RESEARCH PROGRESS REPORT

RESEARCH PROJECT TITLE: Assessing the Impact of Direct Seed (No-Till) and Conventional-Till on Crop, Variety, Soil, and Insect Responses

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INTERIM REPORT (combined) for the project funded FY02-FY04, and for one year funding FY05 (continuation of FY02-04 project). Previous interim reports are included in 2001-2003 STEEP reports.

PROJECT OBJECTIVES:

1. Evaluate crop and variety performance differences between NT and CT production systems in a replicated tillage trial for winter wheat, spring barley, spring wheat, dry pea, and lentil
2. Determine the impact of CT and NT on soil microclimate and fauna and document changes in key soil hydraulic and chemical properties
3. Evaluate incidence and severity of insect pests and their natural enemies on wheat, barley and pea grown under NT and CT practices

KEY WORDS: Tillage, Varieties, Soil Dynamics, Insects

STATEMENT OF PROBLEM: Information and new technologies about crop, variety, soil, insect and disease will help solve problems inherent in conservation practices, particularly NT, in the high rainfall areas of the Pacific Northwest. Past results show that varieties can respond differently to tillage and when evaluated in a replicated trial, those variety differences can be compared and quantified. Understanding the influence of topography on C sequestration and nutrient distribution is necessary to achieve the most efficient application of nutrients to agricultural fields, especially in areas such as the Palouse that are characterized by rolling topography. The relation between macrofauna, porosity, and pore-size distribution in the early stages of NT operations are not known. Differences in population dynamics, crop losses, and variety specific response have not been characterized for Hessian fly and other crop pests in replicated comparisons between CT and NT cereal production systems in the PNW. The importance and dynamics of the natural enemies of insects have also not been quantified in replicated NT comparisons in the PNW. There is a lack of critical information relating soil borne cereal pathogens to previous cropping history and soil properties under replicated NT versus CT plots.

ZONE OF INTEREST: Higher precipitation Palouse region of ID and WA.

ABSTRACT OF RESEARCH FINDINGS: Experimental investigations were carried out according to the proposal except for extensive pathological investigations. Winter wheat, pea, spring wheat and barley varieties were evaluated in the NT versus CT comparison. All crops were established well in both tillage systems, with higher winter wheat plant counts in NT than CT due to a moisture advantage in NT during establishment. The NT winter wheat yield was 4 bu/acre greater, at 106 bu/acre, than the CT. 'Lambert' was the highest yielding variety in NT in 2004, but 'Rod' has the highest three year average in NT. Test weight and seed weight were higher in NT than CT, but plant height, heads/sq. ft., biomass, and harvest index were not different between NT and CT and tended to favor NT with better values. All parameters were different among varieties and did not show a significant interaction with tillage. Pea yield, seed weight, plant stand, vine length, and canopy height were not different between NT and CT. 'Bluebird', 'Stratus', 'Badminton', and 'Rex' were high yielding in both NT and CT with yields over 3000 lb/acre. Lentils were not different between tillage treatments and 'Merrit' and 'Pardina' gave the highest yields in both tillage treatments. Spring wheat yields were not different between CT and NT and averaged 60 bu/a in CT and 62 bu/a in NT. Test weight and seed weights were higher in NT, as in years past, and indicate better grain filling conditions in NT, while crop biomass, lodging, number of spikes, harvest index, and plant height were not different between tillage treatments. There were variety differences but no interactions with tillage. There was no difference due to tillage in barley yields, but test weight, % plump kernels, and seed weights were higher in NT than CT. There were no differences between tillage treatments for all parameters measured, but varieties were different. When averaged over three years, 'Camas, 'Baronesse', and 'Excel' gave the same yields in NT and CT, but 'Harrington', 'Xena', and 'Morex' yields were lower in NT than CT. This shows that some varieties are better adapted to NT production and should be used when taking advantage of the higher quality grain that this study has always produced in NT. The high quality grain should be a large advantage for seed production. Earthworm density data indicate that earthworms responded quickly to NT management. Differences in population density between CT and NT plots can be seen as early as 2001. Since 2001, population density does not appear to be increasing. Annual variation in population density suggests that macroclimate has a large impact on earthworm numbers and that population density values within soils, should not be based on only one year of data. Density data between spring and summer indicate that although populations are higher in NT, there is also considerable mortality that does not occur in CT plots. This pattern is evident for all three years of the study and suggests that earthworm populations are higher in the spring under no-till due to microclimate and plentiful foodsource. The NT system, however, does not appear to be able to support this level of earthworm activity. Total C values suggest that C has increased by approximately 15% within the first 2.5 cm of soil under NT. Due to the short time these plots have been in NT, there were no significant differences in total C or C within selected fractions of soil organic C (LF, Fine iPOM, and Coarse iPOM). Periodic evaluation of these measurements will help determine the potential of Palouse silt loam soils to sequester C as well as the short-and long term effects of NT on soil quality. Sampling was conducted from 2000 to 2002 to evaluate pests and beneficial organisms in CT and NT

production systems. Reduced tillage had no consistent effect on abundance of Hessian fly. Abundance of pea leaf weevil was greater in CT than in NT pea fields in early stages of pea growth, and pitfall trap sampling is not biased by differential weevil activity. Among the natural enemies, five species of ground beetles were numerically dominant: *Poecilus scitulus*, *P. lucublandus*, *Pterostichus melanarius*, *Calosoma cancellatum* and *Microleseis linearis*. Their activity-density patterns differ by species and tillage systems within crops.

RESULTS AND INTERPRETATION:

Previous results from this study can be found in 2001, 2002, and 2003 STEEP annual reports. Results are also available on line at our website: http://www.ag.uidaho.edu/cereals

Experimental Site Management. At the Kambitsch farm north of Genesee, a tillage comparison trial included 15 varieties of winter wheat, 12 varieties of spring dry pea, 6 varieties of lentil, 6 varieties of spring barley, and 9 varieties of spring wheat. They were evaluated in a replicated no-till (NT) versus conventional till (CT) comparison in 2004. Each crop was raised on the previous crop residue as part of the rotation winter wheat-spring wheat-pea from the previous year (2003). This three-year rotation and tillage treatments have been in place since the winter of 2000. Winter wheat was seeded on October 22, 2004 using a Great-Plains NT drill with turbo-colters. A burn-down herbicide was applied 5 weeks prior to seeding and dry fertilizer was broadcast applied at 93-31-0-21 lb/a before seeding. Winter wheat was top-dressed with 40-0-0-6 lb/a dry fertilizer broadcast applied. Spring crops were seeded 4 weeks after a burn-down application using a small plot drill with Flexi-coil shank openers. Spring wheat and barley were seeded on April 27, 2004 with 99-32-0-22 lb/a of fertilizer banded below the seed, but no fertilizer was applied to the pea area seeded the same day. The tillage treatment included a chisel plow about 8 inches deep in the fall and two cultivations with a field cultivator/harrow prior to seeding. The no-till treatment was not disturbed except for seeding. In the bulk areas, 'Brundage 96' winter wheat, 'Monarch' pea, and 'Camas' spring barley were seeded. Weed control included a 2.5 oz/acre rate of Pursuit in the pea area, and Buctril and Harmony Extra at standard rates in the cereals. A few weed escapes were hand weeded. Overall, weed control was good and should not have had any impact on crop yields. Pea leaf weevil levels were well below application thresholds and pea seed weevil and aphids were controlled by an application of Capture at bloom. Insect control was excellent.

Over winter there was no noticeable vole feeding in the winter wheat area as there was in 2001 and 2002. The winter wheat established well and growth was better in NT than conventional till due to moisture retained in NT causing earlier germination than in CT where soil moisture was lost due to tillage. The spring crops had a normal seeding date and crop establishment was uniform and typical. About a month after seeding, a period of rain accumulated over 6 inches with several intense rain events. There was slight evidence of soil movement in the tilled areas, but none in the direct seeded. Soil moisture was good to adequate for most of the remainder of the crop season, but became short for later crops during grain filling. The lack of moisture during grain filling was most evident for spring wheat. All the crops had produced a lot of early growth during the early favorable growing conditions, but could not sustain that high yield potential during grain filling and this resulted in lower test weights and smaller seed size than desired, and also had a small impact on yield.

