

Economic Optimization of Water

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Introduction

- General Information on Irrigated Crops
- Economic Theory
 - Production Economics
- Related Study
- Data & Methods
- Preliminary Results
- What does it all mean?



Alberta
Environment

**THE
SOUTH SASKATCHEWAN
RIVER BASIN**

— SOUTH SASKATCHEWAN
RIVER BASIN BOUNDARY

— PLANNING AREA BOUNDARY

PRODUCED BY
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT
PLANNING REGION, LETHBRIDGE, MARCH 2002

ALBERTA
MONTANA

Irrigated crops in the SSRB

	Acres	% of Total
Cereals	408,586	30.5
Forages	607,514	45.3
Oil Seeds	128,044	9.6
Specialty Crops	169,155	12.6
Other	26,462	2.0

Cereals

Barley	167516
CPS Wheat	21597
Durum	63921
Grain Corn	1199
Hard Spring Wheat	95289
Malt Barley	1485
Oats	7341
Rye	1915
Soft Wheat	39489
Winter Wheat	8834

Forages

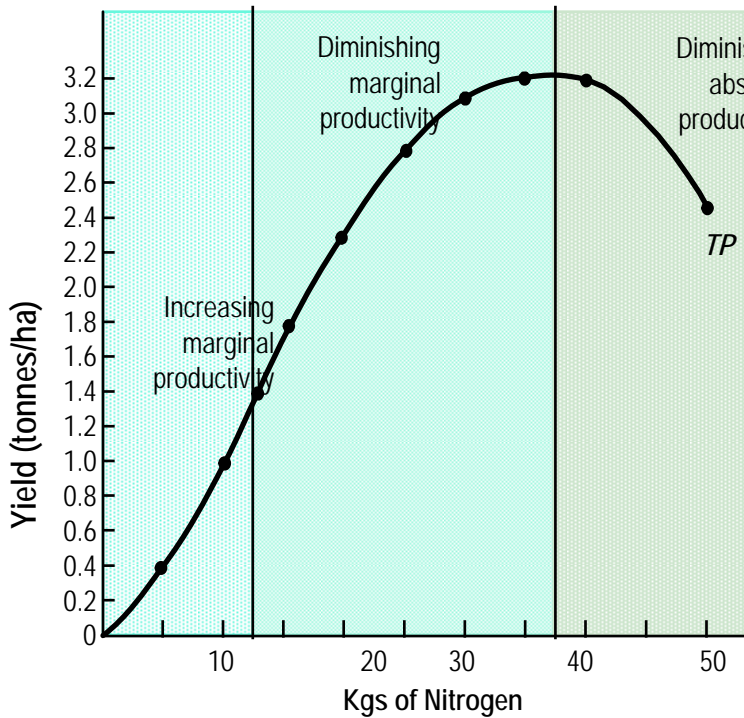
Alfalfa - Two cuts	68668
Alfalfa - Three cuts	3527
Alfalfa Hay	163507
Alfalfa Silage	10088
Barley Silage	83806
Barley Silage (underseeded)	2197
Brome Hay	2247
Corn Silage	37208
Grass Hay	31576
Green Feed	15456
Milk Vetch	368
Native Pasture	20828
Oats Silage	1612
Sorghum/Sudan Grass	454
Tame Pasture	117435
Timothy Hay	39169
Tritcale Silage	9368

Specialty Crops

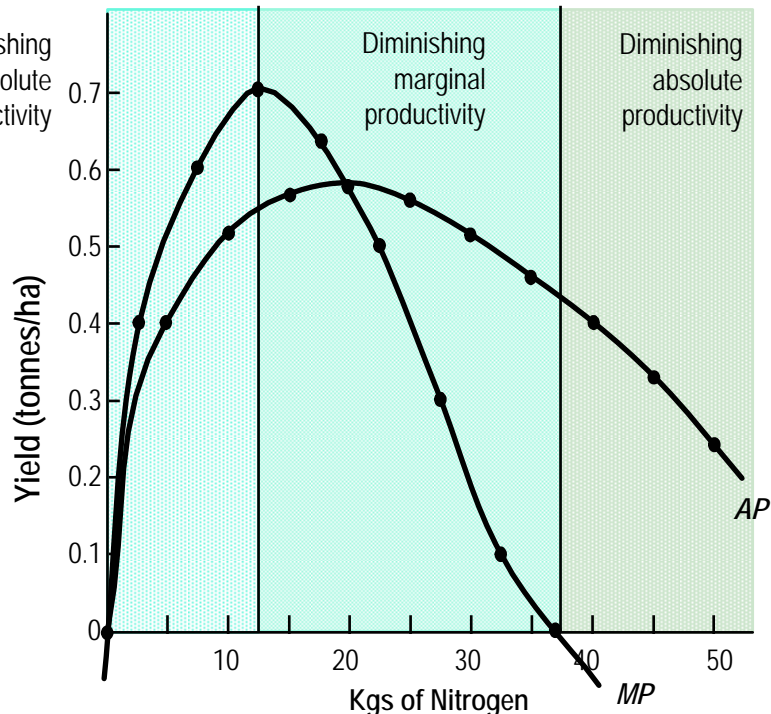
Alfalfa Seed	10451	Lentils	62
Caraway Seed	65	Market Gardens	1064
Carrots	1009	Mint	1681
Chick Peas	1203	Nursery	2297
Dill	897	Onions	531
Dry Beans	48102	Potatoes	40519
Dry Peas	8836	Safflower	287
Faba Beans	703	Seed Potatoes	576
Fresh Corn (sweet)	3973	Small Fruit	107
Fresh Peas	4189	Sugar Beets	34993
Grass Seed	3895	Sunflower	927
Hemp	451		
Lawn Turf	2337		

