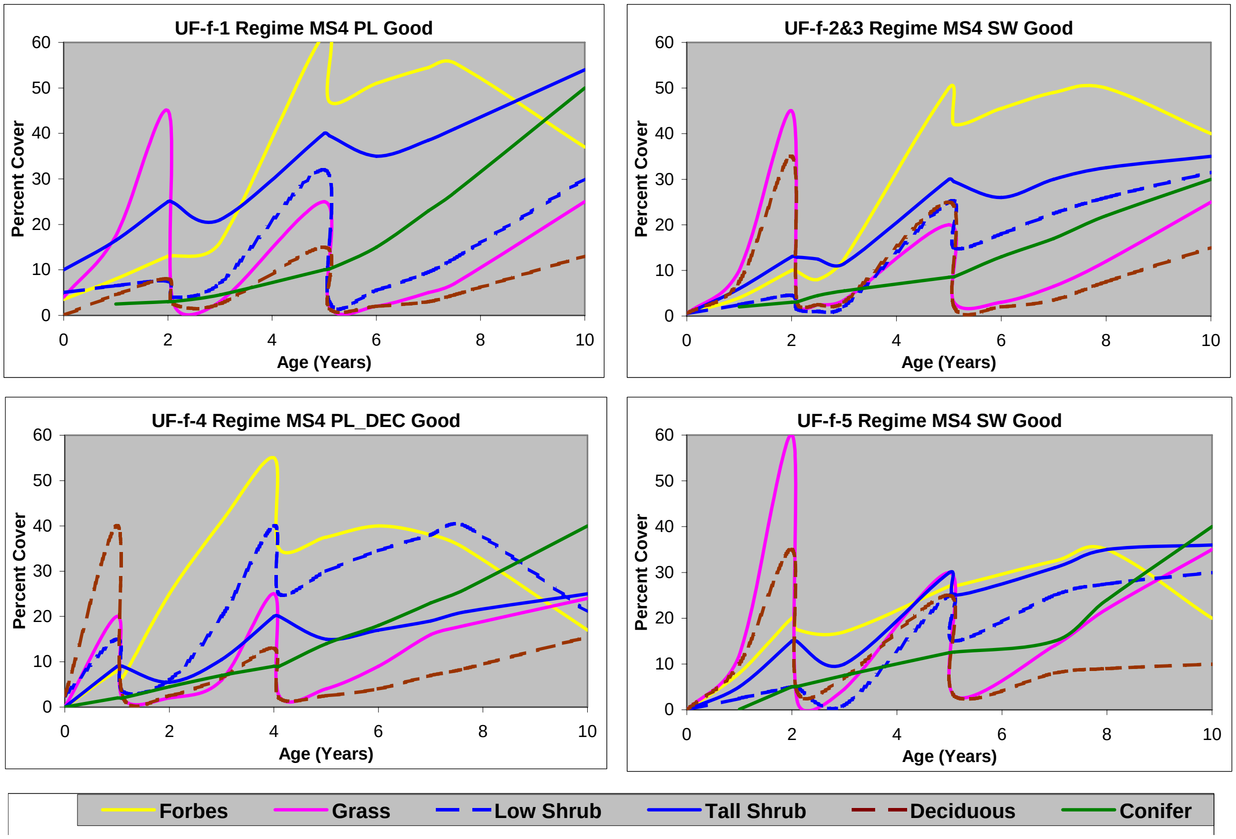

Figure 6. Upper Foothills plant community assembly diagrams - Continued.

