Table 1. Comparison of W-3147 and SDC-348 Multistate Projects

	W-3147	SDC-348
Objective 1	To identify and characterize new biological agents, microbial community structures and functions, naturally suppressive soils, cultural practices, and organic amendments that improve control of diseases caused by soilborne plant pathogens.	Evaluate the population genetic diversity of soilborne pathogens and antagonistic microorganisms in different growing systems and regions using traditional and metagenomic approaches.
Objective 2	To understand how microbial populations and microbial gene expression are regulated by the biological (plants and microbes) and physical environments and how these influence disease**.**	Examine the effect of traditional or newly developed management strategies (chemical, cultural, and biological), soil physicochemical properties, or introduced biological control agents on the microbial community and its ability to suppress soilborne pathogens.
Objective 3	Implement sustainable management strategies for soilborne pathogens that are biologically based and are compatible with soil health management practices.	
Objective 4	Provide outreach, education, extension and technology transfer to our clients and stakeholders-growers, biocontrol industry, graduate and undergraduate students, K-12 students and other scientists.	

Table 2. Comparative analyses of research on disease systems in the two Regional Projects

DISEASE SYSTEM	W-3147	SDC 348
Vegetables		
Seedling diseases	NY,MI	OK, MS, TN,
Seed borne diseases	WA, CA-D	
Sclerotinia-potato, lettuce, Lima bean	CA-D, CA-ARS	
Fusarium wilt	WA, CA-D	
Damping-off	MT, WA, NY,MI	NC, TN
Phytophthora	NM, NY,MI	TN
Rhizoctonia-beans	NY	TN
Pythium	NY, MT, OR, CA-ARS, MI	TN, NH, OK
Macrophomina	CA-R	NH
Botrytis	CA-ARS, WA	
Verticillium	CA-ARS, WA, MT	PA
Field crops		
Wheat		
Seedling disease		MS, OK, TN
Take-all	TX, WA-ARS	
Pythium-Rhizoctonia,	WA-ARS	
Fusarium	WA-ARS, NE, MT	
Soybean		
Sclerotinia	MI	NH
Pythium-Rhizoctonia	NE, IL	IA, TN
Fusarium		
Phytophthora	IL	
Snap beans		
Seedling disease	NY	MS, IA, TN
Rhizoctonia	NY	TN,
Fusarium	NY	
Pythium	NY	
Phialophora	IL	
Thielaviopsis	NY	
Cotton		
Seedling disease		OK, TN, MS
Potato *Streptomyces*	MN	
Sugarbeet		
Aphanomyces	MT	
Damping-off	NE, MT	
Corn		
Fusarium		MS
Seed disease	MT	
Legumes		
Seedling disease	WA-ARS, NY	
Ornamentals and turf		

Anthracnose	NE	
Fescue - leaf spot	NE	
Seedling disease	NE	TN
Phytophthora-Pythium	CA-R,OR	OK
Nematode diseases		
Sugarbeet cyst	CA-R, NY, MT	
Root knot	CA-R, MT, NY	
Soybean cyst	CA-R, IL	
Root lesion (apple)	WA	
Citrus, avocado		
Phytophthora	CA-R	
Melons – *Monosporascus*	CA-R	
Olpidium	CA-R	
Tree Diseases		
Phytophthora ramorum	OR	
Peach Replant	CA-R	
Apple Replant- *Rhizoctonia* *Pythium,* *Phytophthora, Cylindrocarpon*	WA-ARS	
Strawberry		
Macrophomina, Pythium, Fusarium		

Table 3. Project Leaders

Project Leaders.

Resources State	**Agency/ Institution**	**Principal Leader**	**Cooperators**	**Area of Specialization**	**SY**	**PY**	**TY**
California	University of California, Riverside	J. Borneman		Plant Path.	0.10		
California	University of California, Riverside	M. Stanghellini		Plant Path.	0.10		
California	University of California, Riverside	J. O. Becker		Nematology	0.15		
California	University of California, Riverside	A.T. Ploeg		Nematology	0.15		
California	University of California, Davis	Krishna V. Subbarao		Plant Path.	0.10		
Illinois	University of Illinois	Darin Eastburn		Plant Pathl.	0.10		
Michigan	Michigan State University	Jianjun Hao		Plant, Soil & Microbial. Sci.	0.10		
Minnesota	University of Minnesota	Linda Kinkel		Plant Path., Microbial Ecology	0.10		
Montana	Montana State University	Barry Jacobsen	Alan Dyer	Horticulture/ Plant Path.	0.25		0.25
Nebraska	University of Nebraska	Gary Yuen	Robert Harveson	Plant Path.	0.20		
New Jersey	Rutgers University	James White		Plant Path.	0.20		
New Mexico	New Mexico State	Soun Sanogo	Manoj Shukla	Plant Path.	0.10		
New York	NY SAES Geneva	G. S. Abawi		Plant Path/ Nematol.	0.10		0.3
New York	NY SAES Geneva	Chris Smart		Plant Path.	0.10		0.1
New York	NY SAES Geneva	Gary Harman		Plant Path.			
Maryland	USDA-ARS Foreign Disease - Weed Science Research Unit	Tim Widmer		Plant Path.	0.15		
Maryland	University of Maryland	Kathyrn Everts		Plant Path.	0.5		
Mississippi	Mississippi State Univ.	Nina Ghanem		Plant Pathology	0.3		
Mississippi	Mississippi State Univ.	Sead Sabanadzovic		Plant Pathology	0.1		

