“A WALK THROUGH THE SCHOOL – AN INVESTIGATION OF SCHOOL INTEGRATED PEST MANAGEMENT IN GEORGIA (USA)”

by

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Under the Direction of

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ABSTRACT

The status of School Integrated Pest Management (SIPM) in the schools of Georgia remains widely unknown. While the Environmental Protection Agency (EPA) aspires to have SIPM implemented in all states by 2015, relatively little is known about the current pest control practices in schools in Georgia. An IPM criteria survey was conducted in five schools in Georgia in three counties; Bartow, Catoosa, and Coweta. All schools scored higher than a 90% on the survey and were all implementing IPM practices. Furthermore, a complete set of elementary, middle, and high school lesson plans were developed to be integrated into the school systems in Georgia to promote IPM education.

INDEX WORDS: School Integrated Pest Management, SIPM, IPM, Georgia, Curriculum, Lesson Plans

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION OF INTEGRATED PEST MANAGEMENT

What is Integrated Pest Management?

Throughout the years, Integrated Pest Management (IPM) has had several definitions but the philosophy of IPM has remained fairly constant (Smith and Smith, 1949; Sawyer and Casagrande, 1983; Ellsworth, 2001; Ehler, 2006). Integrated Pest Management can be utilized in agricultural, ornamental, or structural environments and, contrary to some beliefs, IPM does not require a lack of pesticide use, but instead controlled application in situations that require chemical intervention. Integrated Pest Management entails five major aspects; understanding the pests' biology, establishing thresholds, monitoring for pest populations, evaluating effectiveness of management strategies, and establishing lines of communication. The first aspect of IPM is understanding the pests' biology. This includes what pests feed on, what habitats the pests are found in, and any natural enemies the pests might have. If a pest has natural enemies, it is important to understand some of the natural enemies' biology, including susceptibility to insecticides.

Secondly, in an IPM program thresholds are determined. In agricultural settings, thresholds are typically established for economic and aesthetic damages. Management strategies are generally employed when the financial cost of doing nothing to manage the pest exceeds the cost of action. In agricultural settings these thresholds can be easily determined based on cost benefit models (Kogan, 1998). However, knowing when to employ management strategies in a school setting is more complicated as there are several thresholds that need to be considered.

Thresholds that may apply in a school setting are based on both the public perception of the pest and the location in which the pest is found. This makes determining thresholds complex and difficult in a school environment. However, the thresholds that should be considered are economic, aesthetic, health and safety, legal, and public opinion (Maryland Department of Agriculture). Economic thresholds, like carpenter bees (Apidae: *Xylocopa*) damaging wood, can still be determined by simple cost benefit models. However, potential employee bias towards "quick fix" management strategies against pests they have phobias towards can be harder to measure and determine. Furthermore, tolerance of a single pest can be variable. While one person may find one cockroach unacceptable in a classroom, another might find the presence of three tolerable (Wood *et al.* 1981; Robinson and Zungoli, 1995). The third aspect of IPM is to monitor pests and determine multiple strategies to suppress pests. These include chemical treatments such as insecticides or baits, and non-chemical treatments such as removing food, water, and habitat, and maintaining and fixing building areas where the pests may enter (Daar *et al.* 1997; Messenger *et al.* 2010). If chemical treatments are used, they must be used in a way that will minimize the risks to people, property, and the environment. Chemical treatments are used only when necessary and in conjunction with other non-chemical treatments. According to IPM, chemical treatments can only be used after monitoring indicates that pesticides are needed in accordance to pre-existing guidelines and treatment thresholds (Messanger *et al.* 2010). Because everyone is responsible to some degree for pest control, educational practices are important so people understand how pests are entering the premises and what food items the pests may eat. Monitoring should not only be used to determine initial management strategies but also to determine the effectiveness of those management strategies through an evaluative program.

Finally, an effective IPM program needs to establish lines of communication and education to everyone who is involved in the management of pests. This includes establishing contacts between school administrators, IPM contractors (coordinators), buildings managers, pest management employees, and pesticide applicators. All parties involved should be educated not only on the pests' biology but on the mindset and problem solving aspects of IPM (Green and Breisch, 2002).

IPM Definition

Integrated Pest Management has had over seventy definitions since its first enactment in the 1970's. The University of Georgia defines IPM as "a science-based decision making process that employs biological, mechanical, cultural, and chemical control methods in such a way as to minimize economic, environmental, and public health risks associated with pests and pest management" (UGA, 2014). However, IPM in schools involves implementation of the program by faculty and staff within the school. All involved parties need to understand the importance and mindset of IPM so everyone can be cognizant of the way that their behavior affects pest management. Furthermore, an integral part of IPM is an evaluative process so that applicators, administrators, and contractors can assess if their IPM strategies are effective.

Therefore, for the purposes of this dissertation IPM is defined as "a decision making process for long term, sustainable, pest prevention and suppression. It is a science based process which determines thresholds and sets action strategies based on monitoring before employing some combination of biological, mechanical, cultural, and chemical control methods that minimize economic, environmental, and public health risks. IPM establishes lines of communication between all involved parties and educates all people who can potentially have an effect on the success of the management program."

