



Appendix II. Growth & Yield Monitoring Plan

Introduction

The Growth & Yield Monitoring Plan has been developed in support of Objectives 22 and 25 of the Sundance Forest Management Plan. It is intended to provide information for the establishment of appropriate Annual Allowable Cuts and for demonstration that site productivity is being maintained. To optimize the time and effort required to maintain the program, it needs to be cost-effective, scientifically valid and consistent with assumptions used for timber supply analysis.

The goals adopted for this plan provide the basis for long term data collection and analysis that support timber supply modeling outputs. The goals are:

1. Estimate historical growth rates and succession on the Sundance FMA area at the forest and yield stratum level.
2. Validate yield curves for the Sundance FMA area and develop new curves, if necessary.

Data Sources

Alberta Vegetation Inventory (AVI)

A complete forest inventory, to Alberta Vegetation Inventory (AVI) standards has been prepared using aerial photography from 1989 and 1994. Land base deletions and the subsequent netdown have been completed to June 2005 for the timber supply analysis. The timber harvesting landbase has been divided into 8 yield strata, using the AVI information. Details on the stratification and other landbase attributes may be found in the Development of the Landbase section of the FMP.

Sundance PSP's

A total of 98 PSPs were established for the previous management plan. The plots were systematically positioned at township corners in four-plot clusters. Should harvesting occur on any of the PSP's, they will be re-established in the cutover areas. Where fire occurs, the plots will not be re-established. This allows for long term monitoring of the growth of managed stands. Three of the current permanent sample plots were established on cutover areas in the Sundance FMA area. Figure II-1 shows plot locations.

Data collection follows the protocol of Hinton Wood Products' Permanent Growth Sample Plot program (MCH Forestry Ltd. 2004) so that data may continue to be shared with that company. Plots 0.04 hectares in size are located 101.0 m at 45-degrees from cardinal directions from the cluster center. A 20 metre buffer is established around each plot.

Alberta Sustainable Resource Development PSP's

Alberta Sustainable Resource Development also has 20 permanent sample plots on the Sundance FMA area. Ten plots with four 202 m² to 2,023 m² sub-plots were established in 1976 and have had 2 re-measurements. One Spatial Data System plot was established in 1987. The remaining nine plots were established in 1990 and have been re-measured once by Sundance personnel. Locations of the plots are shown in Figure II-1.

Data collection is consistent with the Permanent Sample Plot Field Procedures Manual (Alberta Sustainable Resource Development 2005). Available information will be converted to a format compatible with the Sundance PSP data to allow for processing of all data together. Although there is a range of sizes, information will still be useable once it is converted to the Hinton Wood Products format.

Sundance TSP's

Temporary sample plot (TSP) data were collected during 1999 using a systematic grid. Sample points were selected using the Alberta Township System grid at the NW corner of sections 1, 5, 15, 25 and 29 in each township. A triangular transect, with each side 800 metres long, was placed at each grid point. Circular sample plots with regeneration subplots were established at 200 m intervals along the triangle, 12 plots per transects. This exercise provided 1,352 plots for analysis.

The systematic design of the TSP program did result in proportional representation of yield strata and age classes across the landbase. An additional 114 plots were surveyed in 2005 in older age class types to provide additional information for this FMP.

Growth & Yield Program Goals

The first goal of this growth and yield program is to estimate historical growth rates and succession on the Sundance FMA area at the forest and yield strata level. The information will be used to validate information generated by timber supply models and to improve modeling capabilities for land excluded from the timber harvesting landbase. Data from both Sundance and SRD permanent sample plots will be used to measure growth and succession.

Growth Rate on the FMA Landbase

To develop an unbiased estimate of the actual growth occurring on the Sundance FMA area, a grid of permanent sample plots has been established. Comparison of the average permanent sample plot (PSP) rate of growth over the forest harvesting landbase will result in an overall unbiased estimate of volume per hectare for the forested landbase. It will give an estimate of annual growth and the total growing stock and will provide a useful comparison to the annual allowable cut.

At the forest level, it is useful to have a general idea of overall productivity. This estimate helps to define the parameters within which a company operates by providing an overall validation of the yield prediction. Over time, permanent sample plot data will provide estimates of growth for each yield stratum. These estimates can be compared to those derived from temporary sample plot data. Where differences are evident, they will be investigated.



