A Cost Assessment of Ecosystem Services Procurement Using Three Mechanisms: Outright Purchases, Conservation Easements, and ALUS

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EXECUTIVE SUMMARY

This project was commissioned by ALUS Canada to compare the costs of procuring ecosystem services from agricultural land using the ALUS program model of annual payments with the costs of alternative procurement through land securement via easements and purchases. The project identifies the key cost drivers underlying the different procurement options.

Procurement costs were estimated using methods from the literature on agricultural economics and ALUS data on actual program delivery costs. In addition an agricultural land value model was developed to estimate the costs of procurement through easements and land purchase. Interviews were used to validate assumptions.

The main difference between the procurement options is in fixed transaction and administration costs as well as ongoing management costs and their distribution between procuring agencies and farmers. Findings indicated that in most cases, ALUS projects carried lower costs for average ALUS project sizes. However the marginal cost of each additional project acre was higher for ALUS than for conservation easements, suggesting that conservation easements may be better suited to conserving large tracts of land. Outright purchase of land was found to be more expensive than either of the other two mechanisms.

The project illustrates the difficulty of comparing these mechanisms. While an ALUS project can happen almost anywhere on an agricultural property, a conservation easement or purchase is bound by legal land boundaries. ALUS can provide more spatial flexibility than typical land procurement methods, enabling a more diffuse model of ecosystem services procurement to occur.

The major conclusion of this report is that at the scale that ALUS currently operates – small, diffuse projects that are incorporated into the working landscape – it generally has lower costs than an easement or purchase would have at a comparable scale. Savings from lower transaction and management costs generally outweigh the costs of an annual payment.

Since ALUS projects do not operate at the same scale as easements and purchases, there are differences in the ecosystem services provided as well as the permanence and risks associated with different securement options. Estimating benefits was outside the scope of the analysis. The cost effectiveness of different procurement options applies to cost per hectare and cannot be assumed to

extend to cost per unit of ecosystem service. The key message is that ALUS can enable ecosystem service procurement in areas that cannot be easily accessed using easements and purchases at a comparable or lower cost. Conversely, ALUS projects are likely not ideal to conserve large areas of land as economies of scale make easements more economical. For sensitive ecological areas which require intensive management outright purchase is likely the best option.

In summary each mechanism has strengths and weaknesses and ultimately the best option depends on program goals.

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1 INTRODUCTION

The amount of land protected through land trusts, which are non-profits dedicated to holding and stewarding land, has been increasing rapidly in the United States for over 30 years (Merenlender, Huntsinger, Guthey, & Fairfax, 2004; Parker, 2004; Silver, Attridge, MacRae, & Cox, 1995). Canada has seen similar trends emerge (Silver et al., 1995). Permanent procurement of conservation through land purchases and conservation easements is widely used in the United States and Canada, though these mechanisms may cause conflict with local communities and it is more difficult to get land owners to participate in permanent protection programs (Main, Roka, & Noss, 1999; Merenlender et al., 2004).

The Alternative Land Use Services (ALUS) program has emerged as a potential alternative method to procure ecosystem services (ES) from farmland. The ALUS program delivers annual payments to farmers to convert marginal land from agricultural production to a state for which its primary purpose is the provision of ES.

The goal of this study is to explore the costs to a conservation agency (CA) of converting farmland to a native ecosystem using these three different mechanisms: outright purchases of land (OP), conservation easements (CEs), and ALUS payments for project. The study areas are Norfolk County, Ontario, and Vermilion County, Alberta.

The remainder of the report describes the study areas and the costs associated with each procurement method, as well as how costs are categorized. A crop yield model is developed to estimate the opportunity costs from lost production due to farmland conversion. Conversion and other costs are obtained from ALUS project data and interviews. Results are provided and discussed. The appendices contain details of the assumptions (Appendix 1), as well as the full framework for the cost analysis (Appendix 2), the interview questions (Appendix 3), and a sample cost calculation (Appendix 4).

2 METHODS

2.1 STUDY SITES

The first study site, Norfolk County, Ontario is a primarily agricultural county with a land area of 1,607.6 km^2 and a population of 63,175 people (Statistics Canada, 2011a). There are 2,180 farms in Norfolk. Almost half are oilseed and grain farms, with the rest a mix of cattle, livestock, vegetable, and greenhouse operations (Statistics Canada, 2011b). Norfolk's largest crop in terms of area is soybeans, followed by corn and then wheat. Norfolk County has a lower number of cattle farms than the provincial average in Ontario, likely due to a history of tobacco farming in the area1. There are currently over 1,000 ALUS projects in the county, including bird habitats, constructed wetlands, shelterbelts, forests, water control structures, modified agricultural practices, and native grasslands.

The second study site is Vermilion River County, in Alberta, Canada. Vermilion River's population is 7,905 on a land area of 5,518.18 km^2 (Statistics Canada, 2011c). There are 1,029 farms in the county with just over half focused on oilseeds, grains, and other crops, and the majority of the remaining farms focused on cattle ranching (Statistics Canada, 2011b). Vermilion's largest crop is canola, followed by wheat and then barley (Statistics Canada, 2011f). There is also a much higher proportion of tame pasture, woodlands, and natural pasture land in Vermilion than in Norfolk, in spite of the fact that roughly the same proportion of farms are classified as cattle or livestock farms (Statistics Canada, 2011g).

Although both counties are primarily agricultural the average farm size in Alberta is larger; Vermilion average farm size is 1,195 acres compare to Norfolk's average farm size of 224 acres (Statistics Canada, 2011f). In spite of their smaller size, farms in Norfolk County have higher total expenses than those in Vermilion (Statistics Canada, 2011e). Overall, these data suggest that Vermilion County's farms are larger than Norfolk's farms, with lower per acre costs, more natural areas and tame pastures, and different crop rotations.

1 Based on farmer interviews.

2.2 INPUT DATA PREPARATION

Depending on the acquisition strategy there are five potential costs to convert a given parcel of land from agricultural use to a natural ecosystem: acquisition costs, transaction costs, management costs, opportunity costs, and nuisance costs (Naidoo et al., 2006). These costs are summarized in Table 1. Table 1 also indicates whether farmers or CAs bear the costs under different mechanisms. Only costs borne by CAs are considered in the cost comparison. A full framework for cost and benefit comparison is available in Appendix 2.

Acquisition costs for CEs and OPs depend on agricultural land values. The present value of land consists of two components: the market value of the land for current agricultural uses and the Option Value (O_i), representing the profit that could be made by converting the land from agriculture into another land use in the future (A. J. Plantinga, 2007; A. Plantinga, Lubowski, & Stavins, 2002).

To estimate land values, a farm budget model was constructed using crop prices, yields, and costs. The data used to construct the farm budget model is summarized in Table 2. Annual yields and standard deviations were calculated by averaging provincial average yields for Ontario (OMAFRA 2015a) and Alberta (AARD 2014) over a period of ten years. Crop prices were obtained from Alberta (AARD 2014) and Ontario (OMAFRA 2015b) for 2013 and converted to 2016 dollars using the consumer price index (Bank of Canada, 2016). Crop costs were taken from field crop budgets from Ontario (OMAFRA 2016a). Alberta crop costs were taken from Manitoba data (MAFRD 2015, 2016) since Alberta does not produce crop budgets (Boxall et al., 2008).

