An Assessment of Differences between Organic and Conventional Farming Practices in St. Lawrence County and Subsequent Impacts on Biodiversity

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I. Summary

A large percentage of the land in St. Lawrence County is devoted to agricultural uses. Agriculture is currently a major threat to biodiversity due to intensive use of synthetic chemicals and fertilizers, increased tillage, and habitat fragmentation that results from partitioning the landscape. Literature suggests however, that practices used on organic farms lead to an increase in biodiversity. We used Geographic Information Systems (GIS) and Breeding Bird Atlas Data to investigate the effects of farming on local biodiversity in the county. While we found no significant difference in species richness between organic and conventional farms, more research needs to be done to assess existing habitats on and around both farm types, as this can greatly impact species assemblages, richness and abundance. Since one third of Saint Lawrence County is farmed, the use of sustainable practices by local farmers could potentially benefit wildlife in the area. While the preservation of wildlife is a primary goal of any conservation project, the importance of farming to the local economy and culture must also be taken into consideration when developing conservation management strategies. Educating local farmers and providing financial support to help them implement sustainable practices on their farms would benefit regional biodiversity while maintaining and promoting a key cultural component of Saint Lawrence County.

II. Introduction

A. Importance of Biodiversity

Throughout history, human presence has been linked to the degradation of natural habitats. Since prehistoric times, humans have consumed natural resources and transformed ecosystems, thus impacting the native biota and their interactions. While
there have been efforts in the past to reduce our impact on nature, it has not been until recently that we have developed a field devoted to this cause. The discipline of conservation biology arose in the 1980’s to face the task of protecting biodiversity around the globe (Groom, Meffe and Carroll, 2006). While the primary concern of conservation biologists is to defend natural ecosystems, species and populations, they also attempt to reconcile this effort with local interests, economists and politicians. Conservation biology differs from most scientific fields in that conservation biologists seek to protect culture and cultural practices when making management suggestions. They also attempt to work with economists in order to develop plans that are economically feasible. Politicians are involved in the process of making management decisions in order to ensure adherence to public policy. And finally, one important goal for conservation biologists is to work with the general population in order to teach them about the importance of biodiversity, obtain public opinions about management decisions, and gain as much support as possible to fuel the conservation movement. Thus, the field of conservation biology is highly multidisciplinary (Class Notes, Jan. 22).

Conservation biologists are charged with protecting biodiversity, and thus this field is inherently value-laden. As a result, decisions must be made based on valid scientific evidence (Class Notes, Feb. 2). While conservation biologists aim at making well-determined and strongly supported decisions, this field remains a crisis discipline in which decisions must be made as soon as possible to most effectively protect the world’s biodiversity.

Biodiversity is often thought of simply in terms of the number of species in an area. However, biodiversity encompasses a significantly wider range than just the
consideration of species. Genetic diversity (biodiversity at the level of genes) provides the evolutionary potential for a population and thus greatly affects its viability. Population level diversity is vital in order to protect speciation potential. Ecosystem diversity is not often considered as a vital component of the overall protection of biodiversity. However, all species are linked by interactions within and between ecosystems. Thus, the protection of a diverse array of ecosystems is important if we want to conserve species, their interactions, and ecosystem functioning (Class Notes, Feb. 2).

Species richness, or the number of species in an area, is the most familiar level of biodiversity. However, it is important to understand that biodiversity truly covers a much wider range of biotic factors.

Another way to view biodiversity is to consider that it is compositional, structural and functional. The compositional component of biodiversity takes into account the genes present in a population, the species present in a community, and landscape types, for example. Structural biodiversity examines genetic structure, population structure and landscape patterns. Finally, functional biodiversity looks at the genetic processes at work in a population, the life histories of species, interactions between species, and landscape processes (Class Notes, Jan. 24). Thus, when examining and assessing biodiversity, it is important to consider that it is a broad and complex topic that must synthesize information from a variety of biological perspectives.

The goal of conservation biologists is to protect the various levels and components of biodiversity. Thus, it is imperative to consider the importance of biodiversity in our world. Biodiversity can be valued both instrumentally and intrinsically. The instrumental value of nature can be viewed as what nature provides us.
For example, nature supplies us with goods such as food, water, and materials for shelter. It also provides us services such as carbon sequestration, climate regulation, water purification, and erosion control. These services are often referred to as ecosystem services because they are processes that are naturally carried out by ecosystems, which provide us with a healthy and functional environment. Nature also provides us with information that we can put to use in our societies such as genetic engineering and systems function (Class Notes, Feb. 2). All of these aspects of nature that benefit humans are considered to be instrumental. Nature can also have intrinsic value, which is the value nature has simply because it exists. We should understand that both of these value systems are important in light of protecting biodiversity. Although these value systems differ, the outcome of both systems can be the same: the protection of nature and biodiversity. It is vital that we understand how our actions impact biodiversity, and that we make changes that will alter the course of the conservation crisis.

**B. Human Impact of Agriculture**

Habitat loss and degradation, overexploitation, invasive species establishment, pollution and disease have been identified as the main threats to the world’s biodiversity. One-third of species in the United States are at risk of extinction because of these biodiversity threats (Groom, Meffe and Carroll, 2006). In the United States, of these threats, habitat degradation results in the highest percentage of at risk species (Groom, Meffe and Carroll, 2006). Habitat degradation is the temporary transformation of the biotic and abiotic characteristics of an area that does not affect all species. Agriculture is a form of habitat degradation. Agro-industry, shifting, organic and family farms that are practicing cultivation or raising animals contribute to the degradation of natural habitat in
different ways and to varying degrees. Problems with all forms of agriculture include clearing land, water issues, overgrazing, monoculture production, pesticide and herbicide use and the impacts of genetically modified organisms. Biodiversity, in the forms of plant genetic resources, livestock, insects and soil organisms, is decreasing worldwide (Thrupp, 2000). In general, agriculture has an impact on biodiversity worldwide (FIG. 1 and FIG 2); however, it is small-scale, family agriculture that causes the most habitat degradation because of its prevalence across the globe (FIG. 2) (Class Notes, Feb. 19). Worldwide the amount of land being used for agriculture has increased from 655 million hectares in 1700 to 3.6 billion hectares today (Class Notes, Feb. 19). Such a conversion translates into 98% of the arable land having been transformed to support agriculture (Class Notes, Feb. 19). With the current, but ever-increasing 6.5 billion people who use the earth’s resources to feed themselves, agriculture and its associated habitat degradation will only intensify.

C. Farming in St. Lawrence County

In 2005, 9.3 billion acres of land in the United States were devoted to agricultural practices (U.S. Department of Agriculture, 2007). In New York there were 7.66 million acres of land in agricultural use in 2002 (U.S. Department of Agriculture, 2007). In 2002, 25.4% of New York land was devoted to agriculture producing mostly dairy, wheat, fruits, vegetables and their products (U.S. Department of Agriculture, 2007). New York ranks third in the U.S. in state dairy production; in 2005 the state grossed $119.3 million (U.S. Department of Agriculture, 2007).

St. Lawrence County is one of the top ten dairy producing counties for New York State; it is also in the top ten for beef and maple syrup production (Ag. Dist. 2 Eight Year
In 2006, 586,322 acres (one-third of the county’s land), was devoted to agriculture (Ag. Dist. 2 Eight Year Report, 2006). Such acreage makes St. Lawrence County the county in New York with the largest percentage of land used for farming activities (Ag. Dist. 2 Eight Year Report, 2006). Since 1997 the number of farms in St. Lawrence County has grown by 6% while the number of acres farmed has decreased by 4% (FIG. 3) (Ag. Dist. 2 Eight Year Report, 2006). Production of milk has also increased 6% while the number of cows has decreased 6% (Table 1) (Ag. Dist. 2 Eight Year Report, 2006). Trends of increased production and farms with decreased cows and farming acreage suggests an intensification of agriculture. Both this intensified use of farm resources and previous conversions of one-third of the county for agricultural practices has transformed the natural habitat and affected the wildlife. Although farming has negative impacts on biodiversity, it helps support the economic stability of the county; in 2000 agriculture employed 1,925 people (Fountain 2005).

St. Lawrence County is located in northeastern New York and stretches from the St. Lawrence Seaway to the Adirondack Park. The northern section of the county is lower in elevation and is the floodplain for the St. Lawrence River; most of the habitat is wetland and temperate deciduous forest. Moving south in the county into the foothills of the Adirondack Mountains the elevation as well as the forested land increases (FIG. 4). The fertile soil, water resources and topography in the northern part of the county has caused a high percentage of the land to be converted to agriculture. This conversion has impacts on the natural habitats and therefore the species living in St. Lawrence County. Most farming, whether crop or livestock, in the county requires land to be cleared of trees (the exception is maple syrup production). Often farms are monocultures, replacing what
was once a species rich forest or wetland with acres of one or two varieties crops. Converting woodland or wetland habitat causes the loss of ecosystem services. Beyond the loss of ecosystem services, conversion can cause erosion, resulting siltation and contamination of water resources with herbicides, pesticides and organic matter. Contamination of lakes, rivers and tributaries, has both biological and anthropogenic implications. Most commonly the addition of organic matter to water systems adds excess nitrogen causing increased algal blooms and creating bottom-up effects on the local aquatic community (Moffat 1998). Quality of water resources is also important from the perspective of humans as drinking water can easily become contaminated. This relationship between water and agricultural land is especially important in St. Lawrence County where there are high numbers of both farms and water elements in close proximity to each other (FIG. 5).

