Final Report: ECA –Water Yield Response Pembina Forest Management Area
Weyerhaeuser Canada, Edson/Drayton Valley Divisions

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Swartz Creek Monitoring Site - South of Edson

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Executive Summary

The hydrologic effects of forest harvesting and watershed disturbance in the Drayton Valley Forest and Edson Forest of Weyerhaeuser Canada's Pembina Forest Management Area were assessed using the ECA-AB model.

A hydrologic land base was developed for each forest with 55 small to modest sized watersheds in each Forest. Hydrologic inputs of annual water yield and annual precipitation were estimated for each forest using data available from Water Survey of Canada and the Meteorological Branch of Environment Canada. Harvest inputs in terms of watershed size, harvest block size, year of harvest, and species were supplied by Weyerhaeuser Canada and prepared for input by Timberline.

Simulation results reported for each watershed included percent increases in maximum annual water yield, maximum watershed ECA, and decadal water yield and watershed ECA and hydrologic recovery in years. Simulations were run for 150 years starting with the first year of cut for a watershed as defined by the spatial harvest sequence for each forest. Harvesting started in 2004 and ended around 2064-2066. Graphs of hectares cut per year, annual water yield increases and decadal water yield increase and watershed ECA were done for each watershed.

Drayton Valley Forest

Maximum annual water yield increase in the Drayton Forest ranged from < 1% - 25%. Water yield responses less than 1% were considered "unharvested". Average water yield increases for all watersheds was 8%. Average area harvested in all watersheds ~ 28%, with a maximum of 72%. Watershed disturbance as measured by %ECA ranged from < 1% - 45% . Average %ECA for all watersheds with values > 1% was 17%. Median %ECA among the 55 watersheds was ~ 11%. The maximum annual water yield increase in Stevens Creek (25%) corresponded to a %ECA of 8%.

Decadal water yield increases for the forest as a whole (i.e. average of all watersheds) showed a low response with decadal values varying 2.4 - 4.4%. Average decadal %watershed ECA followed a similar pattern with values ranging from 4.6-10.7%. These low values represent "average conditions" which was a mix of watersheds ranging from newly harvested to well advanced towards hydrologic recovery. At the watershed level disturbance was more variable with decadal water yield increases and %ECA ranging from 13-19% and 29-43% respectively.

Hydrologic recovery was defined to occur when increased water yields were ≥ 5%. Hydrologic recovery in the Drayton Forest varied from 0 to 58 years, with an average of 19 years. Hydrologic recovery in 28 watersheds was zero because of low levels of harvesting and low water yield responses.

Edson Forest

Maximum annual water yield increases in the Edson Forest ranged from < 1% to a maximum of 21% in Granada Creek. Average water yield increase for all watersheds was 7%. Maximum annual increases in water yield followed an increasing trend similar to that in the Drayton Forest. Harvesting in 4 watersheds with increases > 15% averaged 60%, with minimum and maximum values of 53% and 80%. The average area harvested in all watersheds was 25%, with minimums less than 1% and a maximum of 80%.

Watershed disturbance ranged from < 1% - 41%. Average %ECA for all watersheds with water yields > 1% was 14%. Median %ECA was 13%. The maximum annual water yield increase of 21% corresponded to a %ECA of ~ 10%.

Hydrologic recovery in the Edson Forest varied from 0 to 42 years, with an average time of 14 years. Hydrologic recovery was zero in 28 watersheds because of low levels of harvesting and lower water yield responses (i.e. < 5%).

Decadal water yield increases and %ECA in the Edson Forest was similar to those in the Drayton Valley Forest. At a landscape scale (i.e. average of all watersheds) responses were low. Average decadal water yield and % ECA ranged from 3.2%-4.4% and 4.8- 11.5% respectively. At the watershed scale responses were higher with maximum watershed values varying from 8.%-15% and 9-39% respectively.

In conclusion, simulated water yield increases in the Drayton Valley and Edson forests varied from nil to modest. Water yield increases in 85-95% of the watersheds in the Pembina FMA were less than 15%. Water yields resulting from these increases are expected to have recurrence interval of ~ 3 years and to fall within the range of variability defined by their mean water yield ± 0.3 standard deviation. Water yields resulting from increases greater than 15% are expected to be ~ 4 years and to fall within the range of variability defined by their mean water yield ± 0.5 standard deviation. Change in the frequency of occurrence for increased water yield would be ~ 25 years.

Increases in water yield in both forests will be elevated above average conditions for short periods of time, assuming prompt regeneration that allows hydrologic recovery. The magnitude of changes will decrease with time being faster in watersheds with low responses and slower in watersheds with high responses. Significant changes in stream channel morphology and aquatic habitats are not anticipated. Large changes in peak flow events, which are not addressed in this assessment, are not expected. Recent literature suggests that sustained increases > 50% in bankfull discharge, which is defined equivalent to the 1.5-2 year recurrence intervals for peak flows, can contribute to permanent changes in stream channel morphology and aquatic habitat (Guillemette et al 2005: Verry 2004). Such changes are not anticipated to occur as a result of the proposed harvest assessed in this report.

Simulations indicate maximum annual water yield responses in the next 15 years will occur in 6 of 55 watersheds in the Drayton Forest and 12 of 55 watersheds in the Edson Forest. The increases during this period will be higher than the overall average for all watersheds, but are still in an acceptable range. Average maximum increase in water yield for 2008-2003 in the Drayton Forest is 16% with a maximum value of 25% (n= 6). In the Edson forest the average maximum water yield increases is 13% with a maximum of 21% (n=12). Higher responses probably should be expected given the objective of reducing pine content as a measure to slow or reduce the potential for mountain pine beetle attack in the region.

In summary:

- Maximum increases in annual water yield increases varied from minimums less than 1% to maximums of 20-25%.
- Watersheds with water yield increases <1% were considered unharvested.
- Water yield increases were greatest in watershed with high levels of harvesting.
- Percent area harvested in watersheds with water yield increases >15% ranged from 40-80%.
- Percent watershed ECA in both FMAs ranged from <1% up to maximums of 41-45%.
- Average watershed ECA in the Edson and Drayton Valley Forests was 14% and 17% respectively.
- Average decadal changes in water yield increases and %ECA indicated a low to modest response to forest harvesting at the FMA or landscape scale.
- Maximum decadal changes in water yield and %ECA indicated periodic increases generated by forest harvesting at the watershed level followed by periods of less harvesting, allowing for hydrologic recovery.
- Hydrologic recovery, measured from the time of maximum annual water yield increase in the Drayton Valley and Edson forests varied from 0-58 and 0-42 years respectively.
- Maximum increases in water yield are expected to be short in duration and not result in significant changes in stream channel morphology and aquatic habitats.

- **DISCLAIMER**

The assessment of hydrological impacts of harvesting presented in this report reflects the output from hydrologic simulation models and does not necessarily reflect actual impacts that may be observed. Ultimately, the reliability of estimates produced using ECA-AB and other hydrological models depends on the availability of representative climatic/hydrometric data, and regional forest growth and yield data, and harvesting plans. In this context, Watertight Solutions has evaluated the hydrometric data used in this analysis and considers these data to be a reliable reflection of hydrologic conditions for the analysis. Limitations or errors due to deviation in actual forest growth rates from provincial average growth rates or limitations imposed by spatial/temporal scale of analysis are outside the author's control. In particular, the spatial distribution of harvested blocks, as well as the presence of additional disturbances (fire, insects, etc.) will also affect water yields.

Furthermore, it is re-emphasized that the ECA-AB model projects average annual water yield changes over time based on un-routed flow (generated runoff), assuming average climatic/hydrologic conditions in the region and the rate of stand regeneration. Therefore, changes in annual water yield due to disturbance will vary from simulations based on the actual variability in climate and the degree of departure from average climatic conditions.

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Introduction

The hydrologic effects of forest harvesting on water yield and watershed disturbance in Weyerhaeuser Canada's Pembina Forest Management Area was assessed using the ECA-AB model (Silins 2000).

Methods

Data requirements and inputs for ECA-AB are outlined in Table 1.

Table 1 Data requirements for ECA AB

Watershed Area (hectares)	*Source*
Harvest Block Areas (hectares)	*Timberline*
Species Coding for each Stand (harvest block)	
Site Quality (good, medium, fair)	
Year of Harvest for each Stand (harvest block)	
Average Annual Precipitation (millimeters)	*Watertight Solutions*
Average Annual Water Yield (millimeters)	
Age at Full Hydrologic Utilization (Rotation) White spruce 120, Block spruce 120, Lodgepole pine 80, Hardwoods 60 years	
Regeneration Lag 0 years	
Simulation Period 150 years	

Average precipitation and water yield for each watershed was estimated from isolines for the forest management area (FMA) (Figure 1, 2). Long term average precipitation and water yield data from Environment Canada (2002, 2003) were used to build isolines for precipitation and water yield.

Percent watershed ECA for each watershed was based on basal area growth. Total watershed area was used for each ECA calculation. This included areas within and outside of FMA boundaries (Figure 1, 2). This approach was taken at it expresses the amount of disturbance within each watershed attributable to timber harvesting conducted by Weyerhaeuser Canada. The effects of other land uses and disturbances (e.g. oil and gas development, roads) within each watershed were not included in these calculations.

Percent increase in water yield within the ECA-AB model is obtained by expressing the extra water generated by harvesting (i.e. reduction of evapotranspiration) as a percent of the average annual water yield for a watershed. Percent water yield increases therefore will tend to be smaller in areas of high water yield and greater in areas of low water yield.

Hydrologic recovery, the time for increased water yield to return to pre-disturbance levels, was assumed to occur when increases were $\leq$ 5%. This was used as basal area is a conservative estimator of hydrologic recovery. The $\leq$ 5% assumption was judged to provide a more realistic estimate of hydrologic recovery (i.e. time for maximum leaf area recovery = full recovery of evapotranspiration). Hydrologic recovery at the watershed level however can be sustained or delayed if harvesting is continuous (i.e. no temporal break to allow recovery).

Results

Hydrologic Land Base

A hydrologic land base for the Drayton Valley and Edson forests was created to identify watersheds that could be affected by forest harvesting activities. The land base includes watersheds fully within each FMA and those that extend beyond the boundaries of the FMAs (Figures 1, 2). Average watershed size in the FMA was173.6 km^2 with minimum and maximum of 11.4 and 717.7 km^2 . The average percent watershed area harvested was 23.5% with a maximum of 80% and minimums of < 1%. Watersheds with < 1% harvesting were classed as unharvested.

Isolines for precipitation ranged from 500 mm at the eastern boundary up to a maximum of 600 mm at the western edge in intervals of 50 mm. Isohyets for water yield varied from 100 mm to 225 mm in intervals of 25 mm. Values assigned to each watershed were visually estimated using the isolines as guides (Appendix 1). Following initial simulations adjustments were made to some individual watersheds where estimated water yield increases were considered unrealistic. Adjustment was done by comparing water yield increases to the difference between precipitation and a regional evapotranspiration (i.e. Q = P – ET).

Figure 1 Hydrologic Land Base for Pembina Forest Management Area with isolines for precipitation.

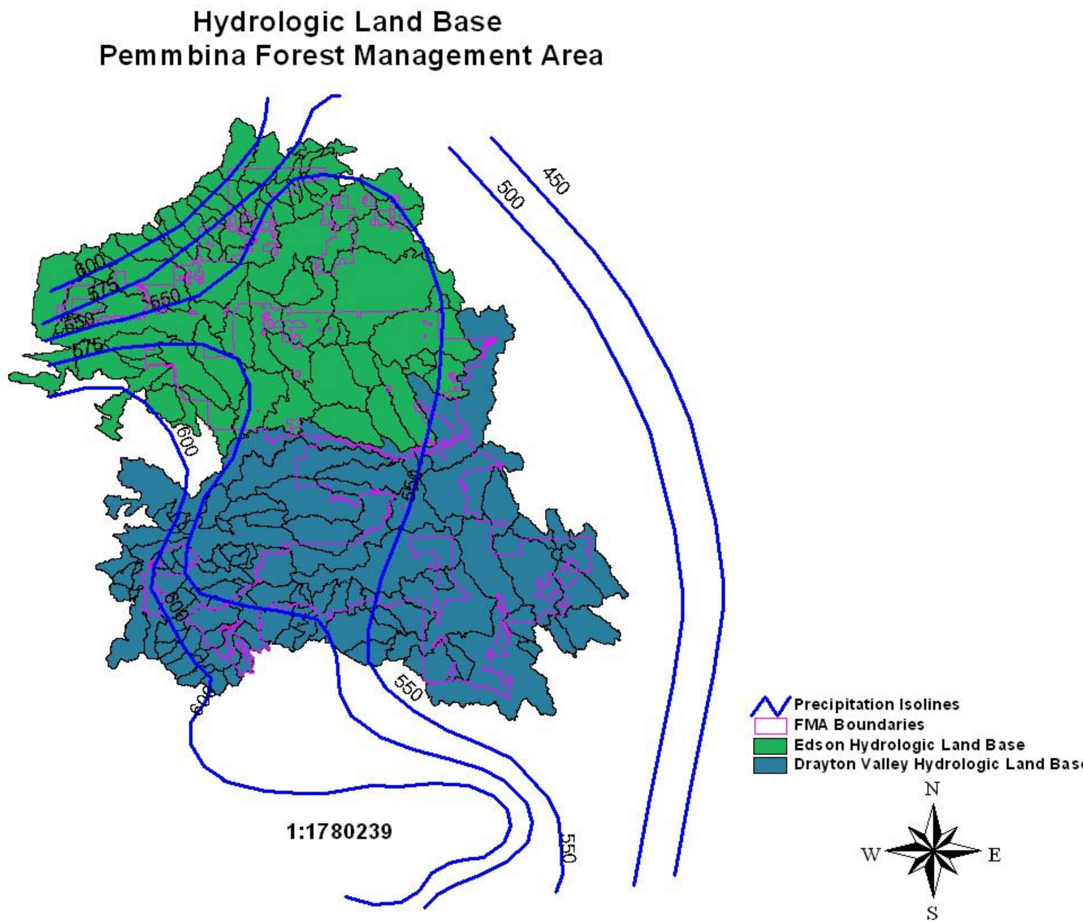
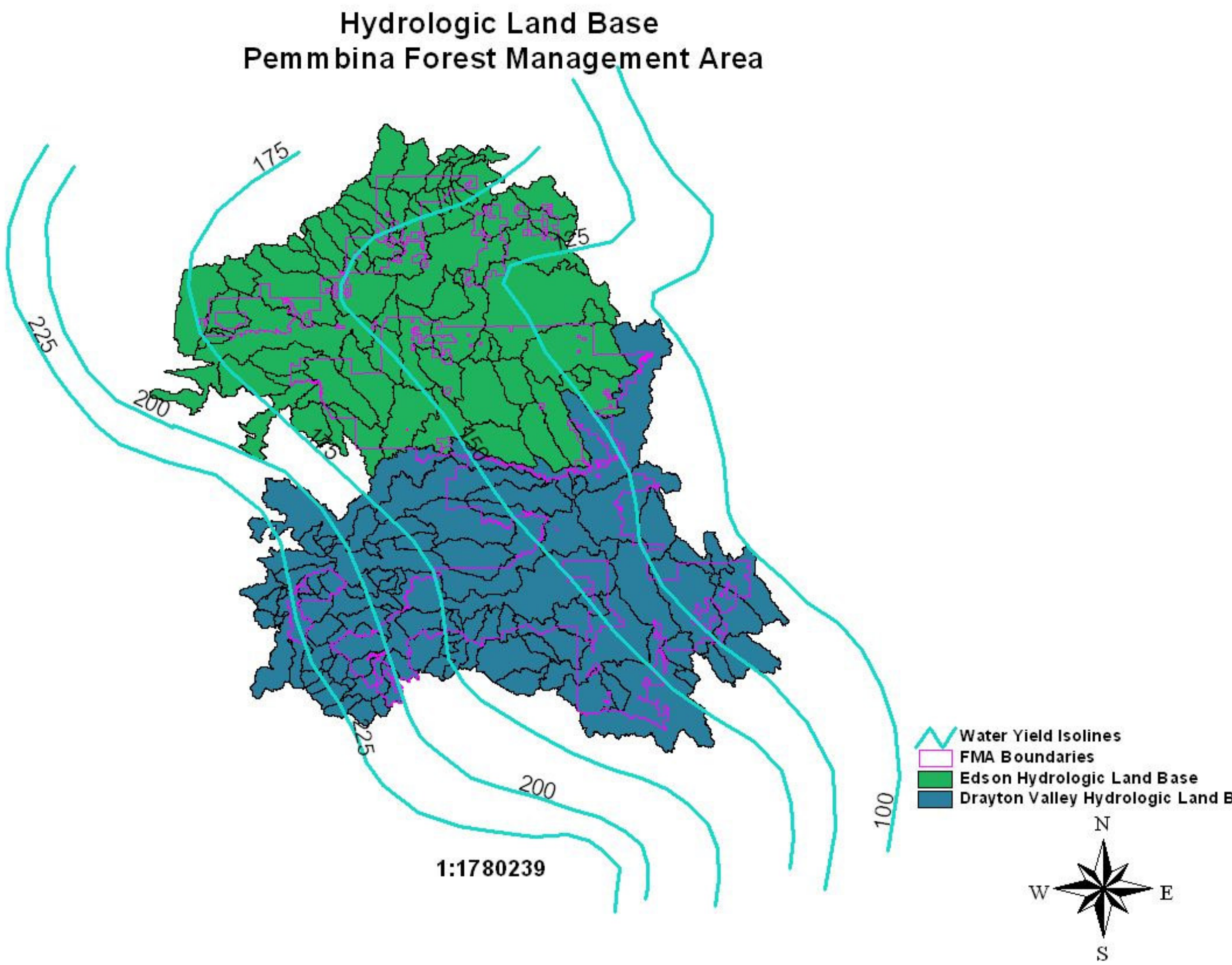


Figure 2 Hydrologic Land Base for Pembina Forest Management Area with isolines for water yield.

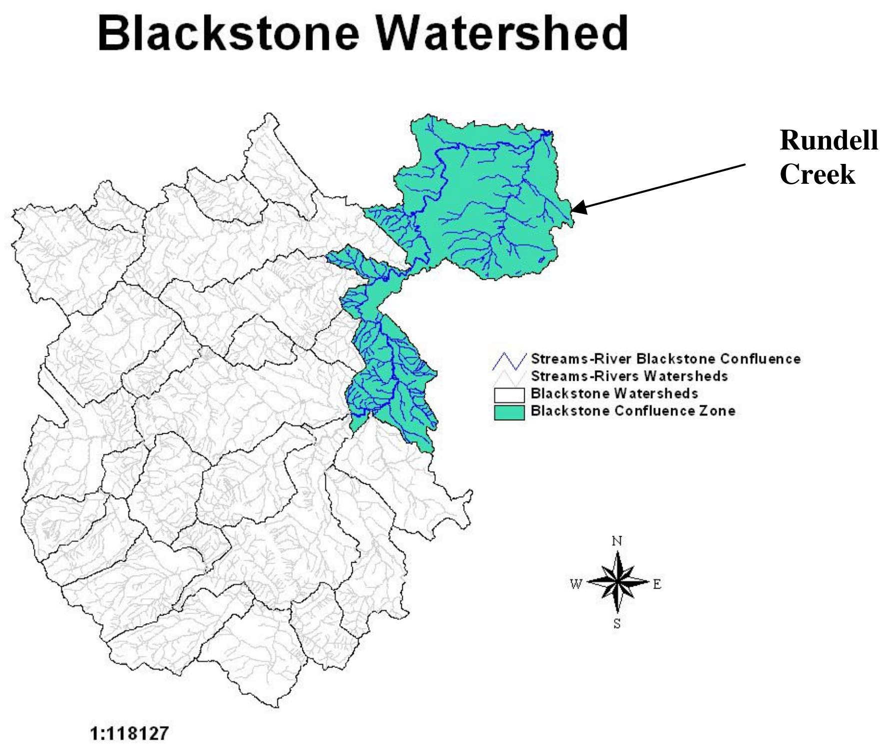


Two hydrologic units were defined in the hydrologic land base: watersheds and confluence areas. Watersheds are natural drainage areas defined by topographic boundaries that identify the height of land and a single outlet or intersection with a larger order stream. Confluence areas are zones that cannot be described by topographic boundaries as done for watersheds. Confluence areas usually occur in the bottom of major valleys and parallel the main watercourse usually with numerous small 1st - 2nd order tributaries.

An example of watersheds and confluences is shown in Figure 3 for the Blackstone River. The area in white represents watersheds for which boundaries and an outlet can be defined. The area in green is a confluence zone which contains numerous small watersheds, but as a single unit cannot be easily defined as a watershed, without including all of the upstream watersheds.

Some adjustments and boundary corrections need to be made for watersheds and confluence zones in the hydrologic land base. For example, Rundell Creek is included in the Blackstone Confluence Zone. Rundel should be identified as a separate watershed.

Figure 3 Watersheds and confluence zone for Blackstone watershed. The confluence zone needs to be corrected with the removal of Rundel Creek.



Drayton Valley Forest

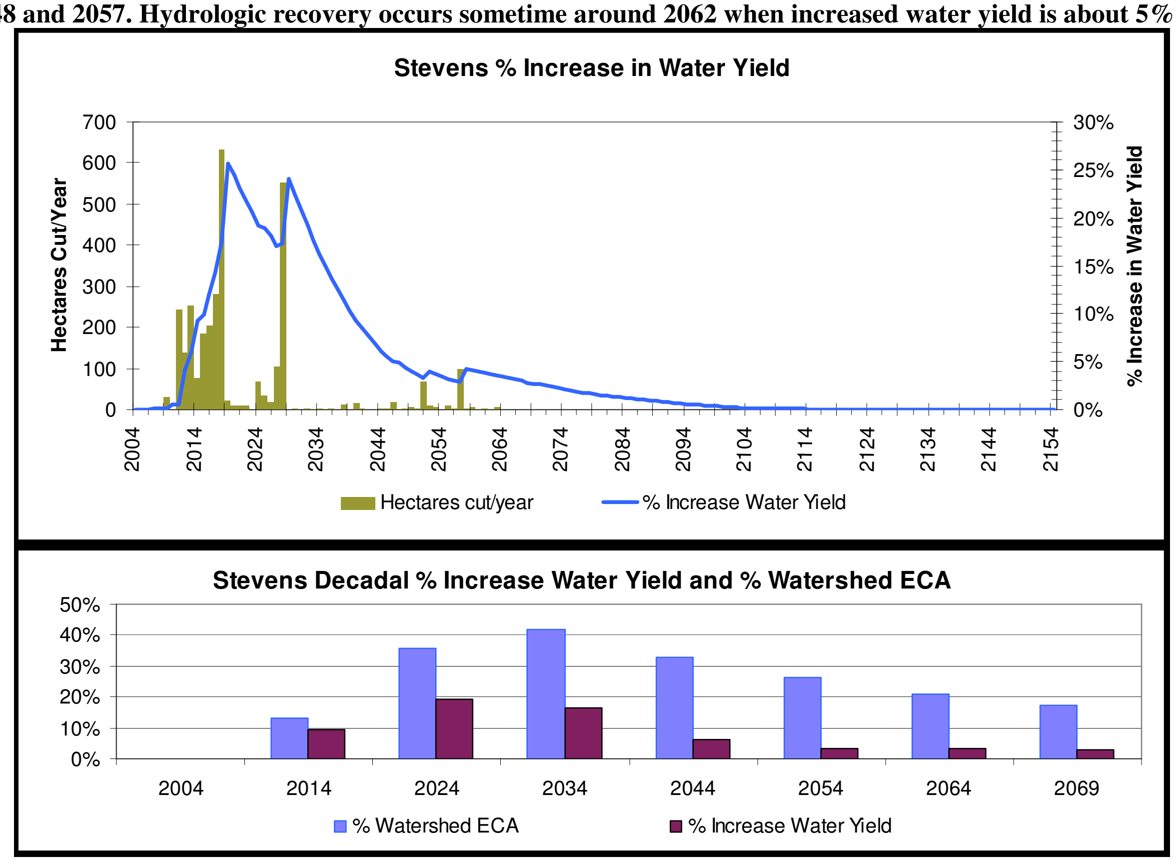
Maximum Annual Water Yield Increases

An example of the general pattern for water yield responses is shown in Figure 4. Water yield from the start of each watershed simulation shows a steady increase with the advance of forest harvesting, with maximum increases in water yield usually coinciding with peaks in the rate of harvesting or the cessation of harvesting. More than one peak in water yield is possible if forest harvesting is continued in a watershed as shown in Figure 4 for Stevens Creek.

Following the cessation of harvesting water yields decrease annually with the recovery of evapotranspiration as forest regeneration develops. Hydrologic recovery is the time it takes for increased water yields to approach "pre-disturbance conditions or some defined level. In this report hydrologic recovery was assumed to occur when increased water yields were < 5%. Hydrologic recovery is measured from the year of maximum increase in water yield. Hydrologic recovery can be delayed if harvesting continues in a watershed at a regular rate and at short intervals.

The second graph in Figure 4 shows decadal values for increase water yield and % Watershed ECA. A graph for each watershed is provided in Appendices 2 and 3 for the Drayton Valley Forest and the Edson Forest.

Figure 4 Simulated water yield response to forest harvesting in Stevens Creek. Maximum increase of 25% in water yield occurred in 2019, followed by a second peak in 2026. Recovery follows with two small peaks in 2048 and 2057. Hydrologic recovery occurs sometime around 2062 when increased water yield is about 5%.



Simulated water yield increases showed an increasing trend with percent watershed area harvested (Figure 5). Water yield increases varied from a maximum of 25% in Stevens Creek to <1% in 11 other watersheds

(Table 1, Figure 6). Average water yield increase for all watersheds with increases >1% was 8.4%. Among the 55 watersheds in the FMA, 7 (13%) had increases > 15%, 8 (15%) had increases of 10-15%, 12 (22%) had increases of 5-10% and 28 (51%) had increases of 0-5%. Average area harvested for all watersheds was ~22% with minimum and maximum values of 1.4% and 72% (Figure 7).

Figure 5 Simulated percent increase in water yield regressed on percent of watershed area harvested.

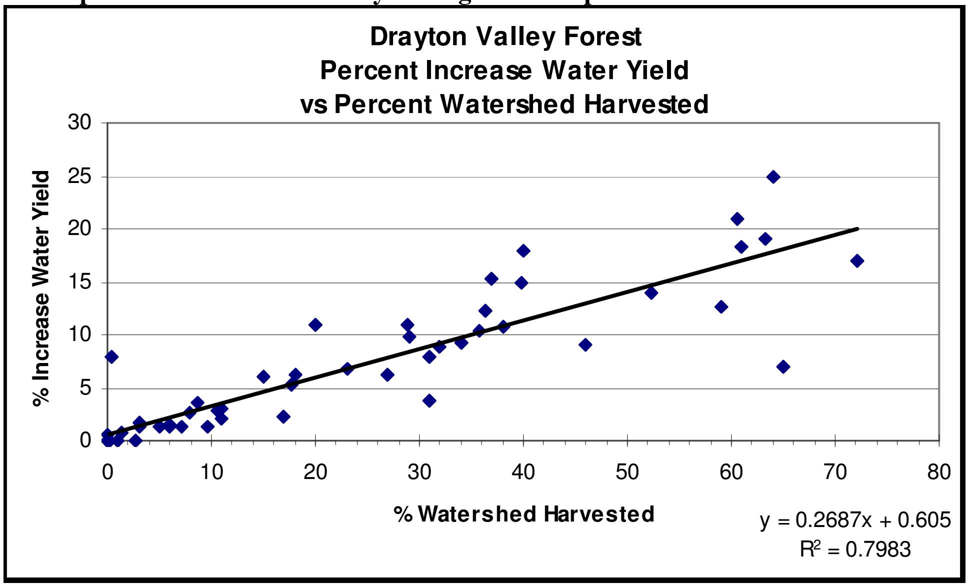


Figure 6 Water yield responses to forest harvesting Drayton Valley Forest. Watersheds showing no response are those with less than 1% of watershed area harvested.

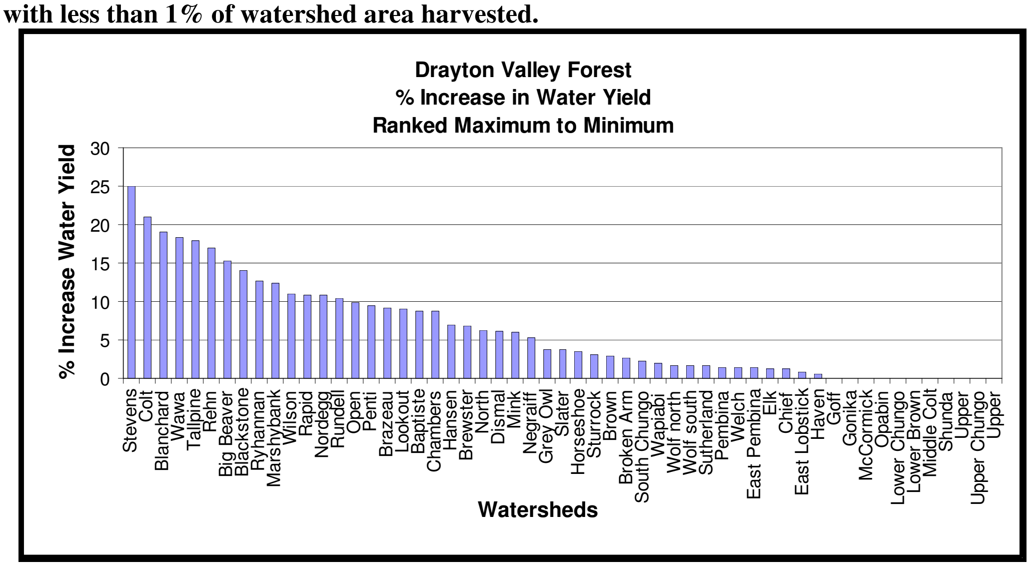


Figure 7 Percent of watershed area harvested, Drayton Valley Forest. Watersheds with no values shown had less than 1% of area harvested.

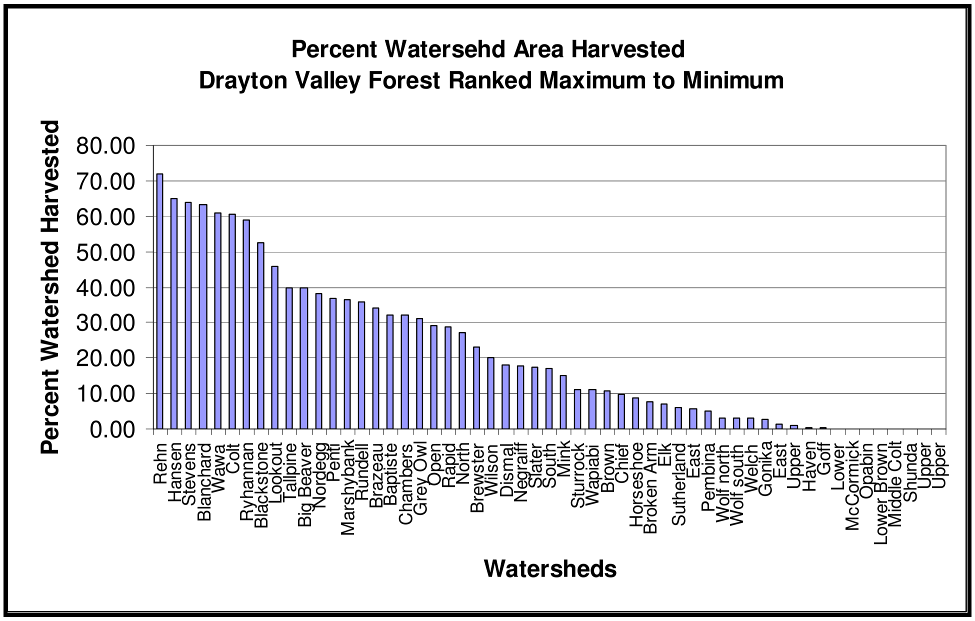


Table 2 Water yield responses to harvesting Drayton Valley Forest ranked maximum to minimum

Watershed Name	Area km^2	% Harvest	Maximum % Increase Water Yield	Year of Maximum Increase	Maximum % Watershed ECA	Years to Hydrologic Recovery = $\Delta Q \leq 5\%$
Stevens	49.470	64.00	25.0	2019	46%	28
Colt	16.543	60.54	21.0	2029	44%	17
Blanchard	42.156	63.35	19.0	2024	45%	17
Wawa	97.400	61.00	18.3	2019	41%	28
Tallpine	213.470	40.00	17.9	2024	24%	21
Rehn	21.592	72.07	16.9	2063	37%	14
Big Beaver	85.740	39.93	15.3	2059	23%	16
Blackstone	113.780	52.42	14.0	2018	26%	58
Ryhannan	13.640	59.00	12.6	2013	39%	15
Marshybank	19.807	36.43	12.3	2028	26%	17
Wilson	222.330	20.00	11.0	2055	14%	37
Rapid	94.058	28.85	10.9	2023	18%	12
Nordegg	640.950	38.00	10.8	2029	20%	37
Rundell	245.911	35.80	10.4	2017	20%	19
Open	187.037	29.03	9.9	2049	17%	18
Penti	50.894	36.89	9.4	2028	22%	15
Brazeau	221.670	34.00	9.2	2029	23%	43
Lookout	57.757	45.87	9.0	2019	24%	11
Baptiste	62.414	32.00	8.8	2034	18%	18
Chambers	157.890	32.00	8.8	2034	18%	18
Hansen	14.100	65.00	6.9	2064	35%	4
Brewster	170.380	23.00	6.8	2029	13%	12
North Saskatchewan	1105.160	27.00	6.2	2044	12%	10
Dismal	436.480	18.00	6.2	2024	11%	5
Mink	63.358	14.99	6.0	2057	9%	2
Negraiff	717.745	17.73	5.3	2029	11%	0
Grey Owl	53.580	31.00	3.7	2029	17%	0
Slater	362.850	17.50	3.7	0	0%	0
Horseshoe	76.050	8.60	3.5	2060	5.4%	0
Sturrock	57.750	11.00	3.0	2065	6%	0
Brown	70.616	10.61	2.9	2029	7%	0
Broken Arm	219.758	7.81	2.7	2029	5%	0
South Chungo	19.670	17.00	2.2	2063	11%	0
Wapiabi	104.870	11.00	2.0	2029	6%	0
Wolf north	174.000	3.00	1.7	2064	3%	0
Wolf south	417.030	3.00	1.7	2064	3%	0
Sutherland	11.363	6.00	1.6	2030	4%	0
Pembina	818.692	5.03	1.4	2024	2%	0
Welch	179.050	3.00	1.4	2049	2%	0
East Pembina	84.394	5.86	1.4	2063	3%	0
Elk	325.002	7.06	1.3	2029	3%	0
Chief	43.764	9.57	1.3	2029	7%	0
East Lobstick	58.460	1.35	0.8	2062	1%	0

Table 2….continued

Watershed Name	Area km^2	% Harvest	Maximum % Increase Water Yield	Year of Maximum Increase	Maximum % Watershed ECA	Years to Hydrologic Recovery = $\Delta Q \leq 5\%$
Haven	67.090	0.20	0.6	2064	0.21%	0
Goff	18.350	0.20	0.0	2059	0.16%	25
Gonika	33.530	2.70	0.0	2056	0.08%	0
McCormick	21.412	0.07	0.0	2021	0%	0
Opabin	58.468	0.04	0.0	2062	0%	0
Lower Chungo	82.564	0.08	0.0	2062	0%	0
Lower Brown	114.278	0.04	0.0	2062	0%	0
Middle Colt	18.914	0.02	0.0	2027	0%	0
Shunda	288.030	0.00	0.0	2063	15%	7
Upper Blackstone	65.050	1.00	0.0	0	0%	0
Upper Chungo	67.860	0.00	0.0	0	0%	0
Upper Saskatchewan	513.460	0.00	0.0	0	0%	0

Decadal Water Yield Increases (DV)

Water yield increases expressed by decade showed a low response to forest harvesting at the landscape scale. Decadal increases ranged from a minimum of 2.45% at year 10 to a maximum of 4.4% at year 20 followed by a decrease to 2.59% in year 65 (Figure 8). At the watershed scale maximum increases by decade years ranged from 13-19%. Maximum decadal water yield increases > 15% averaged from 5.2% to 12.3% (Figure 8).

The differences between the two plots in Figure 8 illustrate the effects of averaging water yield increases in the FMA and the lack of synchronicity generated in water yield increases when harvesting is dispersed in time and space. Maximum water yield increases were more frequent in 2024, 2027-2030 and 2062-2064 (Figure 9). The break in harvesting between 2027-2030 and 2062-2064 allowed time for hydrologic recovery.

Figure 8 Average and maximum decadal water yield increases 1999-2070, Drayton Valley Forest. "Average" = average water yield increase for all 55 watersheds in the FMA in each decade year. "Average Maximums >15%" = average of maximum water yield increases > 15% for each decade year.

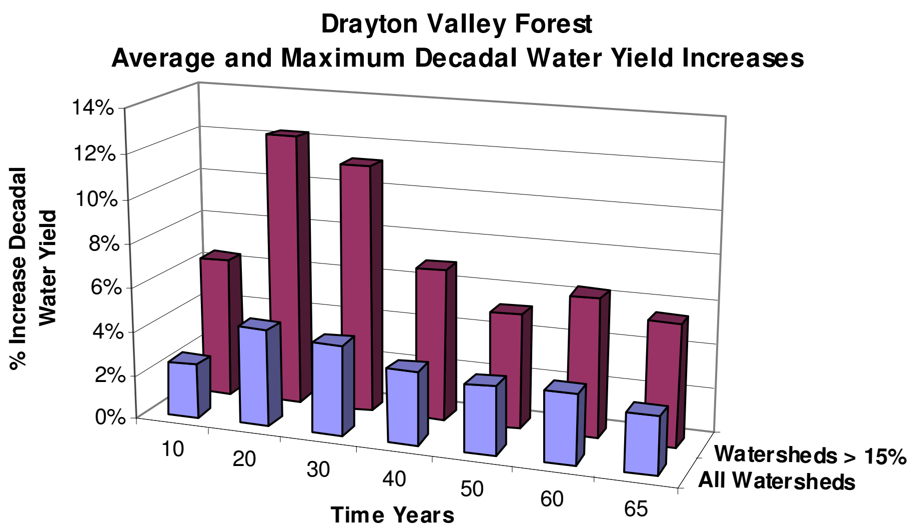


Figure 9 Frequency of maximum increases in annual water yield for individual watersheds by year, for Drayton Valley Forest. For example, the graph shows that in 2024 maximum increase in annual water yield occurred in 4 watersheds.

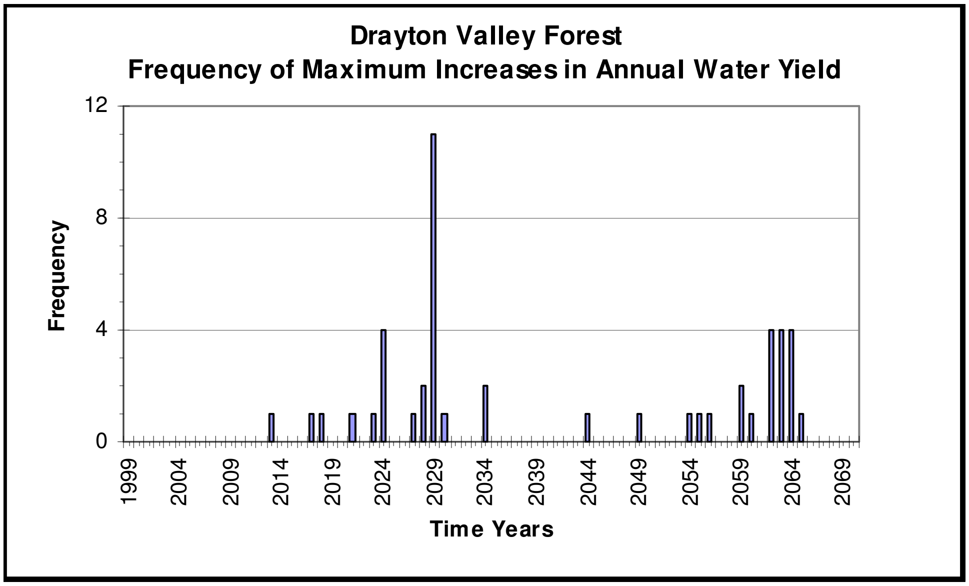

Drayton Valley Forest
Frequency of Maximum Increases in Annual Water Yield
Frequency
12
8
4
0
1999
2004
2009
2014
2019
2024
2029
2034
2039
2044
2049
2054
2059
2064
2069
Time Years

Table 3 Decadal water yield increases for 10, 20, 30, 40, 50, 60, and 65 years from start of simulation, Drayton Valley Forest. Maximum water yield response for each decade are highlighted in yellow shading. Note- where is the shading through out?? Also head on second part of table is inconsistent with this header

Watersheds	Starting Year	Decadal % Water Yield Increases						
		10	20	30	40	50	60	65
Baptiste	2002	4.67	6.87	8.63	7.70	5.30	3.21	2.30
Big Beaver	2001	3.12	3.54	3.92	7.56	10.19	14.60	11.80
Blackstone	2009	13.59	12.51	8.01	8.34	8.41	8.01	6.23
Blanchard	2008	7.81	14.50	7.09	2.10	2.39	4.14	3.47
Brazeau	1999	1.02	5.18	9.29	6.46	5.87	6.54	8.02
Brewster	1999	3.16	4.59	6.80	5.78	3.80	2.46	1.88
Broken Arm	2009	2.64	2.66	1.65	1.15	0.67	0.39	0.29
Brown	2008	1.35	2.76	1.85	1.22	0.68	0.85	0.64
Chambers	2000	2.57	2.44	2.29	1.71	1.25	0.87	0.59
Chief	2004	0.02	0.11	0.97	0.58	0.21	0.11	0.08
Colt	2005	10.45	12.83	13.38	5.55	1.63	1.74	1.42
Dismal	2001	2.14	5.08	4.88	2.51	1.50	1.41	1.23
East Lobstick	2038	0.25	0.50	0.58	0.19	0.04	0.01	0.01
East Pembina	2000	0.17	0.94	0.75	0.96	1.21	1.23	1.26
Elk	2001	0.51	0.77	1.19	0.65	0.62	0.78	0.73
Goff	2013	0.03	0.02	0.03	0.04	0.07	0.05	0.04
Gonika	2055	0.07	0.06	0.04	0.03	0.01	0.00	0.00
Grey Owl	2004	1.17	4.52	4.47	3.80	5.15	3.34	2.32
Hansen	2009	4.64	2.71	1.81	4.07	4.79	4.75	3.12
Haven	2014	0.05	0.04	0.02	0.01	0.10	0.09	0.07
Horseshoe	2004	0.10	1.03	1.03	1.69	2.88	3.01	2.07
Lookout	2004	8.28	6.50	4.05	1.89	4.42	8.77	6.58
Lower Brown	2012	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Lower Chungo	2012	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Marshybank	2009	0.06	12.10	7.88	4.23	2.99	4.07	3.41
McCormick	2009	0.06	12.10	7.88	4.23	2.99	4.07	3.41
Middle Colt	2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mink	2004	0.12	4.17	2.88	3.74	5.70	4.32	3.02
Negraiff	2002	1.04	4.42	4.84	2.84	1.70	1.20	0.86
Nordegg	1999	2.56	9.37	10.80	9.49	7.39	6.46	5.94
North Saskatchewan	2000	2.60	4.56	5.73	5.88	5.85	5.28	5.02
Opabin	2045	0.00	0.02	0.01	0.00	0.00	0.00	0.00
Open	2005	0.76	2.98	5.90	8.66	9.72	6.58	4.12
Pembina	2004	0.80	1.38	1.01	0.84	0.76	1.07	0.82
Penti	2009	8.44	9.35	6.58	5.91	6.65	5.61	4.40
Rapid	2007	4.91	8.55	5.02	2.85	2.85	1.41	0.94
Rehn	2001	1.03	7.50	10.79	12.36	11.02	13.84	14.12
Rundell	2000	2.33	10.03	7.35	3.93	2.25	2.56	2.41
Ryhannan	2008	13.63	6.85	2.21	0.90	2.17	3.90	2.86
Sand	2000	2.11	5.51	7.09	6.22	6.28	7.53	7.44
Shunda	2056	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slater	2008	0.89	2.05	3.01	3.53	3.04	3.22	2.56

Table 4 ……continued

Watersheds	Starting Year	Decadal % Water Yield Increases						
		10	20	30	40	50	60	65
South Chungo	2010	0.02	0.01	0.02	0.03	0.03	0.01	0.01
Stevens	2004	9.26	19.22	16.28	6.12	3.47	3.44	2.71
Sturrock	2006	1.17	0.83	0.72	0.72	1.37	2.83	2.48
Sutherland	2003	0.39	1.24	1.31	0.60	0.19	0.09	0.06
Tallpine	2002	3.99	12.46	12.07	6.53	4.05	4.52	3.79
Upper Blackstone	2036	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Upper Chungo	2036	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Upper Saskatchewan	2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wapiabi	2007	0.54	1.65	1.49	0.76	0.94	1.62	1.16
Wawa	2001	8.91	16.15	15.36	7.80	3.71	1.78	1.20
Welch	2021	0.19	0.96	1.26	0.93	0.38	0.12	0.06
Wilson	2014	0.66	1.05	4.19	11.02	8.47	3.43	2.12
Wolf north	2012	0.17	0.20	0.35	0.98	1.45	1.00	0.68
Wolf south	2000	2.74	3.45	5.24	8.16	13.27	16.82	15.06

Maximum Percent Watershed ECA (DV)

Watershed disturbance as expressed by %ECA varied from <1% - 46% (Table 3, Figure 10). Average percent ECA for all watersheds with values >1% was 17%. Among the 46 watersheds with %ECA >1%, 3(1%) had values >40%, 3(1%) had values of 30-40%, 9 (20%) had values of 20-30%, 12 (26%) had values of 10-20% and 15 (33%) had values of 1-10%. The average watershed ECA corresponded to a water yield increase of ~ 8% (Figure 11).

Figure 10 Watershed %ECA Drayton Valley Forest. Ranked maximum to minimum.

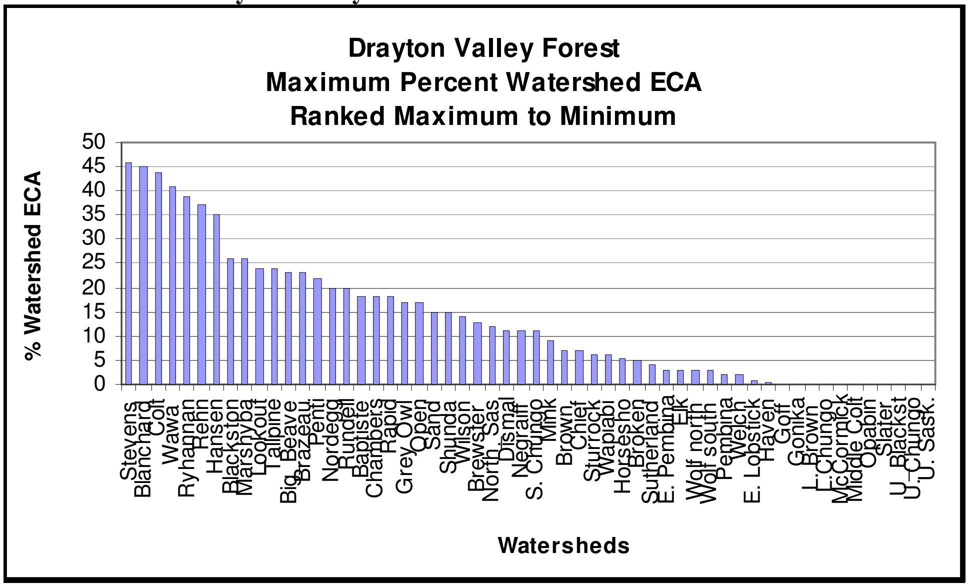
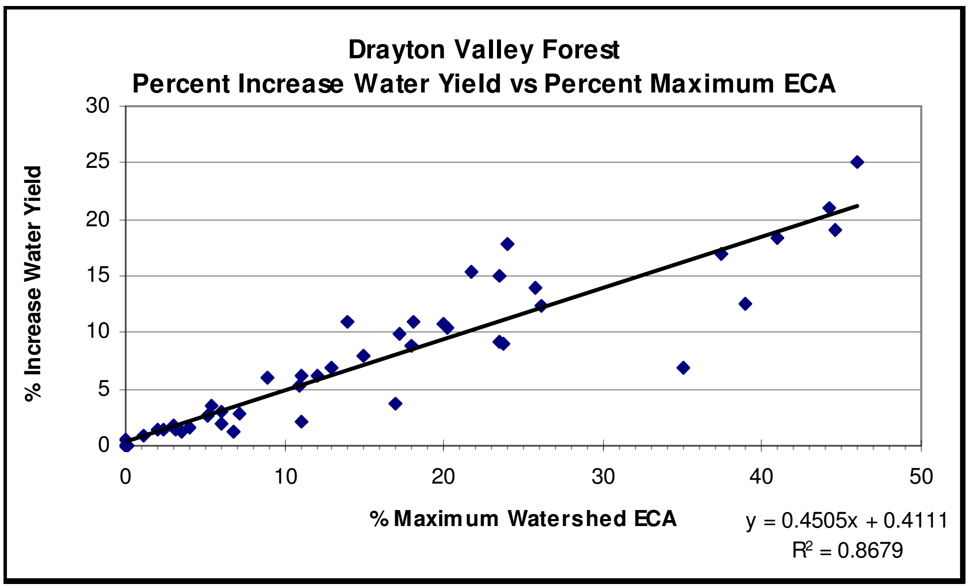


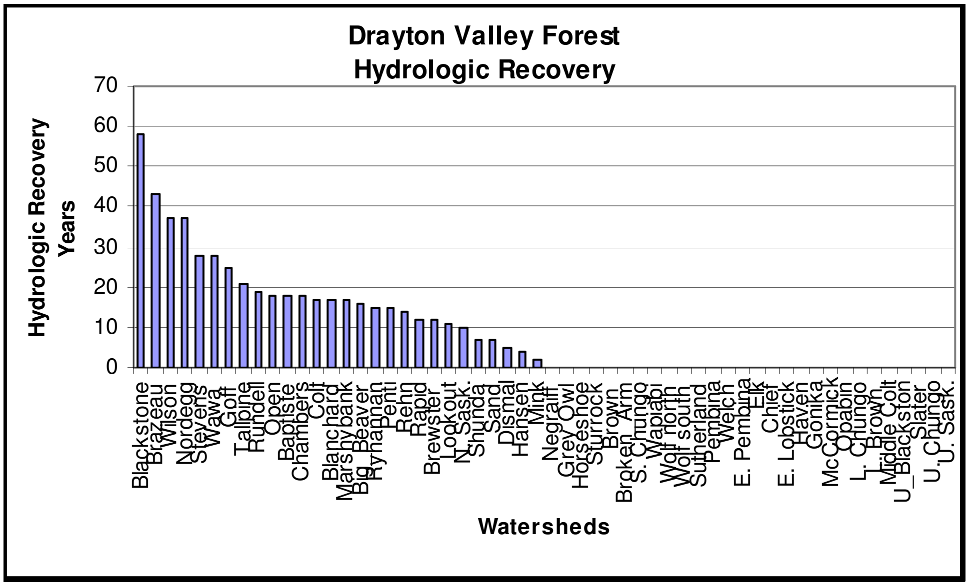
Figure 11 Percent increase in water yield regressed on % maximum watershed ECA for Drayton Valley Forest.



Hydrologic Recovery (DV)

Hydrologic recovery is the time for water yield increases to approach predisturbance conditions. It was defined to occur when water yield increases were < 5%. Hydrologic recovery in the Drayton Valley Forest varied from 0 to 58 years, with an average time of 19 years (Figure 12). Hydrologic recovery in 28 watersheds was zero because of low levels of harvesting and low water yield responses (i.e. < 5%).

Figure 12 Hydrologic recovery for watersheds in Drayton Valley Forest.



Decadal Percent Watershed ECA (DV)

Average percent watershed ECA by decade for all watersheds varied from 4.6% -10.7% (Table 4). Watershed disturbance was relatively constant for years 20-65 with values ranging from 8.9-10.7%. (Figure 13). Disturbance at the watershed level was more variable with maximum values for watersheds in each decade year ranging from 29-43%. Average % ECA for watersheds with maximum water yield increases > 15% ranged from 10.5% to 29.4% for decade years 10-65 (Figure 13)

Figure 13 Average and maximum decadal %watershed ECA 1999-2070, Drayton Valley Forest. Average of all watersheds = "All Watersheds". Average of watersheds with maximum water yield increases >15% = Watersheds > 15%.

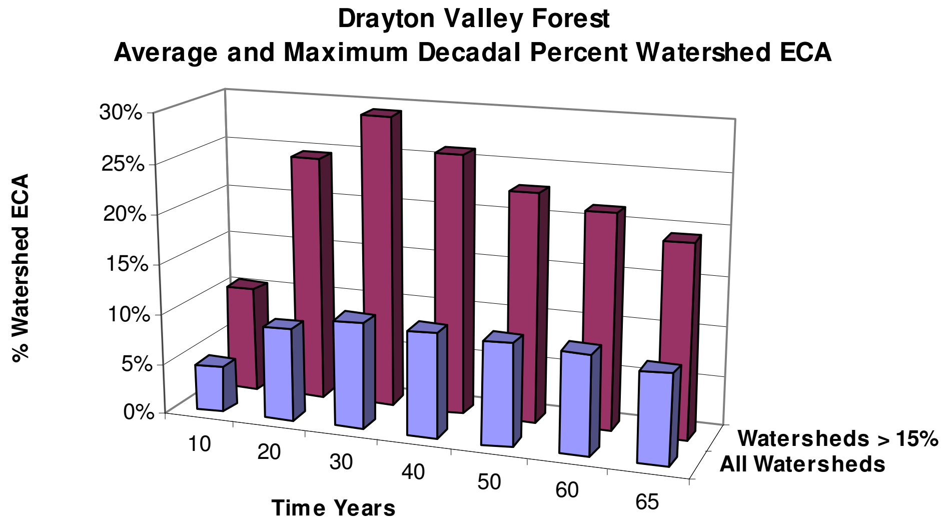


Table 4 Decadal water % watershed ECA for 10, 20, 30, 40, 50, 60, and 65 years from start of simulation, Drayton Valley Forest. Maximum %ECA response for each decade are highlighted in yellow shading.

Watersheds	Starting Year	Decadal % Watershed ECA						
		10.00	20.00	30.00	40.00	50.00	60.00	65.00
Baptiste	2002	6.25	11.00	16.04	17.67	16.10	12.88	10.98
Big Beaver	2001	3.41	4.81	6.30	11.14	16.24	23.60	22.69
Blackstone	2009	21.64	25.70	23.69	24.43	23.90	22.81	19.97
Blanchard	2008	17.45	40.91	34.89	26.46	22.18	21.03	17.82
Brazeau	1999	1.31	6.92	14.49	14.27	15.06	15.89	17.45
Brewster	1999	4.59	7.67	12.33	13.11	11.73	9.74	8.47
Broken Arm	2009	3.94	5.05	4.67	4.09	3.06	2.08	1.67
Brown	2008	2.80	6.70	6.15	5.63	4.53	4.63	4.03
Chambers	2000	14.10	17.75	20.73	19.49	17.25	13.73	11.33
Chief	2004	0.10	0.68	6.25	6.10	4.71	3.39	2.67
Colt	2005	18.51	29.15	38.87	30.64	22.31	16.57	13.44
Dismal	2001	3.28	8.58	10.96	9.31	7.77	6.39	5.51
East Lobstick	2038	0.26	0.64	1.00	0.74	0.51	0.30	0.21
East Pembina	2000	0.27	1.39	1.51	2.07	2.64	2.91	3.04
Elk	2001	1.18	2.05	3.41	2.93	2.93	3.03	2.85
Goff	2013	0.06	0.05	0.08	0.10	0.16	0.14	0.12
Gonika	2055	0.08	0.08	0.07	0.06	0.05	0.04	0.04
Grey Owl	2004	2.44	10.29	13.44	14.54	17.71	14.85	12.78
Hansen	2009	18.13	17.39	17.07	23.73	27.59	30.59	26.27
Haven	2014	0.10	0.09	0.07	0.06	0.21	0.19	0.18
Horseshoe	2004	0.10	1.33	1.71	2.72	4.45	5.25	4.56
Lookout	2004	15.75	17.15	16.20	12.96	16.02	23.71	20.89
Lower Brown	2012	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Lower Chungo	2012	0.02	0.02	0.02	0.04	0.05	0.04	0.03
Marshybank	2009	0.13	26.06	22.79	18.85	16.58	17.90	15.93
McCormick	2009	0.13	26.06	22.79	18.85	16.58	17.90	15.93
Middle Colt	2015	0.01	0.02	0.01	0.01	0.01	0.00	0.00
Mink	2004	0.12	4.49	4.46	6.03	8.40	7.93	6.81
Negraiff	2002	1.69	7.76	10.83	9.83	8.38	6.71	5.59
Nordegg	1999	3.19	12.28	17.37	19.42	18.86	17.55	16.36
North Saskatchewan	2000	2.89	6.28	9.23	11.09	12.35	12.23	12.00
Opabin	2045	0.00	0.04	0.03	0.03	0.02	0.01	0.01
Open	2005	0.79	3.29	8.05	13.23	17.23	15.91	13.54
Pembina	2004	1.04	2.02	2.04	2.12	2.11	2.42	2.10
Penti	2009	15.68	20.43	18.57	18.74	20.72	19.57	17.48
Rapid	2007	7.70	16.96	15.63	13.75	12.62	9.09	7.48
Rehn	2001	1.54	12.21	20.55	27.00	28.83	33.54	34.78
Rundell	2000	3.80	18.74	19.88	17.58	14.13	12.40	11.05
Ryhannan	2008	35.99	30.93	24.53	17.79	15.65	17.17	14.29

Table 4 …….continued

Watersheds	Starting Year	Decadal % Watershed ECA						
		10.00	20.00	30.00	40.00	50.00	60.00	65.00
Sand	2000	2.55	6.98	10.95	12.13	13.22	14.84	14.92
Shunda	2056	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Slater	2008	1.87	4.90	7.69	9.69	9.60	10.59	9.58
South Chungo	2010	0.06	0.05	0.07	0.09	0.09	0.07	0.06
Stevens	2004	13.17	35.64	41.81	32.67	26.11	20.74	17.21
Sturrock	2006	2.65	2.86	3.09	3.02	3.94	6.26	5.76
Sutherland	2003	0.82	2.95	3.98	3.32	2.47	1.75	1.42
Tallpine	2002	5.19	17.01	22.70	19.91	17.14	15.38	13.42
Upper Blackstone	2036	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Upper Chungo	2036	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper Saskatchewan	2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wapiabi	2007	1.07	3.75	4.67	3.97	4.24	5.64	4.90
Wawa	2001	14.67	32.00	39.56	33.69	26.66	19.23	15.79
Welch	2021	0.20	1.16	1.91	1.97	1.48	0.98	0.75
Wilson	2014	0.75	1.34	4.84	12.92	13.56	10.21	8.66
Wolf north	2012	0.24	0.35	0.59	1.34	2.02	1.88	1.64
Wolf south	2000	3.04	4.85	8.09	12.71	20.47	27.57	27.74

Edson Forest

Maximum Annual Water Yield Increases (Ed)

Simulated water yield increases showed an increasing trend with percent watershed area harvested (Figure 14). Water yield increases varied from a maximum of 21% in Granada Creek to <1% in 6 other watersheds (Table 1, Figure 15). The water yield increase in Granada Creek seems relatively small given that 80% of the watershed was harvested. However, annual harvesting in Granada was low, averaging 30-50 hectares per year for most of the simulation period. This was also the case for many other watersheds in both the Edson and Drayton Valley forests, which favored low to medium water yield increases.