History of IPM

Supervised Control:

Before the idea of IPM was established, people were already beginning to understand that strict chemical control of some pests was ineffective. The concept of biological control surfaced in the late 1880's when the non-native cottony cushion scale (*Icerya purchase:* Maskell, 1878) was introduced into California and proceeded to wreak havoc on citrus orchards. Chemical treatment did not hinder the cottony cushion scale. Thus the vedalia beetle (*Rodolia cardinalis:* Mulsant, 1850), a type of ladybug, was introduced into California from Australia in an effort to reduce the cottony cushion scale population. Within a year, the cottony cushion scale was successfully controlled by the vedalia beetle (Caltagirone and Doutt, 1989). Despite a few successful biological control stories, chemical control remained the predominant method for controlling and managing pests. Integrated pest management began shortly after World War II when synthetic insecticides were applied to crops with minimal regard for the environment and public health. Dichlorodiphenyltrichloroethane (DDT) and Hexachlorocyclohexane (HCH) were used indiscriminately to control fora variety of pests. DDT was initially used to control for mosquitoes in military structures to prevent diseases like malaria, but soon its agricultural and domestic uses became apparent. Farmers' main concern was to increase crop yield and minimize damage for maximum profit and many farmers indiscriminately used insecticides for maximum crop yield. During this period, DDT and HCH were used in cities and many people used these insecticides in their homes to manage pests like mosquitoes, lice, fleas, and bedbugs (Pedigo and Rice, 2009).

During this period of extensive insecticidal use, entomologists in California and the southern United States developed dual ecological and insecticide regimens that took into account the pests' biology to help curb insect resistance, ecological ramifications, and human health risks. By 1950 entomologists at the University of California articulated, supervised, and integrated pest management plans in agricultural systems and termed the program "supervised control" which was the predecessor of modern IPM. Under this program of "supervised control", insect management had to be supervised by a qualified entomologist (Smith and Smith, 1949). These entomologists would survey and monitor crops periodically searching for both pests and natural enemies. Supervised control was different from the competing pest control programs because insecticides were only used when necessary instead of the widespread strict calendar-based treatments traditionally used to manage pests. The first adopted supervised control program started in the 1950's and was used to treat the alfalfa caterpillar, *Colias eurytheme:* Boisduval, 1852 (Ehler, 2006; US Bureau of Entomology and Plant Quarantine, 1952).

<u>The Beginning of Integrated Pest Management:</u>

In the 1960's there was a need for more strategically applied pest management due to evidence of pest resistance to insecticides, pest resurgence, secondary pest outbreaks, and environmental contamination. Entomologists at the University of California proposed "integrated control" which the next precursor for modern IPM. These entomologists also were the first to introduce concepts about the injury level necessary to warrant pest treatment (Stern *et al.* 1959). Likewise, in 1971, entomologists started two pilot IPM projects; one for tobacco in North Carolina and the other for cotton in Arizona. The emphasis of these programs was to monitor pest populations and only apply pesticides when pests were numerous enough to start causing economic damage (Rajotte *et al.* 1979).

In the late 1960's and early 1970's several specific developments occurred that spurred the official adoption of IPM. First, the pink bollworm (*Pectinophora gossypiella:* Saunders,

1844) expanded its geographical range from the cotton belt to Arizona and southern California, leading to the increased spraying of DDT (Naranjo *et al*. 2002). Because cattle were ingesting DDT from their feed, detectable amounts of DDT was found in milk and exceeded federal tolerances (Brown *et al.* 1966; Kogan, 1998; Pedigo and Marlin, 2009). Second, the United States Department of Agriculture organized an IPM program for North Carolina due to increased parathion poisonings of agricultural workers in specific farms (Kogan, 1998; Daniel, 2007). Another development was that the gypsy moth (*Lymantria dispar*: Linnaeus, 1758) and the southern pine beetle (*Dendroctonus frontalis*: Zimmerman, 1868) numbers were surging supposedly due to the reduced use of DDT since its ban for use in forest control in 1957 (Kogan, 1998). Rachel Carson wrote the book *Silent Spring* which outlined the ecological and human health risks associated with the overuse of DDT including the ramifications of bioaccumulation. This was the first time that ecological concerns of the use of pesticides had been raised and this led to the public outcry and ban of DDT in 1972. Integrated Pest Management was then drafted as a national policy (BioControl Reference Center, 1995; Carson, 1962; Pedigo and Rice, 2009).

Pesticide Regulation:

Two laws were passed in the early 1900's to regulate pesticides. The first was the Pure Food and Drug Act (1906) which required the labeling of all drugs and established tolerable purity levels. This effectively spurred the creation of the Food and Drug Association (FDA). The second was the Federal Insecticide Act (1910), which ensured quality pesticides were sold to farmers and consumers and included proper labeling. During the 1930's and 1940's federal regulation for laws were updated due to the growing concerns of the effects of pesticides on the environment and public health. In 1938 the Pure Food and Drug Act (1906) was updated and amended to set maximum allowable amounts for pesticide residues, primarily stomach poisons like lead arsenate, on food. Under the new Food, Drug, and Cosmetic Act (1938), all pesticides also had to be colored to prevent people from mistaking them as common household cooking items, like flour. It was updated again in 1954 to include more stringent laws concerning pesticide residues on food and tolerances were placed on all foods. In 1958, the law was updated again to disallow carcinogens on food for human consumption (Food, Drug, and Cosmetic Act, 1938; Pedigo and Rice, 2009).

