

V(A). Planned Program (Summary)**Program # 4****1. Name of the Planned Program**

Global Food Security and Hunger

 Reporting on this Program**V(B). Program Knowledge Area(s)****1. Program Knowledge Areas and Percentage**

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships			2%	
133	Pollution Prevention and Mitigation			5%	
135	Aquatic and Terrestrial Wildlife			2%	
201	Plant Genome, Genetics, and Genetic Mechanisms			4%	
202	Plant Genetic Resources			4%	
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants			5%	
204	Plant Product Quality and Utility (Preharvest)			6%	
205	Plant Management Systems			5%	
206	Basic Plant Biology			2%	
212	Diseases and Nematodes Affecting Plants			11%	
213	Weeds Affecting Plants			5%	
301	Reproductive Performance of Animals			16%	
302	Nutrient Utilization in Animals			2%	
305	Animal Physiological Processes			5%	
307	Animal Management Systems			14%	
308	Improved Animal Products (Before Harvest)			1%	
701	Nutrient Composition of Food			2%	
702	Requirements and Function of Nutrients and Other Food Components			2%	
903	Communication, Education, and Information Delivery			7%	
	Total			100%	

V(C). Planned Program (Inputs)**1. Actual amount of FTE/SYs expended this Program**

Year: 2014	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	11.0	0.0
Actual Paid	0.0	0.0	17.4	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	873971	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	1155709	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	2039	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Conduct applied and discovery research in multiple aspects of plant and dairy cattle agriculture, agronomy, pathology, related genetics and genomics, nutrition, and integrated aquaculture, involving shellfish, finfish, invertebrates, and seaweed. Disseminate recommendations to stakeholders in the state and region agricultural community.

2. Brief description of the target audience

Research conducted under this planned program are meaningful to different target audiences. These include consumers of animal and plant-based foods and products, organic and conventional farmers, aquaculture ventures, restaurants and other businesses reliant on local foods, master gardeners, home gardener associations, consumers and legislators, and those engaged in the extensive food systems network. Audiences also includes scientists, veterinarians, agricultural researchers, extension specialists, agricultural teachers, graduate and undergraduate students, and the faculty and staff of the region's land-grant universities.

3. How was eXtension used?

The results of a sweetpotato early harvest study in northern New England were disseminated using eXtension (http://extension.unh.edu/resources/files/Resource004491_Rep6396.pdf). The impact of harvest date on yield and sweetness were determined. Marketable yield nearly tripled from an early harvest in August, and to the third harvest in late September. Potatoes must be stored at cool temperatures for at least three weeks so that some starch reverse break down to simple sugars. Results of a two year brussel sprouts variety trial and management by topping, conducted at the NHAES Woodman Farm, were disseminated using eXtension, <http://extension.unh>.

edu/resources/files/Resource003914_Rep5563.pdf None of the open pollinated varieties did well under these field conditions. Several hybrid varieties were identified as having high marketable yields. Varieties yields varied between the two years of the trials.

V(E). Planned Program (Outputs)

1. Standard output measures

2014	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	21917	9799	176	250

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2014
 Actual: 1

Patents listed

PCT/US14/29910 Rick H. Cote, Karyn B. Cahill, and KEVIN D. SCHUSTER. Methods of Identification and Use of Nematicide Compounds.

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2014	Extension	Research	Total
Actual	2	39	41

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of undergraduate students directly involved in the projects

Year	Actual
2014	74

Output #2

Output Measure

- Number of graduate students directly involved in the research

Year	Actual
2014	40

Output #3

Output Measure

- Number of university courses in which project results have been incorporated

Year	Actual
2014	7

Output #4

Output Measure

- Number of presentations at regional, national, or international scientific meetings

Year	Actual
2014	39

Output #5

Output Measure

- Number of workshops, training sessions and presentations to non-scientific stakeholders

Year	Actual
2014	16

Output #6

Output Measure

- Number of reviewed, bulletin, popular and other publications

Year	Actual
2014	1

Output #7

Output Measure

- Number of websites in which project results have been incorporated

Year	Actual
2014	12

Output #8

Output Measure

- Number of surveys or other means of gathering information and data from participants

Year	Actual
2014	2

Output #9

Output Measure

- Number of postdocs and other scientists trained in cutting edge research methods

Year	Actual
2014	4

Output #10

Output Measure

- New varieties of mellow, pumpkin and squash developed in cooperative breeding programs between NHAES and several seed companies

Year	Actual
2014	32

Output #11

Output Measure

- Establish a mapping population from a natural hybrid *Berberis x ottawensis* from Lime CT for mapping wheat stem rust (*Puccinia graminis*) resistance the alternative host for the fungus.