Average water yield increase for all watersheds with increases >1% was 7.6%. Among the 55 watersheds in the Edson Forest, 4 (7%) had increases > 15%, 5 (9%) had increases of 10-15%, 17 (31%) had increases of 5-10% and 25 (45%) had increases of 0-5%. Average area harvested in all 55 watersheds was 25%. The average harvested area in watersheds with water yield increases > 15% was ~ 60%.

Figure 14 Simulated percent increases in water yield regressed on percent of watershed area harvested.

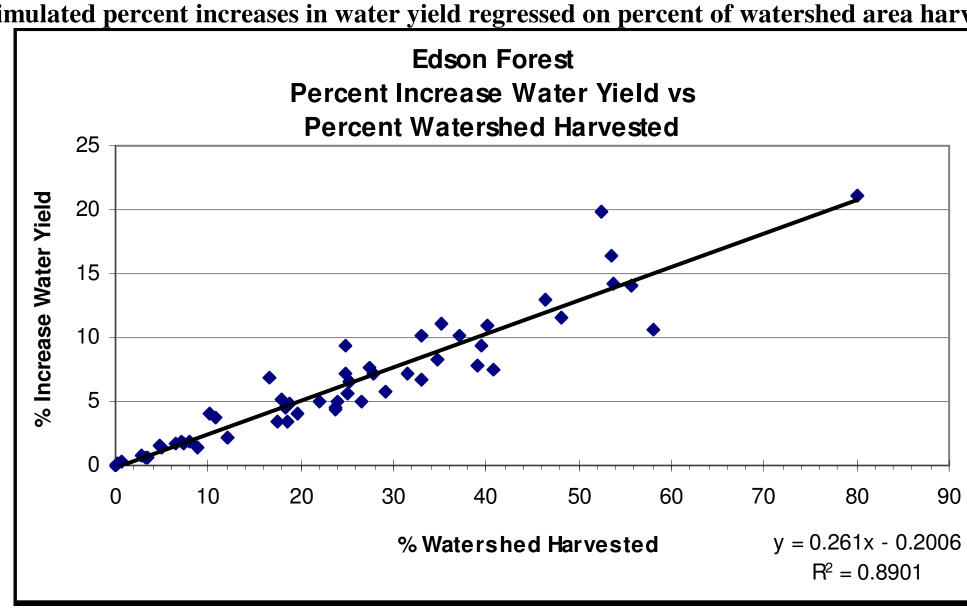


Figure 15 Water yield responses to forest harvesting Edson Forest. Watersheds showing no response are those with less than 1% of watershed area harvested.

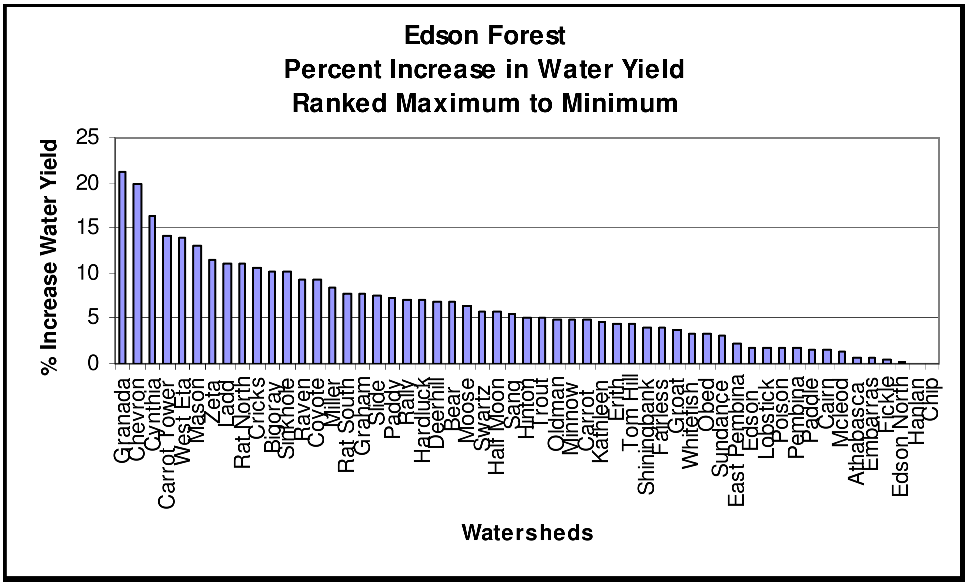


Figure 16 Percent of watershed area harvested, Edson Forest. Watersheds with no values shown had less than 1% of area harvested

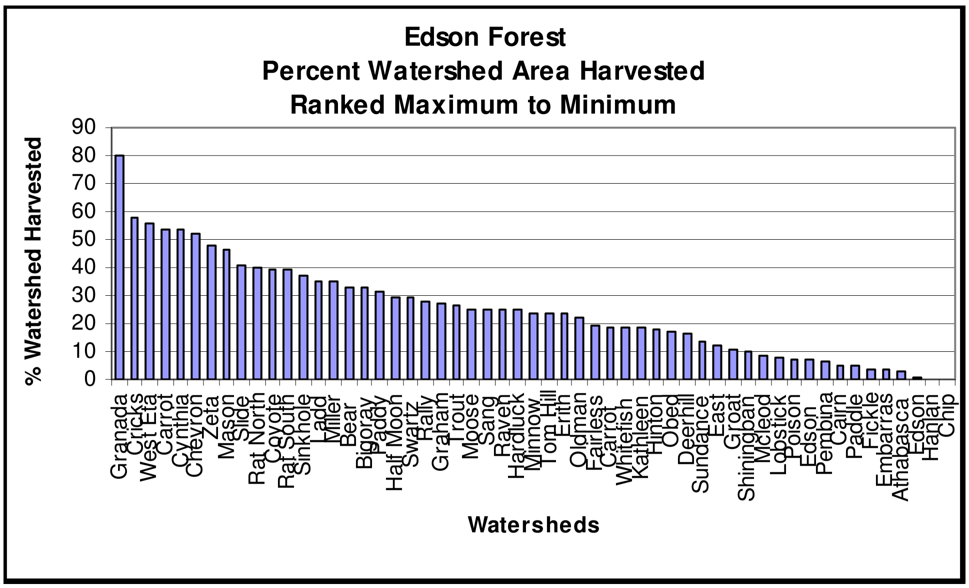


Table 5 Water yield responses to harvesting Edson Forest ranked maximum to minimum.

Watershed Name	Area km2	% Harvest	Maximum Annual % Increase Water Yield	Year of Maximum Increase	Maximum % Watershed ECA	Years to Hydrologic Recovery ΔQ ≤ 5%
Granada	21.85	80.17	21.17	2047	40.92	29
Chevron	23.66	52.38	19.90	2053	30.48	26
Cynthia	42.74	53.53	16.39	2064	27.48	15
Carrot Tower	44.56	53.69	14.17	2060	30.10	15
West Eta	133.98	55.72	14.02	2029	27.14	42
Mason	12.02	46.30	13.03	2063	28.50	11
Zeta	207.07	48.18	11.57	2023	22.84	31
Ladd	41.04	35.20	11.12	2019	22.56	12
Rat North	309.08	40.25	10.98	2029	21.35	28
Cricks	70.20	58.00	10.62	2062	28.06	11
Bigoray	472.54	33.01	10.17	2056	17.05	16
Sinkhole	146.74	37.08	10.16	2057	19.26	18
Raven	164.42	24.91	9.35	2022	15.72	18
Coyote	255.06	39.42	9.30	2024	19.65	22
Miller	20.39	34.66	8.31	2030	19.23	14
Rat South	178.17	39.10	7.77	2011	16.71	20
Graham	93.75	27.44	7.69	2030	12.27	12
Slide	46.82	40.84	7.48	2028	19.13	12
Paddy	238.95	31.50	7.20	2024	13.60	9
Rally	33.46	27.86	7.17	2063	14.94	5
Hardluck	152.59	24.85	7.14	2063	14.15	5
Deerhill	126.01	16.72	6.87	2063	9.33	4
Bear	193.70	33.11	6.79	2022	14.27	5
Moose	146.07	25.34	6.51	2058	15.31	8
Swartz	246.98	29.04	5.82	2064	16.08	1
Half Moon	198.68	29.11	5.81	2022	15.18	7
Sang	231.82	25.02	5.58	2028	12.70	2
Hinton	31.31	17.95	5.14	2049	12.94	0
Trout	15.23	26.46	5.03	2061	12.95	0
Oldman	147.59	21.96	4.97	2023	10.38	0
Minnow	149.50	23.86	4.94	2016	10.78	0
Carrot	278.09	18.71	4.88	2043	10.70	0
Kathleen	67.96	18.29	4.54	2024	9.24	0
Erith	316.43	23.79	4.48	2024	11.08	0
Tom Hill	104.53	23.84	4.38	2057	12.36	0
Shiningbank	78.47	10.10	4.06	2053	6.20	0
Fairless	31.89	19.59	4.04	2047	10.03	0

Table 5 ….continued						
Watershed Name	**Area km2**	**% Harvest**	**Maximum Annual % Increase Water Yield**	**Year of Maximum Increase**	**Maximum % Watershed ECA**	**Years to Hydrologic Recovery $\Delta Q \leq 5\%$**
Groat	26.15	10.84	3.76	2045	6.28	0
Whitefish	156.71	18.51	3.40	2024	8.12	0
Obed	124.99	17.49	3.36	2039	8.02	0
Sundance	392.22	13.32	3.07	2048	7.51	0
East Pembina	843.94	12.00	2.12	2023	5.26	0
Edson	328.95	7.19	1.86	2063	4.15	0
Lobstick	827.05	8.01	1.81	2064	3.79	0
Poison	250.52	7.43	1.77	2054	3.82	0
Pembina	818.69	6.48	1.69	2023	3.06	0
Paddle	154.97	4.66	1.49	2064	2.55	0
Cairn	167.73	4.98	1.47	2054	3.61	0
Mcleod	1460.46	8.82	1.40	2049	4.77	0
Athabasca	302.35	2.76	0.75	2058	1.89	0
Embarras	206.85	3.22	0.70	2008	1.65	0
Fickle	151.48	3.37	0.55	2052	1.67	0
Edson North	99.78	0.56	0.25	2008	0.35	0
Hanlan	128.14	0.26	0.10	2026	0.21	0
Chip	40.15	0.06	0.06	2049	0.47	0

Decadal Water Yield Increases (Ed)

Water yield increases in the Edson Forest expressed by decade showed a low response to forest harvesting at the landscape scale. Decadal increases ranged from a minimum of 3.2% in year 10 to a maximum of 4.35% in year 60 with a decrease to 1.95% in year 70 (Figure 17). Average Maximum water yield increases in watersheds with increases > 15% ranged from 7.25% - 15.45% (Figure 17). The differences between these two plots in Figure 17 illustrates the effects of averaging increases for the FMA and the lack of synchronicity generated in water yield increases when harvesting is dispersed in time and space.

Figure 17 Average and maximum decadal water yield increases 1999-2070, Edson Forest. "Average" = average water yield increase for all 55 watersheds in the FMA in each decade year. "Average Maximums >15%" = average of maximum water yield increases > 15% for each decade year.

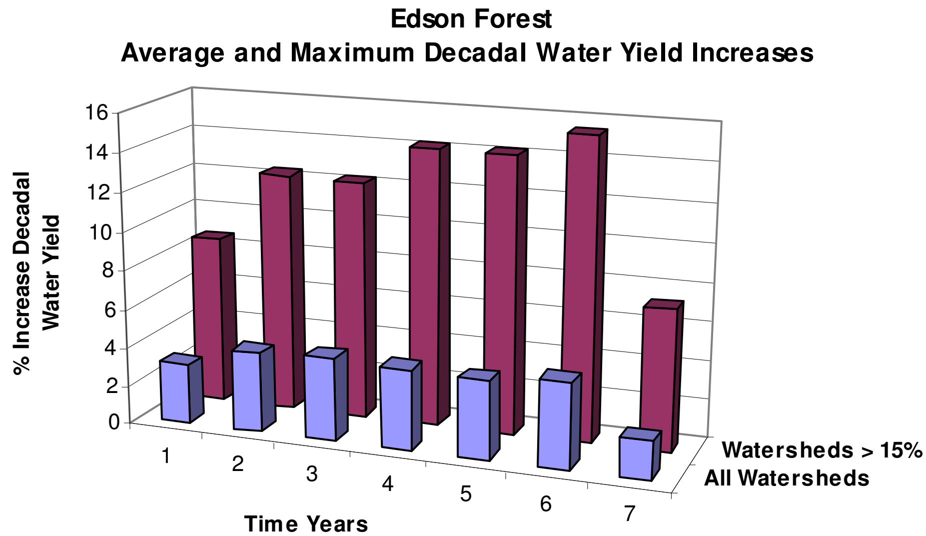


Table 6 Decadal water yield increases for 10, 20, 30, 40, 50, 60, and 65 years from start of simulation, Edson FMU. Maximum water yield response for each decade are highlighted in yellow shading.

Watershed Name	Starting Year	Decadal % Water Yield Increase						
		10	20	30	40	50	60	70
Athabasca	2006	0.09	0.12	0.26	0.47	0.61	0.58	0.25
Bear	2004	4.84	6.62	4.24	3.58	3.18	4.40	1.94
Bigoray	2004	5.29	6.13	7.64	7.81	9.60	9.56	4.69
Cairn	2004	0.59	0.51	0.93	1.08	1.47	1.29	0.48
Carrot	2004	1.57	2.55	3.75	4.8	3.86	2.84	1.29
Carrot Tower	2006	3.52	5.56	9.78	12.82	10.80	11.15	4.78
Chevron	2004	8.36	13.28	14.00	13.23	18.95	14.72	7.65
Chip	2046	0.24	0.23	0.09	0.04	0.02	0.00	0.00
Coyote	2004	5.46	9.30	7.61	5.78	4.49	4.08	1.86
Cricks	2004	6.29	9.16	6.40	6.73	7.82	10.37	4.62
Cynthia	2004	11.04	15.30	13.69	10.51	10.86	16.39	8.12
Deerhill	2004	3.37	3.48	2.48	2.08	3.69	6.75	2.98
East Pembina	2004	1.60	2.05	1.92	1.75	1.93	2.00	0.94
Edson	2004	0.60	0.65	0.72	1.16	1.62	1.83	0.81
Edson North	2005	0.16	0.07	0.03	0.02	0.07	0.05	0.02
Embarras	2004	0.49	0.22	0.29	0.29	0.43	0.37	0.13
Erith	2004	3.09	4.48	3.59	2.99	2.77	3	1.32
Fairless	2005	1.27	0.55	3.28	2.03	3.13	2.38	0.75
Fickle	2004	0.32	0.14	0.35	0.35	0.52	0.51	0.18
Graham	2004	2.55	6.81	7.15	4.63	4.3	6.4	2.76
Granada	2005	6.55	8.34	8.95	18.98	12.77	15.26	5.98
Groat	2005	0.96	0.34	1.48	3.76	2.52	1.98	0.81
Half Moon	2004	4.04	5.72	5.23	5.00	3.92	2.76	1.25
Hanlan	2011	0.09	0.09	0.03	0.01	0.00	0.00	0.00
Hardluck	2004	2.14	3.09	3.32	3.20	4.98	6.97	2.99
Hinton	2008	0.27	1.44	4.18	4.50	2.81	1.14	0.45
Kathleen	2004	2.38	4.54	2.66	1.71	1.83	1.67	0.81
Ladd	2004	10.42	8.35	3.67	2.25	1.16	1.36	0.61
Lobstick	2004	1.29	1.39	1.20	1.76	1.36	1.81	0.89
Mason	2004	1.37	0.49	5.91	6.11	4.08	12.33	5.23
Mcleod	2004	0.45	0.70	1.09	1.27	1.29	1.10	0.45
Miller	2004	4.60	2.09	7.37	5.32	3.58	2.02	0.79
Minnow	2004	4.77	3.67	3.64	3.77	2.96	3.26	1.50
Moose	2004	2.11	2.62	2.75	3.07	6.24	6.09	2.82
Obed	2004	0.87	2.04	2.96	2.96	2.37	1.86	0.78
Oldman	2004	2.45	4.85	3.12	2.61	2.73	3.56	1.69
Paddle	2004	0.6	0.52	0.31	0.4	0.691	1.49	0.74
Paddy	2004	5.97	7.2	5.22	5.06	4.52	4.91	2.37

Table 6……continued								
Watershed Name	**Starting Year**	**Decadal % Water Yield Increase**						
		10	**20**	**30**	**40**	**50**	**60**	**70**
Pembina	2004	1.51	1.68	1.22	0.84	0.76	0.88	0.46
Poison	2004	0.71	0.91	1.13	1.16	1.77	1.4	0.48
Rally	2004	3.07	3.87	1.82	2.43	2.75	6.95	3.22
Rat North	2004	4.8	9.65	9.67	7.91	5.95	4.05	1.65
Rat South	2004	7.45	6.81	4.44	4.16	4.72	5.43	2.72
Raven	2004	4.09	9.24	7.13	4.33	1.98	1.15	0.45
Sang	2004	2.99	4.22	5.19	4.39	4.37	3.77	1.58
Shiningbank	2004	0.28	0.1	2.48	2.11	3.8	2.35	0.68
Sinkhole	2004	5.35	6.21	9	8.61	9.16	9.76	4.75
Slide	2004	6.01	7.05	6.31	4.12	4.89	3.23	1.13
Sundance	2004	0.52	1.21	2.45	2.68	2.71	1.82	0.71
Swartz	2004	1.84	3.18	4.24	4.56	5.1	5.82	2.53
Tom Hill	2004	2.25	3.36	3.51	3.67	3.76	3.2	1.31
Trout	2006	3.04	2.99	4.75	3.87	2.47	3.9	2.24
West Eta	2004	6.91	12.95	12.55	10.31	8.14	9.38	3.9
Whitefish	2004	2.74	3.4	2.47	1.97	1.89	2.38	1.11
Zeta	2004	10.79	11.47	8.38	5.93	5.44	5.73	2.53

Maximum Percent Watershed ECA (ED)

Percent watershed ECA varied from a < 1% to 41% (Table 18.Figures 18,19). Average percent ECA for watersheds with values > 1% was ~ 14%. Among the 52 watersheds with %ECA > 1%, 1 (2%) had values greater than 40%, 3 (6%) had values of 30-40%, 7 (13%) had values of 20-30%, 24 (46%) had values of 10-20%, and 18 (35%) had values of 1-10%. Average % watershed ECA corresponded to a water yield increase of ~ 7%.

Figure 18 Percent increase in water yield regressed on % maximum watershed ECA for Edson Forest.

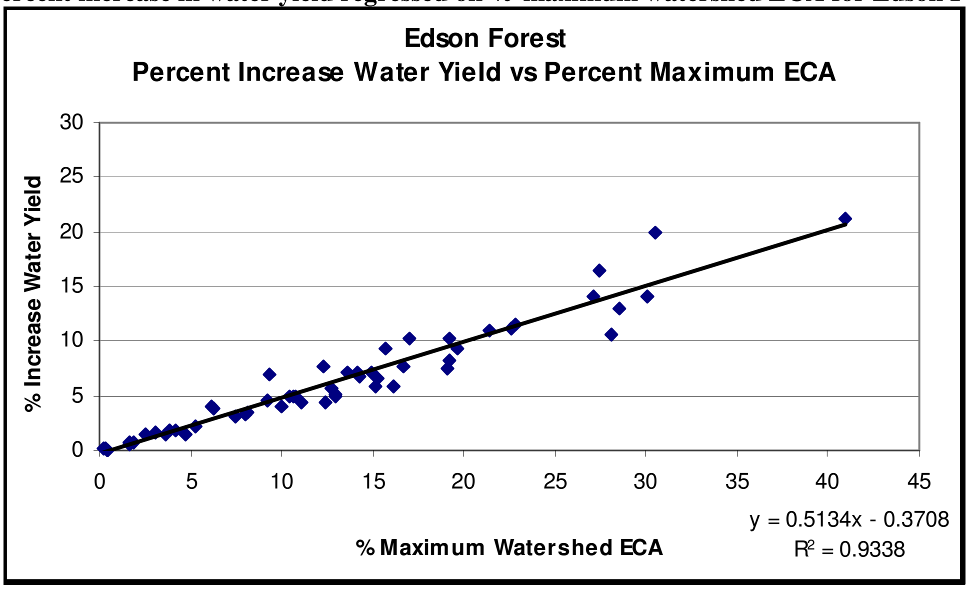
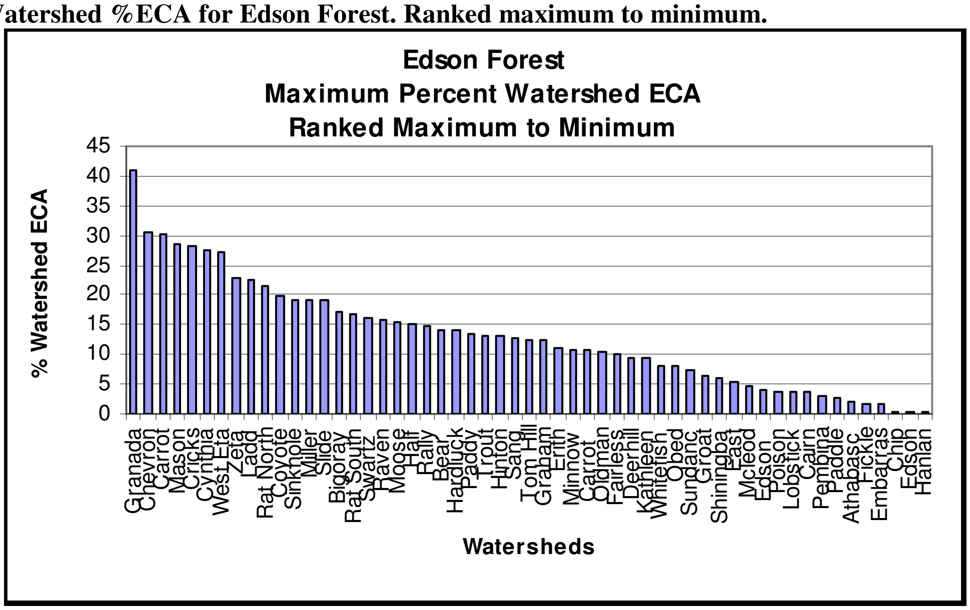


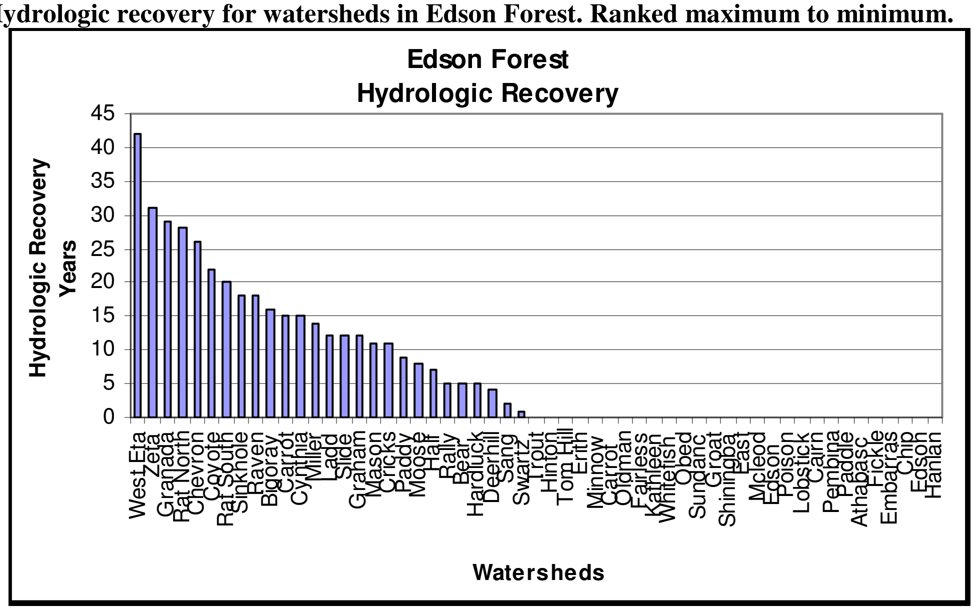
Figure 19 Watershed %ECA for Edson Forest. Ranked maximum to minimum.



Hydrologic Recovery

Hydrologic recovery is the time for water yield increases to approach predisturbance levels. It was defined to occur when water yield increases were < 5%. Hydrologic recovery in the Edson Forest varied from 0 to 42 years, with an average time of 14 years (Figure 20). Hydrologic recovery in 28 watersheds was zero because of low levels of harvesting and low water yield responses (i.e. < 5%).

Figure 20 Hydrologic recovery for watersheds in Edson Forest. Ranked maximum to minimum.



Decadal Percent Watershed ECA (Ed)

Average percent watershed ECA by decade for all watersheds varied from 4.8% - 11.53%. Watershed disturbance followed an increasing trend from year 10-60 with values of 4.8-11.53%. (Figure 21). Disturbance at the watershed level followed a similar trend but was higher with values for watersheds in each decade year ranging from 8.9% - 39%. Average ECA for watersheds with water yield increases greater than 15% ranged from 9.9% - 32% for decade years 10-70 (Figure 21).

Figure 21 Average and maximum decadal % watershed ECA 1999-2070, Edson Forest. Average of all watersheds = "All Watersheds". Average of watersheds with maximum water yield increases >15% = Watersheds > 15%.

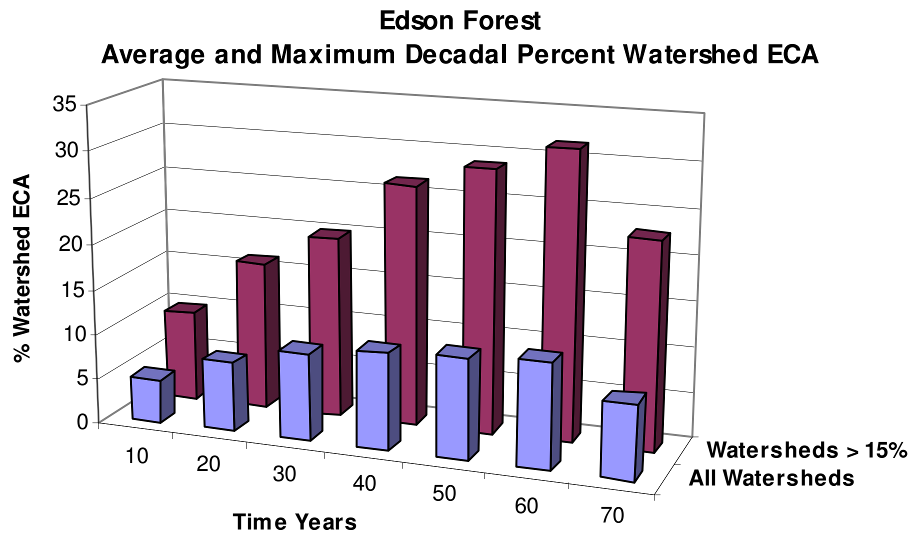


Table 7 Decadal water % watershed ECA for 10, 20, 30, 40, 50, 60, and 65 years from start of simulation, Edson FMU. Maximum %ECA response for each decade are highlighted in yellow shading.

Watershed Name	Start Year	Decadal % Watershed ECA						
		Year 10	Year 20	Year 30	Year 40	Year 50	Year 60	Year 70
Athabasca	2006	0.15	0.25	0.58	1.06	1.53	1.80	1.35
Bear	2004	8.40	14.27	13.57	13.50	12.27	12.82	8.66
Bigoray	2004	5.91	8.29	11.48	13.12	16.08	17.03	12.65
Cairn	2004	0.98	1.15	2.02	2.47	3.46	3.61	2.65
Carrot	2004	2.20	4.21	6.98	9.94	10.19	9.18	6.51
Carrot Tower	2006	4.81	9.19	17.31	25.09	25.61	27.65	19.62
Chevron	2004	8.62	15.64	19.97	22.44	29.94	27.81	20.97
Chip	2046	0.35	0.43	0.33	0.23	0.14	0.07	0.03
Coyote	2004	8.84	17.73	19.47	19.24	17.61	16.15	11.34
Cricks	2004	10.94	18.79	18.87	21.30	23.42	28.00	20.06
Cynthia	2004	11.53	18.64	21.06	20.52	21.86	27.48	20.27
Deerhill	2004	3.55	4.55	4.37	4.25	5.82	9.33	6.97
East Pembina	2004	2.41	3.82	4.55	4.80	5.18	5.21	3.65
Edson	2004	0.98	1.31	1.64	2.41	3.38	4.15	3.11
Edson North	2005	0.30	0.24	0.20	0.14	0.18	0.13	0.09
Embarras	2004	0.99	0.78	1.02	1.06	1.37	1.39	0.98
Erith	2004	5.29	9.29	10.09	10.33	10.38	10.62	7.59
Fairless	2005	2.79	2.30	7.10	6.44	9.32	8.70	5.95
Fickle	2004	0.64	0.51	1.00	1.12	1.55	1.67	1.19
Graham	2004	2.82	8.79	11.96	11.14	10.67	12.27	8.26
Granada	2005	9.58	14.75	18.78	36.24	34.74	39.55	27.30
Groat	2005	1.68	1.28	2.86	5.94	5.34	5.24	3.80
Half Moon	2004	6.84	11.75	13.67	15.05	13.97	11.85	8.39
Hanlan	2011	0.16	0.20	0.16	0.12	0.08	0.05	0.03
Hardluck	2004	3.06	5.34	7.03	7.74	10.42	14.12	10.41
Hinton	2008	0.48	2.79	9.00	11.69	10.88	8.04	5.48
Kathleen	2004	4.08	9.24	8.55	7.69	7.15	5.88	3.68
Ladd	2004	18.46	21.28	17.86	15.02	10.87	8.44	5.06
Lobstick	2004	1.66	2.28	2.54	3.47	3.27	3.79	2.73
Mason	2004	2.75	2.09	11.57	16.05	15.47	27.91	20.13
Mcleod	2004	0.91	1.70	2.95	3.93	4.57	4.61	3.29
Miller	2004	8.89	7.17	18.13	17.68	15.75	11.52	7.34
Minnow	2004	7.50	8.06	9.62	10.62	10.00	10.32	7.42
Moose	2004	3.21	5.00	6.27	7.92	13.57	15.31	11.67
Obed	2004	1.39	3.65	6.10	7.51	7.75	7.35	5.25
Oldman	2004	3.93	9.04	8.64	8.93	9.10	10.38	7.57
Paddle	2004	0.89	1.07	1.03	1.16	1.43	2.55	1.90

Table 7 …..continued

Watershed Name	Start Year	Decadal % Watershed ECA						
		10	20	30	40	50	60	70
Paddy	2004	8.55	12.76	12.90	13.56	12.81	12.71	8.95
Pembina	2004	2.08	2.95	3.02	2.73	2.49	2.36	1.65
Poison	2004	0.94	1.62	2.27	2.71	3.77	3.69	2.53
Rally	2004	5.56	8.64	7.02	7.93	8.28	14.87	11.01
Rat North	2004	6.91	15.79	20.23	21.18	19.94	16.72	11.54
Rat South	2004	13.02	15.66	15.02	15.09	15.83	16.47	11.87
Raven	2004	5.40	14.39	15.44	14.07	10.87	8.24	5.39
Sang	2004	4.54	7.54	10.92	11.52	12.65	12.20	8.83
Shiningbank	2004	0.36	0.27	2.98	3.52	6.07	5.37	3.69
Sinkhole	2004	6.05	8.30	13.29	15.33	17.74	19.25	14.11
Slide	2004	10.66	15.68	18.33	16.80	17.43	13.87	8.92
Sundance	2004	0.80	2.10	4.81	6.35	7.48	6.67	4.66
Swartz	2004	2.85	6.06	9.16	11.53	13.73	16.08	11.88
Tom Hill	2004	3.75	6.85	8.61	10.32	11.24	10.93	7.63
Trout	2006	5.90	7.51	11.35	11.33	9.64	11.10	8.06
West Eta	2004	8.81	19.42	24.14	25.53	24.40	25.87	18.14
Whitefish	2004	4.89	7.55	7.65	7.37	7.01	7.57	5.29
Zeta	2004	16.23	21.91	22.43	20.62	19.45	18.43	12.77

Summary

Drayton Valley Forest

Simulated maximum increases in annual water yield in the Drayton Valley Forest were small to modest in magnitude, ranging from <1% up to 25%. Average water yield increase for all watersheds was 8.4% with minimum and maximum values of < 1% to 25% in Stevens Creek. Watersheds with ≤ 1% increases in water yield were considered to be "unharvested".

Maximum water yield increases occurred in watersheds with more harvesting. Harvesting in watersheds with water yield increases ≥ 15% ranged from 40-72%. Average area harvested in watersheds was ~22% with minimum and maximum values of 1.4% and 72%.

Watershed disturbance in the Drayton Valley Forest ranged from < 1% - 45% . Watersheds with %ECA <1% were considered as undisturbed (i.e. unharvested). Average %ECA for all watersheds in the FMA with values >1% was 17%. Median %ECA among the 55 watersheds was ~ 11%. The maximum annual water yield increase (Stevens Creek 25%) corresponded to a %ECA of ~8%.

Water yield increases and %ECA expressed by decade provide a long term view of changes in water yield and watershed disturbance. Average decadal water yield increases and % ECA (for each decade year - 10, 20, 30, 40, 50, 60, 65) from the start of the proposed harvest plan for all watersheds indicated low responses in the forest with values of 2.45-4.4% and 4.6-10.7% respectively. These low values reflect "average conditions" which was a mix of watersheds ranging from newly harvested to well advanced towards hydrologic recovery. A pattern of spatially and temporally dispersed harvesting tends to reduce the hydrologic effects of harvesting at the landscape scale.

Examination of maximum decadal changes in water yield increases (i.e. increases >15%) and % ECA illustrates the effects of harvesting at the watershed scale. Maximum decadal changes in water yield increases and %ECA among the 55 watersheds ranged from 13-19% and 29-43% respectively. Maximum increases in water yield are driven primarily by the extent and frequency of harvesting in a watershed.

Hydrologic recovery is the time for water yield increases to approach predisturbance conditions. It was defined to occur when water yield increases were < 5%. Hydrologic recovery in the Drayton Valley Forest varied from 0 to 58 years, with an average time of 19 years. Hydrologic recovery in 28 watersheds was zero because of low levels of harvesting and low water yield responses (i.e. < 5%).

Edson Forest

Simulated maximum increases in water yield in the Edson Forest were similar to those in the Drayton Valley Forest. Water yield increases varied from 21% in Granada Creek to <1 % in 6 other watersheds. Average water yield increase for all watersheds in the Forest with increases >1% was 7.6%. Watersheds with increases <1% were assumed to be a zero increase in water yield (i.e. "unharvested).

The water yield increase in Granada Creek seems relatively small given that 80% of the watershed was harvested. However, annual harvesting in Granada was low, averaging 30-50 hectares per year for most of the simulation period. This was also the case for many other watersheds in both the Edson and Drayton Valley forests, which favored low to medium water yield increases.

Maximum annual water yield increases followed an increasing trend with percent watershed area harvested. Harvesting in the 4 watersheds with increases >15% averaged 60% with minimum and maximum values of 53% and 80%. The average area harvested for all watersheds was ~25% with minimum and maximum values of 0.06 and 80%.

Watershed ECA in the Edson Forest ranged from a maximum of 41% to minimums < 1% . Watersheds with %ECA < 1% were considered as undisturbed (i.e. unharvested). Average %ECA for watersheds with water yield increases greater than 1% was 14%. Median %ECA was ~13%. Average %ECA corresponded to a water yield increase of ~7%.

Hydrologic recovery is the time for water yield increases to approach predisturbance levels. It was defined to occur when water yield increases were < 5%. Hydrologic recovery in the Edson Forest varied from 0 to 42 years, with an average time 14 years. Hydrologic recovery in 28 watersheds was zero because of low levels of harvesting and low water yield responses (i.e. < 5%).

Decadal water yield increases and %ECA in the Edson Forest were similar to those in the Drayton Valley Forest. At a landscape scale (i.e. FMA) responses to forest harvesting were low. Average decadal water yield and %watershed ECA ranged respectively from 3.2% to 4.4% and 4.8 to 11.5%. At the watershed scale responses were higher and more variable. Maximum decadal changes in water yield increases and %ECA varied from 8% to 15% and 9% to 39% in years 10 and 60 respectively.

Discussion

In conclusion, simulated water yield increases in the Drayton Valley and Edson forests varied from nil to modest. Water yield increases in 85-95% of the watersheds in the Pembina FMA were less than 15%. Water yields resulting from these increases are expected to have recurrence interval of ~ 3 years and to fall within the range of variability defined by their mean water yield ± 0.3 standard deviation. Water yields resulting from increases greater than 15% are expected to be ~ 4 years and to fall within the range of variability defined by their mean water yield ± 0.5 standard deviation. Change in the frequency of occurrence for increased water yield would be ~ 25 years.

Increases water yields in both forests will be elevated above average conditions for short periods of time, assuming prompt regeneration that allows hydrologic recovery. The magnitude of changes will decrease with time being faster in watersheds with low responses and slower in watersheds with high responses. Significant changes in stream channel morphology and aquatic habitats are not anticipated. Large changes in peak flow events, which are not addressed in this assessment, are not expected. Recent literature suggests that sustained increases > 50% in bankfull discharge, which is defined equivalent to the 1.5-2 year recurrence intervals for peak flows, can contribute to permanent changes in stream channel morphology and aquatic habitat (Guillemette et al 2005: Verry 2004). Such changes are not anticipated to occur as a result of the proposed harvest assessed in this report.

Simulations indicate maximum annual water yield responses in the next 15 years will occur in 6 of 55 watersheds in the Drayton Forest and 12 of 55 watersheds in the Edson Forest. The increases during this period will be higher than the overall average for all watersheds, but are still in an acceptable range. Average maximum increase in water yield for 2008-2003 in the Drayton Forest is 16% with a maximum value of 25% (n= 6). In the Edson forest the average maximum water yield increases is 13% with a maximum of 21% (n=12). Higher responses probably should be expected given the objective of reducing pine content as a measure to slow or reduce the potential for mountain pine beetle attack in the region.

Conclusions

In short summary:

- Maximum increases in annual water yield increases varied from minimums less than 1% to maximums of 20-25%.
- Watersheds with water yield increases <1% were considered unharvested.
- Water yield increases were greatest in watershed with high levels of harvesting.
- Percent area harvested in watersheds with water yield increases >15% ranged from 40-80%.
- Percent watershed ECA in both FMAs ranged from <1% up to maximums of 41-45%.
- Average watershed ECA in the Edson and Drayton Valley Forests was 14% and 17% respectively.
- Average decadal changes in water yield increases and %ECA indicated a low to modest response to forest harvesting at the FMA scale or landscape scale.
- Maximum decadal changes in water yield and %ECA indicated periodic increases generated by forest harvesting at the watershed level followed by periods of less harvesting, allowing for hydrologic recovery.
- Hydrologic recovery, measured from the time of maximum annual water yield increase in the Drayton Valley and Edson forests varied from 0-58 and 0-42 years respectively
- Maximum increases in water yield are expected to be short in duration and not result in significant changes in stream channel morphology and aquatic habitats. ….

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Appendix 1 Hydrologic Inputs for ECA-AB

Appendix 1 Table 1 Hydrologic inputs for Drayton Valley Forest. Precipitation and Water Yield from isolines. Water yield estimates adjusted to maintain an evapotranspiration value ~ 300-400 among watersheds.

Drayton Valley Forest ECA-AB Inputs			
Watersheds	**Precipitation mm**	**Water Yield m**	**Evapotranspiration mm**
Baptiste	540	145	395
Big Beaver	540	125	415
Blackstone	575	175	400
Blanchard	570	200	370
Brazeau	560	150	410
Brewster	545	155	390
Broken Arm	560	165	395
Brown	570	220	350
Chambers	540	130	410
Chief	540	145	395
Colf	560	175	385
Dismal	565	165	400
East Lobstick	525	125	400
East Pembina	540	165	375
Elk	570	210	360
Goff	575	200	375
Gonika	575	170	405
Grey Owl	560	200	360
Hansen	575	200	375
Haven	575	200	375
Horsehoe	525	125	400
Lookout	580	200	380
Lower Brown	570	200	370
Lower Chungo	570	210	360
Marshybank	600	225	375
McCormick	560	175	385
Middle Colt	560	225	335
Mink	525	115	410
Negraff	560	175	385
Nordegg	560	145	415
North Saskatechwan	540	130	410
Opabin	600	225	375
Open	525	125	400
Pembina	560	150	410
Penti	580	210	370
Rapid	560	170	390
Rehn	550	130	420
Rundell	565	175	390
Ryhannan	570	200	370
Sand	540	130	410
Appendis 1Table 1 …….continued			

Drayton Valley Forest ECA-AB Inputs			
Watersheds	**Precipitation**	**Water Yield**	**Evapotranspiration**
Shankland	580	210	370
Shunda	565	160	405
Slater	600	225	375
Smith	560	220	340
South Chungo	575	200	375
Stevens	560	175	385
Sturrock	580	200	380
Sutherland	565	200	365
Tallpine	560	145	415
Upper Blackstone	575	175	400
Upper Chungo	575	210	365
Upper Colt	560	175	385
Upper Saskatchewan	540	130	410
Wapaibi	590	215	375
Wawa	570	180	390
Welch	525	125	400
Wilson	525	115	410
Wolf north	525	125	400
Wolf South	525	125	400

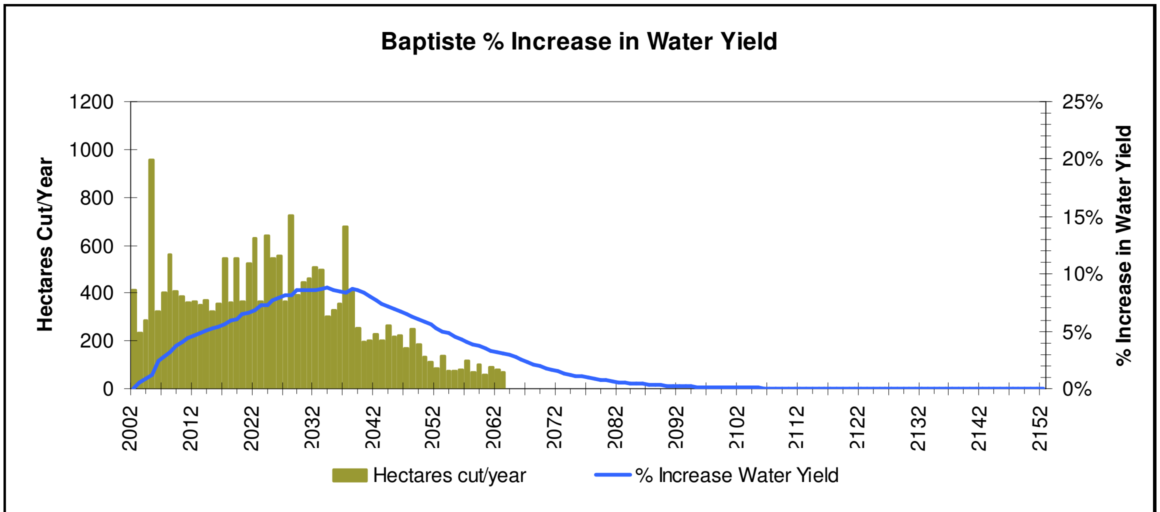
Appendix 1 Table 2 Hydrologic inputs for Edson Forest. Precipitation and Watrer Yield from isolines. Water Yield estimates adjusted to maintain an evapotranspiration value ~ 300-400 among watersheds.

Edson Forest ECA-AB Inputs			
Watersheds	**Precipitation mm**	**Water Yield mm**	**Evapotranspiration mm**
Athabasca	575	200	375
Bear	550	175	375
Bigoray	550	125	425
Cairn	590	180	410
Carrot	560	160	400
Carrot tower	560	150	410
Chevron	550	125	425
Chip	550	140	410
Coyote	565	175	390
Cricks	560	175	385
Cynthia	550	125	425
Deerhill	580	125	455
East Pembina	530	150	380
Edson	550	160	390
Edson north	590	180	410
Embarras	580	190	390
Erith	575	185	390
Fairless	560	175	385
Fickle	560	185	375
Graham	550	130	420
Granada	560	150	410
Groat	560	150	410
Half moon	560	175	385
Hanlan	575	185	390
Hardluck	550	150	400
Hinton	550	185	365
Kathleen	560	175	385
Ladd	560	180	380
Lobstick	550	140	410
Mason	560	175	385
McLeod	550	200	350
Miller	560	180	380
Minnor	570	170	400
Moose	575	175	400
Obed	575	185	390
Oldman	580	180	400
Paddle	550	150	400
Paddy	550	150	400
Pembina	560	150	410
Poison	550	150	400
Rally	575	180	395
Rat north	560	160	400
Rat south	560	180	380
Raven	580	160	420
Sang	570	170	400

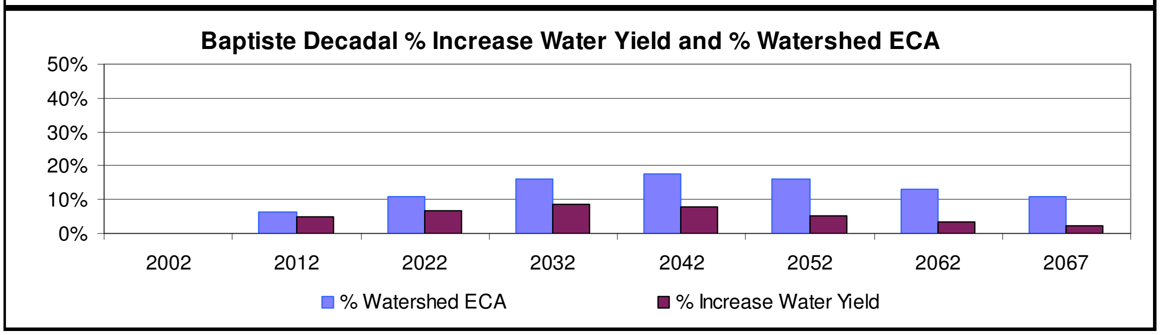
Appendix 1 Table 2 ….. continued

Watersheds	Precipitation mm	Water Yield mm	Evapotranspiration mm
Shinningbank	560	125	435
Sinkhole	530	125	405
Slide	560	175	385
Sundance	575	175	400
Swartz	575	175	400
West eta	560	150	410
Whitefish	560	180	380
Tom Hill	580	180	400
Trout	560	175	385
Zeta	560	160	400

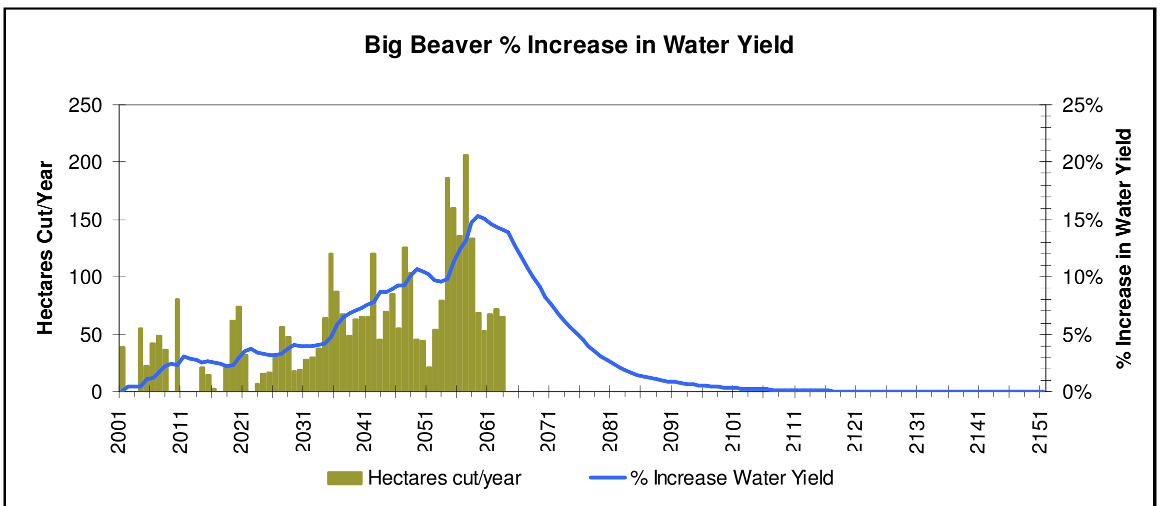
Appendix 2 – Simulation results for Drayton Valley Forest watersheds.



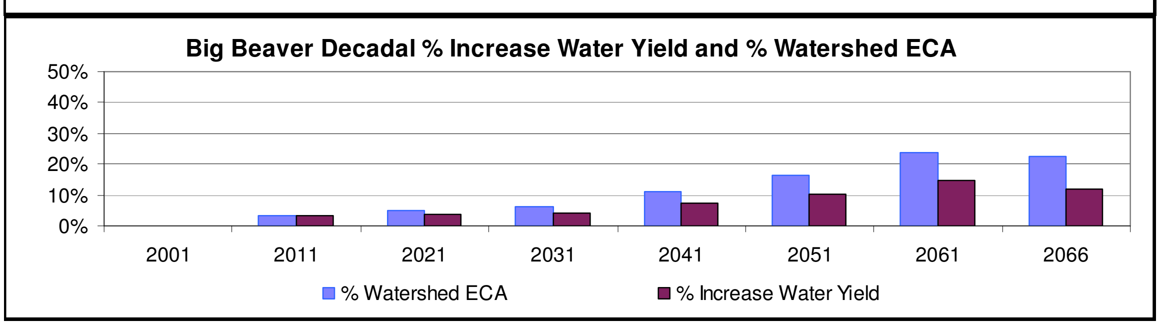
Baptiste % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1200
1000
800
600
400
200
0
25%
20%
15%
10%
5%
0%
2002
2012
2022
2032
2042
2052
2062
2072
2082
2092
2102
2112
2122
2132
2142
2152
Hectares cut/year
% Increase Water Yield



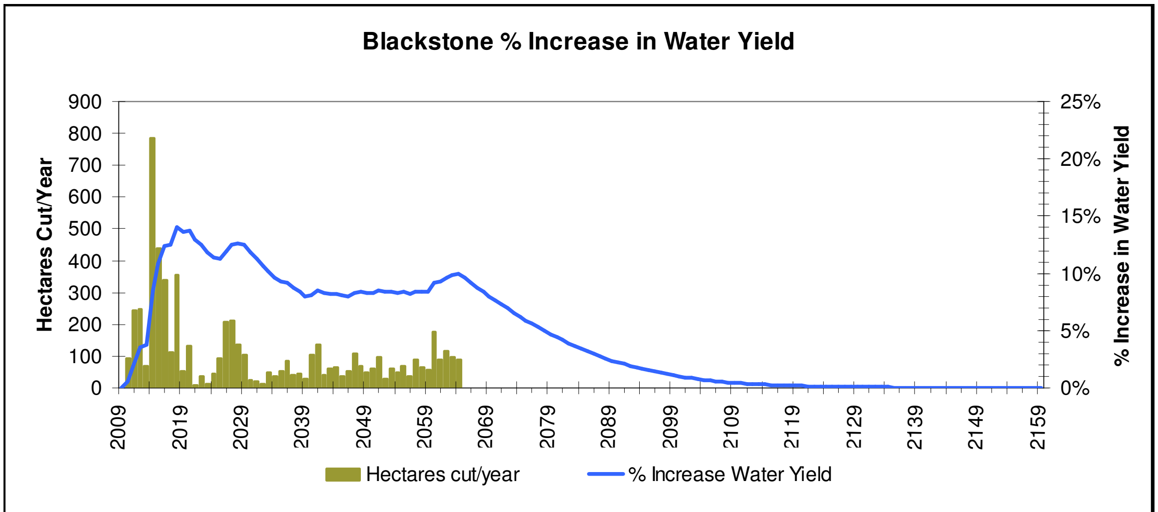
Baptiste Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2002
2012
2022
2032
2042
2052
2062
2067
% Watershed ECA
% Increase Water Yield

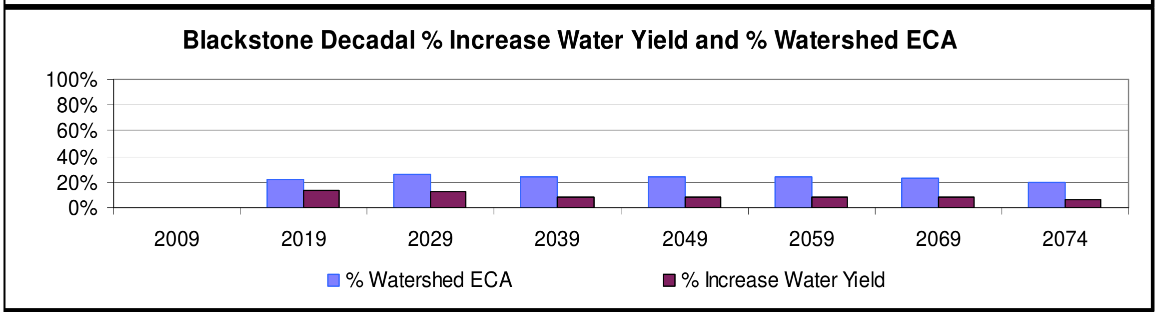


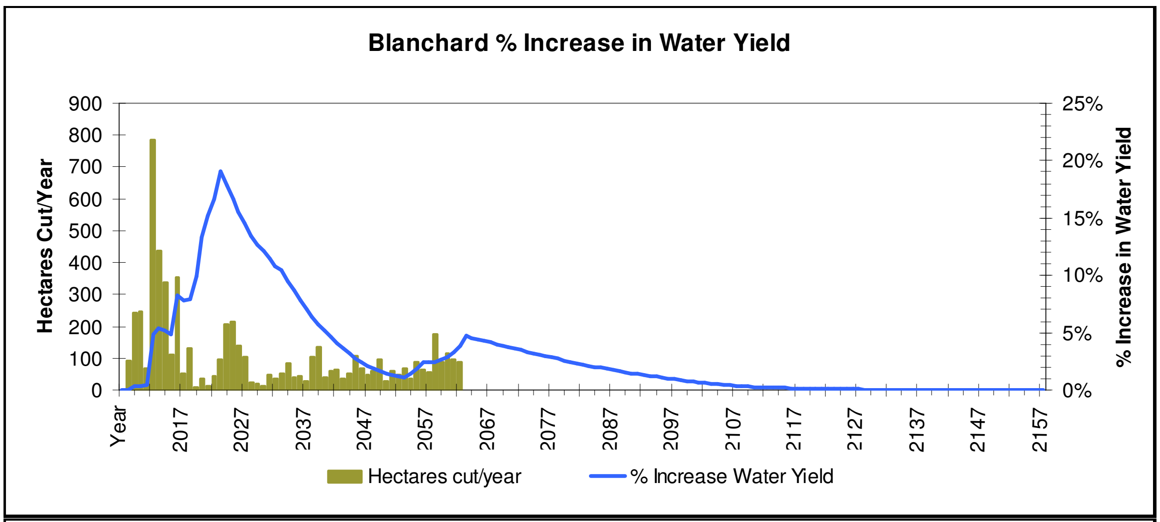
Big Beaver % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2001
2011
2021
2031
2041
2051
2061
2071
2081
2091
2101
2111
2121
2131
2141
2151
Hectares cut/year
% Increase Water Yield

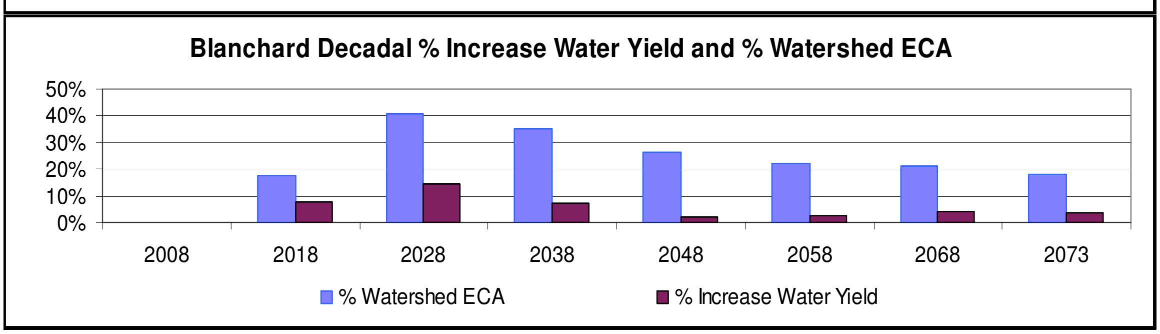


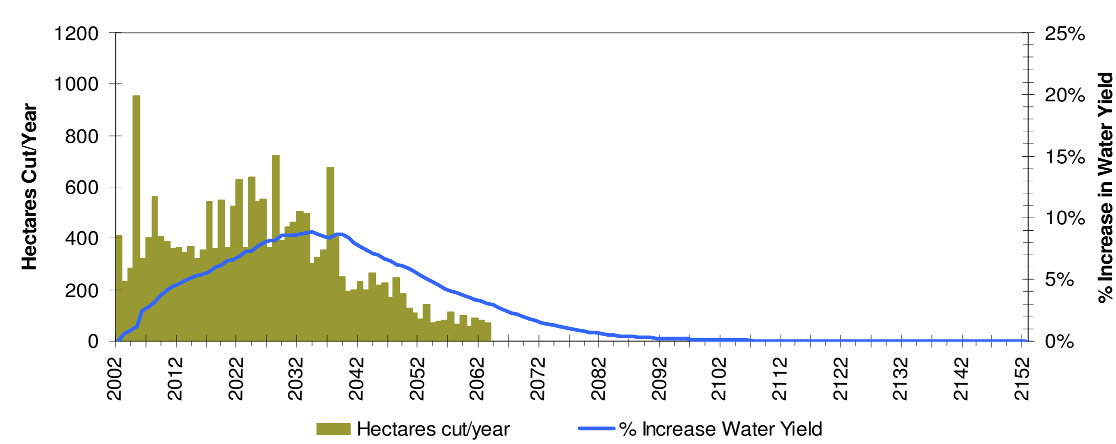
Big Beaver Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2001
2011
2021
2031
2041
2051
2061
2066
% Watershed ECA
% Increase Water Yield


Blackstone % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
900
800
700
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
2009
2019
2029
2039
2049
2059
2069
2079
2089
2099
2109
2119
2129
2139
2149
2159
Hectares cut/year
% Increase Water Yield