Data from expert interviews as well as government sources for taxes and fees for transferring title and ownership were used to calculate transaction costs. Management costs consist of initial conversion costs, and recurring stewardship costs. Stewardship costs and the costs of baseline studies were derived from expert interviews, and published land trust documents (Doscher et al., 2007; Richman & Loza, 2011a).

Table 1 Representation of cost categories (Naidoo et al., 2006) for ALUS (A), Conservation Easement (CE), and Outright Purchase (OP). Far right columns assign the cost categories to the Conservation Authority (CA) or farmer under each of the programs.

Cost Category	Included Costs		Notation	Data Sources	CA			Farmer		
					OP	CE	A	OP	CE	A
Acquisition Costs	Present value profits from land		$P(i)$	See Table 3	•	•				
	Option value of land		O_i	Plantinga et al. 2002, MLS data	•	•				
	Estimated market value of land		$V(i)$	$P(i) + O(i)$	•	•				
	Present value ALUS annual payments		$Y(i)$	ALUS data			•			
Management Costs (m)	Fixed organizational overhead (exclude)		N/A	Assume equivalency	•	•	•			
	Conversion Costs	Baseline Study and Management Plan	b_i	Land Trust Interview	•	•				
		Fencing	ω_i	ALUS data Farmer Interview	•	•	•			•
		Planting	ω_i	ALUS data Farmer Interview	•	•	•			•
		Wetland Construction	ω_i	ALUS data	•	•	•			
		Water System Installation	ω_i	ALUS data Farmer Interview		•	•			•
	Stewardship Costs	Annual upkeep	u_i	Farmer Interview	•				•	•
		Tax rate	tr	See Table 7	•				•	•
		Annual monitoring	M_i	Land trust interview ALUS coordinators interview Richman and Loza 2011b		•	•			
		Insurance	ins_i	Land Trust Interview Farmer Interview Terrafirma 2016	•	•			•	•
		Communications	Com_i	Richman and Loza 2011b		•	•			
		Enforcement	Enf_i	Richman and Loza 2011b		•				
		Recidivism	R	ALUS data			•			
Transaction Costs (α_i)	Appraisal		α_i	Land Trust Interview	•	•				
	Land Transfer Fees and Taxes		α_i	Government of Ontario 2009; Province of Alberta 2015	•	•				
	Negotiation Costs		α_i	Land Trust Interview	•	•	•			
Nuisance Costs	Pests		N/A	Farmer Interviews					•	•
	Wildlife damage		N/A	Farmer Interviews					•	•
	Weed removal		N/A	Farmer Interviews					•	•
	Extra Field Time		N/A	Farmer Interviews					•	•
Opportunity Costs	Present value of land in crops		N/A	See Table 3				•	•	•
	Present value of land in hay		N/A	See Table 3				•	•	•
	Option Value of Land		N/A	Plantinga et al. 2002, MLS data				•	•	

Table 2 Data for the farm budget model used to calculate farm profits and land value. All yields are in bushels per acre and monetary values are CAD 2016.

Crop Type	County	Average Yield (2004 – 2013)	Yield Standard Deviation	Crop Price	Crop Costs ($ ac^{-1})	Average Profit ($ ac^{-1})
Wheat	Vermilion	45.51 bu ac^{-1}	5.79	8.43 $ bu^{-1}	201.36	182.29
Barley	Vermilion	62.67 bu ac^{-1}	7.27	6.17 $ bu^{-1}	182.85	203.82
Canola	Vermilion	36.01 bu ac^{-1}	5.35	13.45 $ bu^{-1}	256.98	227.36
Hay	Vermilion	1.36 ton ac^{-1}	0.36	231.54 $ ton^{-1}	211.34	103.55
Winter Wheat	Norfolk	62.66 bu ac^{-1}	10.21	6.75 $ bu^{-1}	362.25	60.71
Grain Corn	Norfolk	145.07 bu ac^{-1}	17.48	6.19 $ bu^{-1}	514.25	383.73
Soybeans	Norfolk	39.35 bu ac^{-1}	5.55	14.39 $ bu^{-1}	261.55	304.70
Hay	Norfolk	2.46 ton ac^{-1}	0.57	231.54 $ ton^{-1}	316.69	252.90

Table 3 Average conversion costs (ω_i) in CAD 2016 dollars per acre for each project type (*k*) in Alberta.

Project Type	Average Cost to ALUS	Average Cost to Farmer	Average Total Project Cost	Total Observations
Native Grassland	51.99	6.70	58.69	146
Shelterbelt/Trees	95.17	57.69	152.87	24
Wetland	55.34	55.34	110.68	238
Watering System	1409.67	1409.67	2819.33	3
Fencing	3.28 $ m-1	0	3.28 $ m-1	41

Table 4 Average conversion costs (ω_i) in CAD 2016 dollars per acre for each project type (*k*) in Ontario.

Project Type	Average Cost to ALUS	Average Cost to Partner	Average Cost to Farmer	Average Total Project Costs	Total Observations
Native Grassland	311.15	0.00	2.03	313.18	46
Forest/Trees	435.73	705.92	-	1141.65	71
Waterbody	10136.21	4964.81	1216.86	16317.87	24

Conversion costs were derived from ALUS data, and are summarized in Tables 3 and 4. Costs are separated based on the party that assumes them. In Alberta, costs for ALUS projects are split between farmers and ALUS. In Ontario, costs are split between farmers, ALUS, and other partner agencies that contribute to the projects. The data from Vermilion did not indicate involvement of parties other than ALUS and the farmer, though there were examples in Vermilion of farmers joining the ALUS program after having received funding through other sources, though this was not captured in ALUS Vermilion's data. Conversion costs were assumed to be equivalent between all mechanisms, though ALUS does not hold any easements or purchases. In the case of an OP, all conversion costs are assumed to be borne by the organization, whereas in the case of a CE and an ALUS project, costs are split between the farmer, partner organizations (in Ontario), and the CA.

2.3 Calculation of Mechanism Costs

Consistent with Plantinga, Lubowski, and Stavins (2002), the estimated land value was calculated from the present value of profit accrued from the land. As summarized in Equation 1, profits (P) from a plot of agricultural land (i) are based on the price of the crops grown on that land (p_c), the crop yield (y) for each year (t), the costs associated with growing those crops (x_c), and the area of the plot ($A(i)$). In the case of a livestock farmer, p_c is the price of hay which is a proxy for the value of growing forage for livestock. The net present value of the profits (P) is the sum of the profits from each year discounted into the future (T) at the discount rate (d).

$$P(i) = \sum_{t=0}^{T} \frac{(p_c \cdot y_t - x_c) \cdot A(i)}{(1 + d)^t} \tag{1}$$

Consistent with Plantinga et al. (2002), the option value is assumed to depend on the population density of the area in question. Based on the population density and a survey of values of undeveloped bare land in the provinces of Alberta and Ontario, the option value for Vermilion River is assumed to be 0.01% of the agricultural land values, and the option value for

Norfolk is assumed to be 10% of agricultural land values. The estimated market value of a plot of agricultural land ($V(i)$) is given by Equation 2:

$$V(i) = P(i) + O_i \tag{2}$$

All present values were calculated using a 30-year time horizon, and the discount rate was 3.5% (OMB, 2015). Typically, an OP or CE could only be applied to a legal parcel of land, the area of which far exceeds the average size of an ALUS project. Therefore all comparisons are done on a project scale, assuming that the area of a CE or an OP is equivalent to the area of a typical ALUS project. Certain fixed costs were adjusted to fit this assumption, explained in more detail in the appropriate section.