D. Comparison of Conventional and Organic Farms

Habitat degradation caused by conversion of natural habitats to agricultural lands leads to a decreased species richness and a decrease in biodiversity (McNeely 2006). The impacts of habitat degradation on biodiversity are not equal across all farmland. Conventional and organic farms and their associated practices have different effects on species richness and abundance. Organic farming is an agricultural practice that does not use chemical fertilizers, pesticides, herbicides, antibiotics or hormones. In comparison, conventional farming is an agricultural practice that includes the use of synthetic chemicals. In addition, conventional farms sow earlier, plant row crops and till more frequently resulting in lower habitat heterogeneity, less grassland area, lower density of hedges and higher impact on trophic level interactions (Fuller et al, 2005; Hole et al,
In comparison, organic practices increase species richness and abundance of various taxa (Belfrage et al, 2005; Bengtsson et al, 2005; Fuller et al, 2005; Hole et al, 2004; Freeman and Kirk, 2001) as well as increase biodiversity at the gene and species level on organic farms (Codex Alimentarius Commission, 2002). Birds (Belfrage et al, 2005; Fuller et al, 2005), bats (Wickramasinghe et al, 2003), butterflies (Randolf and Smith, 2006), spiders, fungi, predatory insects, microarthropods, soil organisms and plants had higher species richness on organic farms when compared to conventional farms of the same size (Bengtsson et al, 2005; Freeman and Kirk, 2001). The use of herbicides, pesticides and synthetic fertilizers on conventional farms often decreases insect abundance which has a bottom-up effect and leads to decreases in species that feed on insects, such as bats and some birds (Wickramasinghe et al, 2003). Overall, species richness increased by 30% on organic farms (Bengtsson et al, 2005). In one study of paired organic and conventional farms there were 68-100% more plant species, 74-153% more weed species, 5-48% more spider species, 16-62% more bird species and 6-75% more bat species on organic than conventional farms (Fuller et al, 2005). Organic farm practices promote soil stability (Codex Alimentarius Commission, 2002), field margins, edge zones, hedgerows, woodlands (Freemark and Kirk, 2001), natural pastures and wetlands (Bengtsson et al, 2005), all which benefit wild flora and fauna and are less detrimental to the environment. Practices on organic farms provide more natural habitat structure and greater food resources (Randolf and Smith, 2006; Fuller et al, 2005; Wickramasinghe et al, 2003), which are two main reasons why organic farms have higher levels of biodiversity.
New York State has 355 farms registered with the Northeast Organic Farming Association (NOFA) as certified organic, with 61 as first year applicants in 2006 and 37 transitioning dairies (Northeast Organic Farming Association, 2006). In St. Lawrence County, twenty-two farms are registered with NOFA as certified organic, one has signed NOFA’s Farmer’s Pledge (Northeast Organic Farming Association, 2006) and others use organic practices (FIG. 6) (Bennett, pers. comm.). The Farmer’s Pledge goes beyond organic practices and includes a commitment to labor issues, community values and marketing practices (Northeast Organic Farming Association, 2006). It is possible that some of the transitioning dairies in New York State are located in St. Lawrence County, considering the abundance of dairy farms in the area.

**E. Problem Definition**

St. Lawrence County has the largest acreage of all New York State counties (Ag. Dist. 2 Eight Year Report, 2006). Perhaps because of its size, St. Lawrence County has a low population density of 16 persons/km² as compared to Albany County (the county containing the state capital) which has a density of 217 persons/km² as of 2002 census data. The relatively large size of the county, low proportion of human habitation and wide range of habitat types make the county an excellent location for preservation of some of the biodiversity of New York State. St. Lawrence County is not only the largest county; it also has the largest percentage of agricultural land of all New York State Counties (Ag. Dist. 2 Eight Year Report, 2006). Worldwide agriculture poses the greatest threat to biodiversity, St. Lawrence County being no exception. Agricultural practices are important economically and culturally within the county, however they are causing habitat degradation and changing local ecosystems. The overwhelming
importance of agriculture suggests that methods which increase natural habitat within the farm may provide the best options for increasing biodiversity on farmland within the county. As organic farms are known to have higher species richness and abundance of various taxa it is feasible that one solution to the problem is to promote various organic farming practices on conventional farms.

F. Governmental Issues

From the federal to the local level, the government strongly influences the direction of agriculture across the United States. Both levels of government make a variety of decisions concerning areas of farming such as the agricultural market and farming regulations. St. Lawrence County agriculture and thus its environment are influenced at the federal level by the United States Department of Agriculture, at state level by organizations such as the New York Farm Viability Institute and the Northeast Organic Farming Association of New York, and at the local county level by the County Board of Legislators as well as the Environmental Management Council of St. Lawrence County.

The United States Department of Agriculture (USDA) is responsible for “providing leadership on food, agriculture, natural resources, and related issues based on sound public policy, the best available science, and efficient management” (USDA, 2004). Thus, this governmental agency makes decisions concerning local and international agricultural markets, job opportunities in farming and the nutrition and health of America’s populace (USDA, 2004). Additionally, the farm bill is a program developed by the USDA that outlines goals for agriculture in the United States. The newest farm bill (2007), which has not yet been passed, proposes several objectives
which include supporting new generations of farmers in order to help them become
established as producers, increasing conservation funding to $7.8 billion over a ten year
period, strengthening support for healthy eating especially in institutions that participate
in food assistance programs such as public schools, increasing funding for rural
healthcare and growing commitment for moving towards renewable energy (USDA:
Farm Bill, 2007). Thus, it is clear that the USDA is responsible for making many
decisions that impact farmers across the country. The rural community and agricultural
sector of St. Lawrence County are likely to be impacted by some of the objectives of the
farm bill such as conservation and health care goals.

The USDA also sets forth policies including those which regulate the
certification of organic farms. Under the legislation of the USDA, different states have
organizations that are responsible for overseeing adherence to organic regulations.
Within New York State, the Northeast Organic Farming Association (NOFA) is in charge
of monitoring the organic transition process as well as the yearly certification of organic
farms. There are currently two types of organic certification which include crop and
dairy farm certification. The organic crop farm certification has a number of
requirements, which are the same regardless of crop type. For example, prohibited
synthetic fertilizers, herbicides and pesticides must not have been applied in the previous
three years (which is the current transition time for organic crop farms). The crop farmer
must provide a history of the land detailing soil amendments (manure and pest/disease
control used) from the previous three years. Also, crop farmers are expected to follow a
crop rotation system and place buffer zones along fields adjacent to conventionally
farmed fields. A farm inspection must also take place in which the inspector verifies the
practices used on the farm. Other requirements include a soil nutrient analysis, potable water tests, an equipment list and harvest records (Northeast Organic Farming Association, 2006).

The certification process for organic dairy farms also involves a number of strict regulations. According to the USDA Organic Rule, transition time for dairy herds is now one year. During the first nine months, 80% of the herd’s diet must be from farms that are in their last year of transition, 20% of their diet may be from fields in their first or second year of transition or conventional fields. If a farmer chooses to purchase feed for the 80% requirement, it must be certified organic. During the final three months of the transition, 100% of the diet must be from certified organic sources. Additionally, young stock may not be fed crops from fields in transition. Other requirements state that milking herd over six months old are required to have access to pasture during the grazing season and must also have access to the outdoors during winter, tail docking is prohibited, animal identification must be carried out by means of ear tags or tattoos, antibiotics to treat milking animals are prohibited, and buffer zones need to be placed between organic and adjacent conventional fields. The transition process is even more complicated than outlined above as these are just an example of some of the specifications for dairy farmers who plan on transitioning to organic (Northeast Organic Farming Association, 2006).

Certification is an annual process for both crop and dairy farms (Northeast Organic Farming Association, 2006). Thus, the process of transitioning from conventional crop or dairy farming practices to organic practices requires time, effort,
adherence to some stringent regulations, and money including application fees, the goal of which is to ensure the quality of the agricultural products.