Year	Actual
2014	200

Output #12

Output Measure

- Collaborative annotation of the genome of the lamprey eel, a primitive jawless fish

Year	Actual
2014	1

Output #13

Output Measure

- Develop gene expression profiles (RNA-seq) for two genotypes of the marine alga *Porphyra umbilicalis* Kutzing from contrasting habitats: an estuarine tidal rapids, and open coastal

population. These habitats have vastly different levels of nitrogen and phosphorus which are limiting for algal growth.

Year	Actual
2014	3

Output #14

Output Measure

- Molecular marker development and validation contributing to the first high-throughput genotyping platform for strawberry breeding: the Affymetrix Axiom IStraw90 SNP array.

Year	Actual
2014	1

V(G). State Defined Outcomes**V. State Defined Outcomes Table of Content**

O. No.	OUTCOME NAME
1	Increased knowledge about plant varieties and production practices suited to the state and region.
2	New knowledge about dairy production, nutrition, animal health and dairy products important to regional producers.
3	Advances in squash varieties having enhanced eating properties and nutritional benefits including carotenoid concentrations.
4	Increased knowledge about integrated multitrophic aquaculture systems.
5	New genomic knowledge translated into tools and strategies to facilitate varietal selection through marker assisted breeding.
6	New commercialized varieties of cucurbit vegetables suited to state and region growing conditions.
7	Improved range of weed management options available for sustainable and organic growers.
8	A working technology to produce triploid green sea urchins for use in natural harvest and land based aquaculture.
9	Improvement in finfish aquaculture in recirculating production systems
10	Develop regionally appropriate management systems to suppress soil borne pathogens for both organic and conventional farms.
11	Knowledge related to how the neuroendocrine system influences reproduction in fin fish aquaculture and other vertebrate animals and in the control of pest species such as lamprey eels.
12	Produce new genetic and molecular tools to investigate the mechanisms of fungal rust resistance in barberries, an alternative host of wheat stem rust
13	Improve dairy calf health and growth rates.
14	Increase the utilization efficiency of the germplasm collections through phenotypic and genotypic characterization and evaluation of the germplasm held in the collections for high-priority traits, especially resistances to biotic and abiotic stresses and nutritional traits.
15	Production of new varieties of ornamental gourds and pumpkin.
16	Enhance understanding of how actinorhizal symbiosis between the nitrogen fixing bacteria Frankia and its plant hosts contribute to environmental restoration.

17	Develop new methods to study inter-cellular interactions between somatic cells of the ovary, germ cells and the embryo of ruminants.
18	Design of next-generation nematicides with improved target specificity and reduced environmental side effects.
19	Assess the current and historical distribution of invasive weed species in Northern New England.

Outcome #1

1. Outcome Measures

Increased knowledge about plant varieties and production practices suited to the state and region.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	350

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

New Hampshire experiences a challenging growing climate and high land and labor costs, making fruit and vegetable production expensive. Sustaining agriculture requires that growers increase profitability, either through increasing production efficiency or by producing unique, high-value products. Variety trials and evaluation of new production systems, including season extending methods, may help producers improve their bottom line.

What has been done

1. Tomato, cucumber, zucchini and summer squash variety trials were conducted in high tunnels over several years.
2. The results of sweet potato variety trials were disseminated to New Hampshire and northern New England growers.
3. Production of several salad greens mixed were studies in low tunnels and minimally heated greenhouses.
4. Brussel sprout variety trials and topping were conducted in the field over two successive years.

Results

1. Vegetable varieties differ with respect to yields, resistance to pests and diseases, and market desirability, variety choice can greatly impact profits. Results from this research have shown that changing varieties can increase grower's marketable yields by 60 percent or more. For example, for tomato, switching varieties could increase market value of yields from a single 10x32m high tunnel by \$10,000 or even more.

2. The recently published 2012 Agricultural Census stated that

33 acres of sweetpotatoes are grown by more than 100 growers in New England (compared with just four acres in 2007). Assuming an average price per pound of \$1, and an average yield of 10 tons/acre, the annual economic value of this crop would be roughly \$660,000.

3a. Some species (e.g. onions, spinach, kale) frequently survived winters in low tunnels, whereas others experienced variable results (e.g. lettuce, chard, broccoli). However, low tunnels present significant logistical difficulties for growers, and as a result, adoption of this low-cost technique is likely to be limited.

3b. Online Extension tools have been developed for growers, including an enterprise budget that allows growers to evaluate the profitability of winter greens production in minimally heated greenhouses. Due to high temperature requirements for basil, it would require considerably more labor resources than initially planned and budgeted.

