Year 1 Project Status Report

Project Title: Testing the Cover Crop Hypothesis

Project Lead: Yvonne Lawley, University of Manitoba

Project Collaborators:

Kate Congreves, U of Saskatchewan
Steve Shirtliffe, U of Saskatchewan
Melissa Arcand, U of Saskatchewan
Richard Farrell, U of Saskatchewan
Mario Tenuta, University of Manitoba
Lana Shaw, South East Research Farm
Ken Coles, Farming Smarter

Project Funders:

Western Grains Research Foundation,
Manitoba Pulse and Soybean Growers Association,
Manitoba Wheat and Barley Growers Association

Project Objectives:

1. Quantify the potential for cover crop growth across a range of cover crop windows and growing environments in Prairie Canada.
2. Evaluate the reliability of cover crop establishment within annual crop rotations across a range of growing environments in Prairie Canada
3. Evaluate the impact of cover crops in crop rotations on crop yield and quality across a range of growing environments in Prairie Canada
4. Evaluate the impact of cover crops on soil health across a range of growing environments in Prairie Canada
    a. Part A: Soil Health Testing
    b. Part B: Soil microbial activity and communities
    c. Part C: Soil physical properties and soil carbon
    d. Part D: Soil nitrogen cycling
5. Quantify the environmental impact of cover crops on N2O fluxes in three growing environments in Prairie Canada.
6. Evaluate the economic costs and benefits to including cover crops in annual crop rotations across growing environments in Prairie Canada (Lawley)

Project Progress for Year 1 Milestones:

Our project is off to a good start. Activities for objectives 1-4 occurred during the first year of the project. Activities for objectives 5 and 6 are planned to start in year 3 of the project. There were six planned milestones for the first year of the project. Most of these six milestones were accomplished.

1. Establish research station experiments at 4 locations: Carman, Saskatoon, Redvers, Lethbridge. Establish an on-farm experiment at 1 location: Brandon
    - Experiments were established at 4 research station locations during the 2018 growing season at Carman, Saskatoon, Redvers, Lethbridge. See Table 1 for list of crop rotations and cover crops at each site.
    - An on-farm experiment continued from 2017 at the farm of Adam Gurr near Brandon, MB. A fall rye cover crop was established in replicated strips in fall 2017. An edible bean grain crop was grown in 2018. In the fall of 2018, no cover crops were established due to dry conditions and the availability of the farmer's seeder. He had traded in his seeder in for a new model during the summer and the new seeder was not delivered in time to plant the cover crop.
2. Collect, measure and analyze data for base line soil properties and soil carbon, soil nutrient testing, soil temperature and moisture, and soil health measurements
    - We successfully collected, processed, and stored baseline soil samples from each plot at all locations. Samples are being stored (dried or frozen) until graduate students can begin analysis when they start their programs in year 2 and 3.

3. Grow grain crops and cover crops, harvest grain and cover crop samples, analyse data, prepare annual report
    - Grain crops, cover crops, and the perennial check plot were established. Fall cover crops established at all sites but had limited fall growth at all sites due to dry conditions and cooler temperatures (Figure 1). See notes from Milestone 4 for each location.
    - Grain and cover crop data was sent to Dr. Lawley and was reviewed during our collaborator conference call (Figure 1 and 2).
4. Convene one annual conference call meeting of site leads
    - A 2-hour conference call was held on March 29, 2019 with the researchers and technical staff involved in objectives 1-3 at each of the 4 study locations.
    - Experiences and data from the first field season was reviewed for both cash and cover crops. Some of the highlights from the meeting included:
        - Lethbridge: 2018 was not an ideal year for grain or cash crops. Winter was cold with lots of snow but it did not soak in and soil moisture reserves were low. May was very hot and the cover crop trial was one of last seeded at the farm so there was lost spring moisture. Grain crops and the alfalfa established well. The clover cover crop had to be seeded twice (broadcast at heading and after harvest) due to dry conditions. Clover was planted just before a rain shower but it dried up again and it did not

establish. Interseeding/companion planting in spring may be a better method to establish cover crops in this environment because rain and soil moisture are limited later in the season.