Due to the detail required for involvement in this process, many conventional farmers may not consider transitioning to organic. Another potential result of these requirements is that some organic farmers may avoid gaining a certified label. These regulations set forth by the USDA about organic practices and certification were defined in recent years in order to classify farms under the organic label, and they came about in part as a response to conventional farmers claiming their products were organic and selling them under that label in the agricultural market. In order to ensure that consumers were in fact buying organic products, the USDA developed these stringent policies for certification. One example of how strict organic regulations can be is that one small organic farmer was asked by an organic certifying agent to provide the dates on which he had moved crates of zucchini into the cooler the previous year. Many organic farmers grow a variety of crops on their land which would, according to organic certification rules, necessitate exhaustive documentation. Further, the federal government has worked to standardize organic practices. In one such case, composting guidelines were developed which required frequent turning of piles to kill pathogens. The result was that some piles caught fire because they were too dry. Often standardized regulations do not take practices on individual farms into account. As a result, many farmers that follow organic practices may be avoiding the organic label, and the strict regulations imposed on organic farms may be deterring other farmers from transitioning to organic (Fromartz, 2002).
The federal government is not only setting regulations which influence organic certification, but recent federal policy has made it increasingly difficult for dairy farmers to be economically successful. Dairy farmers in St. Lawrence County are experiencing economic pressures (such as greater operating expenses) which require the farmers to increase the size of their dairy herds in order to make a profit; this entails increasing capital investments (St. Lawrence County Public Policy Guide, 1995). However, dairy farmers are not able financially to keep up with the costs of these capital investments due to increased operational costs. Thus, many farmers are intensifying their practices by decreasing farm acreage and increasing the amount of product from the same number of cows (Ag. Dist. 2 Eight Year Report, 2006). While intensification of dairy farms driven by economic pressures is currently taking place, we may not see the environmental impacts immediately. Increasing the number of cows per unit area will result in a higher density of excrement. Runoff carrying this organic matter to local watersheds may result in increased algal blooms and eutrophication, severely damaging aquatic ecosystem interactions. This bottom-up effect could have direct impacts on the biodiversity of aquatic systems and the species that rely on these ecosystems’ resources.

While economic pressures are forcing St. Lawrence County dairy farmers to intensify their practices, organizations such as the Cornell Small Farm Program are working to develop the New York Organic Dairy Initiative. The primary goal of this initiative is to help dairy farms in New York State transition to organic practice dairy farms, which requires the cessation of the use of synthetic fertilizers and hormones, for example. Currently, organic dairy farms in New York State produce only a third of the organic milk demanded by consumers in the state. Thus, New York has potential to
become one of the primary leaders in the organic milk industry and dairy farms in St. Lawrence County have an opportunity to fill this niche in the market (N.Y. Farm Viability Institute, 2006). Support for dairy farmers wishing to convert to organic is vital because the process is intensive and requires many changes.

Even as programs like the New York Organic Dairy Initiative are working to support farms across New York State, the local government has worked to encourage the growth of agriculture in St. Lawrence County. The St. Lawrence County Agricultural and Farmland Protection Board collaborated with the County Planning Board to develop an agricultural development plan for the county. In 2001, this plan was adopted by the County Board of Legislators. The goal of this development plan is to “foster the improvement and advancement of agriculture as an industry, vocation, and social institution in St. Lawrence County” (Ag. Dist. 2 Eight Year Report, 2006). This mission statement makes it clear that farming has strong ties to the economic livelihood and cultural history of the county.

Public policy has also become an important factor in the protection and promotion of agriculture. At the local level, the County Board of Legislators has developed a public policy guide which sets forth the county’s views about the importance of agriculture as well as their support for its further development. One goal is for the county and local government to promote the education of the general public about agriculture. Cornell Cooperative Extension is an outreach program that aims at educating the local community about agriculture and its importance in St. Lawrence County. Another educational program that has been developed for a similar cause is “Agriculture in the Classroom,” which more specifically attempts to reduce conflict between agricultural and
other opposing interests such as development and urbanization. An additional goal of this program is to encourage students to consider a career in agriculture. There are also other efforts to train young community members so as to supply labor for local agricultural ventures, which is carried out by Cornell Cooperative Extension, the Board of Cooperative Educational Services (BOCES), and the county job training efforts. The county also wants to promote the use of computer technology (such as digital soil maps) in agriculture in order to make farming more successful.

Another goal set forth by the County Board of Legislators’ public policy guide is to support the economic potential of agriculture in the county since “viable agricultural lands are one of St. Lawrence County’s most important and irreplaceable economic and environmental resources” (Ag. Dist. 2 Eight Year Report, 2006). Because agriculture is viewed as an instrument of economic growth, efforts are being made to support diversification of agricultural products. The County Board of Legislators also wants support to be given to the development of regional and multi-county marketing strategies that will strengthen agriculture as a source of revenue. The County office of Economic Development and the Industrial Development Agency are also encouraged to “support the development of viable efforts to provide in-county, value added processing and marketing of local produce, livestock and other farm products” (Ag. Dist. 2 Eight Year Report, 2006).

In their public policy guide, the Board of Legislators also stated their support for the conservation of environmental quality. This statement outlines suggestions for the protection of water quality such as the development of watershed management associations that will work to promote water quality and confront flood control and
drainage concerns. The reason for the focus on water quality is most likely related to the fact that St. Lawrence County is located in the floodplain of the St. Lawrence River, and thus farming has direct impacts on the health of many aquatic ecosystems. While it is important to protect water quality which will benefit both residents and natural habitats, it would be more ecologically advantageous to view the environmental impacts of conventional farming at an ecosystem scale. Conventional practices that should be considered because their effects on the environment include the use of pesticides and herbicides, the use of antibiotics, increased tillage, and monocropping. Investigation in these areas would provide the county with a more comprehensive agricultural enhancement plan that would take the health of a variety of species and ecosystems into account.

Finally, the County Board of Legislators supports the continued protection of agricultural land in St. Lawrence County. A primary suggestion the Board gives towards this goal is to promote the agricultural economy which will aid in protecting farming and thus the rural lifestyle. The Board seeks to continue support for agriculture, thus promoting the economic livelihood of the county and protecting the cultural significance that farming has held throughout the county’s history.

In addition to the support of agriculture found within the county, there is also concern for the wellbeing of the environment. The Environmental Management Council (EMC) of St. Lawrence County was developed in 1971 in response to the New York State Local Environmental Protection Act (St. Lawrence County Environmental Management Council, 2007). This organization currently has fifteen volunteer members who advise the County Board of Legislators about environmental issues affecting the
county and seek to promote public understanding of these matters. Some tasks that the EMC seeks to accomplish include but are not limited to public service announcements concerning the burning of solid waste, coordination with other state and county environmental groups, sponsorship of environmental activities including *Adopt-A-Natural-Resource* which is a program developed by the NY Department of Environmental Conservation that seeks to enhance and promote natural resources (New York Department of Environmental Conservation: Adopt a Natural Resource, 1998), monthly speakers who cover topics such as environmentally friendly economic development, and projects presented at local schools (St. Lawrence County Environmental Management Council, 2007). Thus sectors of the local government are currently approaching and managing issues of sustainable development, human impact on the environment and education of the residents of St. Lawrence County concerning these issues. The EMC is one organization that could address the environmental impacts of agriculture and would have appropriate support to set objectives for the county. Additionally, this organization most likely would approach the relationship between farming and the environment comprehensively, taking economy, culture and wildlife into the equation.

**G. Stakeholders**

Stakeholders are individuals who have a real or perceived interest in the outcome of a decision. When considering the issue of farming and its impacts on biodiversity in St. Lawrence County, there are many stakeholders. These include organic farmers, conventional farmers, wildlife, local residents, and the government.

Organic farmers are using ecologically sound practices in order to reconcile the relationship between agriculture and biodiversity, and to promote an environment as well
as products that are healthier for humans. These farmers have chosen a route that requires adherence to strict certification guidelines and regulations. It is not the price of organic products that keep consumers coming back, but rather “the [organic] product is attractive because its quality is high and it is grown without synthetic pesticides in an environmentally sustainable manner” (Fromartz, 2002). Thus, organic farmers often care greatly about the health and sustainability of the earth’s ecosystems and understand the negative impacts of farming on the environment. They have decided to actively be involved in the restoration of our relationship with nature, and thus should be involved in decisions concerning the development of agriculture in St. Lawrence County.

While not all conventional farmers follow ecologically sound practices, they have an intimate relationship with the land. They are also dependent upon farming as their livelihood and it is often the primary way they support their families. The conversion of conventional to organic farming is intensive and can be costly resulting in a possible loss of profit during the transition period. Thus, conventional farmers have a lot at stake including their source of income, in decisions concerning their current practices and the future of agriculture in St. Lawrence County. In the county, agricultural lands are currently being lost to single-lot subdivisions (Ag. Dist. 2 Eight Year Report, 2006), which is due to the conversion of conventional farms to residential uses and not urban growth. (Ag. Dist. 2 Eight Year Report, 2006). This conversion may be a cause of the decrease in acreage farmed in St. Lawrence County in recent years (Ag. Dist. 2 Eight Year Report, 2006).