The fall 2004 site management included a burn-down herbicide application of Roundup and 2,4-D after precipitation gave excellent germination of weeds and volunteer crop. The tilled areas were chiseled on Sept 28 and the winter wheat planting area was worked with a field cultivator as in past years. Winter wheat varieties and Brundage 96 bulk area were planted on October 6, 2004 using the small plot Flexi-coil openers that banded 91-29-0-20 lb/a of fertilizer.

Variety responses, Winter wheat. When grain yield was combined over varieties, CT produced 102 bu/a and NT was higher at 106 bu/a (Table 1). There was no significant interaction of tillage and variety and 10 of 15 varieties yielded more in NT than CT. ‘Lambert’, ‘Stephens’ and ‘Madsen’ were significantly higher yielding (more than 12 bu/a different) in NT than CT. ‘Mohler’, ‘Cashup’ ‘Finch’ and ‘Rohde’ were highest yielding in CT, while Lambert, Rohde, and Stephens were highest in NT. In 2002 and 2003, Rod was the highest yielding in NT and was above average again in 2004. Grain test weight averaged 58.4 lb/bu in CT and was higher in NT at 59.7 lb/bu. Among the soft white varieties, test weight averaged 57.7 lb/bu in CT and 59.3 lb/bu in NT. Eight varieties had significantly higher test weight in NT than in CT and test weight was higher in NT or equal to CT for all varieties. Rohde was outstanding in test weight in both tillage treatments and averaged 61.8 lb/bu. Average seed weight was not significantly different between CT, 6.3 g/200 seeds, and NT, 6.7 g/200 seeds, but three varieties had significantly higher seed weight in NT than in CT. There was not an interaction, but seed weights were different among varieties. Lambert and Stephens were the largest seeded varieties. The consistent advantage of NT compared to CT was once again evident for winter wheat seed weight and test weight that is also consistently found in spring wheat. Growers should take advantage of this quality advantage for NT grain and this also supports a potential benefit to seed production under NT conditions.

Winter wheat establishment occurred mostly during the winter due to late seeding and low moisture before late November. However, when observed over the winter, the NT area was more advanced in growth stage and plants were larger. This was noticed when plants first emerged and is probably attributable to more available moisture in NT early to start plant development. This was also reflected in the stand counts taken in the spring that showed an average of 22 plants/ft^2 in CT versus 27 plants /ft^2 in NT (Table 2) with seven varieties having significantly more plants in NT than CT. Mature plant height was 36 inches, in both NT and CT. Growth analysis showed a few more heads in NT, at 47 heads/ft^2, than in CT, at 46 heads/ft^2. There was not an interaction of variety and tillage for number of heads. Crop biomass was only 300lb/acre different between NT than CT and averaged nearly 13,000 lb/a. Biomass samples tend to be variable due to their size, only one meter of row. Harvest index was calculated based on sample grain weight divided by sample biomass weight. Harvest index averaged 0.39 for CT and 0.42 for NT, and that means that about 42% of the biomass weight was grain. Differences among varieties show Madsen, ‘Boundary’, and ‘Temple’ gave higher harvest index in NT than CT. More winter wheat performance results are needed to find consistent tillage responses. 2004 seed protein and hardness data are not available at report time.

Table 1. Winter Wheat Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

Variety	Seed Yield Conv-Till	Seed Yield No-Till	Test Weight Conv-Till	Test Weight No-Till	Seed Protein[1] Conv-Till	Seed Protein[1] No-Till	Seed Hardness[1] Conv-Till	Seed Hardness[1] No-Till	Seed Weight Conv-Till	Seed Weight No-Till
White Wheat	---bu/acre---		-----lb/bu-----		----- % -----		----0-100----		----g/200----	
Brundage 96	95	104	56.1	58.2*					5.9	6.5
Cashup	112	106	59.3	59.3					6.6	6.4
Finch	110	109	58.7	60.3*					6.2	6.3
Hubbard	102	109	59.3	60.3					6.6	6.8
Lambert	100	115*	57.3	59.1*					7.1	8.2*
Madsen	92	105*	56.6	58.9*					6.0	6.8*
Mohler	113	109	57.6	59.8*					7.0	7.5
Rod	100	109	57.3	58.4					6.0	6.3
Stephens	99	111*	56.8	59.0*					7.4	8.2*
Red Wheat										
Boundary	109	104	58.7	59.8					6.8	7.3
Moreland	88	79	58.9	60.2*					5.7	6.1
Club Wheat										
Coda	99	109	60.6	61.9*					5.8	6.0
Hiller	102	104	57.0	57.7					5.6	5.8
Rohde	110	114	61.6	62.1					6.3	6.4
Temple	101	110	59.4	60.5					6.0	6.4
Average	102	106	58.4	59.7*					6.3	6.7
LSD (0.05)	11	11	1.2	1.2					0.6	0.6
CV	8	8	2	2					7	7

* No-Till values followed by an asterisk are significantly different than Conventional till.

[1]Protein and seed hardness values for 2004 are not analyzed at the time of reporting.

Table 2. Winter Wheat Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

Variety	Stand Count		Plant Height		Spikes		Biomass		Harvest Index	
	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
White Wheat	--no./sq. ft.-		---inches---		no./sq. ft.		- 1000 lb/acre-		----0.0-1.0----	
Brundage 96	22.5	27.2	35	35	47	51	12.5	13.6	0.39	0.43
Cashup	21.5	27.0*	34	35	50	51	13.6	13.6	0.41	0.44
Finch	26.6	27.1	38	37	48	53	12.9	13.5	0.39	0.35
Hubbard	20.3	29.5*	40	42	40	41	12.7	13.1	0.38	0.42
Lambert	17.5	25.3*	38	39	38	41	13.6	13.4	0.40	0.37
Madsen	23.1	31.6*	37	36	43	50	11.6	13.1	0.36	0.42*
Mohler	22.2	30.5*	38	37	44	45	13.3	12.5	0.40	0.43
Rod	22.3	27.5*	34	34	49	52	12.5	13.1	0.40	0.43
Stephens	23.3	28.0	35	35	41	44	12.2	13.2	0.40	0.42
Red Wheat										
Boundary	22.3	26.0	37	35	55	52	13.3	11.6	0.38	0.44*
Moreland	21.8	22.7	33	32	52	51	12.2	10.5	0.37	0.40
Club Wheat										
Coda	22.8	23.3	38	39	40	42	12.0	12.2	0.38	0.40
Hiller	23.5	24.1	34	34	42	41	12.7	12.0	0.41	0.45
Rohde	20.9	27.5*	35	36	42	51	12.5	15.0	0.42	0.41
Temple	24.1	27.0	36	38	51	50	12.8	13.9	0.39	0.45*
Average	22.3	26.9	36	36	46	47	12.7	13.0	0.39	0.42
LSD (0.05)	5.1	5.1	2	2	8	8	2.2	2.2	0.04	0.04
CV	18	18	4	4	14	14	15	15	8	8

* No-Till values followed by an asterisk are significantly different than Conventional till.

Dry pea. The tillage comparison trial yielded 2790 lb/acre in CT and 2670 lb/acre in NT averaged across pea varieties (Table 3). Although not statistically different, this 4% difference was not as great as the average 12% lower yield in NT the previous two years. 'Stratus' and 'Bluebird' were the highest yielding green pea variet in CT and 'Karita' and Bluebird were highest in NT. 'Badminton' and 'Fallon' were the highest yielding yellow varieties in CT, but 'Rex' and 'Swing' were highest in NT. There was no interaction of tillage and variety for any of the pea variables, but all variables had differences among varieties. Seed weights averaged 22.0 g/100 seeds in both CT and NT. Karita and 'Toledo' had highest seed weights. Plant stands were not different between tillage treatments and averaged 9.7 plants/ft^2 in CT and 9.4 plants/ft^2 in NT, and were mostly uniform across varieties. Vine lengths were typical and averaged 29 inches in CT and 28 inches in NT. Canopy heights were similar to vine lengths and only different for the long vine types 'Columbian', 'Joel', and 'Shawnee'. Plants tended to stay more erect in NT than CT.