2.3.1 **Outright Purchase**

An outright purchase is defined as a CA purchasing the deed to a piece of land and managing that land for ES. In order to facilitate a cost comparison between a land purchase and an ALUS project, the land area (Equation 1) was reduced to match the average areas of ALUS projects. The cost to a CA (ca) for the outright purchase of a plot of land (i) for ES procurement ($C_{i,ca}^{OP}$) depended on the market value of the land ($V(i)$), the transaction costs (α_i^{OP}), and the management costs (m_i^{OP}). Management costs vary by project type (k), summarized by Equation 3:

$$C_{i,ca}^{OP} = V(i) + \alpha_i^{OP} + m_{i,k}^{OP} \tag{3}$$

Transaction costs for outright purchase (α_i^{OP}) are composed of three elements: the initial appraisal of the land, the fees and taxes associated with purchasing the land, and the costs associated with negotiating and preparing for the land transfer (Table 1). The negotiation cost included the estimated effort to raise sufficient funds to purchase a property. The assumed values and data sources are summarized in Table 5.

Table 5 Transaction costs CAD 2016 for outright purchase of land (OP) or conservation easements (CE)

Cost type	Description	Value	Data Source
Initial Appraisal (OP)	One-time cost of hiring an appraiser	\$1750	Expert Interview[2]
Initial Appraisal (CE)	One-time cost of hiring an appraiser	\$4500	
Land Transfer Fees	Fees to register the title change of land	Varies by province	Government of Ontario 2009; Province of Alberta 2015
Negotiation and Fundraising Time	Assuming staff hourly rate of \$50 hr^{-1}, including overhead, for 10 days of negotiation, 5 days of fundraising.	\$5625	Richman and Loza 2011

Management costs for outright purchases are summarized in Equation 4. The yearly sum of the property taxes ($tr \cdot V(i)$), the ecosystem upkeep costs (u_i), and insurance costs (ins_i) were discounted to a 30 year time horizon, according to the 3.5% discount rate (d). The one-time cost of a baseline study and the creation of the management plan (b_i) are also included. Management costs are summarized in Table 6. Conversion costs ($\omega_{i,k}$) were estimated from ALUS data and expert interviews. Conversion costs included baseline study creation, planting, fencing, construction, and associated labour costs. Costs varied by project type and location.

$$m_{i,k}^{OP} = \sum_{t=1}^{T} \frac{tr \cdot V(i) + u_i + ins_i}{(1+d)^t} + b_i + \omega_{i,k} \tag{4}$$

2.3.2 Conservation Easement

A CE is the restriction rights to grow crops and raise cattle and/or land conversion for the purpose of providing ES. For the purposes of comparing CEs to OPs and ALUS projects, the CE is assumed to be a permanent purchase of rights. The closest CE analog to an ALUS project is a

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2 K. Good, Executive Director, Legacy Land Trust Society, (Personal Communication, September 29, 2016)

Table 6 Costs (CAD 2016) associated with the management of for outright purchase (OP) by a CA.

Cost type	Description	Value	Data Source
Property Taxes (tr)	The tax paid on owned property.	Varies by county	County of Norfolk 2016; County of Vermilion River 2016
Upkeep Costs (u_i)	An amount set aside to steward the ecosystem. Assume ½ day of staff time each year, $20 per acre for supplies.	$200	Farmer Interviews
	For fencing, add $\$0.33\ m^{-1}\ year^{-1}$.	$\$0.33\ m^{-1}y^{-1}$	Meyer and Olsen 2005
	For forest projects, add $\$10\ ac^{-1}y^{-1}$ every three years after year 13.	$\$10\ ac^{-1}y^{-1}$	Doran and Cubbage 2009
	For grasslands, assume $\$300\ y^{-1}$ for the first three years (weed control) and $\$11.94\ ac^{-1}y^{-1}$ thereafter.	$\$300\ y^{-1}, t<3;\ \$11.94\ ac^{-1}y^{-1}, t>2$	Farmer Interviews Nykoluk 2013
Insurance Costs (ins_i)	Assuming organization holds liability insurance for land, and volunteer insurance.	$150	Alliant Insurance Services, 2010
Baseline Study (b_i)	A study to capture the baseline status of the land.	$4000	Expert Interview[1]

"meets and bounds" easement, wherein the easement is applied to a full legal parcel and stipulates that certain areas of that parcel are converted/managed to produce ES[3]. Based on geospatial data for Vermilion County ALUS projects, there are on average six active ALUS projects within each quarter-section of land (one quarter of a square mile). These projects occupy an average of 27% of the area of the impacted quarter sections. For the purposes of comparing easements to ALUS projects, it is assumed that six ALUS-type projects would be included in a single meets and bounds easement. Therefore, with the exception of the acquisition, conversion, and insurance costs, all easement costs were divided by six in the final calculations.

The cost of a single project within the CE to the CA ($C_{i,ca}^{CE}$) is shown in Equation 5:

3 K. Good, Executive Director, Legacy Land Trust Society, (Personal Communication, September 29, 2016)

$$C_{i,ca}^{CE} = 0.25 \cdot V(i) + \alpha_i^{CE} + m_{i,k}^{CE} \quad (5)$$

Applying an easement to the land will reduce the land value, and the reduction in price is the amount the CA pays to purchase the easement (A. J. Plantinga, 2007). The market price of the land ($V(i)$) is assumed to be reduced by 25% as a result of the easement4. The CA additionally incurs transaction costs (α_i^{CE}) and maintenance costs (m_i^{CE}). CE transaction costs are assumed to be equivalent to those summarized in Table 5. The initial appraisal for a CE is more expensive than an appraisal for an OP, due to extra work the appraiser must do to find easements upon which to base the value[3]. The cost of maintenance of the easement is given by Equation 6:

$$m_i^{CE} = \sum_{t=1}^{T} \frac{M_i + Com_i + Enf_i + ins_i}{(1+d)^t} + \omega_{i,k} + b_i \quad (6)$$

Equation 6 includes the cost of monitoring (M_i), communication with farmers (Com_i), enforcement of minor violations (Enf_i), and insurance for major violations (ins_i). The initial baseline study cost (b_i) is also included. Other costs from Richman and Loza (2011b), such as maintaining structures and signs, amending agreements, and agency overhead, are assumed to not apply to the easement described in this study. The upkeep of the land itself remains the job of the farmer and is therefore not a cost to the CA.

To account for six ALUS-type projects within a single CE, the costs associated with the appraisal, baseline study, minor violation enforcement, monitoring, and communications are all divided by six in the final calculations. The values cited in Table 7 reflect the costs to implement an easement on a full parcel (such as a one-quarter mile section in Alberta) of land. All costs are divided by six in the final calculation, with the exception of insurance costs which apply to the specific projects within the parcel.