Economic Theory

- Total Product and Marginal Product



(a) Total product



(b) Marginal and average product

Economic Theory (2)

- $P \times MP = VMP$ = the increased returns from an increase in the input choice level
- BEST APPLICATION CHOICE
 - Where $VMP = \text{input price}$
- Importance of *ceteris paribus*

Related Research

- Economic Value of Water in Alternative Uses in the SSRB (Prairie Provinces Water Board – PPWB)
 - by Samarawickrema & Kulshreshtha (2005)
 - Used a yield response function (Heikkila et al 2002)
 - Prices were average 10 year – nominal prices
 - Net of labour, repair, maintenance and energy costs

Table 1a: Marginal Value Product (\$/acre inch)

Sub-Basin	Alfalfa	Barley	Barley Silage	Canola	Dry Beans
Bow	20.15	13.16	11.41	11.51	66.20
Oldman	19.43	13.47	11.72	11.92	67.64
Red Deer	19.02	13.26	11.62	11.72	67.43
SSRB - AB	19.02	13.26	11.62	11.62	68.05
SSRB-SK	14.49	18.60	12.13	14.39	67.94

Source: The Prairie Provinces Water Board

Table 1b: Marginal Value Product (\$/acre inch)

Sub-Basin	Tame Grass	HRS Wheat	SWS Wheat	Potato	Sugar Beet
Bow	16.45	9.56	15.11	114.51	28.99
Oldman	17.37	9.66	15.52	118.52	29.81
Red Deer	16.96	9.66	15.32	117.28	29.81
SSRB - AB	16.75	9.66	15.32	116.46	29.40
SSRB-SK	16.34	9.87	15.52	112.45	

Source: The Prairie Provinces Water Board

Discussion

- Prairie Provinces Water Board results are estimated at point of estimated current usage
- Average Estimated Usage by Sub-Basin:

Sub-Basin	Amount (inches)
Oldman	16.78
Bow	22.52
Red Deer	21.61
SSRB	16.06

Data & Methods

- Bow River Irrigation District
- Linear Optimization Model that maximizes the total net income of agriculture in the district
 - Optimizes cropping patterns in the district
 - Cobb-Douglas yield response function
 - Water constraint used to estimate shadow values, i.e. VMP
 - Able to capture how the value changes as application rate changes
 - Results comparable to Prairie Provinces Water Board results
 - Source: Arbenser et al (2005)