A large percentage of St Lawrence County is conventionally farmed, and the practices followed on these farms are known to negatively impact wildlife (species,
populations and ecosystems). The primary goal of this study is to examine the relationship between farming practice and biodiversity and develop suggestions for the betterment of local wildlife. The conversion of wetlands, forests and other habitats into agricultural lands has impacted many species. Specifically, amphibians and woodland bird species have lost breeding sites and abundance of wetland and forest flora has decreased as a result of habitat degradation. In comparison, the fields created by many grain producing farms has created habitat for grassland bird species. Thus, the protection of local habitats (including those created by farms) and species are the primary concerns of this study. The consideration of wildlife will hold the most weight in the process of suggesting conservation management proposals for local farmers.

Local residents of the county are also stakeholders in the outcome of decisions about farming practices in St. Lawrence County. They may have complaints about odors from intensive dairy farms or concerns about local water quality which is at risk from increased siltation and eutrophication. People with these concerns may support converting to organic practices in order to lessen these negative effects of conventional agriculture. Others, however, may have family and friends who are financially dependent on conventionally farmed plots, and thus would support the continuation of these practices. Many residents may encourage and want to promote organic farming practices because they are able to purchase local organic products. As mentioned earlier, organic dairy farms in New York State provide only a third of the organic milk demanded in the state. Thus, some local residents may want a greater number of organic farms because of their role in providing local agricultural products.
The government, especially at the local level, needs to have a significant role in the decision making process. The Board of County Legislators has detailed their support for the role of agriculture as an important component of the county’s economy, culture and history. In order for changes to be made in agriculture that will promote local biodiversity, the suggestions of the local government must be taken into account as their support is vital for the success of this project.

III. Analysis of Farming and Biodiversity

A. Methods

Although the assumption is that organic farms have higher biodiversity than conventional farms a literature review of such studies found that 66 showed increased biodiversity (species richness) on organic farms, 8 showed increased diversity on conventional farms and 25 found no difference between the two farms types (Hole et al, 2004). Thus, before the suggestion that organic farms and their practices should be increased is made, the hypothesis that organic farms have greater species richness than conventional farms must be supported in St. Lawrence County. Doing this analysis required the use of Geographic Information Systems (GIS) to obtain information about organic and conventional farm size (FIG. 7) and location and using the Breeding Bird Atlas (BBA) data from 2000-2005 to assess the impact of organic farms on species richness. In one study comparing conventional and organic farms, trends in species richness of bees and butterflies matched that of birds indicating that birds can be used as measures of biodiversity for lower trophic levels (Belfrage et al, 2005). To supplement the GIS and BBA data we surveyed organic and conventional farmers.
The Breeding Bird Atlas is a “comprehensive, statewide survey that reveals the current distribution of breeding birds in New York” (DEC Breeding Bird Atlas, 2005). This survey was done by over 1,100 registered volunteers during a five year period. The state is divided into 5,333 blocks in which surveys of various habitats are done. Each block is 5km x 5km and is surveyed for confirmed, probable and possible breeding birds. Indicators of confirmed breeding include the presence of used nests or fledglings, adults carrying fecal sacs and identifiable nests with eggs. Singing male present, territorial displays, courtship displays and nest building indicate probable breeding. Possible breeding indicators include a singing male present in suitable habitat during the breeding season.

We compared twenty-three certified organic or organic practice farms to twenty-three conventional farms in St. Lawrence County (FIG. 8). Locations of organic farms were determined using a combination of the NYS Real Property Data from 2006 (land divided into tax parcels), addresses found on the NOFA website and personal communications. We compared the total number of species present on organic and conventional farms (FIG. 9). Although the original intention was to assess biodiversity on individual farms, the data resolution of the Breeding Bird Atlas was much larger than any individual farm (FIG. 10). Despite the resolution of the data the effect of organic farms on species richness was assessed based on the presence of organic farms within a Breeding Bird Atlas block. We hypothesized that if an organic farm was present in a block the total species richness would be higher than that of blocks without organic farms. We also hypothesized that blocks with organic farms would have higher numbers of species confirmed, probably and possibly breeding; however, we thought there would
be less difference between organic and conventional farms as breeding status became less confirmed. To enable us to test these hypotheses we randomly selected twenty-three conventional farms within St. Lawrence County that were not located in the same block as an organic farm. We also paired organic and conventional farms by size, except for the three largest organic farms, which had no conventional farms large enough that fulfilled the necessary requirements. Both organic and conventional farms were randomly distributed across the northern section of the county. We dealt with the fact that some BBA blocks had more than one organic farm by calculating the percent of the block that was organic farm (Table 2). After the selection of all the farms, the average acreage for organic farms was 202.6 acres and 175 acres for conventional, the total being 4,659.8 acres and 4,549.5 acres respectively. This is less than five acres different per farm.

We determined the total number of breeding bird species and the number of confirmed, probable and possible breeding species for each BBA block. We then ran a regression comparing the number of species of each breeding type to the percentage of organic farm in each BBA block.

Our eight question survey was designed to gather information about property characteristics and practices of the farms. The ultimate goal was to compare results of these questions between organic and conventional farms. The section on property characteristics included an aerial photograph of each farm and requested that farmers draw in natural features and those that relate to farming practices. In addition to the general questions on farming practices there was a chart asking about the use of thirteen specific practices that are commonly found on organic and conventional farms.
B. Results

When we compared average total species richness (all breeding types: confirmed, probable and possible) between organic and conventional farms our results showed that blocks with organic farms have an average of 75.2 breeding bird species, (11.6 standard deviation) while blocks with no organic farms (only conventional farms) have an average of 69.6 species (12.3 standard deviation) (p=0.073) (FIG. 9).

There is a significant relationship between total number of breeding bird species and the percent of the block that is organic farm ($r^2=0.1389; p=0.0389$). As the percentage of a block that is organic farm increases, the total number of breeding bird species decreases (FIG. 11). There is also a significant relationship between number of confirmed breeding species and the percent of the block that is organic farm ($r^2=0.1328; p=0.0439$). The number of confirmed breeding bird species decreases as the percentage of a block that is organic farm increases (FIG. 12). We found no significant relationship between probable ($r^2=0.0558; p=0.2007$) or possible ($r^2=0.0399; p=0.2811$) number of breeding bird species and percent of block that is organic farm (FIG. 13 and FIG. 14).

Almost thirty percent (28.6%) of the surveys were returned, however a disproportionate number, 71 percent, were from organic farmers. Practices common among organic farmers in St. Lawrence County include: crop rotation, manual removal of weeds during the growing season, green manure and grass fed animals (Table 4).

C. Conclusions from Data Analysis

As we hypothesized, blocks with organic farms had slightly more total average species richness than blocks with no organic farms, however, there was no significant difference between breeding bird species richness on the two farm types. Although it
may be surprising that blocks with smaller proportions of organic farms had higher total species richness of total and confirmed numbers of breeding bird species, there are two possible explanations. First, size of the farm may be equally as important to practice and biodiversity as type of farm; second, landscape characteristics were not included in this analysis. A study in Sweden found that there was a greater difference in bird diversity and abundance based on the size of the farm than the farming type (Belfrage et al, 2005). 56% more bird species were found on small organic farms than large organic farms (Belfrage et al, 2005). Reasons for this difference in species richness and abundance based on size may be related to management practices and increased habitat heterogeneity of landscapes around small organic farms. The fact that the habitats surrounding the organic farms were not examined or taken into consideration during analysis is perhaps the most evident reason for the results. It is possible that small organic farms are located in areas with more natural habitat than large organic farms. Since organic farms are required to place a buffer between themselves and adjacent conventional farms, it may follow that small organic farms may be more vulnerable to the effects of being next to conventional farms because a larger percentage of their total area will be exposed to conventional practices than that of a large organic farms. Thus, small organic farms may be located further away from the intensive practices of conventional farms and closer to other habitat types and may explain why blocks with smaller organic farms may host a greater number of bird species.

D. Areas for Future Research

In order to assess the hypothesis that smaller organic farms are located in areas with greater landscape heterogeneity we need to use GIS to analyze entire breeding bird
blocks that include organic farms. Determining the percentage of conventional farming activity within these blocks may help further explain differences in species richness between large and small organic farms. At a smaller scale, individual organic and conventional farms should be assessed for the number and percentage of habitats within their farm. The number of communities found on each farm, or community turnover, is another way to measure biodiversity. Biodiversity assessed by change in communities is called beta diversity (Wilson and Shmida 1984). We hypothesize that organic farms will have a greater number and percentage of natural habitat than conventional farms and thus, higher beta diversity. Comparing conventional and organic farms of similar size and type of product is important in this analysis. Doing this analysis will require the use of aerial photos (Digital Orthophotos) and the digitization of habitat types within individual farms; digitizing is the process of making groupings of landuse types such as wheat field, wetland, road. The small organic farms may grow a greater diversity of crops. Thus, habitat heterogeneity on an individual farm may also explain the differences in numbers of breeding bird species on both blocks with a small and a large percentage of organic farms (although this difference was not significant in our current study).