Ongoing research into the use of mixed effect models may result in repeat PSP measurements being used for yield curve development in the future.

Succession

Much of the Sundance landbase is forested but not available for timber production. The area is important for wildlife habitat and should be realistically modeled to help show the change in non-timber values over time. Mortality rates, which increase coarse woody debris and snags, and species composition need to be determined. By using Sundance and permanent sample plot data, it will be possible to monitor successional changes to be used in timber supply modeling. Prediction of habitat characteristics will also improve.

Death ages and succession patterns used in the timber supply analysis will be compared to permanent sample plot information, as it becomes available. Prior to a new timber supply analysis, PSP data will be compared to the assumptions used to see if they remain appropriate.

Validation of Yield Curves

The second goal of this growth and yield program is to validate yield curves on the Sundance FMA area and develop new curves, if necessary. Yield curves used in the current timber supply analysis for Sundance were developed primarily using temporary sample plot data from the Sundance FMA area. For yield classes where data sets were insufficient for model development, permanent sample plot data from the Hinton Wood Products FMA area were used.

Yield Strata Volumes

Volumes will be validated regularly to ensure that actual yields are comparable to predicted. Delivered volume will be compared to planned volume on a block-by-block basis annually. Over time, the delivered volume per hectare should be comparable to the predicted volume per hectare for each stratum. If individual strata are not giving accurate predictions, they will be checked and new curves will be developed, as required.

Managed Stand Performance

The adoption of Alternative Reforestation Standards for the Sundance FMA area have provided a mechanism to link reforestation to growth and yield. Ongoing work in the development of regeneration models will allow mean annual increment to be forecast for each opening that has a performance survey conducted. Performance of yield strata relative to existing yield curves and timber supply assumptions will be assessed in each timber supply quadrant. Early growth of managed stands will be measured as described in the Alternative Reforestation Standards (West Fraser Mills, ANC Timber & Sundance Forest Industries 2006) and future revisions. The data collected will also be used to refine reforestation models.

Data Requirements

Alberta Vegetation Inventory (AVI)

Sundance has committed to maintaining a forest inventory that is no more than 20 years old for timber supply analyses. In 2011, new photography will be collected for Compartments 19 to 24.

Additional inventory work will be done at the rate of approximately 30,000 hectares per year in the following years so that the existing inventory will be replaced by 2017.

Permanent Sample Plots

Permanent sample plots (PSP's) are an effective means of collecting growth information for a forest. However, they are very expensive to establish and maintain. In addition to the initial measurements and scheduled monitoring, they must be protected from disturbance by other activities that may affect the rates of growth of the plot trees until such time as they are harvested.

Individual plot clusters are assigned to either a 5-year or 10-year re-measurement cycle, depending on the rate of change between measurements. Existing Sundance plots that have been established in low productivity stands will be measured less frequently than those that are actively growing. A list of permanent sample plots and the associated measurement schedule is shown in Table II-1.

Given the increased emphasis on the prediction of managed stand growth, all future permanent sample plots will be established in cutover areas. To ensure that the locations and subsequent data are unbiased, a more intense grid has been established for new plots. The existing and proposed grids are shown in Figure II-1. When the new grid is overlaid on existing cutblocks and the spatial harvest sequence for the preferred forest management scenario, 29 additional cluster centres, representing an additional 116, plots are identified. The new locations are shown in Figure II-2.

As treatments continue to occur and a final yield stratum is not assigned until a performance survey has been completed, plots will be located in cutover areas that are more than 14 years past harvesting. Locations and dates for new permanent sample plots are shown in Table II-2.

The Sundance Pine Strategy includes a temporary increase in annual allowable cut with a focus on pine stands. This means that, in the short term, more new permanent sample plots will be established in the pine yield stratum. Once the total number of pine plots reaches 75, the need for some of the existing plots in mature timber will be re-assessed. At that time, measurements may be discontinued in some of the mature plots.

ASRD has no plans at present to establish any new permanent sample plots in the Sundance FMA area.