Oklahoma	Oklahoma State	Michael Anderson		Microbial ecology	0.50		
Oregon	Oregon State University	Jennifer Parke	Nik Grünwald	Plant Path./Soil Science	0.15		
Texas	Texas A and M	Elizabeth Pierson					
Washington	ARS/USDA	Timothy Paulitz		Plant Path.	0.15		
Washington	ARS/USDA	Mark Mazzola		Plant Path.	0.15		
Washington	ARS/USDA	Dave Weller	 L. Thomashow D. Mavrodi	Molecular Biol.	0.10 0.2	 0.2	
Washington	ARS/USDA	Patricia Okubara		Molecular Biol.	0.10		
Washington	Washington State University	Lindsey Du Toit		Plant Path.	0.15		

Table 4. Pathogens Targets by State in W-3147 Project

Pathogen	State	Obj. 1 (Identification)	Obj. 2 (Mechanisms)	Obj. 3 (Development)	Obj. 4 (Outreach)
Fusarium	Illinois	X	X	X	X
	Maryland	X			X
	New York	X			X
	Oregon	X		X	X
	Washington	X	X	X	
	Maryland	X		X	X
	Montana	X		X	
	Minnesota		X		
Heterodera	California	X	X	X	X
	Montana	X		X	X
	Washington				X
Meloidogyne	California	X	X	X	X
	New York	X	X		X
	New Mexico	X	X		X
	Montana	X		X	X
Pratylenchus	New York	X	X		X
	Washington				X
Gaeumannomyces	Washington	X	X	X	X
	Texas		X		X
Macrophomina	Washington	X			
Phialophora	Illinois	X			
Pythium					
	Texas		X		X
	California	X		X	X
	Montana				X
	New York	X		X	X
	Oregon	X	X	X	X
	Washington		X		X
	Nebraska	X	X	X	X
	Minnesota	X	X	X	X
	Michigan			X	
Phytophthora	California	X	X	X	X
	New Mexico	X	X		X
	Oregon	X			X
	New York				X
	Michigan			X	

Rhizoctonia	California Illinois Montana New York Washington	X X X X X	X X X	X X X X X	X X X X X
Thielaviopsis	New York	X		X	X
Sclerotinia	California Michigan Maryland	X X		X X X	X X
Verticillium	New Mexico California Montana	X X	X	 X	X X X
Botrytis	WA CA				X X
Monosporascus	California	X			X
Olpidium	California	X			X
Streptomyces scabies	Minnesota Michigan	X	X	X X	X

Table 5. Biological Control Category 1: Biocontrol of pathogen inoculum.

Contributing State	**Target pathogen**	**Biocontrol agent**
CA-Riverside	*Meloidogyne* spp.	Suppressive soil; *Pochonia chlamydosporium*
CA-Riverside	*Heterodera schachtii*	Suppressive soil, *Fusarium* spp., *Dactylella oviparasitica*
CA-Riverside	*Phytophthora cinnamomi*	*Rozella* sp. *Bacillus* sp., *Hyphodontia* sp., *Trichoderma* sp.
CA-Riverside	*Monosporascus cannonballus*	Actinomycetes
CA-Riverside	Zoosporic pathogens	Biosurfactant-producing bacteria
CA-Davis	*Sclerotinia* spp.	*Brassica* amendments, green manure
Illinois	*Rhizoctonia solani, Fusarium virgaliforme, Phialophora gragata*	Cultural practices
Maryland	*Fusarium oxysporium* *Sclerotinia sclerotiorum*	Suppressive soils, *Coniothyrium minitans*
Michigan	*Sclerotinia sclerotiorum*	*Coniothyrium minitans, Trichoderma* spp.
Michigan	*Streptomyces scabies*	*Bacillus* spp., suppressive soil
MT	*Rhizoctonia solani, Botrytis cinerea, Pythium* sp.	*Muscodor albus, Bacillus pumilis*
MT	*Verticillium dahliae*	*Muscodor albus*
MN	*Streptomyces scabies* *Pythium, Phytophthora* *Fusarium*	*Streptomyces spp.,* suppressive soils, cultural practices
New Mexico	*Verticillium dahliae* *Phytophthora capsici*	Green manure and organic amendments
NY	*Meloidogyne hapla* *Fusarium, Rhizoctonia, Pratylenchus*	Cultural practices
NY	*Phytophthora capsici*	cultural practices, *Muscodor albus,*
OR	*Phytophthora* spp.	cultural practices, solarization, *Trichoderma* spp.
ARS-WA	*Aphanomyces euteiches*; *Fusarium solani*; *Fusarium oxysporum*	Suppressive soils

Table 6. Biological Control Category 2: Biological protection of plant surfaces.