In 1947, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was drafted to replace the Federal Insecticide Act (1910). Under FIFRA, all pesticides for sale in interstate commerce had to be registered with the USDA. FIFRA required pesticides to be labeled and ensured the safety of the insecticides if the user followed the labeled instructions. In 1959, FIFRA was updated to include other forms of pesticides including nematicides, plant regulators, defoliants, and desiccants. In 1964, FIFRA was updated again to improve safety through specific label requirements. Both FIFRA and the Food, Drug, and Cosmetic Act were administered and regulated by both the USDA and Food and Drug Administration (FDA). Subsequently the Environmental Protection Agency (EPA) was created in 1970 after growing concerns of ecological and environmental quality were raised in the aftermath of DDT. Enforcement of FIFRA and the Pure Food, Drug, and Cosmetic Act became the newly formed EPA’s responsibility. In 1972 the Federal Environmental Pesticide Control Act (FEPCA), also known as FIFRA amended, was enacted and is fundamentally the act that regulates current pesticide use in the United States. In the years until 1988, amendments were added to improve the effectiveness of the registration process and strengthen the EPA’s regulatory authority (FIFRA, 1947; Pedigo and Rice, 2009). In 1996, the Food Quality Protection Act (FQPA) was passed in response to safety concerns for children. The FPQA mandated that all federal agencies were required to implement IPM. Furthermore, the EPA was required to create a list of public health pests, pesticides were retested for endocrine disruptors, and all pesticides were required to be retested every fifteen years (Green and Breisch, 2002, FQPA, 1996).

Pesticide Bans in Urban Environments:

Integrated pest management remained a primarily agricultural practice throughout the 1970’s and 1980’s. Biologists had not considered studying the biology, botany, and ecology of urban settings up until the 1970’s (Ebeling, 1976; Frankie and Ehler, 1978; Frankie and Koehler, 1978; Li, 1969; Stearns, 1970). During the 1980’s entomologists started to question the public health implications of misused insecticides by untrained people and reexamine insecticidal treatments in urban settings. Because insecticides can easily be misused, entomologists were concerned about public health due to exposure to high levels of insecticides and other contaminants in urban environments. Throughout the 1970’s and 1980’s many insecticides that were used in domestic residences were banned due to their environmental and human health impacts (Pedigo and Rice, 2009). Researchers began developing urban IPM programs with safer pesticide use and pesticide laws were clarified, strengthened, and all relevant laws were transferred to the EPA for regulation and management.

One of the first insecticides to be banned after DDT was Mirex, an organochoride insecticide. It was used throughout the 1960’s and 1970’s to control imported fire ants, which became invasive in the early and mid-1900’s and was banned in 1976 because of its biomagnification and bioaccumulation properties in apex predators (Culpepper, 1953; Metcalf, 2002; Pedigo and Rice, 2009). Chlordane, an organochlorine, was used for the control of termites in addition to controlling pests on lawns and domestic gardens. It was banned in 1983 because it posed health risks to people and contaminated groundwater due to its relatively slow degradation in the environment (Metcalf, 2002; Pedigo and Rice, 2009). Two years later, α-HCH and β-HCH were banned due to the chemicals' vast environmental impacts which led to the subsequent ban of other HCHs. The final HCH banned was Lindane (γ-HCH) which was banned for agricultural use in 2006, but can still be used in shampoos and lotions to treat lice and scabies (EPA, 2006; US Department of Health, 2005; Pedigo and Rice, 2009; NIH, 2012). Throughout the 2000's several insecticides were removed from the household market or had restricted uses in buildings due to the potential negative effects on children. Dursban is a chlorpyrifos that was introduced in 1965 and was used for fire ant and termite control. However, in 2001 it was withdrawn from the market for household use and in areas where children would be present including schools, daycare centers, and parks due to overuse and suspected, later confirmed, negative neurological effects (Landrigan *et al.* 1999; Waldvolgel and Buhler, 2000; Pedigo and Rice, 2009; Horton *et al.* 2012). Diazinon, an organophosphate insecticide, was used heavily throughout the 1970's and 1980's for domestic pest control for insects including cockroaches, silverfish, ants, and fleas. However, its domestic use was discontinued in 2004 by the EPA (Pedigo and Rice, 2009; EPA, 2012b). Finally, Endosulfan, an organochlorine insecticide, was banned in 2011 by the EPA with a five year phase-out period in several countries due to its potential bioaccumulation and harmful effects to people. While Endosulfan was never used in homes, it was used in horticultural crops to control for whiteflies and aphids among other insects, and was found to have a detrimental effect on children, potentially causing reproductive and developmental disorders (Silva and Gammon, 2009; Pedigo and Rice, 2009; Lubick, 2010). These subsequent bans show the changes in attitude, perceptions, environmental awareness, and regard for potential toxicity to humans.

Integrated Pest Management in Urban Environments:

Although IPM had become a well-known practice by the 1990's in agriculture, many farmers and pest control industries were slow to adopt the program and many people refused to implement IPM practices. Because it was presumed that many people either did not know of IPM or had misunderstandings of its effectiveness, efforts were made to improve education about IPM to farmers by extension specialists, industry researchers, and land grant schools. Studies conducted demonstrated that IPM practices do not detrimentally affect crop yield (McNamara *et al.* 1991; Smith *et al.* 1987). Many people had misconceptions about the practices and cost of IPM and educational material was created and land grant schools were encouraged to educate local farmers about the benefits, techniques, and cost of IPM programs (McNamara *et al*. 1991; Wearing, 1998; Ellsworth and Jones, 2001; Yang *et al*. 2005).

Some efforts were made to educate the general public about IPM in urban environments as well. A book, *Common Sense Pest Control*, was published in 1991 for homeowners looking for ways to control domestic (cockroaches, silverfish, ants) and garden pests (aphids, white flies, leafhoppers) although its academic integrity has been criticized. It combines a variety of methods and looks to educate the general public about pest identification, biological control, monitoring for pests, and choosing the appropriate combination of management strategies including sanitation, trapping, and insecticidal use (Olkowski *et al.* 1991). Beginning in the late 1990's, researchers noted the necessity for IPM in urban environment because of the overuse of pesticides, including many illegal pesticides, and their detrimental effects and close proximity to children (Landrigan, 1999). The goal of urban IPM is to reduce pests while avoiding excessive and ineffective pesticide use in structural environments (Ebeling, 1975; Robinson and Zungoli, 1995; Granovsky, 1997; Kells, 2009). Integrated Pest Management in structural space is important because there is a high use of pesticides associated with these areas and pest tolerance in these areas is low (Sawyer and Casagrande, 1982; Robinson 1996b). High pest populations in structural can be easily facilitated because there are many microhabitats for which pests can thrive free of predators and competition (Frankie and Ehler, 1978; Robinson 1996b). Therefore, effective management strategies must be employed to reduce risk to people and the environment and to satisfy clientele.