4 K. Good, Executive Director, Legacy Land Trust Society, (Personal Communication, September 29, 2016)

Table 7 Costs associated with maintaining a conservation easement (Doscher et al., 2007; Richman & Loza, 2011a).

Cost type	Description	Value	Data Source
Monitoring (M_i)	Site visits and remote monitoring, assuming 7.5 hours of staff time at $50 hr^{-1}.	$375	(Richman & Loza, 2011a)
Communication (Com_i)	Communications with the farmer, assuming 1.7 hours of staff time and $25.50 in material costs.	$110.50	(Richman & Loza, 2011a)
Enforcement of Minor Violations (Enf_i)	Correcting minor violations, assuming 22.5 staff hours, with a 5% annual chance on each easement.	$56.25	(Richman & Loza, 2011a)
Insurance (ins_i)	Insurance offered to CAs to mitigate the risk of a litigated dispute.	$60	Terrafirma 2016
	Liability insurance	$25	Expert Interview5
Initial baseline study and management plan (b_i)	The initial baseline study and creation of a management plan[3].	$4500	Expert Interview[5]

2.3.3 **ALUS Program**

The price of converting a plot of agricultural land to produce ES as part of the ALUS program is calculated using Equation 7:

$$C_{i,ca}^{A} = Y_i + m_{i,k}^{A} \tag{7}$$

The cost ($C_{i,ca}^{A}$) to ALUS is the sum of the present value of the annual payments (Y_i) and the management costs of the project ($m_{i,k}^{A}$). The annual ALUS payment in Alberta is assumed to be $50 per acre for wetlands, and $30 per acre for uplands, and in Ontario assumed to be $150 per acre. The maintenance costs are given by Equation 8:

5 K. Good, Executive Director, Legacy Land Trust Society, (Personal Communication, September 29, 2016)

$$m_{i,k}^{A} = \sum_{t=1}^{T} \frac{M_i}{(1+d)^t} + \omega_{i,k} + \sum_{t=9,19,29}^{T} \frac{\omega_{i,k} \cdot 0.07}{(1+d)^t} \qquad (8)$$

Equation 8 captures the costs of monitoring (M_i), the initial costs of establishing the project ($\omega_{i,k}$), and the costs of recidivism. Monitoring costs and conversion costs were assumed to be equivalent to the other two mechanisms, summarized in Tables 7, and 3 and 4, respectively. ALUS projects do not incur a cost associated with a baseline study.

Recidivism is the withdrawal of projects from the ALUS program, which may occur under increasing commodity prices (Hellerstein & Malcolm, 2011; Secchi & Babcock, 2007). ALUS projects do not involve the legal transfer of ownership or rights to land, and so the projects are more vulnerable to recidivism than OPs or CEs, which are considered permanent. In the case of the ALUS program, when a project is withdrawn, the funding earmarked for that project is re-directed to another area of land. The economic impact of a withdrawn project is the costs ALUS incurs to establish a new project of equivalent type and size[6]. Table 8 summarizes observed recidivism rates in the data from ALUS. The cost of recidivism is the net present value of the percentage of the conversion costs ($\omega_{i,k}$) equivalent to the recidivism rate, applied every ten years. Recidivism is assumed to continue unchanged for the duration of the study with average recidivism of 7% and equal recidivism across project types.

Table 8 Recidivism rates in Vermilion and Norfolk counties from wetland, forest, and grassland projects. Withdrawn projects may still be present on the landscape, removed projects have been destroyed.

County	Total Projects	Withdrawn Projects	Removed Projects	Recidivism Rate
Vermilion	416	38	1	9%
Norfolk	195	9	1	5%

6 B. Gilvesy, Executive Director, ALUS Canada (Personal Communication, August 18, 2016)

3 RESULTS

Projects were compared on the basis of their average size, which was taken from ALUS data (Table 9). Project size distributions were skewed left; 71% of ALUS Vermilion's projects were less than 3 acres, and 90% of ALUS Norfolk's projects were less than 3 acres. Higher acreage projects were generally special projects that did not conform to the typical ALUS payment rates.

Table 9 Average project sizes from ALUS project data. Shelterbelt projects were excluded from the Alberta data.

Project Type	County	Average size (ac)	Standard Deviation	Observations
Grassland	Norfolk (ON)	3.73	6.48	46
Forest Patch	Norfolk (ON)	1.57	1.68	71
Wetland Construction	Norfolk (ON)	0.43	0.36	24
Grassland	Vermilion (AB)	15.49	31.99	146
Forest Patch	Vermilion (AB)	16.97	-	1
Wetland Rehabilitation	Vermilion (AB)	1.66	3.56	238

Based on the project sizes in Table 9, the total project costs were compared between the three mechanisms. Separate analyses were done for Ontario and Alberta, to account for different crop prices, crop rotations, yields, and project costs (Tables 2, 3, and 4). Most farms in Norfolk (52%) and Vermilion (73%) are classified as either producing cattle, or grains and oilseeds (Statistics Canada, 2011c). Therefore, to capture the majority of farms in the analysis, project costs were estimated for both crop-based and livestock-based farms. Projects selected for comparison were those similar in nature between Norfolk and Vermilion: grasslands, forested areas, and wetlands. Other projects such as water control structures, bird habitats, and pollinator grass patches were not used in the analysis.

Interviews were conducted with farmers, ALUS staff, and a land trust expert to build the comparison model and validate model assumptions. In addition, interviews with farmers explored the motivation behind their participation in ALUS. Qualitative results indicate that the pre-existing environmental attitude of the farmers is an important motivator for participation in ALUS. Most farmers were interested in quantifying both project costs and ecological returns, and many had participated in other agri-environmental programs. Interview questions are provided in Appendix 3.

Interviews revealed differences between projects in the two sites. In Vermillion, fencing was an important cost. Fenced lowlands in the county of Vermilion will readily convert to wetlands therefore excluding cattle from an area is the most cost effective way to rehabilitate wetlands. In comparison, ALUS Norfolk wetland projects involve digging down to the water table, and planting the area with aquatic plants. Because of the need for heavy equipment and labour, the cost of wetland construction in Norfolk is much higher than wetland restoration in Vermilion (Tables 3 and 4). Projects involving planting grasslands and forest patches also showed higher costs in Norfolk. Interview results suggest that this is due to the higher use of contract labour for Norfolk projects, while in Vermilion project establishment may be carried out more frequently with volunteers[7]. Furthermore, Vermilion projects were typically undertaken on cattle farms where fencing was already in place, reducing conversion costs. The results may have also been impacted by differences in cost accounting procedures between ALUS Vermilion and ALUS Norfolk[7].