Contributing State	**Target pathogen**	**Biocontrol agent**
CA-Riverside	*Meloidogyne* spp.	Suppressive soils; *Pochonia chlamydosporium*
CA-Riverside	*Heterodera schachtii*	Suppressive soils; *Fusarium* spp., *Dactylella oviparasitica*.
CA-Riverside	Plant-parasitic nematodes	Biorational nematicides
CA-Riverside and ARS-WA	*Rhizoctonia solani, R. oryzae*	Suppressive soils
MT	*Pythium ultimum* *Aphanomyces cochlioides* *Rhizoctonia solani*	*Pseudomonas aureofaciens* *Bacillus pumilis*
NY	*Rhizoctonia solani, Pythium ultimum, Thielaviopsis basicola, Fusarium oxysporum f. sp. phaseoli Meloidogyne hapla, Pratylenchus penetrans*	*Trichoderma harzianum. Bacillus subtilis, Gliocladium virens, Laetisaria arvalis, Streptomyces* sp.
Oregon	root-infecting fungi	*Burkholderia cepacia*
ARS-OR and ARS-WA	*Rhizoctonia solani, Pythium* spp.	*Pseudomonas fluorescens* Pf5,
ARS-WA and ARS-CA	*Pythium* spp.	Suppressive soils
ARS-WA	*Gaeumannomyces graminis var. tritici*	Suppressive soils
ARS-WA and TX	*Gaeumannomyces graminis var. tritici, Rhizoctonia solani, R. oryzae, Pythium* spp.	*Pseudomonas fluorescens, P. aureofaciens, Bacillus* sp.
ARS-WA	*Gaeumannomyces graminis* var. *tritici, Rhizoctonia solani, R. oryzae, Pythium* spp.	Superior colonizing strains of *Pseudomonas fluorescens*
Michigan	*Streptomyces scabies*	*Bacillus amyloliquefaciens*

Table 7. Strategy 1: The treatment of plant material and soil with biocontrol agents to maintain soil quality and health.

Contributing State	Target pathogen	Biocontrol agents
CA-Riverside	*Heterodera schachtii,* *Meloidogyne spp.*	*Dactylella oviparasitica, Pochonia chlamydosporium, biorational nematicides*
Michigan	*Streptomyces*	Chestnut tissue
MT	*Verticillium dahliae, Colletotrichum coccodes Pythium ultimum Aphanomyces cochlioides Rhizoctonia solani Heterodera schachtii, Meloidogyne spp.*	*Muscodor albus*
MN	Potato scab, *Pythium, Phytophthora,Fusarium*	*Streptomyces*
NM	*Phytophthora capsici Verticillium dahliae Rhizoctonia solani*	Seed and soil treatment with *Bacillus* and S*treptomyces* species
NY	*Rhizoctonia, Fusarium, Pythium,and Thielaviopsis* spp., *Meloidogyne hapla Pratylenchus penetrans*	*Bacillus subtilis, Gliocladium virens*, strain T22 of *Trichoderma harzianum* (Bioworks, NY), *Streptomyces* sp.
OR	*Phytophthora* spp.	*Muscodor albus*
ARS-OR	*Rhizoctonia solani, Pythium* spp.	*Pseudomonas fluorescens* Pf5
ARS-WA	*Gaeumannomyces graminis* var. *tritici, Rhizoctonia solani, R. oryzae, Pythium* spp.	*Pseudomonas fluorescens* Q8R1 and other isolates

Table 8. Strategy 2: To encourage natural biological control with mulches, soil composts, and/or cropping practices to increase and support biocontrol agents.