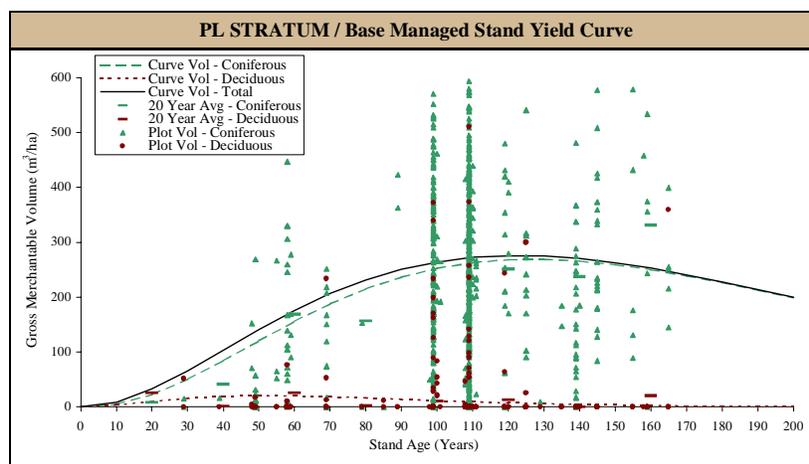




Table II-1 Existing Permanent Sample Plots

Line No.	Plot No.	Cluster Centre	Stratum	Origin Date	Estab.	1st Meas.	Next Meas.
10	01	Twp42 R17 NW	PL	1890	2001	2007	2017
10	02	Twp42 R17 NW	PL	1890	2001	2007	2017
10	03	Twp43 R17 SW	PL	1890	2001	2007	2017
10	04	Twp43 R17 SW	PL	1890	2001	2007	2017
10	05	Twp42 R19 NW	PL	1880	2001	2007	2017
10	06	Twp42 R19 NW	PL	1880	2001	2007	2017
10	07	Twp43 R18 SW	PL	1890	2001	2007	2017
20	01	Twp44 R16 SW	PL	1890	2001	2006	2016
20	02	Twp44 R16 SW	PL	1890	2001	2006	2016
20	03	Twp44 R16 SW	PL	1890	2001	2006	2016
20	04	Twp44 R16 SW	PL	1890	2001	2006	2016
20	05	Twp44 R17 SW	PL	1900	2001	2006	2016
20	06	Twp44 R17 SW	PL	1900	2001	2006	2016
20	07	Twp44 R17 SW	SW	1900	2001	2006	2016
20	08	Twp44 R18 SW	PL	1890	2001	2006	2016
30	01	Twp45 R13 SW	SB	1900	2000	2005	2015
30	02	Twp45 R13 SW	LT	1930	2000	2005	2015
30	03	Twp45 R14 SW	SB	1910	2000	2005	2015
30	04	Twp45 R14 SW	SB	1910	2000	2005	2015
30	05	Twp45 R15 SW	SB	1900	2001	2006	2016
30	06	Twp45 R15 SW	SB	1900	2001	2006	2016
30	07	Twp45 R15 SW	AS	1900	2001	2006	2011
30	08	Twp45 R15 SW	AS	1900	2001	2006	2011
30	09	Twp45 R16 SW	PL	1890	2001	2006	2011
30	10	Twp45 R16 SW	PL	1890	2001	2006	2011
30	11	Twp45 R16 SW	SB	1890	2001	2007	2016
30	12	Twp45 R16 SW	PL	1890	2001	2006	2011
30	13	Twp45 R17 SW	SB	1890	2000	2005	2015
30	14	Twp45 R17 SW	SB	1890	2000	2005	2015
30	15	Twp45 R17 SW	SB	1890	2000	2005	2015
30	16	Twp45 R17 SW	SB	1890	2000	2005	2015
40	01	Twp46 R12 SW	PA	1890	1999	2004	2009
40	02	Twp46 R12 SW	PA	1890	1999	2004	2009
40	03	Twp46 R12 SW	SB	1890	1999	2004	2009
40	04	Twp46 R12 SW	PA	1890	1999	2004	2009
40	05	Twp46 R13 SW	PL	1941	1999	2004	2009
40	06	Twp46 R13 SW	PL	1941	1999	2004	2009
40	07	Twp46 R13 SW	PL	1941	1999	2004	2009
40	08	Twp46 R13 SW	PL	1941	1999	2004	2009
40	09	Twp46 R14 SW	PA	1900	1999	2004	2009
40	10	Twp46 R14 SW	PL	1900	1999	2004	2009
40	11	Twp46 R14 SW	PA	1900	1999	2004	2009
40	12	Twp46 R14 SW	PA	1900	1999	2004	2009
40	13	Twp46 R15 SW	PL	1900	1999	2004	2009
40	14	Twp46 R15 SW	PA	1900	1999	2004	2009
40	15	Twp46 R15 SW	PA	1900	1999	2004	2009
40	16	Twp46 R15 SW	PA	1900	1999	2004	2009
40	17	Twp46 R16 SW	PL	1890	1999	2004	2009
40	18	Twp46 R16 SW	PL	1890	1999	2004	2009
40	19	Twp46 R16 SW	PL	1890	1999	2004	2009
40	20	Twp46 R16 SW	PL	1890	1999	2004	2009
40	21	Twp46 R17 SW	PL	1996	2000	-	2010
40	22	Twp46 R17 SW	PL	1996	2000	-	2010
40	23	Twp46 R17 SW	PL	1996	2000	-	2010
40	24	Twp46 R17 SW	PL	1890	2000	2005	2010
40	25	Twp46 R18 SW	PL	1890	2000	2005	2010
40	26	Twp46 R18 SW	PL	1890	2000	2005	2010
40	27	Twp46 R18 SW	PL	1890	2000	2005	2010
40	28	Twp46 R18 SW	PL	1890	2000	2005	2010
40	29	Twp46 R19 SW	PL	1860	2000	2005	2015
40	30	Twp46 R19 SW	SB	1860	2000	2005	2015
40	31	Twp46 R19 SW	PL	1860	2000	2005	2015
40	32	Twp46 R19 SW	PL	1860	2000	2005	2015
50	01	Twp46 R14 NE	SB	1890	2000	2005	2015
50	02	Twp46 R15 NE	DEC	1890	1999	2004	2009
50	03	Twp46 R15 NE	DEC	1890	1999	2004	2009
50	04	Twp47 R14 SW	AP	1890	1999	2004	2009
50	05	Twp46 R16 NE	PL	1900	1999	2004	2009
50	06	Twp46 R16 NE	PL	1900	1999	2004	2009
50	07	Twp47 R15 SW	PL	1900	1999	2004	2009
50	08	Twp47 R15 SW	PL	1991	1999	2004	2009
50	09	Twp47 R16 SW	PL	1890	1998	2003	2013