Results show that procurement using ALUS generally carried a lower project cost than a CE or OP (Table 10, Figure 1)[8]. OP carried the highest cost due to high acquisition costs. Maintenance costs were also high compared to other programs where these were at least partially born by the farmer. CE costs were lower than OP costs. CEs had much lower acquisition costs, and lower management costs. ALUS costs were generally lower than CEs due to a lower management costs, an absence of transaction costs, and the acquisition costs being distributed and discounted over time and not up-front. Since ALUS projects do not necessitate carrying insurance, legal fees, or contract enforcement, stewardship costs consisted only of monitoring,

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7 C. Whitelock, Program Coordinator, ALUS Norfolk, (Personal Communication, October 14, 2016); C. Elder, ALUS Coordinator, County of Vermilion River, (Personal Communication, October 13, 2016)

8 A fully worked example calculation is provided in Appendix 4.

and a cost for recidivism. Therefore, although ALUS projects had a recurring annual payment, the overall costs the ALUS mechanism were usually the lowest (Table 10, Figure 1).

Table 10 Project costs under ALUS, CE and OP. Variance in costs results from the yield distribution which impacts property values. Property values do not directly impact ALUS annual payments, therefore ALUS costs do not have a variance.

Mechanism			ALUS	CE		OP	
Project Type	Project Size (ac)	Farm Type		Mean	Standard Deviation	Mean	Standard Deviation
Forest Patch (Alberta)	16.97	Cattle	12,579	15,818	1,368	48,748	6,864
		Crop	12,579	23,809	795	88,847	3,992
Forest Patch (Ontario)	1.57	Cattle	6,366	8,264	220	12,821	926
		Crop	6,366	8,285	163	12,908	688
Native Grassland (Alberta)	15.49	Cattle	10,848	14,322	1,169	45,707	5,864
		Crop	10,848	22,051	822	84,498	4,124
Native Grassland (Ontario)	3.73	Cattle	13,029	11,687	634	25,822	2,676
		Crop	13,029	11,685	254	25,814	1,069
Wetland Construction (Ontario)	0.43	Cattle	7,141	10,510	51	12,702	215
		Crop	7,141	10,510	36	12,703	152
Wetland Restoration (Alberta)	1.66	Cattle	4,869	8,426	130	15,192	654
		Crop	3,335	7,764	88	14,145	444

ALUS costs were higher than CE costs for native grassland projects in Ontario, for both crop and cattle farms. Grasslands were the largest project type from Ontario (3.73 ac), so although both conversion and stewardship costs were shown to be lower for ALUS than for the CEs, the acquisition cost of ALUS was almost double that of the CE. Since the modeled profits for cattle and crop farmers in Ontario were very close (Table 2), results for both farm types were very similar. Other project types in Ontario had a smaller average size, which reduced acquisition costs to the point that ALUS costs were lower than CE costs.

In Alberta total CE costs were higher than total ALUS costs. The annual payments ALUS delivered to farmers in Alberta were lower than the annual payments in Ontario, allowing for lower acquisition costs. Conversion costs in Alberta were also lower. Unlike Ontario, Alberta's modeled land values were different between crop and cattle farms. The model created this

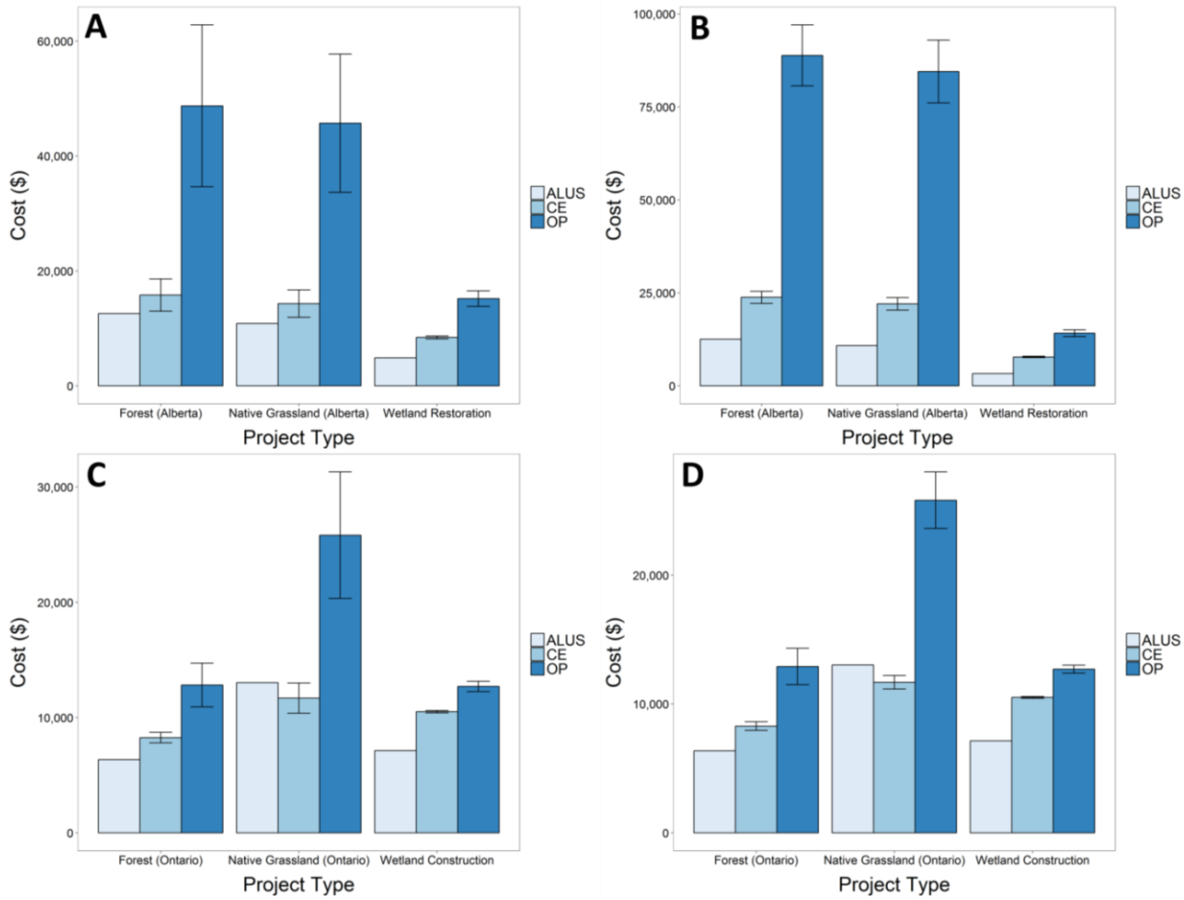

Figure 1 Average project costs (CAD 2016) under ALUS, CE, and OP. Error bars represent 95% confidence intervals (N=20) based on yields, normally distributed through ten years of provincial average yields. ALUS costs do not have a variance. Analyses captured show A) Alberta cattle farm, B) an Alberta crop farm (canola, barley, wheat), C) an Ontario cattle farm, and D) an Ontario crop farm (corn, soybeans, wheat).

difference because the average yield of hay in Alberta is much lower than in Ontario, and therefore profits from a single acre of grazing land are lower (Table 2). Since the property value directly impacted the mechanisms costs, the results in Alberta showed lower costs on cattle farms and higher costs on crop farms.