- Redvers: Grain yields for wheat and barley were good, canola yields were okay, but pea yields were poor due to aphanomyces. Cover crops were drilled after harvest in dry conditions. Oats in cover crop mix came up first. Faba bean came up in September after rain and then it got cold. There was limited cover crop shoot growth above ground but observed good root growth below ground (not measured). Selecting frost tolerant cover crop species was important with the cool fall in 2018.
- Saskatoon: the cover crops were seeded in late September because the seeded was late to arrive. Cover crops did establish despite late seeding but they have very little growth. Tillage radish had lowest emergence, while rye had the best establishment. The berseem/oat mix was primarily oat and may want to increase seeding rate of berseem next year. Red clover established although it had to be seeded twice during the season. Rye cover crop took off after potato harvest. Deer kept eating alfalfa and pea crop to the point that there was no pea crop to harvest.
- Carman: Very dry growing season. The crops and alfalfa established fine. The clover that was interseed into wheat and the radish that was interseeded into soybeans both established but eventually died due to dry conditions. They were successful when seeded a second time after harvest but had limited growth. The rye and barley/pea mix was drilled after harvest. We had successful establishment after harvest but disappointing growth because of cool conditions in the fall of 2018.

- The protocol was reviewed and revised the gain and cover crop management and measurements for the second year of the study. Major points discussed included:
  - Redvers, Lethbridge, and Carman site will be managed with direct seeding/no-till (Carman site has conventional till history). Saskatoon site will be managed using rotational tillage: direct seeding in all years except the potato year. Potatoes will be seeded and managed with new minimum tillage methods.
  - Fertilizer rates for grain crops: Each site will base fertilizer rates for each crop types (i.e. all phases) using spring soil tests and soil test lab recommendations based on target yields for each location/growing environment. Fertilizer rates for the experiment will be calculated using the average rate recommended for the 4 no cover crop treatment plots for each crop type.
  - Residual herbicides will be avoided. Seed treatments will be used for crops where they are commonly used (e.g. Canola will have seed treatment, but cereals will not).

        - The perennial crop check will be mowed twice per year to a height of 6 inches. The biomass will be left in the plot (not removed). It will be fertilized if annual spring soil tests identify a deficiency.
    - Extension actives for the second year of the project were also reviewed and coordinated.
        - Lethbridge – will invite Yvonne Lawley to speak about the project at Farming Smarter summer field day
        - Redvers – will invite Yvonne Lawley to speak about the project at their summer field day
        - Saskatoon – Canadian Soil Science Society conference will have a summer field tour in July, may have a stop at the experiment on field tour.
        - Carman – invitation for Yvonne to speak at Manitoba Crops-a- Palooza about cover crops.
5. Create YouTube video to introduce project, establish cover crops project Twitter feed
    - Dr. Lawley has been sharing information about the experiment on twitter and in the future we will be using #prairiecovercrops to assemble tweets from the group of people involved in the project. You Tube videos to introduce the project will be created once Dr. Lawley's graduate student begins in Year 2 (fall 2019).
6. Recruit one graduate student
    - Dr. Congreves has recruited MSc student Olivia Otchere. She started her program in summer 2019 at the U of Saskatchewan.
    - Dr. Lawley has recruited PhD student Callum Morrison. He will start his program in fall 2019 at the U of Manitoba.

Challenges encountered during Year 1:

Agronomy: Dry conditions during 2018 at all sites impacted both crop and fall cover crop growth. These conditions were extreme but representative of conditions across the prairies in 2018. This project will run for four field seasons with a fully phased treatment design. This means that the project benefits from testing cover crops over several years and hopefully in a wide range of conditions. Fall cover crops established at all sites but did not accumulate much biomass. Due to shortages of grass, deer were grazing the cover crops and perennial check plots. The need for fall fencing was discussed at the project conference call for each site. All sites indicated that they had access to some fencing equipment but were not sure if it would be adequate for the job. Fencing will be purchased in year 2 for sites that do not have access to adequate fencing.

The site at Saskatoon had access to irrigation to establish the cover crops. However, the site had a delay in planting cover crops after harvest. During the project conference call in March, we discussed what happened in the fall of 2018 and a plan to purchase the seed ahead of time is in place for fall 2019 so that cover crops can be planted right after harvest.