Lentil. Lentil yields averaged across varieties were 2040 lb/acre in CT and 1940 lb/acre in NT, a non-significant difference of 5% (Table 4). 'Brewer' and 'Pardina' were highest yielding in CT, but Brewer was significantly lower is NT. Pardina and 'Merrit' were highest yielding in NT. Seed weights averaged 4.7 g/100 in CT and 4.9 g/100 in NT and 'Pennell' and Merrit had the largest seed. Lentil plant stands were similar between tillage treatments and adequate across the trial for yield. Plant heights averaged the same between tillage treatments and Pardina was shortest.

Table 3. Pea Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

Variety	Seed Yield		Seed Weight		Plant Stand		Vine Length		Canopy Ht.	
	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
Green Pea	----lbs/acre----		-----g/100-----		Plants/sq.ft.		---inches---		---inches---	
Columbian	2620	2230*	19.2	18.5	9.3	10.0	37	39	15	18
Bluebird	3040	2940	22.0	22.3	9.2	8.5	23	22	23	22
Joel	2540	2450	23.2	22.8	9.7	10.7	42	41	16	17
Karita	2780	2980	25.0	24.8	10.1	10.8	27	27	23	27
Stirling	2730	2780	20.1	19.9	10.1	9.5	23	24	23	24
Stratus	3060	2810	21.8	22.6	9.8	8.4	20	21	17	21
Toledo	2600	2340	24.4	23.7	7.8	6.6	27	23	27	23
Average	2780	2650	22.2	22.1	9.4	9.2	28	28	21	22
Yellow Pea										
Badminton	3080	2840	20.0	20.2	11.2	10.4	23	23	20	22
Fallon	2970	2510*	21.6	22.0	9.4	9.4	27	26	15	19
Rex	2890	3000	22.2	22.3	10.6	9.3	30	32	16	18
Shawnee	2530	2300	23.0	23.0	9.8	10.5	40	36	15	16
Swing	2600	2860	21.9	21.6	9.7	9.0	26	27	21	25
Average	2810	2700	21.7	21.8	10.1	9.7	29	29	17	20
Average	2790	2670	22.0	22.0	9.7	9.4	29	28	19	21
LSD (0.05)	320	320	0.9	0.9	1.6	1.6	4	4	4	4
CV	10	10	3	3	14	14	11	11	19	19

*No-Till values followed by an asterisk are significantly different than Conventional till.

Table 4. Lentil Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

Variety	Seed Yield		Seed Weight		Plant Stand		Plant Height	
	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till	Conv-Till	No-Till
	----lbs/acre----		-----g/100-----		Plants/sq.ft.		---inches---	
Brewer	2230	1880*	5.3	5.6	13	11	17	18
Eston	1870	1580	3.0	3.1	11	13	19	18
Merrit	2110	2130	5.8	6.0	14	13	18	18
Pardina	2270	2200	3.4	3.6	12	12	16	17
Pennell	1700	1530	6.1	6.0	13	14	19	18
Richlea	2040	2040	4.7	4.8	13	12	17	19
Average	2040	1940	4.7	4.9	13	12	18	18
LSD (0.05)	220	220	0.3	0.3	3	3	2	2

CV	9	9	6	6	20	20	10	10

* No-Till values followed by an asterisk are significantly different the Conventional till.

Spring Wheat. Spring wheat grain yield averaged 60 bu/a in CT, not different than, but slightly lower than NT at 62 bu/a (Table 5). There were variety differences with tillage treatments, and 'Tara 2002' and 'Jefferson' were highest in NT and CT. 'Wawawai' and 'Alturas' both were significantly higher yielding in NT than CT. When yields were combined over the past three years, 'Hank' was highest yielding in CT, while Jefferson was highest in NT. However, grain protein is lower in NT than CT and growers that want to produce hard red spring wheat in NT should manage nitrogen levels carefully to obtain quality grain. As in previous years, grain test weight was significantly higher in NT, 55.9 lb/bu, than in CT, 54.4 lb/bu. All varieties had higher test weights in NT than in CT and eight of twelve varieties had significantly higher test weights in NT than in CT. Seed weights were also higher in NT, 5.9 g/200 seeds compared to 5.5 g/200 seeds in CT. Although the growing season had ample moisture during the vegetative growth periods, there was limited moisture during grain fill. The plants were large, but did not fill grain well, hence the low test weights and the advantage to NT. Plant height was equivalent in NT and CT (Table 6). All stands in both tillages were good. Spike density was the same between tillage treatments, 49 spikes/sq. ft., but was highest for Jefferson, a hard red, in NT and 'Eden' soft white club in CT. Biomass averaged 9,200 lb/a in both NT and CT and was not different in previous years. In past years, grain protein was always lower in NT than CT. Harvest index is lower in spring wheat than the winter wheat, because of the shorter growing season available to spring wheat. Among varieties, the lowest average harvest index was for Penawawa, at 0.28, and was highest for Westbred 936, at 0.38, and means that 38% of the biomass was grain for Westbred 936.

Table 5. Spring Wheat Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

	Seed Yield		Test Weight		Seed Protein[1]		Seed Hardness[1]		Seed Weight	
Variety	Conv -Till	No-Till	Conv-Till	No-Till	Conv -Till	No-Till	Conv-Till	No-Till	Conv -Till	No-Till
White Wheat	---bu/acre---		-----lb/bu-----		------ % ------		----0-100----		----g/200----	
Alturas	58	64*	53.8	55.2*					5.3	5.8*
Eden	57	63	55.0	56.8*					4.8	5.1
Penawawa	41	46	51.8	52.8					4.9	4.9
Wawawai	56	62*	54.6	56.7*					6.1	6.7*
Zak	53	56	53.1	54.0					5.4	5.8
Lolo (HW)	60	57	56.5	57.9*					5.7	6.1
IDO377s (HW)	61	62	55.5	56.5					4.9	5.1
Red Wheat										
Hank	67	65	52.7	54.7*					5.7	6.4*
Jefferson	69	68	55.2	56.8*					5.3	5.6
Westbred 926	64	63	53.7	55.3*					5.6	6.0*
Westbred 936	60	62	53.2	56.0*					5.6	6.6*
Tara 2002	73	70	57.2	58.0					6.4	6.4
Average	60	62	54.4	55.9*					5.5	5.9*
LSD (0.05)	5	5	1.1	1.1					0.4	0.4
CV	7	7	2	2					6	6

* No-Till values followed by an asterisk are significantly different the Conventional till.

[1]Protein and seed hardness values for 2004 are not analyzed at the time of reporting.

Table 6. Spring Wheat Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

Variety	Plant Height		Lodging		Spikes		Crop Biomass		Harvest Index	
	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till	Conv-Till	No-Till	Conv -Till	No-Till
White Wheat	---inches---		------%------		--no./sq.ft.---		lb/acre x1000		---0.0-1.0---	
Alturas	34	33	14	5*	52	57	9.2	10.1	0.33	0.36
Eden	32	32	6	2	54	59	9.0	9.8	0.33	0.38*
Penawawa	29	30	3	4	53	54	8.3	8.1	0.30	0.26
Wawawai	37	36	12	13	50	49	9.2	8.6	0.30	0.34
Zak	33	33	1	1	50	50	8.8	9.2	0.33	0.35
Lolo (HW)	34	33	3	7	45	43	9.8	9.5	0.37	0.38
IDO377s (HW)	33	34	4	7	50	52	9.8	9.6	0.36	0.32
Red Wheat										
Hank	32	30	0	1	37	36	8.4	8.3	0.36	0.39
Jefferson	34	34	1	3	55	53	10.0	9.1	0.32	0.37*
Westbred 926	33	32	0	2	42	45	9.1	9.3	0.37	0.36
Westbred 936	30	29	5	0	46	44	8.8	9.3	0.39	0.38
Tara 2002	36	35	4	5	52	47	10.5	9.4	0.37	0.39
Average	33	33	4	4	49	49	9.2	9.2	0.34	0.35
LSD (0.05)	2	2	6	6	7	7	1.2	1.2	0.04	0.04
CV	4	4	130	130	12	12	11	11	10	10

* No-Till values followed by an asterisk are significantly different the Conventional till.