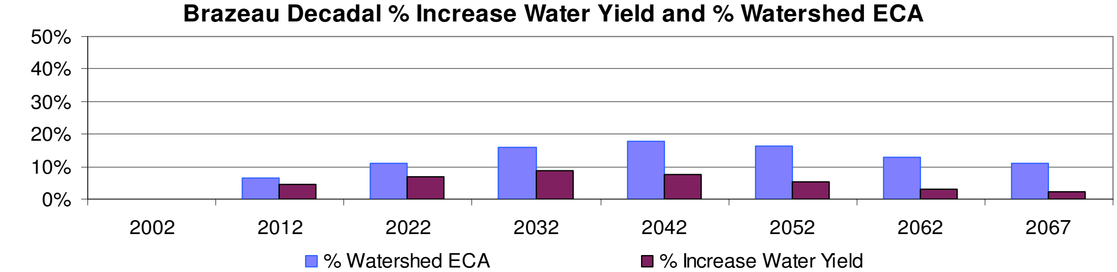

Blackstone Decadal % Increase Water Yield and % Watershed ECA
100%
80%
60%
40%
20%
0%
2009
2019
2029
2039
2049
2059
2069
2074
% Watershed ECA
% Increase Water Yield


Blanchard % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
900
800
700
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
Year
2017
2027
2037
2047
2057
2067
2077
2087
2097
2107
2117
2127
2137
2147
2157
Hectares cut/year
% Increase Water Yield

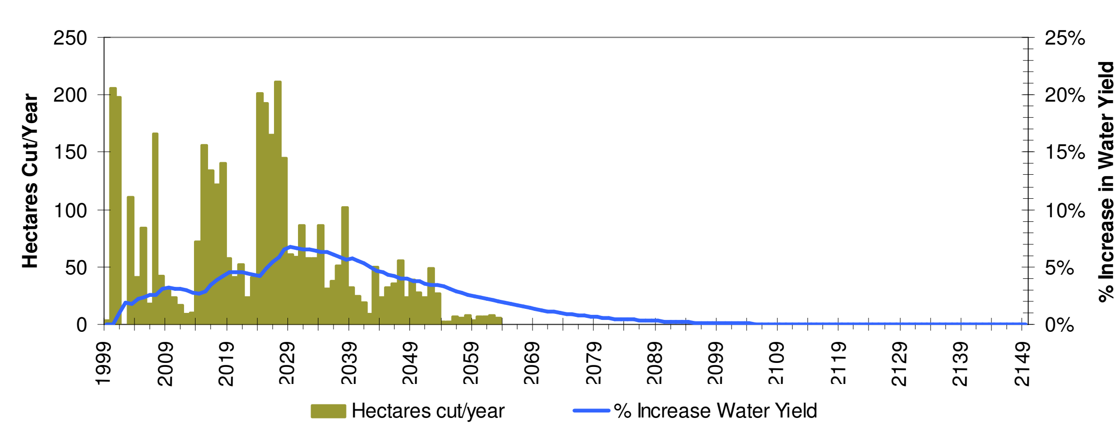

Blanchard Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2008
2018
2028
2038
2048
2058
2068
2073
% Watershed ECA
% Increase Water Yield



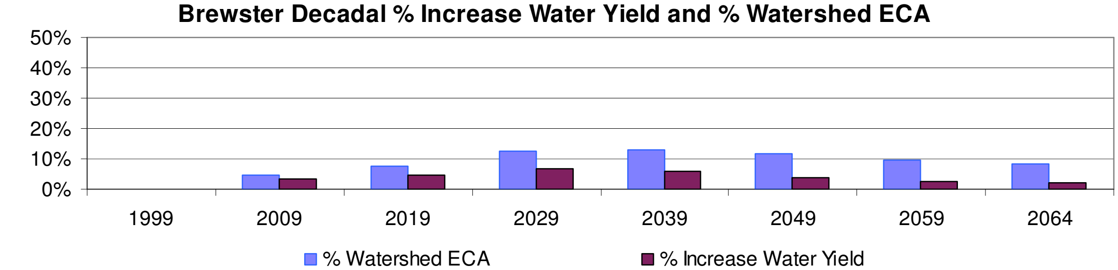
Brazeau % Increase in Water Yield



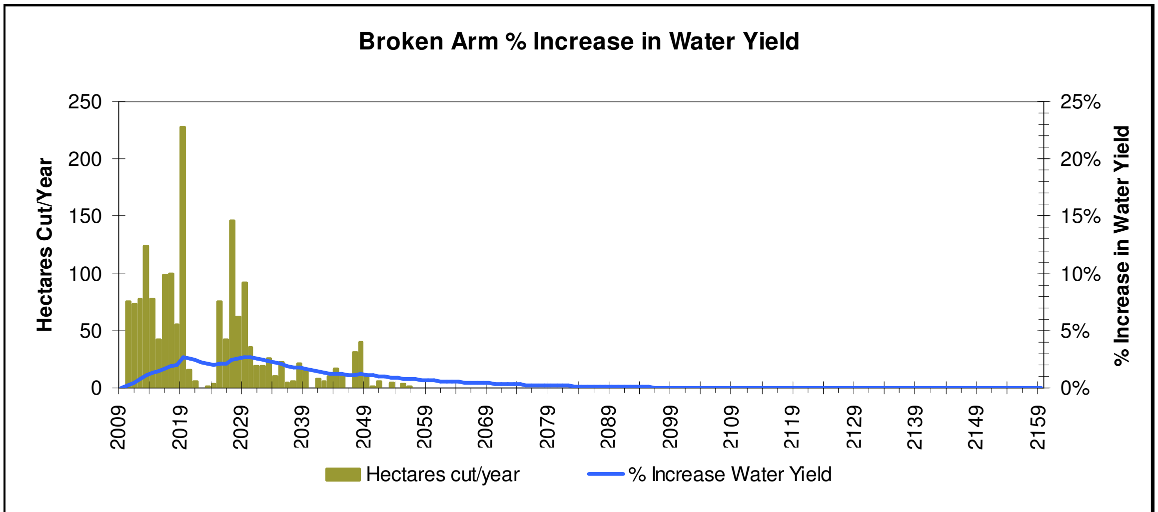
Brazeau Decadal % Increase Water Yield and % Watershed ECA

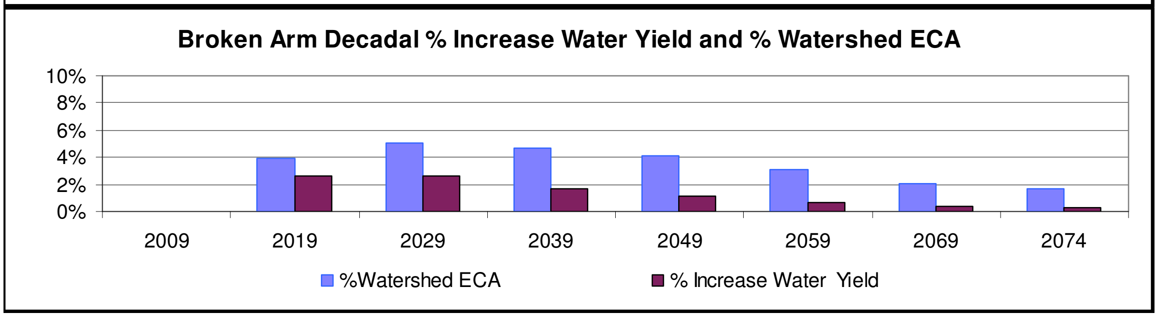


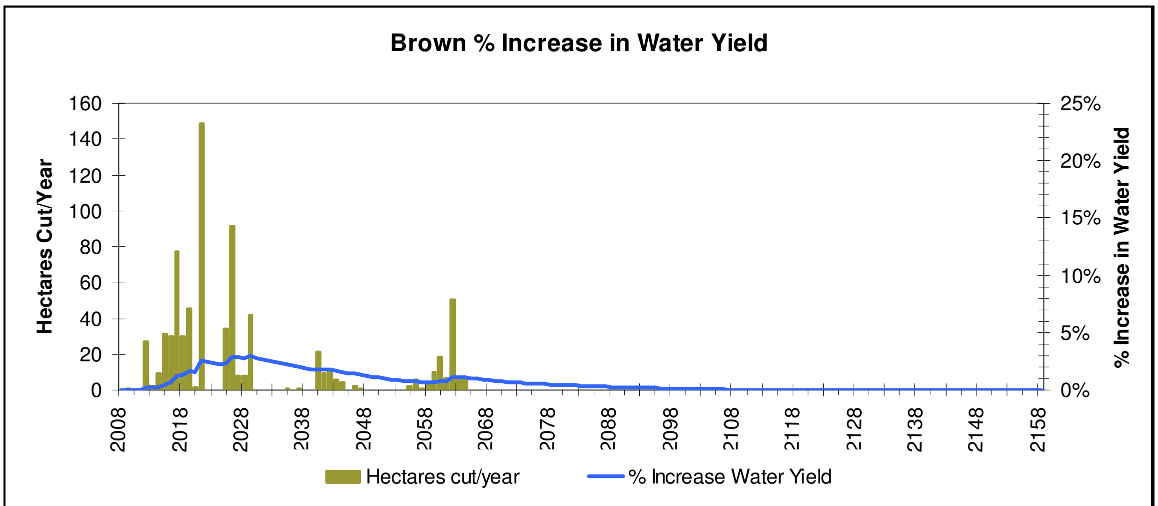
Brewster % Increase in Water Yield

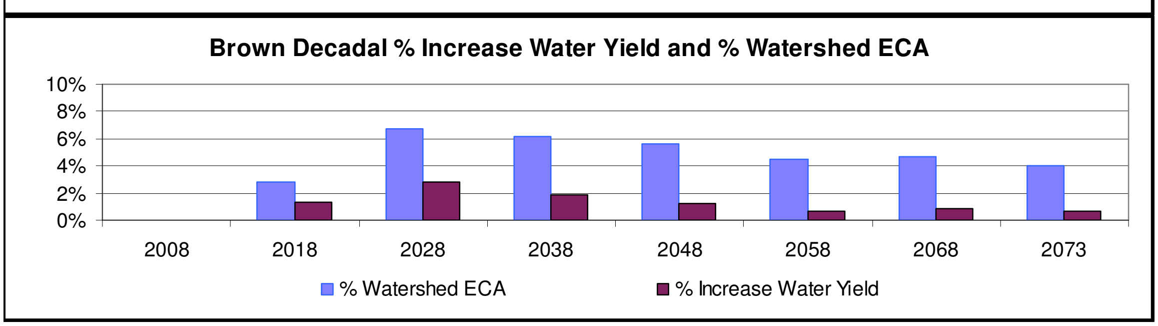


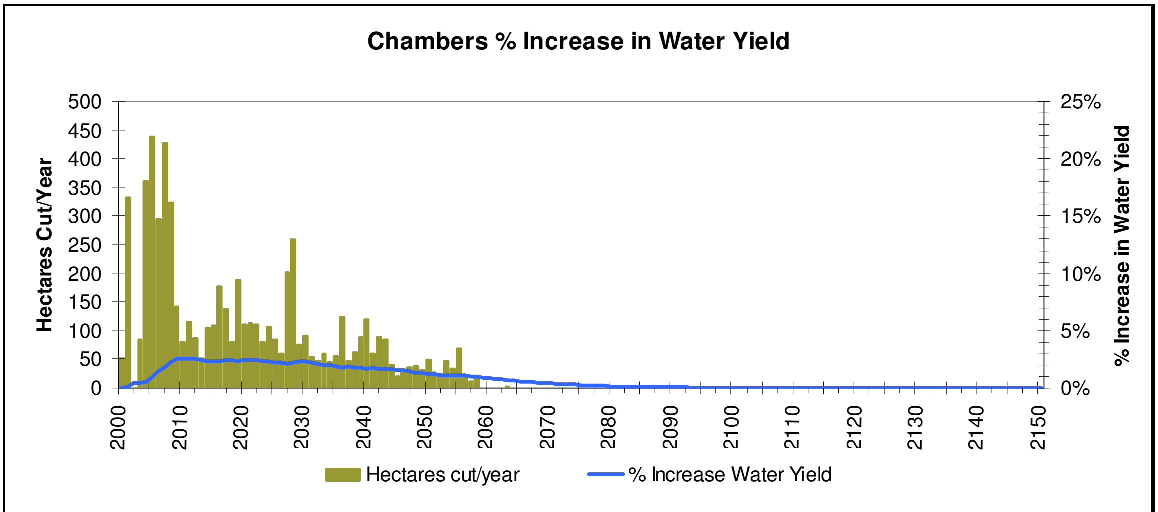
Brewster Decadal % Increase Water Yield and % Watershed ECA

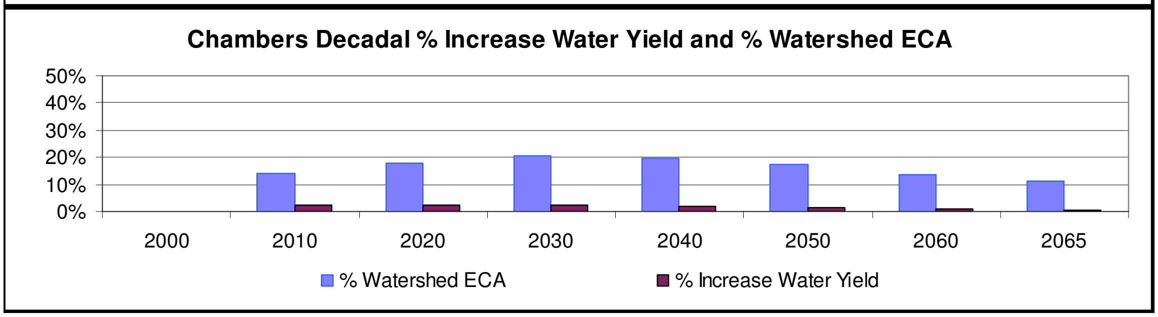

Broken Arm % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0 50 100 150 200 250
0% 5% 10% 15% 20% 25%
2009 2019 2029 2039 2049 2059 2069 2079 2089 2099 2109 2119 2129 2139 2149 2159
Hectares cut/year
% Increase Water Yield

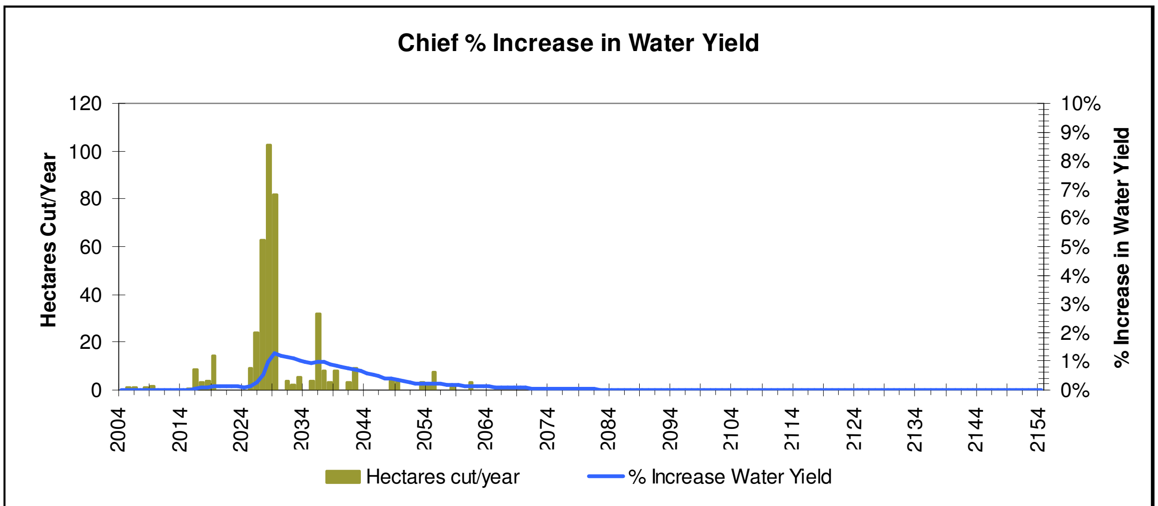

Broken Arm Decadal % Increase Water Yield and % Watershed ECA
0% 2% 4% 6% 8% 10%
2009 2019 2029 2039 2049 2059 2069 2074
%Watershed ECA
% Increase Water Yield

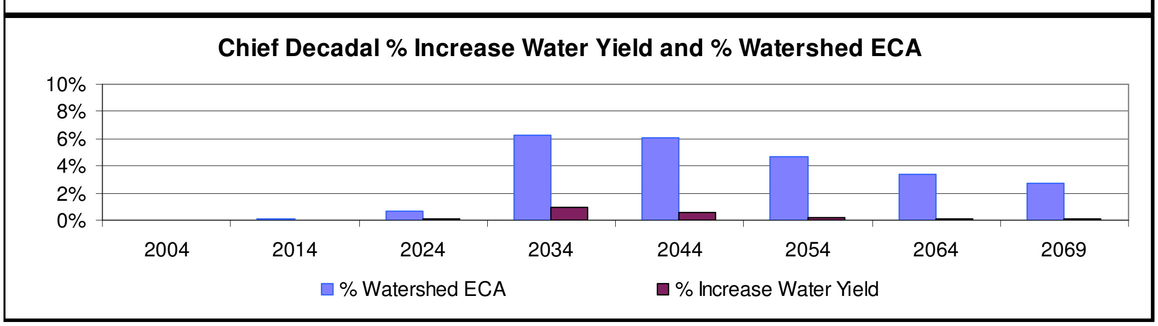

Brown % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0 20 40 60 80 100 120 140 160
0% 5% 10% 15% 20% 25%
2008 2018 2028 2038 2048 2058 2068 2078 2088 2098 2108 2118 2128 2138 2148 2158
Hectares cut/year
% Increase Water Yield

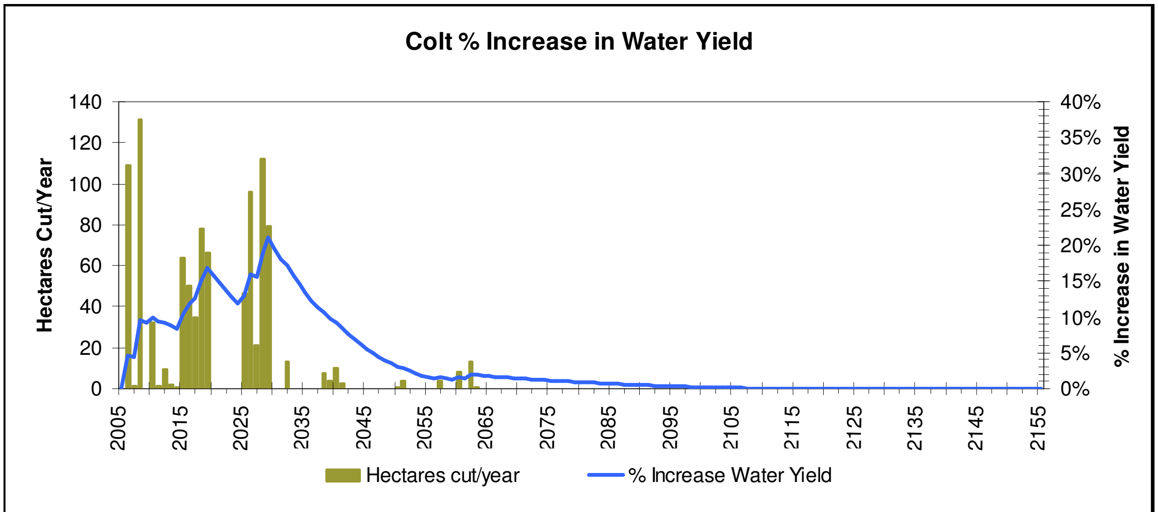

Brown Decadal % Increase Water Yield and % Watershed ECA
0% 2% 4% 6% 8% 10%
2008 2018 2028 2038 2048 2058 2068 2073
% Watershed ECA
% Increase Water Yield

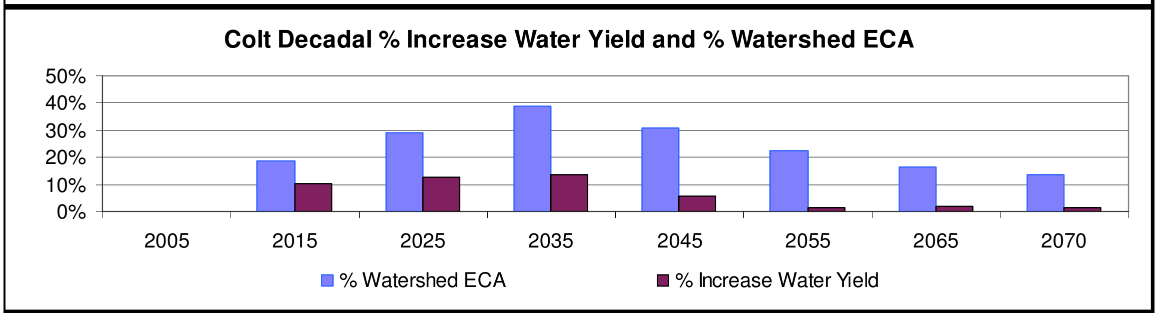

Chambers % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
50
100
150
200
250
300
350
400
450
500
0%
5%
10%
15%
20%
25%
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2130
2140
2150
Hectares cut/year
% Increase Water Yield

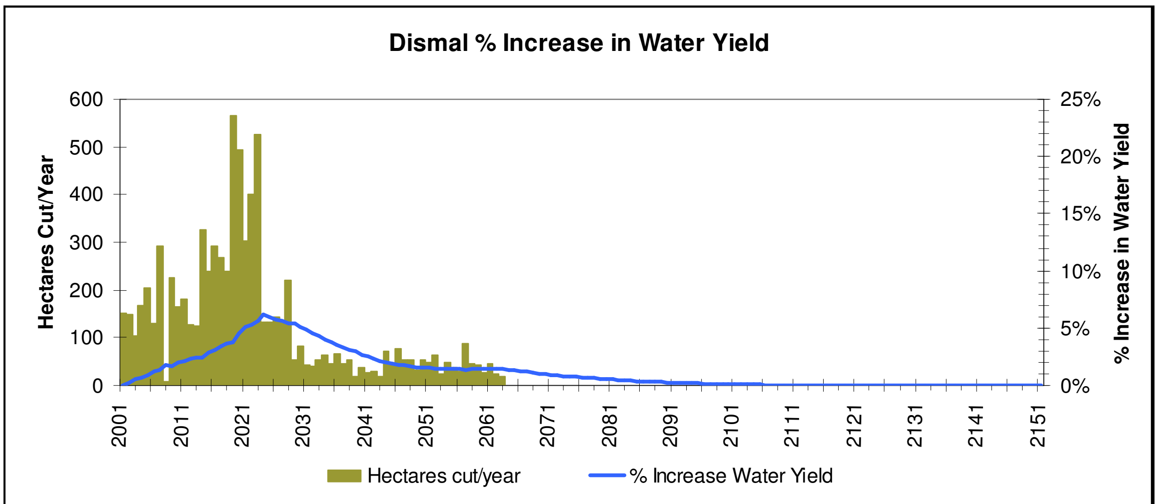

Chambers Decadal % Increase Water Yield and % Watershed ECA
0%
10%
20%
30%
40%
50%
2000
2010
2020
2030
2040
2050
2060
2065
% Watershed ECA
% Increase Water Yield

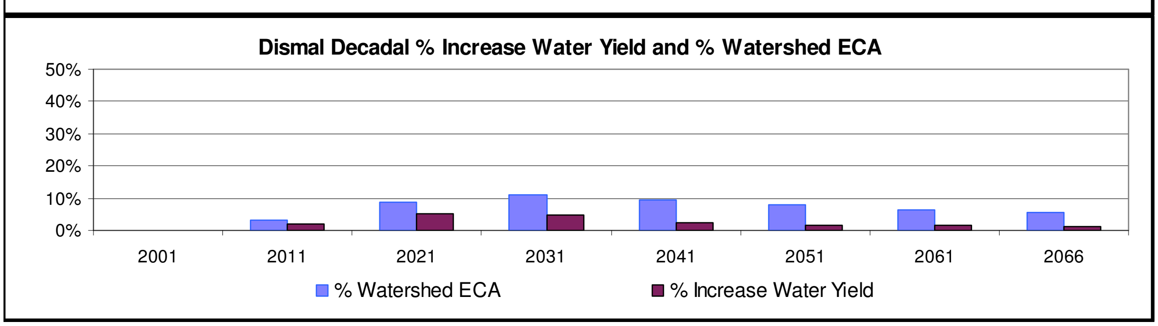

Chief % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
20
40
60
80
100
120
0%
1%
2%
3%
4%
5%
6%
7%
8%
9%
10%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

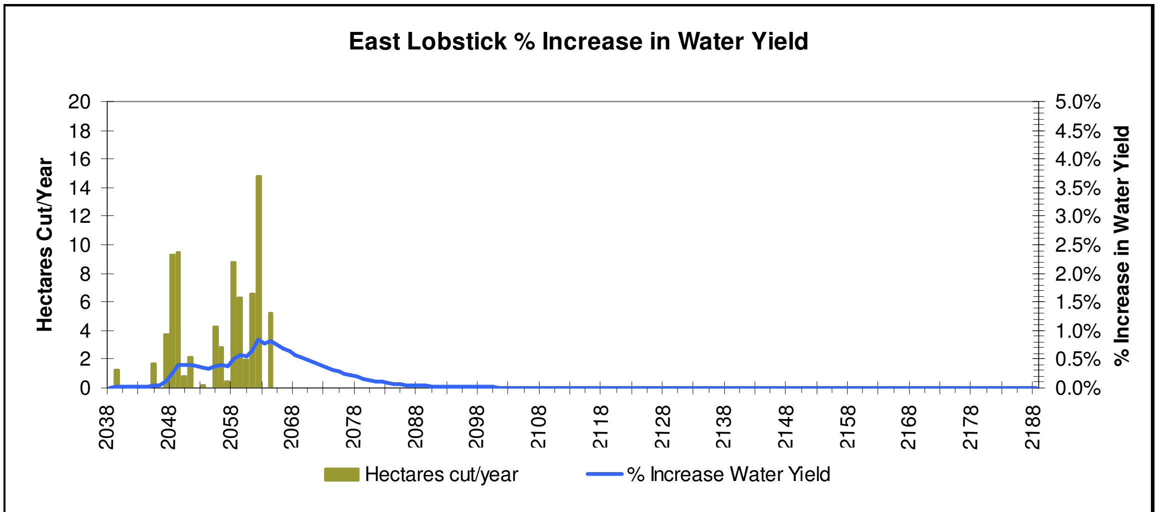

Chief Decadal % Increase Water Yield and % Watershed ECA
0%
2%
4%
6%
8%
10%
2004
2014
2024
2034
2044
2054
2064
2069
% Watershed ECA
% Increase Water Yield

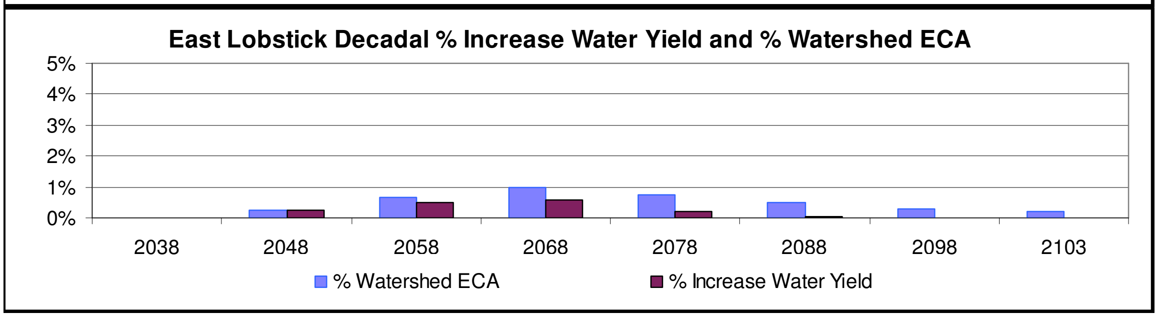

Colt % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
20
40
60
80
100
120
140
0%
5%
10%
15%
20%
25%
30%
35%
40%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield

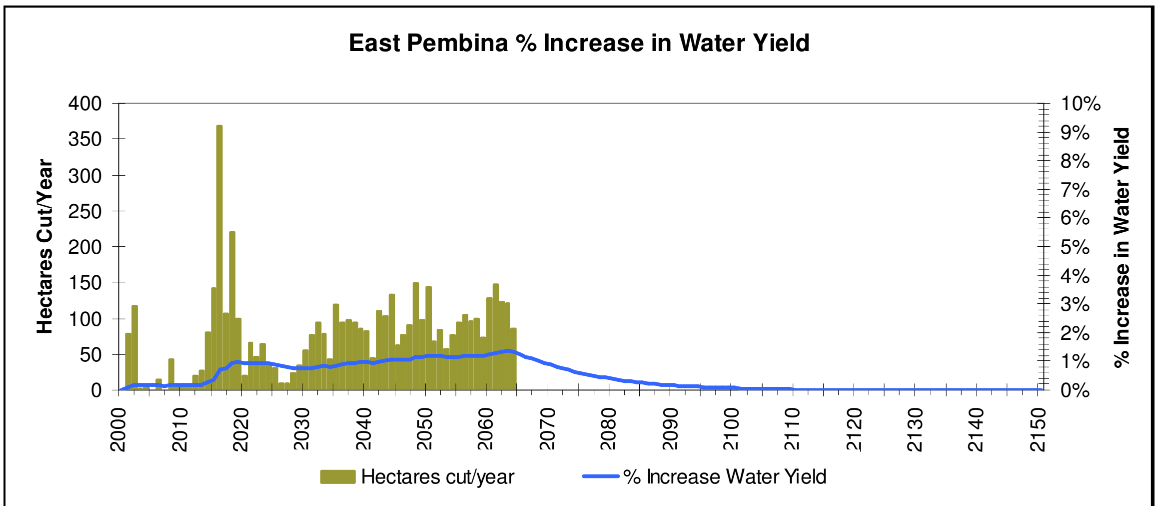

Colt Decadal % Increase Water Yield and % Watershed ECA
0%
10%
20%
30%
40%
50%
2005
2015
2025
2035
2045
2055
2065
2070
% Watershed ECA
% Increase Water Yield

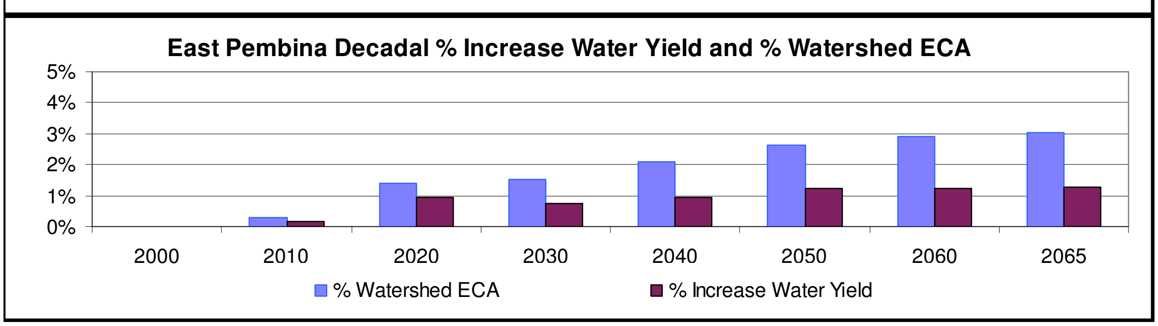

Dismal % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
100
200
300
400
500
600
0%
5%
10%
15%
20%
25%
2001
2011
2021
2031
2041
2051
2061
2071
2081
2091
2101
2111
2121
2131
2141
2151
Hectares cut/year
% Increase Water Yield

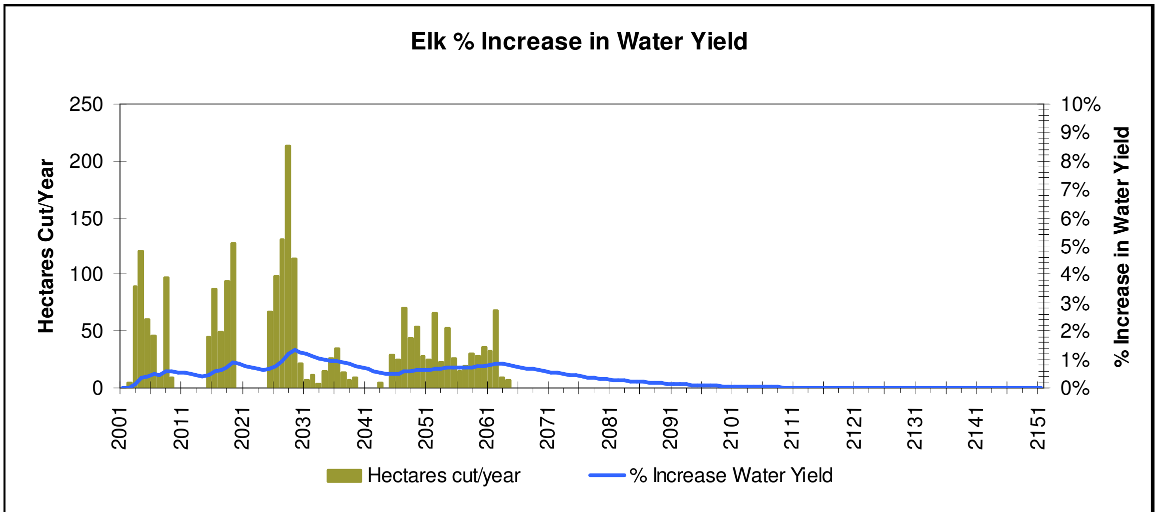

Dismal Decadal % Increase Water Yield and % Watershed ECA
0%
10%
20%
30%
40%
50%
2001
2011
2021
2031
2041
2051
2061
2066
% Watershed ECA
% Increase Water Yield

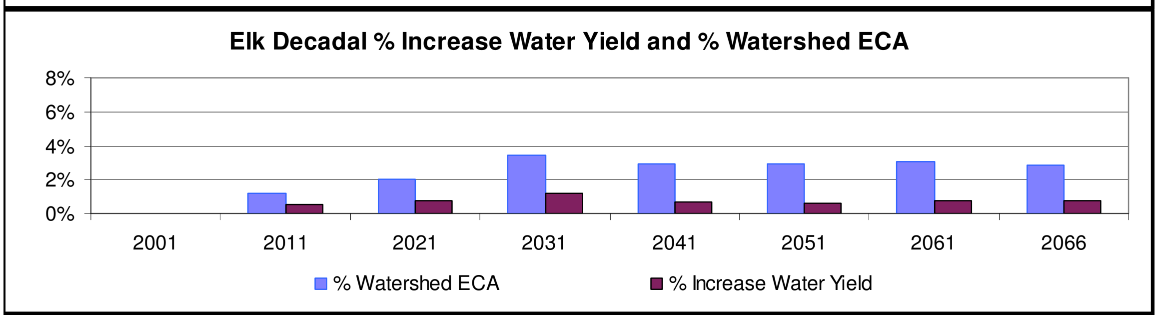

East Lobstick % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

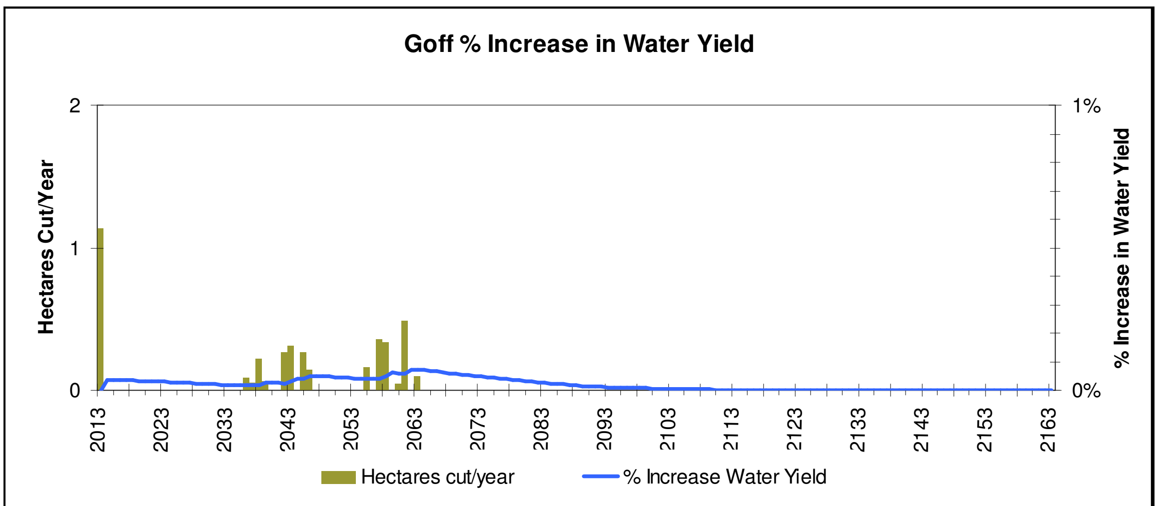

East Lobstick Decadal % Increase Water Yield and % Watershed ECA
2038
2048
2058
2068
2078
2088
2098
2103
% Watershed ECA
% Increase Water Yield

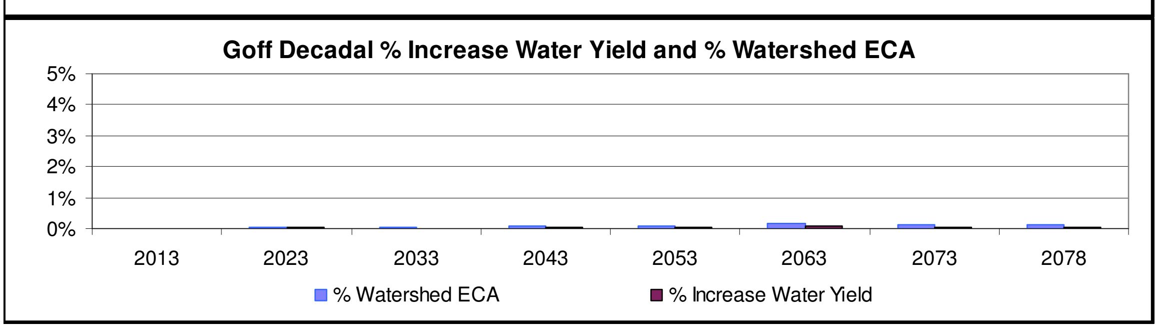

East Pembina % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

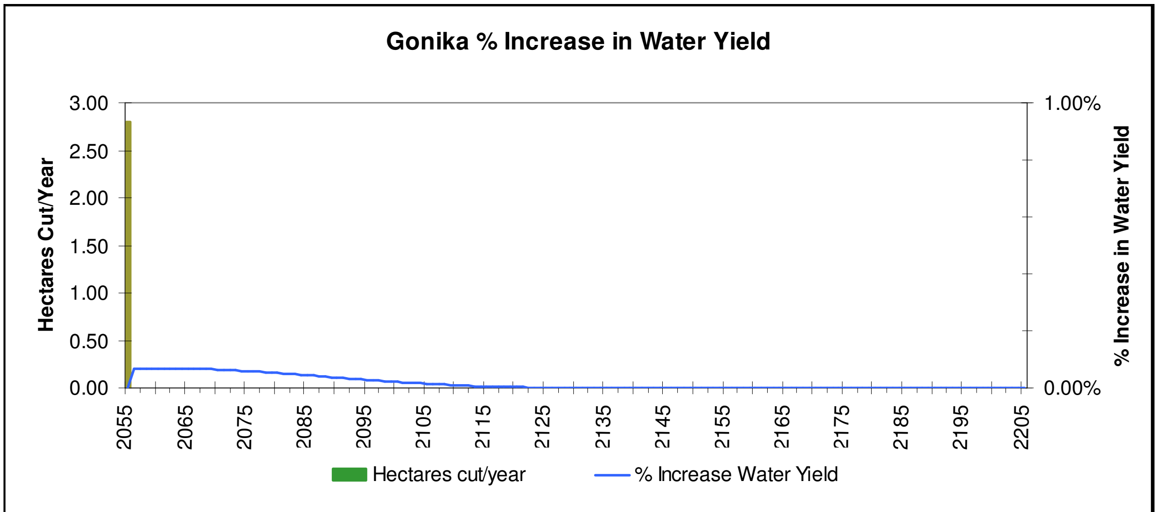

East Pembina Decadal % Increase Water Yield and % Watershed ECA
2000
2010
2020
2030
2040
2050
2060
2065
% Watershed ECA
% Increase Water Yield

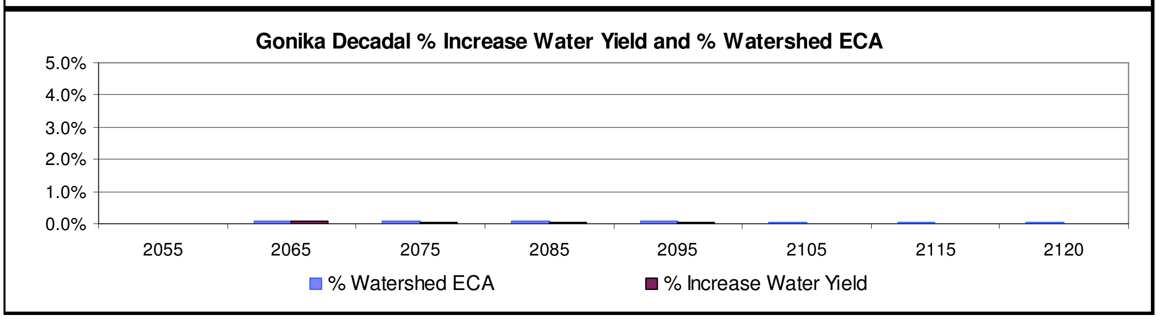

Elk % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
250
200
150
100
50
0
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
2001
2011
2021
2031
2041
2051
2061
2071
2081
2091
2101
2111
2121
2131
2141
2151
Hectares cut/year
% Increase Water Yield

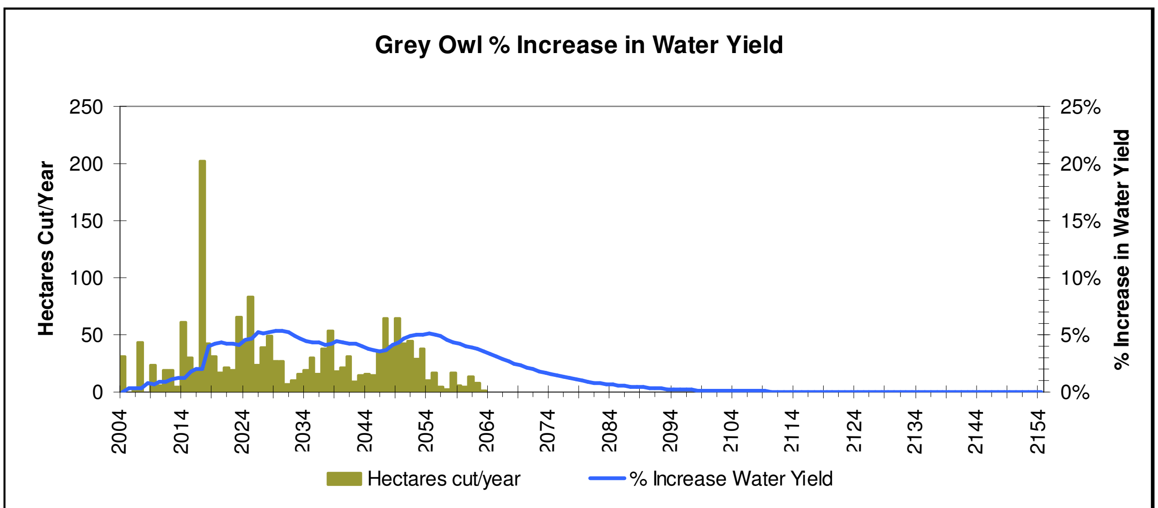

Elk Decadal % Increase Water Yield and % Watershed ECA
8%
6%
4%
2%
0%
2001
2011
2021
2031
2041
2051
2061
2066
% Watershed ECA
% Increase Water Yield

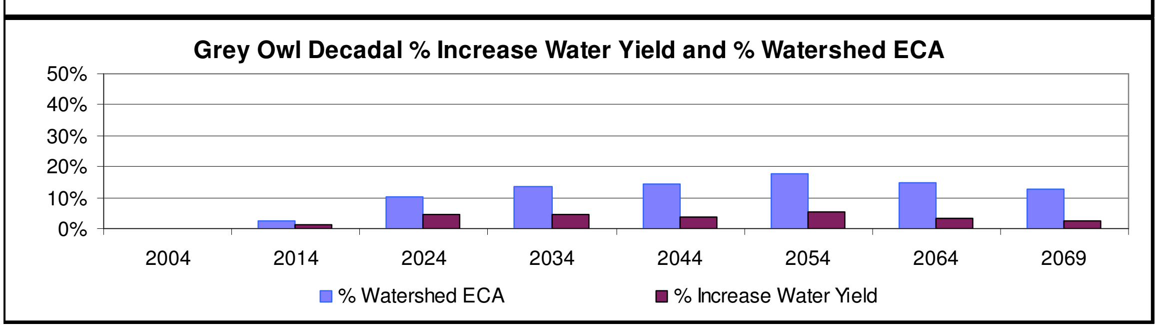

Goff % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
2
1
0
1%
0%
2013
2023
2033
2043
2053
2063
2073
2083
2093
2103
2113
2123
2133
2143
2153
2163
Hectares cut/year
% Increase Water Yield

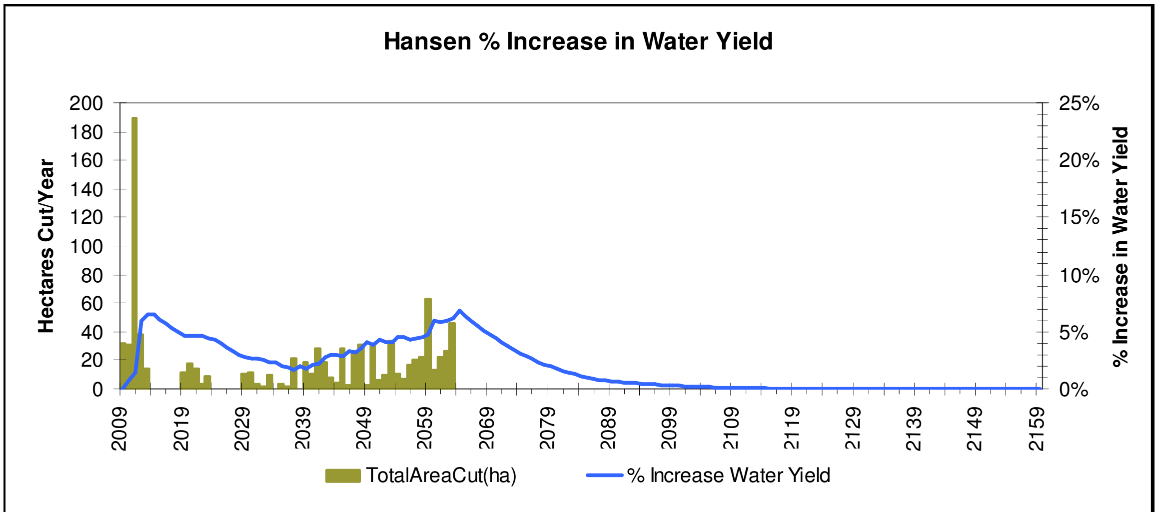

Goff Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2013
2023
2033
2043
2053
2063
2073
2078
% Watershed ECA
% Increase Water Yield

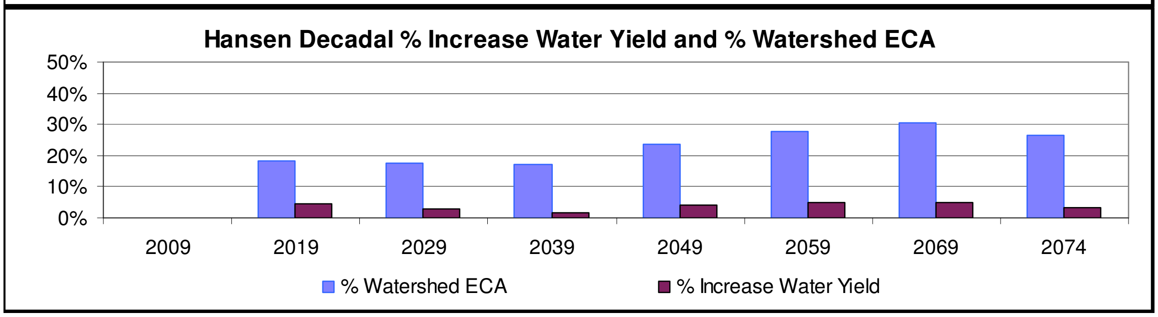

Gonika % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1.00%
0.00%
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
2165
2175
2185
2195
2205
Hectares cut/year
% Increase Water Yield

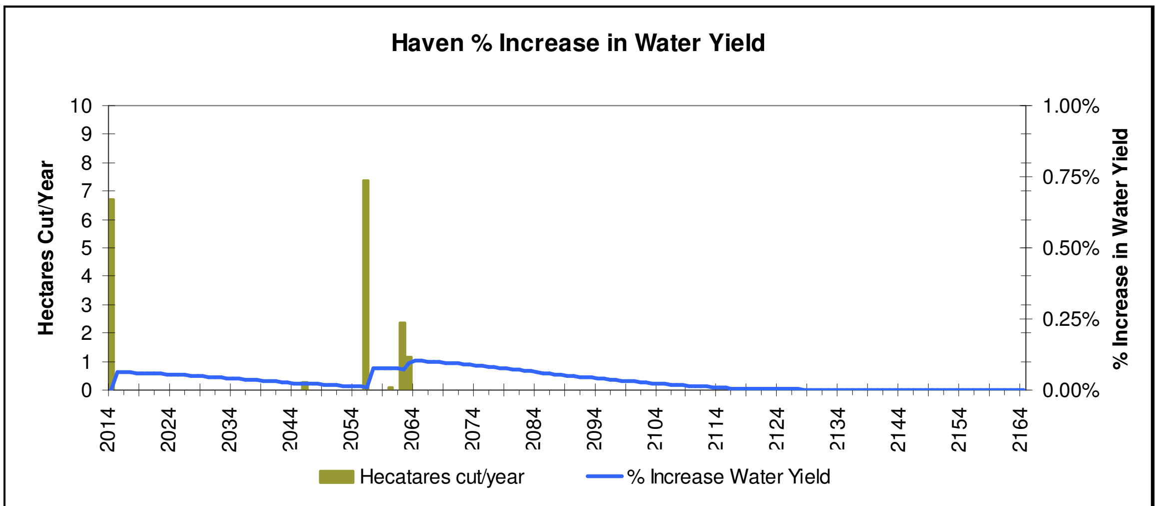

Gonika Decadal % Increase Water Yield and % Watershed ECA
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
2055
2065
2075
2085
2095
2105
2115
2120
% Watershed ECA
% Increase Water Yield

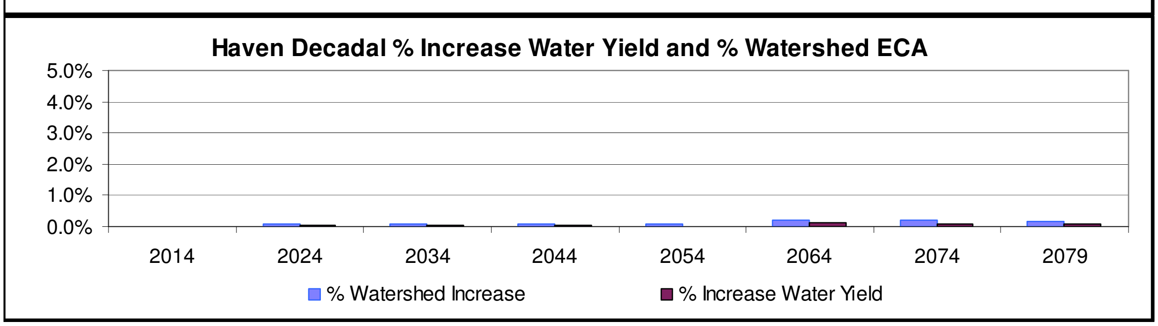

Grey Owl % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

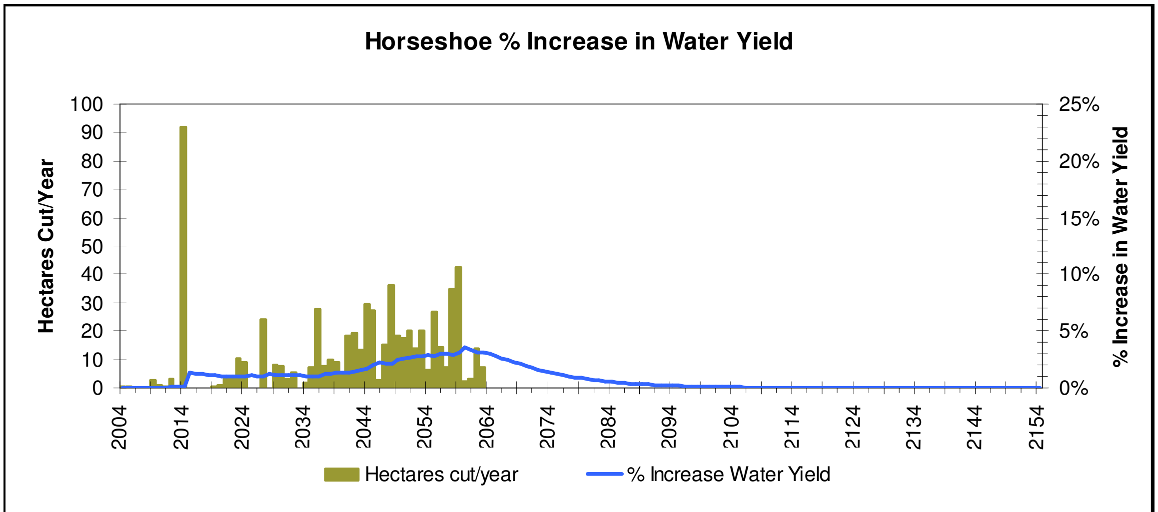

Grey Owl Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2004
2014
2024
2034
2044
2054
2064
2069
% Watershed ECA
% Increase Water Yield

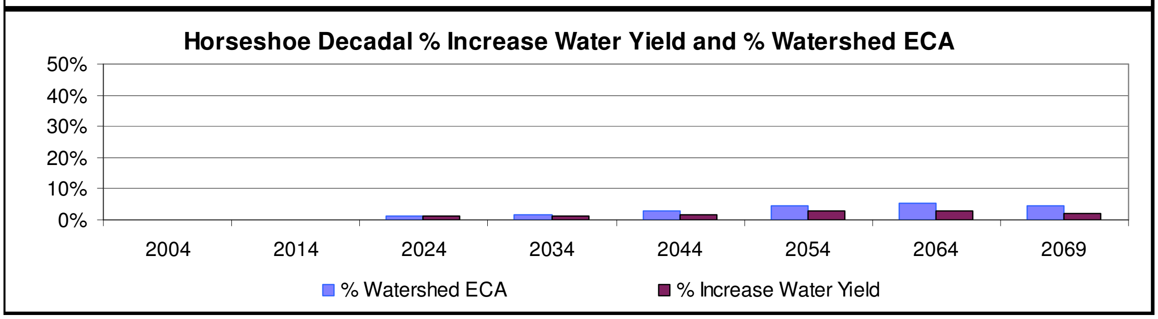

Hansen % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
200
180
160
140
120
100
80
60
40
20
0
25%
20%
15%
10%
5%
0%
2009
2019
2029
2039
2049
2059
2069
2079
2089
2099
2109
2119
2129
2139
2149
2159
TotalAreaCut(ha)
% Increase Water Yield

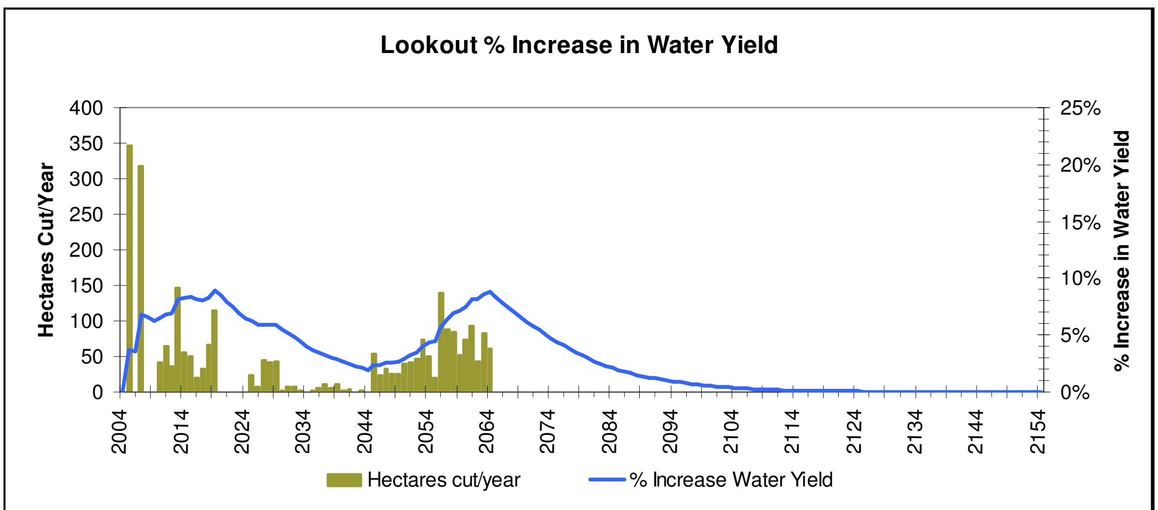

Hansen Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2009
2019
2029
2039
2049
2059
2069
2074
% Watershed ECA
% Increase Water Yield

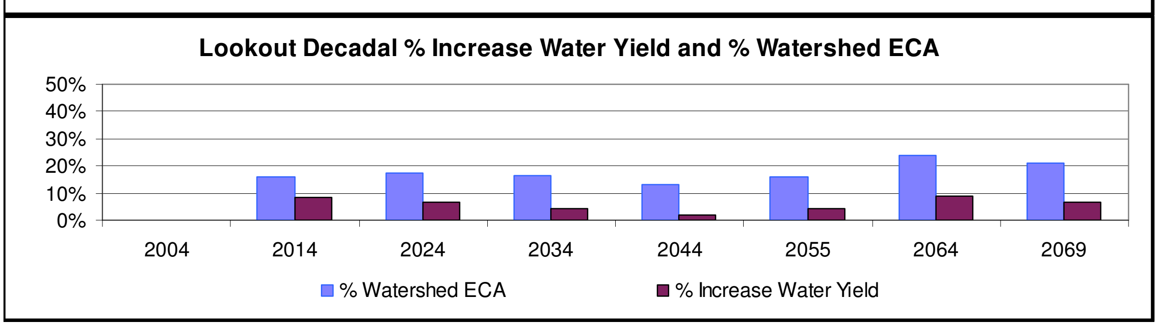

Haven % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
10
9
8
7
6
5
4
3
2
1
0
1.00%
0.75%
0.50%
0.25%
0.00%
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
2164
Hecatares cut/year
% Increase Water Yield