4. Results of a two year brussel sprout variety trial and management by topping, conducted at the NHAES Woodman Farm, were disseminated using eXtension,

http://extension.unh.edu/resources/files/Resource003914_Rep5563.pdf None of the open pollinated varieties did well under these field conditions. Several hybrid varieties were identified as having high marketable yields. Varieties yields varied between the two years of the trials.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #2

1. Outcome Measures

New knowledge about dairy production, nutrition, animal health and dairy products important to regional producers.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Purchase feeds including forages and grains constitute most expenses for organic and conventional dairy farms in the Northeast. Research with alternative forage crops (AFC) and alternative feed sources are needed to reduce feed costs and increase the social and economic sustainability of dairy farming in the region.

What has been done

1. Surveys and focus group studies were conducted with Northeast dairy farmers about challenges surrounding sustainability of providing high quality animal feeds.
2. Feeding trials were conducted with alternative protein sources including field peas supplemented with rumen protected lysine and methionine

Results

1. Results from surveys and focus groups of Northeast dairy farmers confirm that opportunities exist to develop resilient alternative forage crops systems (e.g., warm and cool season grasses, summer annuals, brassicas) that provide supplemental forage for grazing and/or silage feeding during periods of limited biomass production (e.g., early spring, the "summer slump", and late fall). Opportunities also exist to better understand energy and protein use efficiency and animal health in dairy cows fed supplements such as field peas and flaxseed meal.
2. Preliminary results indicate that alternative forage crops have potential to extend the grazing season and replace traditional forages in dairy farms. Our preliminary results also showed that field peas can replace corn meal and soybean meal in dairy diets without a negative impact on milk production and milk components (i.e., fat, protein, and lactose).

4. Associated Knowledge Areas

KA Code	Knowledge Area
302	Nutrient Utilization in Animals
305	Animal Physiological Processes
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Advances in squash varieties having enhanced eating properties and nutritional benefits including carotenoid concentrations.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Hybrid varieties of fresh market winter squash and pumpkin have largely supplanted open-pollinated varieties because of their uniformity and consistency of yield and fruit quality. Open pollinated varieties, on the other hand, are still the dominate type grown by farmers for the pie and baby food processing industry. The potential of interspecific hybrids for the fresh market squash industry is no less than that of the processing industry. However, the hybrids tested to date produce exceptionally early female flowers and tend to set some fruit too close to the crown of the plant, thereby suppressing vegetative growth and resulting in variability in fruit size and flesh quality.

What has been done

Current breeding efforts are focused on developing strains of Cucurbita moschata fresh market types of squash which flower later and have a higher ratio of male to female flowers such as occurs in some of the processing cultigens. It is expected that such strains in hybrid combination with C. maxima will result in a more acceptable pattern of fruit set.

Results

1. Seven fresh market inter-specific hybrids were evaluated during the summer of 2014. Fruit size for several hybrids were good but fruit DW and soluble solids were marginal. One notable trait in fruit of all interspecific hybrids was excellent shelf life and resistance to common storage rot diseases. One hybrid, NH1311, has been selected for further evaluation.

2. The interspecific hybrid NH1310 (NH65 x SC936) produced yields greater than 60 metric tons per hectare in 2012 and 2013, and fruit solids content (8.0 to 9.5 percent) was acceptable for pie processing. However, the texture of the pumpkin puree appeared excessively stringy for use for pie puree stock.

2. One of the new C. moschata and two of the new bush C. maxima lines are uniform enough for making experimental hybrids. In a replicated field trial during the summer of 2014 four experimental, interspecific hybrids were evaluated for growth habit, patterns of fruit set, fruit traits, and uniformity: NH1310, NH1321, [NH65 x Long Island Cheese (LIC)], NH1320 (NH65 x NH176-29), and NH1323 (NH65 x NH204-3916). All hybrids showed high tolerance to powdery mildew and leaf canopies were more resistant to late season senescence than in C. moschata hybrids growing in an adjacent plot. Mesocarp dry weight (DW), in the hybrids were similar, with values of 9.6, 9.1, 9.1, and 9.7 percent and this was unexpected because flesh dry matter in squash

generally shows additive genetic variation with hybrid dry weights close to the mean of the two parents.

3. In an effort to improve puree texture both for pie stock and baby food, additional bush *C. maxima* and vining *C. moschata* breeding lines are being developed with selection for improved textural properties of the cooked flesh and with carotenoid profiles enhanced for nutritional value.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)

Outcome #4

1. Outcome Measures

Increased knowledge about integrated multitrophic aquaculture systems.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The increased interest in Integrated Multi-Trophic Aquaculture (IMTA) provided the focus for studies to investigate integrating the culture of finfish, oysters, sea urchins and seaweeds in various combinations with the goals of: (1) increasing the economic potential of an aquaculture enterprise and (2) to determine the potential environmental advantages of reducing waste production through combining species.

What has been done

A series studies were conducted testing various combinations of species that might be integrated into aquaculture systems in New England.