Administrative: Contracts between the University of Manitoba and the University of Saskatchewan took a very long time and most were signed just before fiscal year end. This delayed the flow of funds to U of S collaborators that had budget in the first year of the project. Both Kate Congreves and Melissa Arcand had planned activities to process and analyze base line soil samples in this first year of the project. These activities were minimized or did not occur and will now occur when graduate students start their programs. See the budget section below for the plan to carryover funds from year 1 to enable this work to happen in subsequent years.

Working to set up the 4 subcontracts through the University of Manitoba with U of S collaborators took Dr. Lawley's time away from the plan to purchase new field and lab equipment for soil health in the first year of the project. This coupled with the later than expected start time for the PhD graduate student, has pushed these activities into the second year of the project. An amendment is being proposed to facilitate these activities. See budget section for more details.

Student Recruitment: Dr. Lawley was successful in recruiting a PhD student for her portion of the project. However, the student will start their program later than planned in the proposal. This has delayed soil carbon sample analysis of base line soil samples collected in the first year of the project. See the budget section below for the proposed plan to move unspent analysis funds to year 2 of the project. The delayed start of the student also impacted the travel budget as there were funds budgeted for the student to travel to each site to collect site characterization soil samples and measure soil physical properties. These activities will now occur the third and fourth year of the study.

New Opportunities:

Due to their growing interest in cover crops in Manitoba, General Mills has contributed funds that were match by Manitoba Agriculture (CAP) to add a 5th site for the study on clay soils near Glenlea, MB starting in spring 2019. This funding will also support 3-4 additional on-farm experiments in Manitoba to compliment the one on-farm experiment funded by this project. The additional on-farm sites will significantly improve the planned economic analysis that will be possible for Objective 6.

Dr. Matthew Bakker, a new microbiologist at the University of Manitoba in the Department of Science, with experience researching soil and whole plant microbiomes has expressed interest in joining our team of collaborators and to work with samples from the rotation study. Dr. Lawley and Dr. Bakker are exploring options with the new NSERC grant programs to see if funds from this existing project could be matched to expand the scope of the project or bring more resources to existing objectives, such as a PDF that could help with integrating data analysis across objectives and publication of manuscripts in the last two years of the study. Once we

know more about the new Alliance program, we would like to talk with WGRF, MPSG, and MWBGA to see if they would support a team based application to NSERC as partners.

Project communication activates:

There were no project communication activities during the first year of the project.

Project Budget:

The attached financial report was developed for this project in consultation between WGRF and the U of M Budgets and Grants office. The budget for the first year of the study was $268,749.25. Total project spending in the first year of the study was $73,942.26.

An error in the U of M contract budget was found when preparing this financial statement. The budget for Dr. Cate Congreves in the first year of the project for $28,543. This amount correctly appears in year 2 in the table itemizing her portion of the project, but that same amount is included in the total for year 1 for the total project budget. This amount is highlighted in blue print and noted at the bottom of the financial report. Dr. Congreves intended to utilize these funds in year 2.

Funding of $10,350 for Dr. Melissa Archand in year 1 of the project were not available for her to spend because of delays in contracts between the U of M and the U of S. These funds were intended for the analysis of samples collected in the first year of the project. These samples have been stored and we are requesting carryover for these funds into Year 2 for this analysis to occur.

Dr. Lawley is requesting $155,914 in carryover from year 1. Reasons contributing to the large amount of carryover from year 1 include: delay in PhD student starting program, less travel for sampling and delayed sample analysis in year 1 with graduate student starting later, salary from summer students was covered from other projects in year 1, delay in equipment purchasing due to focused on project admin in year 1. Please refer to Table 2 for the proposed plan for re-allocating carryover by budget category in years 2, 3, and 4 of the project. The plan for each spending category is as follow:

- Salary: Hire additional undergraduate student/seasonal labor to help with sample collection and processing from existing work plan at the U of M in Year 3 and 4 at peak sample collection.
- Equipment: Purchase of equipment will occur in year 2 and 3.
- Travel: Reallocate research travel to knowledge transfer travel in order to organize an annual workshop or field tour in Years 3 and 4. This event will bring the 4 graduate

students together at either the U of M and U of S (expecting to alternate locations) to learn about all areas of the project and meet with farmers and agronomists interested in cover crops from different regions of the prairies. Funds would be used to accommodate student transportation, accommodation, meals for travel to the workshop/field day from the non-host institution.