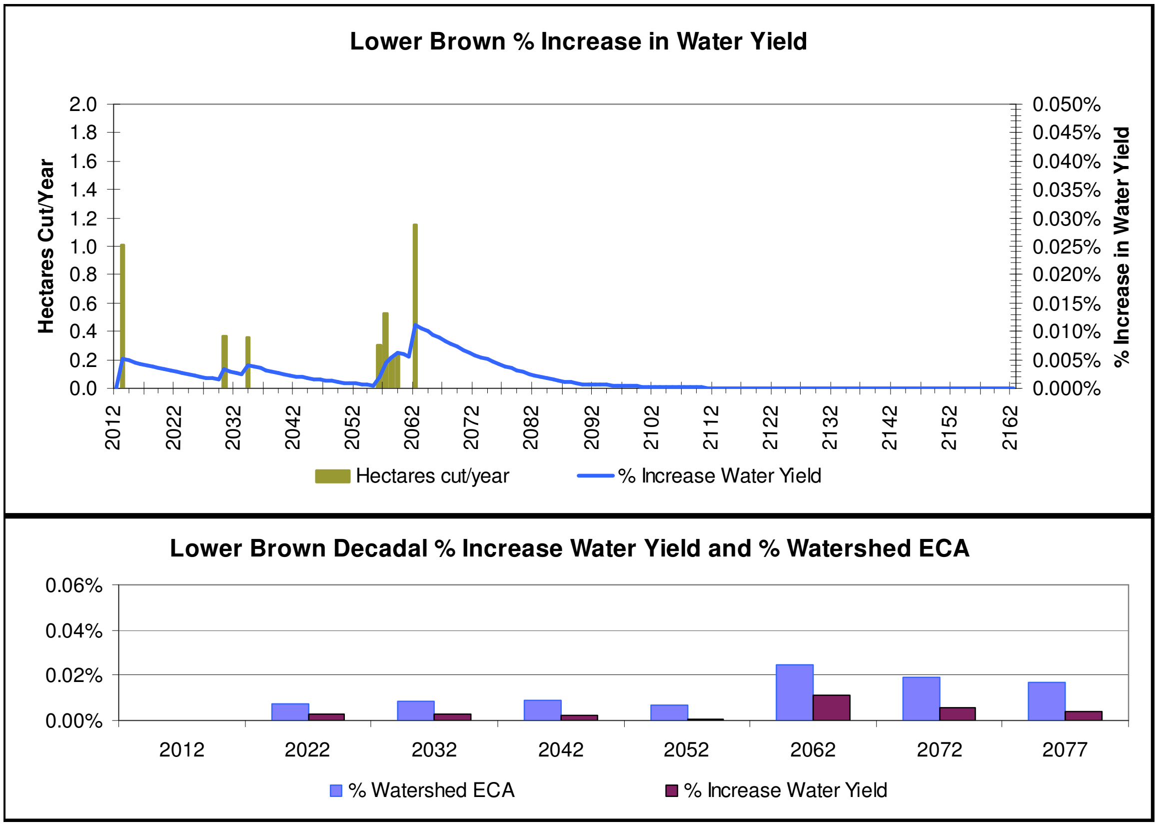

Haven Decadal % Increase Water Yield and % Watershed ECA
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
2014
2024
2034
2044
2054
2064
2074
2079
% Watershed Increase
% Increase Water Yield

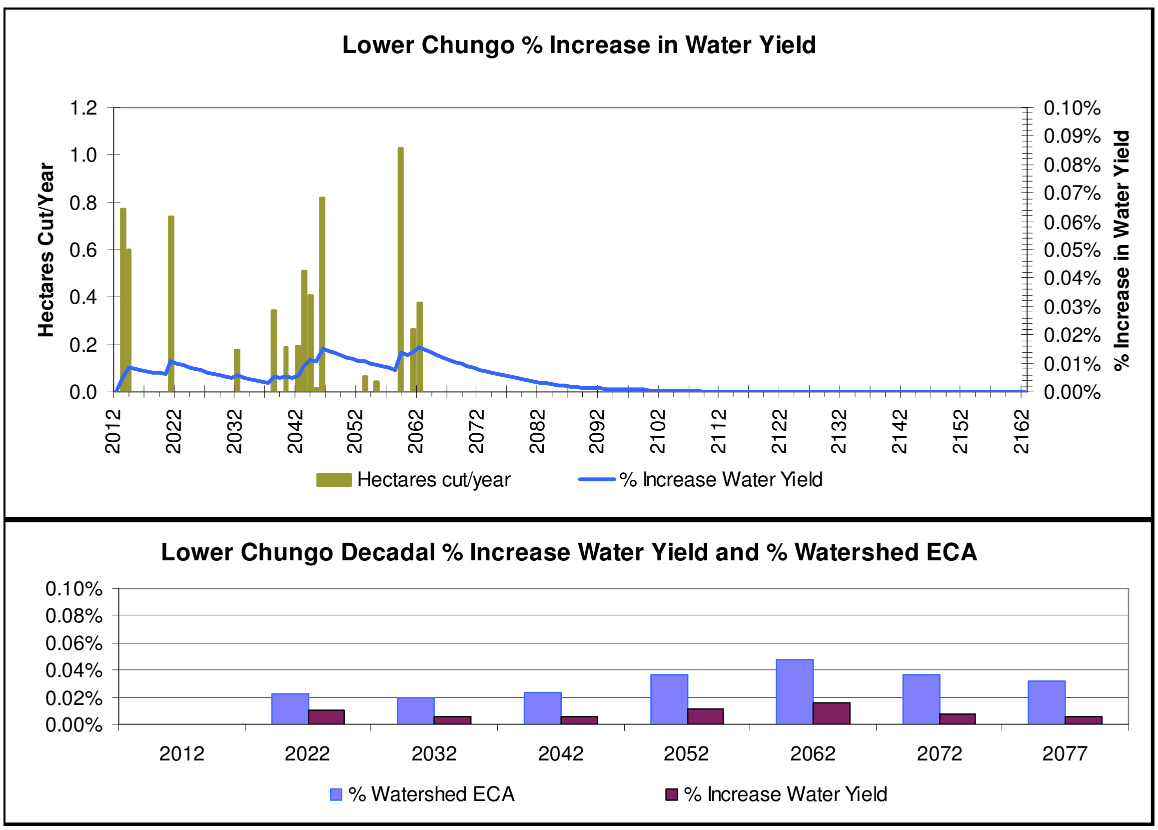

Horseshoe % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
100
90
80
70
60
50
40
30
20
10
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

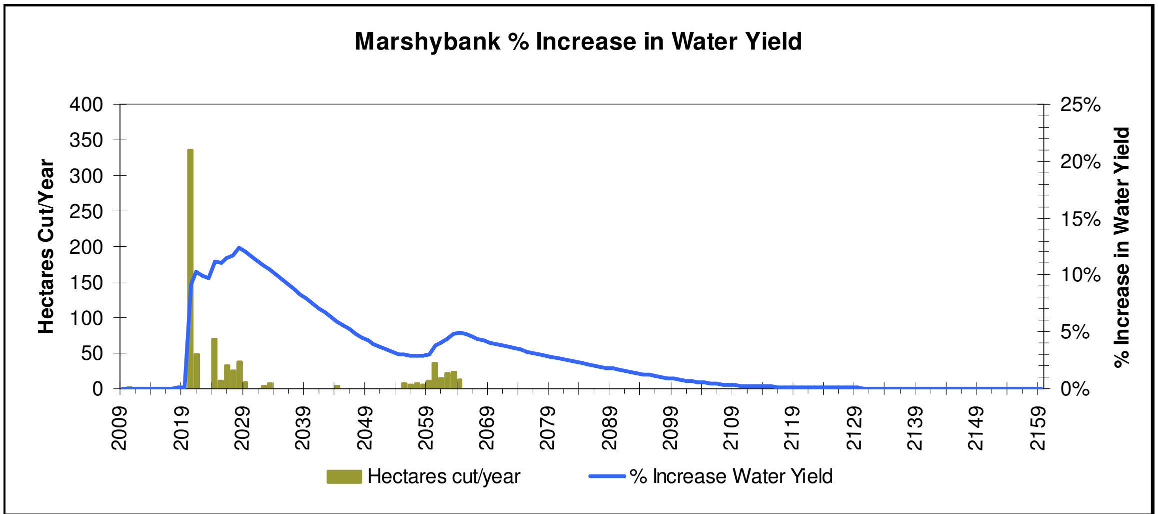

Horseshoe Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2004
2014
2024
2034
2044
2054
2064
2069
% Watershed ECA
% Increase Water Yield

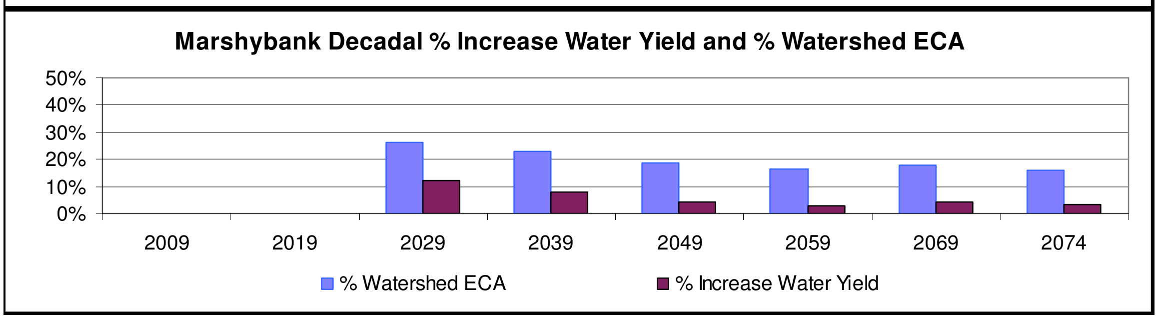

Lookout % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

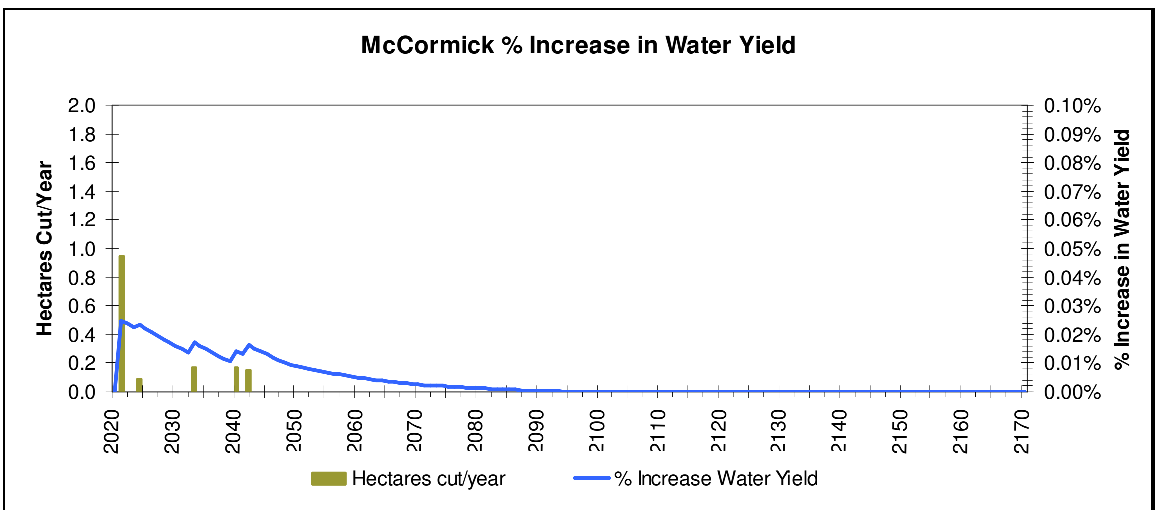

Lookout Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2004
2014
2024
2034
2044
2055
2064
2069
% Watershed ECA
% Increase Water Yield

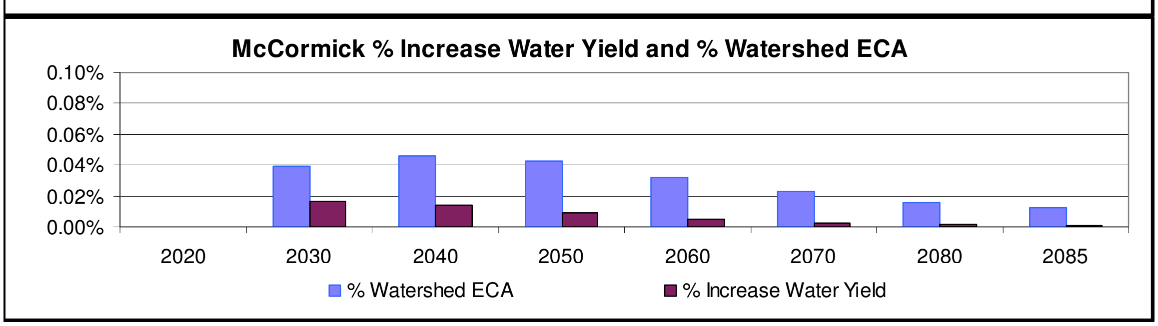

Lower Brown % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield
Lower Brown Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

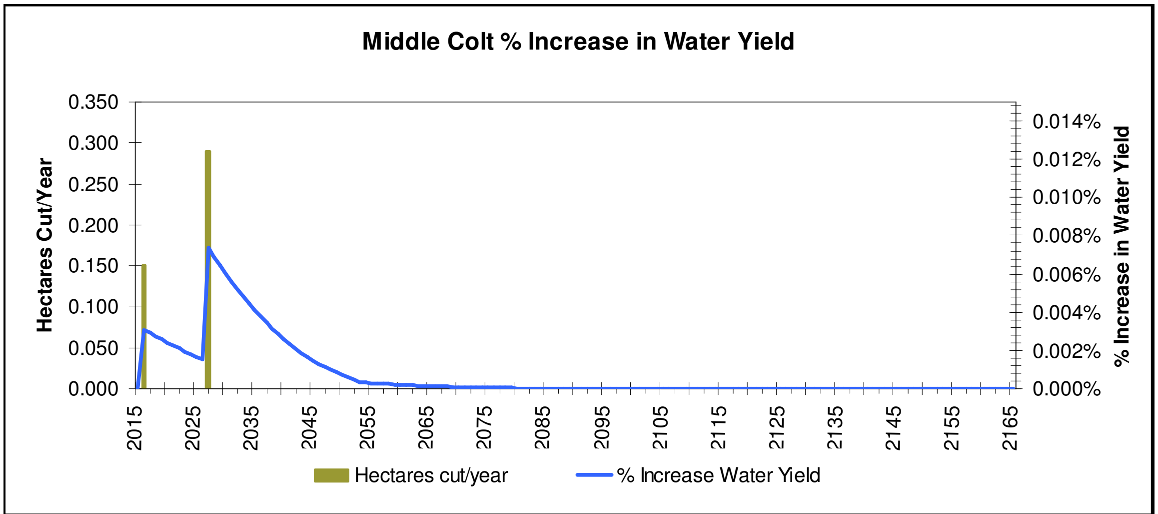

Lower Chungo % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield
Lower Chungo Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

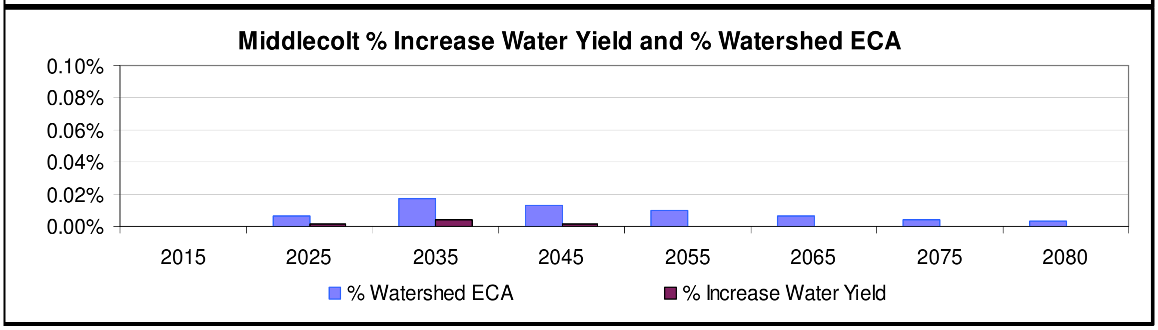

Marshybank % Increase in Water Yield
Hectares Cut/Year
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
% Increase in Water Yield
2009
2019
2029
2039
2049
2059
2069
2079
2089
2099
2109
2119
2129
2139
2149
2159
Hectares cut/year
% Increase Water Yield

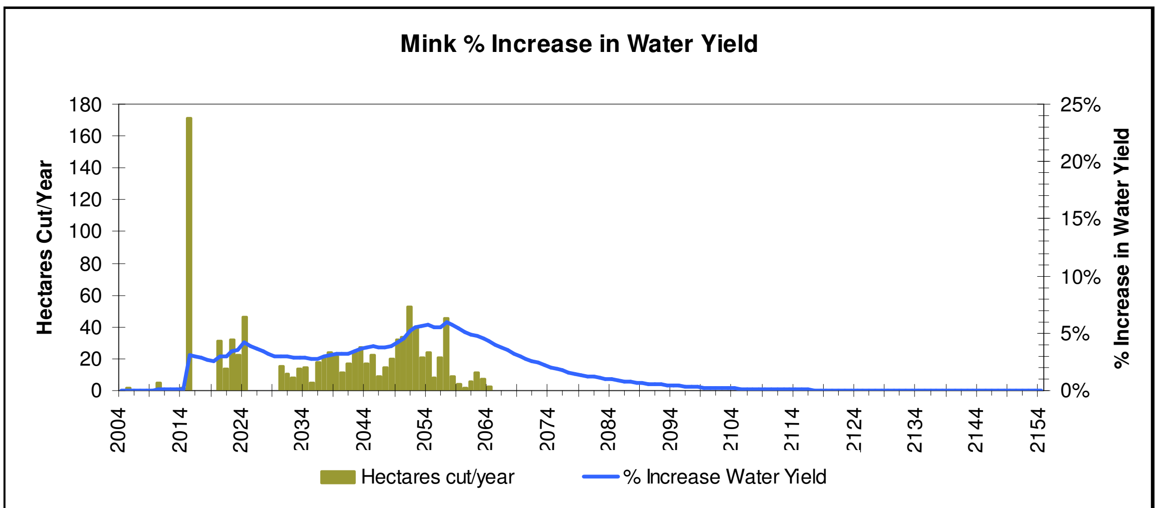

Marshybank Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2009
2019
2029
2039
2049
2059
2069
2074
% Watershed ECA
% Increase Water Yield

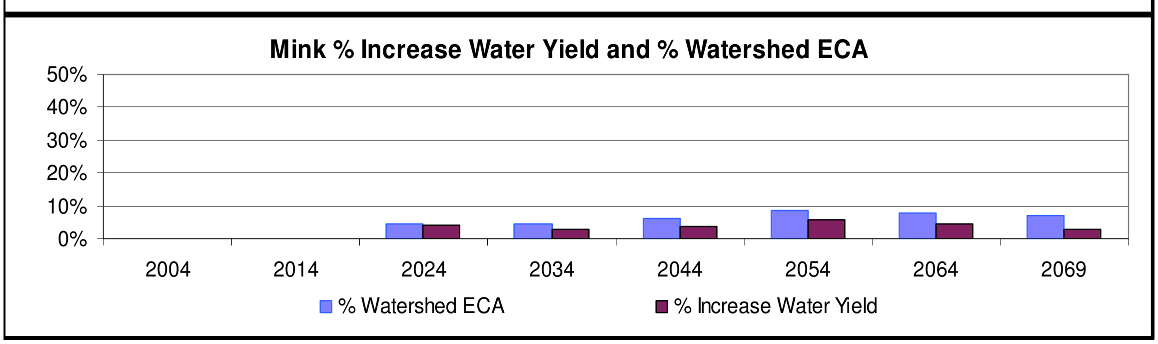

McCormick % Increase in Water Yield
Hectares Cut/Year
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.10%
0.09%
0.08%
0.07%
0.06%
0.05%
0.04%
0.03%
0.02%
0.01%
0.00%
% Increase in Water Yield
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2130
2140
2150
2160
2170
Hectares cut/year
% Increase Water Yield

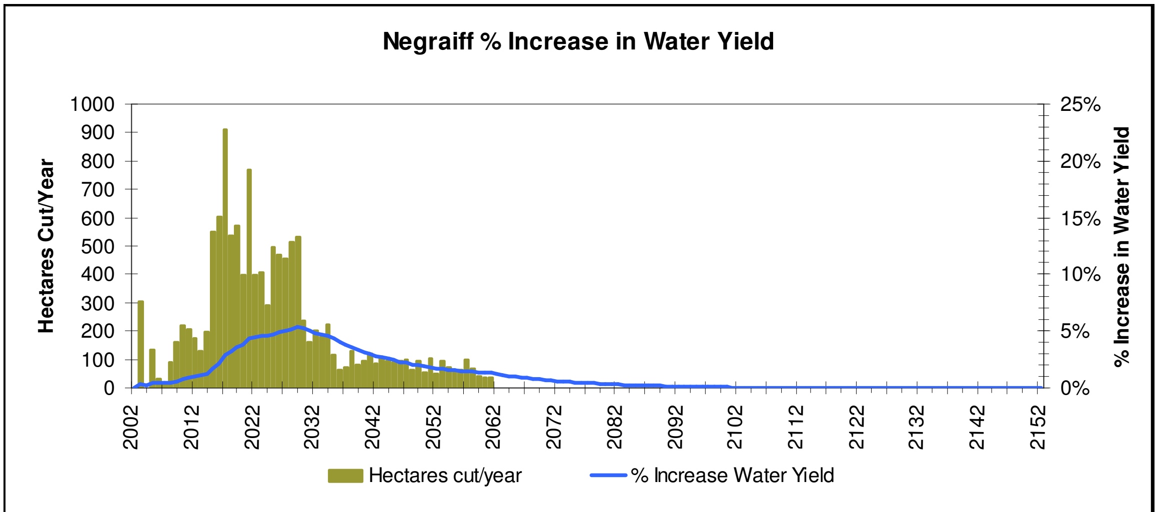

McCormick % Increase Water Yield and % Watershed ECA
0.10%
0.08%
0.06%
0.04%
0.02%
0.00%
2020
2030
2040
2050
2060
2070
2080
2085
% Watershed ECA
% Increase Water Yield

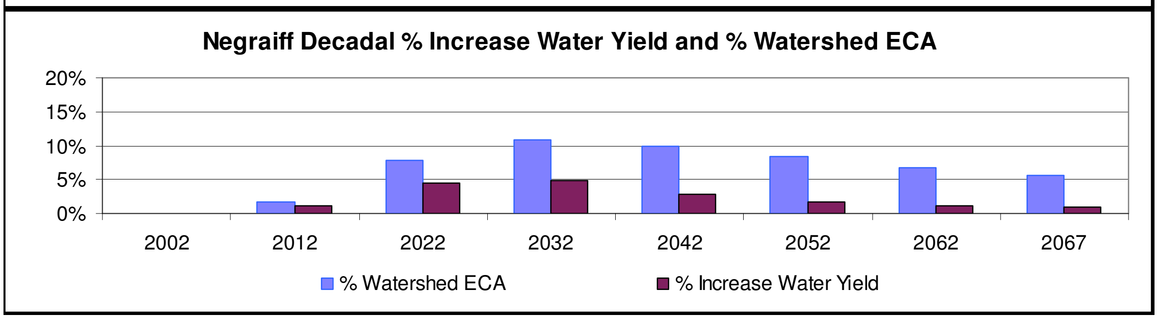

Middle Colt % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.014%
0.012%
0.010%
0.008%
0.006%
0.004%
0.002%
0.000%
2015 2025 2035 2045 2055 2065 2075 2085 2095 2105 2115 2125 2135 2145 2155 2165
Hectares cut/year
% Increase Water Yield

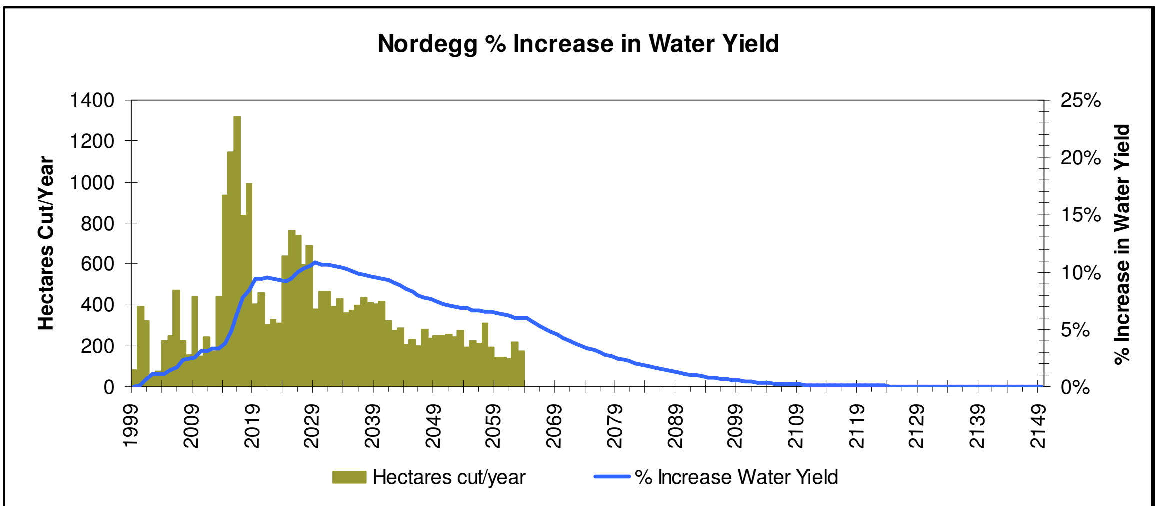

Middlecolt % Increase Water Yield and % Watershed ECA
0.10%
0.08%
0.06%
0.04%
0.02%
0.00%
2015 2025 2035 2045 2055 2065 2075 2080
% Watershed ECA
% Increase Water Yield

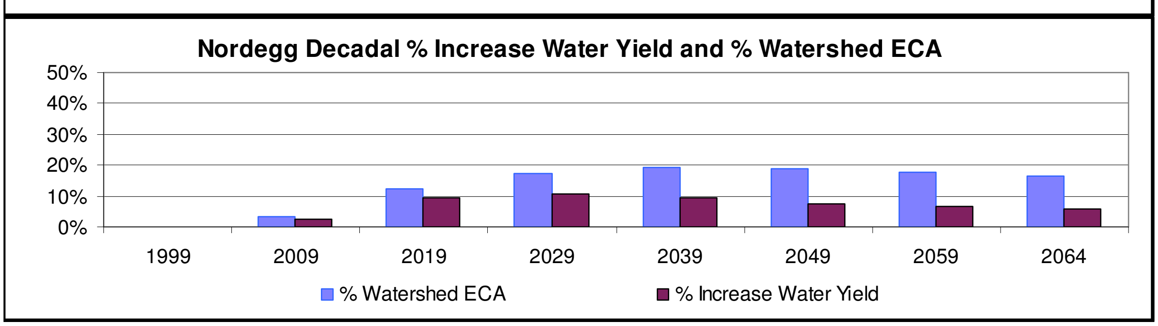

Mink % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
180
160
140
120
100
80
60
40
20
0
25%
20%
15%
10%
5%
0%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield

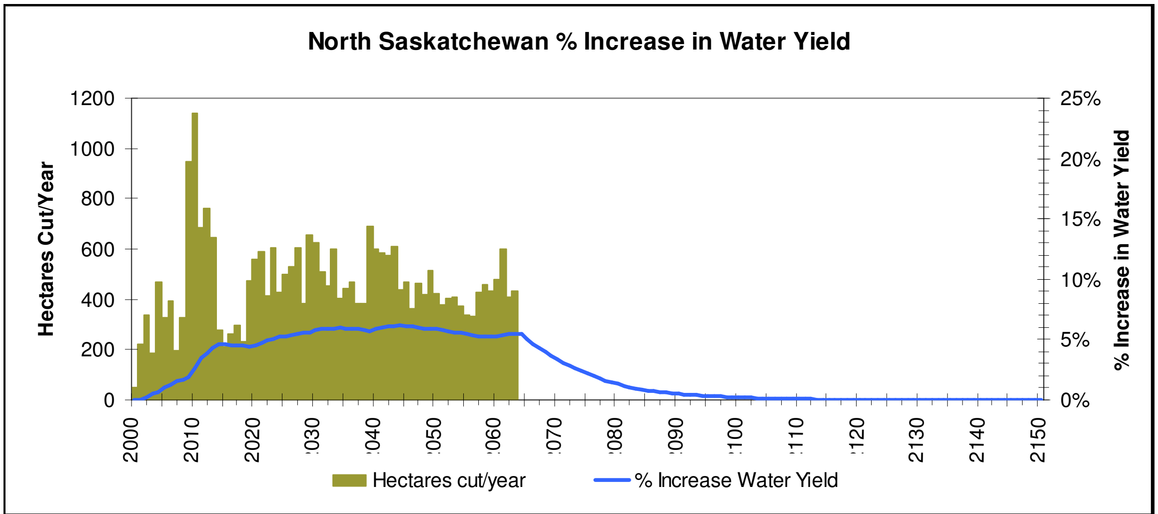

Mink % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2004 2014 2024 2034 2044 2054 2064 2069
% Watershed ECA
% Increase Water Yield

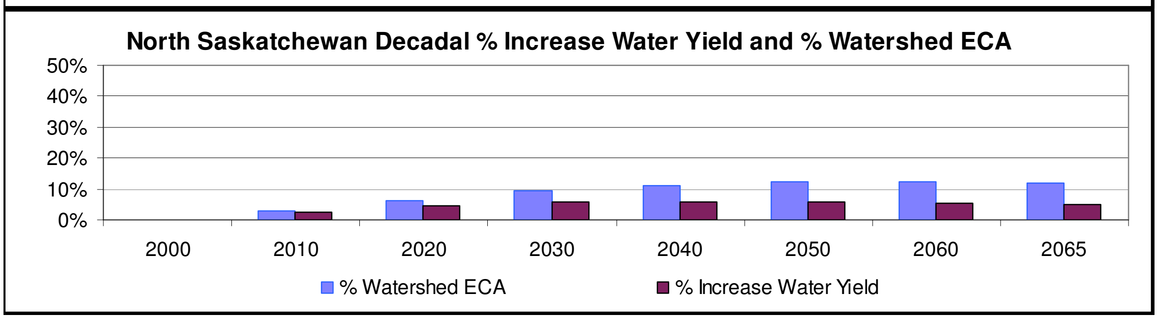

Negraiff % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1000
900
800
700
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
2002
2012
2022
2032
2042
2052
2062
2072
2082
2092
2102
2112
2122
2132
2142
2152
Hectares cut/year
% Increase Water Yield

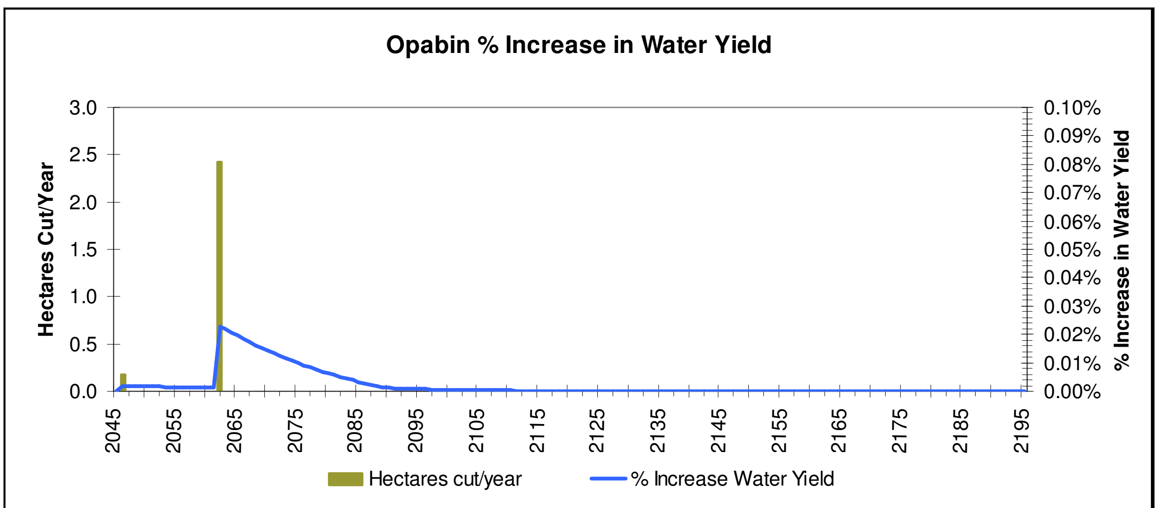

Negraiff Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2002
2012
2022
2032
2042
2052
2062
2067
% Watershed ECA
% Increase Water Yield

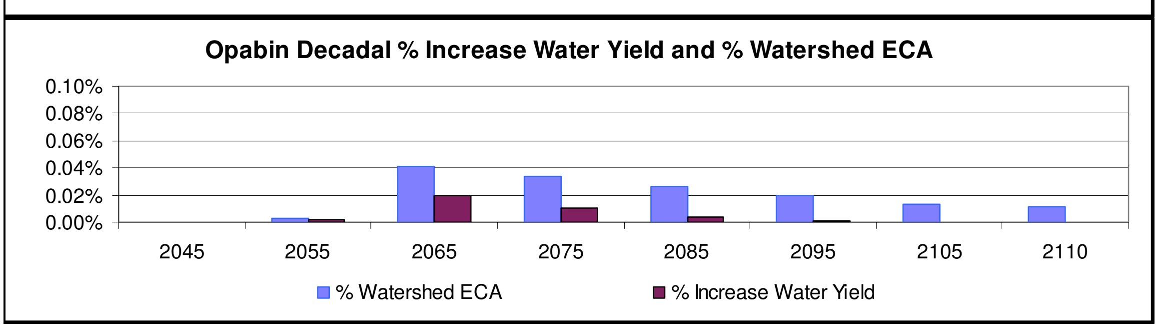

Nordegg % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1400
1200
1000
800
600
400
200
0
25%
20%
15%
10%
5%
0%
1999
2009
2019
2029
2039
2049
2059
2069
2079
2089
2099
2109
2119
2129
2139
2149
Hectares cut/year
% Increase Water Yield

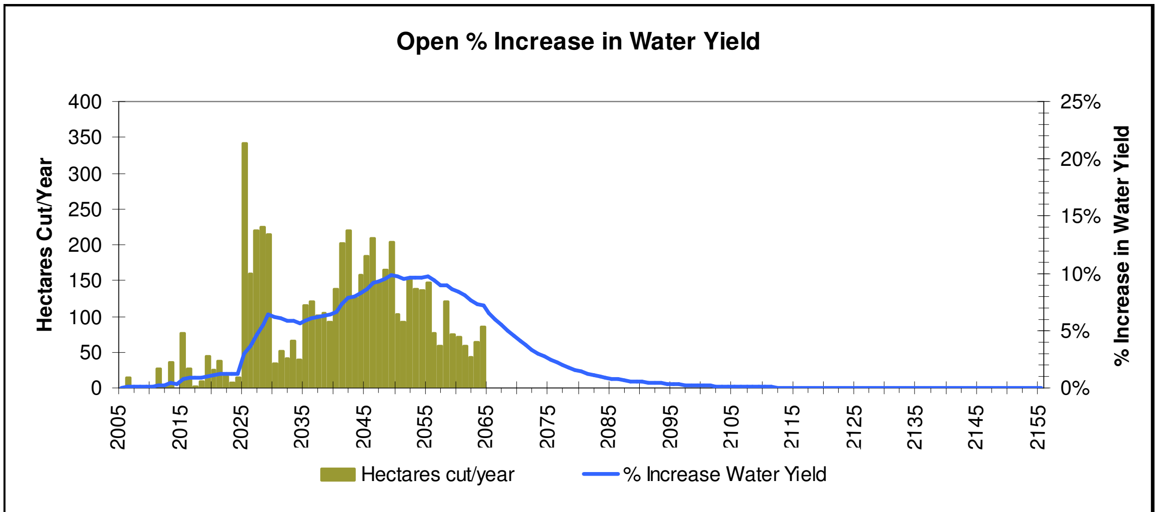

Nordegg Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
1999
2009
2019
2029
2039
2049
2059
2064
% Watershed ECA
% Increase Water Yield


North Saskatchewan % Increase in Water Yield
Hectares Cut/Year
1200
1000
800
600
400
200
0
% Increase in Water Yield
25%
20%
15%
10%
5%
0%
2000
2010
2020
030
040
050
060
070
080
090
100
110
120
2130
2140
2150
Hectares cut/year
% Increase Water Yield

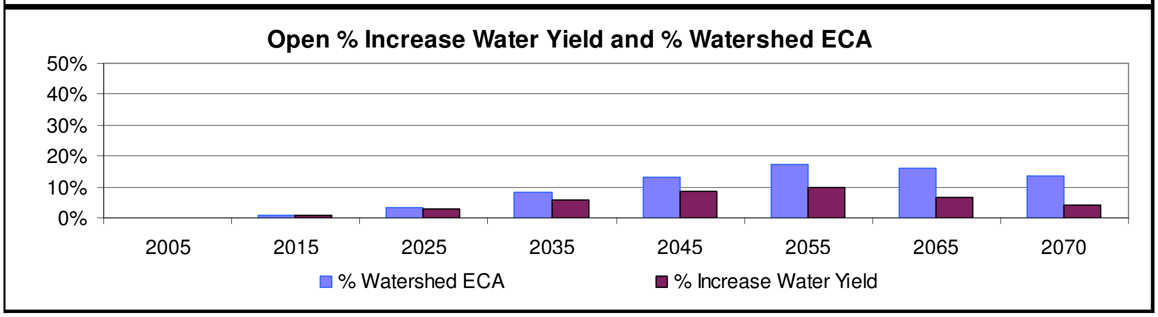

North Saskatchewan Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2000
2010
2020
2030
2040
2050
2060
2065
% Watershed ECA
% Increase Water Yield


Opabin % Increase in Water Yield
Hectares Cut/Year
3.0
2.5
2.0
1.5
1.0
0.5
0.0
% Increase in Water Yield
0.10%
0.09%
0.08%
0.07%
0.06%
0.05%
0.04%
0.03%
0.02%
0.01%
0.00%
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
2165
2175
2185
2195
Hectares cut/year
% Increase Water Yield

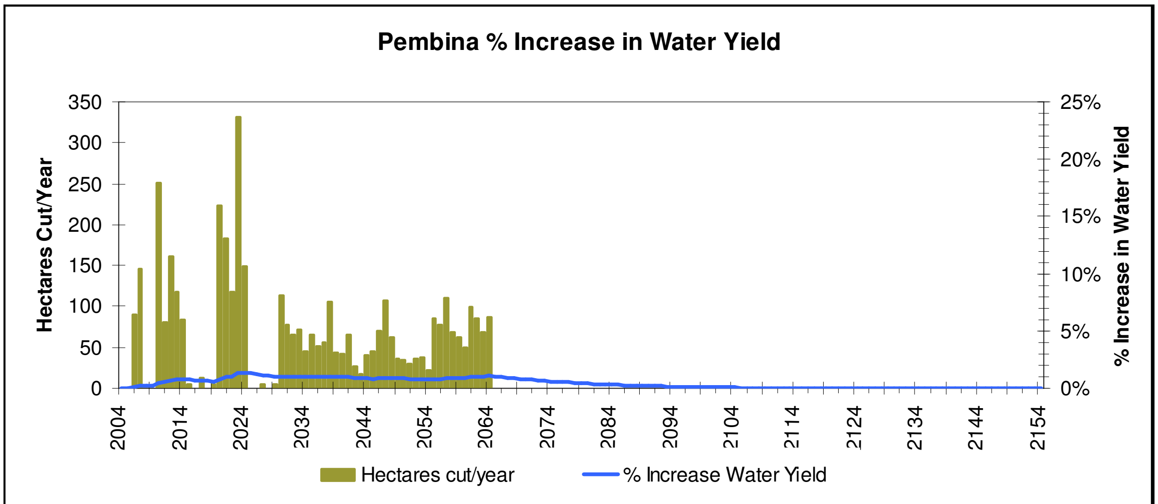

Opabin Decadal % Increase Water Yield and % Watershed ECA
0.10%
0.08%
0.06%
0.04%
0.02%
0.00%
2045
2055
2065
2075
2085
2095
2105
2110
% Watershed ECA
% Increase Water Yield



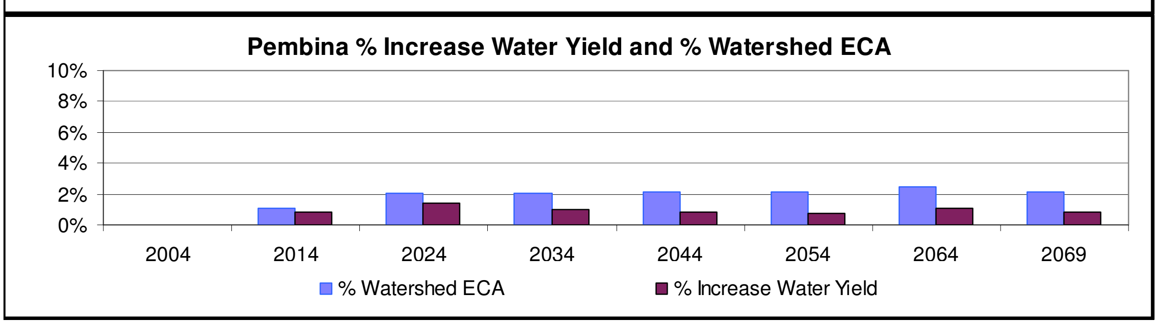
Open % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield



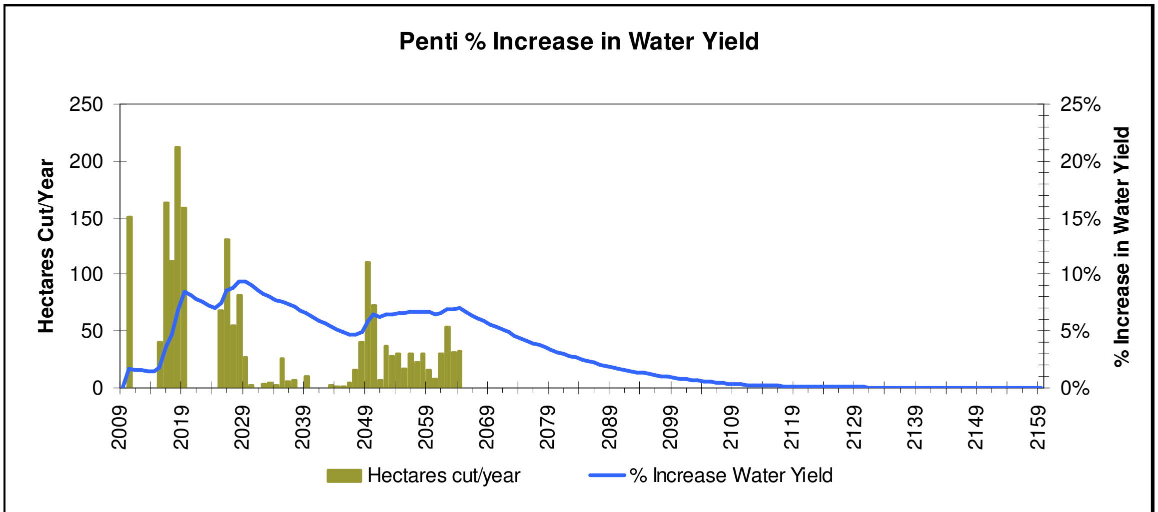
Open % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2005
2015
2025
2035
2045
2055
2065
2070
% Watershed ECA
% Increase Water Yield

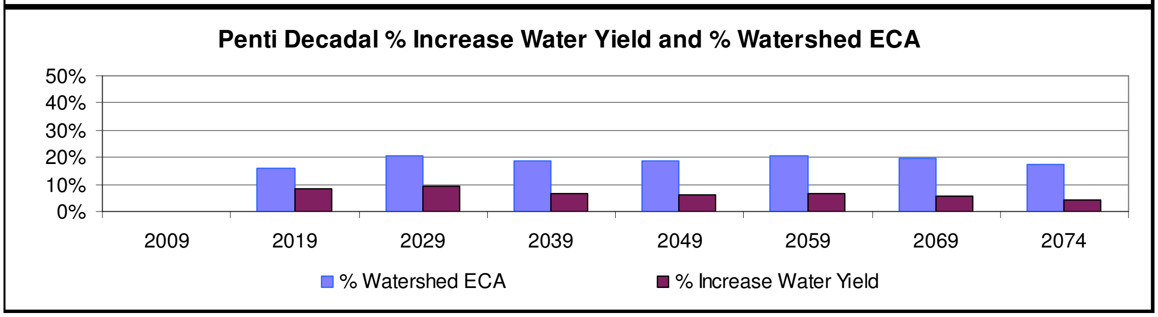


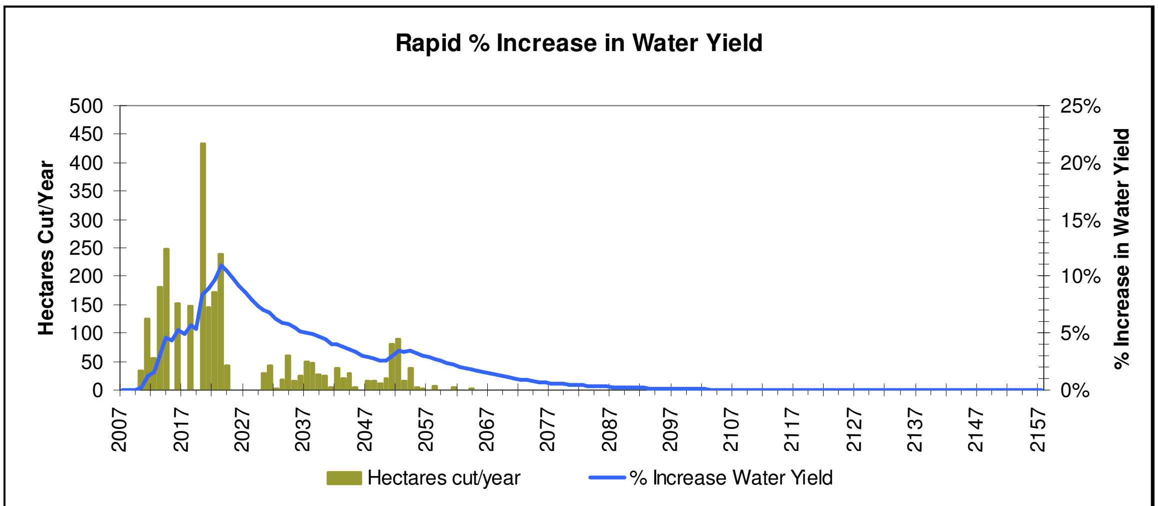
Pembina % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

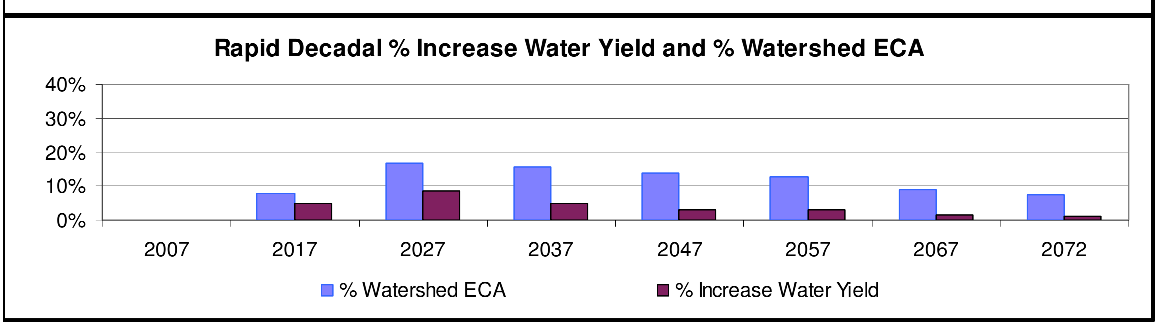


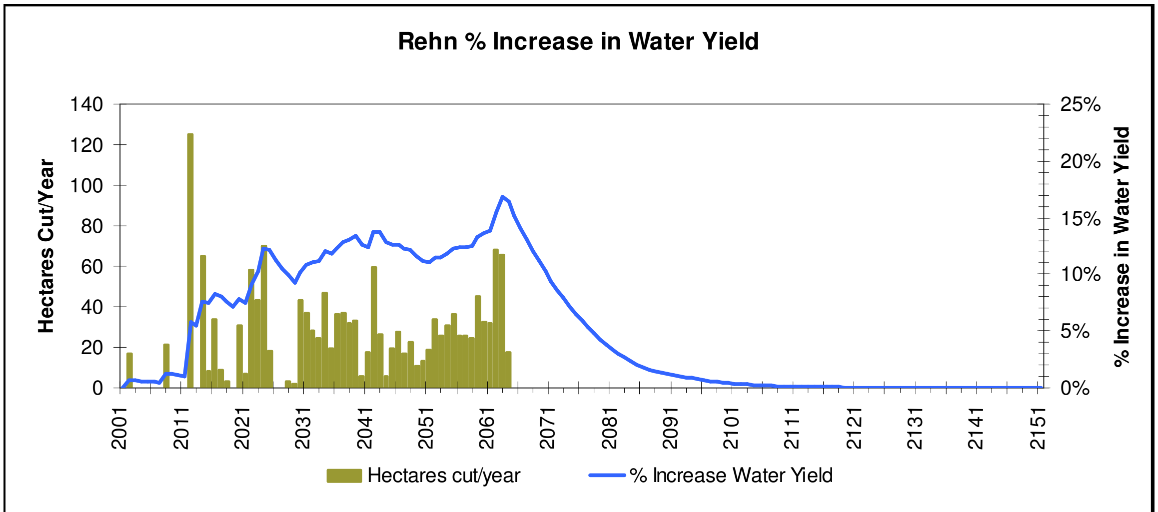
Pembina % Increase Water Yield and % Watershed ECA
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2069
% Watershed ECA
% Increase Water Yield

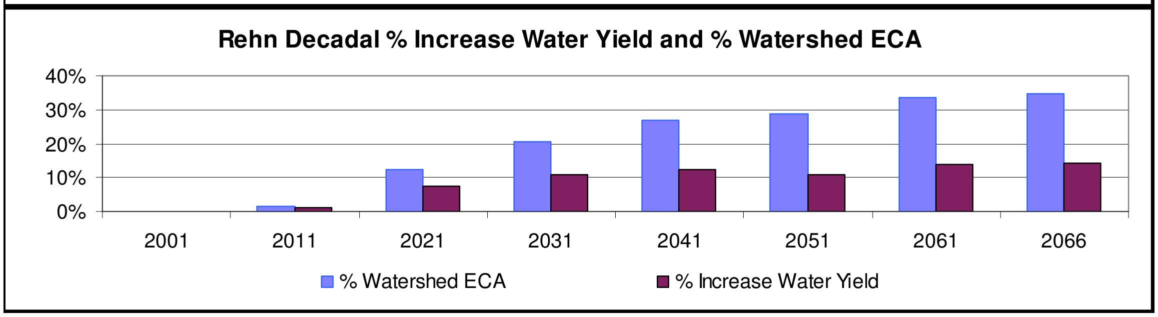

Penti % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2009 2019 2029 2039 2049 2059 2069 2079 2089 2099 2109 2119 2129 2139 2149 2159
Hectares cut/year
% Increase Water Yield

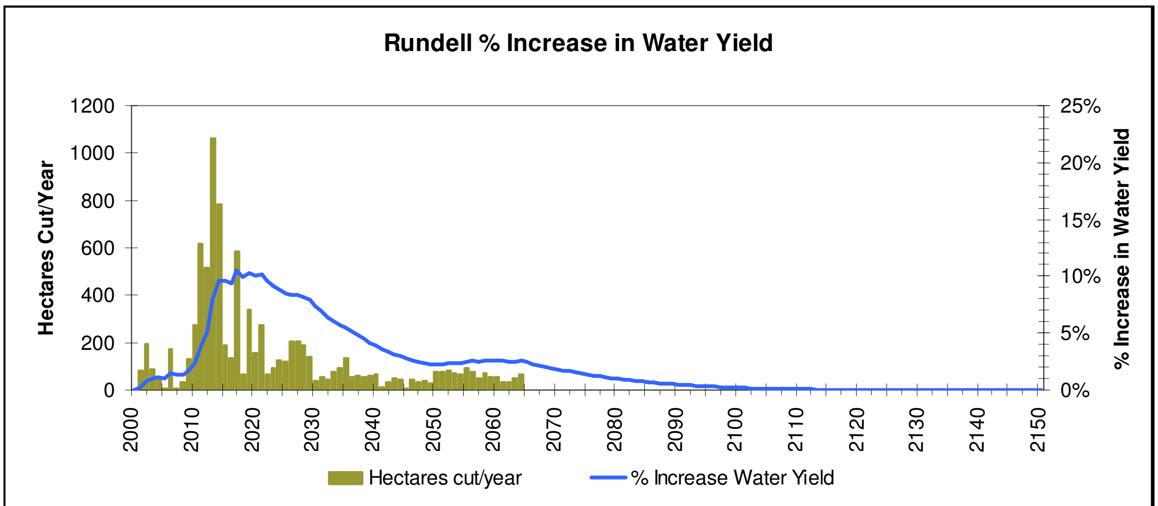

Penti Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2009 2019 2029 2039 2049 2059 2069 2074
% Watershed ECA
% Increase Water Yield

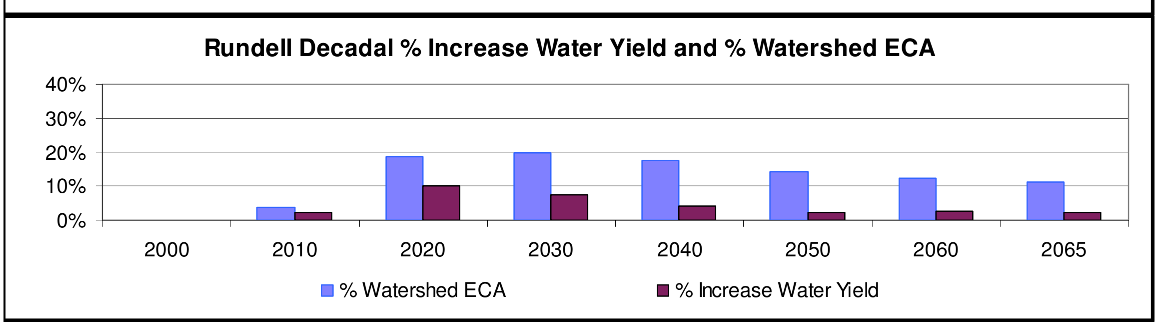

Rapid % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
500
450
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2007 2017 2027 2037 2047 2057 2067 2077 2087 2097 2107 2117 2127 2137 2147 2157
Hectares cut/year
% Increase Water Yield

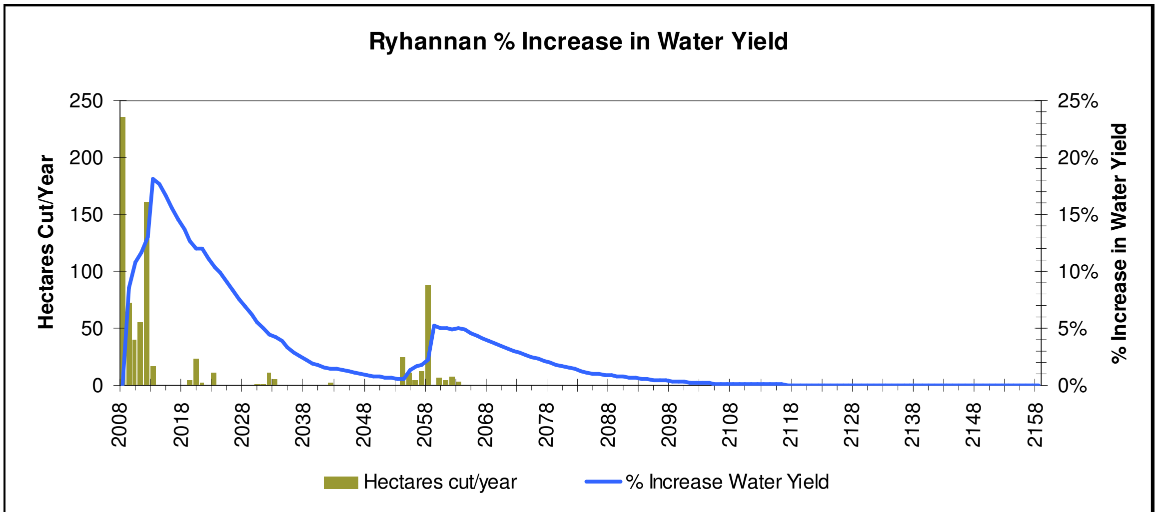

Rapid Decadal % Increase Water Yield and % Watershed ECA
40%
30%
20%
10%
0%
2007 2017 2027 2037 2047 2057 2067 2072
% Watershed ECA
% Increase Water Yield

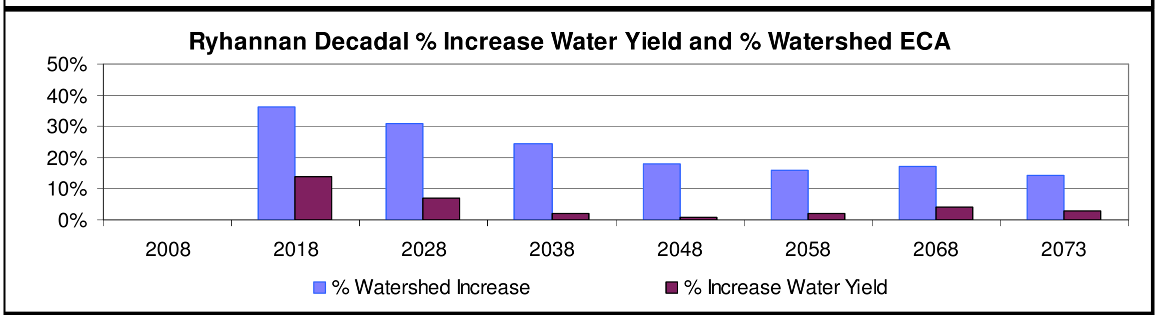

Rehn % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
140
120
100
80
60
40
20
0
25%
20%
15%
10%
5%
0%
2001
2011
2021
2031
2041
2051
2061
2071
2081
2091
2101
2111
2121
2131
2141
2151
Hectares cut/year
% Increase Water Yield

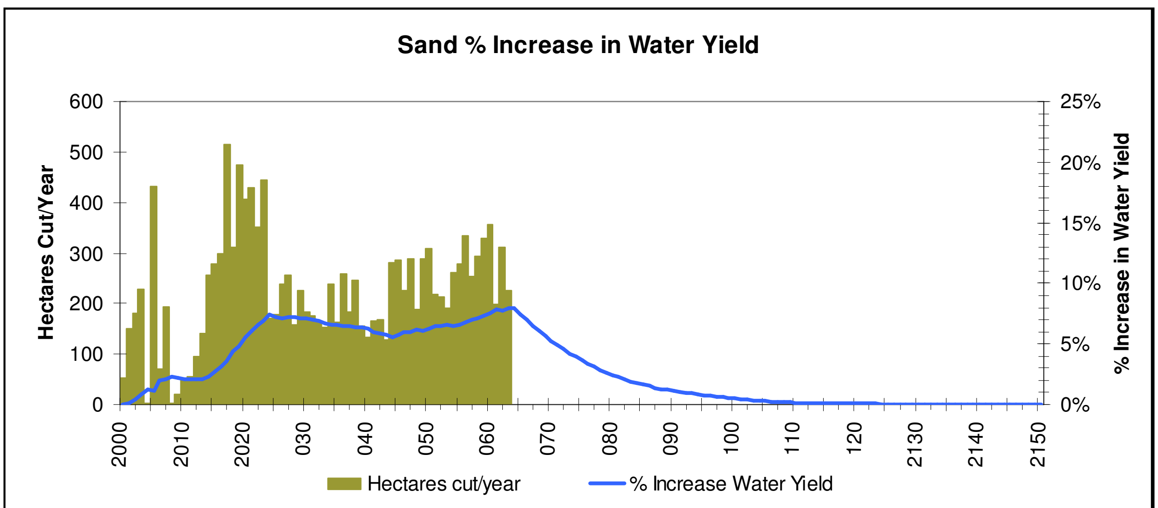

Rehn Decadal % Increase Water Yield and % Watershed ECA
40%
30%
20%
10%
0%
2001
2011
2021
2031
2041
2051
2061
2066
% Watershed ECA
% Increase Water Yield