1. The portion of the project focused on eastern oyster (*Crassostrea virginica*) farming in combination with seaweeds and sea urchins, with the overall aim being an assessment of the IMTA potential for New Hampshire oyster farmers.

2. Studies were conducted that focused on determining ammonia production rates from American oysters of different sizes and densities (0.006 kg/L and 0.013 kg/L), juvenile black sea bass (*Centropristis striata*) and hybrid striped bass (*Morone saxatilis* x *M. chrysops*) held at two densities (0.005 kg/L and 0.010 kg/L). The studies with the hybrid striped bass served as a foundation for later aquaponic studies in which these fish were co-cultured with lettuce and other greens, in freshwater systems.

3. The primary focus of the seaweed work has been to develop and optimize techniques for the nursery production of several native species of seaweed.

Results

1. Results for combined eastern oyster, seaweed and urchins studies were highly variable. The major issue that became evident early on was that the type of gear used to deploy the seaweeds was critical to their growth. Typically used approaches such as rope culture did not work on in New Hampshire estuarine sites due to strong tidal currents that caused rapid fouling by drifting material. While experiments demonstrated potential for oyster/seaweed IMTA and identified gear development as the most important area for further research.

2. High density hybrid striped bass treatment group produced 3.7 times more ammonia (224 mg/kg) than the low density treatment (60.5 mg/kg) over a 12-hour period. Black sea bass are extremely sensitive to ammonia production and the experiments were terminated prior to (12 hour) completion. Ammonia production was inversely proportional to size in American Oysters. Aquaponic studies with both fish species were successful over 60-day periods, during which marketable greens were produced.

3. To grow sea vegetables in coastal or shore based aquaculture systems, it is necessary to have a reliable source of "seed stock," that can be grown out at the aquaculture site. The accomplishment of this portion of the project has been to determine optimum culture conditions (temperature, light level, day length, and nutrient concentrations) for the production of spores and growth into sporelings that can be out-planted at aquaculture sites. Methods were developed for freezing sporelings so that they can be stored for later grow-out. This is a key accomplishment as it allows a continuous and reliable supply of sporelings for commercial operations, for IMTA.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
302	Nutrient Utilization in Animals
307	Animal Management Systems
903	Communication, Education, and Information Delivery

Outcome #5

1. Outcome Measures

New genomic knowledge translated into tools and strategies to facilitate varietal selection through marker assisted breeding.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The US ranks number one in the world for strawberry production. Because the domesticated strawberry is octaploid, it is very difficult to breed with conventional tools, and strawberries are propagated by vegetative cloning. Newly available genomic resources for diploid strawberry will facilitate the use by breeders of molecular markers as an aid to plant breeding (marker assisted breeding = MAB), to efficiently exploit wild related species as gene sources for improvement of cultivated strawberries, and to aid in the ultimate production of superior varieties that will benefit growers and consumers.

A prerequisite for implementation of MAB is the identification of marker-trait associations.

What has been done

NHAES (@0299267) researchers contributed substantially to the advancement of MAB in strawberry by helping to design and evaluate the first high-throughput genotyping platform for strawberry: the Affymetrix Axiom IStraw90 SNP array

Results

1. The design of high-throughput genotyping platforms requires the prior development of genomic resources such as reference genome assemblies and genetic linkage maps. Using marker data from the IStraw90 array, NHAES researchers have constructed the first genetic linkage map of the ancestral diploid strawberry species, *Fragaria iinumae*.
2. The Affymetrix Axiom IStraw90 SNP array is now available for commercial purchase from Affymetrix, Inc., and its use is being adopted widely throughout the world.
3. NHAES researchers identified markers associated with novel flower color traits in the context of a breeding program aimed at combining fruit quality and ornamental values in new strawberry cultivars. As a consequence of this effort, ten advanced selections were chosen for potential

variety protection, and ten innovation disclosures have been filed with the UNH Office of Sponsored Research.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)

Outcome #6

1. Outcome Measures

New commercialized varieties of cucurbit vegetables suited to state and region growing conditions.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Development of new varieties has been a key underpinning for production of abundant and nutritious vegetables in North America. 1)An important method for use in reducing the cost of hybrid seed production in melon is to employ female parents in hybrid production that are gynocious, or largely produce only female flowers.

2)In summer squash, the glabrous trait argely eliminates the large trichomes (spines) on stems and petioles which irritates the skin of workers and results in unsightly abrasions to harvested fruit.

What has been done

1)In melon, the gynocious (female flowering) trait was developed in New Hampshire melon lines in the early 1970s. Numerous backcrosses of female lines to acceptable parentage have been required to eliminate undesirable genes that were transferred from the original plant sources of genes for female flowering, a phenomenon called linkage drag.