Spring Barley. Barley grain yield was 102 bu/a in CT and 97 bu/a in NT, not significantly different (Table 7). 'Xena' was highest yielding in CT, but 'Camas' was highest in NT. When grain yield is compared over 2002-2004, Camas, 'Baronesse', and 'Excel' have equivalent yields between NT and CT, while 'Harrington', Xena, and 'Morex' averaged over 9 bu/a less in NT than CT. This shows that some varieties are better adapted to NT conditions and some varieties should be avoided in NT. Grain test weight, plumpness, and seed weight were significantly higher in NT than in CT. The consistent benefit of grain quality in spring cereals adds value to NT crops, and coupled with equivalent yields for well adapted varieties, could make it a system of choice from a crop productivity standpoint and highly preferred for seed production. Plant height and lodging were slightly lower in NT than in CT. The number of spikes averaged 54/square foot in both NT and CT, but varied from 70/sq.ft. for Baronesse to 37/sq.ft. for Morex. Biomass was slightly less in NT than CT, but significantly higher in NT for Camas, but lower for Xena and Morex. Harvest index was 0.42 in CT and 0.45 in NT showing a higher grain to biomass ratio in NT. Baronesse had a significantly higher harvest index in NT than CT. A high harvest index indicates an efficient conversion of plant growth into harvested yield. A low harvest index can indicate a stress during the grain filling period, such as disease, weed pressure, insect feeding, or water limitation. There was ample water for vegetative growth, as supported by high biomass levels, but limited late in the season during grain filling giving low test weights, seed size, kernel plumpness and a low harvest index. The NT treatment seems to provide better available moisture later in the season, improving crop performance and quality.

Table 7. Spring Barley Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 200.

Variety	Seed Yield		Test Weight		Plump Seed		Grain Protein[1]		Seed weight	
	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till
2-ROW	---bu/acre---		-----lb/bu-----		-- % <6/64"--		------%------		----g/200----	
Baronesse	94	98	46.4	48.0*	77	85*			7.7	8.4*
Camas	101	106	48.8	49.9*	87	94			8.6	9.2*
Harrington	91	84	45.0	45.8*	64	74*			6.9	7.5*
Xena	120	105*	49.5	49.6	93	93			9.0	9.3
6-ROW										
Excel	95	102	44.0	46.0*	61	85*			6.2	7.3*
Morex	111	89*	45.9	46.3	77	78			7.0	7.2
Average	102	97	46.6	47.6*	76	85*			7.6	8.1*
LSD (0.05)	9	9	0.7	0.7	7	7			0.4	0.4
CV	7	7	1.3	1.3	8	8			5	5

* No-Till values followed by an asterisk are significantly different the Conventional till.

Table 8. Spring Barley Variety Performance Under Replicated Conventional-Tillage and No-Till Management near Genesee, ID, 2004.

Variety	Plant Height		Lodging		Spikes		Biomass		Harvest Index	
	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till	Conv -Till	No-Till
2-ROW	---inches---		-----%------		--no./sq. ft.-		x1000 lb/acre		----0.0-1.0----	
Baronesse	35	34	55	47	73	68	10.2	9.6	0.36	0.44*
Camas	35	34	33	41	46	54*	8.3	9.9*	0.45	0.46
Harrington	36	35	57	66	65	71	9.2	10.0	0.36	0.39
Xena	35	34	50	33	63	56	10.7	8.7*	0.44	0.47
6-ROW										
Excel	42	40	83	80	41	38	10.1	10.4	0.43	0.48
Morex	45	43	81	60	38	36	9.9	8.5*	0.45	0.46
Average	38	37	60	54	54	54	9.7	9.5	0.42	0.45
LSD (0.05)	2	2	19	19	7	7	1.3	1.3	0.05	0.05
CV	5	5	27	27	11	11	11	11	9	9

* NT values followed by an asterisk are significantly different than the CT value.

[1]Protein and seed hardness values for 2004 are not analyzed at the time of reporting.

<u>Soil Properties:</u> *Methods:* Earthworm density was determined in both spring and summer in 2001, 2002, and 2003. Soil samples were taken once during each of these same three years. In 2004, as part of the second phase of this continuing project, soil cores were taken to determine soil physical properties and earthworms were sampled in the spring prior to any field operations. Earthworms and cocoons were counted and expressed on a number per unit area basis. Total C and N of soil samples from the 0-2.5, 2.5-5, 5-10, 10-15 and 15-20 cm depths were determined by dry combustion in a Carbon, Nitrogen, and Sulfur analyzer. Saturated hydraulic conductivity was determined on core samples using a constant head technique adapted from Hillel (1998). Soil moisture, temperature, and CO_2 were monitored throughout the 2004 growing season. Soil moisture and temperature readings were recorded hourly. Carbon dioxide was sampled from 10 and 50 cm depths by drawing a volume of air from a stainless steel tube inserted into the soil to the appropriate depth using a gas-tight syringe. The air sample was injected into a sealed bottle and returned to the laboratory for analysis which was completed the same day. Carbon dioxide was analyzed by injecting a volume of the air sample into a gas chromatograph with a mass selective detector (MSD). The MSD allowed us to use argon as an internal standard in each sample.

Aggregate stability within both CT and NT plots was assessed using a modified version of the high-energy moisture characteristic technique (Pierson and Mulla, 1989; Collis-George and Figueroa, 1984). Briefly, dry soil sieved to 0.5-1mm is placed on a sintered glass funnel. Using a hanging water column attached to the funnel the soil is brought to saturation through upward water movement with either a slow (2cm/min) or a fast (20cm/min) wetting treatment. Once the soil is saturated, a moisture characteristic curve is obtained by measuring the outflow of water as the height of the hanging water column is decreased stepwise from 0 to -30cm. Aggregates broken during fast rewetting result in a curve that is different than that obtained from the slow treatment. Once an equation is fitted to this curve, the volume of drainable pores and the modal suction can be calculated. These indices are used to calculate a stability ratio. The stability ratio ranges from 0 to 1 indicating complete break down of aggregates to complete stability, respectively.

Soil organic carbon (SOC) from the 0 to 10cm depth in each plot was fractionated using size and density exclusion techniques (Six, et al., 1998; Cambardella and Elliott, 1992). Total carbon and nitrogen were determined in each fraction. Fractions collected include a light fraction (LF) (<1.85 g/cm^3), a coarse intra-aggregate particulate organic matter fraction (Coarse iPOM) - (2000-250µm; >1.85 g/cm^3), a fine iPOM fraction (250-53µm; >1.85 g/cm^3), and a mineral- associated and water-soluble fraction (mSOM). To isolate the light fraction, soil was gently wet sieved on a 250µm sieve. Sodium metatungstate (1.85g/cm^3) was then added to the fraction remaining on the sieve to float the light fraction. The resulting heavy fraction at the bottom was separated into fine and coarse iPOM by first shaking with a 5g/L hexametaphosphate solution to disperse aggregates then wet sieving through 250 and 50µm sieves. A subsample of both iPOM fractions was combusted to ash at 500˚C to allow for correction of mineral sand.

Results and Discussion: Comparison of mean earthworm density numbers collected in spring over the three year study, indicate that earthworms responded quickly to the change in tillage management (Figure 1). Interestingly, earthworm numbers do not appear to have significantly increased between 2001 and 2004. Comparison of earthworm density with time indicates a high degree of temporal variability. Higher numbers in 2001 and 2003 are probably due to differences in climatic conditions between years. Soil moisture, temperature, and precipitation data collected in 2003 and 2004 are currently being analyzed to help determine the influence of macro and microclimate on earthworm population density.