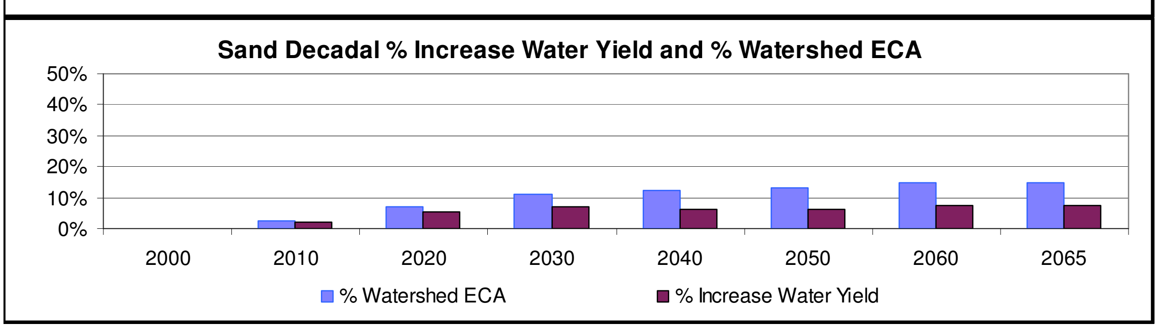

Rundell % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1200
1000
800
600
400
200
0
25%
20%
15%
10%
5%
0%
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2130
2140
2150
Hectares cut/year
% Increase Water Yield

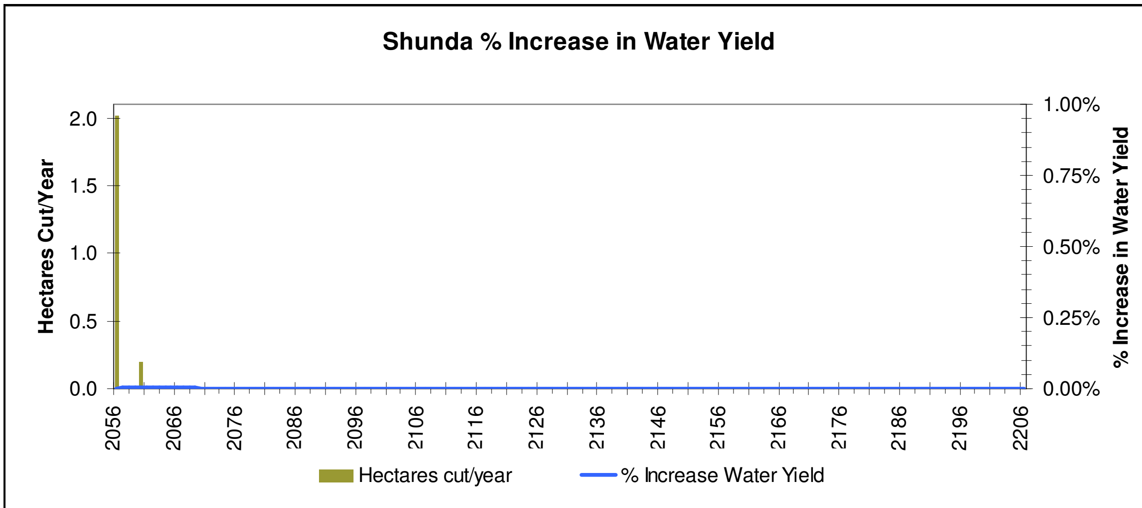

Rundell Decadal % Increase Water Yield and % Watershed ECA
40%
30%
20%
10%
0%
2000
2010
2020
2030
2040
2050
2060
2065
% Watershed ECA
% Increase Water Yield

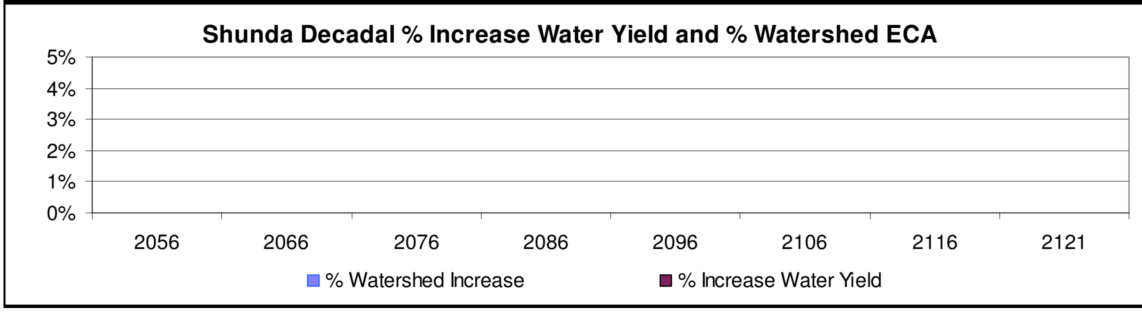

Ryhannan % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2008
2018
2028
2038
2048
2058
2068
2078
2088
2098
2108
2118
2128
2138
2148
2158
Hectares cut/year
% Increase Water Yield

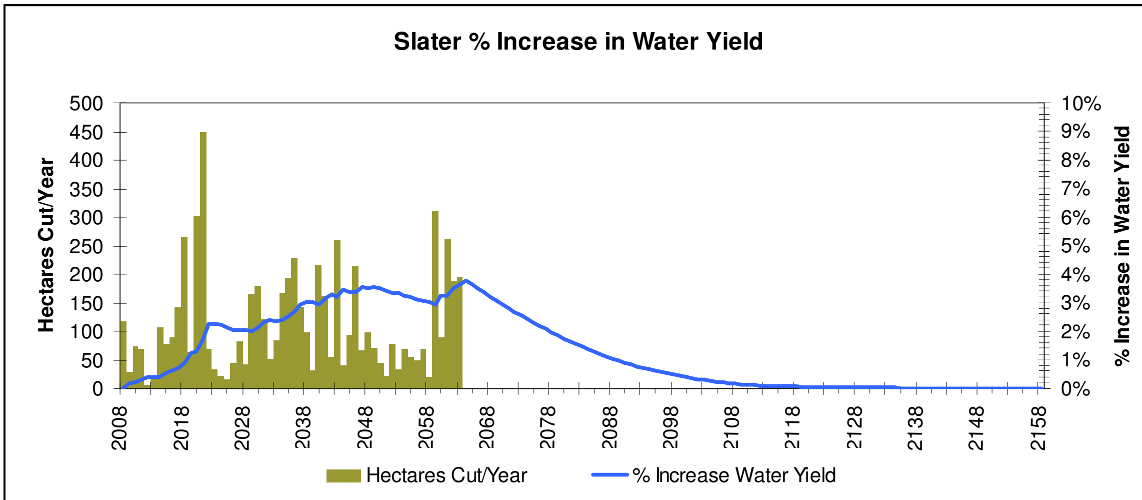

Ryhannan Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2008
2018
2028
2038
2048
2058
2068
2073
% Watershed Increase
% Increase Water Yield

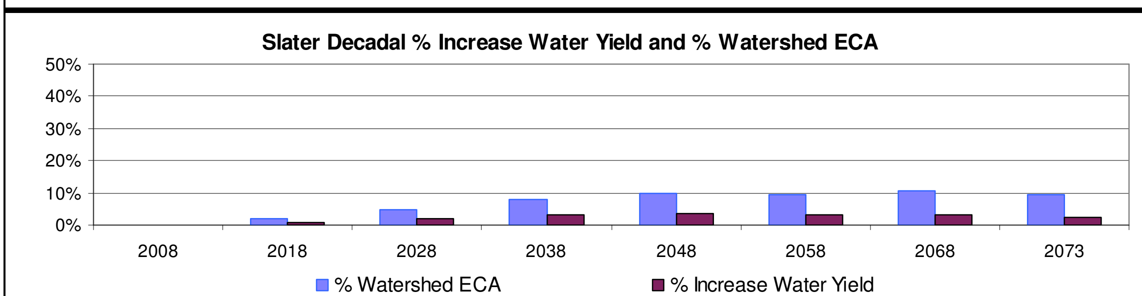

Sand % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
2000
2010
2020
030
040
050
060
070
080
090
100
110
120
2130
2140
2150
Hectares cut/year
% Increase Water Yield

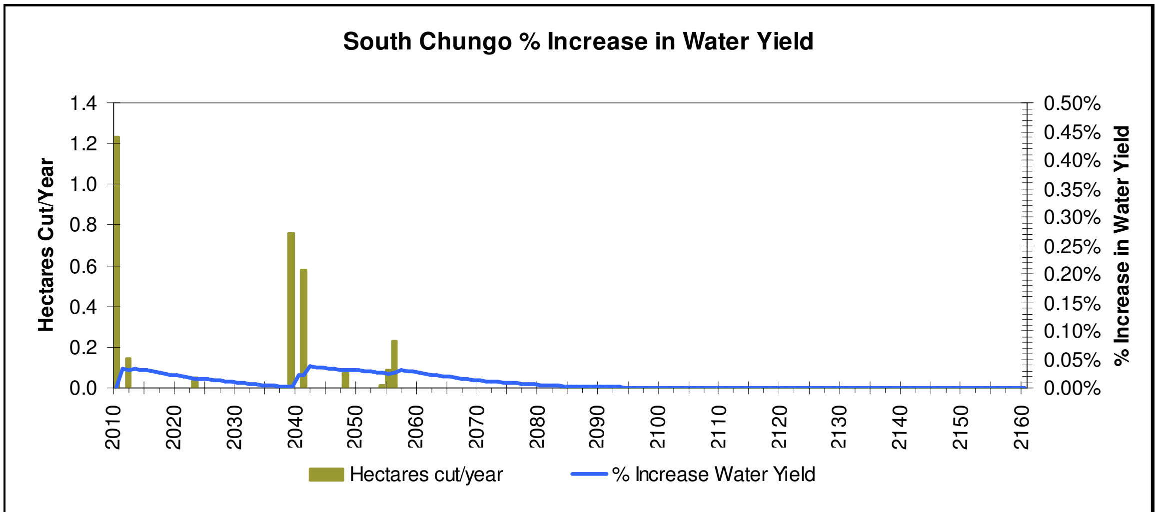

Sand Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2000
2010
2020
2030
2040
2050
2060
2065
% Watershed ECA
% Increase Water Yield

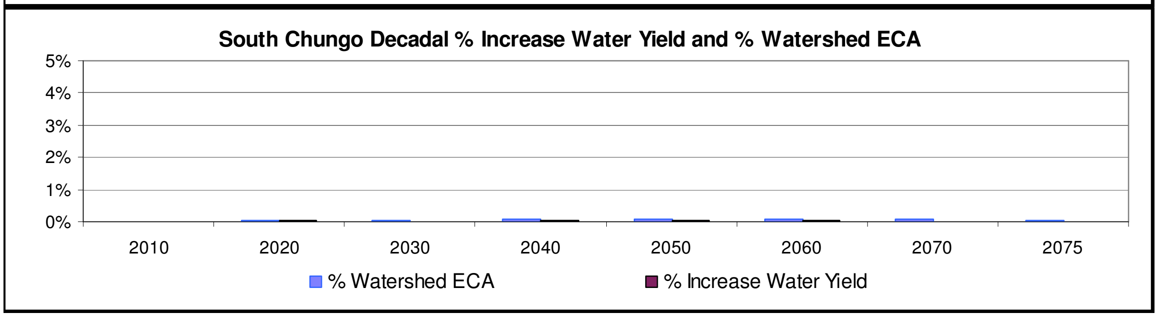

Shunda % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
2.0
1.5
1.0
0.5
0.0
1.00%
0.75%
0.50%
0.25%
0.00%
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
2166
2176
2186
2196
2206
Hectares cut/year
% Increase Water Yield

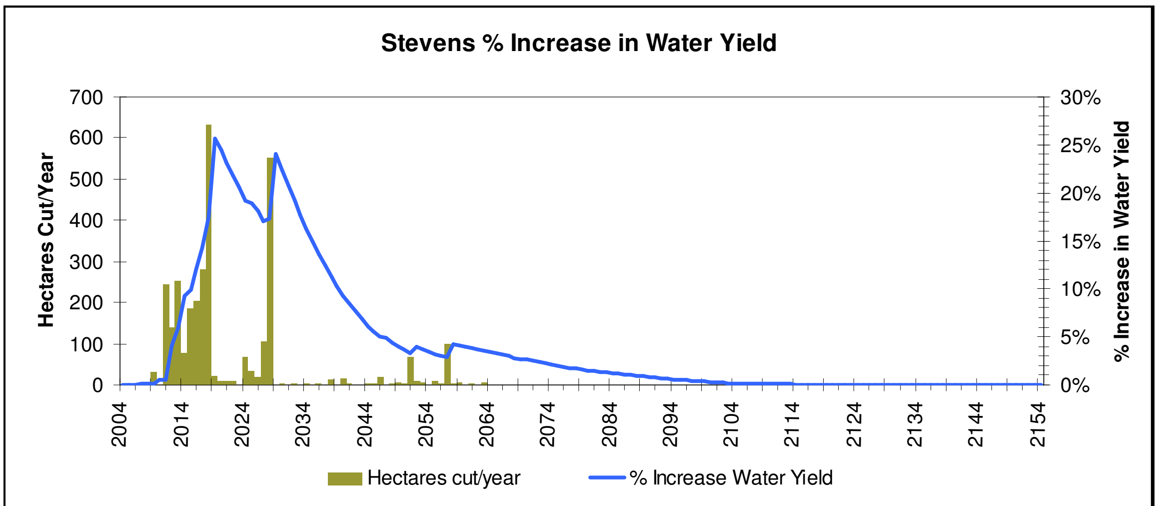

Shunda Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2056
2066
2076
2086
2096
2106
2116
2121
% Watershed Increase
% Increase Water Yield

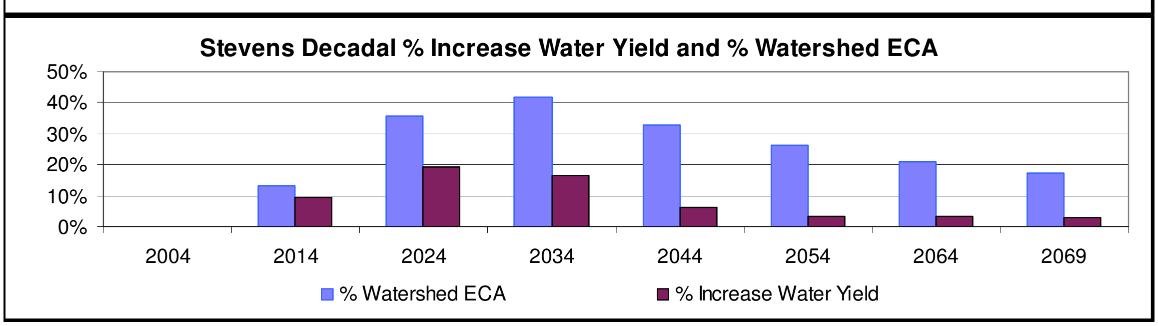

Slater % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
500
450
400
350
300
250
200
150
100
50
0
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
2008
2018
2028
2038
2048
2058
2068
2078
2088
2098
2108
2118
2128
2138
2148
2158
Hectares Cut/Year
% Increase Water Yield

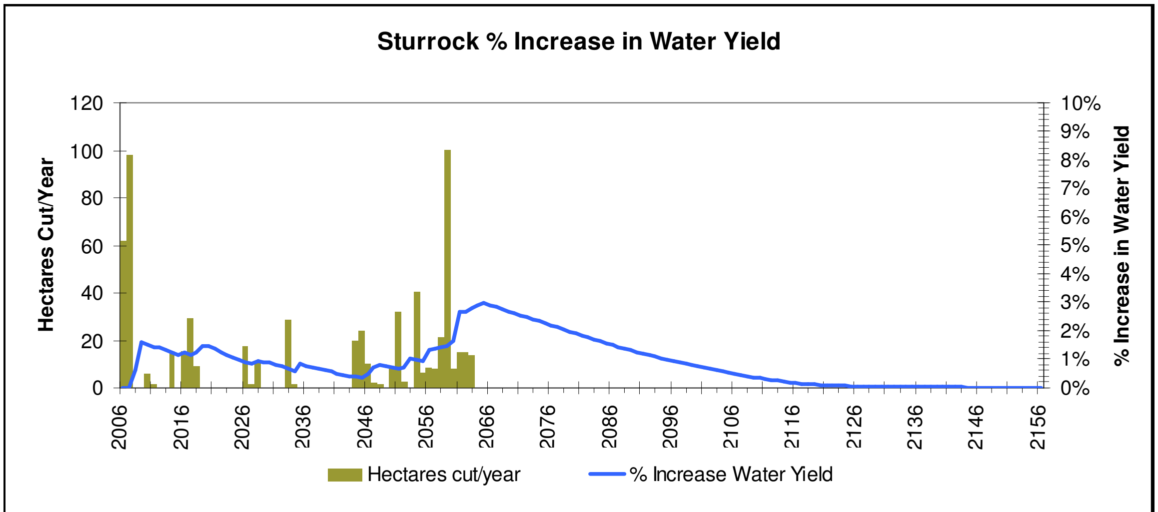

Slater Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2008
2018
2028
2038
2048
2058
2068
2073
% Watershed ECA
% Increase Water Yield

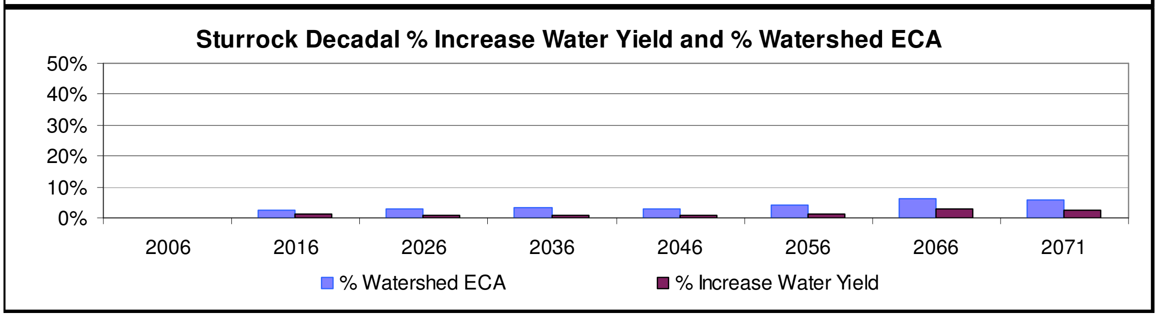

South Chungo % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

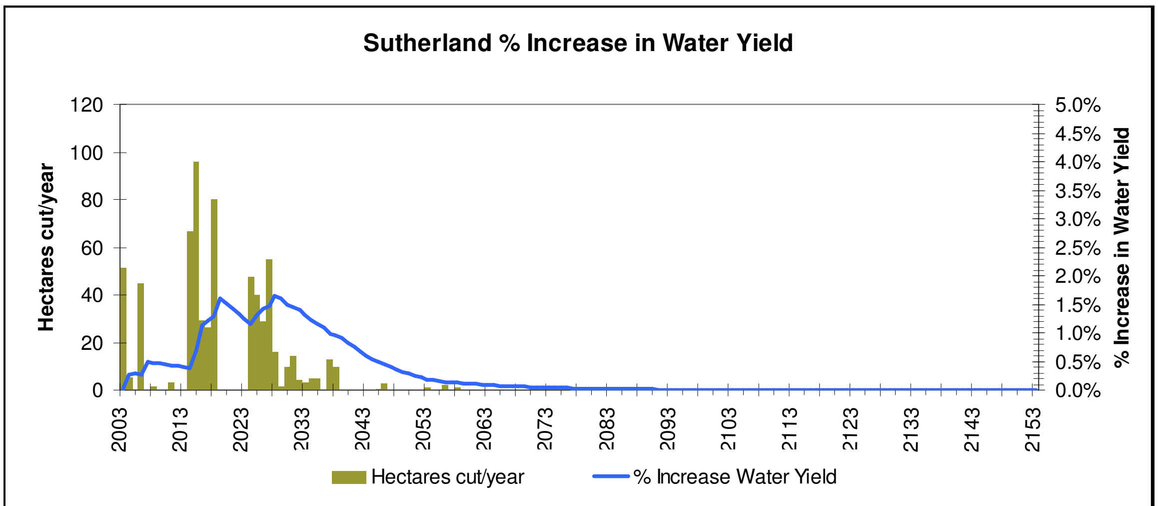

South Chungo Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

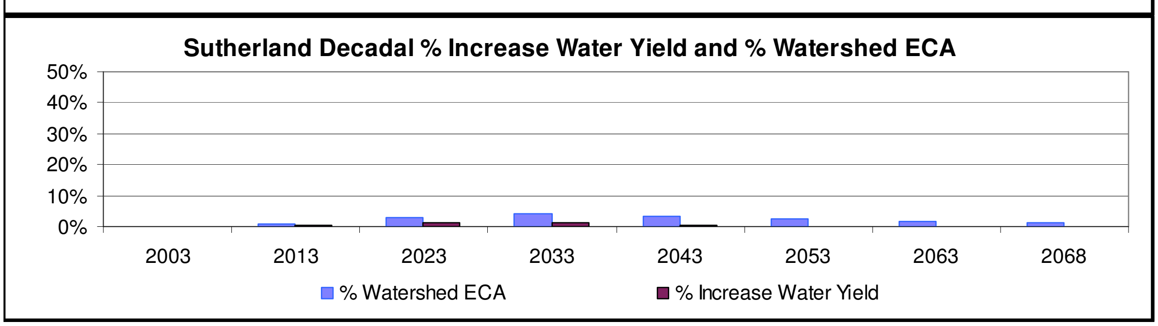

Stevens % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

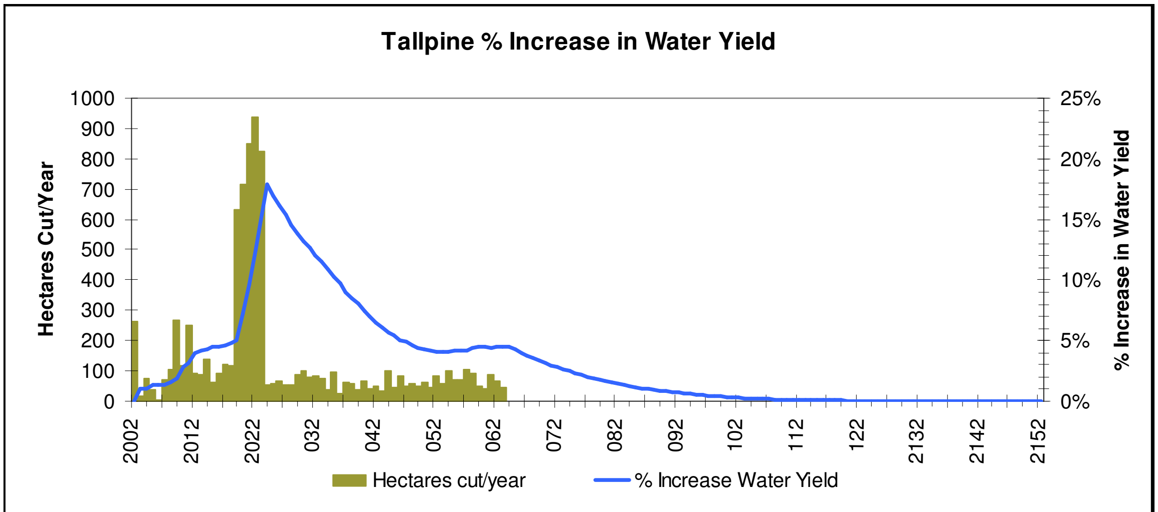

Stevens Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

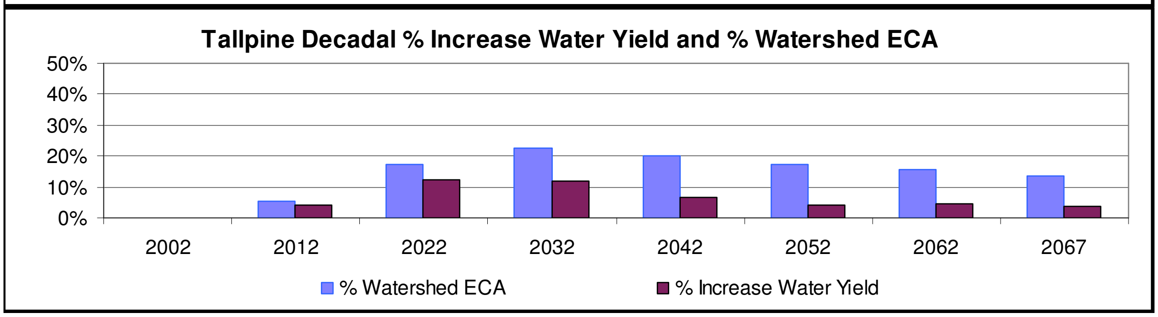

Sturrock % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
120
100
80
60
40
20
0
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
2006
2016
2026
2036
2046
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
Hectares cut/year
% Increase Water Yield

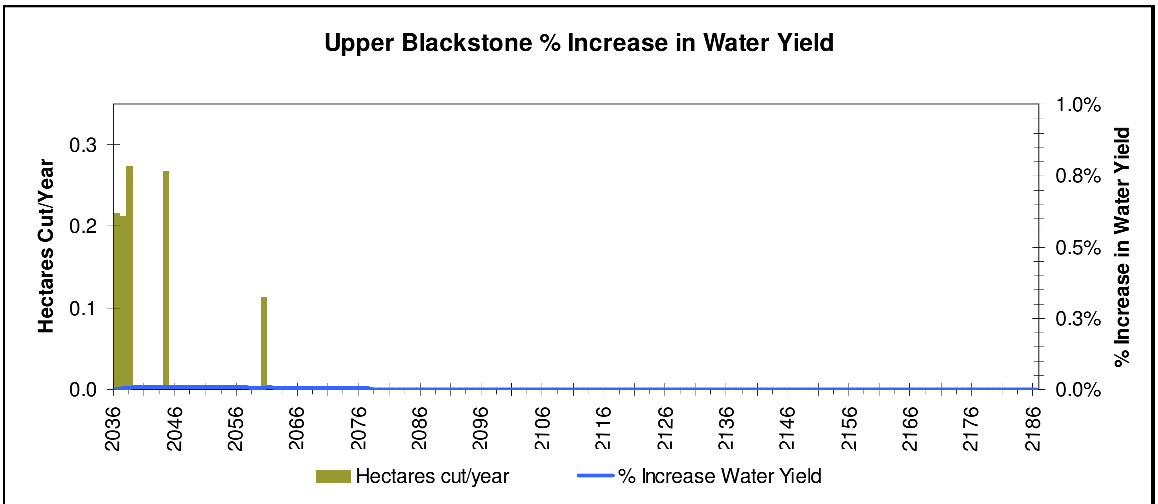

Sturrock Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2006
2016
2026
2036
2046
2056
2066
2071
% Watershed ECA
% Increase Water Yield

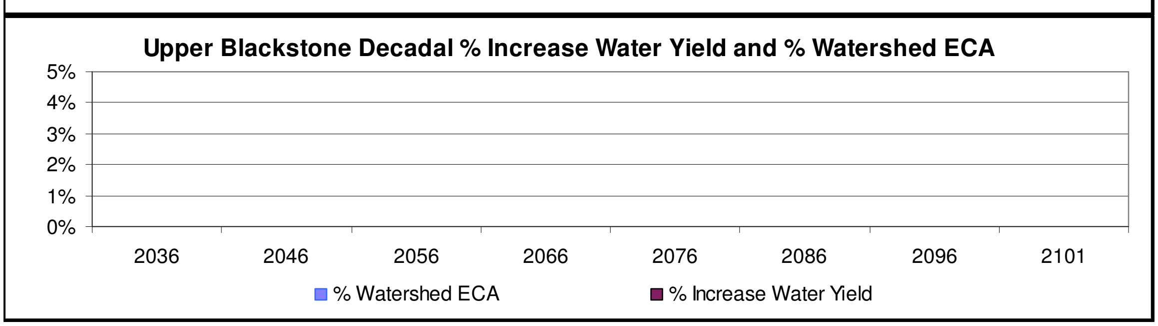

Sutherland % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
120
100
80
60
40
20
0
5.0%
4.5%
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
2003
2013
2023
2033
2043
2053
2063
2073
2083
2093
2103
2113
2123
2133
2143
2153
Hectares cut/year
% Increase Water Yield

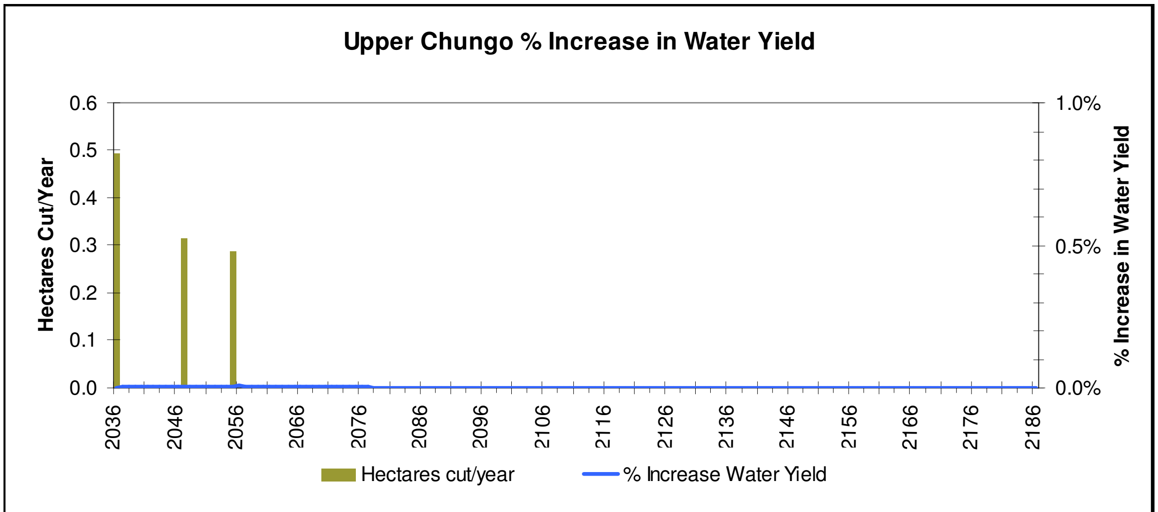

Sutherland Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2003
2013
2023
2033
2043
2053
2063
2068
% Watershed ECA
% Increase Water Yield

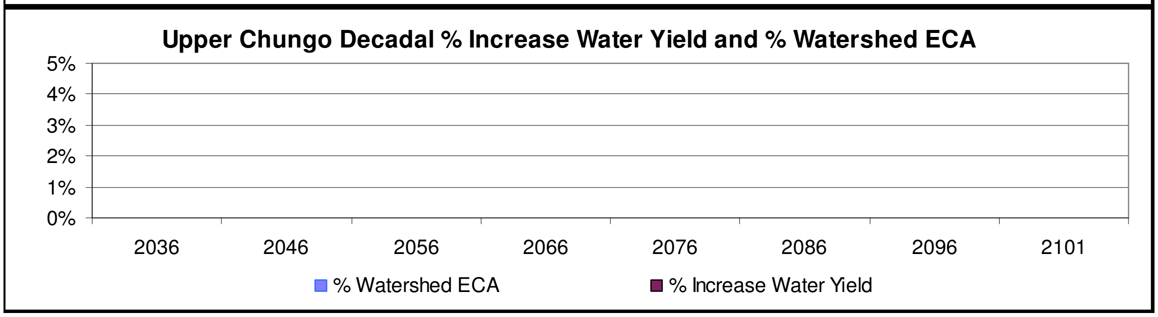

Tallpine % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1000
900
800
700
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
2002
2012
2022
032
042
052
062
072
082
092
102
112
122
2132
2142
2152
Hectares cut/year
% Increase Water Yield

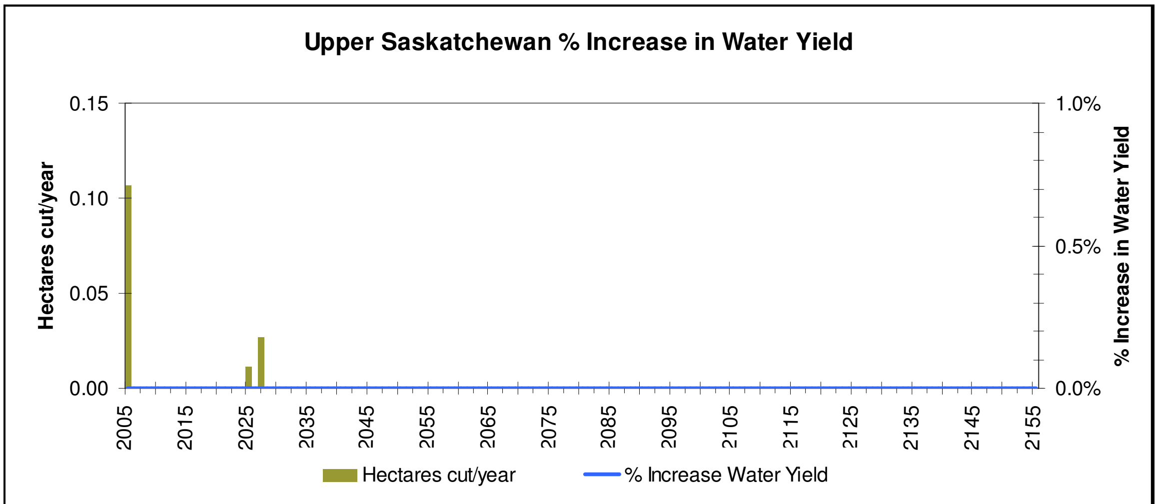

Tallpine Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2002
2012
2022
2032
2042
2052
2062
2067
% Watershed ECA
% Increase Water Yield

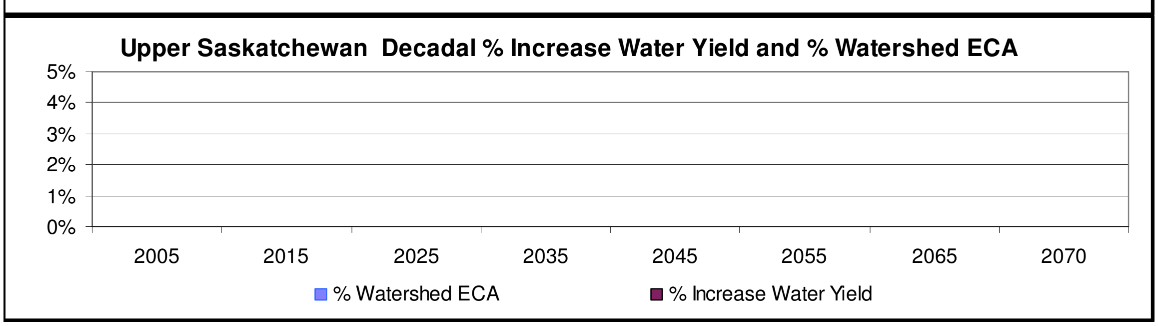

Upper Blackstone % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0.3
0.2
0.1
0.0
1.0%
0.8%
0.5%
0.3%
0.0%
2036
2046
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
2166
2176
2186
Hectares cut/year
% Increase Water Yield

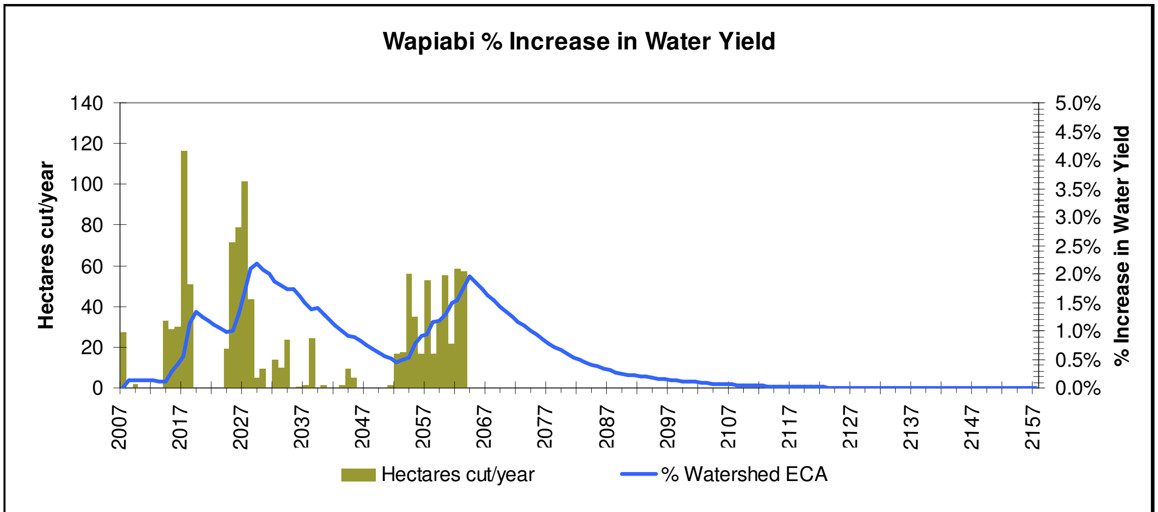

Upper Blackstone Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2036
2046
2056
2066
2076
2086
2096
2101
% Watershed ECA
% Increase Water Yield

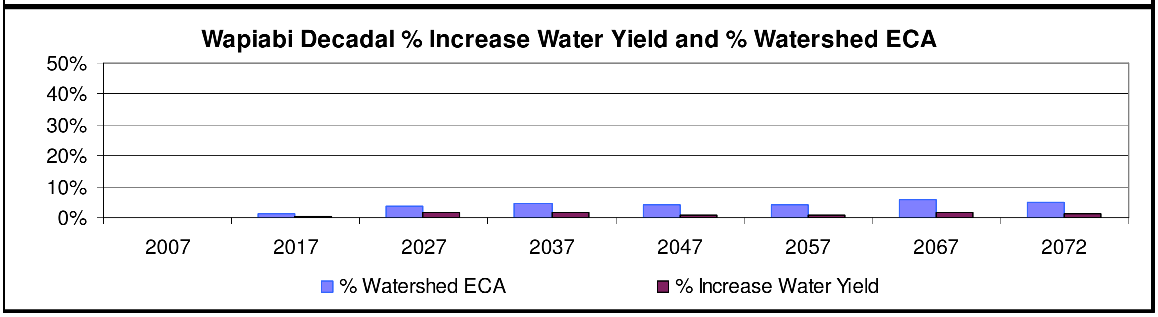

Upper Chungo % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.0%
0.5%
0.0%
2036
2046
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
2166
2176
2186
Hectares cut/year
% Increase Water Yield

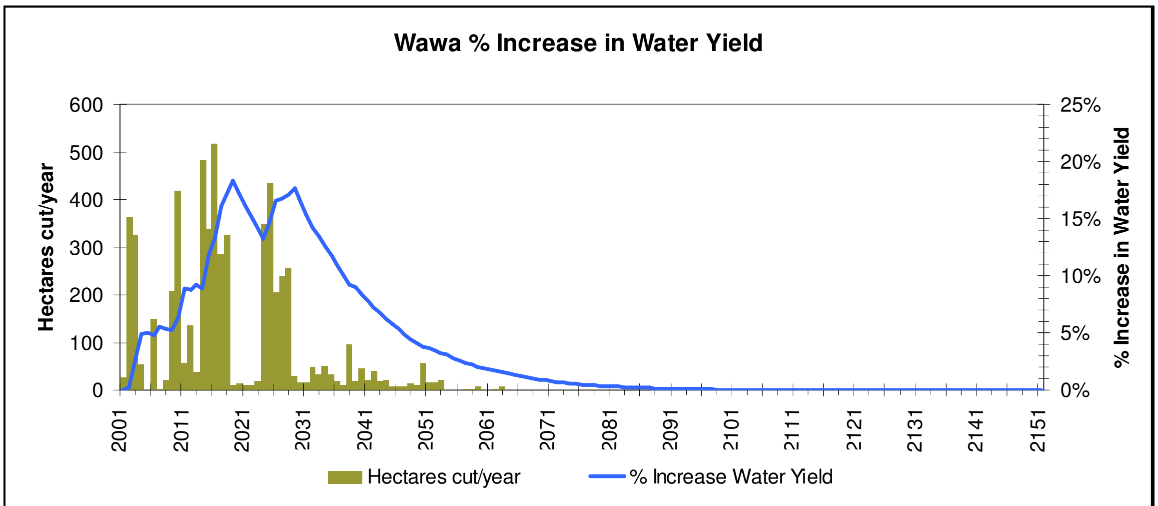

Upper Chungo Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2036
2046
2056
2066
2076
2086
2096
2101
% Watershed ECA
% Increase Water Yield

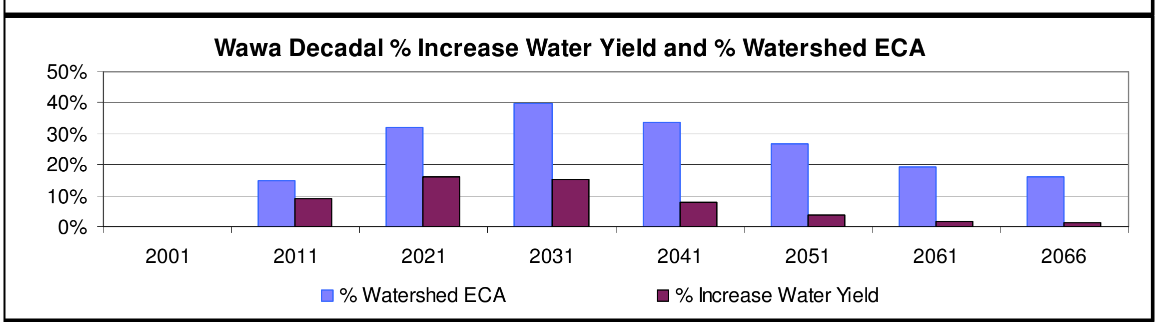

Upper Saskatchewan % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
0.15
0.10
0.05
0.00
1.0%
0.5%
0.0%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield

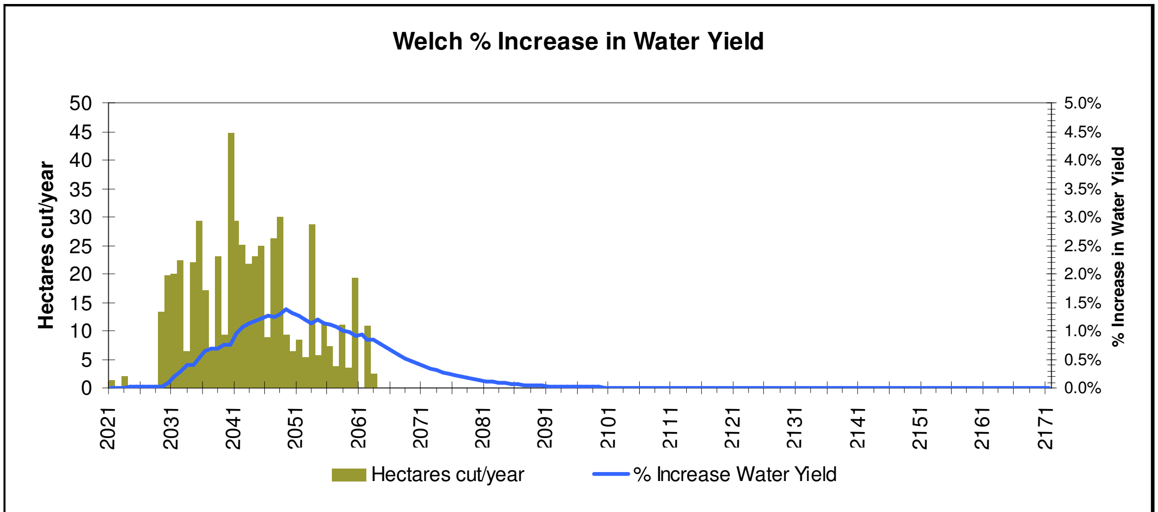

Upper Saskatchewan Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2005
2015
2025
2035
2045
2055
2065
2070
% Watershed ECA
% Increase Water Yield

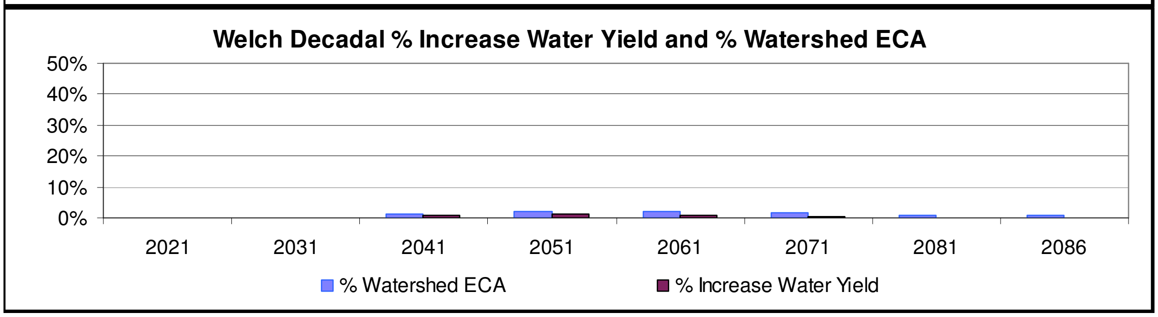

Wapiabi % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
Hectares cut/year
% Watershed ECA

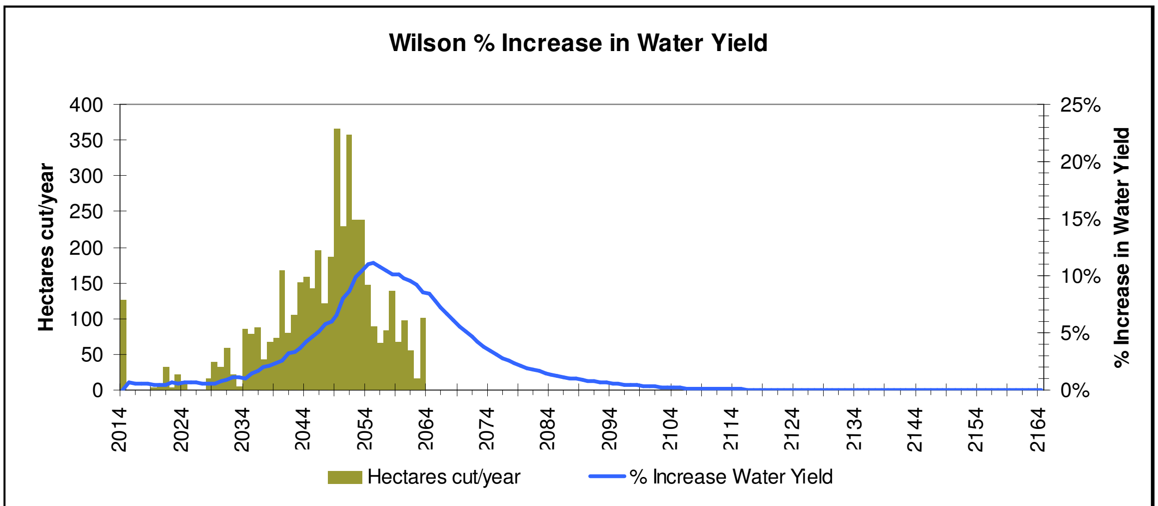

Wapiabi Decadal % Increase Water Yield and % Watershed ECA
2007
2017
2027
2037
2047
2057
2067
2072
% Watershed ECA
% Increase Water Yield

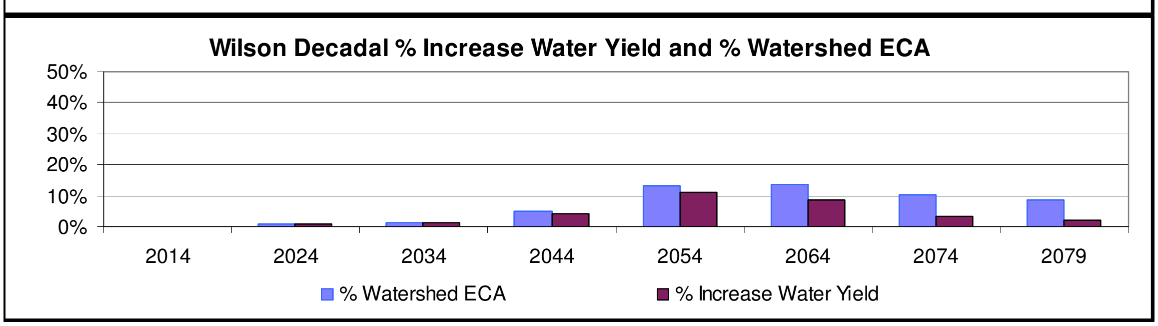

Wawa % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

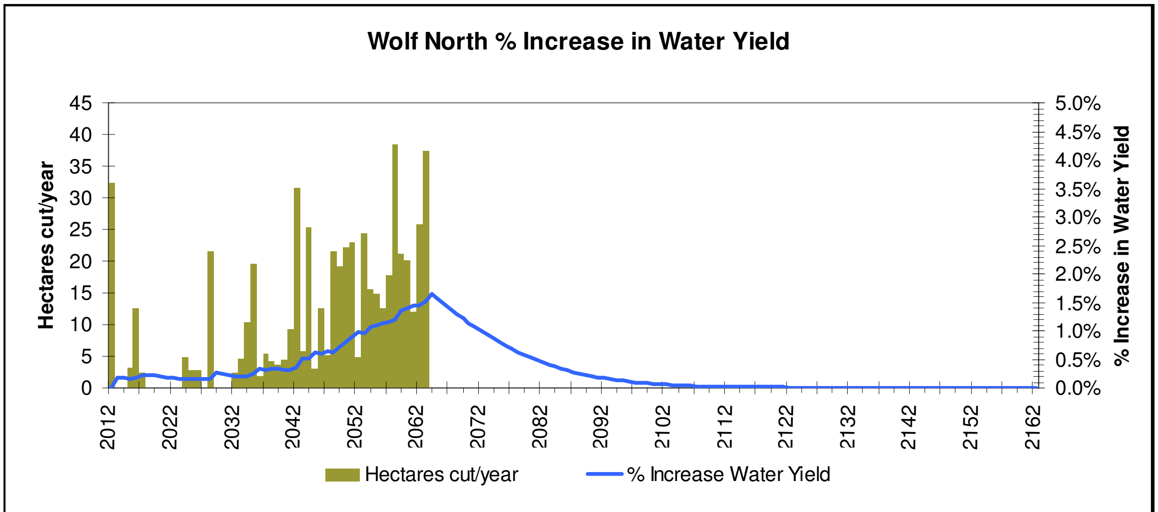

Wawa Decadal % Increase Water Yield and % Watershed ECA
2001
2011
2021
2031
2041
2051
2061
2066
% Watershed ECA
% Increase Water Yield

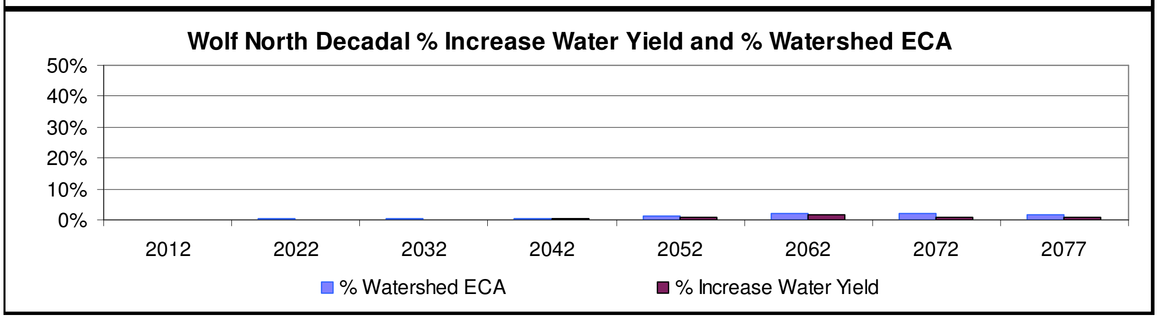

Welch % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

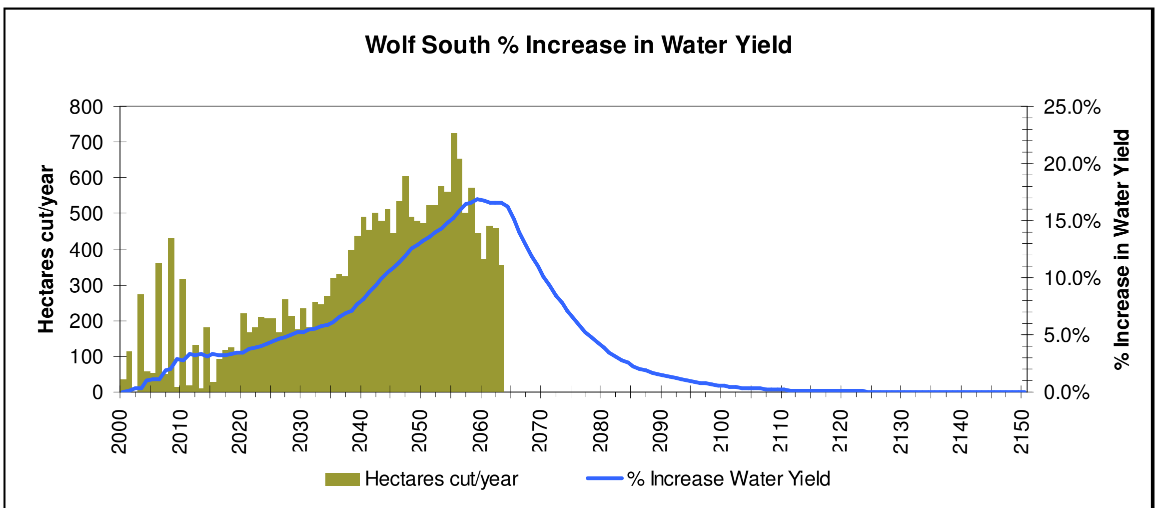

Welch Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

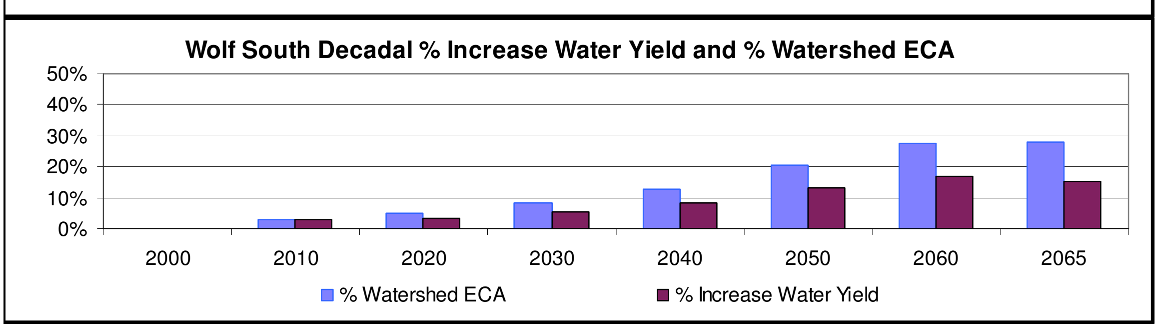

Wilson % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield


Wilson Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

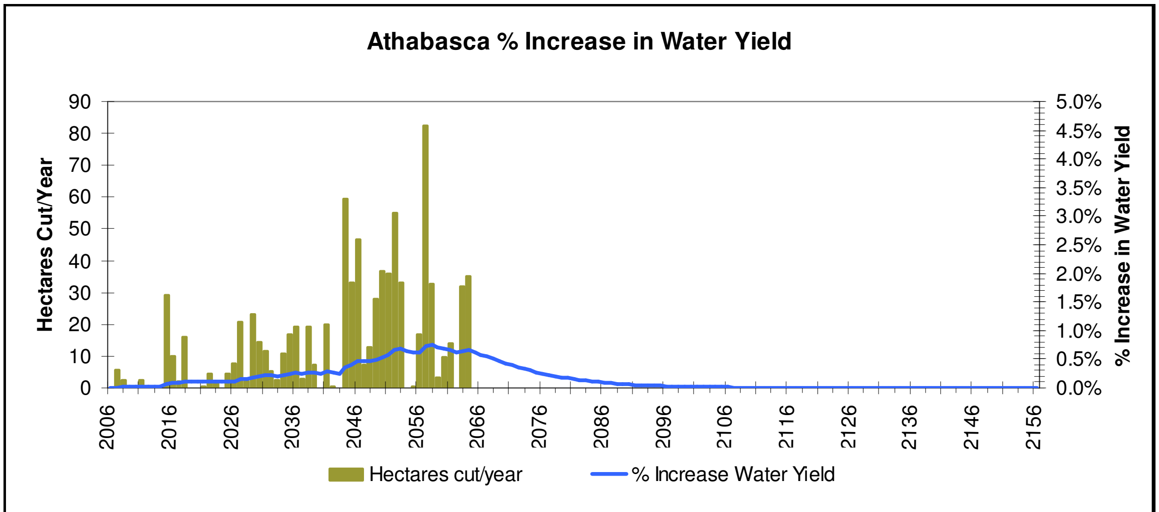

Wolf North % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

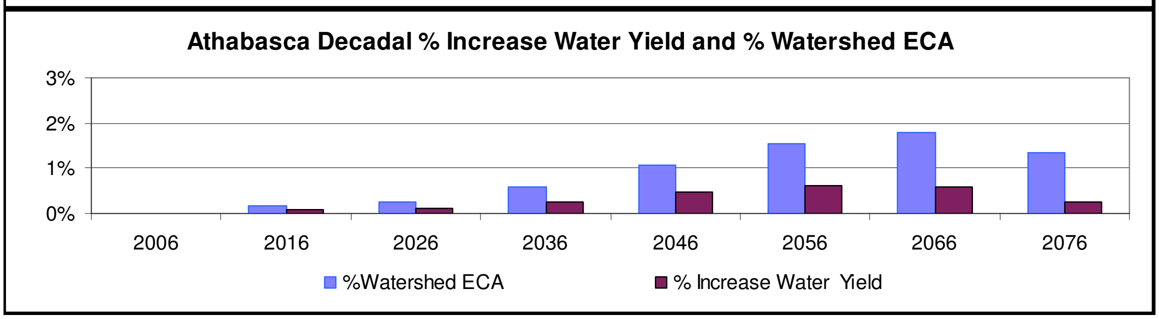

Wolf North Decadal % Increase Water Yield and % Watershed ECA
2012
2022
2032
2042
2052
2062
2072
2077
% Watershed ECA
% Increase Water Yield

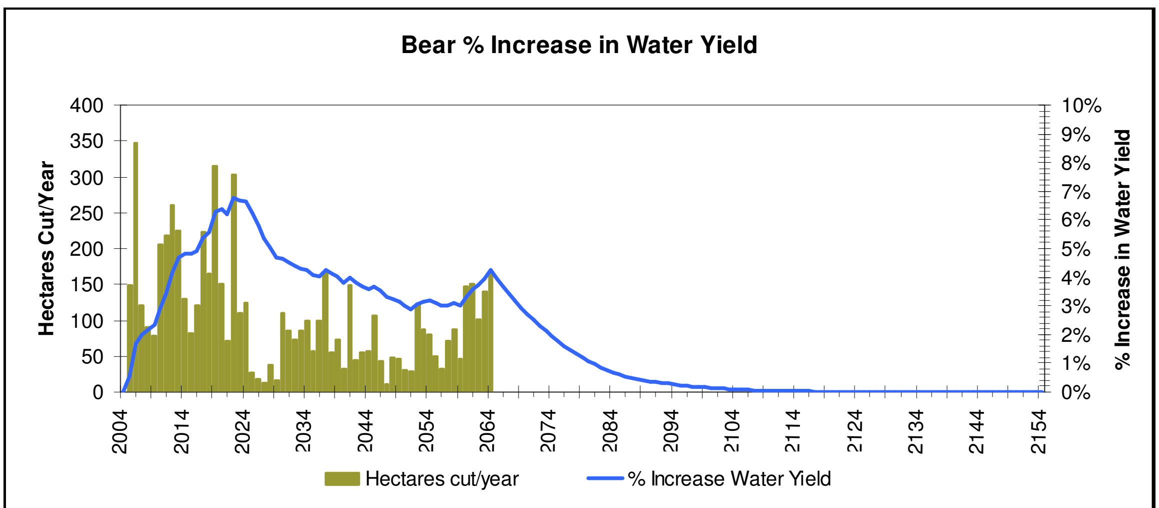

Wolf South % Increase in Water Yield
Hectares cut/year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

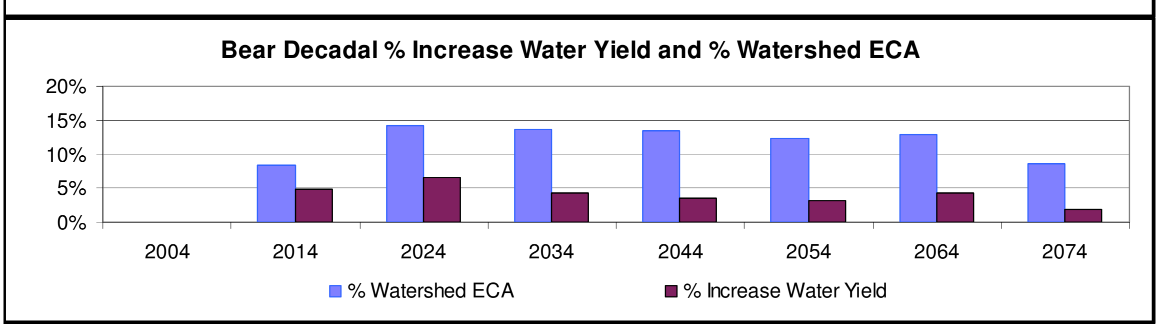

Wolf South Decadal % Increase Water Yield and % Watershed ECA
2000
2010
2020
2030
2040
2050
2060
2065
% Watershed ECA
% Increase Water Yield

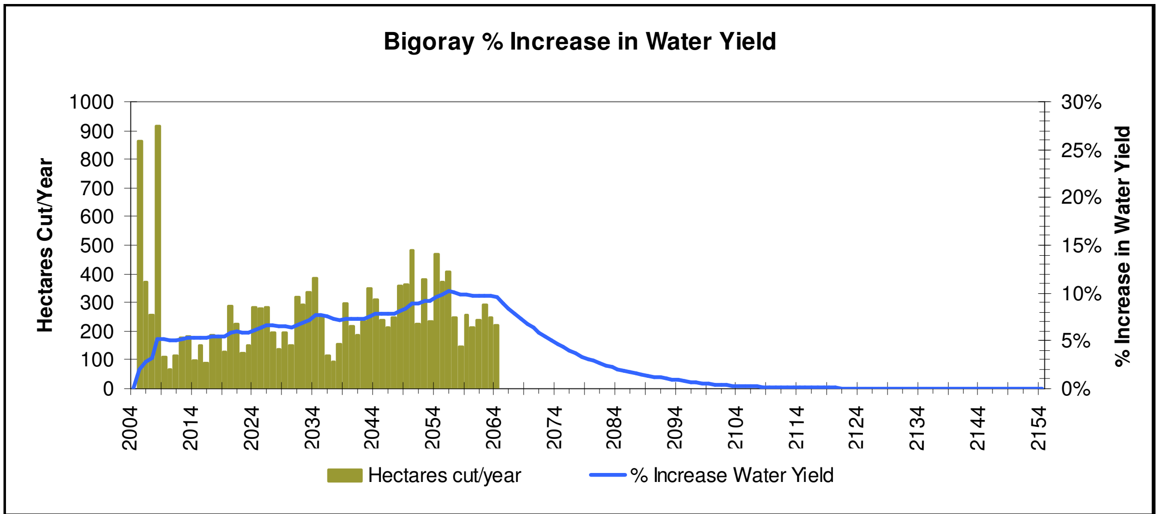
Appendix 3– Simulation results for Edson Forest watersheds.