2)In yellow summer squash, a glabrous mutant was discovered in 1992 in a relic variety. This

trait has been utilized at the University of New Hampshire to develop improved inbred lines for producing hybrids, one of which was released in 2009.

Results

NHAES researchers successfully developed one Galia (green fleshed) inbred and two cantaloupe inbred lines with good eating quality, appearance, and resistance to powdery mildew and fusarium wilt. These lines can either be used directly for making hybrids or can be further improved for specific melon types with minimal additional breeding input.

2)In 2014,22 experimental hybrids carrying the glabrous trait were tested for resistance to powdery mildew disease. Several of the hybrids looked promising for commercial use and one has been released to a seed company for commercial production.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)

Outcome #7

1. Outcome Measures

Improved range of weed management options available for sustainable and organic growers.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Organic producers routinely cite weed control as a significant challenge to their operations and request applied research aimed at developing more effective and sustainable weed management strategies. Cover crops grown as monocultures or as mixtures may provide opportunities for ecologically-based weed management.

What has been done

1. Field experiments aimed at determining the effects of cover crops and cover crop mixtures ("cocktails") on weed population dynamics were established at the UNH Kingman and Woodman Research Farms.
2. Two field experiments were established at the UNH Kingman and Woodman Research Farms to examine how mixtures of perennial ryegrass affect stand dynamics, forage productivity, and weed abundance relative to ryegrass monocultures. Ryegrass and weed biomass have been measured twice each growing season.

Results

1. Cover crop cocktails did not suppress weeds as well as the most weed-suppressive cover crop monoculture (buckwheat) and that cover crop biomass was more important than species identity in determining which weed species were suppressed.
2. In general, ryegrass productivity could be increased by 21 percent relative to the most productive monoculture simply by planting a six-cultivar mixture.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
205	Plant Management Systems

Outcome #8

1. Outcome Measures

A working technology to produce triploid green sea urchins for use in natural harvest and land based aquaculture.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Edible sea urchin fisheries are high-value commercial enterprises on all coasts of the United States. Drastic overfishing of this natural resource has resulted in a near collapse of the fisheries. Alternatives to direct harvest of wild sea urchins are vital to sustain this fishery that provides an exportable product for American fishermen and with potential to help the US trade deficit.

What has been done

1. Laboratory methods were developed to generate triploid green sea urchin embryos.
2. Various methods were explored to transfer embryos to hatcheries and maintain embryos through sequential stages of metamorphosis.

Results

This study has established that a variety of individuals can produce triploid sea urchins. However the difficult step in the overall aims of study was the successful transfer of triploid late plutei to a hatchery facility. In each case, our recirculation regimedamaged the larvae. As a result, embryos did not achieve metamorphosis and did not generate adult triploid sea urchins. This aspect of this study requires more attention.

The techniques to accomplish this are in press in the following book, Sea Urchin and Sea Cucumber Aquaculture Hardcover, eds. Nicholas Brown & Steve Eddy to be published June 15, 2015, by Wiley-Blackwell. Methods developed in this study the enhancement of nutritive phagocyte size, taste and availability will be readily available to all involved in sea urchin aquaculture.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems

Outcome #9

1. Outcome Measures

Improvement in finfish aquaculture in recirculating production systems

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The growth of aquaculture is meeting resistance in many areas because of issues related to sustainability. One remedy for all of these concerns is to grow fish in tanks in land-based systems that continuously re-use water (recirculating systems). Because of the expenses involved in recirculating high-value fish, such as summer flounder and black sea bass must be produced. Growth rate remains the dominant factor controlling profitability of land based culture of these species, and the costs associated with juvenile growth to market size must be reduced to gain competitiveness.

What has been done

The use of the phytoestrogen genistein to feminize summer flounder populations was investigated. The effects of population density were determined on sex differentiation in black sea bass.

Results

The major finding of these studies included gene expression profiles during sex differentiation (summer flounder) and sex change (black sea bass). As growth is sexually dimorphic in these species, these findings provide insight into improving profitability of marine aquaculture, and development of monosex populations (all female) will have a dramatic economic impact on production costs for producers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
135	Aquatic and Terrestrial Wildlife
305	Animal Physiological Processes
307	Animal Management Systems
308	Improved Animal Products (Before Harvest)

Outcome #10

1. Outcome Measures

Develop regionally appropriate management systems to suppress soil borne pathogens for both organic and conventional farms.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The overarching goals of the project are to determine the mechanisms by which alternative control strategies, such as cultivar mixtures, cover crops, and organic amendments, alter the microbial community in the soil including both pathogenic and beneficial organisms. Alternative control strategies will lessen the need for chemical control of fungal pathogens, and protect beneficial organisms need to maximize crop yields.