Mean values of plant available N for 2001 and 2003 are shown in Figure 2. Differences in the total amount of plant available N in 2001 and 2003 are probably a function of fertilizer inputs (wheat, for example, received 95 lbs N/ac in 2001 and 133 lbs/ac in 2003), climatic conditions, and differences in plant uptake. In general, there appears to be higher levels of plant available N in the near surface soil within no-till plots (Figure 3). Plant available N data will be analyzed with fertilizer inputs and climatic conditions and will be discussed in next year's STEEP report.

Carbon dioxide concentrations may be used as an indicator of microbial activity in soils. Measurements made over the 2004 year are shown in Figure 4. Concentrations of CO_2 in the plots planted to pea were much higher and showed a different pattern than those measured in plots planted to wheat and barley. Higher CO_2 levels may be caused by a combination of crop-specific factors as well as variability in soil moisture across the field. Within plots planted to pea, NT generally resulted in lower CO_2 concentrations in early June when soil temperatures are still increasing. When the soil started to dry, however, soil air across all treatments and depths had similar CO_2 concentrations. In plots planted to wheat and barley, CO_2 concentrations do not significantly differ between tillage within a depth.

Between 2001 and 2003, the mean total C in NT plots increased by about 15%, from an average of 1.81% to 2.08% within the 0 to 2.5 cm depth (Figure 5). Total N values mirrored those of C (data not shown). The impact of NT management on soil C at the 2.5 to 5 cm depth is not as evident. The lack of dramatic responses in soil C to tillage is not surprising in that changes in total soil carbon are expected to occur over relatively long time periods. Total C on a mass per unit area will be determined based on bulk density measurements. These same data will be taken following the next three year rotation cycle to continue to track changes in C storage.

Carbon fractionation procedures are often used to determine impacts of land use change sooner than what would be evident in measurements of total soil carbon. Long-term management with NT (~25 years) has been shown to increase carbon in the fine iPOM fraction compared to CT practices (Six, et al., 1998) presumably due to a slower turnover of carbon stored within aggregates (iPOM-carbon). No-till practices can promote growth of fungal hyphae leading to increased macroaggregate formation (Beare et al., 1993) and protection of this iPOM-carbon pool within aggregates. Carbon stored in the fine iPOM fraction was 136 g/m^2 for NT and 153 g/m^2 for CT (Table 9), however, these differences in carbon amounts were not statistically significant. The lack of statistical differences in iPOM-carbon is due to the short time the plots have been in under NT management. Turnover times for carbon in the iPOM-carbon can be as long as 20 years (Six, et al., 2001) and differences may not be evident in the first years while transitioning to NT. Six, et al. (1998) found similar amounts of fine iPOM carbon in native sod (174 g/m^2) and in NT (99g/m^2) systems sampled to 20cm depth.

The average, combined CT and NT C:N ratio in the fine iPOM fraction (14.1) was lower than C:N ratios found in the coarse iPOM (16.5) or light fractions (17.5) suggesting increased microbial action. The C:N ratio of the LF (POM outside of aggregates) was higher in CT, presumably due to annual incorporation of fresh, carbon rich plant material that would otherwise be left on the surface in NT systems. The majority of C and N in the bulk soil was found in the mSOC fraction containing 83.8% of the total C and 85.6% of the total N, while in these relatively weekly aggregated, silt loam soils, iPOM carbon and nitrogen accounted for only 6.43% of C and 7.19% of N in the bulk soil.

Based on our preliminary evaluation of aggregate stability data, the relative stability index, which can range from 0 (all unstable) to 1 (all aggregates are stable), ranges from approximately 0.72 in CT plots to 0.76 in NT plots. Although these numbers are not significantly different, they may indicate that higher organic matter inputs and earthworm activity and reduced disturbance are influencing hydraulic properties. Tracking these measurements over time will help us determine the time required to improve soil physical and hydraulic properties that are important for plant growth.

Table 9. Grams of C per unit area basis in each fraction of C analyzed. Results are shown for the 0 to 10 cm depth. POM fractions have been corrected for the sand content.

	Bulk soil	LF	Fine iPOM	Coarse iPOM	Clay and silt associated
	g C m^{-2}				
No-till	2701	212.5	135.6	35.3	2317.9
Conv. till	2321	239.8	153.0	37.2	1891.2

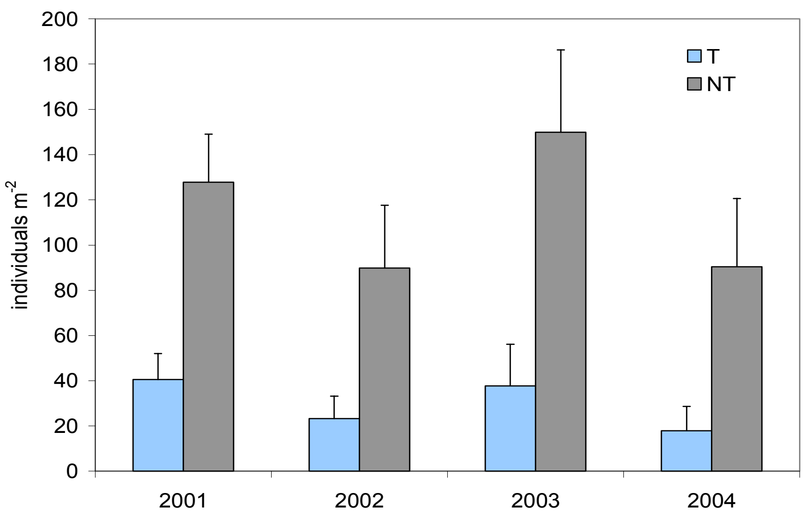

Figure 1. Number of earthworms m^{-2} in T and NT plots sampled in spring of 2001, 2002, 2003, and 2004. Vertical bars indicate standard error.

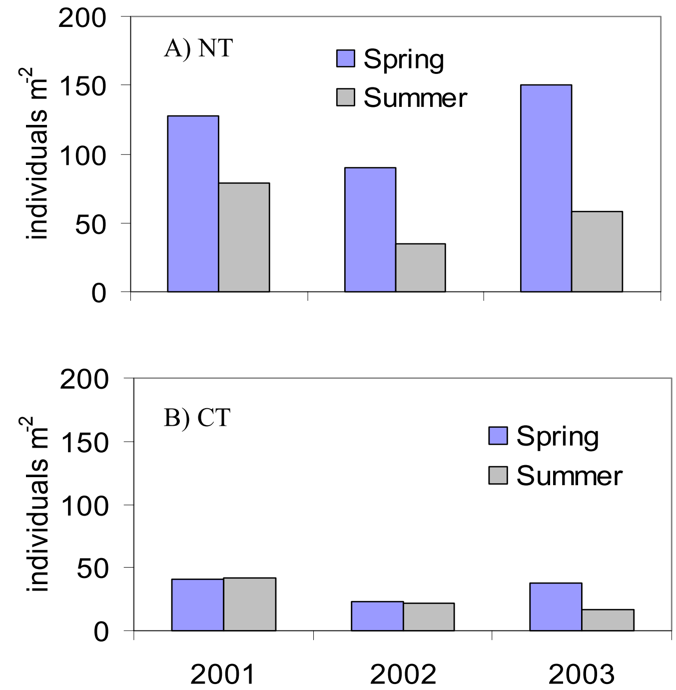

Figure 2. Earthworm population density in spring and summer in both A) NT and B) CT plots.