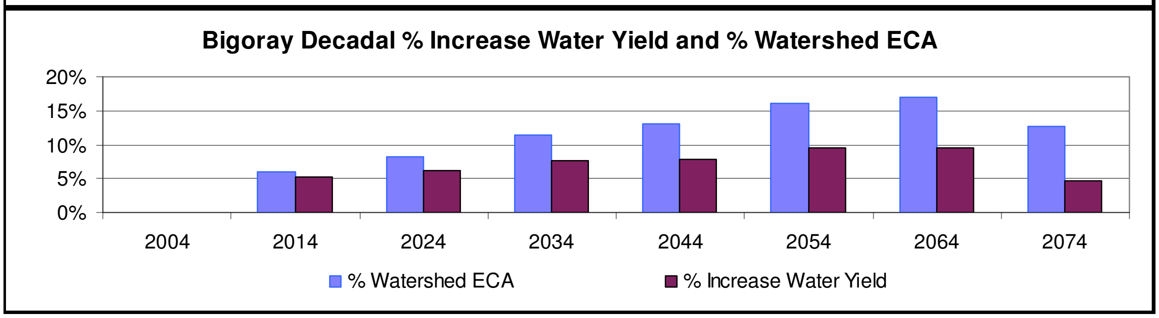

Athabasca % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
90
80
70
60
50
40
30
20
10
0
5.0%
4.5%
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
2006
2016
2026
2036
2046
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
Hectares cut/year
% Increase Water Yield

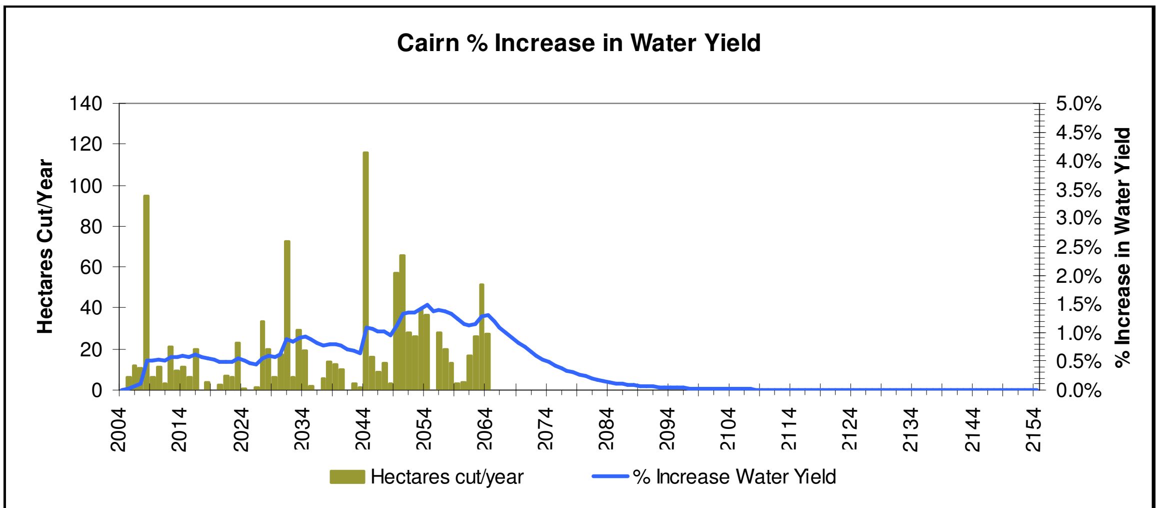

Athabasca Decadal % Increase Water Yield and % Watershed ECA
3%
2%
1%
0%
2006
2016
2026
2036
2046
2056
2066
2076
%Watershed ECA
% Increase Water Yield

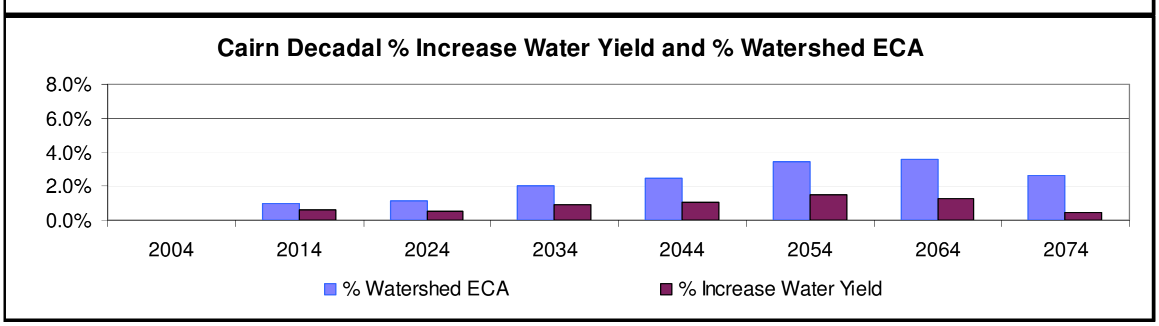

Bear % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

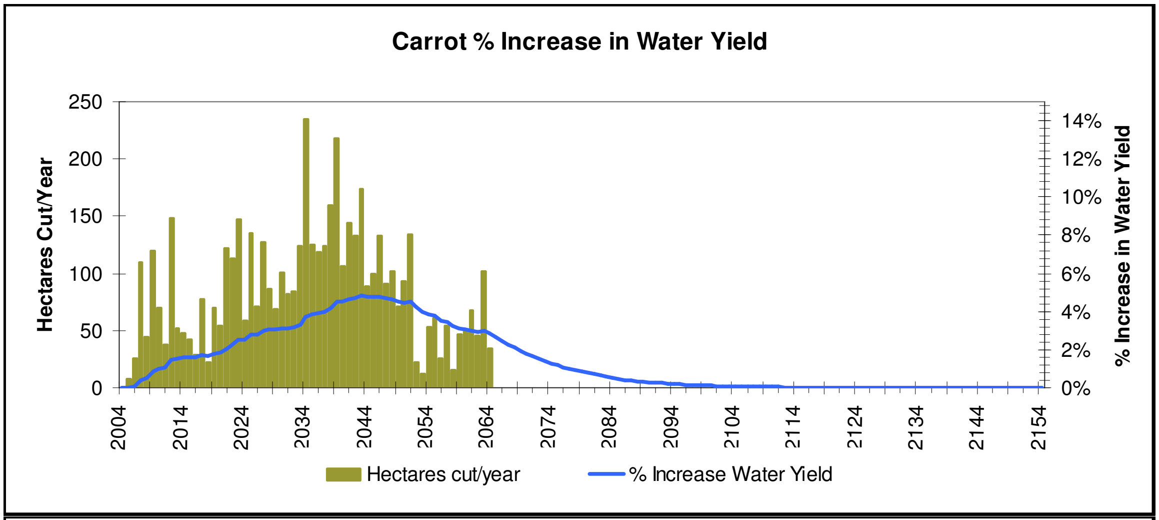

Bear Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

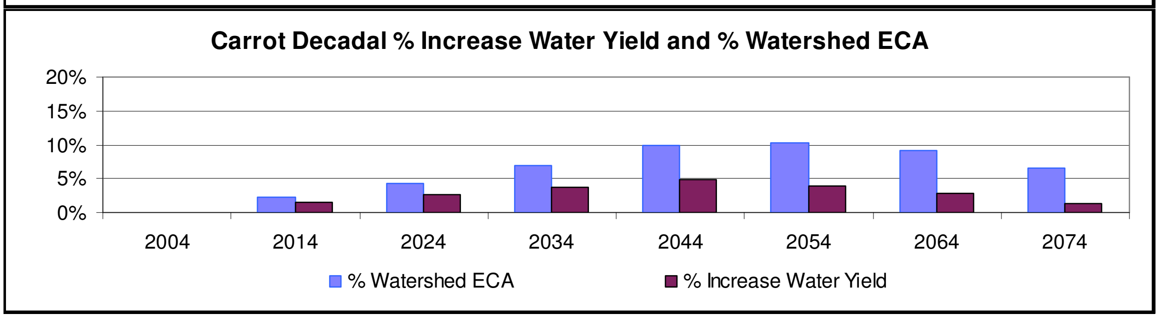

Bigoray % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1000
900
800
700
600
500
400
300
200
100
0
30%
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

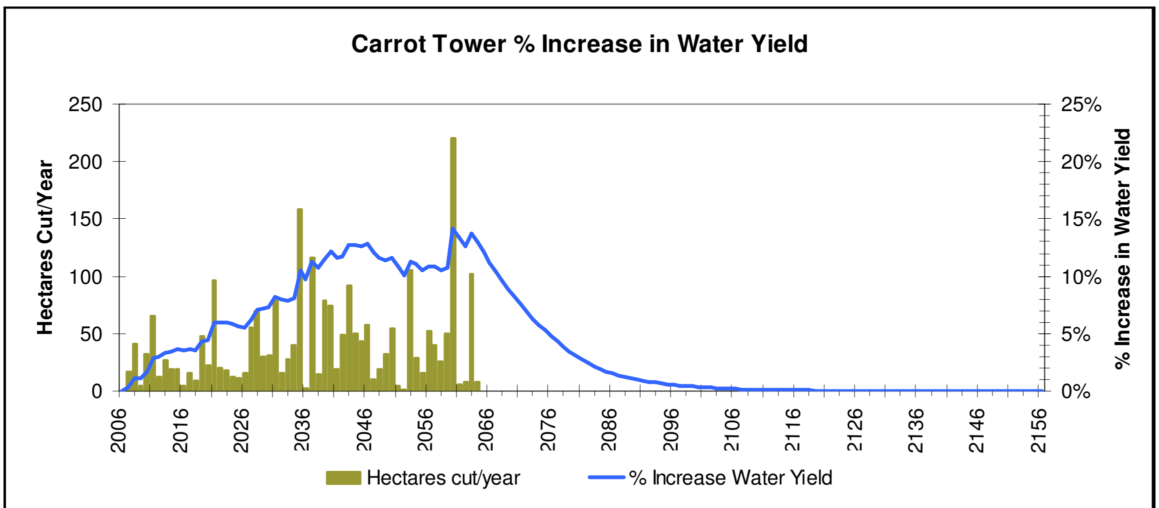

Bigoray Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

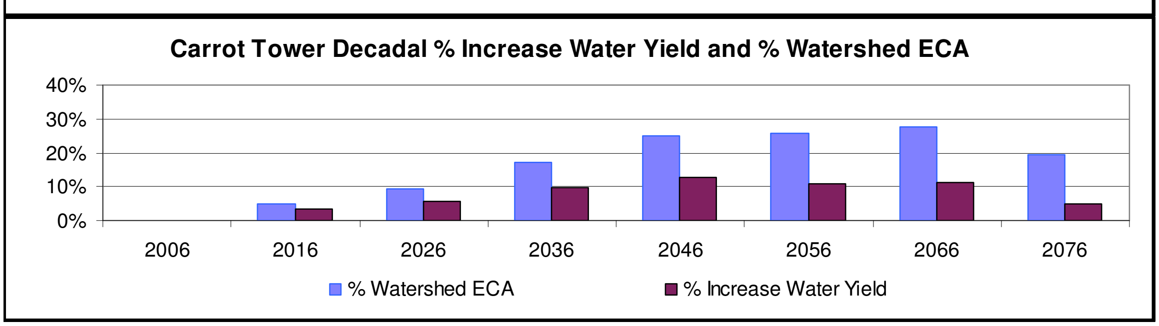

Cairn % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
140
120
100
80
60
40
20
0
5.0%
4.5%
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

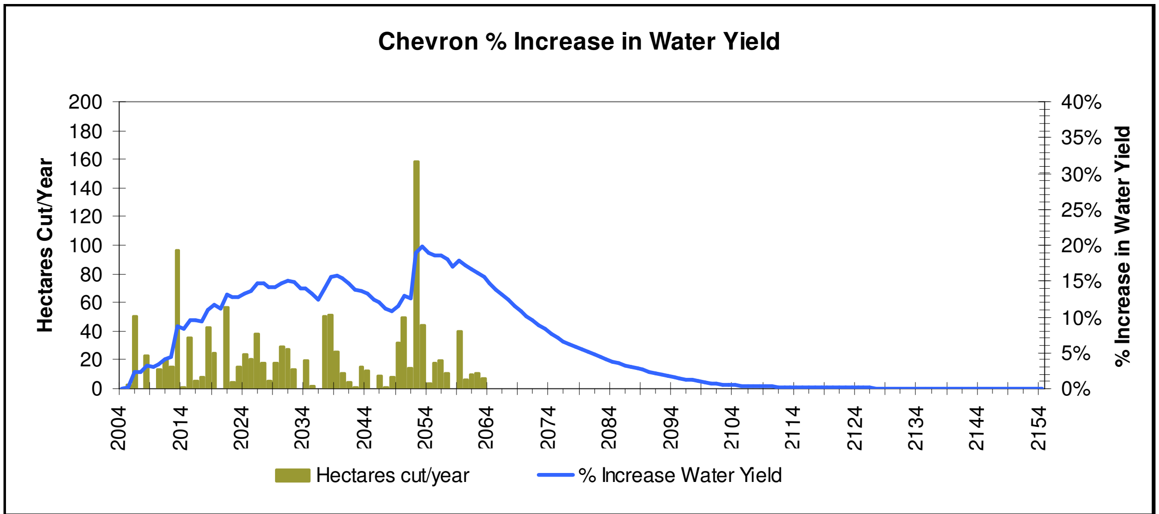

Cairn Decadal % Increase Water Yield and % Watershed ECA
8.0%
6.0%
4.0%
2.0%
0.0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

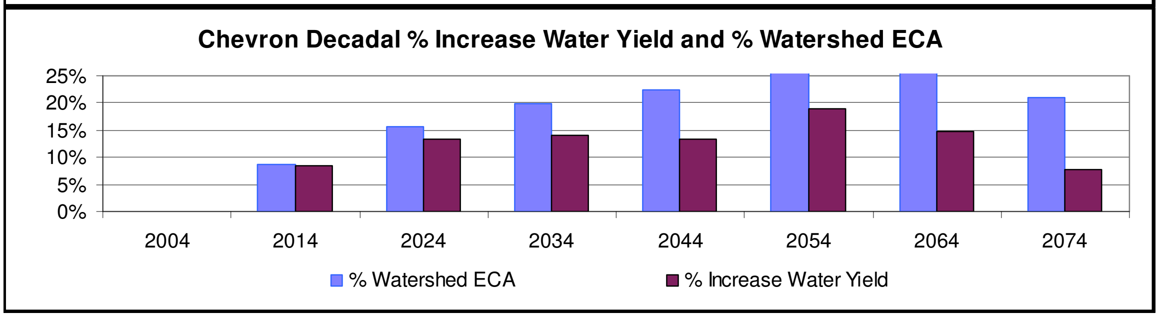

Carrot % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

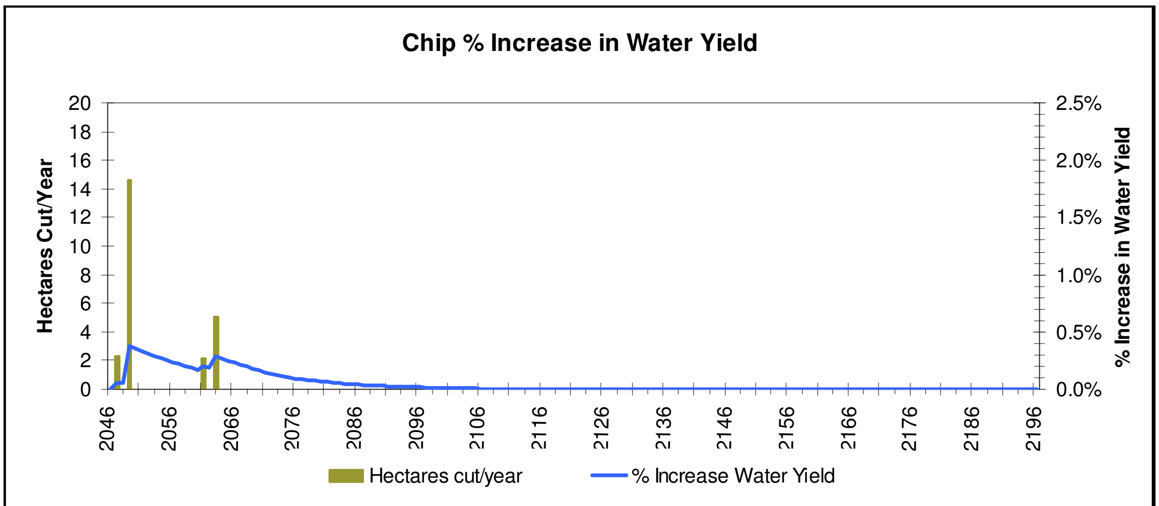

Carrot Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

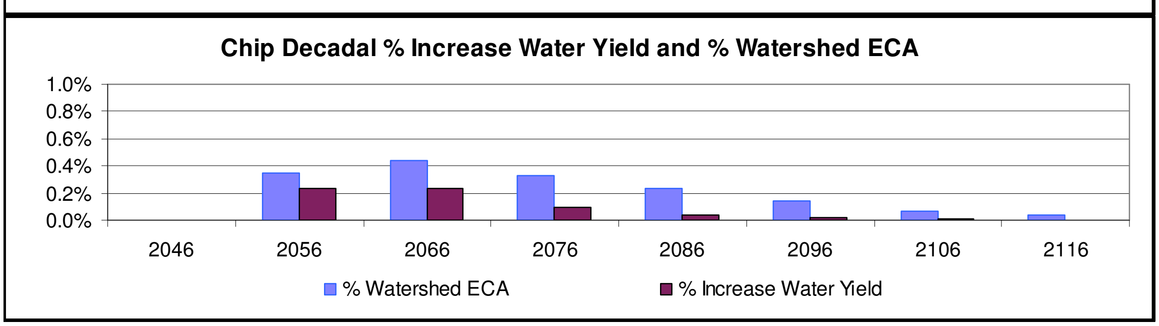

Carrot Tower % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

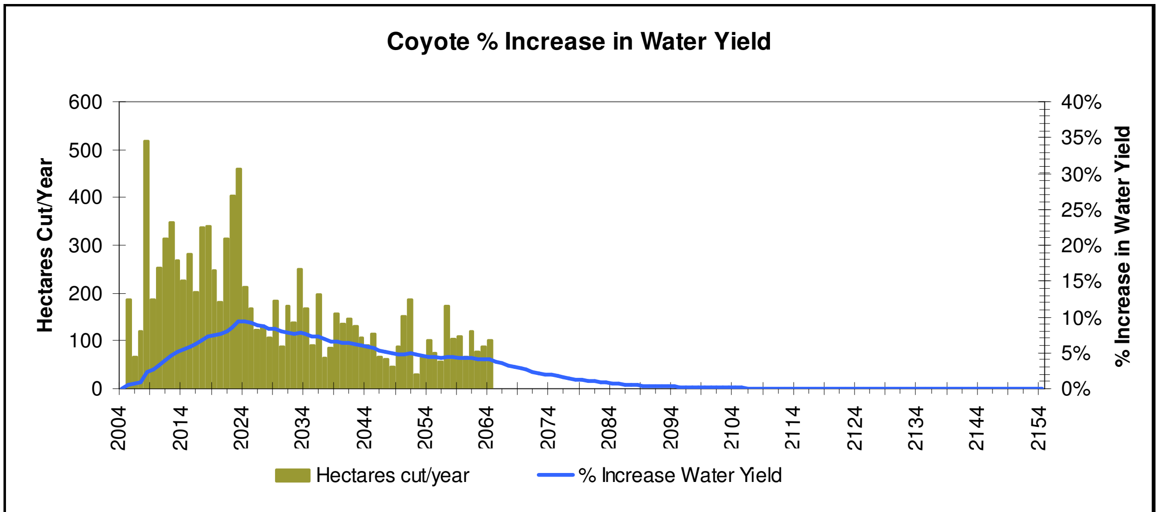

Carrot Tower Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

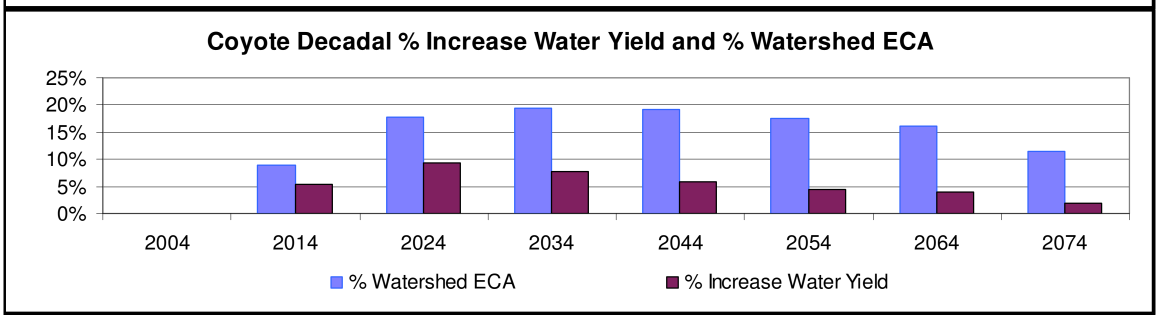

Chevron % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
200
180
160
140
120
100
80
60
40
20
0
40%
35%
30%
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

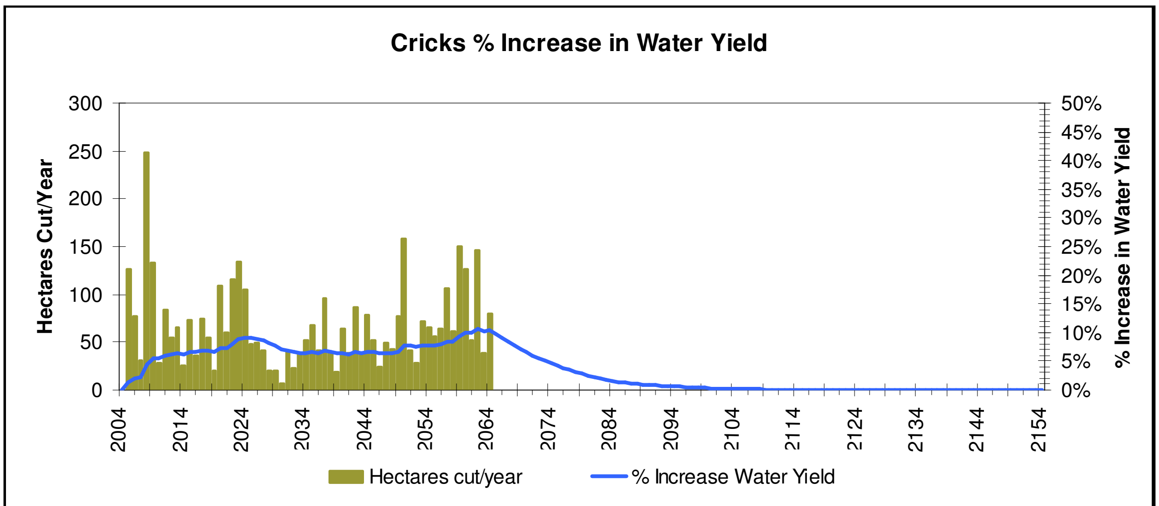

Chevron Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

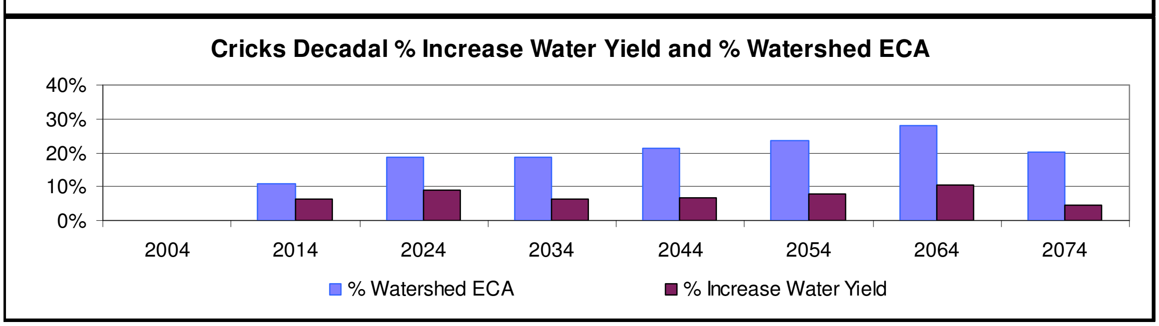

Chip % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
20
18
16
14
12
10
8
6
4
2
0
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
2046
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
2166
2176
2186
2196
Hectares cut/year
% Increase Water Yield

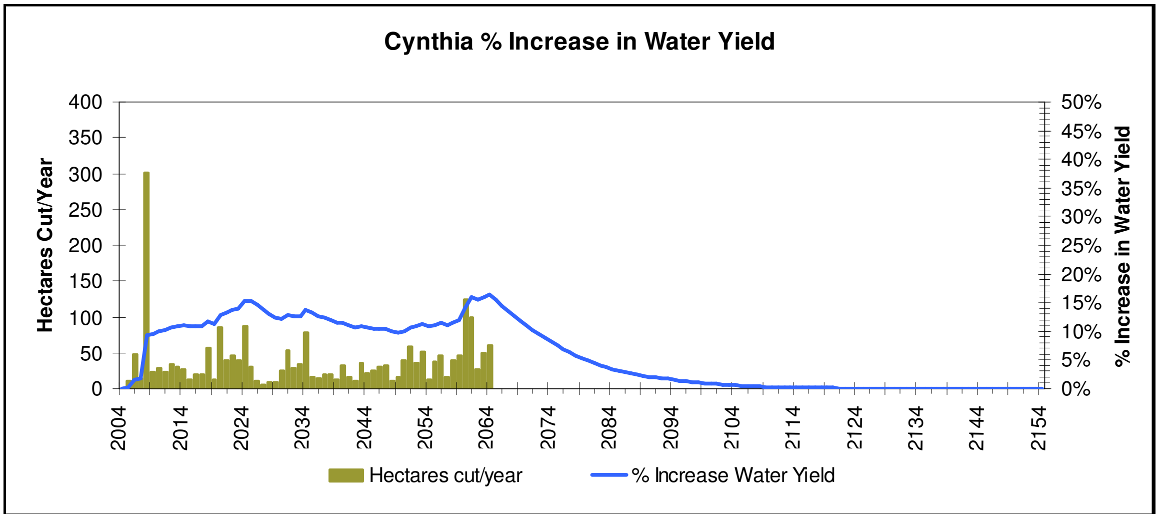

Chip Decadal % Increase Water Yield and % Watershed ECA
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
2046
2056
2066
2076
2086
2096
2106
2116
% Watershed ECA
% Increase Water Yield

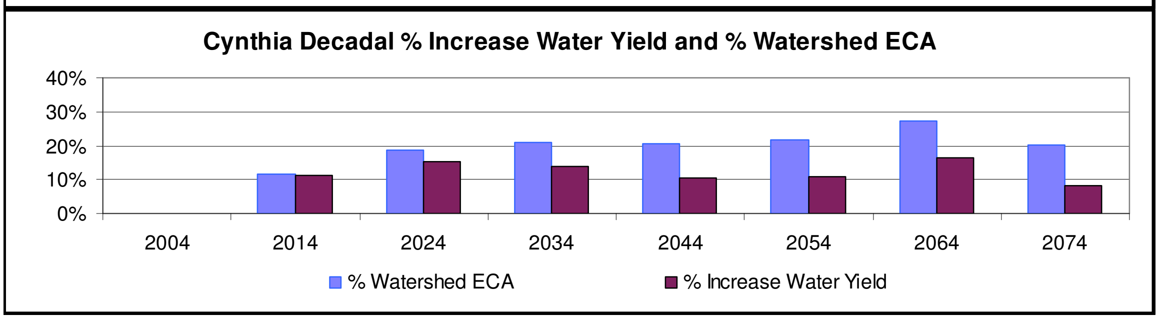

Coyote % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
100
200
300
400
500
600
0%
5%
10%
15%
20%
25%
30%
35%
40%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

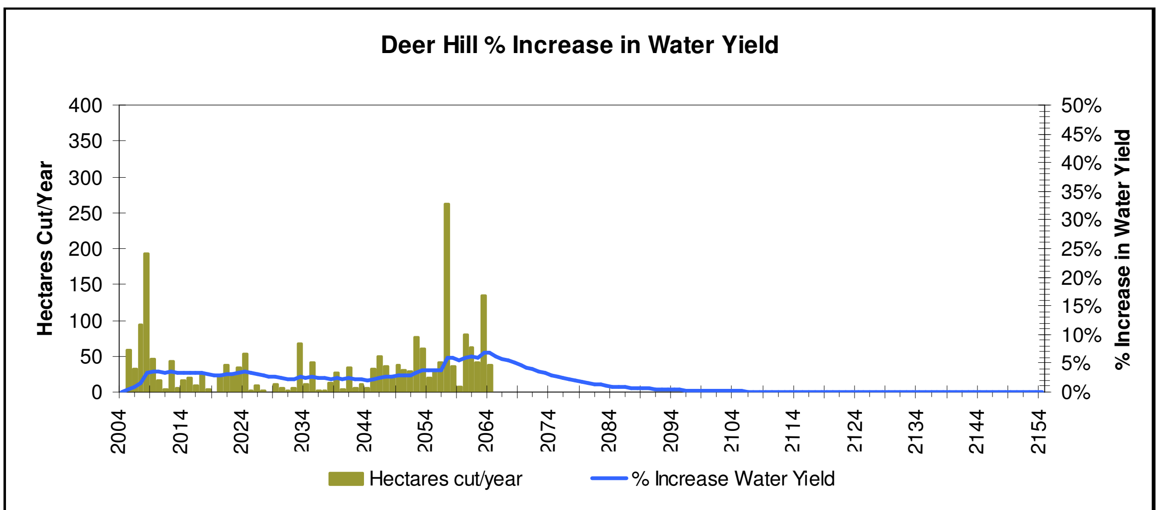

Coyote Decadal % Increase Water Yield and % Watershed ECA
0%
5%
10%
15%
20%
25%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

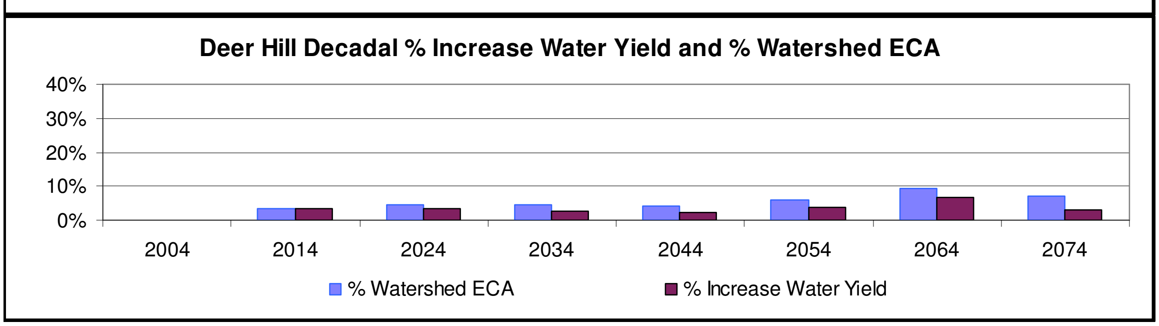

Cricks % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
50
100
150
200
250
300
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

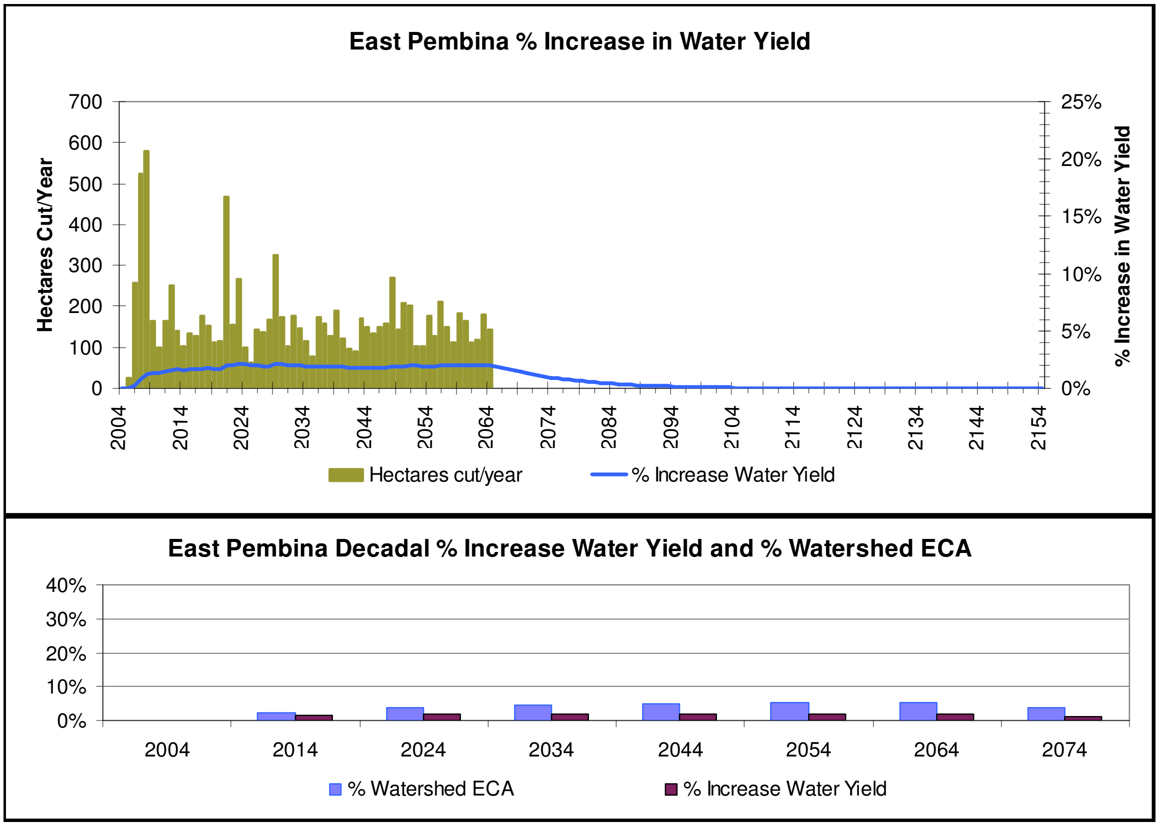

Cricks Decadal % Increase Water Yield and % Watershed ECA
0%
10%
20%
30%
40%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

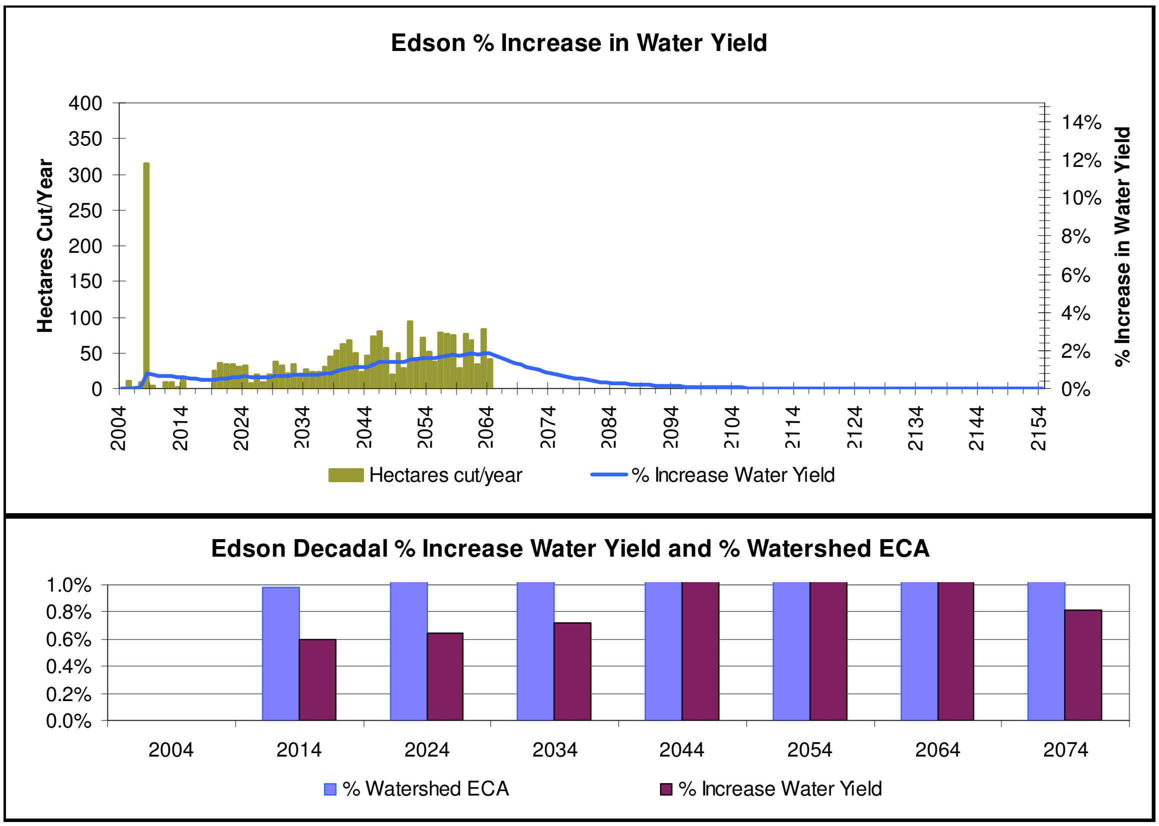

Cynthia % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

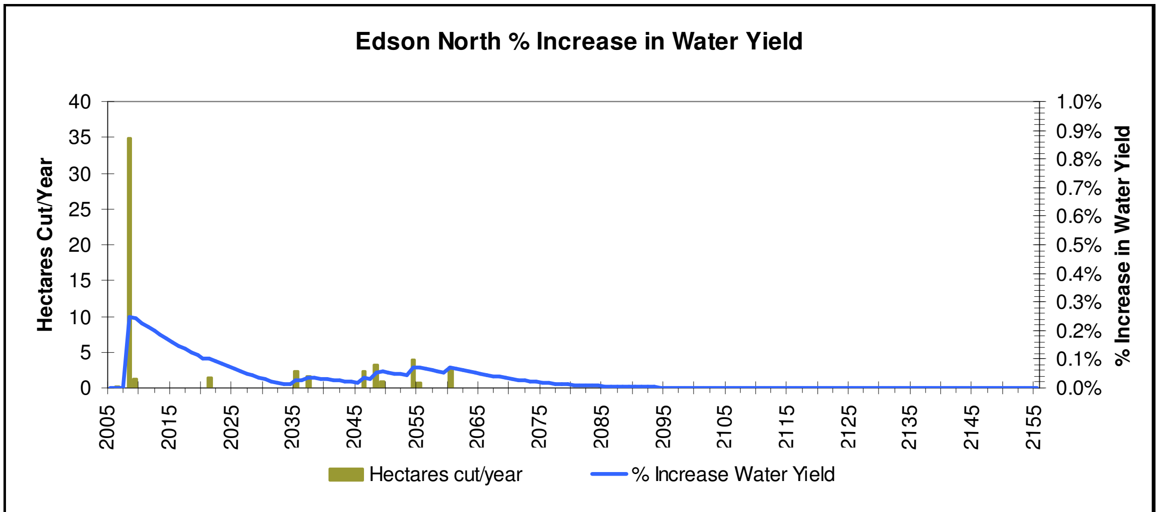

Cynthia Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

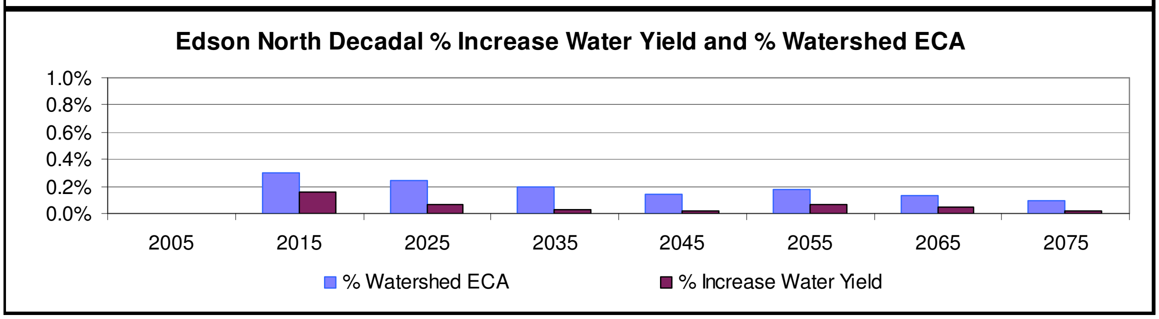

Deer Hill % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

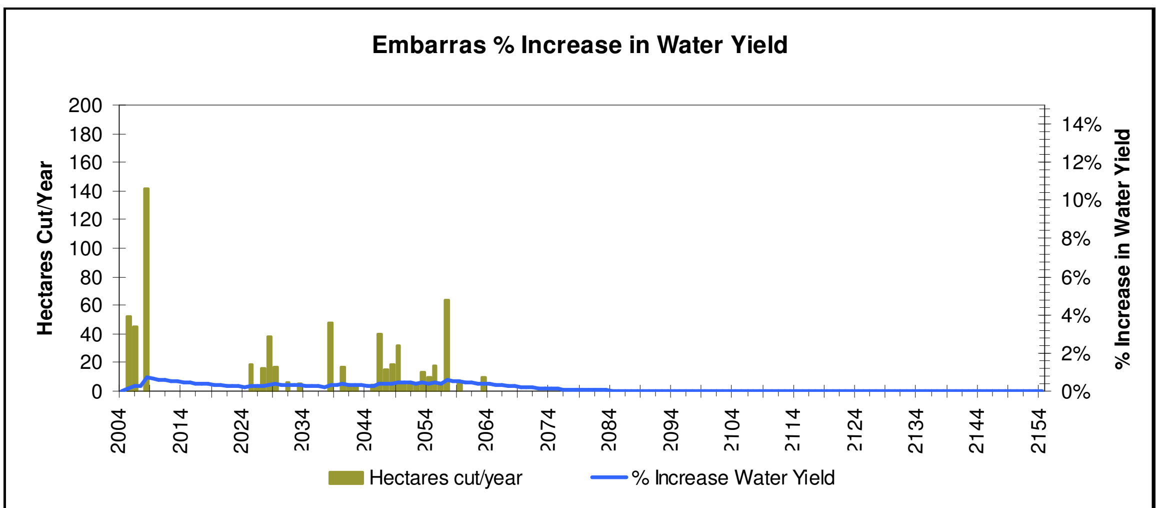

Deer Hill Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

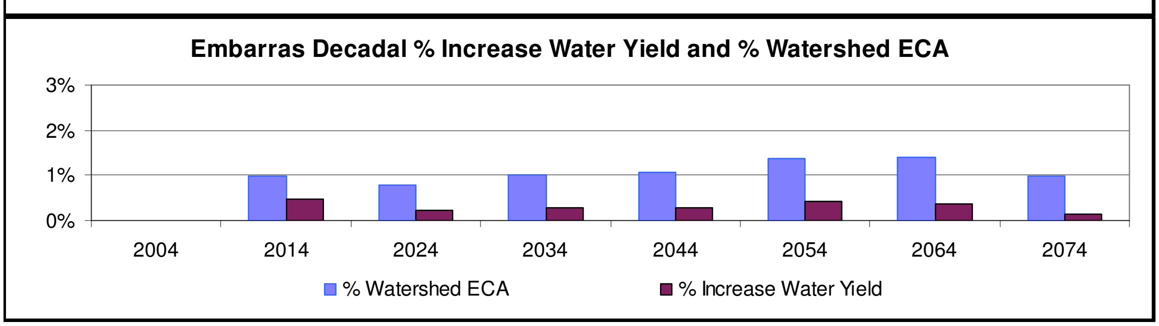

East Pembina % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield
East Pembina Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

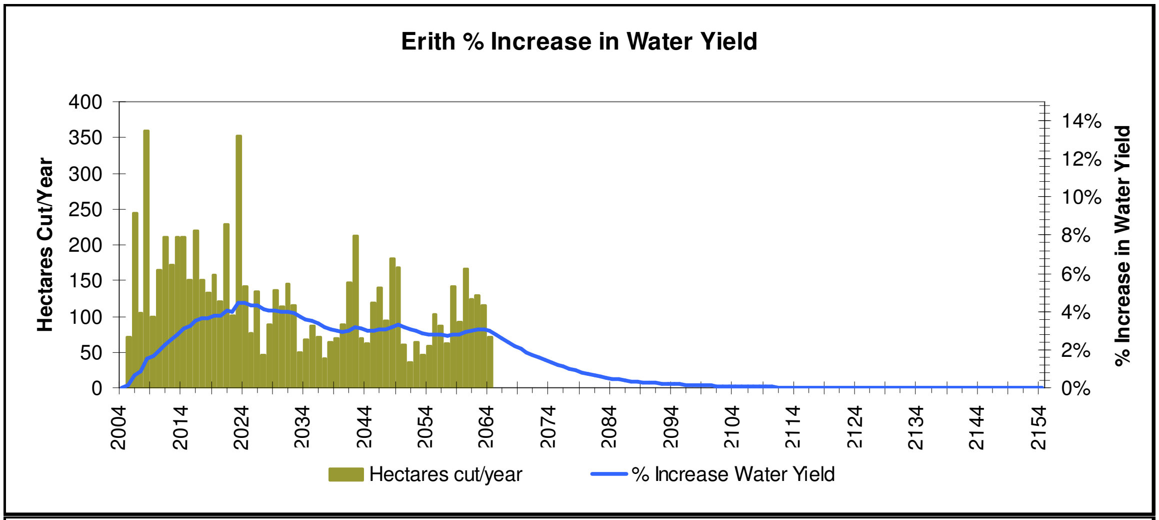

Edson % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield
Edson Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

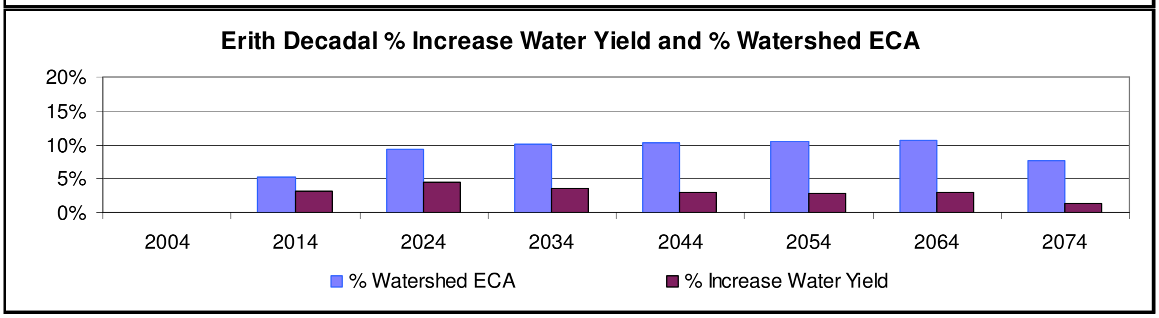

Edson North % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
40
35
30
25
20
15
10
5
0
1.0%
0.9%
0.8%
0.7%
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield

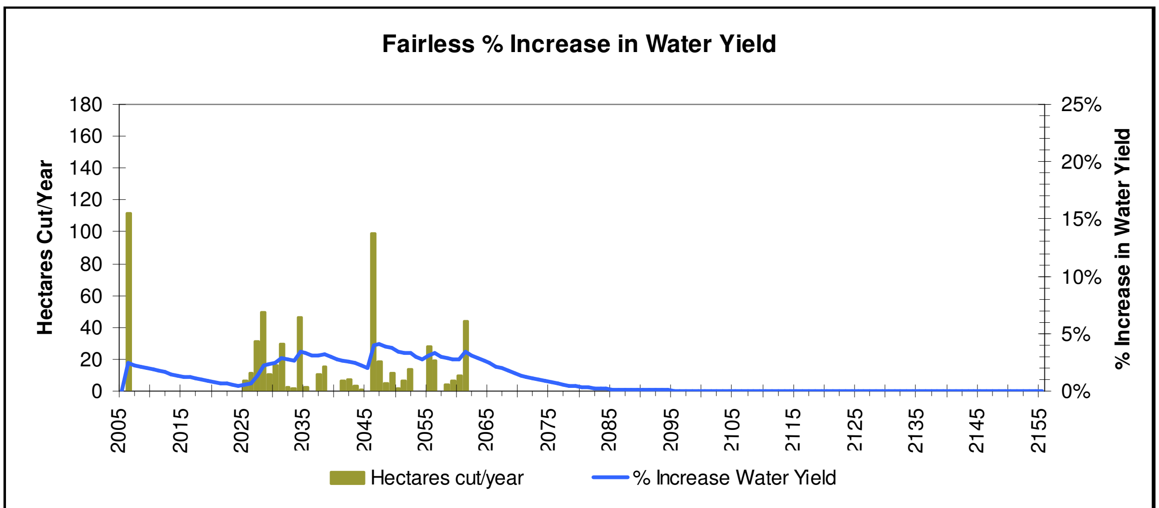

Edson North Decadal % Increase Water Yield and % Watershed ECA
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
2005
2015
2025
2035
2045
2055
2065
2075
% Watershed ECA
% Increase Water Yield

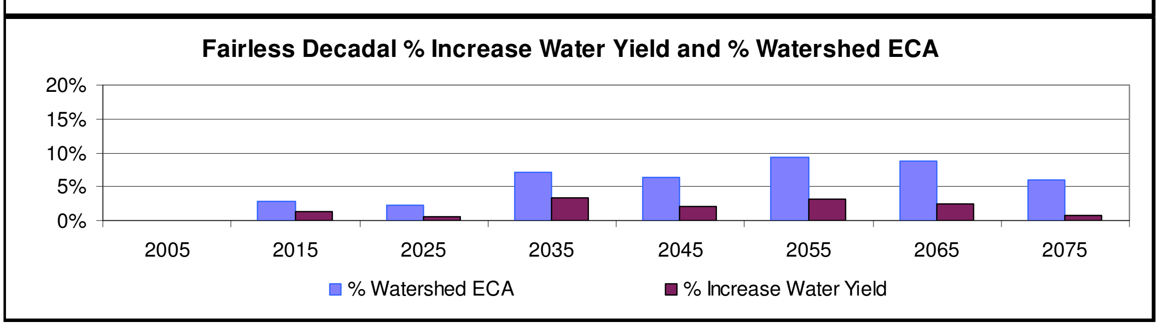

Embarras % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
200
180
160
140
120
100
80
60
40
20
0
14%
12%
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

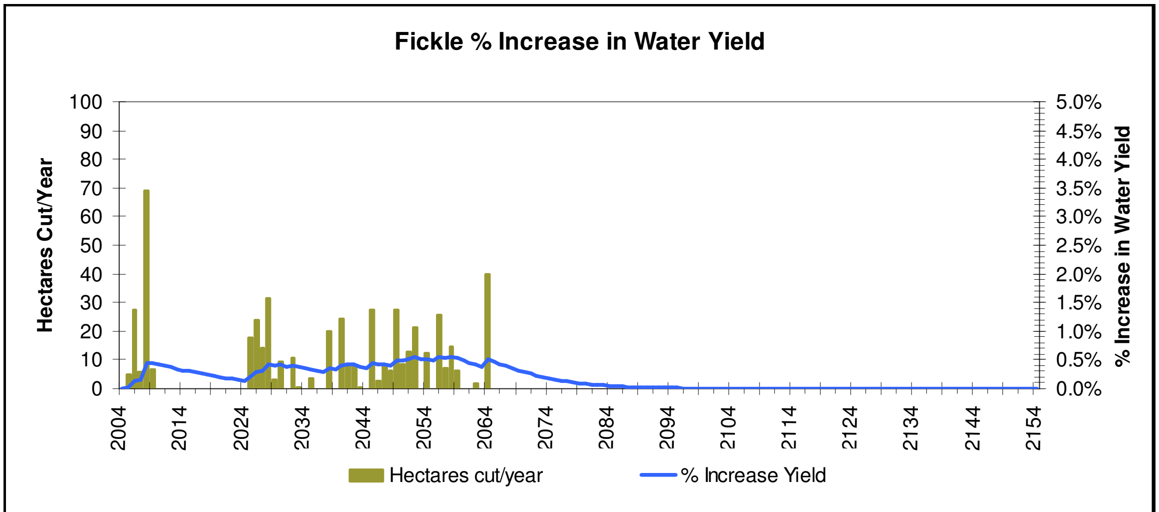

Embarras Decadal % Increase Water Yield and % Watershed ECA
3%
2%
1%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

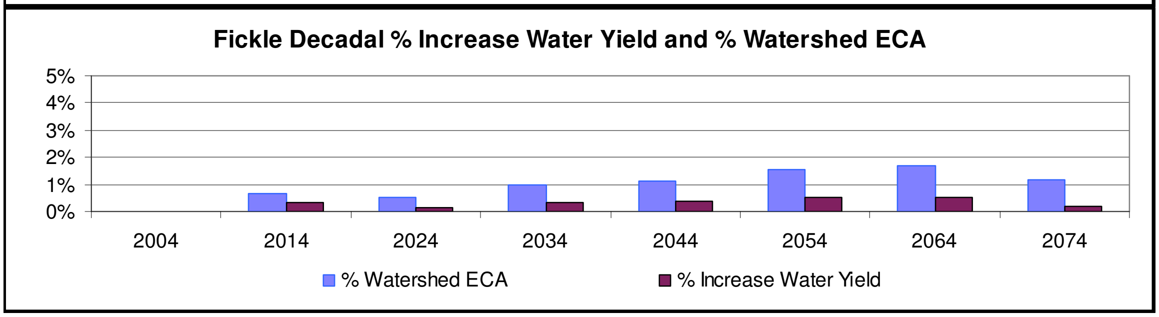

Erith % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
14%
12%
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