What has been done

1. Alternative assays were developed for screening for resistance to soilborne root and wilt pathogens for strawberry.
2. Comparative genomics was used to investigate what factors may control why some strains of *V.dahliae* infect strawberry while other infect mint.
3. Fungal biomass was evaluated after mixtures of perennial ryegrass were established at sites in Maine, New Hampshire, Pennsylvania and Vermont.

Results

1. The green fluorescent protein (GFP) labeled strain of *V. dahliae* to measure colonization of susceptible, tolerant (visually healthy but ingress of fungal hyphae present), and resistant (visually healthy no ingress of fungal hyphae). This process was initiated in the past year and protocols for inoculum production, inoculation, and visualization by confocal microscopy have all been standardized. Screening strawberry cultivars with known levels of resistance and susceptibility has been initiated.
2. Preliminary results indicate that the strawberry strains of *V. dahliae* belong to genetically distinct lineages. One of the strawberry strains is more closely related to a strain recovered from lettuce than to the other strawberry strain. This may indicate that virulence to strawberry is present in several lineages of *V. dahliae*.
3. Soil has been collected from four sites in three consecutive years. Significant increase in fungal biomass was measured at all locations one year after the plot were established. However, a decrease in fungal biomass was measured at the end of year two, likely due to the fact that there was a significant winter-kill of the perennial ryegrass, that left many of the plot with 70-90 percent clover. This dramatic shift the plant community had an important effect on the soil microbial community.
4. A survey was completed of fungal pathogens *Rhizoctonia* associated with wheat, canola, soybean, and dry bean.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
205	Plant Management Systems
212	Diseases and Nematodes Affecting Plants

Outcome #11

1. Outcome Measures

Knowledge related to how the neuroendocrine system influences reproduction in fin fish aquaculture and other vertebrate animals and in the control of pest species such as lamprey eels.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Controlling reproduction either by improving efficiency or preventing population increases in commercially important and non-indigenous fish species, respectively, is of critical importance to farmers and fish and wildlife biologists. To control reproduction, it is critical to understand the underlying mechanisms of neuroendocrine control; i.e. the hormones and receptors that mediate these processes: gonadotrophin releasing hormone (GnRH) and its receptors in the brain.

What has been done

Major brain and pituitary reproductive hormones and receptors as well as expression of these hormones in black sea bass, hagfish and lampreys. The identified hormones are the major hormones that control reproduction in these fish as well as other vertebrates.

Results

1. Identification and functional studies of the glycoprotein hormone (GpH) in hagfish and lamprey pituitaries.
2. The distribution of the three identified GnRH receptors in the brain and pituitary and other tissues of lampreys were determined at three distinct life stages.
3. Two GnRH receptors were identified different stages of development in the black sea bass brain.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals
305	Animal Physiological Processes

307 Animal Management Systems

Outcome #12

1. Outcome Measures

Produce new genetic and molecular tools to investigate the mechanisms of fungal rust resistance in barberries, an alternative host of wheat stem rust

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Wheat is one of three grains that produce 60 percent of the world's caloric intake. Barberries, (*Berberis* spp.) is the alternative host of *Puccinia graminis* f. sp. *tritici*, the causal organism of wheat stem rust. Barberries were eradicated in the wheat belt, in the 1900's. However barberries are wide spread as an ornamental in the Northeast United States. Wheat production has returned to the NE USA. Developing genomic resources for barberries will support global barberry surveillance efforts to detect new strains of wheat rust. These resources also will aid in understanding how some species of barberry are resistant to *Puccinia*.

What has been done

A *Berberis* spp. germplasm collection is being built at the NHAES, for the purpose of developing taxonomic molecular markers.

A naturally occurring hybrid population *B. ×ottawensis* was identified in Lime Kiln CT. Controlled crosses were made to develop mapping populations for barberry.

Results

200 offspring of the hybrid *B. ×ottawensis* were phenotyped, sampled, propagated. Genotyping-by-sequencing was carried out on four barberry accession to provide molecular markers for mapping resistance genes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms

202 Plant Genetic Resources

Outcome #13

1. Outcome Measures

Improve dairy calf health and growth rates.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Dairy producers are interested in improving calf health and growth. This will result in decreased veterinary and medical expenses along with optimal growth response resulting in an earlier age at first calving. Calves are born with a naive immune system and must obtain their initial immune functioning system from the first secretion of the udder-colostrum. Approximately 60 percent of the nation's newborn dairy herd fails to adequate immunity (defined as 10g/L immunoglobulin G at 24 hours of age).

What has been done

1. Investigate whether the diet of the prepartum cow impacts immunoglobulin G uptake in their calves.
2. Compare dairy calf development on alternative diets of high protein milk replacer compared to conventional milk replacer.