Subsequent studies provided educational materials or explained the IPM process to residents specifically in apartment buildings. This is particularly important because if the IPM program is misunderstood or the IPM program fails then the client may lose interest and resort to previous, possibly ineffective, treatments (Robinson 1996a; Kells, 2009). Researchers completed effectiveness and cost analysis studies on IPM practices for controlling cockroaches in contrast to traditional insecticidal practices. Most of the studies found that IPM methods were either cost effective or slightly more expensive than traditional practices, but all studies found that the IPM practices significantly reduced cockroach populations (Brenner *et al.* 2003; Miller and Meek, 2004; Wang and Bennett, 2006; Kass *et al.* 2009). In turn, because of the reduced pesticide use and fewer numbers of cockroaches, allergen problems were also reduced (Landrigan, 1999; Kass *et al.* 2009).

Bedbugs are another common pest problem in urban environments. However, due to their long term absence in the United States from the overuse of DDT, not much research has been conducted on them. However, bedbugs are resurging and are showing insecticidal resistance, which may make IPM an important component to their control. These IPM practices may include heat treatments and vacuuming (Romero *et al.* 2007). However such treatments do not seem to be effective on their own (Pereira *et al*. 2009). Concerns for treatment of pests in public buildings have arisen but no extensive studies have been conducted. It appears that bed bug surveillance by employees and targeted treatments are equally as effective as routine traditional pesticide application (Green and Breisch, 2002). This is important, because IPM studies and control have not been extensively studied for pests that are common problems in both housing and other public buildings.

Termite IPM began in the late 1990's and specific monitoring and baiting practices were used in attempts to reduce pesticide use (Su and Scheffrahn, 1998). Other methods of control were tried, including heat treatments in combination with fumigation for global infestations of a structure and electric and cold treatments in association with targeted insecticides for local infestations (Lewis and Haverty, 1996). The most effective current IPM measures are using barriers with termiticide to prevent infestations, and later using baits and surveillance to control populations (Rust and Su, 2012). Similarly, ants have provided similar concerns. While basic sanitation and bait traps are effective in houses and other structures, there are larger concerns for fire ant control on building grounds. Researchers are hopeful that recently introduced biological controls of the phorid (Phoridae) flies and the fungus (*Thelohania solenopsae*) can be effective enough to reduce the need for insecticides (Williams *et al.* 2001; Valles and Pereirs, 2003; Rust and Su, 2012). In addition to the importance of educating the clientele about IPM strategies, pest management company employees must also be educated to use IPM in structural areas. Unfortunately, IPM training adoption has been slow. In the past, employees of pest management companies had little if any training in IPM practices (Frankie *et al.* 1986). Today, small and local pest management companies supplement basic pest management training with IPM practices in "on the job" training. Training for structural IPM is often underestimated or ignored by professionals (Kells, 2009). Therefore it is difficult to determine what training pest management company employees have. Furthermore, IPM texts which are designed to educate management companies on IPM practices often teach specific actions to take for specific pests (Ebeling, 1975; Mallis, 2004; Radcliff *et al* 2009). However, they do not teach the mindset, attitude, or general understanding of what an IPM process is (Brannon, 2011).

<u>The Beginning of Integrated Pest Management in Schools:</u>

In the mid 1990's the Monroe County Community School Corporation (MCCSC) in Indiana developed and implemented a school IPM program. The goal of their program was similar to other IPM programs but specifically targeted to schools. In addition to traditional monitoring, this school IPM program focused on educating the staff and students about pests while reducing pesticide use. Using the MCCSC, or the Monroe model, the EPA expanded MCCSC pilot program throughout Indiana. In 2008, the EPA initiated a school IPM (SIPM) program throughout the United States (EPA, 2012a).

School Integrated Pest Management

It is estimated that fifty three million students and six million faculty spend a significant amount of time on school property in the United States (EPA, 2012a). Therefore, it is necessary to have a pest management plan that is both effective and reduces the amount of pesticides people are exposed to. The over application of pesticides in a school environment have been a concern for over twenty years (Fenske *et al.* 2000) and IPM in schools can be an effective solution to this problem (Owens, 2009). Attempts to make SIPM (School Integrated Pest Management) federally mandated have been unsuccessful (Owens, 2009). The EPA and the IPM Institute of North America have set a goal that all schools in the United States will have to abide by some form of state regulated SIPM (EPA, 2012a). SIPM has become a "proving ground" for the efficacy and feasibility of urban IPM programs (NRC, 1993; EPA, 2002).

Current SIPM Status in the United States:

In some states school integrated pest management (SIPM) has already been mandated. For example, California not only has state mandated SIPM (Healthy Schools Act, 2000) but a complete model program to help schools transition to use IPM in schools (Messanger *et al.* 2010). School integrated pest management has not been widely accepted by schools that are not required to have SIPM programs. Therefore, SIPM adoption has been slow (EPA, 2012a). This could be because school administrators have a low tolerance for pests and are more willing to use pesticides to treat symptomatic problems (Rambo, 1999; Owens, 2009). Some states, like Georgia, South Carolina, and North Carolina have some volunteer SIPM programs but it is likely that the majority of the schools in these states have not adopted a formal SIPM program. Many states do have more restrictions on pesticide use in schools (NASBE Center for Safe and Healthy Schools, 2013). A table (Table 1.1) was created to determine the current status of SIPM in schools.