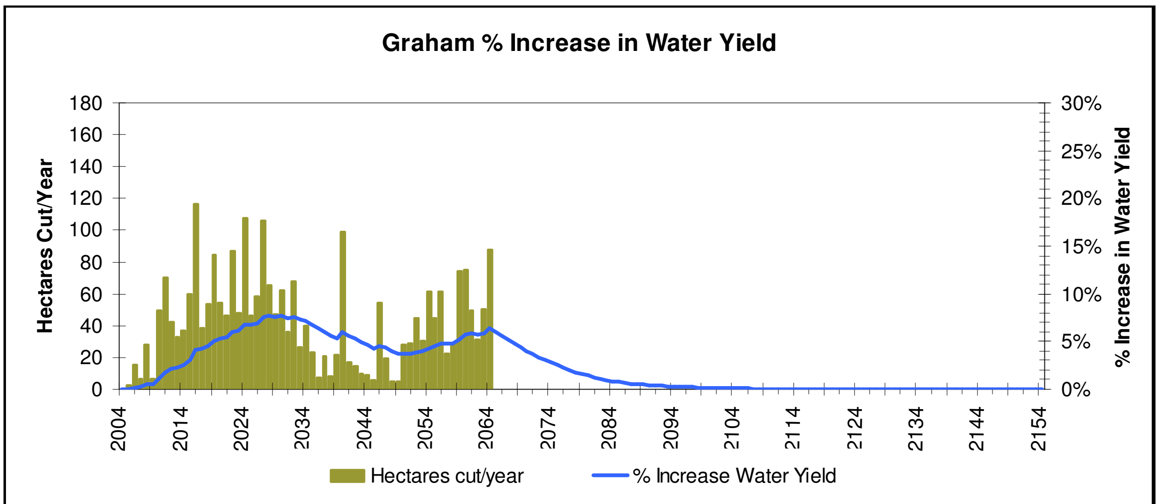

Erith Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

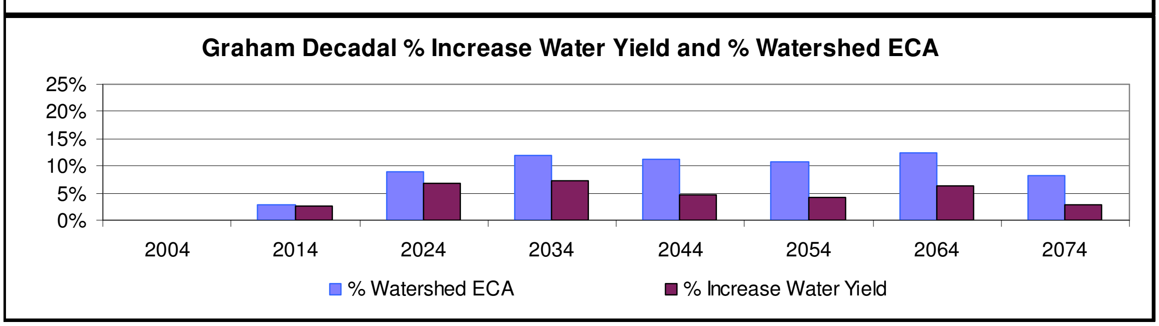

Fairless % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
180
160
140
120
100
80
60
40
20
0
25%
20%
15%
10%
5%
0%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield

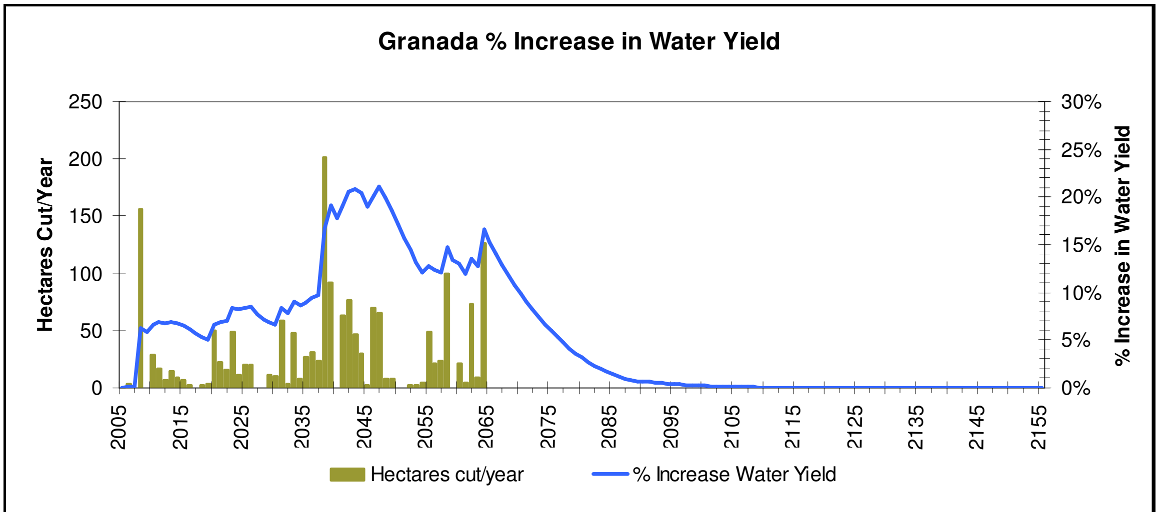

Fairless Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2005
2015
2025
2035
2045
2055
2065
2075
% Watershed ECA
% Increase Water Yield

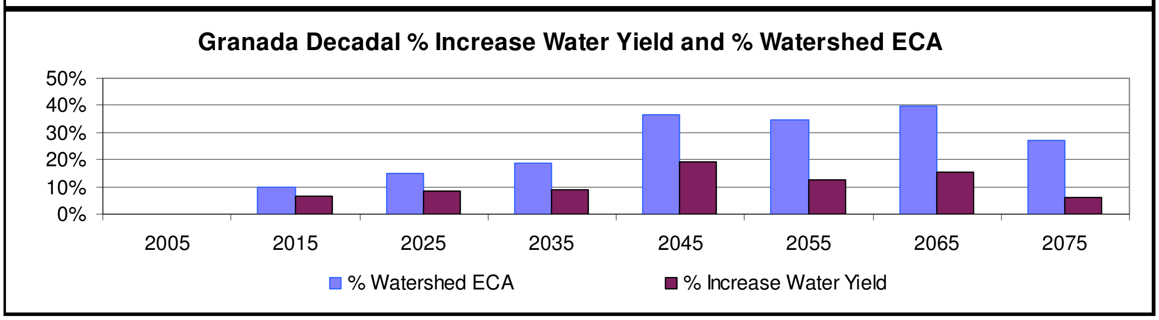

Fickle % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
100
90
80
70
60
50
40
30
20
10
0
5.0%
4.5%
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Yield

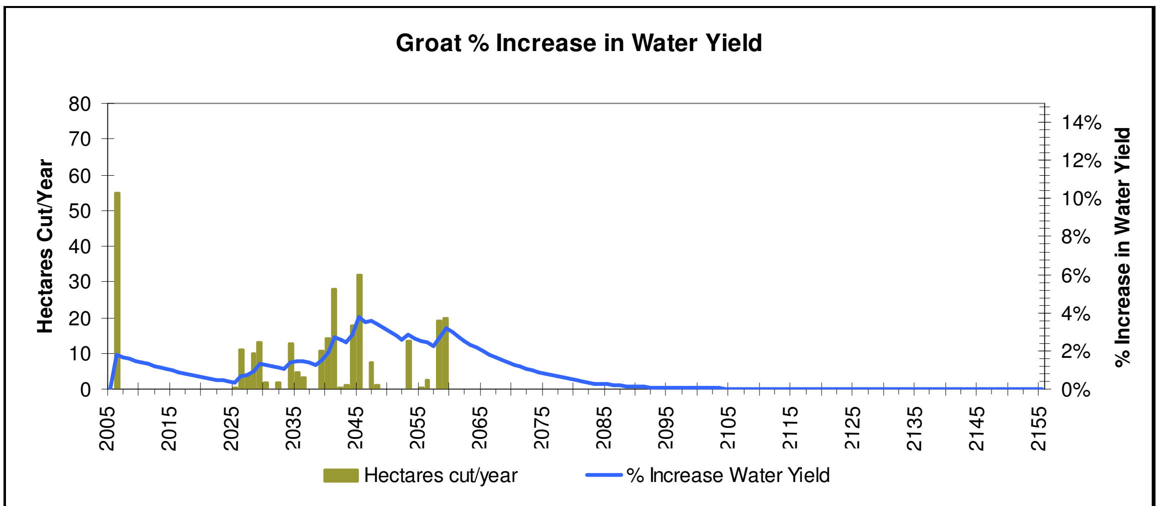

Fickle Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

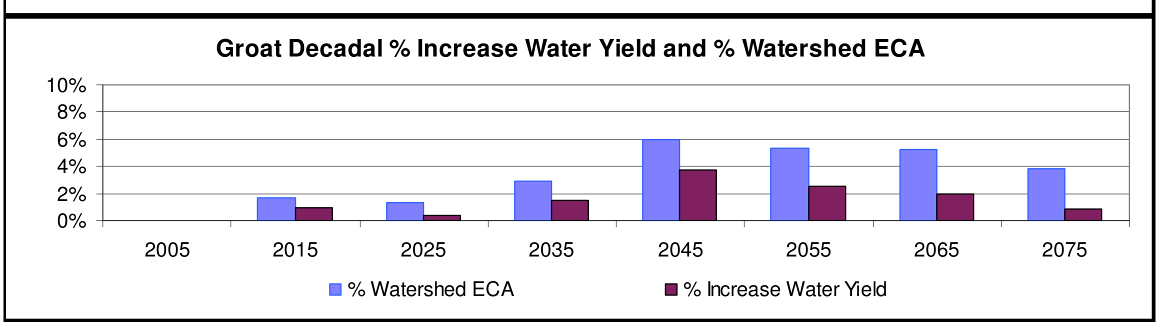

Graham % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
180
160
140
120
100
80
60
40
20
0
30%
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

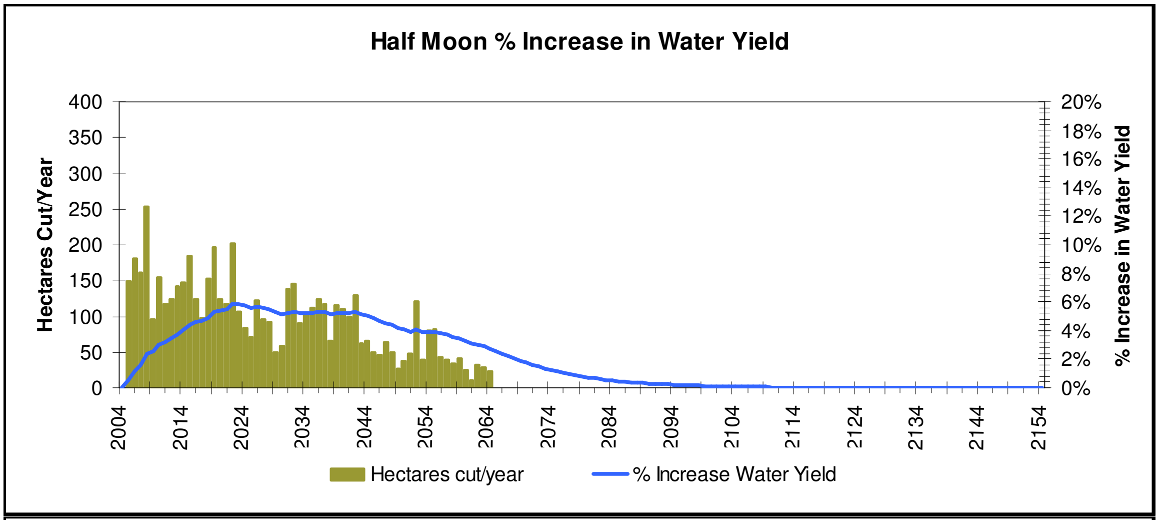

Graham Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

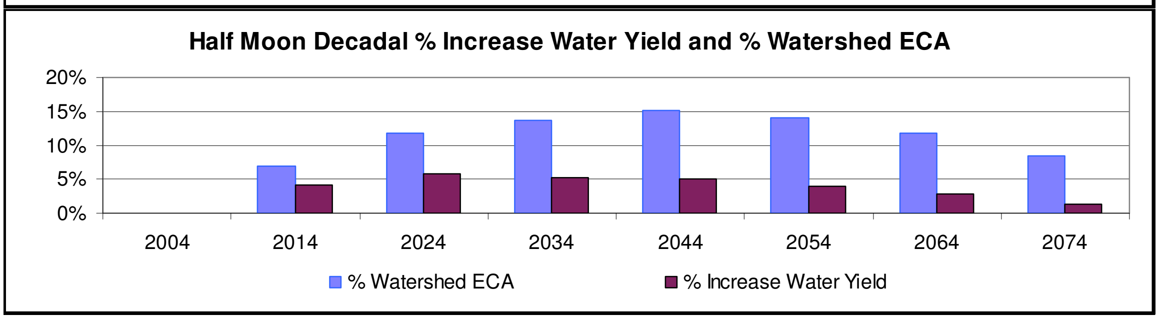

Granada % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
250
200
150
100
50
0
30%
25%
20%
15%
10%
5%
0%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield

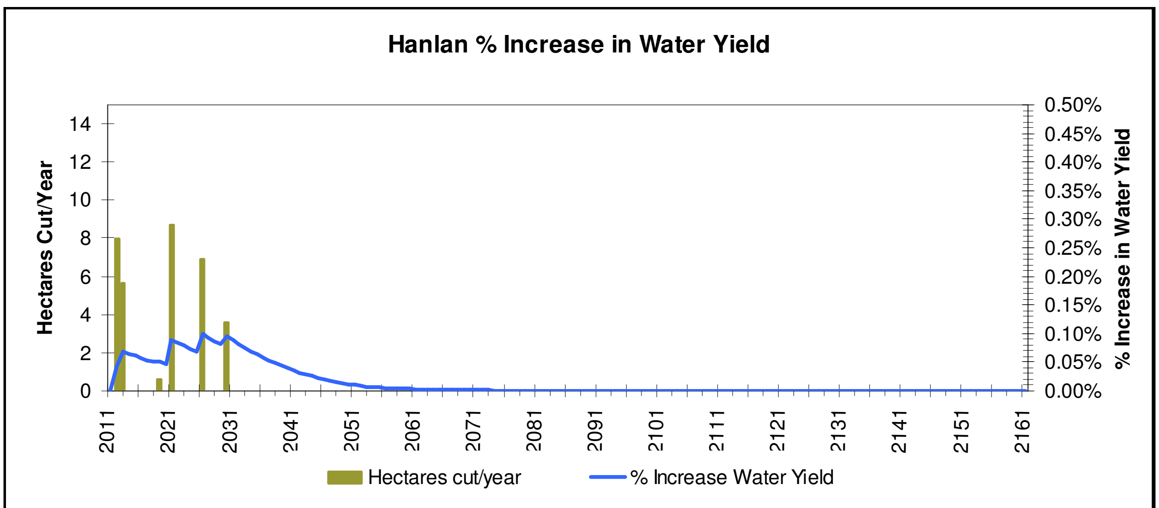

Granada Decadal % Increase Water Yield and % Watershed ECA
50%
40%
30%
20%
10%
0%
2005
2015
2025
2035
2045
2055
2065
2075
% Watershed ECA
% Increase Water Yield

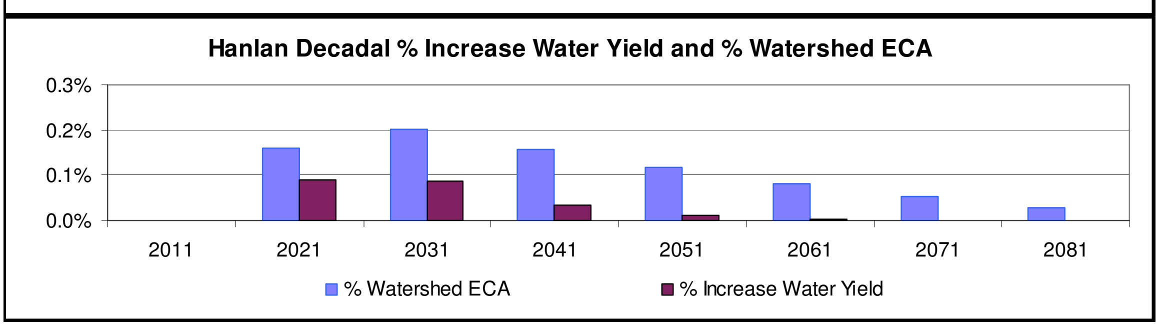

Groat % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
80
70
60
50
40
30
20
10
0
14%
12%
10%
8%
6%
4%
2%
0%
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
2105
2115
2125
2135
2145
2155
Hectares cut/year
% Increase Water Yield

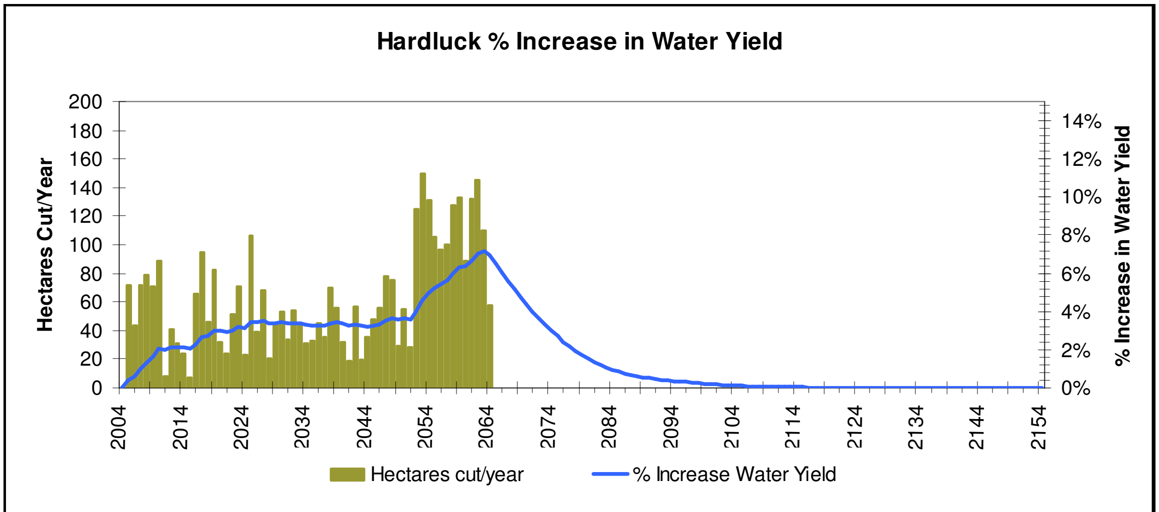

Groat Decadal % Increase Water Yield and % Watershed ECA
10%
8%
6%
4%
2%
0%
2005
2015
2025
2035
2045
2055
2065
2075
% Watershed ECA
% Increase Water Yield

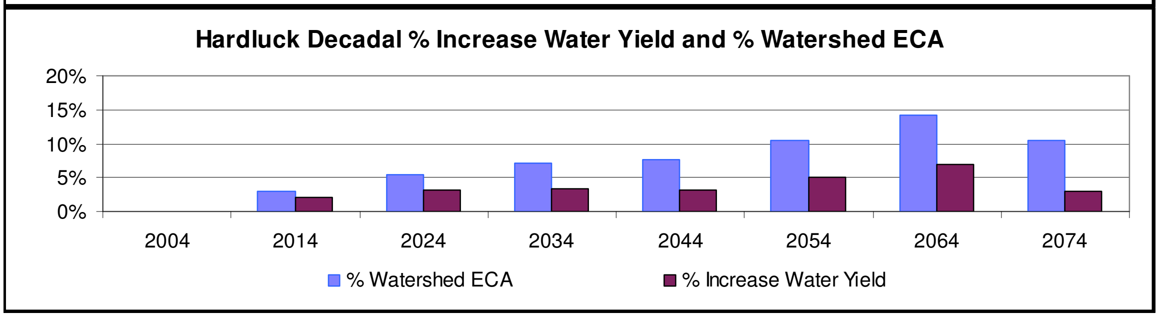

Half Moon % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

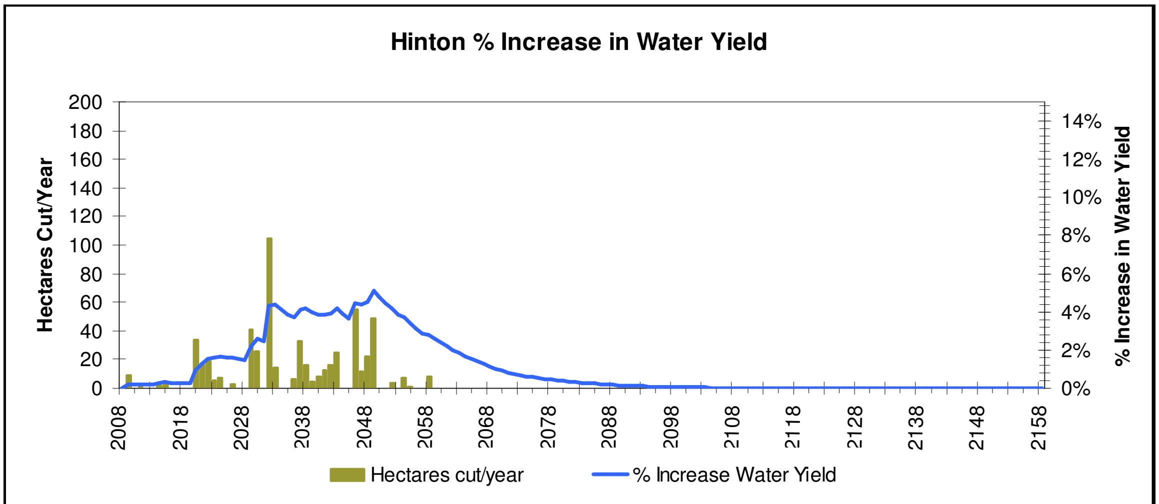

Half Moon Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

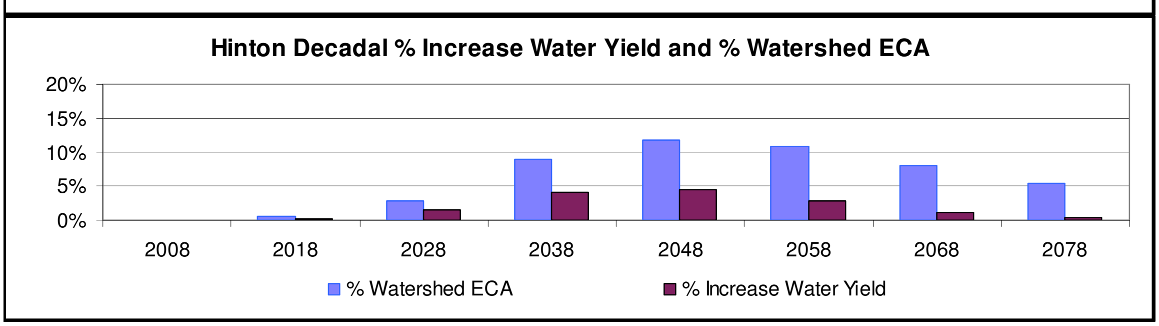

Hanlan % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
14
12
10
8
6
4
2
0
0.50%
0.45%
0.40%
0.35%
0.30%
0.25%
0.20%
0.15%
0.10%
0.05%
0.00%
2011
2021
2031
2041
2051
2061
2071
2081
2091
2101
2111
2121
2131
2141
2151
2161
Hectares cut/year
% Increase Water Yield

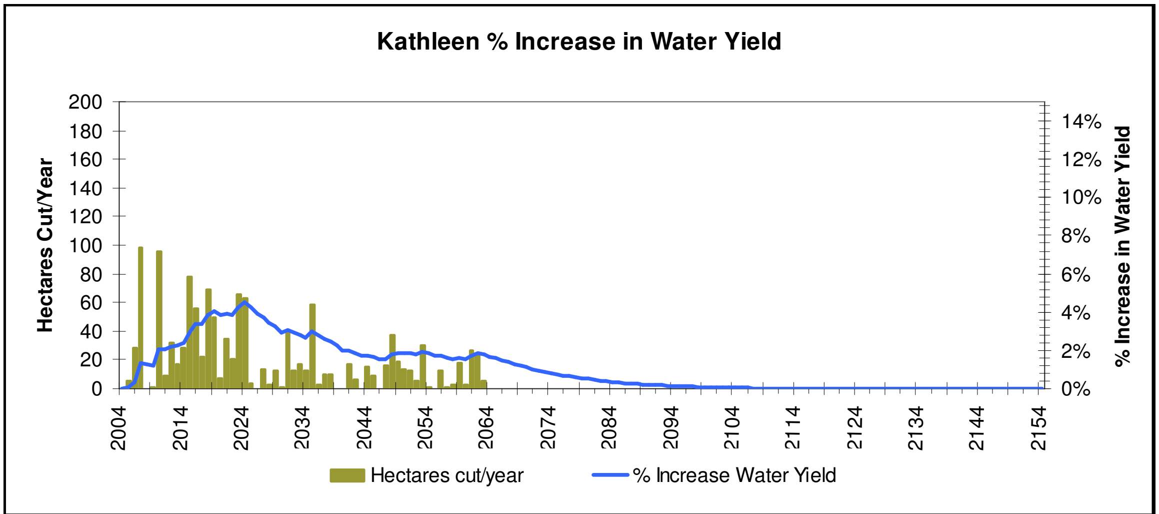

Hanlan Decadal % Increase Water Yield and % Watershed ECA
0.3%
0.2%
0.1%
0.0%
2011
2021
2031
2041
2051
2061
2071
2081
% Watershed ECA
% Increase Water Yield

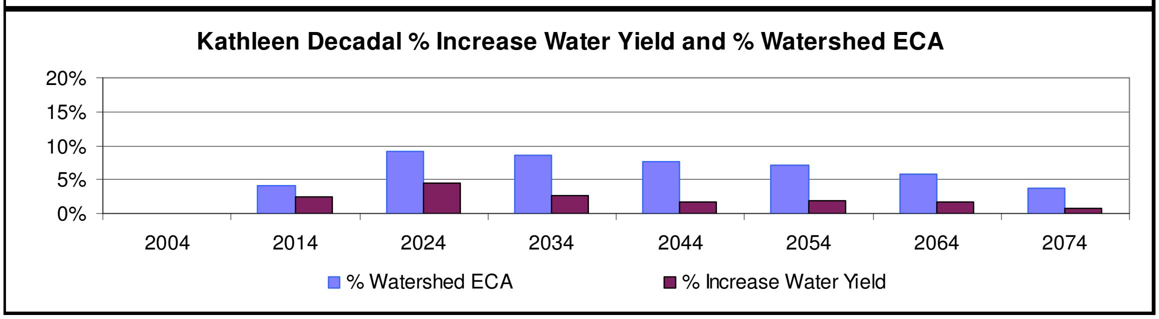

Hardluck % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
200
180
160
140
120
100
80
60
40
20
0
14%
12%
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

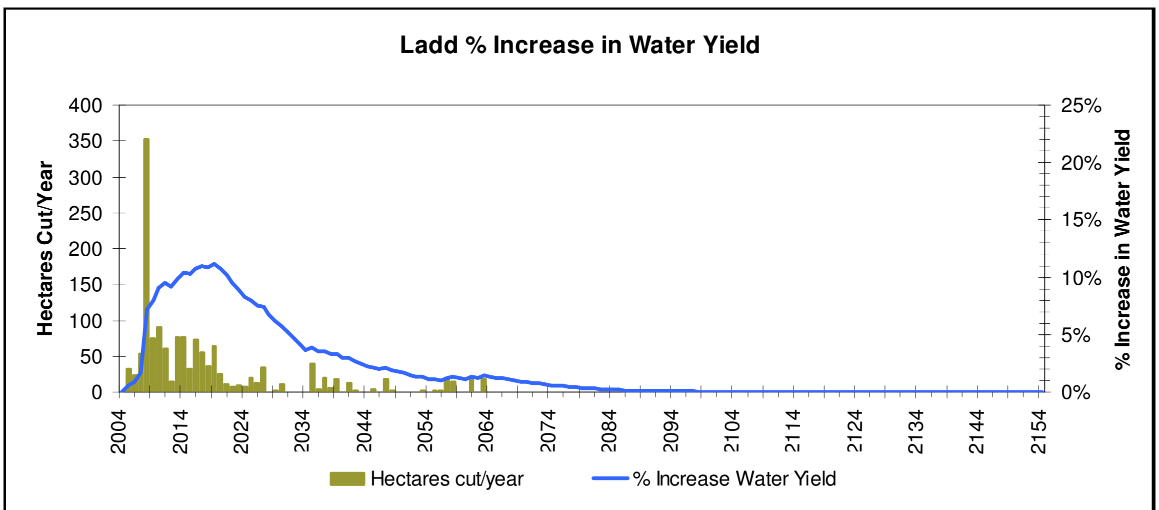

Hardluck Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

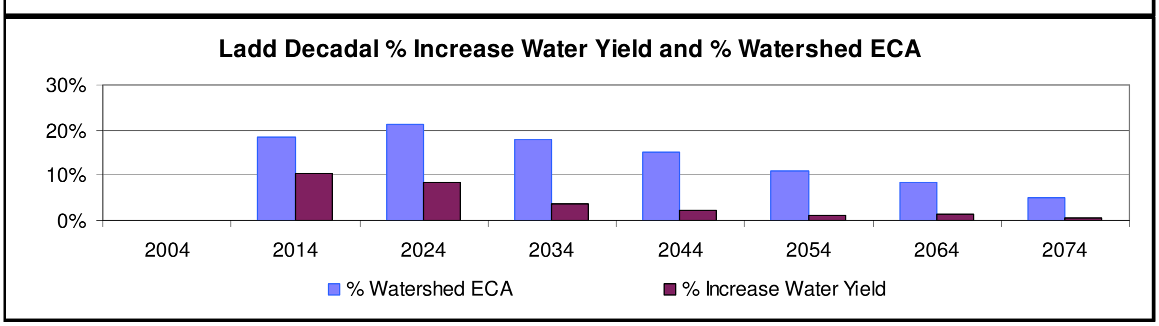

Hinton % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
200
180
160
140
120
100
80
60
40
20
0
14%
12%
10%
8%
6%
4%
2%
0%
2008
2018
2028
2038
2048
2058
2068
2078
2088
2098
2108
2118
2128
2138
2148
2158
Hectares cut/year
% Increase Water Yield

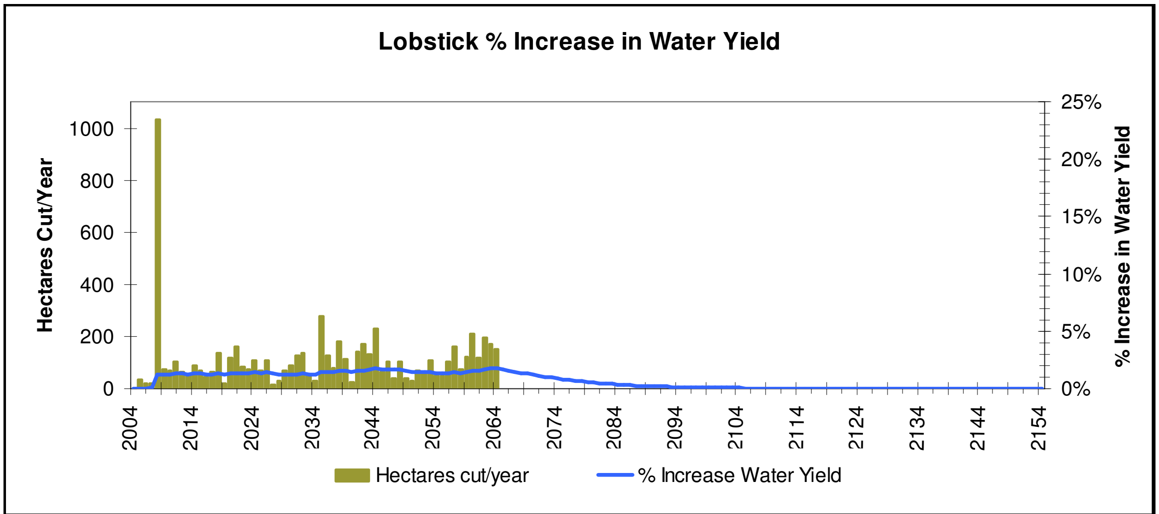

Hinton Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2008
2018
2028
2038
2048
2058
2068
2078
% Watershed ECA
% Increase Water Yield

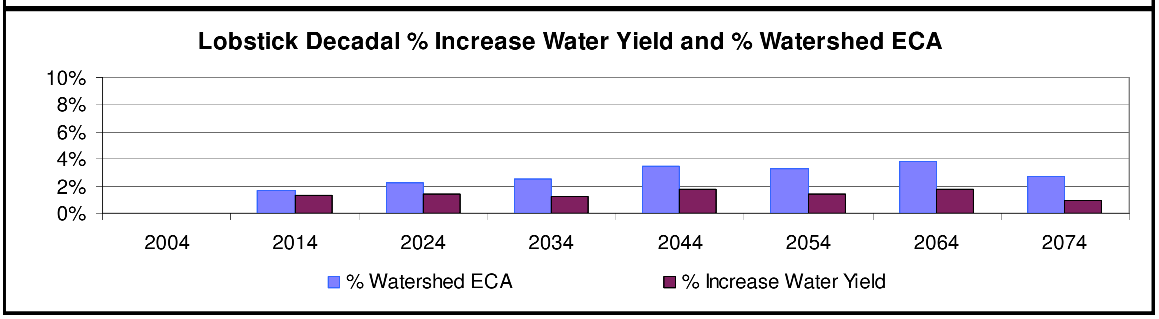

Kathleen % Increase in Water Yield
Hectares Cut/Year
200
180
160
140
120
100
80
60
40
20
0
% Increase in Water Yield
14%
12%
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

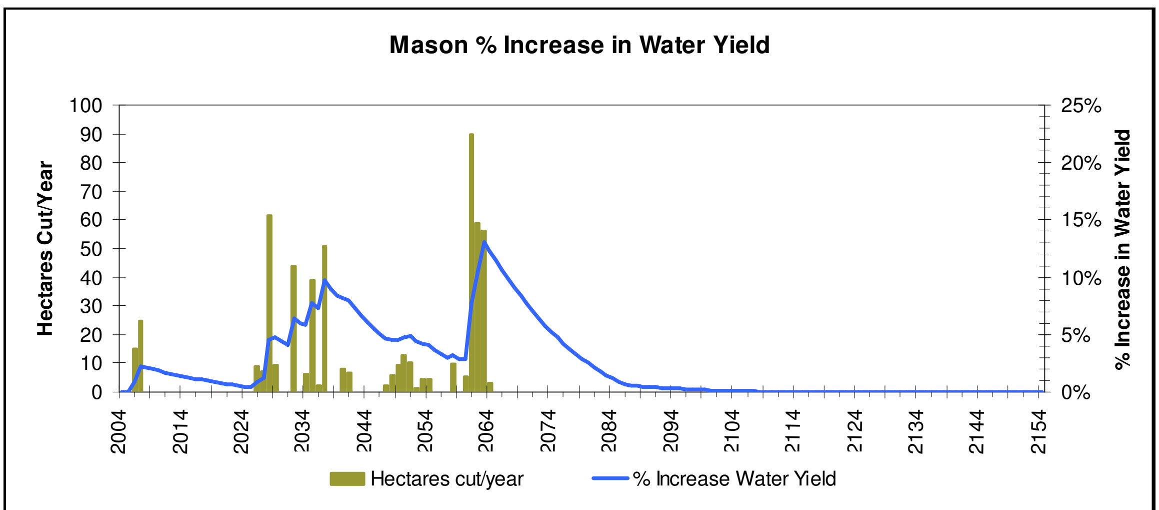

Kathleen Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

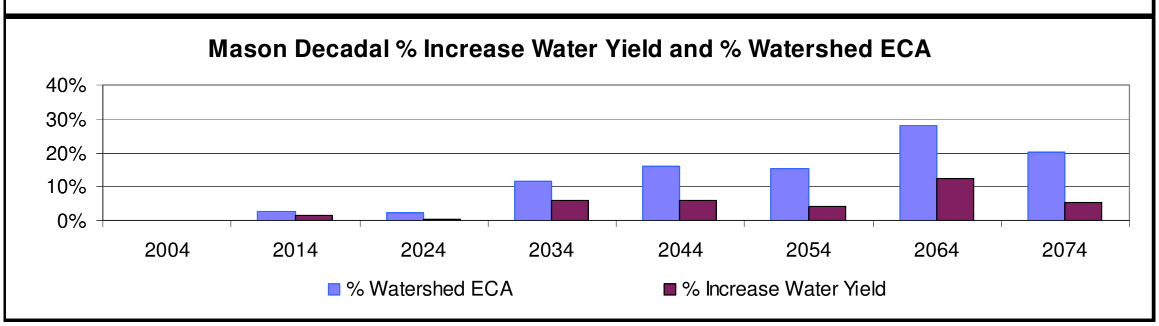

Ladd % Increase in Water Yield
Hectares Cut/Year
400
350
300
250
200
150
100
50
0
% Increase in Water Yield
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

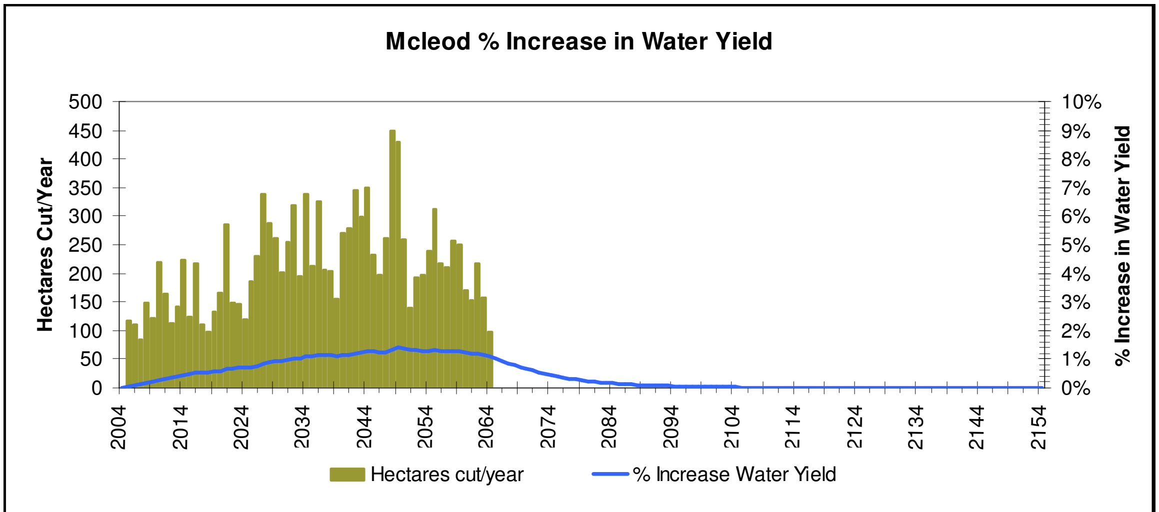

Ladd Decadal % Increase Water Yield and % Watershed ECA
30%
20%
10%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

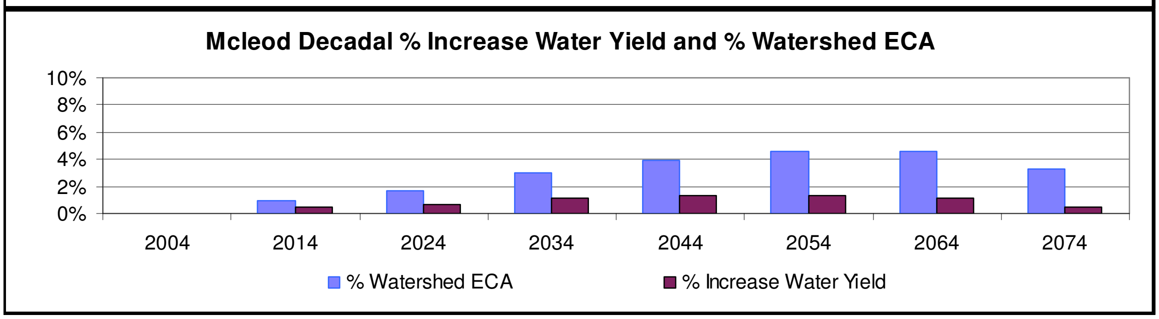

Lobstick % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
200
400
600
800
1000
0%
5%
10%
15%
20%
25%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

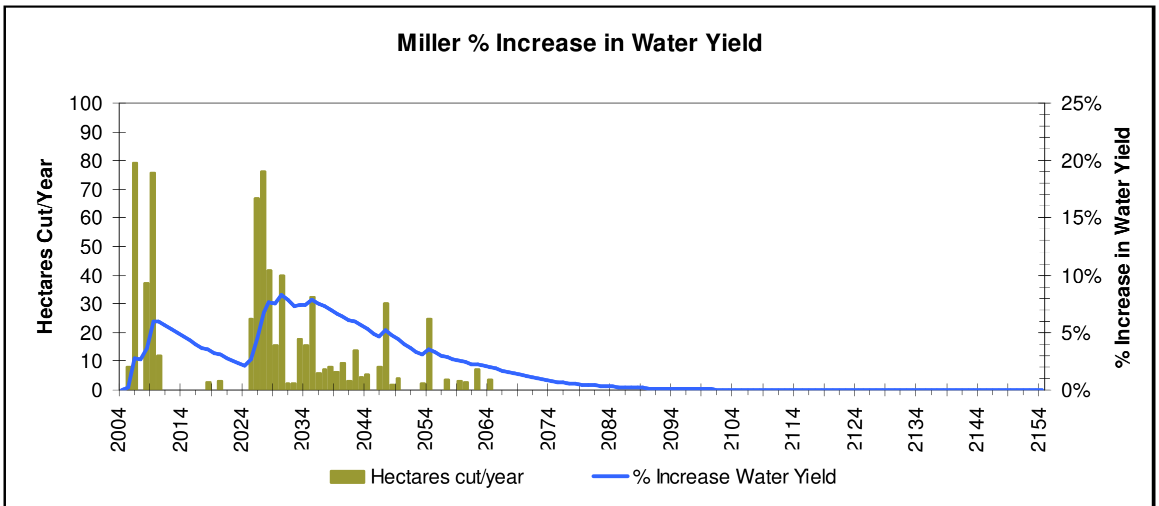

Lobstick Decadal % Increase Water Yield and % Watershed ECA
0%
2%
4%
6%
8%
10%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

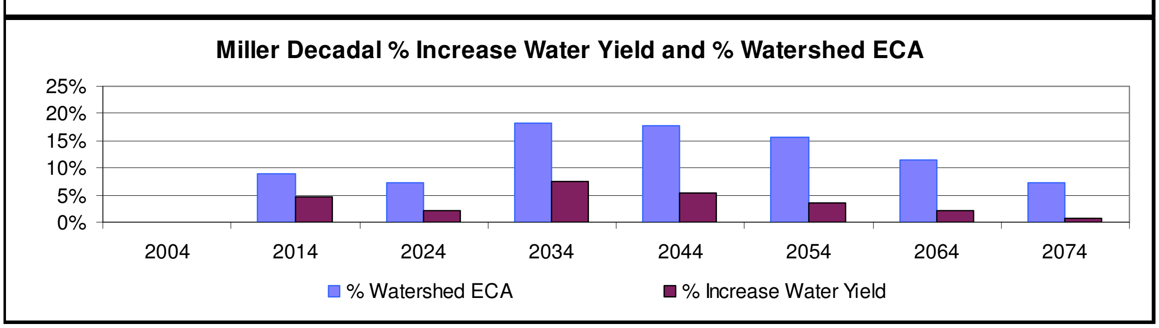

Mason % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0
10
20
30
40
50
60
70
80
90
100
0%
5%
10%
15%
20%
25%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

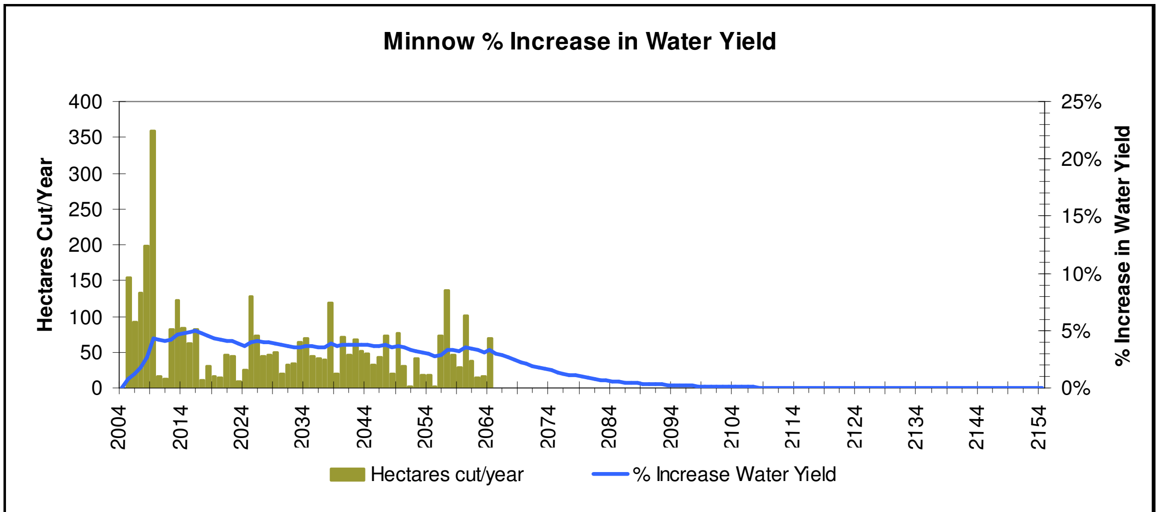

Mason Decadal % Increase Water Yield and % Watershed ECA
0%
10%
20%
30%
40%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

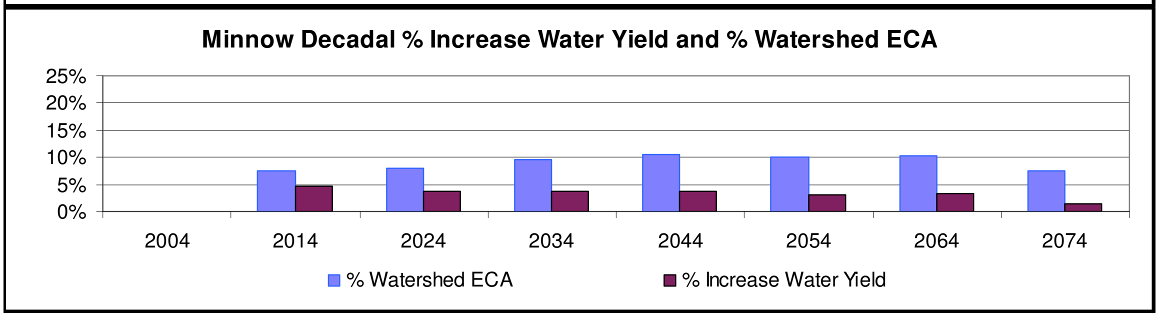

Mcleod % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
500
450
400
350
300
250
200
150
100
50
0
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

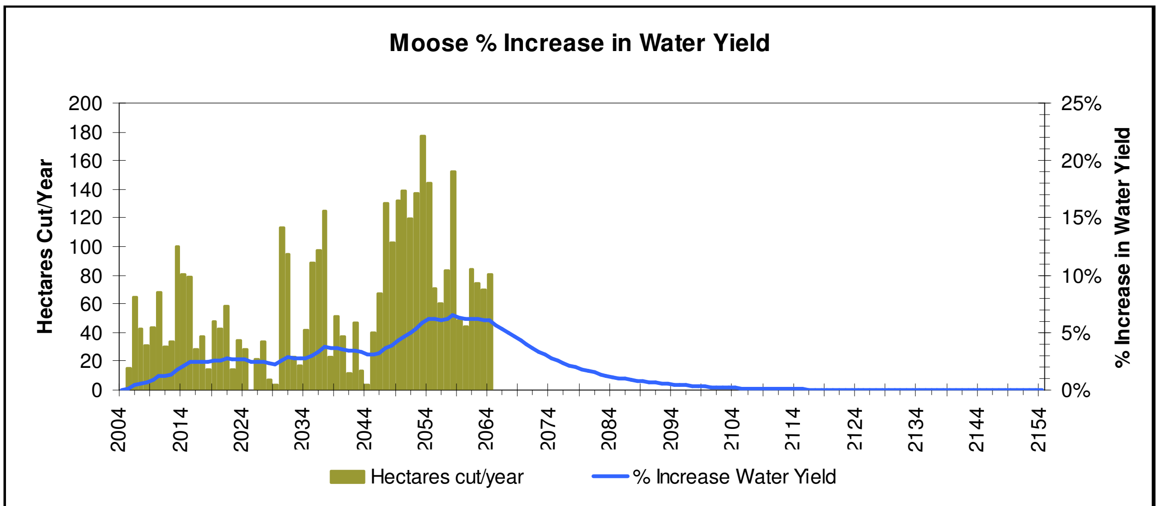

Mcleod Decadal % Increase Water Yield and % Watershed ECA
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

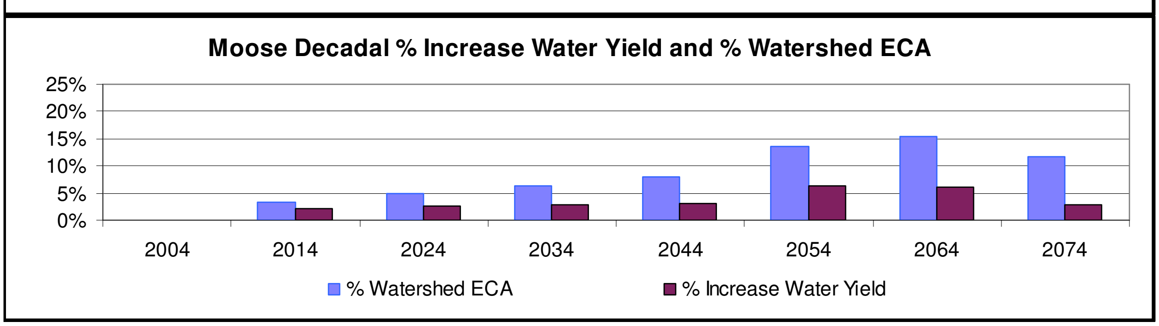

Miller % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
100
90
80
70
60
50
40
30
20
10
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

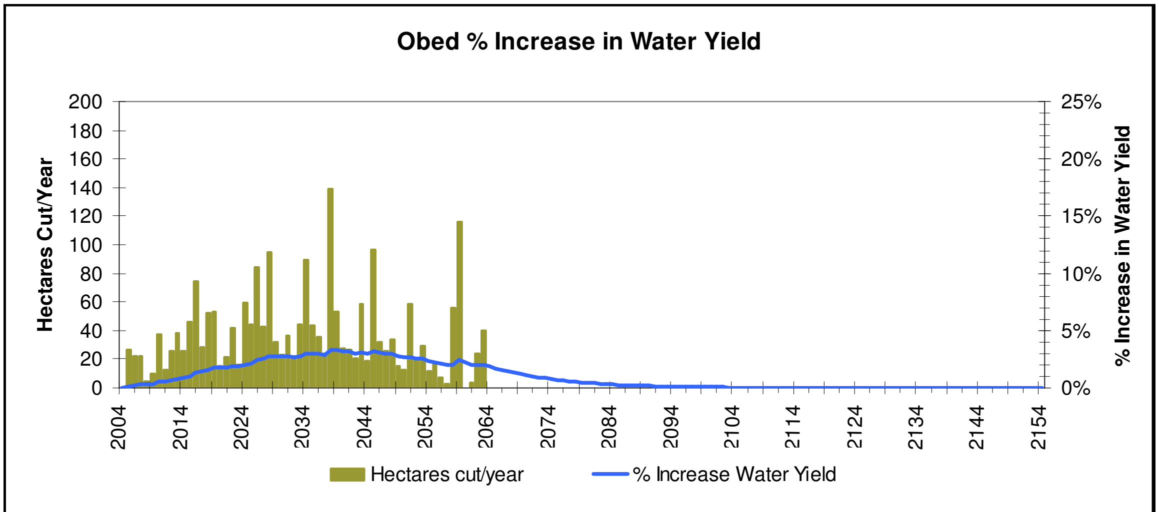

Miller Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

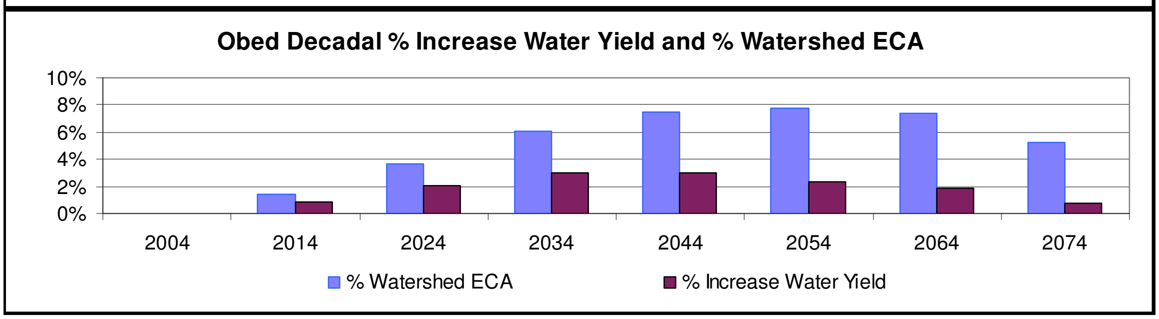

Minnow % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

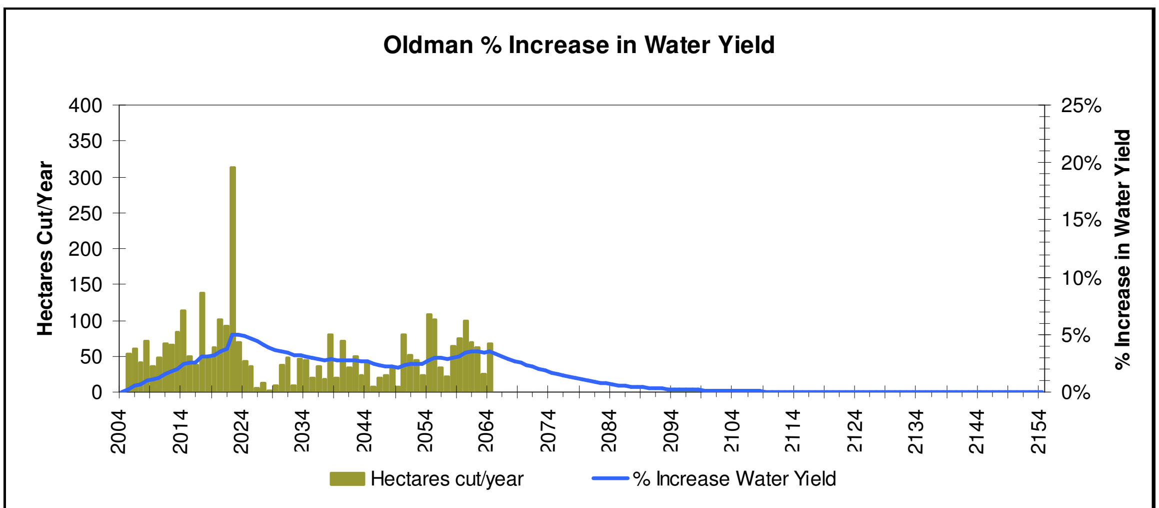

Minnow Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

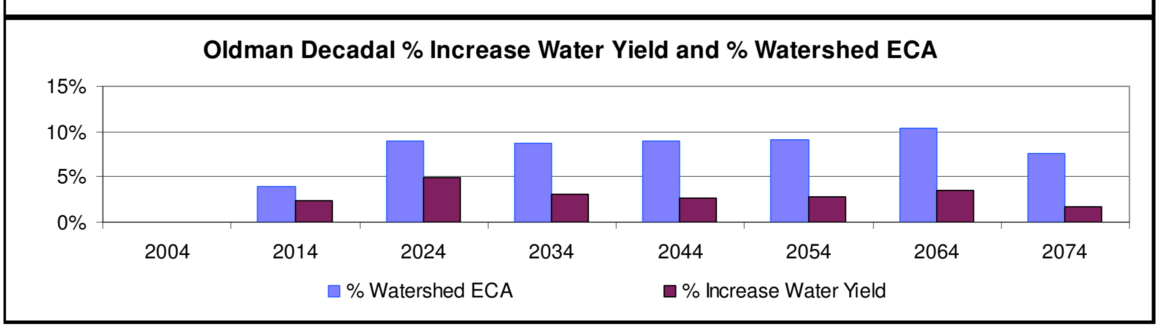

Moose % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield

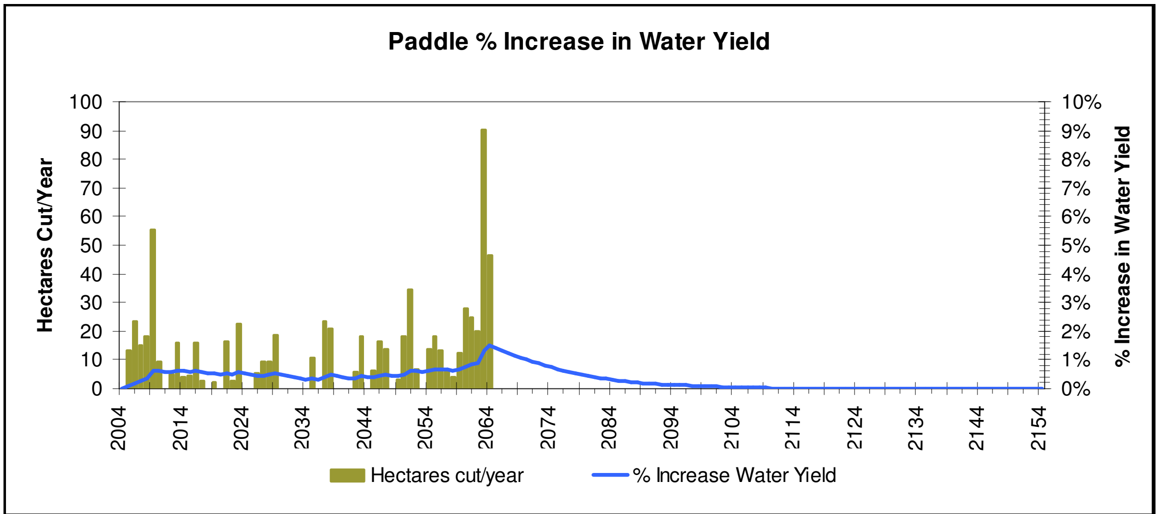

Moose Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

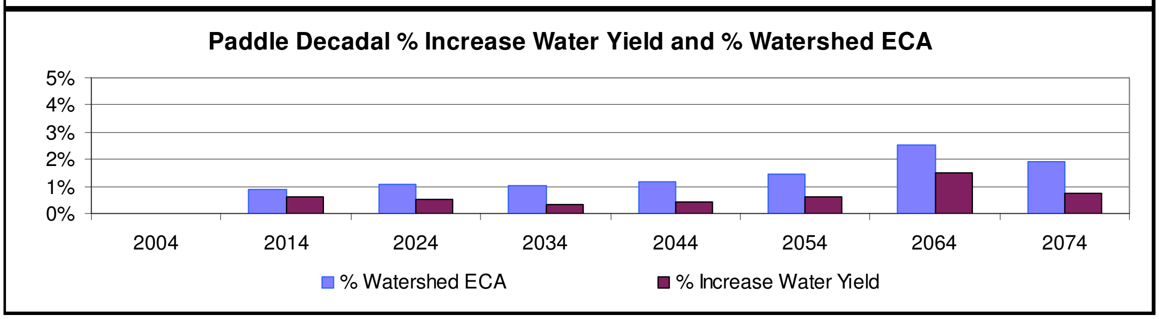

Obed % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
200
180
160
140
120
100
80
60
40
20
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