Results

1. Modifications on the diet that the cow receives prepartum can affect immunoglobulin G uptake by their respective calf. This is important because producers may be able to correctly feed their prepartum dams to maximize immunoglobulin G uptake by their respective calf.
2. Calves fed a high-protein milk replacer (26 percent crude protein) grow at a faster rate, but produce twice as much urine and are only about 50 per cent as efficient in utilizing dietary nitrogen compared to calves fed a conventional milk replacer (22 per cent crude protein).
3. These new management strategies will be disseminated to regional dairy farms via the NH Dairy Report, in the next fiscal year.

4. Associated Knowledge Areas

KA Code	Knowledge Area
133	Pollution Prevention and Mitigation
302	Nutrient Utilization in Animals
305	Animal Physiological Processes
307	Animal Management Systems

Outcome #14

1. Outcome Measures

Increase the utilization efficiency of the germplasm collections through phenotypic and genotypic characterization and evaluation of the germplasm held in the collections for high-priority traits, especially resistances to biotic and abiotic stresses and nutritional traits.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Hull-less pumpkin seeds are an important oil seed crop in Eastern Europe, and are used in North America as a snack seed and in trail mixes. However, currently available cultivars of hull-less pumpkin seed pumpkins have low seed yield.

What has been done

Several hull-less seeded breeding lines have been developed at the University of New Hampshire during the past 30 years, as a result of combining germplasm from various sources, including a plant introduction accession from Poland which was instrumental in breeding for larger seed size and improved seed fill. The inbred lines developed at UNH have been used for F1 hybrids, two of which were previously commercialized.

Results

In 2014, eight semi-bush experimental hybrids were evaluated, seven of which had powdery mildew resistance. Seed fill was excellent and seed size good (161 to 222 mg) in all hybrids. Plot yields among the hybrids, extrapolated to an acre basis, ranged from 1,944 to 2,639 pounds of

hull- less seed, the highest yields obtained to date in hull-less pumpkins.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants
204	Plant Product Quality and Utility (Preharvest)

Outcome #15

1. Outcome Measures

Production of new varieties of ornamental gourds and pumpkin.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Traditional breeding projects at the University of New Hampshire have been highly successful in developing new varieties of ornamental pumpkins and gourds that enhance the capacity of farmers to provide a diversity of these ornamentals at local markets such as roadside stands, farmers markets, and related retail markets. Prior to 1996, the white nest egg gourd was a rare variety, late in maturity and relatively unproductive.

What has been done

1. Several color and pattern traits have been introgressed into egg gourd, along with the bush habit of growth and earlier maturity.
2. The color and pattern genes are being transferred from egg gourd lines into ornamental pumpkin

Results

- 1.A multiline variety released from this effort is called Goblin nest egg gourd.
- 2.In 2014, pumpkins in the 500 to 2000 g size class were obtained with multiple color and striping

combinations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
202	Plant Genetic Resources
204	Plant Product Quality and Utility (Preharvest)

Outcome #16

1. Outcome Measures

Enhance understanding of how actinorhizal symbiosis between the nitrogen fixing bacteria Frankia and its plant hosts contribute to environmental restoration.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The actinorhizal symbiosis represents an important ecological and economic role in agriculture. The plants involved are also of economic significance with respect to land reclamation, reforestation, soil stabilization, landscaping, fuel, and as a food source for ruminant animals. Actinorhizal plants provide an excellent mechanism to restore disrupted environmental sites. Genomic data resulting from this research provide new insights as how Frankia contributes to environmental restoration. One of the most serve environmental factors affecting arable land is salinity. Other environmental factors impacting arable land are contamination with heavy metals.

What has been done

1. Continue studies to identify and clarify the roles of Frankia natural products play in the actinorhizal symbiosis and for life in the rhizosphere, the Frankia genomes have been data mined and potential novel natural products have been identified.
2. Several Frankia strains that were isolated from Casuriana plants, which are known to be salt tolerant, were evaluated.
3. A comparative analysis of the Frankia genomes has provided several models to explain heavy metal tolerance levels among the Frankia strains.

Results

1. Analysis of the Frankia genomes suggested that some of these strains have the metabolic potential to degradation naphthalene and other toxic hydrocarbons.
2. Key genes involved in Frankia response to harsh saline conditions were identified by comparative gene expression studies.
3. Lead (Pb+2) tolerance concurs via a binding mechanism that uses carbohydrates and phosphate molecules. Copper (Cu+2) tolerance was also shown to driven by another binding mechanism that generated Cu+2 containing nanostructures found on the surface of the cells.
- 3.

4. Associated Knowledge Areas

KA Code	Knowledge Area
203	Plant Biological Efficiency and Abiotic Stresses Affecting Plants

Outcome #17

1. Outcome Measures

Develop new methods to study inter-cellular interactions between somatic cells of the ovary, germ cells and the embryo of ruminants.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

The pregnancy rate in lactating cows on the average US dairy farm is currently at an all-time low (between 20-30 percent). Resulting infertility costs that exceed \$350 million annually to dairy producers. The research focuses on the ovarian and embryonic mechanisms that underlie the causes of anovulation, fertilization failure, and early embryonic loss in ruminants.