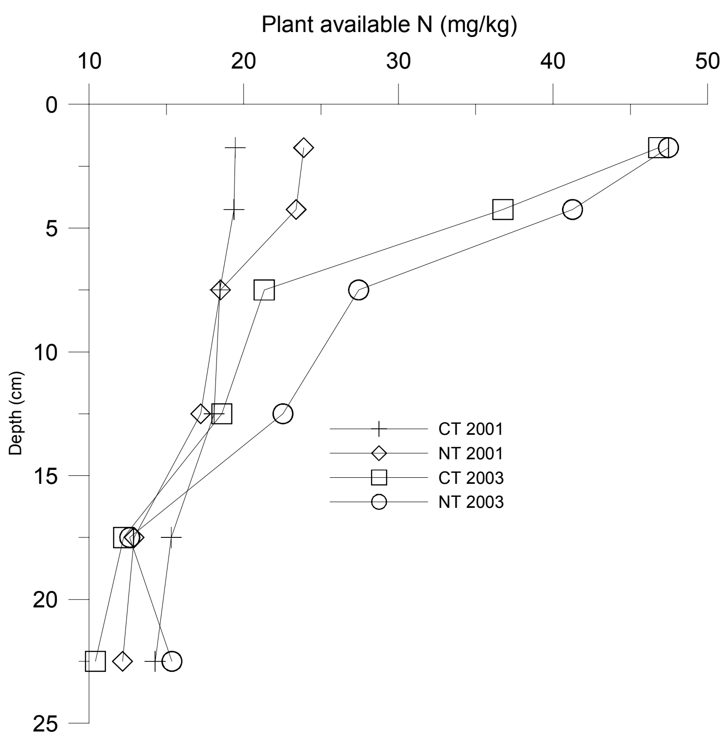

Figure 3. Trends in plant available N (ammonium + nitrate) within CT and NT plots in 2001 and 2003.

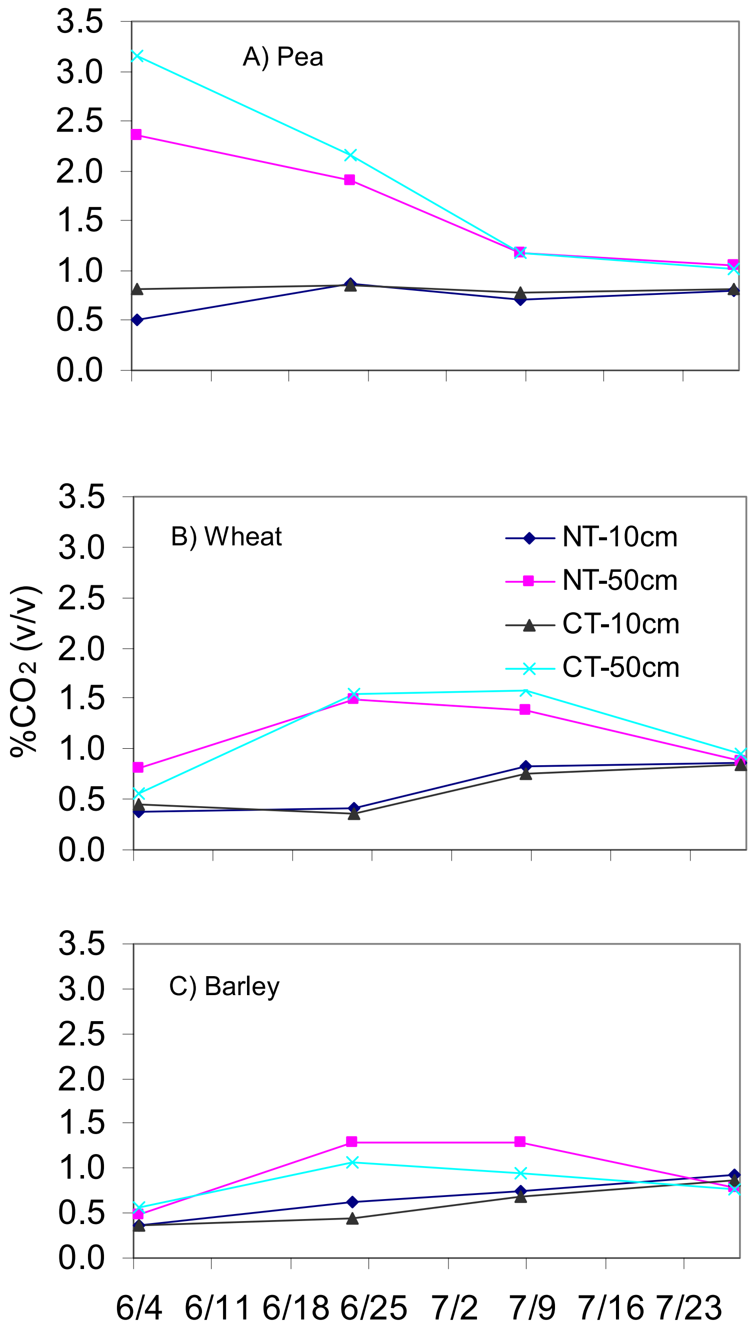

Figure 4. Concentrations of CO_2 in soil air collected from 10 and 50 cm depths in A) pea, B) wheat, and C) barley in 2004.

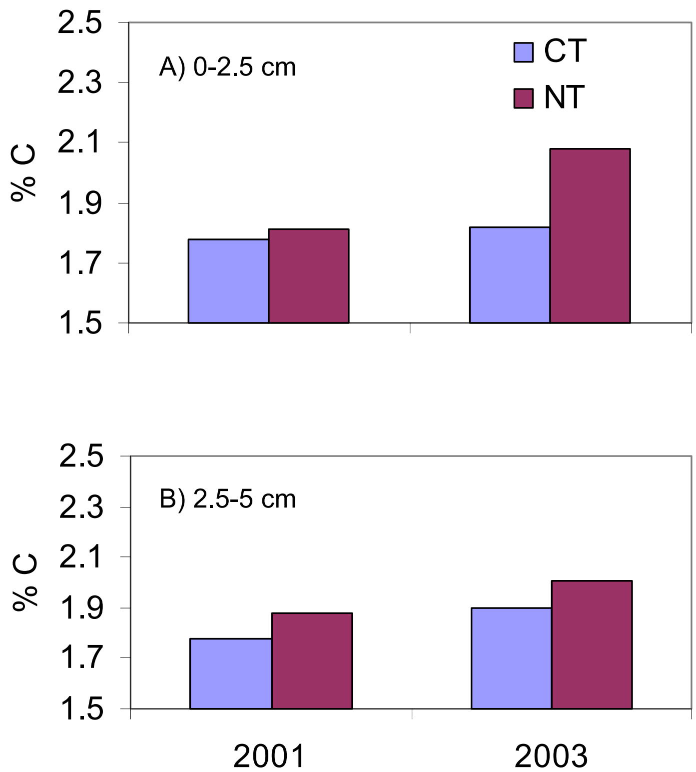

Figure 5. Changes in total soil organic C at the A) 0-2.5 cm and B) 2.5-5 cm depths between 2001 and 2003.

References:
Cambardella, C.A., E.T. Elliot. 1992. *Particulate soil organic-matter changes across a grassland cultivation sequence.* Soil Sci. Soc. Am. J. 56:777-783.
Collis-George, N. and B.S. Figueroa. 1984. *The use of high energy moisture characteristic to assess soil stability*. Aust. J. Soil Res. 22:349-356.
Hillel, D. 1998. Environmental Soil Physics, pp.194. Academic Press, San Diego, CA.
Pierson, F.B. and D.J. Mulla. 1990. *Aggregate stability in the Palouse Region of Washington: Effect of landscape position*. Soil Sci. Soc. Am. J. 54:1407-1412.
Pierson, F.B. and D.J. Mulla. 1989. *An improved method for measuring aggregate stability of a weakly aggregated loessial soil*. Soil Sci. Soc. Am. J. 53:1825-1831.
Six, J., E.T. Elliot, K. Paustian, and J.W. Doran. 1998. *Aggregation and soil organic matter accumulation in cultivated and native grassland soils*. Soil Sci. Soc. Am. J. 62:1367-1377.