There are many misconceptions about the cost, effectiveness, and ease of implementing an SIPM program. Schools do not know what the philosophy of IPM is and so many are not enacting IPM programs (Lame, 2005). Thus, similar to what many researchers found in the 1990's, educational programs are essential for school administrators to adopt an IPM program (McNamara *et al.* 1991; Messenger *et al.* 2010; EPA, 2012a). Administrators, faculty, staff, and students need to be educated not only on what an IPM program entails, but understand basic pest biology. School administrators and staff need to work together to keep the school clean to reduce habitat and food that pests can utilize. Facility managers need to maintain building integrity and permanently and sustainably fix any structural problems (Messenger *et al.* 2010; EPA, 2012).

However, many school administrators feel that insecticide use is cheaper and easier than implementing an IPM program.

Obtaining specific information about whether states have SIPM programs is difficult because information is scattered through several inaccurate references and in some cases is reported incorrectly. For example, there are some reports that Georgia has an Integrated Pest Management plan in schools because of a bill, “Georgia School Pesticide Act” that was drafted in 2003 (House Bill 1042, 2003). However the bill was never passed and Georgia still does not have an official Integrated Pest Management plan. In Georgia, pest control is either done in-house by staff members or is contracted out to a professional pest control company, but all pesticides and applications must be used in accordance to the current pesticide laws. While there are no restrictions on the types of pesticides that can be used in schools, there are regulations stating when and where pesticides can be applied and that pesticides should be applied in a manner that minimizes the exposure of the product to the students (Georgia Structural Pest Control Commission).

In Georgia, little research has been done about the status of school pest control programs and it is not state mandated. There was a bill put forth in Georgia attempting to mandate SIPM in Georgia but it was never passed. In 2003 a school was cited for non-compliance of pesticide records and there was a fine of 96,000 USD. Field agents directed by the Georgia Department of Agriculture inspected other schools on their pest management strategies and many violations were noted. This prompted the Georgia Georgia Structural Pest Control Commission to update their specific school regulations in the Rules of Georgia Structural Pest Control Commission – “Treatment of Schools” Ch. 620-1-11 (Harron, 2009). Through these regulations, and the other pesticide laws stated in the the Rules of Georgia Structural Pest Control Commission, Georgia regulates the pesticide industry in schools. These laws, combined with regular pesticide use inspections and health code inspections, regulate the pesticide use in schools. However, no formal SIPM program has been adopted by the state or any schools for school implementation.

List of States with SIPM Programs and Date of Implementation

Table 1.1: States that have an SIPM program. If the program is state mandated, the year of implantation is indicated. If the states have a voluntary program, the status is noted. States were determined to be "voluntary" if there was some indication that the state universities, educational systems, or lawmakers applied integrated pest management suggestions but are not legally upheld. States with no SIPM policy and no website were not included in the list. (NASBE, 2013)

State	Year Mandated	Website
Alabama	Voluntary	http://www.ag.auburn.edu/enpl/schoolipm/index.php
Alaska	2002*	http://www.touchngo.com/lglcntr/akstats/AAC/Title18/Chapter090/Section625.htm
Arizona	Voluntary	http://cals.arizona.edu/urbanipm/schools/index.html
California	2000	http://apps.cdpr.ca.gov/schoolipm/
Colorado	Voluntary	http://ipm.agsci.colostate.edu/schools-homes-school-ipm/
District of Columbia	Voluntary	http://osse.dc.gov/sites/default/files/dc/sites/osse/publication/attachments/Healthy_Schools_Act_Legislation.pdf
Florida	2008	http://www.nasbe.org/healthy_schools/hs/state.php?state=Florida http://schoolipm.ifas.ufl.edu/admn_rg1.htm
Georgia	Voluntary	http://www.nasbe.org/healthy_schools/hs/state.php?state=Georgia#Pesticide%20Use
Illinois	2008	http://www.idph.state.il.us/rulesregs/rules-indexbytopic.htm#ipm
Indiana	Voluntary	http://extension.entm.purdue.edu/schoolipm/indiana_page.html
Iowa	Voluntary	http://www.ipm.iastate.edu/ipm/schoolipm/
Kansas	Voluntary	http://www.ksre.ksu.edu/pesticides-ipm/p.aspx?tabid=24
Kentucky	2002	http://www.lrc.state.ky.us/kar/302/029/050.htm
Louisiana	1995	http://www.beyondpesticides.org/documents/LASchoolLaw.pdf?lawbody=RS&title=3%A7ion=3382
Maine	2005	http://www.maine.gov/dacf/php/integrated_pest_management/school/index.shtml
Maryland	2000	http://mda.maryland.gov/plants-pests/Pages/Integrated-Pest-Management-%28IPM%29-in-Schools.aspx
Massachusetts	2000	http://massnrc.org/ipm/schools-daycare/child-protection-act-2000/full-text.html
Michigan	Voluntary	http://www.michigan.gov/documents/MDE_Asthma_Policy_Board_10_2004_115301_7.pdf
Minnesota	Voluntary	http://www.mda.state.mn.us/plants/pestmanagement/ipm/ipmschools.aspx