- Sample analysis (other direct project costs spending category) will be allocated to Years 2, 3, and 5 to support more in-depth/frequent soil and gas sampling for existing measurements being conducted by graduate student supervised by Lawley, Arcand, and Congreves, Farrell and Tenuta in Objectives 4 and 5.

Table 1: Experiment crop rotation and cover crop treatments for each site

Trt #	Treatment	Phase	Crop type	Carman	Saskatoon	Redvers	Lethbridge
1	4 year Rotation with cover crop	Phase 1	cash crop	wheat	wheat	wheat	wheat
			cover crop	Red clover	Red clover	Mix 1:Faba/flax/clover/ ryegrass/plantain	clover
		Phase 2	cash crop	canola	canola	canola	canola
			cover crop	Barley/pea	Berseem/oat	Mix 1: Faba/flax/clover/ ryegrass/plantain	lentil
		Phase 3	cash crop	oat	potato	barley	durum
			cover crop	rye	rye	Mix 2: Oat/flax/plantain	radish
		Phase 4	cash crop	soybean	pea	pea	pea
			cover crop	radish	radish	Mix 2: Oat/flax/plantain	FR/WP
2	4 year rotation without cover crop	Phase 1	cash crop	wheat	wheat	oat	wheat
		Phase 2	cash crop	canola	canola	soybean	canola
		Phase 3	cash crop	oat	potato	wheat	durum
		Phase 4	cash crop	soybean	pea	canola	pea
3	2 year short rotation reference	Phase 1	cash crop	wheat	wheat	wheat	wheat
		Phase 2	cash crop	canola	canola	canola	canola
4	4 year perennial crop reference	N/A	cash crop	Alfalfa and grass mix	alfalfa	Alfalfa, grass, and alsike blend	alfalfa

Results from the first year of the study:

Figure 1: 2018 Average crop cover crop biomass in each phase of the crop rotation grown at four experiment locations.