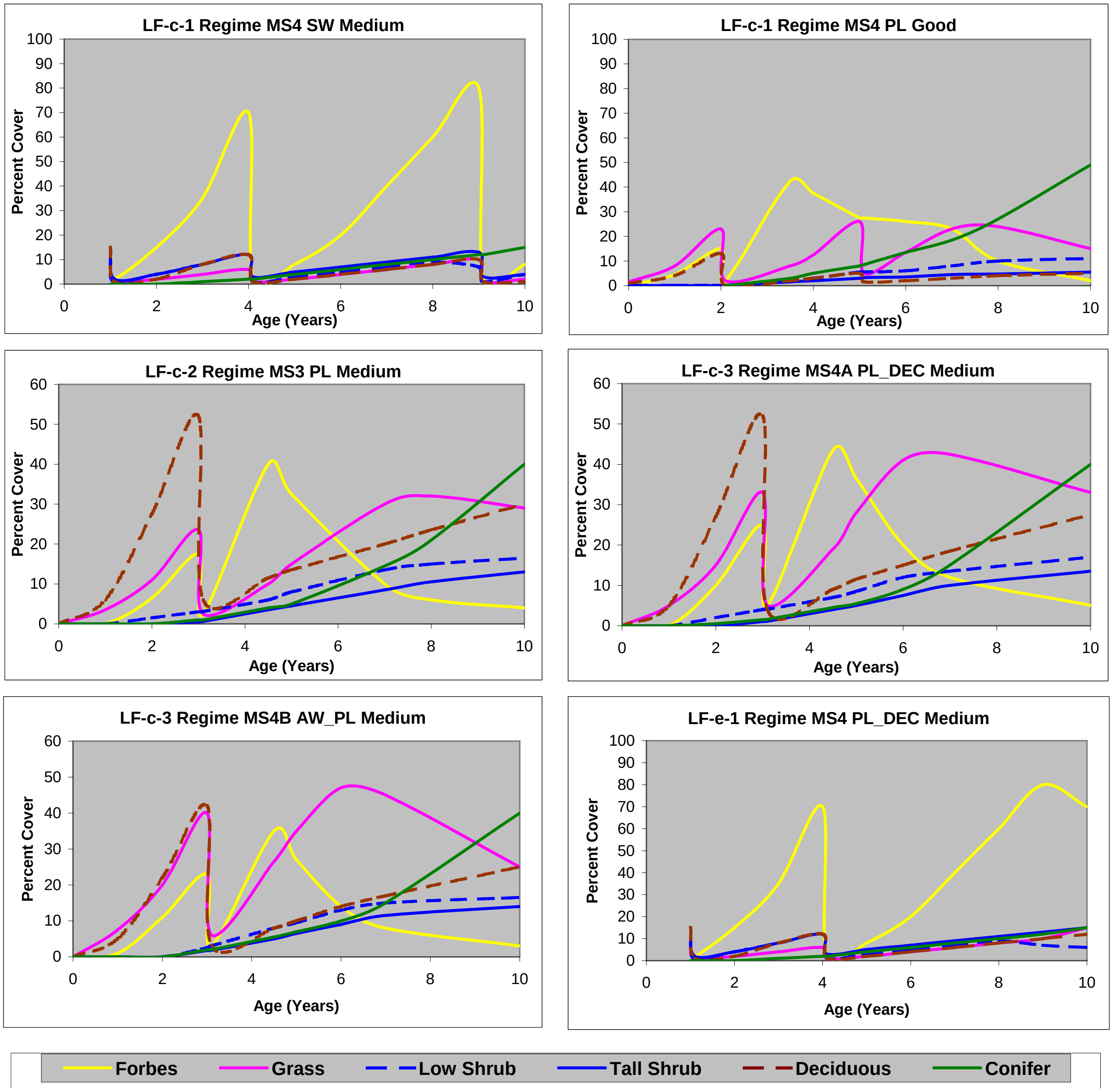

Figure 7. Lower Foothills plant community assembly diagrams.