What has been done

A serum-free, bovine granulosa cell (bGC) culture system has been developed which will enable further investigation of signal transduction pathways invoked during immune-mediated apoptosis, and potential mechanisms to evade such attack.

Results

This culture system provides for hormone-induced cell proliferation, cytokine-induced cell death, and the variable expression of pro-survival, hormone receptor, and steroidogenic genes of bGCs in a manner similar to that described for previously reported culture models. Importantly, however, the current model provides for culture of bGCs from small follicles in a manner that preserves animal variation for experimental purposes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
301	Reproductive Performance of Animals

Outcome #18

1. Outcome Measures

Design of next-generation nematicides with improved target specificity and reduced environmental side effects.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Agricultural damage caused by nematodes primarily occurs through the crops root system. Traditional nematicides are typically neurotoxins that are environmentally dangerous, of limited efficacy, and toxic to humans, birds, fish, and bees. There exists a need to develop next-generation nematicides with greater target discrimination, efficacy, and environmental safety profiles.

What has been done

Bioinformatic analyses of known endoparasitic nematode genomes (and other nematode genomes, including the completed genome of *C. elegans*) have been conducted to identify and categorize putative nematode phosphodiesterase (PDE) genes into phylogenetically distinct

families referenced to the Class I vertebrate PDE superfamily. PDE3 and PDE4 inhibitors show particular promise for disrupting the physiology of nematodes *C. elegans* and *Meloidogyne hapla* (root knot nematode)

Results

The nematode PDE3 sequences form a clade that exists as an out-group of other metazoan phyla; similar results are seen for PDE4. Furthermore, within the Anthropoda phylum, PDE3 is absent in the Insecta species examined and was present only in the Arachnida class. The evolutionary divergence of nematode PDEs and the absence of PDE3 in insects makes PDE3-selective inhibitor compounds particularly attractive targets for development of nematicides with reduced adverse effects on animals other than nematodes.

The research conducted in this project has led to a patent application PCT/US14/29910 Methods of Identification and Use of Nematicide Compounds

4. Associated Knowledge Areas

KA Code	Knowledge Area
212	Diseases and Nematodes Affecting Plants
305	Animal Physiological Processes

Outcome #19

1. Outcome Measures

Assess the current and historical distribution of invasive weed species in Northern New England.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2014	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)

Ongoing climate changes will make new habitats suitable for both native and invasive weeds in the Northern New England (NNE: Vermont, New Hampshire, Maine) region, resulting in new problems for weed management and potentially added costs to growers.

What has been done

Extensive seedbank surveys were conducted on 77 organic vegetable farms across the three states in Northern New England. Geographic and climatic data specific to each of the 77 farms that were sampled across the three participating states. Contemporary and historical genetic/genomic patterns of variability were assessed within each of the targeted weed species, three distinct approaches were taken with respect to ten species.

Results

More than 52,000 seedlings were identified and enumerated, providing a broad picture of weed distribution in the three state region. Species differed markedly with respect to morphological diversity, ranging from a lack of evident diversity among samples of hairy galinsoga (*Galinsoga ciliata*) to remarkable ranges of diversity in pigweed (*Amaranthus* spp.) and yellow wood sorrel (*Oxalis stricta*), the latter including variations in flower color and size, the extent of stem and petiole "hairiness," leaf color, and others.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
213	Weeds Affecting Plants

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Other (None)

Brief Explanation

None

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The primary criteria for productivity for projects covered in this planned program are a robust record of peer-reviewed publication. Projects in this planned program produced 41 peer reviewed papers as well as five graduate theses, and three book chapters.

Key Items of Evaluation

- NHAES researchers contributed to the first high-throughput platform for genotyping for strawberry, the Affymetrix Axiom IStraw90 SNP array. This is being widely adapted for Marker Assisted Breeding (MAB) in strawberry.
 - Four hybrid varieties of kabocha (buttercup) squash have been released which are being commercially marketed.
 - Field peas, an alternative forage crop, has been shown to replace corn meal and soybean meal in dairy diets without negative impact on milk production and quality. These will reduce feed costs for dairy farmers in the Northeast.
 - Tomato variety trials in Northern New England have demonstrated that switching

varieties could increase market value of yields from a single 10x32m high tunnel by \$10,000 or even more.

- New Hampshire Producers have greatly expanded production of sweet potatoes following NHAES/UNHCE field trials. The crop value for sweet potatoes has grown from \$33,000 to \$660,000 over a five year period.