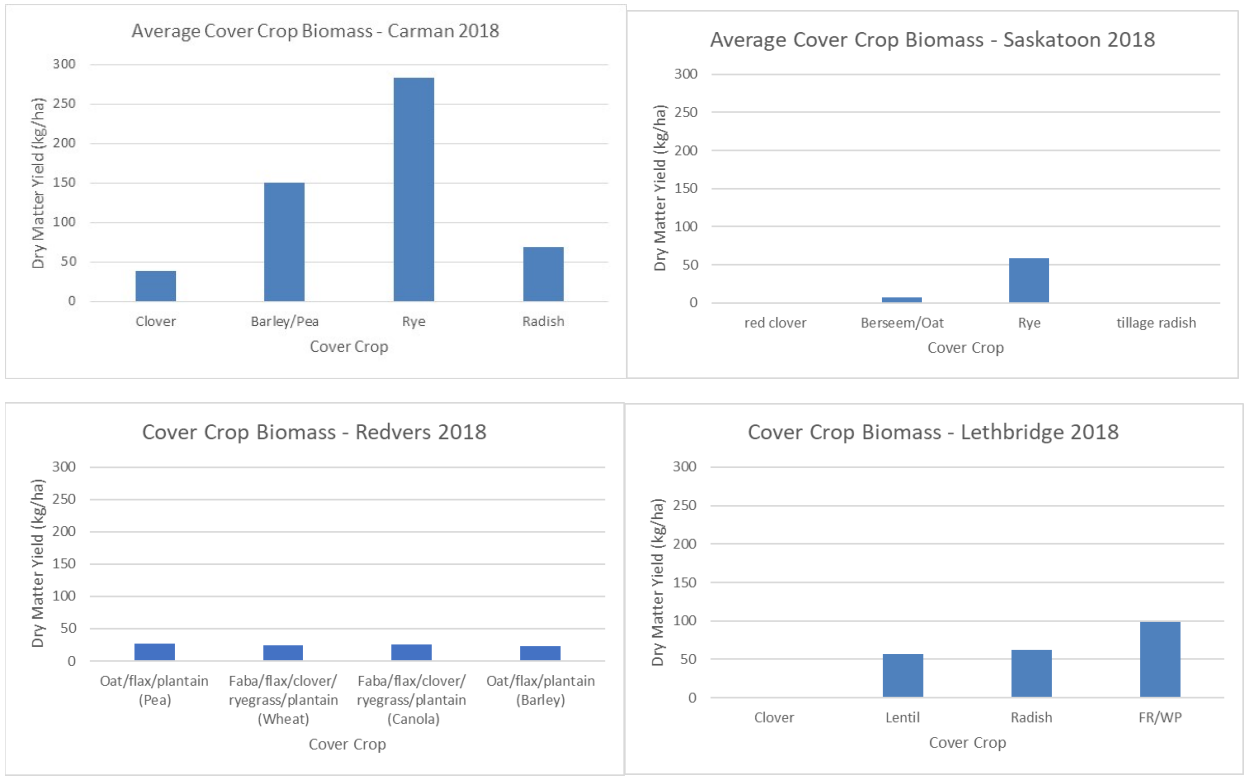
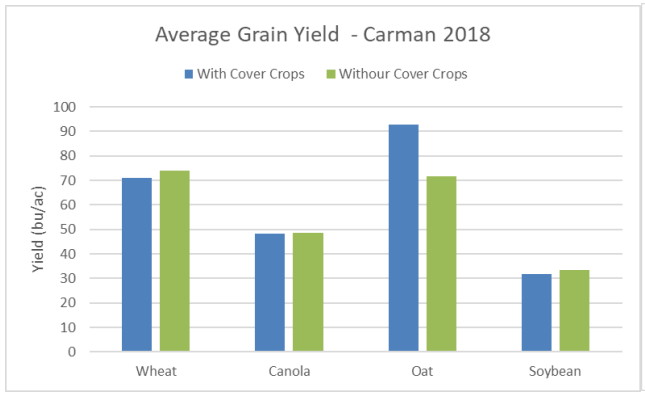
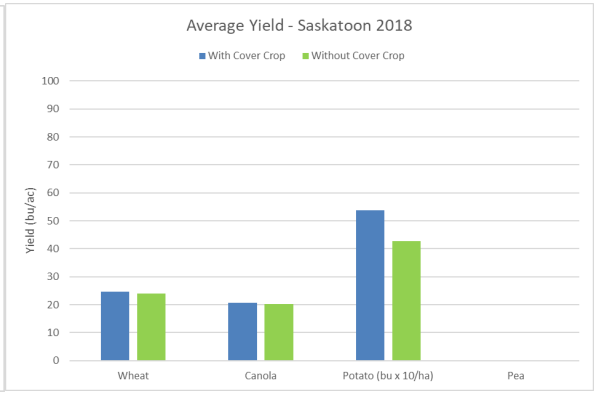
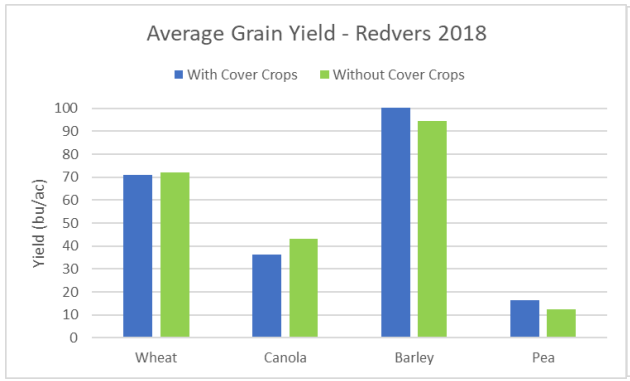
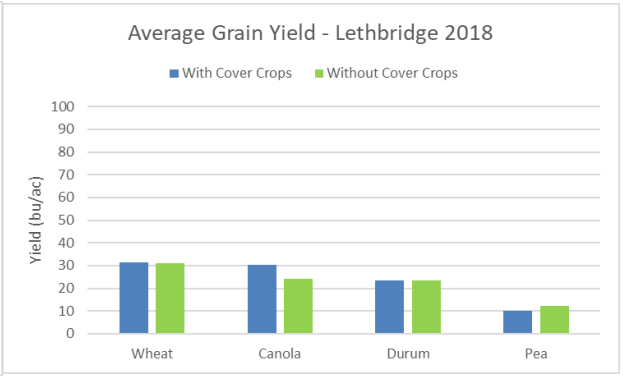


Figure 2: 2018 Average crop yields for cash crops in each phase of the crop rotation grown with and without cover crops at four experiment locations. There were no significant differences between crop yields with and without cover crops at all locations (p=0.05).