Mississippi	2010	http://billstatus.ls.state.ms.us/documents/2010/pdf/SB/2300-2399/SB2393SG.pdf
Missouri	Voluntary	http://mda.mo.gov/plants/ipm/ipm.php
Montana	Voluntary	http://ipm.montana.edu/school.html
Nebraska	Voluntary	http://pested.unl.edu/schoolipm
New Jersey	2003	http://www.nj.gov/dep/enforcement/pcp/ipm-laws.htm
New York	Voluntary	http://www.nysipm.cornell.edu/buildings/
North Carolina	2006	http://schoolipm.ncsu.edu/
North Dakota	Voluntary	http://www.nd.gov/ndda/program/integrated-pest-management-ipm-schools
Ohio	Voluntary	http://bugs.osu.edu/schoolipm/
Oklahoma	Voluntary	http://oces.okstate.edu/ipm-oklahoma/ipm-program-areas/school-ipm
Oregon	Voluntary	http://www.ipmnet.org/tim/IPM_in_Schools/IPM_in_Schools-Main_Page.html
Pennsylvania	2002	http://extension.psu.edu/pests/ipm/schools/administrators/pa-schools-ipm-manual
Rhode Island	Voluntary	http://environmentcouncilri.org/content/integrated-pest-management-ri-schools
Tennessee	Voluntary	http://schoolipm.utk.edu/
Texas	1991	http://schoolipm.tamu.edu/files/2011/08/History-of-School-IPM-Program-in-Texas.pdf
Utah	Voluntary	http://utahpests.usu.edu/schoolIPM/htm/right-widget/school-ipm-forms/
Vermont	Voluntary	http://pss.uvm.edu/pd/schoolipm/?Page=#practice
Virginia	Voluntary	http://www.sites.ext.vt.edu/schoolipm/
Washington	Voluntary	http://schoolipm.wsu.edu/
West Virginia	1996	http://nrckids.org/default/assets/File/StateRegs/WV/wv_61_12J.pdf
Wisconsin	Voluntary	http://datcp.wi.gov/Plants/Pesticides/School_IPM/?AspxAutoDetectCookieSupport=1
Wyoming	Voluntary	http://www.uwyo.edu/wyschool_ipm/

References

1. Brannon SL. 2011. Integrated Pest Management (IPM) in Urban Entomology: Training, Regulation, and Education. University of Georgia, Athens GA.

2. Brown WH, Witt JM, Whitnig FM, Stull JW. 1966. Secretion of DDT in Milk by Fresh Cows. *Bulletin of Environmental Contamination and Toxicology* 1:21-28.

3. BioControl Reference Center Acosta, EW. 2006. The history of integrated pest management (IPM).

4. Brenner BL, Markowitz S, Rivera M, Romero H, Weeks M, Sanchez E, Deych E, Garg A, Godbold J, Wolff MS, Landrigan PJ, and Berkowitz G. 2003. Integrated pest management in an urban community: a successful partnership for prevention. *Environmental Health Perspectives* 111(13): 1649-1653.

5. Caltagirone, LE, and Doutt, RL. 1989. The history of the vedalia beetle importation to California and its impact on the development of biological control. *Annual Review of Entomology* 34: 1-16.

6. Carson, R. 1962. *Silent Spring.* Houghton Mifflin.

7. Culpepper GH. 1953. The distribution of the imported fire ant in the Southern States. *Proceedings of the Association of Agricultural Workers* 50: 102.

8. Daar S, Drlik T, Olkowski H, and Olkowski, W. 1997. *IPM for Schools: A How-To Manual.* Bio-Integral Resource Center, Berkley, CA.

9. Daniel P. 2007. *Toxic Drift: Pesticides and Health in the Post World War II South.* Baton Rouge: LSU Press.

10. Ebeling W. 1976. Urban entomology. Agricultural Science Publications, Division of Agricultural Science, University of California, Berkeley CA.

11. Ehler LE. 2006. Perspective: Integrated pest management (IPM): definition, historical development, and implementation, and other IPM. *Pest Management Science* 62:787-789.

12. Ellsworth PC and Jones JS. 2001. Cotton IPM in Arizona: A decade of research, implementation, & education. Cotton Reports. College of Agriculture, University of Arizona.

13. Environmental Protection Agency (EPA). 2002. Protect children, protect our future. Protecting children in schools from pests and pesticides. Office of Children's Health Protection. Washington, DC. Retrieved Nov 10, 2014 from http://www.epa.gov/opp00001/health/protecting-children.pdf.

14. Environmental Protection Agency (EPA). 2006. Lindane-Cancellation Order. *Federal Register* 71(239):74905-74907.

15. Environmental Protection Agency (EPA). 2012a. Strategic and Implementation Plans for School Integrated Pest Management.

16. Environmental Protection Agency (EPA). 2012b, May 9. Diazinon: Phase out of all residential uses of the insecticide. *U.S. Environmental Protection Agency*. Retrieved October 21, 2014 from http://www.epa.gov/pesticides/factsheets/chemicals/diazinon-factsheet.htm.

17. Federal Food, Drug, and Cosmetic Act. 1938. 21 U.S.C. ch. 9 §301 et seq.

18. Fenske R, Black KG, Elkner KP, Lee C, Methner MM, Soto R. 1999. Potential exposure and health risks of infants following indoor residential pesticide applications. *American Journal of Public Health* 80: 689-693.

19. Federal Insecticide, Fungicide, and Rodenticde Act (FIFRA). 1947. 61 Stat. 163, 7 U.S.C. §136-136j.

20. Frankie GW and Ehler LE. 1978. Ecology of insects in urban environments. *Annual Review of Entomology* 23:367-387.

21. Frankie GW and Koehler CS. 1978. *Perspectives in Urban Entomology*. Academic Press, New York, NY.

22. Frankie GW, Grieshop JL, Grace JK, and Fraser JB. Education, information, transfer, and information exchange. In Bennett G and Owens JM (eds). *Advances in Urban Pest Management.* Van Nostrand Rienhold Company. New York, NY.