Although species richness is a measure of biodiversity and important for development of any conservation management scheme, examination of which species occur on conventional compared to organic farms is important. Another hypothesis is that more specialist species will be found on organic farms, where generalist species will be found on both organic and conventional farms. The combination of generalist and specialist species on organic farms (because of habitat heterogeneity) may be a reason for higher species richness. Species of bats that were found on both farm types had life
history traits making them habitat generalists, whereas species found only on organic farms, habitat specialists, were more easily impacted by habitat degradation (Wickramasinghe et al, 2003). There are at least two threatened species, Sedge Wren (*Cistothorus platensis*) and Pied-billed Grebe (*Podilymbus podiceps*) that occur within blocks containing organic farms. These species should be assessed for their presence on the two farm types. It is also important to consider invasive birds such as the European Starling (*Sturnus vulgaris*) and European Sparrow (*Passer domesticus*) and consider what farms they are present on (if any) and if their presence should be considered as adding to the species richness of the farm. Species richness provides an important way to compare biodiversity on farm types, but determining which species are found on each farm type (using the Breeding Bird Atlas data) and considering their life history characteristics and conservation status is also important.

We also should conduct direct species richness surveys by doing actual fieldwork assessing number and types of species on organic and conventional farms. This will provide us with direct information about the relationship between farming practices and species richness. Breeding bird atlas data, although a useful tool is on a scale that is not easily applied to the small size of individual farms. Thus, our ability to carry out research in the field will strengthen our understanding of the effects of farming on biodiversity.

IV. Development of Solutions

A. Historical, Economic and Cultural Importance of Farming in SLC

The history of farming in Saint Lawrence County dates back to the years of European settlement. The first European settlement in Saint Lawrence County was Ft. La Presentation, a fur trading post and mission. Interactions between Natives and Europeans
allowed both peoples to learn about new farming techniques and methods that would help them survive the harsh winters and have more productive harvests. Farming made it possible for Native Americans and the first European settlers to survive in early Saint Lawrence County, and it has continued to play a significant role in the county’s history. The county’s farming history can be divided into the following four broad eras: the ash era, the sheep era, the cheese factory era and the milk marketing era (St. Lawrence County Agricultural Development Plan, 2001). Today, dairy farming continues to be the primary agricultural practice in the county.

Farming also plays an essential role in the economic livelihood of the county. In 1997, farms in the county produced $89,078,000 in sales of which $82,378,000 was from livestock-related farming. In this same year, farming and associated businesses provided 2,441 full or part-time jobs (St. Lawrence County Agricultural Development Plan, 2001). When comparing annual gross farm sales for one of the two county’s agricultural districts between 1998 and 2006, it is clear that there is an increase in the percentage of farms that gross between $200,000 and $499,000 as well as in those that gross over $500,000.

The current culture of Saint Lawrence County is strongly tied to agriculture. Through the months of May to October, weekly Farmer’s Market gatherings take place in a number of town centers including Potsdam and Canton. Both local organic and conventional farmers bring their produce to sell to community members, joined by a number of other local artisans who sell a range of items including baked goods and crafts. These gatherings provide farmers with a chance to sell their produce locally, and allow residents of St. Lawrence County to buy freshly grown crops and locally produced goods. Farming culture also permeates local classrooms. The Learning Farm is a program that
seeks to educate both children and adults about agricultural practices and the importance of agriculture in the local area. The Learning Farm is run by Cornell Cooperative Extension of Saint Lawrence County and promotes the development of agriculture in the county (Extension Learning Farm, 2006).

Programs also exist in St. Lawrence County that build simultaneously upon the economic and cultural component of farming. Community Supported Agriculture is an example of such a system in which community members, or “share-holders,” pledge their support to a farm and offer financial assistance to cover operational costs of the farm and the farmer’s salary. In return, the farmer provides them with a portion of his or her harvest. The result is that “the farmland becomes, either legally or spiritually, the community's farm, with the growers and consumers providing mutual support and sharing the risks and benefits of food production” (USDA: Community Supported Agriculture, 2007). Thus the farmers and the community support each other economically which results in farming becoming an integral part of the community’s culture. Another program which connects agriculture with the local community is Farm to School. The objective of this program is to meet two goals concurrently; serve healthy food in school cafeterias and support local farmers (Farm to School, 2004). Schools in this program buy a range of items from nearby farms including fruits, vegetables, eggs, honey, meat and beans. Serving healthy meals is part of a goal to improve student nutrition and in addition these healthy meals are supplemented with health and nutrition education opportunities to ensure that the change to a healthy lifestyle will last a lifetime. Students are further able to learn about farming through visits to nearby farms where they are taught about local foods and sustainable agriculture (Farm to School, 2004). Farmers, in
turn, are thus able to access a new market for their products and connect with the regional community as they teach students about farms and farming practices.

**B. Parameterizing Solutions**

Farming has had and will continue to have a significant impact on the economy and culture of Saint Lawrence County. In order to develop solutions concerning the impacts of farming on local wildlife, we must be sure to consider the economic livelihood of county residents as well as the county’s history and culture. A satisfactory solution would include supporting local organic and conventional farmers and wildlife biodiversity in St. Lawrence County. These solutions must consider the difficulties currently faced by organic and conventional farms as well as the effects of habitat degradation on biodiversity.

Conventional farmers are facing issues of economies of scale due to regulations imposed by the Federal Government. Such regulations make it so economic profits are only returned when farm operations are large. Along with size increases come cost increases. Most farmers in St. Lawrence County do not have the financial capacity to make the capital investments necessary to successfully increase the size of their farms. The trend instead is intensification of agriculture, where more output is produced from a smaller amount of land and livestock. Not only are there incentives to increase farm size, conventional farmers are also paying a higher price for the same amount of herbicides, pesticides, fertilizer and gasoline than in previous years. The structure and success of agriculture in much of the United States is based on tax breaks and subsidies. While these tax breaks and subsidies have not increased, the cost of equipment, labor insurance rates and regulatory costs have increased (St. Lawrence County Agricultural
Another problem for conventional farmers is the conversion of their land to single-lot subdivisions. It is possible that farmers are selling off parts of their land for residential uses to be able to afford other farm-related costs. These sales are not desirable and if it was economically viable, some farmers would rather continue farming all of their land (Personal Communication, 24 April 2007).

Both organic and conventional farmers face high transportation costs. The geographical location of St. Lawrence County and relative distance from any major urban areas and thus from markets for their products reduces profit margins as more money must be spent on transportation. In addition, due to the capital investments necessary for processing of goods, diversification of value-added products has not occurred in the county as much or on as large a scale as possible. Although milk is one of the main agricultural products there are few cheese, yogurt or ice-cream factories. Exporting raw milk requires transportation to a processing plant, as far away as Syracuse, and return transportation of the final product back to the county before it can be sold. Exporting a value added product would make transportation costs less detrimental and products would gross a higher profit. Having a local processing plant would also saves costs on importing the finished product back into the county once it has been processed. The sale of value added products by farmers in St. Lawrence County would increase their earnings. Improved financial stability of farmers would allow them to devote more resources to promoting biodiversity. Another problem both farm types have is the lack of skilled farm laborers. As fewer people are educated about the importance and specific practices of agriculture when they are young, fewer people have aspirations to become farmers and fewer people are qualified as skilled farm laborers. Similarly, fewer people
have the business savvy and managerial skills necessary to run a farm, thus there are not only fewer farm laborers, but also fewer people interested in running farms. Nuisance animals are another challenge to conventional and organic farmers. Deer, geese and turkey are especially damaging as they eat the tender shoots and seeds of the crops. Farmers raising poultry also face problems from skunks, raccoons and foxes eating the eggs and killing birds. Complaints of farmers mostly center around the intense regulations they are forced to follow and the lack of governmental support they receive to follow them (St. Lawrence County Agricultural Development Plan, 2001). These regulations include the necessary permitting for the removal of nuisance animals as well as the separation of wild ungulates from livestock based on the rules of the Concentrated Animal Feeding Operations (St. Lawrence County Agricultural Development Plan, 2001).

Although all of the above problems faced by organic and conventional farmers do not seem related to biodiversity conservation, they are. Any circumstance of farming in St. Lawrence County that makes it more difficult to manage an economically viable farm in the long run will likely correlate with decreases in biodiversity. Farmers are not likely to leave some of their land as habitat between fields or buffer between water if they need to have all their possible land in cultivation in order to sustain their livelihood. Thus, the economic problems as well as the decreasing cultural significance of farming in St. Lawrence County must both be considered when developing solutions to biodiversity management in the highly agricultural North County.