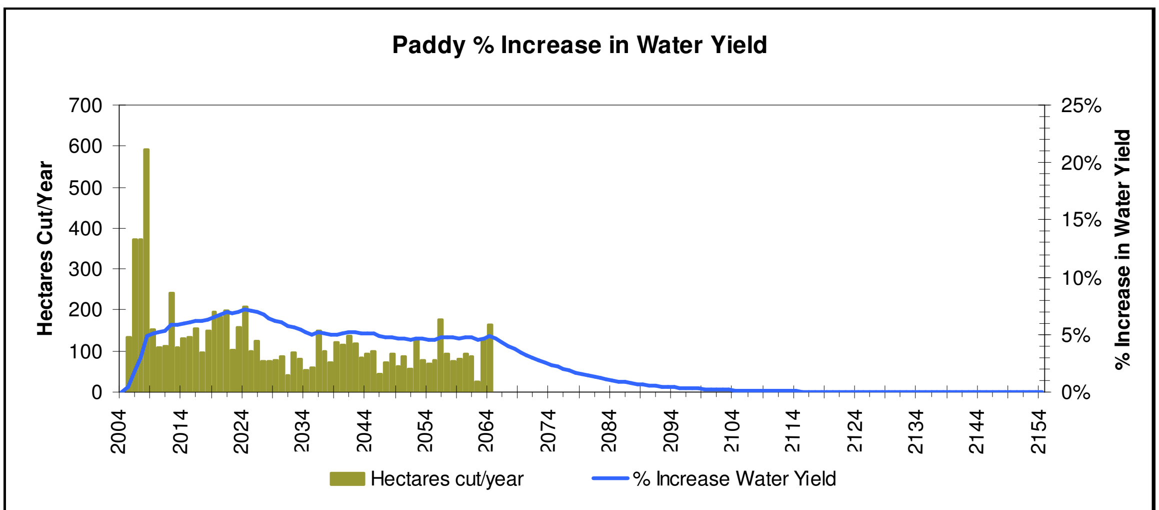

Obed Decadal % Increase Water Yield and % Watershed ECA
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

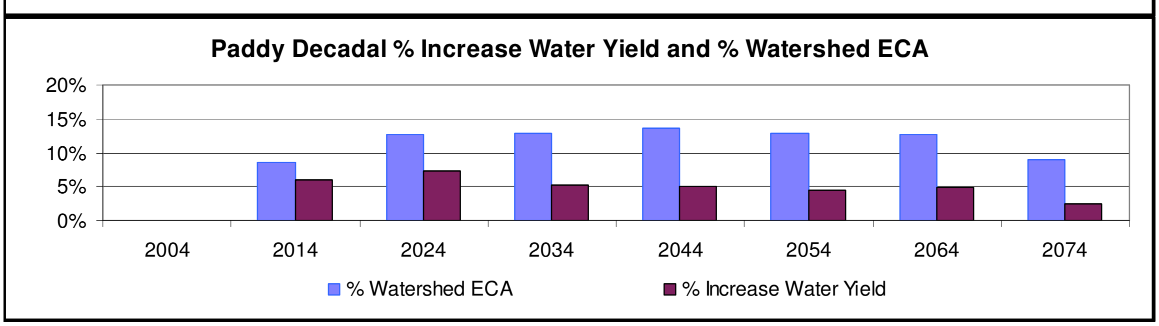

Oldman % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

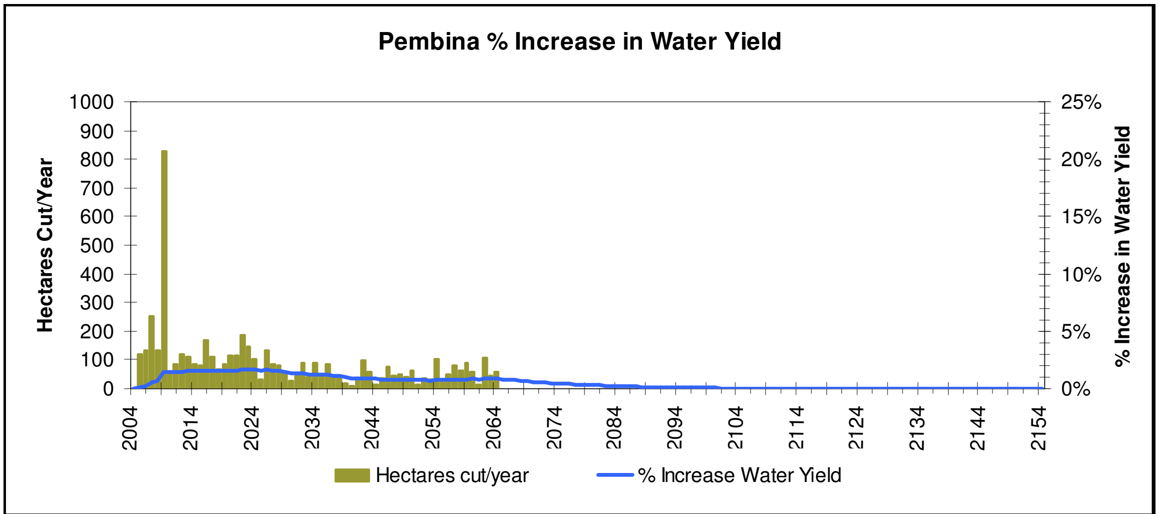

Oldman Decadal % Increase Water Yield and % Watershed ECA
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

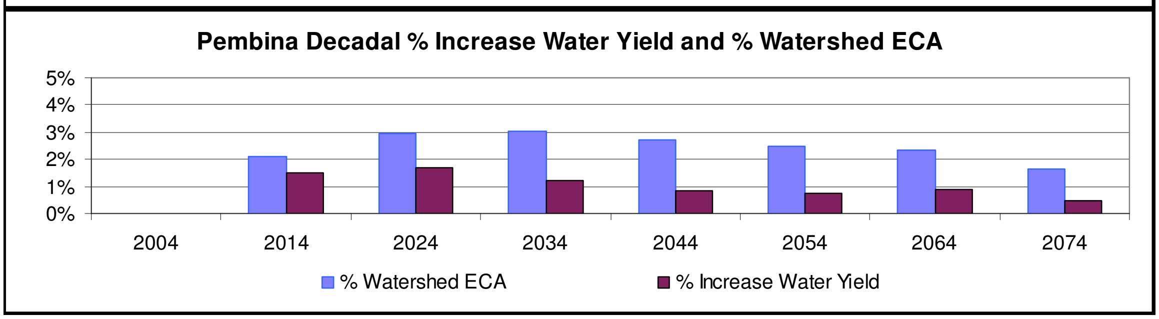

Paddle % Increase in Water Yield
Hectares Cut/Year
100
90
80
70
60
50
40
30
20
10
0
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
% Increase in Water Yield
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

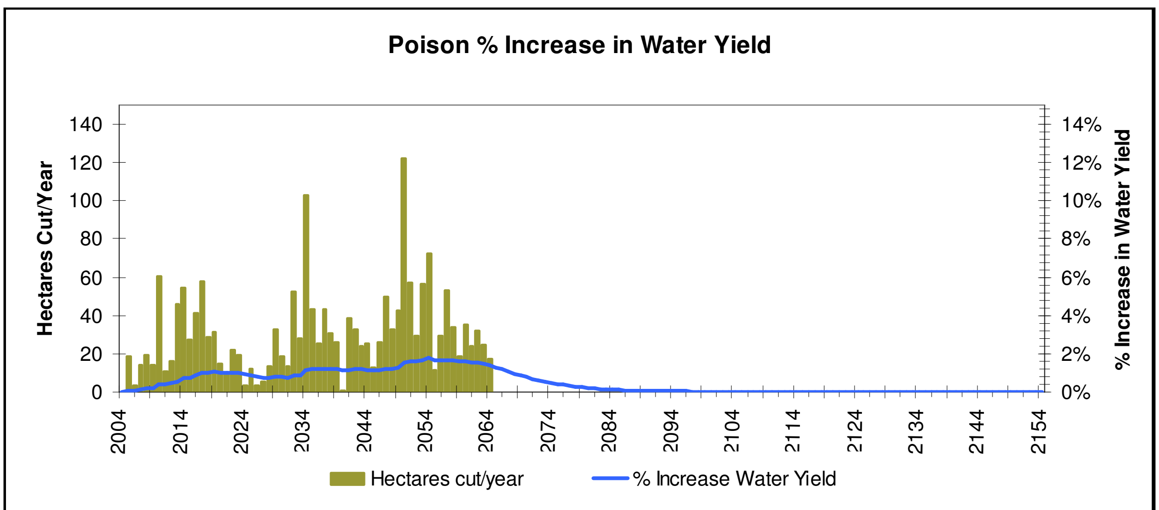

Paddle Decadal % Increase Water Yield and % Watershed ECA
5%
4%
3%
2%
1%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

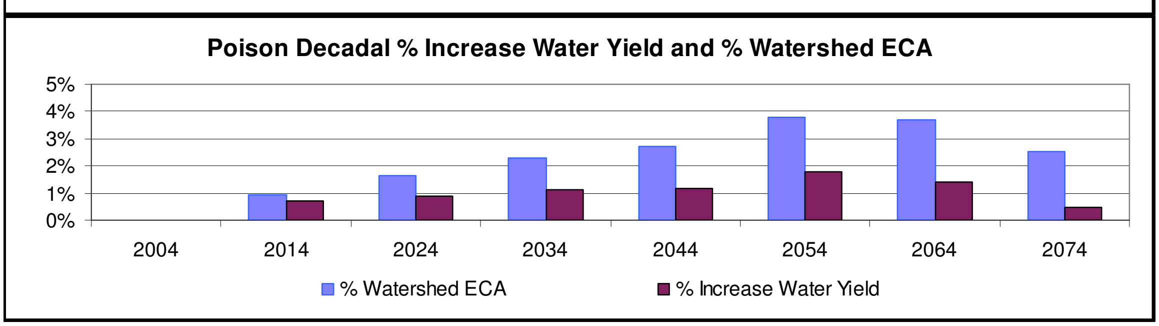

Paddy % Increase in Water Yield
Hectares Cut/Year
700
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
% Increase in Water Yield
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

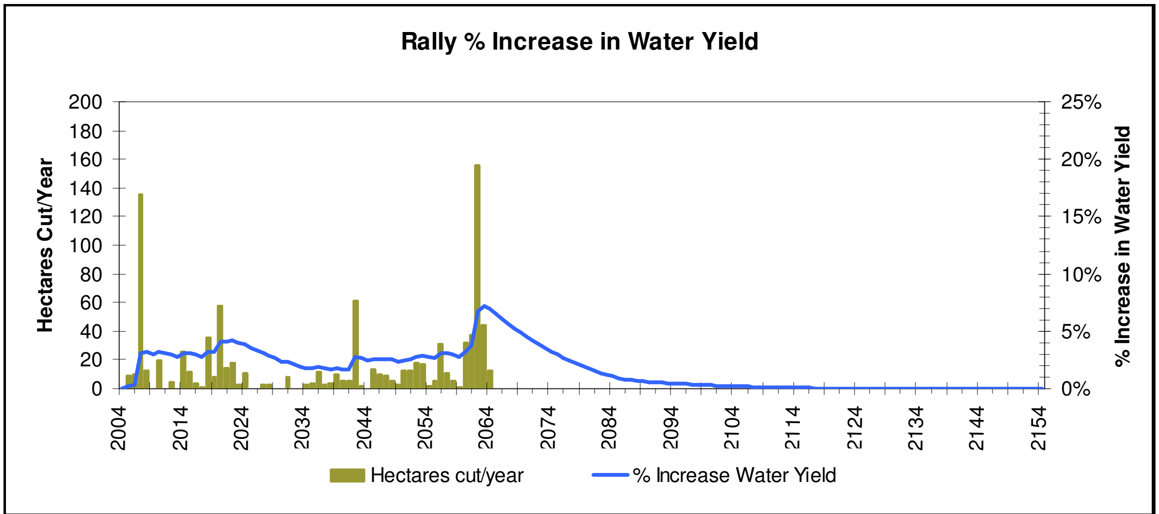

Paddy Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

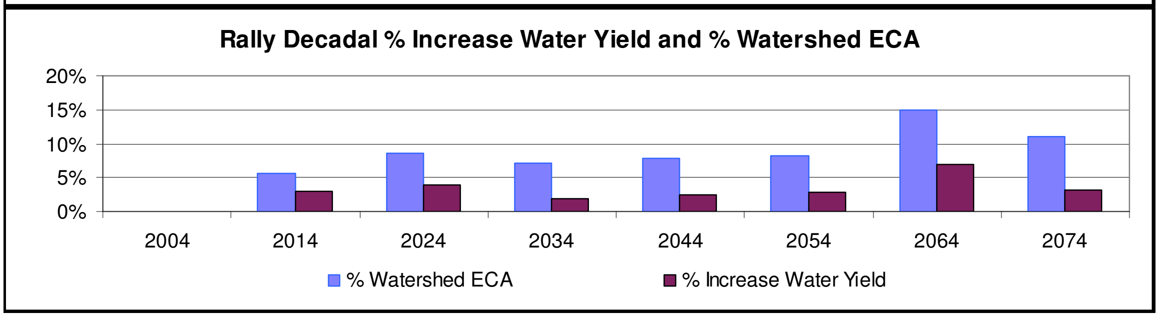

Pembina % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0 100 200 300 400 500 600 700 800 900 1000
0% 5% 10% 15% 20% 25%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield

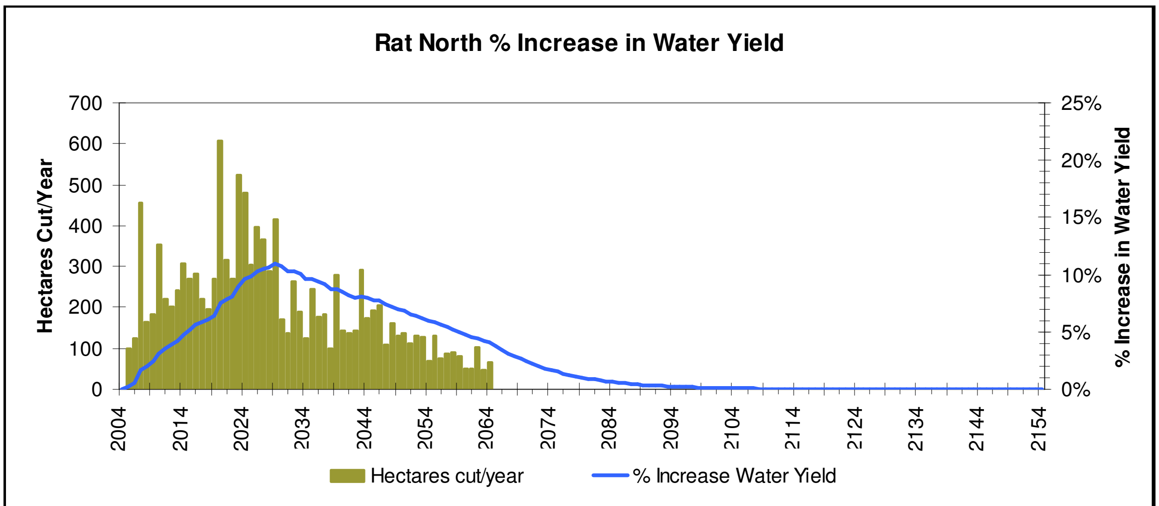

Pembina Decadal % Increase Water Yield and % Watershed ECA
0% 1% 2% 3% 4% 5%
2004 2014 2024 2034 2044 2054 2064 2074
% Watershed ECA
% Increase Water Yield

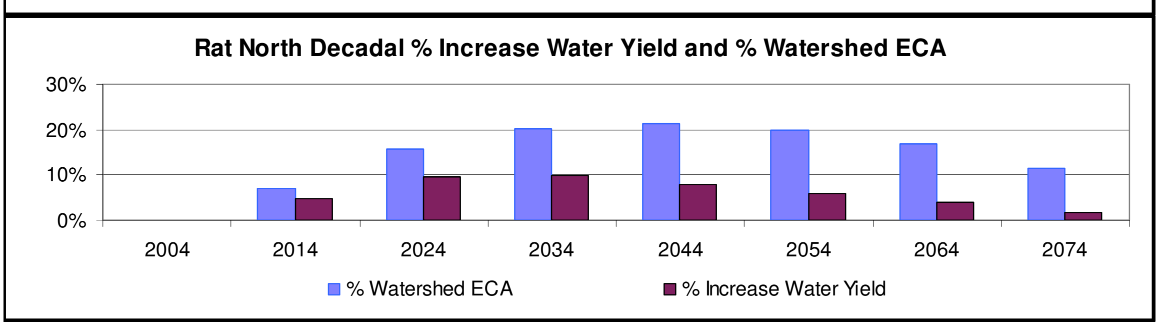

Poison % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0 20 40 60 80 100 120 140
0% 2% 4% 6% 8% 10% 12% 14%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield


Poison Decadal % Increase Water Yield and % Watershed ECA
0% 1% 2% 3% 4% 5%
2004 2014 2024 2034 2044 2054 2064 2074
% Watershed ECA
% Increase Water Yield

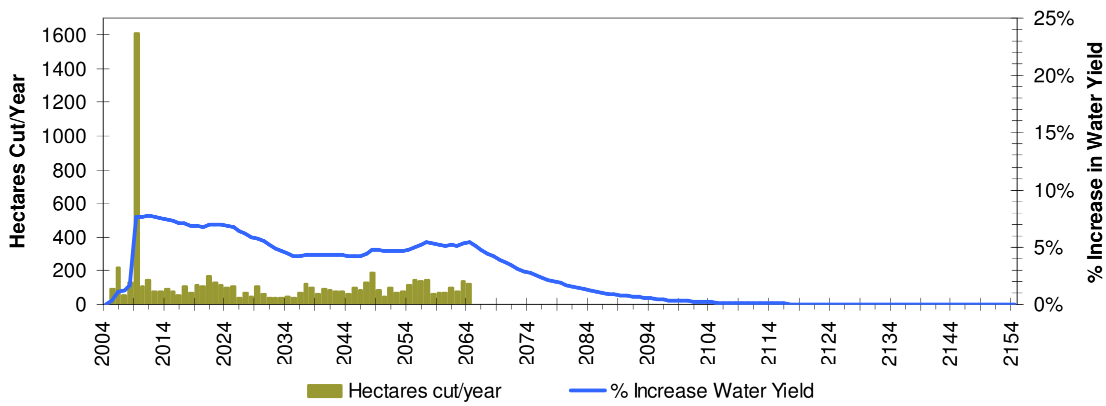

Rally % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield


Rally Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

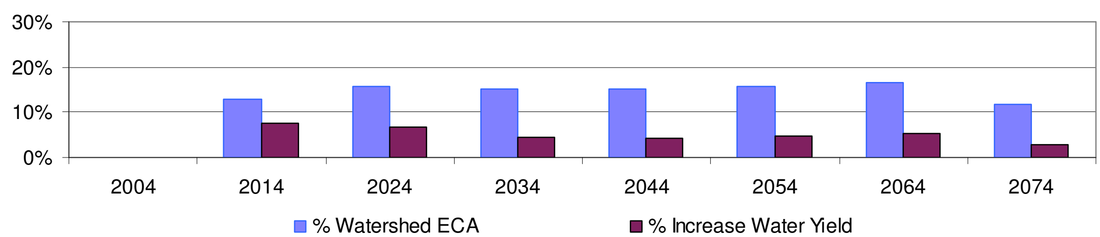

Rat North % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
Hectares cut/year
% Increase Water Yield


Rat North Decadal % Increase Water Yield and % Watershed ECA
% Watershed ECA
% Increase Water Yield

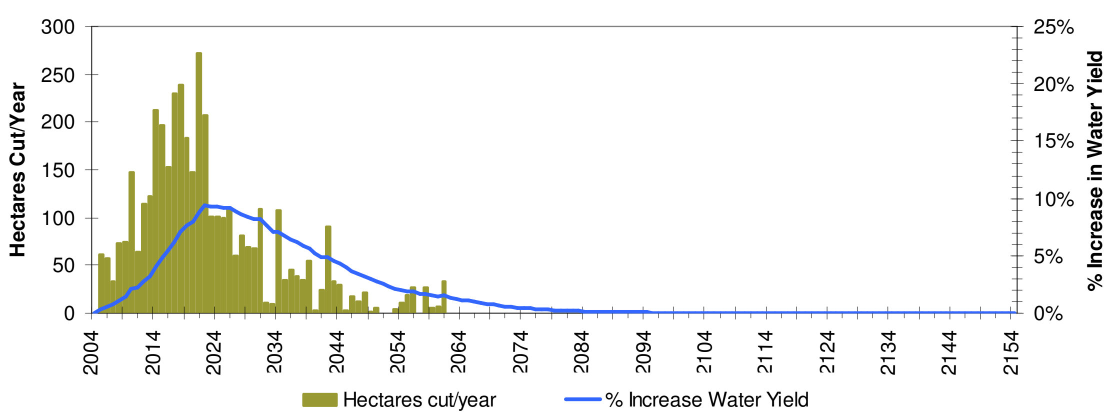
Rat South % Increase in Water Yield



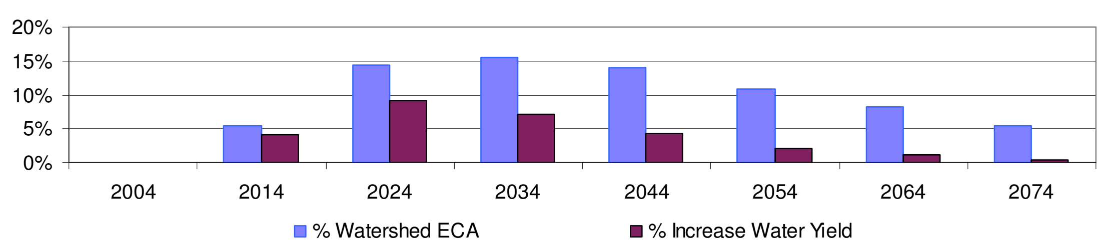
Rat South Decadal % Increase Water Yield and % Watershed ECA

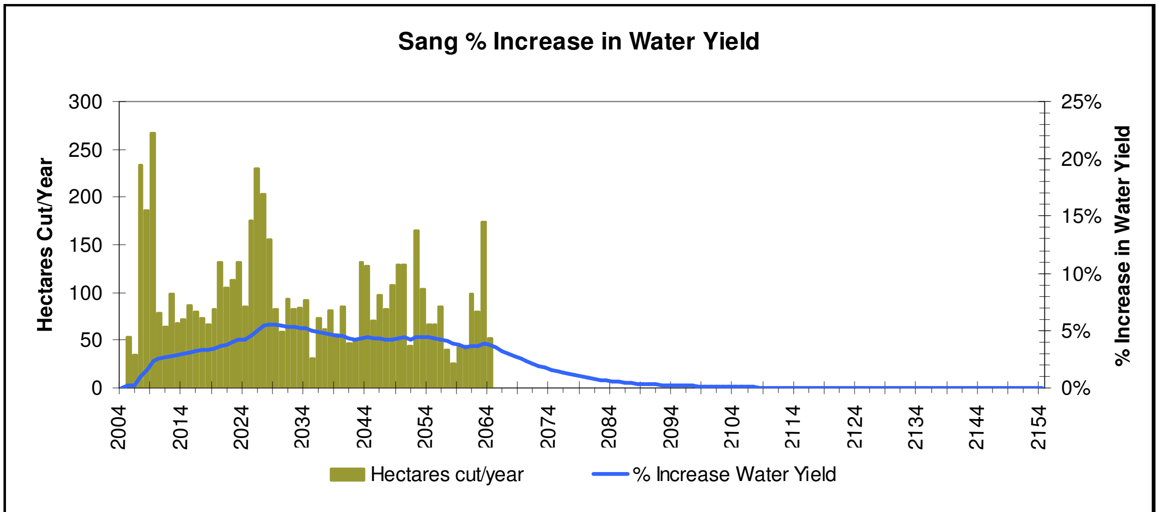


Raven % Increase in Water Yield

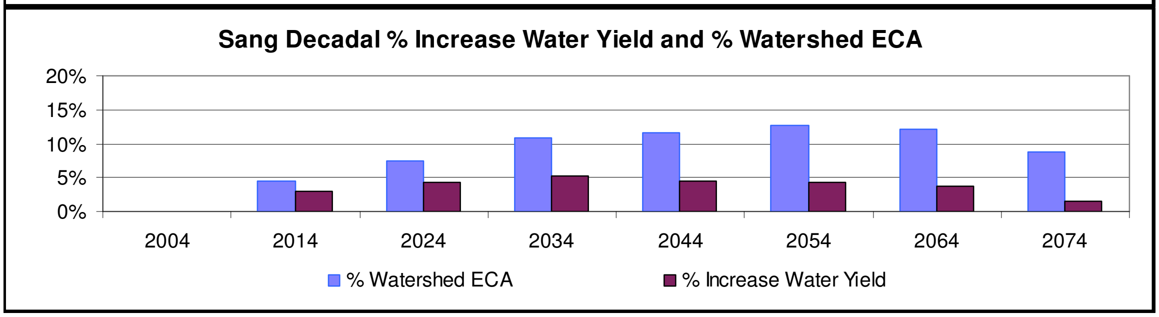


Raven Decadal % Increase Water Yield and % Watershed ECA

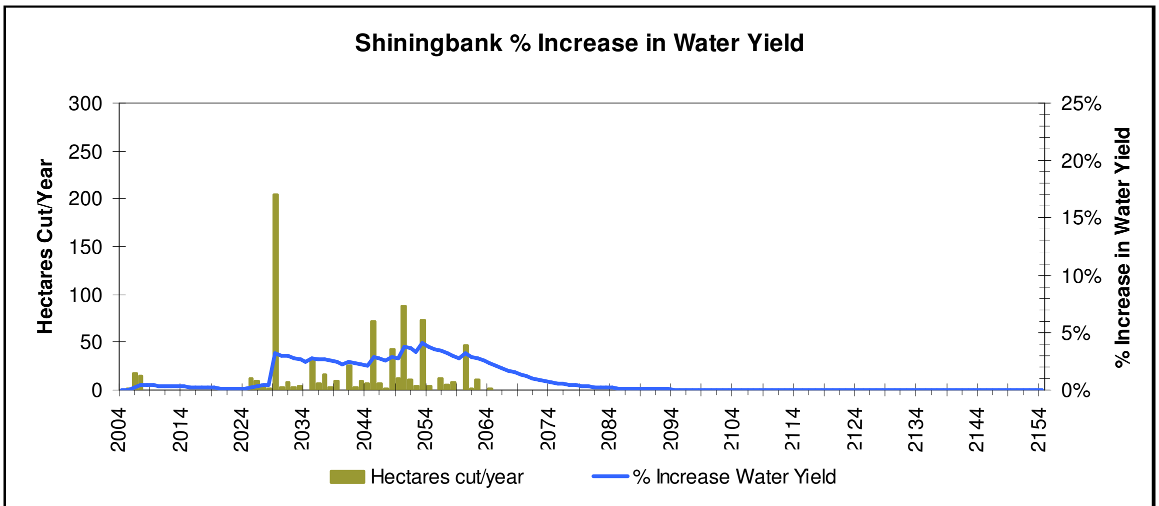




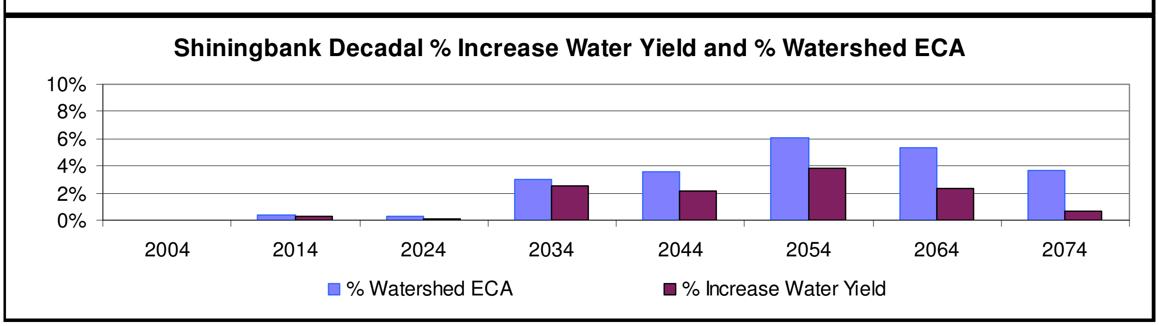
Sang % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield



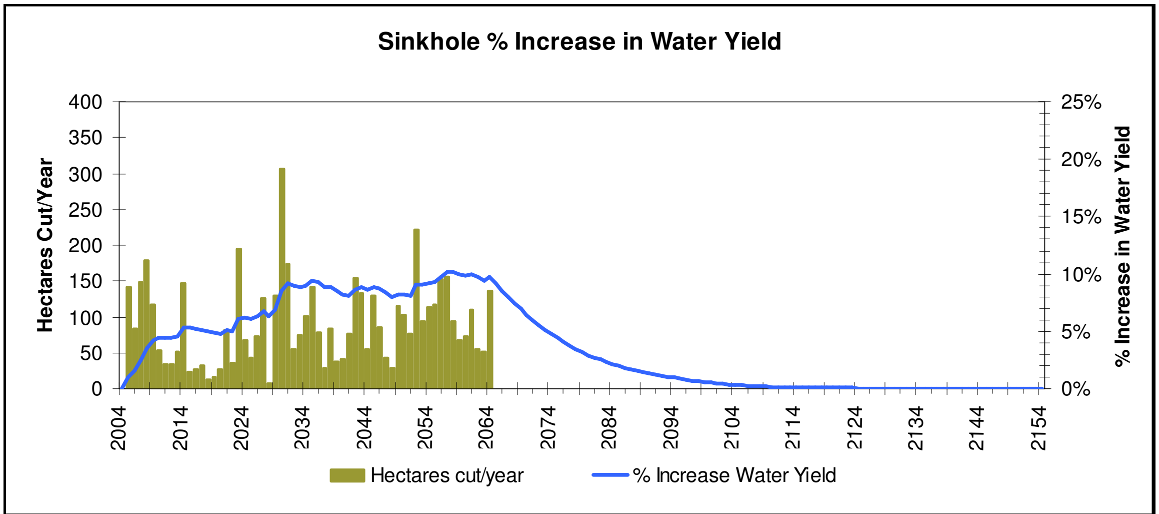
Sang Decadal % Increase Water Yield and % Watershed ECA
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

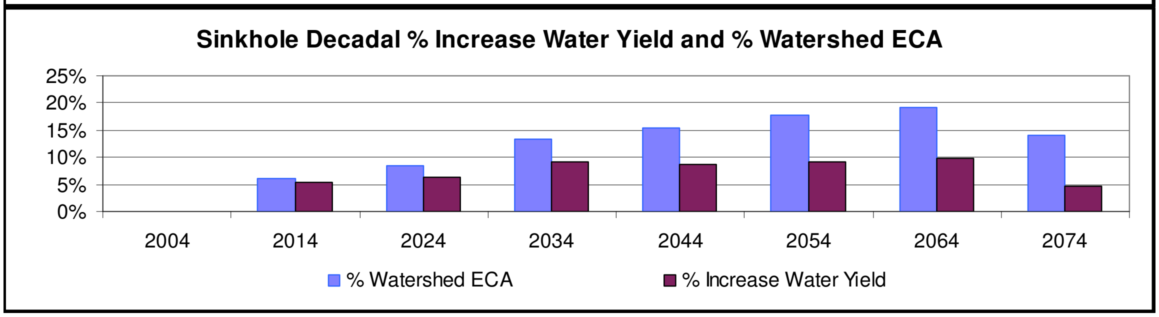


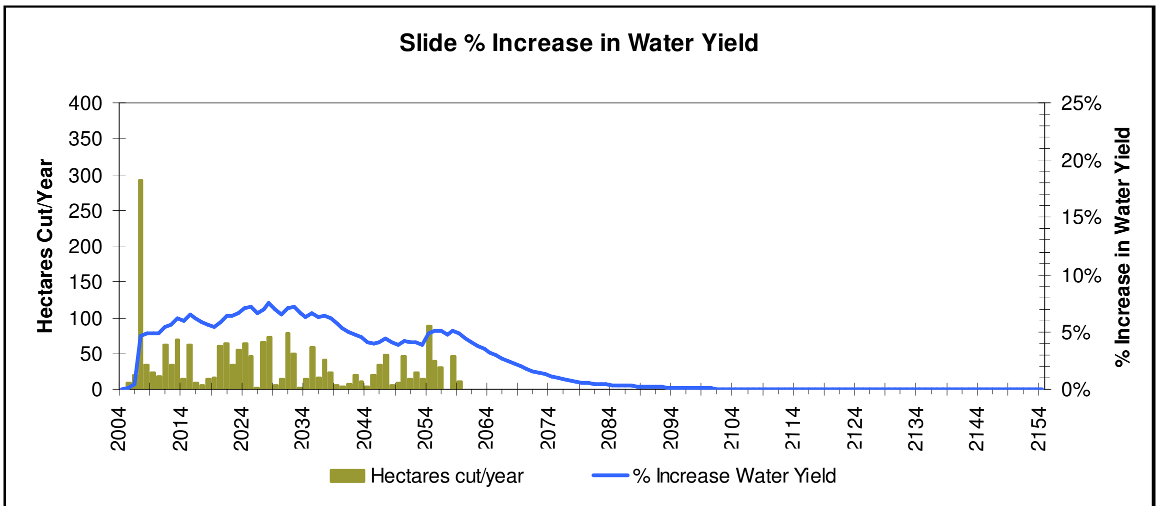
Shiningbank % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

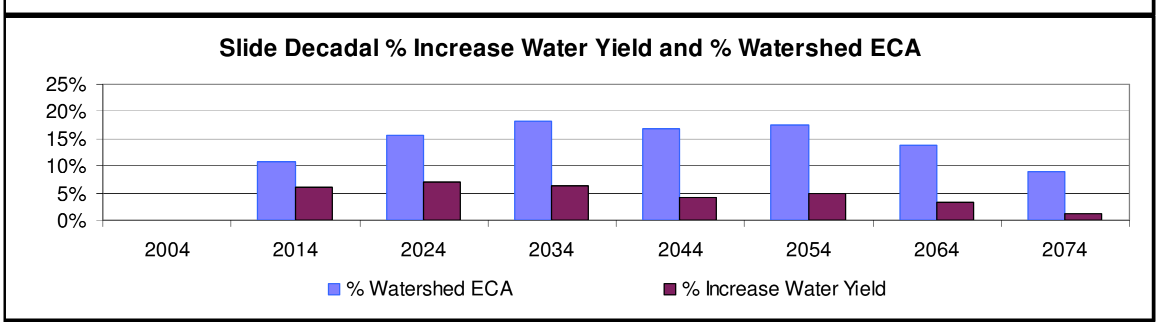


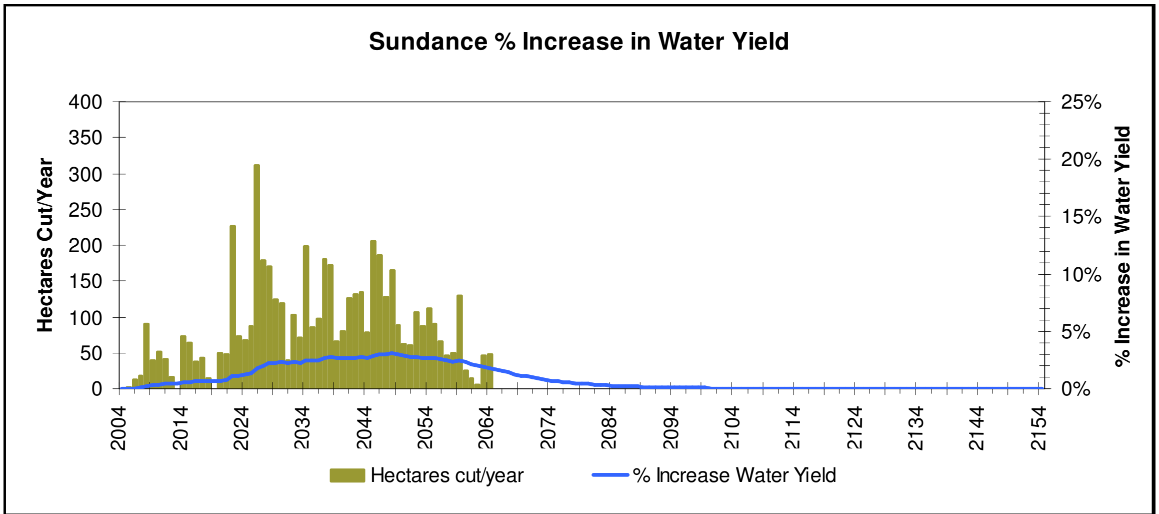
Shiningbank Decadal % Increase Water Yield and % Watershed ECA
10%
8%
6%
4%
2%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

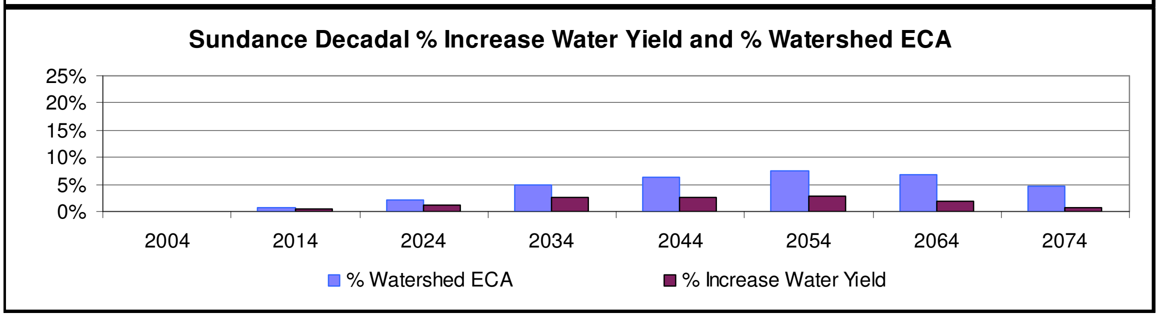

Sinkhole % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

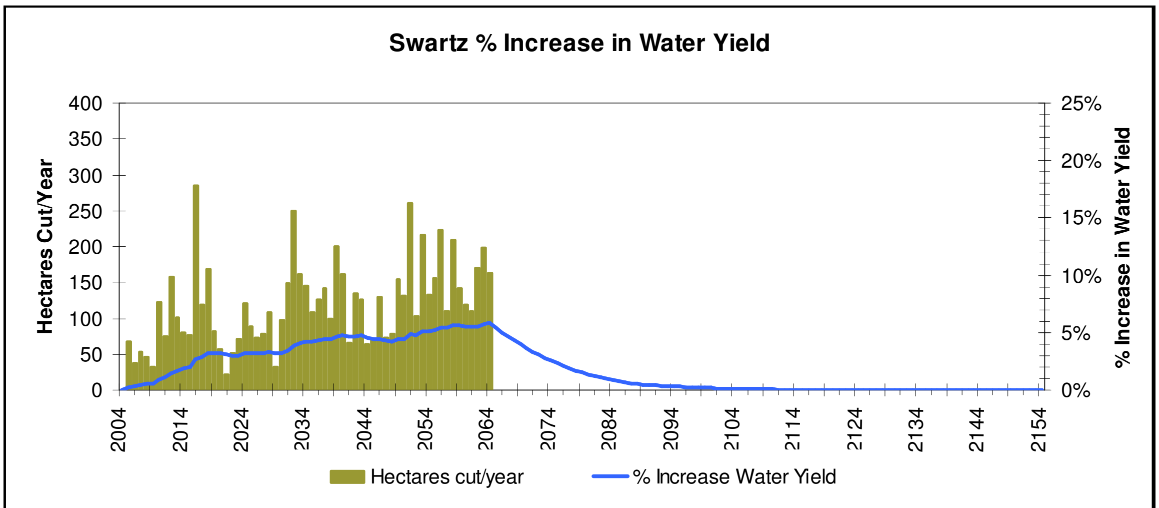

Sinkhole Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

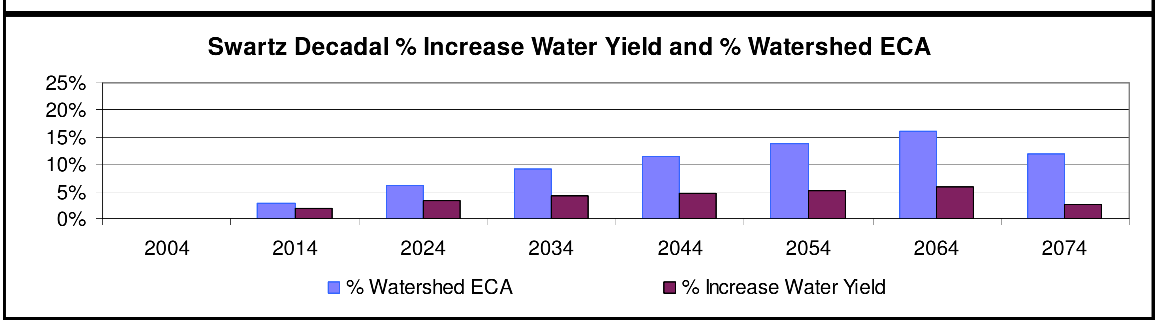

Slide % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

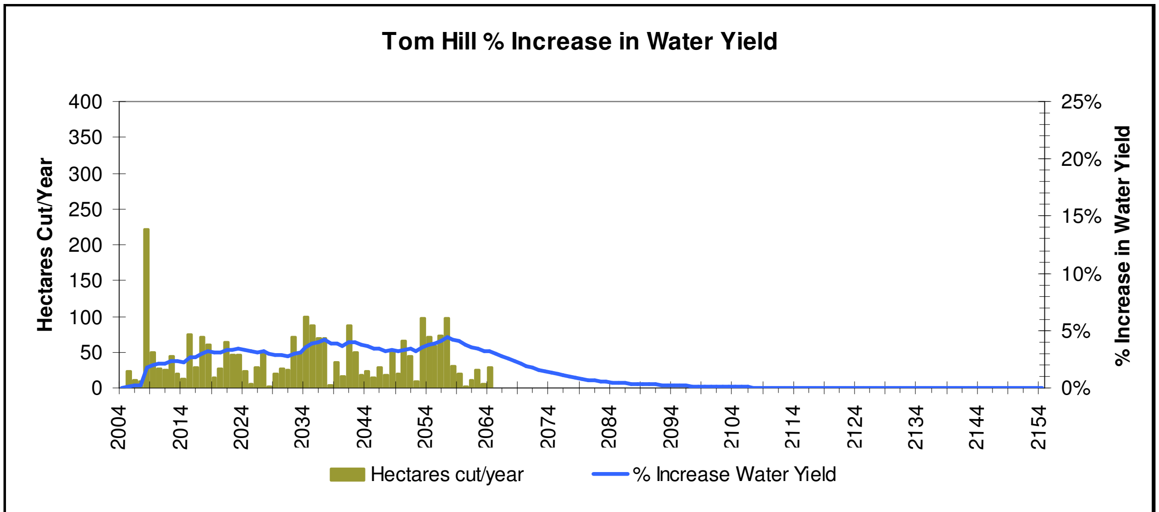

Slide Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

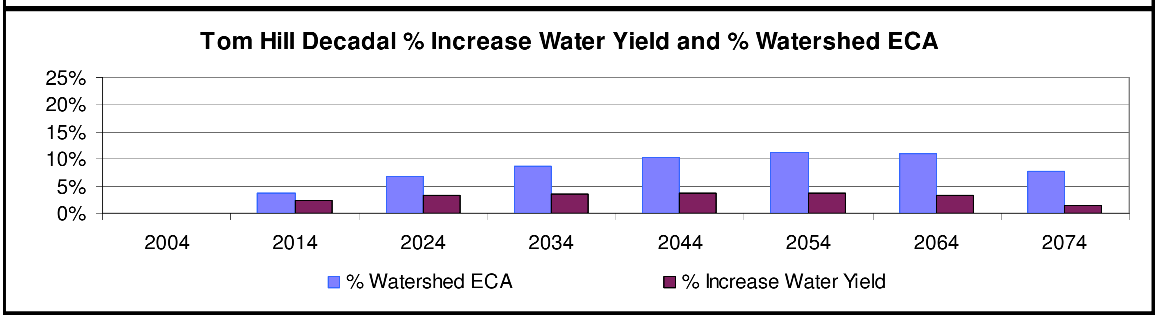

Sundance % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield

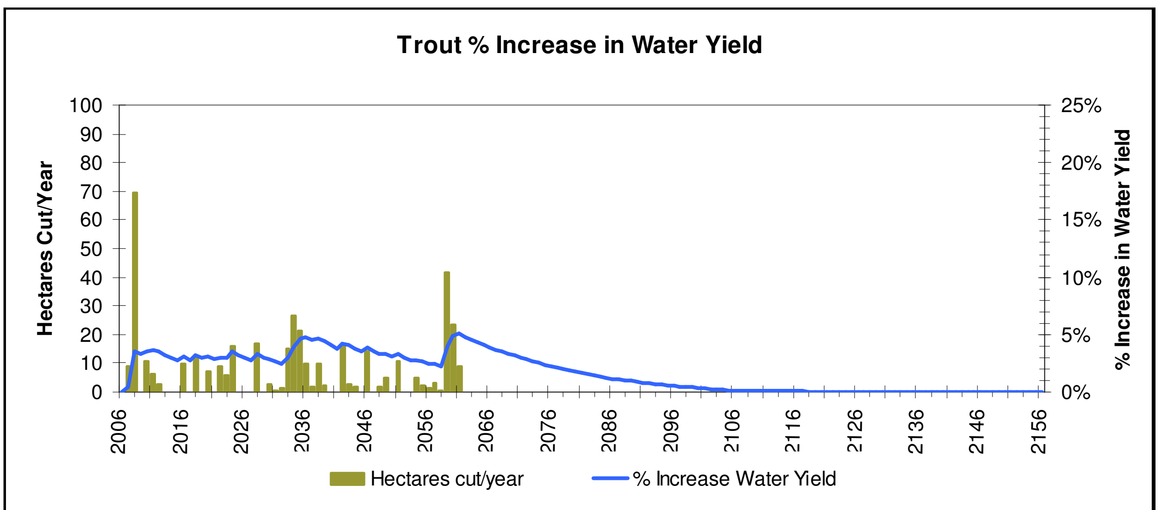

Sundance Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004 2014 2024 2034 2044 2054 2064 2074
% Watershed ECA
% Increase Water Yield

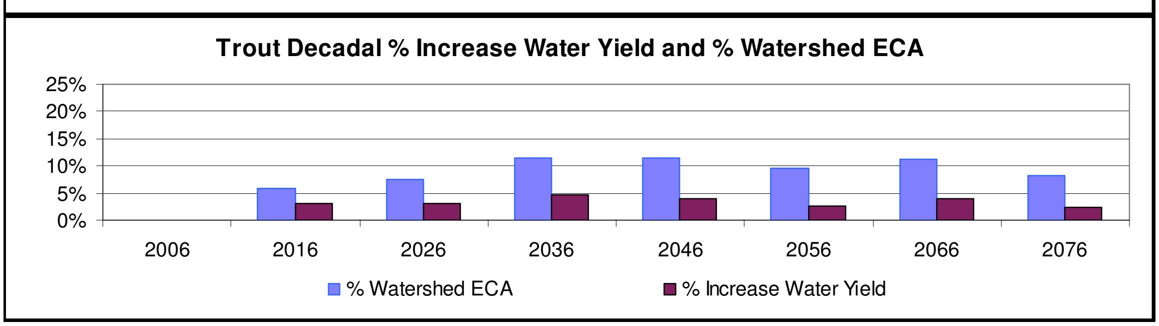

Swartz % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield

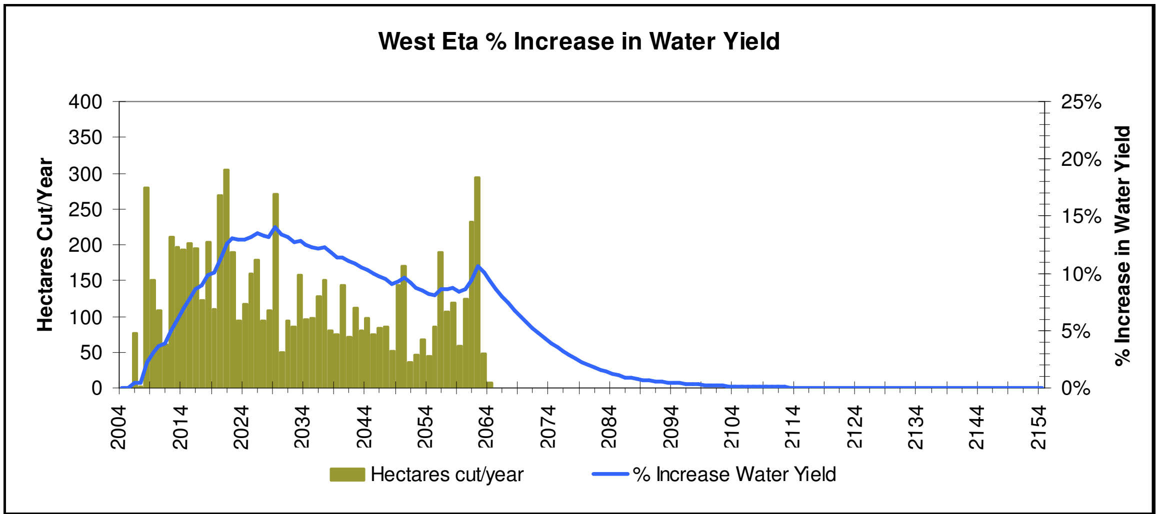

Swartz Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004 2014 2024 2034 2044 2054 2064 2074
% Watershed ECA
% Increase Water Yield

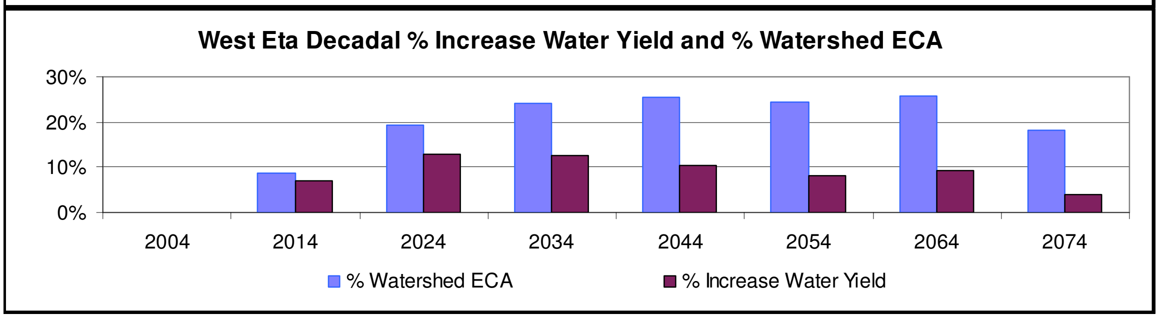

Tom Hill % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
400
350
300
250
200
150
100
50
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield

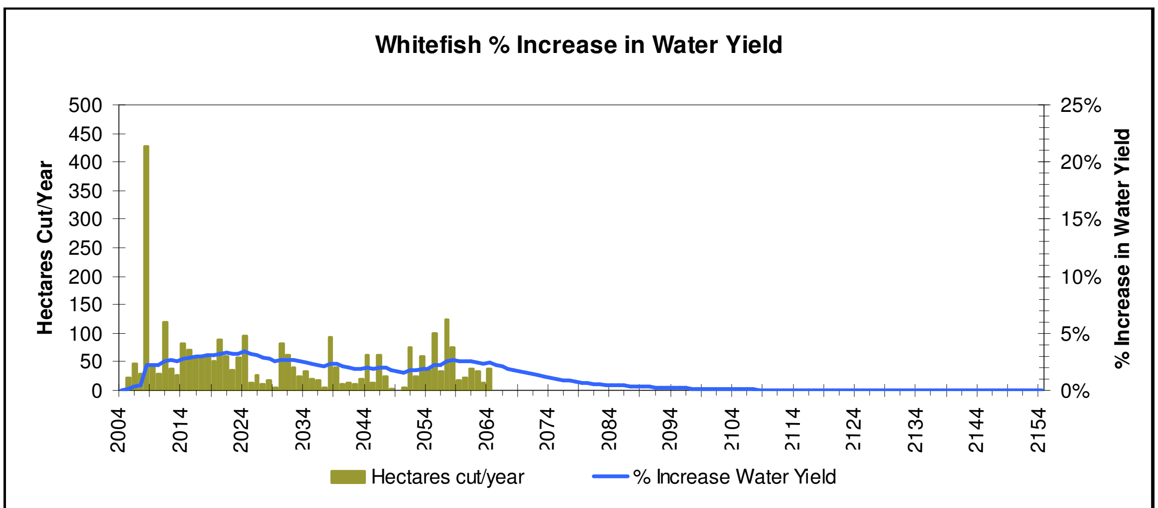

Tom Hill Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield

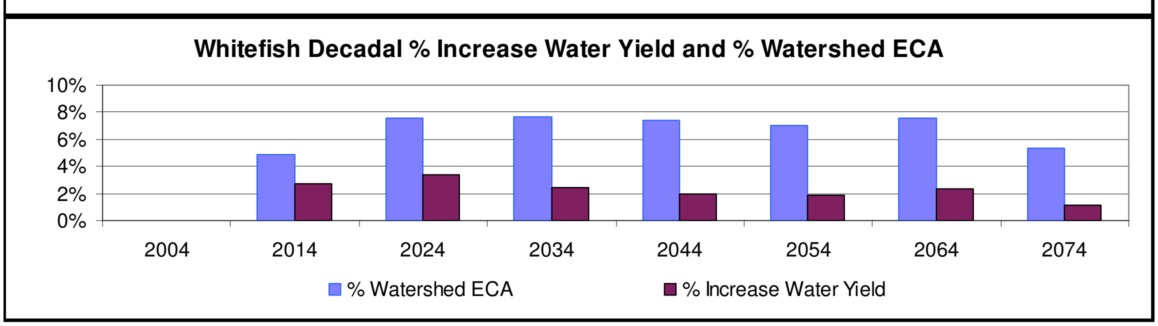

Trout % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
100
90
80
70
60
50
40
30
20
10
0
25%
20%
15%
10%
5%
0%
2006
2016
2026
2036
2046
2056
2066
2076
2086
2096
2106
2116
2126
2136
2146
2156
Hectares cut/year
% Increase Water Yield

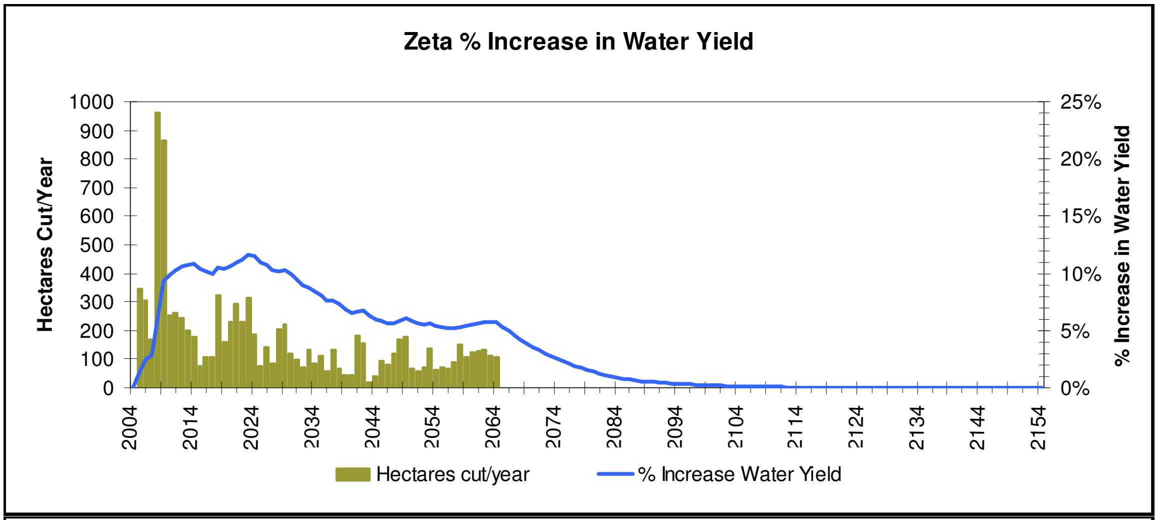

Trout Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2006
2016
2026
2036
2046
2056
2066
2076
% Watershed ECA
% Increase Water Yield

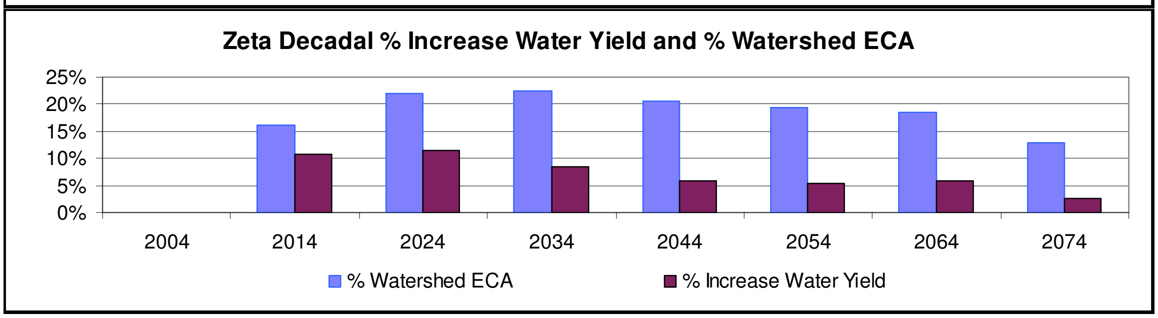

West Eta % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0 50 100 150 200 250 300 350 400
0% 5% 10% 15% 20% 25%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield


West Eta Decadal % Increase Water Yield and % Watershed ECA
0% 10% 20% 30%
2004 2014 2024 2034 2044 2054 2064 2074
% Watershed ECA
% Increase Water Yield


Whitefish % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
0 50 100 150 200 250 300 350 400 450 500
0% 5% 10% 15% 20% 25%
2004 2014 2024 2034 2044 2054 2064 2074 2084 2094 2104 2114 2124 2134 2144 2154
Hectares cut/year
% Increase Water Yield


Whitefish Decadal % Increase Water Yield and % Watershed ECA
0% 2% 4% 6% 8% 10%
2004 2014 2024 2034 2044 2054 2064 2074
% Watershed ECA
% Increase Water Yield


Zeta % Increase in Water Yield
Hectares Cut/Year
% Increase in Water Yield
1000
900
800
700
600
500
400
300
200
100
0
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
2084
2094
2104
2114
2124
2134
2144
2154
Hectares cut/year
% Increase Water Yield


Zeta Decadal % Increase Water Yield and % Watershed ECA
25%
20%
15%
10%
5%
0%
2004
2014
2024
2034
2044
2054
2064
2074
% Watershed ECA
% Increase Water Yield