Entomology. Sampling was conducted at the Kambitsch experimental farm from 2000 to 2002 to evaluate incidence and severity of insect pests and their natural enemies on wheat, barley and pea grown under NT and CT practices. Sampling for Hessian fly was carried out throughout the growing season in six spring wheat varieties subjected to natural pressure from Hessian fly. Plants were examined for presence of Hessian fly eggs, larvae and puparia, and number of insects per plant and percentage of plants infested determined. Hessian fly egg densities were not significantly different among treatments, indicating ovipositing females showed no preference for spring wheat variety or tillage treatment. The mean number of Hessian fly puparia per plant at the end of the growing season was greater in CT plots in 2000, whereas the reverse pattern occurred in 2001, except for the variety Wawawai. Tillage had no effect on number of Hessian fly per plant in 2002. More puparia were collected from susceptible compared to resistant varieties in 2000 and 2002. In 2001, susceptible Penawawa had significantly more puparia than resistant varieties, while the density of puparia on susceptible Westbred 936 was higher than on resistant varieties other than Wawawai. Significant variation in yield among the varieties was observed only in 2000, when fly-resistant Hank yielded the highest of all varieties. Hank also had the highest 100-seed weight in 2000 and 2001, while Jefferson and Penawawa had the lowest 100-seed weights each year. Reduced tillage had no consistent effect on abundance of Hessian fly under the conditions of our experiments.

Pitfall trapping allowed us to examine populations of beneficial arthropods. In our previous STEEP reports we described all the ground-dwelling beetles captured at Kambitsch during 2000 and 2001, including pests and natural enemies of pest species. Of the natural enemies, the following five species of ground beetles were found to be numerically dominant: *Poecilus scitulus*, *P. lucublandus*, *Pterostichus melanarius*, *Calosoma cancellatum* and *Microleseis linearis*. Analysis of these species from 2000 to 2002 shows that activity-density patterns differ by species and tillage systems within crops (Fig. 6). Our data also suggest that these species are influenced strongly by crop type and crop by tillage interactions. Differential response of ground beetles to crop-cultural factors has been reported by several authors in different regions. Understanding the response of individual species to tillage and their potential for biocontrol is needed to identify principles. For instance, the two abundant *Poecilus* species found at Kambitsch and in commercial fields feed readily on crop pests. While in captivity these species consumed pea aphids in our lab. Great abundance and early season activity suggests these species might be important for the control of early season pests such as the pea leaf weevil, and aphids during June. Our data suggest these natural enemies reproduce in crop fields, and hence their predacious larvae might also help control soil dwelling pests during June and July. *Pterostichus melanarius*, on the other hand, becomes active during June. Our data indicate that the activity of this species continues into July and then declines near harvest, although this species likely remains active into the autumn. We also observed this species to readily consume aphids while in captivity in the lab. In other regions, *P. melanarius* has been shown to feed on numerous pest species, and to be an important predator of the pea leaf weevil. At Kambitsch and in commercial fields, we found this species to be significantly more abundant in NT than in CT wheat, and to be very abundant in pea fields.

The present STEEP-funded project together with the project 'Examination of Tillage Factors, Crop Type, Soils and Non-crop Habitat upon Soil Fauna and Ground Dwelling Predators in a Small Inland PNW Watershed' allowed us to evaluate pests and beneficial organisms in CT and NT production systems on-station and on-farm. Results from both projects indicate that pea leaf weevil abundance and crop damage were higher in CT than NT. In all weekly trap collections where significance was observed at Kambitsch, CT plots had greater numbers of pea leaf weevil than NT. When over the season averages are considered, 2002 was the only year with a significant difference, with CT having greater pea leaf weevil counts than NT; however, in all three years the CT collections were greater than NT. In 2000, sampling started too late to observe an early season peak for pea leaf weevil, but a well defined late season emergence peak was observed. In 2001 and 2002, early season immigration peaks were also observed.

As part of the STEEP-funded project 'Assessing the Impact of Direct Seeding (No-Till) and Conventional-Till on Crop, Variety, Soil, and Insect Responses in Years 4-6', pea leaf weevil colonization and abundance were evaluated in NT and CT plots at Kambitsch Farm. Weevils were significantly more abundant in CT plots compared to NT, with a mean of 0.42 weevils per sample in CT vs. 0.18 weevils per sample in NT ($P = 0.03$). Weevil damage was significantly greater in CT plots, with a mean of 1.38 notches per node vs. 0.53 notches per node in NT. Two mark recapture experiments were conducted to evaluate weevil activity patterns. Weevil activity was not significantly different between tillage treatments. In the first mark-recapture experiment, 0.36 weevils per day were collected on average in CT vs. 0.27 in NT. This indicates that 3.2 % of the weevils were collected per day in CT vs. 2.2 % in NT ($P = 0.89$). In the second mark-recapture test, over the course of the experiment, a mean of 10.3 weevils was captured in CT, compared to 12 in NT. That is, the percent of weevils captured per day was 7.0 % in CT, compared to 7.8 % in NT, a non-significant difference. These results show that our pitfall trap sampling method is not biased by differential weevil activity and that abundance of pea leaf weevil is greater in CT than in NT pea fields in early stages of pea growth.

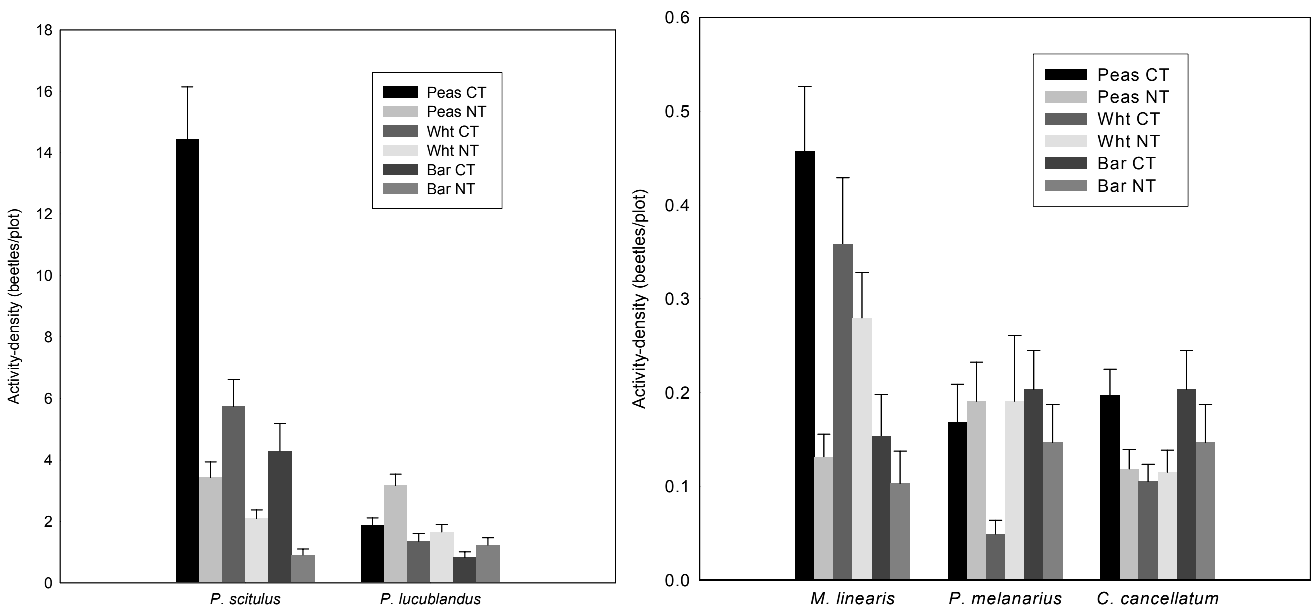

Figure 6. Response patterns of the numerically dominant ground beetles to tillage systems within crops at Kambitsch, Idaho. Wht = wheat, Bar = barley.

References cited:

Carcamo, H.A. 1995. Effect of tillage on ground beetles (Coleoptera:Carabidae): a farm scale study in central Alberta. Canadian Entomologist 127:631-639.

Carcamo, H.A., J.K. Niemala, and J.R. Spence. 1995. Farming and ground beetles: Effects of agronomic practice on populations and community structure. The Canadian Entomologists 127:123-140.

Clark, L.S., S.H. Gage, and J.R. Spence. 1997. Habitats and management associated with common ground beetles (Coleoptera: Carabidae) in a Michigan agricultural landscape. Environmental Entomology 26:519-527.