*pea yield data missing for Saskatoon site due to grazing dear during a drought year.

Table 2: Proposed plan for year 1 carryover funds in Year 2, 3, and 4 for a project budget amendment.

Consolidated Report	Yr 1 Contract Budget	Yr 1 actual - Mar 31 2019	Year 1 Variance	Yr 2 Contract Budget	Year 2 Revised Budet	Year 2 Change	Yr 3 Contract Budget	Year 3 Revised Budet	Yr 3 Change	Yr 4 Contract Budget	Year 4 Revised Budget	Yr 4 Change	Yr 5 Contract Budget	Yr 5 Revised Budget	Yr 5 Change	Total Contract Budget	Total Revsised Budget	Total Projct Change
Salaries	65,500.00	21,766.71	43,733.29	49,750.00	49,750.00		88,750.00	110,616.65	21,866.65	88,750.00	110,616.65	21,866.65	69,250.00	69,250.00		362,000.00	362,000.00	
Equipment	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Capital assets #1-3	48,035.00	0.00	48,035.00	0.00	38,035.00	38,035.00	0.00	10,000.00	10,000.00	0.00	0.00		0.00	0.00		48,035.00	48,035.00	
Supplies	3,000.00	3,922.24	-922.24	3,000.00	3,000.00		6,250.00	6,250.00		6,250.00	6,250.00		3,000.00	3,000.00		21,500.00	22,422.24	922.24
Travel (Research-specific)	10,000.00	2,608.66	7,391.34	3,000.00	3,000.00		15,000.00	15,000.00		15,000.00	15,000.00		3,500.00	3,500.00		46,500.00	39,108.66	-7,391.34
Travel (Knowledge Transfer)	1,000.00	0.00	1,000.00	1,000.00	2,000.00	1,000.00	1,000.00	4,695.67	3,695.67	5,000.00	8,695.67	3,695.67	6,000.00	6,000.00		14,000.00	21,391.34	7,391.34
Service Contracts	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Rent	500.00	0.00	500.00	500.00	500.00		500.00	500.00		500.00	500.00		500.00	500.00		2,500.00	2,000.00	-500.00
Other Direct Project Costs	35,840.00	0.00	35,840.00	18,496.00	27,496.00	9,000.00	71,072.00	84,069.76	12,997.76	101,264.00	114,684.00	13,420.00	33,488.00	33,488.00		260,160.00	259,737.76	-422.24
Overhead on U of M Costs only (15%)	24,581.25	4,244.65	20,336.60	11,361.90	18,567.14	7,205.24	27,385.80	34,669.81	7,284.00	32,514.60	38,361.95	5,847.35	17,360.70	17,360.70		113,204.25	113,204.25	
Other Collaborators (inclusive of OH):																		
Farming Smarter	13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		69,000.00	69,000.00	
Southeast Research Farm	13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		69,000.00	69,000.00	
U of Saskatchewan - Shirtliffe	13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		13,800.00	13,800.00		69,000.00	69,000.00	
U of Saskatchewan - Congreves	28,543.00	0.00	28,543.00	0.00	28,543.00	28,543.00	79,752.50	79,752.50		82,524.00	82,524.00		19,813.35	19,813.35		210,632.85	210,632.85	
U of Saskatchewan - Arcand	10,350.00	0.00	10,350.00	0.00	10,350.00	10,350.00	53,682.00	53,682.00		51,934.00	51,934.00		16,675.00	16,675.00		132,641.00	132,641.00	
U of Saskatchewan - Farrell	0.00	0.00		0.00	0.00		49,228.05	49,228.05		42,644.30	42,644.30		9,726.70	9,726.70		101,599.05	101,599.05	
Grand Total	**268,749.25**	**73,942.26**	**194,806.99**	**128,507.90**	**222,641.14**	**94,133.24**	**434,020.35**	**489,864.44**	**55,844.08**	**467,780.90**	**512,610.56**	**44,829.66**	**220,713.75**	**220,713.75**	**0.00**	**1,519,772.15**	**1,519,772.15**	**0.00**