Table II-2 Planned Permanent Sample Plots

Cluster Centre		Stratum	Harvest Date	Planned Estab.
Easting	Northing			
527858	5932512	PA	1994	2009
527858	5932512	PA	1994	2009
527858	5932512	PA	1994	2009
527858	5932512	PA	1994	2009
550455	5859973	PL	1995	2010
550455	5859973	PL	1995	2010
550455	5859973	PL	1995	2010
550455	5859973	PL	1995	2010
550504	5855106	PL	1997	2012
550504	5855106	PL	1997	2012
550504	5855106	PL	1997	2012
550504	5855106	PL	1997	2012
560155	5864930	PL	1998	2013
560155	5864930	PL	1998	2013
560155	5864930	PL	1998	2013
560155	5864930	PL	1998	2013
560172	5860136	DEC	1999	2014
560172	5860136	DEC	1999	2014
560172	5860136	DEC	1999	2014
560172	5860136	DEC	1999	2014
569833	5869926	SW	1999	2014
569833	5869926	SW	1999	2014
569833	5869926	SW	1999	2014
569833	5869926	SW	1999	2014
545575	5859920	PL	2003	2018
545575	5859920	PL	2003	2018
545575	5859920	PL	2003	2018
545575	5859920	PL	2003	2018
535887	5850125	PL	2004	2019
535887	5850125	PL	2004	2019
535887	5850125	PL	2004	2019
535887	5850125	PL	2004	2019
549001	5879356	PL	2006	2021
549001	5879356	PL	2006	2021
549001	5879356	PL	2006	2021
549001	5879356	PL	2006	2021
530902	5864648	PL	2007	2022
530902	5864648	PL	2007	2022
530902	5864648	PL	2007	2022
530902	5864648	PL	2007	2022
539204	5879265	PL	2007	2022
539204	5879265	PL	2007	2022
539204	5879265	PL	2007	2022
539204	5879265	PL	2007	2022
540654	5864723	PL	2007	2022
540654	5864723	PL	2007	2022
540654	5864723	PL	2007	2022
540654	5864723	PL	2007	2022
540694	5859879	PL	2007	2022
540694	5859879	PL	2007	2022
540694	5859879	PL	2007	2022
540694	5859879	PL	2007	2022
550353	5869682	PL	2007	2022
550353	5869682	PL	2007	2022
550353	5869682	PL	2007	2022
550353	5869682	PL	2007	2022
560035	5874623	PL	2007	2022
560035	5874623	PL	2007	2022
560035	5874623	PL	2007	2022
560035	5874623	PL	2007	2022
560095	5869795	PL	2008	2023
560095	5869795	PL	2008	2023
560095	5869795	PL	2008	2023
560095	5869795	PL	2008	2023
513115	5927631	SA	2009	2024
513115	5927631	SA	2009	2024
513115	5927631	SA	2009	2024
513115	5927631	SA	2009	2024
550404	5864817	PL	2009	2024
550404	5864817	PL	2009	2024
550404	5864817	PL	2009	2024
550404	5864817	PL	2009	2024