Harmon, B., R. Bardner, L. Allen-Williams, and J.B. Lee. 1990. Carabid populations in field beans and their effect on the population dynamics of Sitona lineatus (L.). Ann. Appl. Biol. 117:51-62.

Publications and Presentations (Since the previous report), *Publications.*

Guy, S.O., N.A. Bosque-Perez, S.D. Eigenbrode, J. Johnson-Maynard, and L.M. Dandurand. 2004. Assessing the impact of no-till and conventional-till on crop, variety, soil, insect, and disease responses. p. 31-46. *In* STEEP 2003 annual report. Pendleton, OR, 7-9 Jan., Univ. of Idaho, Oregon St. Univ., Wash. St. Univ., USDA-ARS, and NRCS.

Smith, L.J., S.O. Guy, Y. Wu, and K.N. Hart. 2004. North-Central Idaho Cooperative Extension Crop Management Trials 2004. 37 pages. Progress Report 370. Univ. of Idaho Coop. Ext., Moscow, ID.

Guy, S.O. and Y. Wu. 2004. Northern Idaho Extension Small Grain and Legume Variety Performance Trials 2002-2003. 49 pages. Progress Report 369. Univ. of Idaho Coop. Ext., Moscow, ID.

Johnson-Maynard, J.L., K. Umiker, and S. Guy. 2004. Earthworm populations during the first five years of direct seeding: Implications for productivity. p. 56. Proceedings of the American Association for the Advancement of Science, Pacific Division. Vol. 23 Part 1. June 13.

Guy. S.O. and Y.Wu. 2003. Variety performance of dry pea in a direct seeded and conventional seeded comparison. ASA annual meeting Nov. 2-6, 2003, Denver, Co. CD ROM. *In* 2003 Agronomy Abstracts, ASA, Madison, WI.

Guy, S.O. and Y.Wu. 2004. Crop variety response in direct-seeded (no-till) and conventional tillage. p. 164-165. *In* abstracts of 4th International Crop Science Congress. 26 Sept.-1 Oct., Brisbane, Queensland, AU.

Guy, S.O. and Y.Wu. 2004. Crop variety response in direct-seeded (no-till) and conventional tillage. CD ROM, 5 pages. *In* Proceedings of 4th International Crop Science Congress. 26 Sept.-1 Oct., Brisbane, Queensland, AU.

Guy, S.O. and Y.Wu. 2004. Crop variety response in direct-seeded (no-till) and conventional tillage. Web publication: www.cropscience.org.au accessed 28 Oct., 2004.

S.O. Guy and Y. Wu. 2004. Northern Idaho Extension Small Grain and Legume Variety Performance Trials 2002-2003. January, 2004. [Online][54 pages in Acrobat PDF format] Available at http://www.ag.uidaho.edu/cereals/nidaho/02-03_tables/nw_idaho_0003.htm (accessed 27 October 2004). UI College of Agriculture and Life Sciences Extension Cereal website, Moscow, ID.

Castle, S.C., N.A. Bosque-Pérez, D.J. Schotzko, and S.O. Guy. The impact of tillage practices on Hessian fly populations on fly-susceptible and resistant spring wheat varieties. Submitted to *Journal of Economic Entomology*.

Bosque-Pérez, N.A., E.J. Souza, and D.J. Schotzko. 2004. Working to control Hessian fly in northern Idaho. *Idaho Grain*, Winter edition. (In Press).

Castle, S. 2003. The effect of tillage practices on management methods for the Hessian fly (*Mayetiola destructor* Say). MS Thesis, University of Idaho.

Hatten, T.D., S.D. Eigenbrode, N.A. Bosque-Pérez, S. Gebbie, F. Merickel, and C. Looney. 2005. Influence of matrix elements on prairie-inhabiting epigeal Curculionidae, Tenebrionidae, and Scarabaeidae in the Palouse: Is conservation tillage conservation biology? Proceedings of the19th North American Prairie Conference (in review).

J.L. Johnson-Maynard, K. Umiker, and S. Guy. 200_. Earthworm population density and dynamics in the first five years of no-till (in prep for the Journal of Soil Biology and Biochemistry).

Presentations.

Guy, S.O. and Y. Wu. November 4, 2003. Variety performance of dry pea in a direct seeded and conventional seeded comparison. ASA annual meeting Nov. 2-6, 2003, Denver, Co. 3,500 in attendance.

Guy, S.O. and Y. Wu. December 3, 2003. Variety performance of dry pea in a direct seeded and conventional seeded comparison. Regional Pea and Lentil Growers Meeting, Moscow, ID, 95 in attendance.

Guy S.O. December 4, 2003. N. Idaho variety performance for cereals and legume crops and tillage interactions with variety performance. Nez Perce Co. Extension advisory committee meeting, Lewiston, ID. 16 attended.

Guy S.O. December 16, 2003. Tillage effects on variety performance of wheat, barley, and pea. Invited presentation at the ClearWater Direct Seeders meeting, Lewiston, ID. 24 attended.

Guy, S.O. and Y. Wu. January 7, 2004. Variety performance of dry pea in a direct seeded and conventional seeded comparison. Poster presentation at the Pacific Northwest Direct Seed Conference, Pendleton, OR. 450 attended.

Guy, S.O. August 30, 2004. Farming on the Palouse, History and No-tillage agriculture. Field lecture to PS104 students, Parker Farm, Moscow, ID. 75 attended.

Guy, S.O. Sept. 9, 2004. N. Idaho variety performance and future planning update. Annual area Extension and research meeting. Pendleton, OR. 24 attended.

Guy, S.O. and Y. Wu. September 29, 2004. Crop variety response in direct-seeded (no-till) and conventional tillage. Poster presentation at the 4th International Crop Science Congress. Brisbane, Queensland, AU. 1000 attended.

Johnson-Maynard, J.L., K. Umiker, and S. Guy. June 14, 2004. Earthworm populations during the first five years of direct seeding: Implications for productivity. American Association for the Advancement of Science, Pacific Division annual meeting. Logan, Utah. 45 attended.

Bosque-Pérez, N. A. 2004. Development of resistant wheat cultivars for management of Hessian fly in northern Idaho. Idaho Wheat Commission Research Review, Boise, Idaho, February 2004.

Hatten, T.D., N.A. Bosque-Pérez, and S.D. Eigenbrode. 2004. Tillage across crops differentially affects the capture efficiency of pitfall traps for three species of ground beetles. Entomological Society of America Pacific Branch 88th Annual Meeting, Bozeman, Montana. June 20-24, 2004.

Hatten, T.D., N.A. Bosque-Pérez, and S.D. Eigenbrode. 2004. Tillage within and across crops differentially affects the activity-density and diversity of ground beetles. Annual Meeting Entomological Society of America, Salt Lake City, Utah, November 14-17, 2004. (poster presentation)

Hatten, T., N.A. Bosque-Pérez, S. Eigenbrode, and S. Gebby. 2004. Influence of habitat fragmentation and matrix elements on the ground-dwelling beetle and spider fauna of the Palouse: Does conservation tillage conserve biodiversity? Latah Soil and Water Conservation District Board Meeting, Moscow, Idaho. March 2, 2004.

Hatten, T.D., S.D. Eigenbrode, N.A. Bosque-Pérez, S. Gebbie, and C. Looney. 2004. Influence of matrix elements on prairie-inhabiting epigeal arthropods of the Palouse: Is conservation tillage conservation biology? 19th North American Prairie Conference, Madison, Wisconsin, August 8-12, 2004.

Hatten, T.D., S.D. Eigenbrode, N.A. Bosque-Pérez, S. Gebbie, and C. Looney. 2004. Is conservation tillage conservation biology? Annual Meeting Washington State University and University of Idaho Interorganismal Interaction Working Group, Camp Wooten, Washington, August 29, 2004.

Schotzko, D.J., R. Dahlquist, T. Hatten, S.D. Eigenbrode, and N. . Bosque-Pérez. 2004. Effect of tillage on pitfall trap capture efficiency and the relative or absolute abundance of the pea leaf weevil in peas. Annual Meeting Entomological Society of America, Salt Lake City, Utah, November 14-17, 2004. (poster presentation).