From the perspective of the wildlife, the solution should include habitat of higher heterogeneity and thus, a wider variety of resources. As previously discussed this habitat
should not be impacted by farming activities. Resources include fresh water without the addition of agricultural runoff and excess nutrients. For species that use agricultural habitat during their breeding season, such as some species of grassland birds, this habitat must remain grassland (not be hayed) until their fledglings have left the nest. For farmers this could translate into a practice as simple as haying a week later than planned. A plan must also be developed to create a harmonious relationship between farmers and animals such as skunk, raccoon, geese and deer which are often seen as nuisance animals. Ecologically these are generalist species and their populations have thrived with the increase in disturbed habitat though continued agricultural practices (Jonsen and Fahrig 1997). Thus, it only seems fair that their needs are respected along with the farmers when a solution is developed. However, it is not only generalist species that should be considered. There are at least two threatened bird species, the Sedge Wren and the Pied-billed Grebe whose habitat requirements should be considered.

It is unlikely that the problems facing organic and conventional farmers and those facing wildlife can all be simultaneously solved. One reason for this is the conflict between the solutions to some of these problems (the relationship between farmers and nuisance animals) and the other is the lack of a direct cause of the problems to biodiversity. Many of the problems facing farmers in the St. Lawrence County are only related to biodiversity through a link to economics and overall production on the farm, with the assumed relationship that if land is being left for uses other than farming it will not be economically profitable. Considering all of these challenges, a solution will address farmers’ economic situation, the relationship between their economic situation and their farming practices and the relationship between their farming practices and
increased biodiversity. The negative effects of habitat degradation caused by agriculture have the potential to decrease when it is not economically detrimental for farmers to maintain natural habitat on their farms. This could happen in three main ways: if farmers are educated on the value of biodiversity and they voluntarily manage for it, if the government encourages farmers to manage for biodiversity or if farmers’ products are worth more so they need to use less land to have an economically viable income. All three pathways to increased biodiversity include a movement away from the current trend of intensification of agriculture in St. Lawrence County.

C. Identification and Evaluation of Potential Solutions

There are a number of solutions which could be aimed at increasing biodiversity in Saint Lawrence County. However, biodiversity is not the only concern. The economic livelihood that farming provides and its cultural impacts are not only necessary to take into consideration for the solution to this issue, but they are tightly linked to the existing problems of agriculture and biodiversity. Thus, the following simply outlines potential solutions to the problem. Solutions include banning all farms in the county, outlawing all but organic farms, increasing the percentage of land left unfarmed on each farm, diversifying crop types, increasing farm distance from hydrologic features, limiting the number of dairy cows per acre and promoting organic practices on conventional farms.

As the conservation of biodiversity is a primary concern for this study, one potential solution is to ban farms from the county. Since agriculture is the leading cause of habitat degradation around the world, the exclusion of agriculture from Saint Lawrence County would be for the betterment of local wildlife. Decreased use of fertilizers and excrement from dairy farms would result in cleaner water with decreased
eutrophication. Healthier riparian and aquatic habitats would benefit local species and ecosystems such as wetlands, and thus restore ecosystem services. Local residents would also benefit from cleaner drinking water. Prohibiting farming in the county would also mean greatly reducing the use of pesticides and herbicides, resulting in a greater number and abundance of insects, in turn increasing species richness and abundance in taxa including birds and bats (Wickramasinghe et al, 2003). Thus, local biodiversity would benefit if farming was prohibited allowing the land to return to its natural state.

However, there would be drawbacks to this solution. Due to the fact that farming has existed in Saint Lawrence County for a number of years, dating back to before European settlers arrived and agriculture was a large component of the Native American’s way of life, many species are now dependent on the existence of farmland in the county. Grassland bird species such as bobolink (*Dolichonyx oryzivorus*), grasshopper sparrow (*Ammodramus savannarum*) and vesper sparrow (*Poecetes gambino*) would be especially affected with the loss a significant proportion of their natural habitat. In addition, the loss of farmland would be detrimental to the county’s economy. Not only would the economy suffer, but farmers would be made to give up their way of life as well as their means of providing for their families. The result would be a greater amount of poverty as well as a higher unemployment rate further damaging the county’s economy. This solution would not only result in damage to the county’s economy, but would also require local residents to part with a significant aspect of their culture. Farming has a long history in the county the elimination of farms would be strongly linked to a loss of local culture.
Instead of outlawing all farming in the county, another solution could be to outlaw all but organic farming. Research supports the fact when comparing organic and conventional farms, organic farms have greater species richness than conventional farms. Thus, permitting the continuation of organic farming and organic practice farms in the county would increase the health of local ecosystems and promote the protection of local wildlife. This solution would also take the economy and culture of the county into consideration more than the first provided solution would. In this scenario, farming could still play a role in the economy provided the products were grown organically. While it would be permitted for conventional farms to transition to organic (instead of simply eliminating the farms permanently), the stringent regulations and rigorous process of this transition may cause some farmers to give up their practice entirely. Thus this solution has the potential to negatively affect the economy by increasing the unemployment rate and causing conventional farmers to lose their farms. Many farmers in this scenario would also be losing their way of life.

If the county were to continue to allow the existence of both organic and conventional farms, one suggestion that may address the issue of farming practice and biodiversity is for regulations to be made concerning the proportion of both conventional and organic farms that are left unfarmed as natural habitat. Since the practices on organic farms often promote biodiversity while conventional practices may be linked to decreases in biodiversity, the percentage of land left unfarmed may be different between the two farm types requiring a greater percentage of land to remain as natural habitat on conventional than on organic farms. Natural land on farms could provide habitat for a variety of species. For example, a farm containing deciduous forest could host an
assortment of bird, bat and mammal species. In order to protect a greater number of species, farms with more than one natural habitat type could be required to conserve both types on their farms. The result would be an increase in habitat heterogeneity which has been linked to increases in species richness (Weibull et al, 2003). Allowing both habitat types to exist on one farm may also increase species richness because many species require more than one habitat type for their life history requirements. The shape of the land left unfarmed could also be regulated in order to decrease edge effects. For example, unfarmed habitat with a greater length of the perimeter exposed to the farmed area would experience more of the effects of pesticides than unfarmed habitat with a smaller length of the perimeter exposed to the farmland. Local organic and conventional farmers may feel the negative financial impacts of this solution. Requiring farmers to cultivate less of their land would be asking them to decrease production on land for which they are paying taxes. As a result of this solution, farmers may lose money and have a harder time keeping their farms. However, since such a large percentage of Saint Lawrence County is farmland, requiring a significant proportion of the farmland to be left as natural habitat could greatly improve the condition of biodiversity in the area.

Another solution would also involve regulating crop farm structure and make-up. Both organic and conventional farms could be required to increase the number of crops they are currently growing thus preventing monocropping. More crop types grown on each farm would increase small-scale habitat heterogeneity and provide a greater number of microhabitats. However, increasing the number of farm crops may not be the most effective solution since dairy farms make up a large percentage of farms in the county. While augmentation of dairy products with a wide variety of crop products has the
potential to help individual producers and offer local residents a greater diversity of product choices, farmers have found it difficult to secure markets and financing for their products (St. Lawrence County Agricultural Development Plan, 2001). Increasing diversity of crops grown on farmland has the potential to promote local biodiversity while allowing farmers to continue farming.

Regulations could also be placed on farms that control their distance from hydrologic features. Since a significant proportion of the county is located in the flood plain of the Saint Lawrence River, farming practices impact local water quality. Restrictions could be made to ensure that farms are a certain distance from any water source. The benefits of this solution include increased health of riparian and aquatic ecosystems which would support species interaction, and humans would also benefit from decreased water contamination. However, this may not be a feasible solution since the county has rivers, streams and lakes running throughout, and it may be difficult to place farms far enough away from these features to ensure increased water quality and ecosystem health. Related to this idea is enforcing strict riparian buffers to decrease the effects of farming on aquatic ecosystems. While this solution takes water quality into consideration, it does not fully address other aspects of the preservation of biodiversity.

Since a large percentage of the agriculture in the county is made up of dairy farming, and intensification in this form of agriculture is increasing due to economic pressures, we could limit the number of dairy cows per unit area in order to decrease intensification. The result would be healthier aquatic ecosystems at the expense of the success of dairy farmers. Because agricultural intensification is occurring in response to federal policy and the inability to increase capital investment, limiting the number of
livestock dairy farmers could have on their land would be likely to cause economic-related failure on these farms. If the number of dairy farms subsequently begins to decrease, the economy of the entire county could be at risk. This solution, as does the previous one, fails to address the health of local wildlife outside of aquatic ecosystems.