23. Georgia Structural Pest Control Commission. Rules of Georgia Structural Pest Control Commission. Ch. 620-1-11.

24. Granovsky, TA. 1997. In Mallis, A. (ed) Stored product pests. *Handbook of Pest Control: The Behavior, Life History, and Control of Household Pests.* Mallis Handbook and Technical Training Company.

25. Green A and Breisch N. 2002. Measuring Integrated Pest Management Programs for Public Buildings. *Journal of Economic Entomology* 95(1): 1-13.

26. Harron J. 2009. Back to School: Educating PMP's on pest management practices in schools that are efficacious, safe and in compliance with state requirements was the goal of a Georgia symposium. Pest Control Technology Online. 37:72-81.

27. Healthy Schools Act. Assem. Bill 2260, 2000. Sess., ch, 718. Cal. Stat.

28. Horton MK, Khan LG, Perera F, Barr DB, and Rauh V. 2012. Does the home environment and sex of the child modify the adverse effects of prenatal exposure to chlorpyrifos on child working memory? *Neurotoxicology and Teratology* 34(5) 534-541.

29. House Bill 1042. 2003. Representatives Ashe of the 42nd, Post 2 and Teilhet of the 34th, Post 2.
http://www.legis.ga.gov/Legislation/20032004/30135.pdf

30. Integrated Pest Management (IPM) Institute of North America. IPM District Survey. 2013. Georgia IPM School District Survey Summary Report.

31. Kass D, McKelvey W, Carlton E, Hernandez M, Chew G, Nagle S, Garfinkel R, Clarke B, Tiven J, Espino C, and Evans D. 2009. Effectiveness of an Integrated Pest Management in Controlling Cockroaches, Mice, and Allergens in New York City Public Housing. *Environmental Health Perspectives* 117:1219-1225.

32. Kells SA. 2009. IPM in structural habitats. In Radcliffe EB, Hutchinson WD, and Cancelando RE. *Integrated Pest Management: Concepts, Tactics, Strategies, and Case Studies.* Cambridge University Press NY.

33. Kogan M. 1998. Integrated pest management: Historical perspectives and contemporary developments. *Annual Review of Entomology* 43: 243-270.

34. Kreiger JW, Takaro TK, Song L, Weaver M. 2005. The Seattle-King County Healthy Homes Project: a randomized, controlled trial of community health worker intervention to decrease exposure to indoor asthma triggers. *American Journal of Public Health* 95: 652-659.

35. Lame ML. 2005. *A Worm in the Teacher's Apple*: *Protecting America's School Children from Pest and Pesticides*. Authorhouse, Bloomington IN.

36. Landrigan PJ, Claudio L, Markowitz SB, Berkowitz GS, Brenner BL, Romero H, Wetmur JG, Matte TD, Gore AC, Godbold H, Wolff MS. 1999. Pesticides and inner-city children: exposures, risks, and prevention. *Environmental Health Perspectives* 107(Suppl 3): 431-437.

37. Lewis VR and Haverty MI. 1996. Evaluation of six techniques for control of the western drywood termite (Isoptera: Kalotermitidae) in structures. *Journal of Economic Entomology* 89: 922-934.

38. Li HL. 1969. Urban botany: need for a new science. *BioScience* 19: 882-883.

39. Lubick N. 2010. Endosulfan's exit: US EPA review leads to ban. *Science* 328: 1466.

40. McConnell RJ, Richardson MJ, Galvan J, Jones C, Thorne PS, and Berhane K. 2005. Educational intervention to control cockroach allergen exposure in the homes of Hispanic

children in Los Angeles: Results of the La Casa study. *Clinical and Experimental Allergy* 35: 426-433.

41. McNamara KT, Wetzstein ME, and Keith Douce G. 1991. Factors affecting peanut producer adoption of integrated pest management. *Agricultural & Applied Economics Association* 13(1): 129-139.

42. Messenger B, Drlik T, Brattesani M, and Hanger A. 2010. *California School IPM Model Program Guidebook (3rd ed).* California Department of Pesticide Regulation, Sacramento, CA. Retrieved Oct 31, 2014 from http://apps.cdpr.ca.gov/schoolipm/managing_pests/guidebook.cfm

43. Metcalf RL. 2002. "Insect Control" in *Ullman's Encyclopedia of Industrial Chemistry*. Weinheim: Wiley-VCH.

44. Miller DM and Meek F. 2004. Cost and Efficacy Comparison of Integrated Pest Management Strategies with Monthly Spray Insecticide Applications for German Cockroach (Dityoptera: Blatellidae) Control in Public Housing. *Journal of Economic Entomology* 97(2): 559-569.

45. NASBE Center for Safe and Healthy Schools. 2013. "Pesticide Use." Date Accessed: Feb 1, 2014.

46. National Institute of Health (NIH). 2012, February 15. Lindane. *Medicine Plus.* Retrieved October 21, 2014 from http://www.nlm.nih.gov/medlineplus/druginfo/meds/a682651.html.

47. Naranjo SE, Butler GD, and Henneberry TJ. 2002. A bibliography of the pink bollworm *Pectinophora gossypiella* (Saunders). E-Book.

48. Olkowski W, Daar S, and Olkowski H. 1991. *Common-Sense Pest Control: Least-Toxic Solutions for Your Home, Gardens, Pets, and Community*. United State of America: Taunton Press Inc.