Contributing State	**Target pathogen**	**Practices**
CA-Riverside	*Heterodera schachtii*, *Meloidogyne* spp.	Cropping sequences to support soil suppressiveness
CA-Davis	*Sclerotinia* spp.	Brassica amendments, green manure
ARS-CA	*Verticillium dahliae*	*Myxobacteria*
MD	*Fusarium oxysporum*	Green manure amendment
MI	*Streptomyces scabies, Pythium, Phytophthora*	Cover crops, suppressive soil
MN	*Streptomyces scabies, Pythium, Phytophthora*	Green manures, organic and targeted nutrient inputs, cropping sequences, tillage frequency
MT	Fusarium crown rot	Green manures
New Mexico	*Verticillium dahliae* *Phytophthora capsici*	Green manure and organic amendments
NY	*Rhizoctonia, Fusarium, Pythium,and Thielaviopsis* spp., *Meloidogyne hapla, Pratylenchus spp.* *Phytophthora capsici*	Crop rotation, tillage systems, green manures, biocontrol agents
OR	*Phytophthora* spp.	Cultural practices
ARS-WA	*Gaeumannomyces graminis* var. *tritici, Rhizoctonia solani, R. oryzae, Pythium* spp., *Fusarium pseudograminearum, F. culmorum*	Effect of direct-seeding (no-till) on development of suppressiveness, cultural practices (fallow, greenbridge control)
ARS-WA	*Gaeumannomyces graminis* var. *tritici, Rhizoctonia solani, R. oryzae, Pythium* spp. *Fusarium pseudograminearum, F. culmorum*	Effect of crop rotation on maintenance of suppressiveness, and influence of host plant on population structure of biocontrol agent and other microbes
ARS-WA	*Pratylenchus penetrans, Pythium* spp., *Phytophthora cactorum, Phytophthora cambivora, Rhizoctonia solani*	Effect of defined amendments on development and maintenance of soil suppressiveness, identification of functional populations, and influence of host genotype on mediating response

Table 9 Milestones/Timeline

	Year 1 2013	Year 2 2014	Year 3 2015	Year 4 2016	Year 5 2017
Objective 1	Develop novel survey techniques to identify suppressive soils. Determine biological cause of suppression	Use culture-based and culture-independent, DNA based next-generation techniques to isolate and identify antagonistic microbial agents or communities to find organisms correlated with disease or pathogen suppression. Holistically examine the role of mixed microbial communities. Focus on fungal communities, building on knowledge of bacterial communities.			Determine crop rotations or cultural methods (organic amendments, cover crops) that induce, sustain or enhance soil suppressiveness
				Culture, isolate and identify putative organisms, including genetically diverse strains of same species Demonstrate through (re-)introduction into disturbed (treated) and undisturbed soil the strains role in suppression (equivalent of Koch's postulates) in greenhouse and field microplots.	
	Evaluate cultural methods in field trials such as strip tillage, greenbridge control, biofumigation, anaerobic soil disinfestation, seedmeal amendments, green manures, trap crops, etc.				
				Create more effective cropping decision model for cyst nematode impacted soils.	

Objective 2	Complete sequencing of additional biocontrol bacteria		Annotate and mine sequences, looking for unique sequences that may identify new chemistries and modes of action.		
	Continue to investigate the mechanisms listed in proposal				
Objective 3	• Establishment and maintenance of research and/or demonstration sites on field research and extension centers • Diagnosis of diseases and quantification of the population and damage of the prevalent major soilborne pathogens in the selected sites. • Identification of disease and soil health management strategies and practices to be included in the evaluation at the selected sites.	• Establish the selected combination(s) of disease and soil health management practices at the research and/or demonstration sites. • Assess the impact of the evaluated management strategies and practices on plant health and productivity at the end of the growing season. • Share and discuss the results obtained with stakeholders and industry personnel.	• Evaluate impact of the selected practices and control strategies for the second growing season (cropping cycle/rotation year 2). • Adjust management options/practices as dictated and based on the results obtained in year 2. • Provide outreach to stakeholders on the prevalent soilborne pathogens and with an update on the results obtained from the research aimed at	• Plant and maintain the research and/or demonstration plots for another growing season. • Quantify the population and damage of soilborne pathogens, crop yield, and soil health parameters. • Determine the cost-benefit of the utilized management options/practices. • Conduct the outreach activities on the damage and management of soilborne pathogens and soil health in	• Final assessment and prioritization of the impact of management strategies and selected practices against soilborne pathogens and soil health. • Promotion and facilitation of the effective management strategies and practices against soilborne pathogens that are compatible with soil health management needs. • Conducting surveys to document the level of adoption and implementation of

			controlling their damage and/or reducing their populations.	general.	promoted strategies and practices against soilborne pathogens by stakeholders.
Objective 4	Identify member (s) from industry for membership in W-3147, invite to meetings				
	Optimize and refine on-line course on *Phytophthora* for nursery growers	Write and incorporate recommendations for organic and conventional production in crops that are covered by members.			
	Provide management strategies for nematodes on vegetables in NY (eg. garlic bloat nematode) and provide ducational materials for *Phytophthora capsici.*				
	Continue with outreach to growers, pest control advisors, industry, science, policy makers, and the general public				