A final solution developed to address the relationship between farming practices and their effects on local biodiversity involves promoting practices on conventional farms that will serve to increase biodiversity, such as less tillage, increased hedgerows and more habitat left unfarmed. While the solution would not require conventional farmers to transition to organic, it would promote the use of ecologically sustainable practices on their farms. An important step in this process would be to educate local farmers about the importance of biodiversity and sustainable practices that they can use on their own farms. One organization that works to this end is Wild Farm Alliance, whose slogan is “Reconnecting food systems with ecosystems” (Wild Farm Alliance, 2006). Supporting sustainable practices on St. Lawrence County farms, though campaigns such as buying local, would help to protect species, ecosystems and other levels of biodiversity. The government’s economic support for farmers that use ecologically sustainable practices would increase the likelihood of farmers following these practices and would help farmers to be more financially successful. Money from the government could also be used to educate both farmers and local residents about the importance of biodiversity. If farmers were aware of ways in which they could protect local biodiversity and if they were to follow these practices on their farms simply for the sake of biodiversity and not an organic title, they would not be subject to the same strict regulations that are imposed
on certified organic farms, and thus might be more willing to consider new farming
techniques and management regimes.

D. Identification of Feasible Solutions

While all of these solutions offer a way to promote local biodiversity, not all of
them are economically or socially viable. The first solution which entails banning all
farms in Saint Lawrence County is not a feasible one. The county is dependent upon
agriculture as a main source of economic growth. Requiring residents to give up their
livelihoods would not only be detrimental to individual families, but also to the economy
of the county as a whole. In addition, farming has been a way of life in this area for
hundreds of years and thus the culture of the county is wrapped up in agriculture. This
solution would only serve to create a host of new problems. Prohibiting all but organic
farming is another solution that is not feasible. The majority of farms in the county are
conventional and thus this solution would have similar impacts as the first. While
farmers would have the option to transition to organic, many would most likely give up
the practice entirely as a result of this new strict regulation.

Requiring farmers to leave a certain percentage of their land unfarmed is a
potentially feasible solution. Farmers would be allowed to keep their business and
support their families and thus this change would not be a radical one. However, the
economic viability of this solution would stand in opposition to this change. The reason
that many farmers would not readily preserve some of their land as natural habitat is
because it would be economically detrimental to reduce production on land for which
they are being taxed. However, if the government was willing to aid farmers in the goal
of protecting biodiversity on their farms by offering them financial compensation, this solution may be approached more seriously by farmers.

The diversification of crops by farmers in order to increase habitat heterogeneity and thus promote species diversity is a feasible solution for Saint Lawrence County. Currently, the Board of Legislators details in the county’s agricultural development plan that agricultural diversification could “Be used to augment the primary dairy business could be helpful to the individual producer as well as the overall agricultural industry in the county” (Saint Lawrence County Agricultural Development Plan, 2001). However, farmers in areas of agriculture outside of dairy farming often find it difficult to secure markets for their products. Perhaps more work could be done to develop a local market and secure financing for these products. As a result, the farmers could benefit from increased sales with more potential to sell to local residents, and the increase in landscape heterogeneity on farms in the county would have the potential to increase biodiversity.  

Since the Northern part of Saint Lawrence County is the floodplain for the Saint Lawrence Seaway, and also includes the majority of farms, regulating agricultural effects on local water sources is vital. Thus, while restrictions placed on distance from local rivers, lakes and other hydrologic features might prove difficult (since many farms are already established in close proximity to water bodies), regulations could still be made concerning riparian buffers which would serve to mitigate the effects of nutrient runoff and other synthetic chemicals into local water bodies. Water is a communal resource which should be healthy and clean not only for wildlife, but also for local residents to drink. Thus, placing regulations on the size and efficiency of buffers between agricultural fields and hydrologic features would most likely be supported by the local
residents and government. Establishing buffers would be a feasible solution because it would not infringe on the current practices of conventional farmers, while at the same time would offer increased protection for wildlife.

In order to decrease agricultural intensification, regulations could be placed on the number of cattle/livestock per unit area. Often limitations are placed on density of livestock in an attempt to control diseases that occur when overcrowding takes place. Confinement acts have also been developed to ensure humane treatment of animals on a farm. Thus, modifying current confinement regulations to decrease the numbers of livestock per unit area is a reasonable solution to alleviate the effects of intensification. However, the reason for intensification is due to economic constraints and the financial inability to increase capital investments. Therefore, this solution may only be feasible if the federal government was able to develop programs for farmers that would help them increase capital investments and decrease operational costs.

The final solution involves educating farmers about the importance of biodiversity and ways in which they can work to promote biodiversity on their farms. Local schools such as SUNY Canton or Saint Lawrence University could work together, perhaps even with the Agricultural school at Cornell University (which is connected to the county through Cornell Cooperative Extension), to develop free classes for local farmers that would educate them about biodiversity. Local and federal government support would also be needed to aid in the development of this solution, however, involvement and support would be reasonable. One idea for government support would be a fund for sustainable practices on farmland. Farmers could apply to this fund to receive a portion of the money it would take them to build a hedgerow, for example. In order to monitor
biodiversity, farmers could receive guides to local birds (and information in classroom 
settings) which they could use to identify birds on their farms. A yearly survey could be 
administered to local farmers that would evaluate progress towards the protection of and 
support for biodiversity. While this solution would require many agencies and people to 
work together, it would be economically and socially feasible.

E. Identification of Best Solutions

The solution to the problem of habitat degradation created though agricultural 
practices in St. Lawrence County is best solved by taking an approach that considers the 
needs of the major stakeholders involved. Although the ultimate goal is biodiversity 
protection, without making compromises that consider the needs of stakeholders other 
than wildlife any conservation plan is likely to meet resistance. As one of the poorest 
counties in New York State and a county that has a culture tied to agriculture, it is 
important that farmers be included in the process of protecting biodiversity but that their 
livelihood is also protected. Thus, the best solution is when the government realizes the 
link between the economic advancement of farmers, their farming practices and 
biodiversity and acts to ensure the economic stability of farmers. Economically 
advancing St. Lawrence County farmers includes grants from the government and new 
capital investment in North Country agriculture. Farmer education (along with economic 
advancement) will encourage voluntary participation in different farming practices that 
promote biodiversity. Finally, biodiversity must be monitored to ensure its preservation 
over the years as such changes are made.
F. Implementation of Solution

A three tiered approach must be taken in the implementation of the solution to habitat degradation caused by agricultural practices. The economic status of farmers, farming practices and biodiversity of wildlife in St. Lawrence County must all be addressed. Improving the economic status of farmers will involve changes in the local government. Increasing the use of farming practices that promote natural habitat will require the education of farmers. Finally, implementation of this solution must ensure that these efforts are successful and increase biodiversity in St. Lawrence County.

Improving the economic status of farmers could take the form of major actions and legislation that uniformly improve the economic viability of all farms in St. Lawrence County, or an individual reward based system that benefits only farmers who promote biodiversity on their farms. The only problem with taking uniform action is that any economic incentive to conserve biodiversity is lost. Although it is not possible to force farmers to manage their farms for wildlife, it is feasible to economically reward those that do. One possible way to reward farmers with practices that promote biodiversity is though a grant based system. Farmers could apply for financial assistance, and based on need and their practices they could receive money. For example, a dairy farmer who maintains a riparian buffer of 20 meters could receive financial assistance paying for part of his taxes. This grant system would also work such that if farmers wanted to make improvements on their farms they could also apply for financial assistance. An example of this type of economic incentive could be a farmer that plans to use green manure (cover crops that return nutrients and organic matter to the soil) so that he can use less chemically synthesized fertilizer on his crops, this farmer might receive
help with the initial capital investment for the improvement project. It would also be possible that a group of farmers could write a grant together, an example of this could be a milk processing plant. Currently dairy farmers must ship their milk to Syracuse or farther to be processed (this is expensive) and for milk to be sold it must be shipped back. It is likely that the main reason a milk processing plant, another cheese factory, or an ice-cream or yogurt factory is not in one of the counties with the highest dairy production is the lack of enough capital to make such a large investment. In this example, such a plant would add value to the products already being produced and save farmers transportation costs. This is a feasible possibility as the value-added scheme is already something the County Agricultural Development Plan promotes. The money to give for such projects could come from a variety of sources. One idea is to take the money paid on taxes on farmland that is kept wild and putting that money into the fund to promote more of such practices. Another idea is to encourage hunting on private farms and then give some of the money from the permitting process to the fund; in essence supporting increased game habitat. The creation of such a fund would also require that one or a group of people be responsible for deciding which farmers get the money and how much they get. It is possible that this could be the task of a volunteer committee with the president being one of the county agricultural officers.