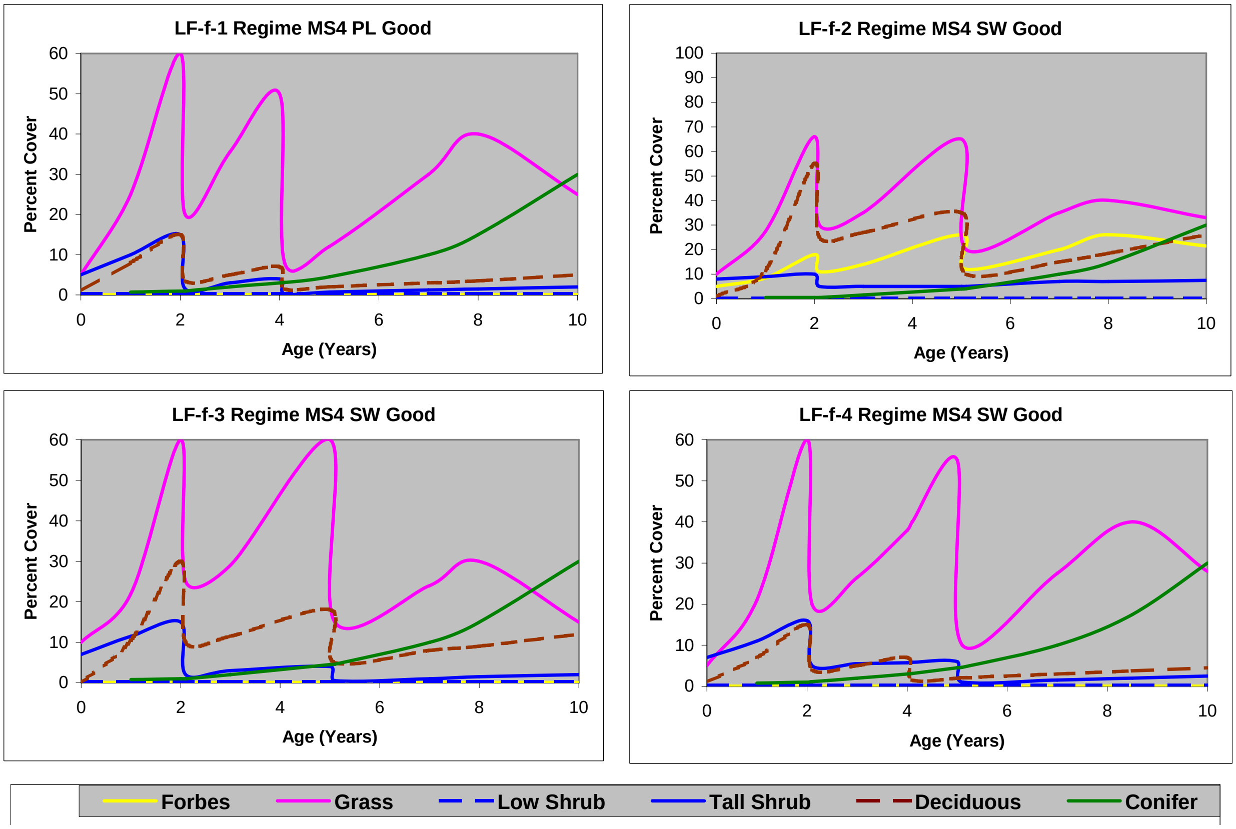

Figure 8. Lower Foothills plant community assembly diagrams - Continued.

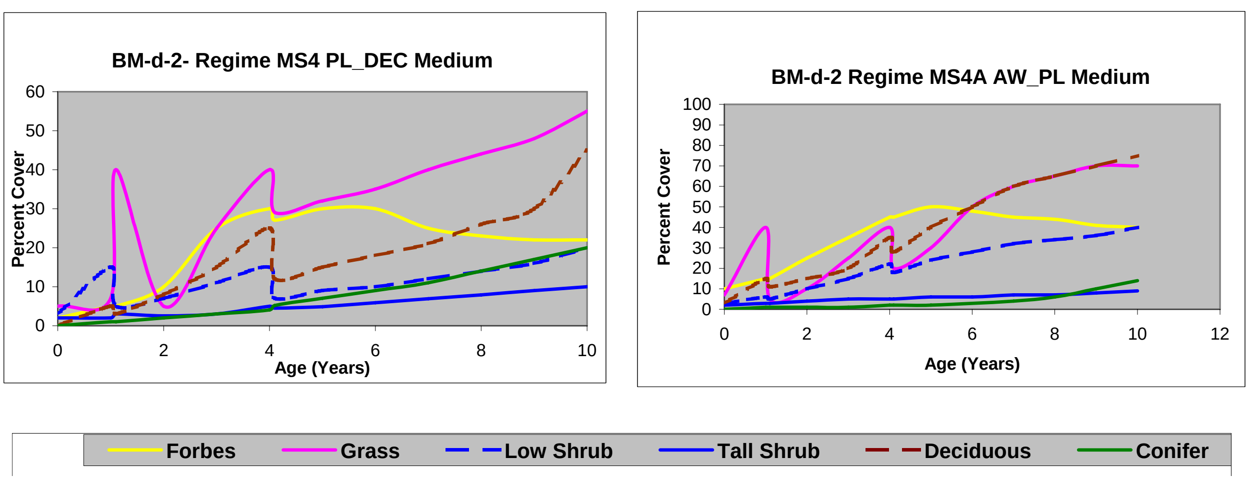

Figure 9. Boreal Mixedwood plant community assembly diagrams.

Note that BAP and FORWARD modelers used subsets of the plant community assembly diagrams as inputs to the modeling process. Further details can be found in the documentation for each of these models.

In a separate validation exercise Mark Dewey, Brian McDonald, and Milo Mihajlovich visited two sites where Mark had collected data for his undergraduate thesis at approximately years three or four in the plant community assembly process. These sites were now in year 10 or 11 and thus provided an opportunity to evaluate longer term projections made by the expert panel. Coniferous tree, low shrub, grass and forb cover values were very similar to those projected by the panel – unfortunately both sites had been brushed a year or two prior to assessment so tall shrub and deciduous tree projections could not be assessed. Furthermore, the motor manual treatment represented a substantial enough departure from the GER for the site type that the data collected could be deemed to be of indicator value only. (Note that the sites were on the Blue Ridge Lumber FMA area and therefore were not being managed as they would be at Millar Western).

Further validation of the plant community assembly diagrams will occur through collection of vegetation community data as part of the Permanent Sample Plot program.

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