The results of the model were strongly impacted by project size. Figure 2 displays the impact of project size on the cost of grassland projects under the three different mechanisms. For grassland projects in Ontario, and on crop farms in Alberta, the marginal cost of each acre under a CE is less than the marginal cost of an acre in an ALUS project. Therefore, as project sizes increase, initial savings on transaction and management costs are eclipsed by increased marginal acquisition costs. For grassland projects on cattle farms in Alberta (Figure 2B), the ALUS annual payment is low enough that the marginal costs of an acre in an ALUS project are lower than for a CE.

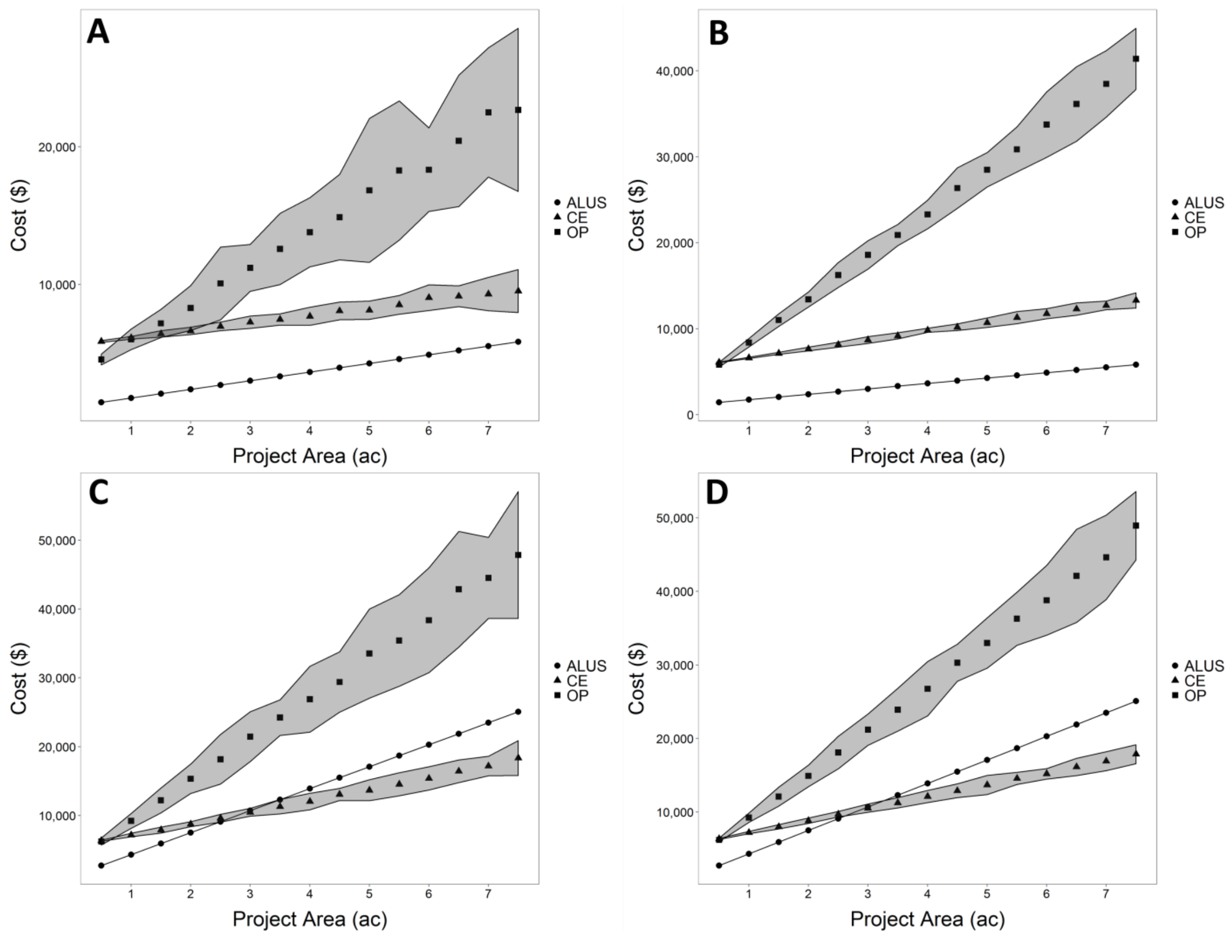

Figure 2 The impact of project size on the predicted cost of grassland projects. Shaded areas represent 95% confidence intervals based on stochastic yield. Conditions of analysis are A) an Alberta cattle farm, B) an Alberta crop farm, C) an Ontario cattle farm, and D) an Ontario crop farm.

The time horizon used to compare the costs was also investigated. It was found that the overall results did not change when the costs were projected to 50, 75, and 100-year horizons. This result is not surprising given the substantial discount applied to future values.

4 DISCUSSION

The three mechanisms examined though this study are not easily compared. They operate at different scales, and have different goals. A purchase of land, for example, is most advantageous when a large area of land must be closely managed by conservation professionals. An easement, by comparison, is often used by land trusts to secure large tracts of pre-existing natural areas, thus protecting that area from development[9]. ALUS is focused on converting marginal pieces of agricultural land to a natural state in which they can be managed by the farmer for ecosystem services alongside active agricultural operations[10]. To enable comparison, simplifying assumptions were applied (Appendix 1). In reality an OP and a CE cannot operate on the same scale as an ALUS project. They must be applied to a legal parcel of land, and by holding the project size constant between the three methods, the model under-estimates acquisition costs of both purchases and easements. Therefore, costs calculated in this model, in particular for CEs, are under-estimates for a per-acre comparison. The overall trends of the comparison are the most important results, and the focus of this discussion.

Overall, the OP mechanism had the highest costs. Acquisition costs of purchasing lands outright involve paying a sum equivalent to the entire land value, which alone exerts a strong upward pressure on project costs. Management costs for OP were higher than for the other mechanisms, because all establishment and upkeep done by farmers is transferred wholly to the CA. For these reasons, OPs were found to be the most expensive mechanism. Purchasing land has utility for protecting large areas of critical habitat that must be managed by conservation professionals, and may not be the ideal tool to procure ES on a working farm.

CE costs were lower than costs associated with OPs, and generally higher than ALUS costs. Though certain costs, such as land appraisals, are higher for conservation easements, management and acquisition costs were lower. It was assumed based on expert interviews that the price of an easement reflected 25% of the value of the land, meaning the acquisition cost of a

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9 K. Good, Executive Director, Legacy Land Trust Society, (Personal Communication, September 29, 2016)

10 B. Gilvesy, Executive Director, ALUS Canada (Personal Communication, April 23, 2016); C. Elder., ALUS Coordinator, County of Vermilion River, (Personal Communication, June 14, 2016)

CE was lower than an OP. Furthermore, it was assumed that some establishment costs and all upkeep costs remained with the farmer[11], meaning that CEs had a lower annual cost than OPs. CEs in the model generally had a higher annual cost than ALUS projects due to extra costs of insurance, communications, and other costs referenced in Table 1. CEs also bore transaction costs, which did not apply to ALUS projects.

ALUS projects were generally found to have lower costs than the other two mechanisms. ALUS projects and CEs were assumed to have identical conversion costs and monitoring costs, so the difference between the two mechanisms originates from acquisition and stewardship costs. Stewardship costs are higher for CEs than for ALUS projects, because CEs are required to carry insurance and perform more extensive monitoring and enforcement. Instead of an upfront acquisition cost, ALUS projects incur acquisition costs over time. The results show that even with conservative estimates of CE costs, ALUS projects have lower costs in ten of the twelve comparisons.