Growth & Yield Plots

The Foothills Growth & Yield Association has a number of studies underway to monitor the response of lodgepole pine cutovers to different densities, competition levels and nutrition. This information will be used in the future to guide the establishment of new permanent sample plots and to adjust existing yield curves.

Establishment Surveys

As of May 1st 2007, all establishment surveys on the Sundance FMA area were required to be completed to the Alternative Reforestation Standard. This will provide data for use in modeling and model validation. Quota holders are subject to this requirement, as are individuals and/or agencies conducting surveys on lands harvested under the authority of Commercial Timber Permits.

Performance Surveys

As of May 1st 2006, all performance surveys on the Sundance FMA area were required to be completed to the Alternative Reforestation Standard. Quota holders have been given responsibility for performance surveys on cutblocks harvested in 1995 and later.

Sundance TSP's

Temporary sample plot (TSP) data will be collected, if required, for the preparation of new yield curves for the 2017 Forest Management Plan. Data collected will include GPS plot locations to enable a spatial linkage to AVI and the net landbase.

Monitoring and Reporting

Monitoring of a growth and yield program is a broad-level check that takes place over an extended period of time. It is an independent validation that includes an evaluation of the assumptions used in model development e.g. green-up periods or early growth. Data will be required from Sundance, the embedded disposition holders and from Alberta Sustainable Resource Development in order to monitor this growth and yield program.

Long term monitoring at the forest level will involve confirmation that the assumptions used in timber supply modeling are appropriate. Data collected from managed stands through permanent and temporary sample plots will provide volume information to confirm the validity of minimum harvest ages, clearcut eligibility and regenerated stand density assumptions. Should the data collected show that the assumptions used are not appropriate, they will be changed.

Implementation and Maintenance

Although forest inventories, yield curve development and timber supply analyses are completed only periodically, maintenance of an effective growth and yield program requires ongoing work. Effective implementation and maintenance of this program by Sundance, quota holders and Alberta Sustainable Resource Development personnel will be required over time to ensure that data are collected and that models are updated.

Sundance has made a commitment to maintain a forest inventory that is no more than 20 years old. The next set of photos will be required in 2009 for those parts of the landbase within the Foothills Area.

Permanent sample plots have been set on a staggered 5-year or 10-year re-measurement schedule with a portion of them being visited each year. Alberta Sustainable Resource Development plots are on a 10-year re-measurement schedule.

Establishment and performance survey data will be collected for Sundance cutblocks as well as for the embedded dispositions.

Table II-3 Growth & Yield Program Implementation and Maintenance Schedule

Plan Component	Activity	Date	Responsibility
Alberta Vegetation Inventory	Re-inventory Compartments 19-24	2011	Sundance
	Re-inventory 30,000 ha.	annually, 2011 - 2017	Sundance
Sundance PSP's	Establish new PSP's	ongoing	Sundance
	Re-measure existing PSP's	ongoing	Sundance
SRD PSP's	Re-measure existing PSP's	ongoing	SRD
Growth & Yield Plots	plot re-measurement	ongoing	Foothills Growth & Yield Association
Establishment Surveys	survey regenerating openings and provide data	ongoing	Sundance, SRD, quota holders
Performance Surveys	survey regenerating openings and provide data	ongoing	Sundance, SRD, quota holders

Reporting

A reporting framework is currently in place for Sundance to provide information on the company's activities to the Alberta Sustainable Resource Development. Every five years, a Stewardship Report is prepared that assesses the company's performance relative to FMP targets. It is intended that progress in implementation of the Growth & Yield Program will be included in the existing reports in order to keep relevant information consolidated. When a detailed study or review is completed, results will be submitted separately with an overview included in the Stewardship Report.