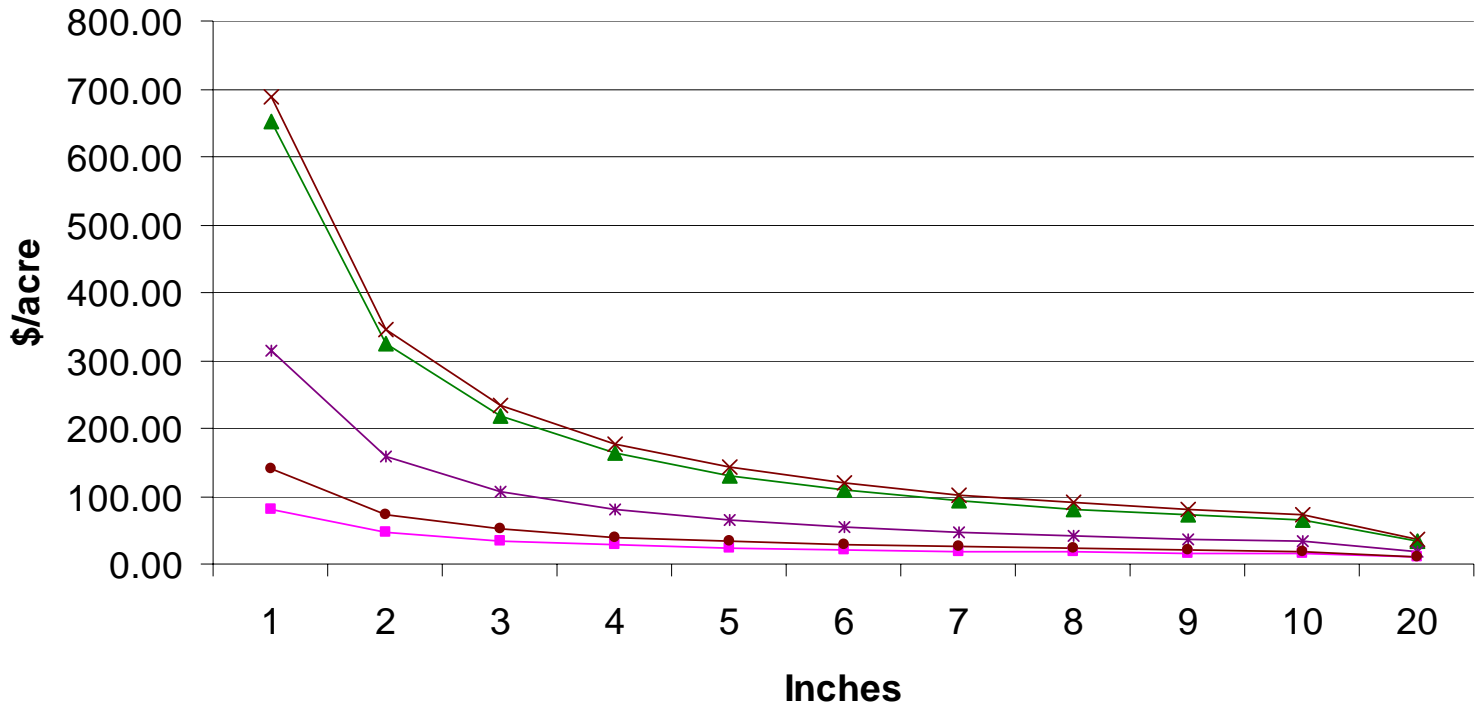
Table 2a: Value of Water (\$ per acre inch)

Inches of Water	HRS Wheat	Durum Wheat	Malt Barley	Feed Barley	Alfalfa Hay	Flax
1	90.94	30.49	87.41	159.11	136.01	80.92
2	52.79	19.79	44.98	79.77	76.02	46.09
3	39.79	16.01	30.73	53.28	55.68	34.20
4	33.10	14.00	23.54	40.01	45.31	28.07
5	28.97	12.70	19.18	32.04	38.94	24.28
6	26.12	11.77	16.24	26.71	34.59	21.66
7	24.02	11.05	14.12	22.90	31.40	19.73
8	22.39	10.48	12.52	20.03	28.95	18.23
9	21.08	10.01	11.26	17.80	27.00	17.03
10	20.00	9.60	10.24	16.01	25.40	16.03
20	14.42	7.31	5.47	7.90	17.40	10.95
Optimal	14.91	7.53	6.86	22.85	15.21	13.49
PPWB (avg)	9.68	n/a	n/a	14.35	18.42	n/a

Table 2b: Value of Water (\$ per acre inch)

Inches of Water	Canola	Alfalfa Seed	Potato	Sugar Beet	Dry Beans
1	80.55	651.57	687.51	314.29	140.36
2	45.52	325.97	346.69	158.61	73.95
3	33.59	217.41	232.91	106.61	51.57
4	27.47	163.12	175.90	80.54	40.23
5	23.68	130.53	141.62	64.85	33.32
6	21.08	108.79	118.71	54.36	28.65
7	19.16	93.26	102.30	46.84	25.26
8	17.68	81.61	89.97	41.18	22.67
9	16.49	72.54	80.34	36.77	20.64
10	15.51	65.28	72.63	33.23	18.98
20	10.53	32.57	37.50	17.07	11.06
Optimal	10.86	76.64	34.68	16.29	11.07
PPWB (avg)	12.23	n/a	115.84	29.5	67.45

VMP of Water (\$/inch)



—■— Canola —▲— Alfalfa Seed —×— Potato —*— Sugar Beet —●— Dry Beans

Discussion (2)

- From PPWB we see that estimated values for water are fairly close across sub-basins for individual crops
- Values vary significantly across crops
- Values are fairly high – but it is assumed that other costs don't change when water is limited
- Values vary significantly with the amount applied

Concluding Comments

- Complexity of Estimating Value
 - And what about timing?
- Would be very important information with water markets
- Can get a rough idea if you know yield response functions
- Research needed in this area
- Questions?