The size of the project strongly impacts the acquisition cost and the conversion cost. The results suggest that CEs can become less costly than ALUS projects if the project size is increased (Figure 2). Conversion costs are assumed to be equivalent between CEs and ALUS projects, so the main impact of size is on the acquisition costs. CE acquisition costs are based on 25% of the cost of an acre, which means that under Ontario conditions, the model predicts that for each marginal acre of land, the up-front acquisition cost to the CA is approximately $1,400 (an average annual profit of $249 per acre discounted to a 30-year time horizon). ALUS's marginal per-acre acquisition cost in Ontario is approximately $2,750. At larger project sizes, the increased marginal acquisition costs outweigh the lower transaction and management fees. This provides some insight into the ALUS business model: ALUS projects are small (over 90% of the Ontario projects are less than 3 acres), and at this small size, they are highly cost efficient. In contrast, CEs are more efficient with larger areas.

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11 K. Good, Executive Director, Legacy Land Trust Society, (Personal Communication, September 29, 2016)

An important limitation of the model was that all per-acre costs were assumed to be independent of overall project size. Smaller projects typically have a higher per-acre cost, though the model does not account for establishment or maintenance per-acre costs changing with project size. Similarly, although project acquisition costs increase proportionately with the project size, the per-acre cost is constant. In practice, the per-acre value of land decreases as the parcel size increases. Since the project sizes considered were much smaller than most agricultural land parcels, the per acre land value was assumed not to change as area was increased.

5 CONCLUSION

This study compares the costs of three different methods of ecosystem service procurement. It was found that the cost of OPs was in each case higher than the costs of CEs and ALUS projects. However the relative cost effectiveness between CE and ALUS depends on project size. When applied at the average size of an ALUS project, CEs are more costly, though the per-acre marginal costs of conservation easements are lower than those of an ALUS projects. Conservation easements have economies of scale and cost effectiveness increases with project sizes.

Wherever possible, this study attempted to be conservative in estimation of conservation easement and purchase costs. Though some farmers accept payments below the ALUS baseline rate, only baseline payment rates were used for ALUS costs. Even so, ALUS was less costly in ten of the twelve comparisons. This suggests that the ALUS model can be a low-cost method for procuring ecosystem services from small diffuse projects that are integrated into working farms.

ALUS can be applied in situations in which a purchase or an easement would be impractical at a much lower cost. The ALUS program compliments the existing mechanisms by enabling smaller, diffuse conservation projects to occur in areas where other mechanisms could not operate. Despite using an annual payment system, by working with farmers on many small projects the ALUS program enables low-cost ES procurement.

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7 APPENDIX I: MODEL ASSUMPTIONS

- Main crops in Ontario are Corn, Soy, and Wheat; main crops in Alberta are Barley, Wheat, and Canola (Agricultural Census, 2011).
- The discount rate is set to 3.5% (OMB, 2015).
- The time horizon is set to 30 years.
- Cost of labour is assumed to be \$50 hr^{-1}.
- Yield variances are based on the 10-year record of county average yields of each crop, from 2004 – 2013, and assumed to be normally distributed (AARD, 2014; Statistics Canada, n.d.).
- Farm Costs are taken from 2016 farm budget models for Ontario and Manitoba (MAFRD, 2015, 2016; OMAFRA, 2016).
- Crop prices are taken from 2013 crop prices from OMAFRA and Alberta Agriculture data (AARD, 2014; Kosinski, 2012). The crop prices were converted to 2016 dollars based on the Consumer Price Index (Bank of Canada, 2016).
- Specific conversion costs of planting native grasses, trees, and fencing were taken from ALUS data. The cost of installing a watering system was estimated from ALUS data.
- Upkeep of installed fencing and forest patches is taken from the literature (Doran & Cubbage, 2009; Meyer & Olsen, 2005), upkeep of water systems is estimated to be an annual payment of 2% of the initial value.
- Option value of the property is assumed to be 1% in Vermillion and 10% in Norfolk, based on brief surveys of land prices and a value decomposition study (A. Plantinga et al., 2002).
- Project areas are set to be equal among the three mechanisms (this underestimates CE and OP costs).
- Easement costs that are applied to a full plot are divided by six, based on an average amount of 5.8 ALUS projects per quarter section in Vermilion County.

8 APPENDIX II: THEORETICAL COST BENEFIT FRAMEWORK

ES Procurement Method	Converted Land Cover	Benefits to Farmer	Costs to Farmer	Benefits to Organization	Cost to Organization
Outright Purchase	All	Productive value of the land Option value of land	Ownership Inheritance for future generations Future flexibility	Permanence	Productive value of the land Option value of the land Conversion costs Taxes Insurance Maintenance Administrative costs of land transfer Organizational overhead
Conservation Easement	All	Productive value of land Possible use of land for forage Aesthetics? Stewardship value?	Decrease in land value Annual Upkeep Taxes Insurance Flexibility Control Nuisance	Permanence	Productive value of the land (potentially minus forage value) Negotiation costs (time) Organizational overhead Monitoring Enforcement (potential legal action)
	Riparian Buffers				Conversion costs: Fencing cost Planting costs
	Wetlands				Conversion costs: Waterer cost

					Fencing cost
	Shelter Trees, Native Grasslands, Pollinator Habitats				Planting costs
ALUS Program	All	ALUS payment income (NPV) ½ conversion costs Use of land for forage Flexibility Control Aesthetics? Stewardship value?	Value of optimal use of land Annual Upkeep Taxes Insurance Nuisance		Annual payments ½ conversion costs Negotiation costs (time) Organizational overhead Monitoring
	Riparian Buffers		½ Conversion costs: Fencing cost Planting costs		½ Conversion costs: Fencing cost Planting costs
	Wetlands		½ Conversion costs: Waterer cost Fencing cost		½ Conversion costs: Waterer cost Fencing cost
	Shelter Trees, Native Grasslands, Pollinator Habitats		½ Conversion costs: Planting costs		½ Conversion costs: Planting costs

9 APPENDIX III: INTERVIEW QUESTIONS

9.1 LAND TRUST INTERVIEW

1. What mechanisms are typically used to convert land from agriculture (or other uses) to natural land for the purpose of ecosystem services procurement?
2. What are the pros and cons of a conservation easement versus a purchase?
3. Are easements used for purposes other than land conversion? What about BMPs?
4. What is the cost difference between a purchase of land and an easement on the land?
5. Do you need a real estate agent if you are a land trust purchasing an easement or a piece of land? If so, can you estimate their fees?
6. How much do you pay in legal fees when purchasing land or an easement?
7. How long does it take to negotiate a typical conservation easement?
8. Do you allow the farmer to use the easement area? How would that impact the cost?
9. Do you lease land?
10. Does the price of a conservation easement include the conversion costs of the land?
11. How much would you estimate it costs to monitor a project every year?
12. Do you have trouble with compliance to conservation easement rules, and if so, at what frequency? What remedial actions are necessary when the agreement is violated?
13. Under what circumstances are conservation easements terminated?
14. Are you required to carry any insurance on the lands or easements owned by the land trust?