As the Sundance FMA area is one landbase, it is essential that silvicultural operations conducted by the imbedded disposition holders be consistent with the approved Sundance Forest Management Plan, the Sundance Timber Harvest Planning and Operating Ground Rules as well as the Alternative Regeneration Standards. Ongoing cooperation of all parties and regular review by Sundance and SRD staff will help to ensure that this growth and yield program provides timely, useful information for management of the Sundance Forest Management Agreement area.



Figure II-1 Proposed Permanent Sample Plot Grid

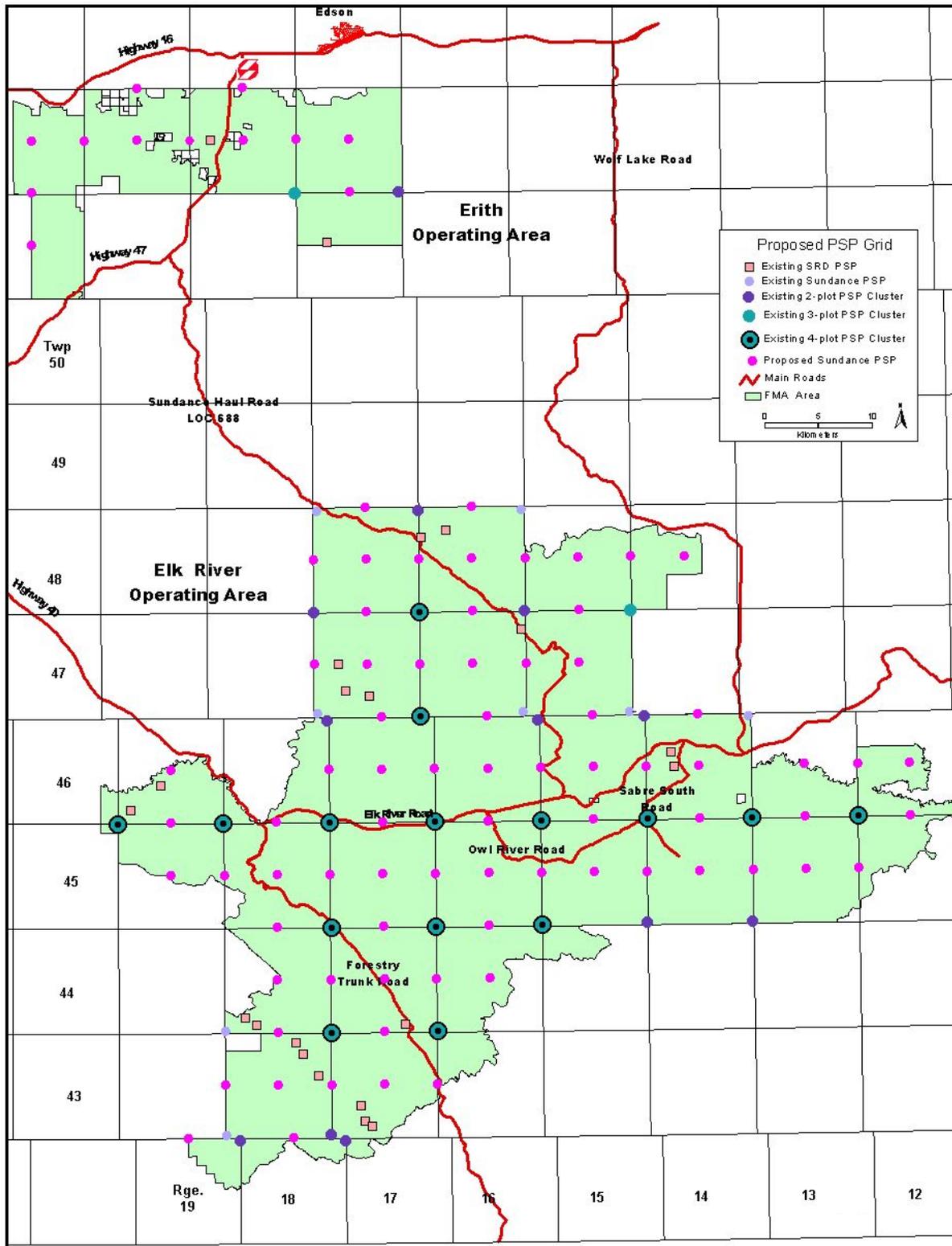
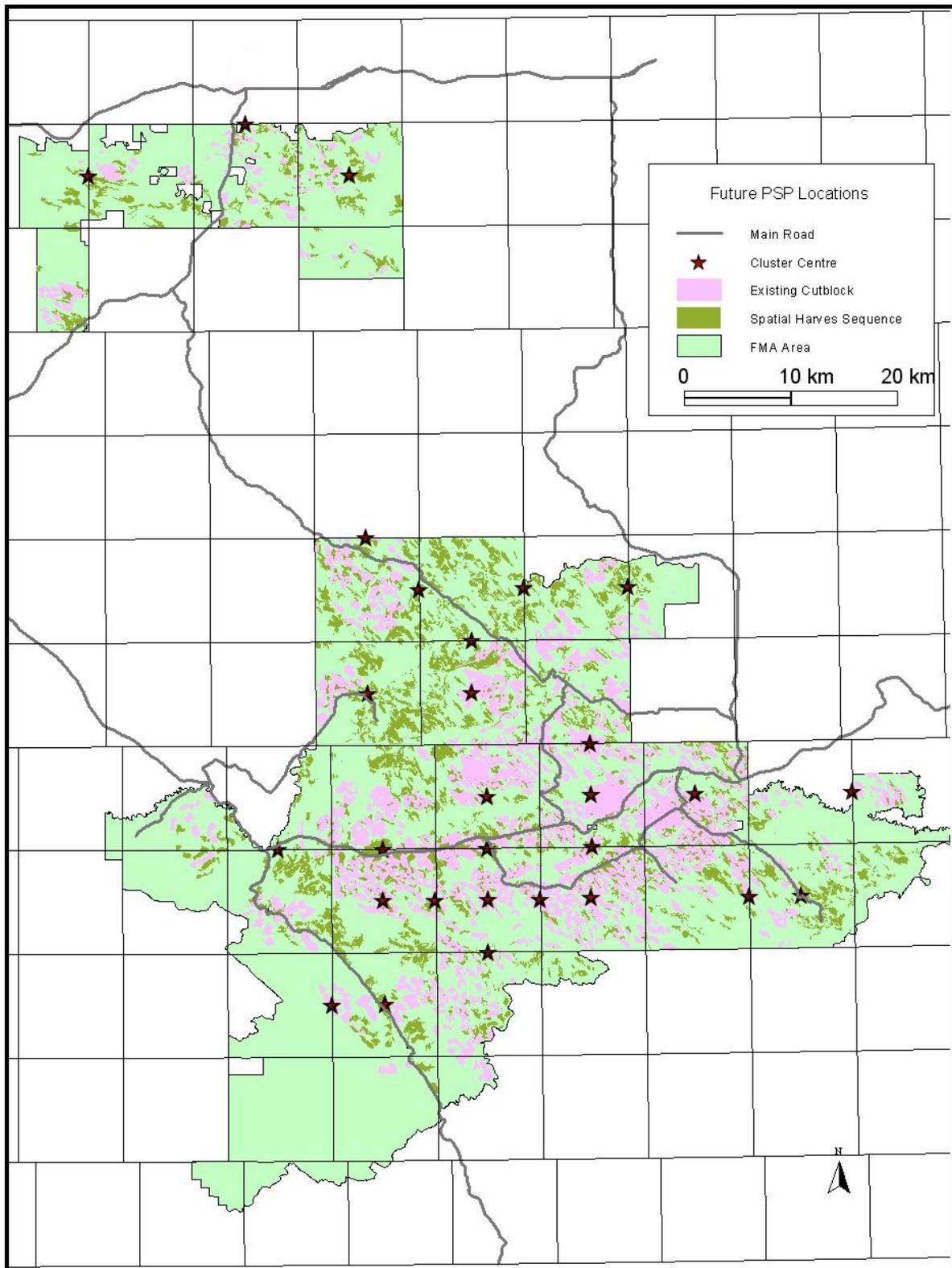


Figure II-2 Future Permanent Sample Plot Locations





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