Education is necessary both for the farmers to understand the importance of biodiversity and to learn the practices that they could implement on their farms to promote it. The problem with any education program is to present the material, in this case new farming practices, in a way that is not condescending. Many of the farmers in St. Lawrence County are working on a family farm that has been run the same way for
generations. It is unlikely that without thoughtful planning and farmer input that any education program could be a success. Although this program will be voluntary, it will be made clear that farmers who implement these new practices will be able to receive financial assistance and help the wildlife. Perhaps the best types of educational programs are hands on workshops where farmers are given the choice among a variety of programs and they can choose those that are most interesting to them. This setup is only logical, as a dairy farmer and hay farmer may need to use different types of practices to achieve the greatest benefits. These workshops would be held every year and would be supported and paid for by the county. Those presenting could be professors from Agricultural schools, such as Cornell, conservation groups such as the DEC, groups working at the intersection between farming and conservation such as the Wild Farm Alliance and farmers who have already been successful in implementing biodiversity promoting farm management. Part of these education sessions would include a farmer survey, the same survey would be given out each year, which would help assess the change in biodiversity on individual farms. The Environmental Management Council of St. Lawrence County could be one primary supporter of this farmer education program. This organization, which often sponsors environmental activities, could also sponsor some of these programs at which farmers learn new techniques and practices to promote biodiversity. The EMC could also be responsible for inviting and compensating the guest speakers and presenters who could talk about topics including environmentally friendly economic development and focus specifically on agriculture in the county. This local governmental group might be able to draw in enough funding to promote educational opportunities about farming and biodiversity.
Wildlife must be monitored while all the changes to farming are being made to ensure that the new practices are actually making a difference. Most important is that the studies are done over a long period of time and with similar methods. Although this may seem like a limiting factor to the solution, the hope is that the farmers themselves will become the monitors. Programs teaching farmers how to assess the biodiversity on their farms though bird surveys done each year have been successful elsewhere. This prevents another organization from having to organize and pay for surveys and it reconnects the farmers with the wildlife. It will be especially powerful for farmers if they can begin to see changes in the species richness of birds on their property over the years after they have changed some of their practices. It is only in implementing strategies to improve the economic status of farmers, developing biodiversity promoting practices and monitoring changes in wildlife that the problem of agricultural caused habitat degradation can be solved.
V. Figures and Tables

FIGURE 1. Distribution of cultivated systems (dark areas) worldwide (defined as in which at least 30% of the landscape is cultivated). (Groom, Meffe and Carroll, 2006)
FIGURE 2. Bird species that are threatened by habitat degradation and loss are primarily affected by forms of agriculture, logging and other tree-clearing, and by infrastructure development. (Groom, Meffe and Carroll, 2006)

FIGURE 3. Number of Farms (blue) and acres of farmland (purple) in St. Lawrence County from 1982-2002. From 1997 to 2002 number of farms has increased by 6% and the acres of farmland has decreased by 4% (Agricultural Development Plan, 2006).

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Milk Cows</th>
<th>Milk Production (1,000s of lbs)</th>
<th>Market Value of Ag. Products Sold ($1,000)†</th>
<th>Total Dairy Products Sold ($1,000)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>47,485</td>
<td>543,900</td>
<td>$151,079</td>
<td>$129,075</td>
</tr>
<tr>
<td>1987</td>
<td>45,876</td>
<td>591,500</td>
<td>$127,634</td>
<td>$105,723</td>
</tr>
<tr>
<td>1992</td>
<td>41,899</td>
<td>607,800</td>
<td>$119,478</td>
<td>$99,236</td>
</tr>
<tr>
<td>1997</td>
<td>40,567</td>
<td>501,400</td>
<td>$98,344</td>
<td>$81,478</td>
</tr>
<tr>
<td>2002</td>
<td>38,018</td>
<td>615,500</td>
<td>$99,715</td>
<td>$80,036</td>
</tr>
<tr>
<td>% Change 1997-1992</td>
<td>-6%</td>
<td>6%</td>
<td>1%</td>
<td>-2%</td>
</tr>
</tbody>
</table>
FIGURE 4. Landuse characteristics in St. Lawrence County. Most of the farmland is located in the northern part of the county. (Landuse/land cover data for SLC)
FIGURE 5. Location of farmland and hydrology (water bodies) in close proximity, St. Lawrence County.

FIGURE 6. Composition of farming types in St. Lawrence County; Green is conventional farms and orange is organic farms.
FIGURE 7. Size distribution of organic (orange) and conventional (green) farms in our study. Organic farm acreage range: 0.2 – 776.40, mean: 202.6. Conventional farm acreage range: 0.3 - 337.1, mean: 175.0.
FIGURE 8. Location of 23 conventional and 23 organic farms in St. Lawrence County. Dots do not represent actual farm size; they simply provide a visual representation of farm location.
FIGURE 9. Total average number of breeding species as a function of farm type. Error bars represent standard deviation. P-value is 0.073
FIGURE 10. Example of breeding bird atlas block size relative to organic farm size. Farms are a very small percentage of land within the BBA blocks.
TABLE 3. Percent of BBA block that is organic farm (data include blocks that have more than one organic farm) and number of total breeding birds species found in that block. Percent of block organic farm range: 0.0032(86) – 12.56(70), mean: 2.4(75) percent (number of total species is in parenthesis).

<table>
<thead>
<tr>
<th>% of Block Organic</th>
<th>Total Species</th>
<th>% of Block Organic</th>
<th>Total Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.973248641</td>
<td>72</td>
<td>9.951730998</td>
<td>63</td>
</tr>
<tr>
<td>0.011331206</td>
<td>88</td>
<td>6.24304045</td>
<td>59</td>
</tr>
<tr>
<td>1.619876678</td>
<td>77</td>
<td>0.004733326</td>
<td>80</td>
</tr>
<tr>
<td>7.345869173</td>
<td>54</td>
<td>0.347220536</td>
<td>77</td>
</tr>
<tr>
<td>2.083612533</td>
<td>76</td>
<td>1.8437914</td>
<td>87</td>
</tr>
<tr>
<td>0.683595489</td>
<td>81</td>
<td>2.95021703</td>
<td>79</td>
</tr>
<tr>
<td>0.003237488</td>
<td>86</td>
<td>0.71357713</td>
<td>59</td>
</tr>
<tr>
<td>2.955021703</td>
<td>90</td>
<td>0.633711530</td>
<td>74</td>
</tr>
<tr>
<td>2.560367002</td>
<td>87</td>
<td>1.393738375</td>
<td>66</td>
</tr>
<tr>
<td>3.493087165</td>
<td>66</td>
<td>0.063074787</td>
<td>65</td>
</tr>
<tr>
<td>1.049073497</td>
<td>83</td>
<td>1.135145093</td>
<td>65</td>
</tr>
<tr>
<td>4.598851016</td>
<td>67</td>
<td>0.847881644</td>
<td>62</td>
</tr>
<tr>
<td>0.061137422</td>
<td>93</td>
<td>2.107604573</td>
<td>65</td>
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<tr>
<td>4.742433687</td>
<td>79</td>
<td>0.014804678</td>
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<tr>
<td>0.534671063</td>
<td>80</td>
<td>12.96194616</td>
<td>70</td>
</tr>
<tr>
<td>0.005556106</td>
<td>103</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ y = -1.4678x + 78.11 \]

\[ R^2 = 0.1389 \]

\[ P = 0.0389 \]

FIGURE 11. Total number of bird species in Breeding Bird Atlas Blocks as function of percent of BBA block that is organic farm.
FIGURE 12. Number of confirmed bird species in Breeding Bird Atlas Blocks as function of percent of BBA block that is organic farm.

FIGURE 13. Number of probable bird species in Breeding Bird Atlas Blocks as function of percent of BBA block that is organic farm.
$y = -0.595x + 25.269$

$R^2 = 0.0399$

$P = 0.2811$

FIGURE 14. Number of possible bird species in Breeding Bird Atlas Blocks as function of percent of BBA block that is organic farm.

TABLE 4. Summary table of survey results on organic and conventional farm practices.

<table>
<thead>
<tr>
<th>Practice</th>
<th>% use on organic farms</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop rotation</td>
<td>75</td>
<td>13</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Use of antibiotics</td>
<td>8</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>No till</td>
<td>25</td>
<td>5</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Grain fed animals</td>
<td>58</td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Addition of soil organisms</td>
<td>42</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Organisms for biological control</td>
<td>17</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Hericide use</td>
<td>33</td>
<td>6</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Hedgerow field separation</td>
<td>42</td>
<td>7</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Manual removal of weeds during growing season</td>
<td>83</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Riparian buffer if applicable</td>
<td>33</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Green manure</td>
<td>58</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Genetically modified organisms</td>
<td>0</td>
<td>2</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Grass fed animals</td>
<td>67</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*Fourteen surveys were returned in total; four of them were conventional farmers*
VI. Literature Cited


Saint Lawrence County Board of Legislators. Agricultural District 2 Eight Year Review Report. 2006.


<http://www.usda.gov/wps/portal/?navid=FARM_BILL_FORUMS>