9.2 FARMER INTERVIEW

1. What motivated you to participate in the ALUS program?
    a. Why specifically did you choose ALUS?
    b. Are you interested in quantifiable ecological results from your work with ALUS?
    c. If so, which ones? For example, air quality, water quality, carbon sequestration, presence of wildlife, or others.
    d. Do you participate or have you participated in other conservation programs?
2. What sort of management practices are you doing with the ALUS program?
    a. Is there anything you would like to do, but are not doing yet?
    b. Have you experienced any nuisance factors from your activities? For example, animal predation, extensive time investment, spreading of weeds, or other inconveniences.
    c. Are you using conservation tillage, or other best management practices?
3. Can you tell us a bit about your farm?
    a. What is the approximate size?
    b. Approximately how many fields and pastures does it have?

   c. Approximately how much of your revenue comes from crops versus cattle? Do you harvest other products as part of farm revenue?
   d. What crop rotation do you typically use?
4. What kind of projects are you doing with ALUS right now?
   a. Could you describe the changes to your farm that ALUS has facilitated?
   b. Have you planted trees, created grasslands, or protected water bodies with ALUS?
   c. Approximately how much land is involved in ALUS projects?

5. Roughly how much does it cost to maintain:
   a. Fencing?
   b. A solar watering system?
6. Can you estimate the cost of:
   a. Installing a km of fencing?
   b. Planting an acre of trees? Of native grass?
   c. Installing a solar watering system?
7. Can you estimate the costs of:
   a. Any pests, like gophers, that have occurred as a result of ALUS?
   b. Any wildlife damage, such as herbivory, that have occurred as a result of ALUS?
   c. Weed removal needed to maintain the ALUS project?
   d. Extra plowing, seeding, and harvesting time due to needing to avoid the inactive land?
8. Are you required to carry any insurance on the land you own?
9. What market conditions would motivate you to convert project land from ALUS to another use (crops, hay, etc.)?
10. What value do you derive from managing the land yourself, as opposed to having to conform to strict guidelines, or even relinquishing management entirely to a land trust?

9.3 ALUS Coordinator Interview

1. How much time would you estimate you spend monitoring a project each year?
2. How much time would you estimate you spend setting up a project?
3. Can you estimate your hourly rate of pay?

10 APPENDIX IV: SAMPLE CALCULATION

This calculation assumes that a cattle farmer from Alberta has decided to allow a 4.4 ac riparian buffer to be put on their land. The following calculations (Table 5) will demonstrate how the cost model derives costs from the input data and assumptions. The time horizon is 30 years, the discount rate is 3.5%.

Table 11 Cost calculation examples

Variable	Description	Calculation
P_i	The present value of a plot of land for a cattle farmer is assumed to have an average yearly profit of \$106.14/ac, based on the price of Hay in 2013 converted to 2016 dollars and a yield between 1-2 tonnes/ac.	$P_i^{OP} = \sum_{t=0}^{29} \frac{\$106.14\ ac^{-1} \cdot 4.4\ ac}{(1+0.035)^t} = \$9{,}246.45$ $P_i^{CE} = P_i^{OP} \cdot 0.25 = \$2{,}311.61$
O_i	The option value is assumed to be 1% of the productive value of the land in Alberta.	$\$9246.45 \cdot 0.01 = \$92.47$
$\omega_{i,k}$	A riparian project is assumed to have a 1126m perimeter, fencing is assumed to cost \$3.28/m (1.23/m for ALUS and CE), planting is assumed to cost \$152.87/ac (\$95.17 for ALUS and CE), and the water system is assumed to cost \$2,819.33 to install (\$1409.67 for ALUS and CE). There is also a cost to do a baseline study and management plan (\$750).	$\omega_i^{OP} = (1126m \cdot \$3.28\ m^{-1}) + (\$152.87\ ac^{-1} \cdot 4.4ac) + \$2{,}819.33 + \$750 = \$7{,}935.24$ $\omega_i^{CE} = (1126m \cdot \$1.23\ m^{-1}) + (\$95.17\ ac^{-1} \cdot 4.4ac) + \$1409.67 + \$750 = \$3{,}963.39$ $\omega_i^{ALUS} = (1126m \cdot \$1.23\ m^{-1}) + (\$95.17\ ac^{-1} \cdot 4.4ac) + \$1409.67 = \$3{,}213.40$
α_i	Transaction costs include an appraisal fee (\$750 for an easement, 291.6 for a purchase), a land transfer fee (in Alberta,	$\alpha_i^{CE} = \$750 + \$50 + \$875 + 6.71 = \$1{,}681.71$ $\alpha_i^{OP} = \$291.6 + \$50 + \$875 + 6.71 = \$1{,}223.31$

	$50 tariff, plus $1 for each $5000 of land value), negotiation and fundraising costs ($875), and title insurance (0.1% of the market value).	
$m_i{}^{OP}$	The annual tax rate in Vermilion County is 1.4%. Annual maintenance costs for fencing is assumed to be $0.33/m. Annual maintenance for the water system is assumed to be 5% of its installation cost. Liability insurance is assumed to cost $25.	$\sum_{t=1}^{29} \frac{(\$9246.45 + \$92.47) \cdot 0.014 + 1126m \cdot \$0.33m^{-1} + \$2819.33 \cdot 0.05 + 25}{(1+0.035)^t} = \$11{,}645.53$
$m_i{}^{CE}$	The maintenance cost for a conservation easement is the sum of the monitoring costs ($62.50), communications ($18.42), enforcement ($9.38), liability insurance ($25), and conservation insurance ($60).	$\sum_{t=1}^{29} \frac{\$62.50 + \$18.42 + \$9.38 + \$25 + \$60}{(1+0.035)^t} = \$3{,}224.13$
$m_i{}^{A}$	The maintenance cost for ALUS is the discounted sum of the annual monitoring costs ($62.50), and the recidivism cost, which is a cost equal to 7.25% of ω_i^{ALUS} every 10 years.	$\sum_{t=1}^{29} \frac{\$62.50}{(1+0.035)^t} + \sum_{t=9,19,29}^{29} \frac{\$3{,}213.40 \cdot 0.0725}{(1+0.035)^t} = \$1{,}454.36$
Y_i	The ALUS annual payment rate is $50/ ac for a wetland or riparian area. Recidivism rate is 7% every 10 years.	$\sum_{t=0}^{29} \frac{\$50/ac \cdot 4.4ac}{(1+0.035)^t} + \sum_{t=9,19,29}^{29} \frac{3{,}213.40 \cdot 0.07}{(1+0.035)^t} = \$4{,}398.90$

$$C_{i,ca}^{OP} = \$9{,}338.92 + \$1{,}223.31 + \$7{,}935.24 + \$11{,}645.53 = \$30{,}143.00$$

$$C_{i,ca}^{CE} = \$2{,}334.73 + \$1{,}681.71 + \$3{,}963.39 + \$3{,}224.13 = \$11{,}203.96$$

$$C_{i,ca}^{A} = \$4{,}398.90 + \$3{,}213.40 + \$1{,}454.36 = \$9{,}066.66$$