49. Owens K. 2009. The schooling of state pesticide laws: 2010 update. *Pesticides and You.* 3:9-20.

50. National Research Council, National Academy of Sciences (NRC). 1993. *Pesticides in the diets of infants and children*. National Academy Press.

51. Pedigo LP and Rice ME. 2009. *Entomology and Pest Management.* New Jersey: Hamilton Printing Company.

52. Pereira RM, Koehler PG, Pfiester M, and Walker W. 2009. Lethal effects of heat and use of localized heat treatment for control of bed bug infestations. *Journal of Economic Entomology* 102(3): 1182-1188.b

53. Pure Food and Drug Act. 1906. 34 Stat. 768, Chapter 3915.

54. Radcliffe EB, Hutchinson WD, Cancelando RE. 2009. *Integrated Pest Management: Concepts Tactics, Strategies and Case Studies.* Cambridge University Press, NY.

55. Rajotte EG, Kazmerczak RF, Norton GW, Lambur MT, and Allen WA. 1979. The national evaluation of extension's integrated pest management (IPM) programs. Appendix 8: Georgia peanut IPM impact study. Virginia Cooperative Extensive Service, Blacksburg VA.

56. Robinson WH. 1996a. Integrated pest management in the urban environment. *American Entomologist* 42: 76-77.

57. Robinson WH. 1996b. *Urban Entomology: Insect and Mite Pests in the Human Environment*. Chapman and Hall. London, UK.

58. Robinson W and PA Zungoli. 1995. Integrated pest management and operational view. In Rust MK, Owens JM, and Reierson (eds). *Understanding and Controlling the German Cockroach.* Oxford University Press. New York, NY.

59. Romero A, Potter MF, Potter DA, Haynes KF. 2007. Insecticide resistance in the bed bug: A factor in the pest's sudden resurgence? *Journal of Medical Entomology* 44(2): 175-178.

60. Rust MK and Su NY. 2012. Managing Social Insects of Urban Importance. *Annual Reviews of Entomology* 57:355-375.

61. Sawyer AJ and Casagrande RA. 1983. Urban pest management: A conceptual framework. *Urban Ecology* 7: 145-157.

62. Silva MH and Gammon D. 2009. An assessment of developmental, reproductive, and neurotoxicity of Endosulfan. *Birth Defects Research. Part B Developmental and Reproductive Toxicology* 86(1): 1-28.

63. Smith GS, Wetzstein ME, and Douce GK. 1987. Evaluation of various pest management characteristics. *Southern Journal of Agricultural Economics* 19: 93-101.

64. Smith RF and Smith GL. 1949. Supervised control of insects: Utilizes parasites and predators and makes chemical control more efficient. *California Agriculture* 3(5): 3-12.

65. Stern VM, Smith RF, van den Bosch R, and Hagen KS. 1959. The integration of chemical and biological control of the spotted alfalfa aphid. The integrated control concept. *Hilgardia* 29:81-101.

66. Stearns F. 1970. Urban ecology today. *Science* 170(3961): 1006-1007.

67. Su NY and Scheffrahn RH. 1998. A review of subterranean termite control practices and prospects for integrated pest management programmes. *Integrated Pest Management Reviews* 3(1): 1-13.

68. United States Bureau of Entomology and Plant Quarantine. 1952. *Control of the Alfalfa Caterpillar*. Washington D.C. US Department of Agriculture.

69. United States Department of Health and Human Services Agency for Toxic Substances and Disease Registry. 2005. Toxicological profile for Alpha-Beta-Gamma and Delta Hexachlorocyclohexane. <http://www.atsdr.cdc.gov/toxprofiles/tp43.pdf>

70. Valles SM and Pereirs RM. 2003. Hydramethylnon potentiation in *Solenopsis invicta* by infection with the microsporidium *Thelohania solenopsae*. *Biological Control* 27:95-99.

71. Waldvogel M and Wayne B. 2000. EPA eliminates nearly all household uses of "Dursban". *Pesticide Update* XVIII(2): 1-8.

72. Wang C and Bennett GW. 2006. Comparative Study of Integrated Pest Management and Baiting for German Cockroach Management in Public Housing. *Journal of Economic Entomology* 99(3):9879-885.

73. Wang C, Gibb T, and Bennett GW. 2009. Evaluation of two least toxic integrated pest management programs for managing bed bugs (Heteroptera: Cimicidae) with discussion of a bed bug intercepting device. *Journal of Medical Entomology* 46(3): 566-571.

74. Wearing CH. 1998. Evaluating the IPM implementation process. *Annual Review of Entomology* 33: 17-38.

75. Williams DF, Collins HL, and Oi DH. 2001. The red imported fire ant (Hymenoptera: Formicidae): an historical perspective of treatment programs and the development of chemical baits for control. *American Entomologist* 47: 146-159.

76. Wood FE, Robinson WH, Kraft SK, and Zungoli. 1981. Survey of attitudes and knowledge of public housing residents toward cockroaches. *Bulletin of the Entomological Society of America.* 27: 9-13.

77. Yang P, Li K, Shi S, Xia J, Guo R, Li S, and Wang L. Impacts of transgenic Bt cotton and integrated pest management education on smallholder cotton farmers. *International Journal of Pest Management* 51(4): 231-244.

CHAPTER 2:

THE SCHOOL INTEGRATED PEST MANAGEMENT CRITERIA SURVEY AND GEORGIA MODEL CONTRACT

The purpose of the school integrated pest management project was to assess the current Integrated Pest Management (IPM) status, strategies, and pest management within schools in Georgia. Because a goal of the Environmental Protection Agency (EPA) is for School Integrated Pest Management (SIPM) to be implemented in all states by 2015, it is necessary to gauge the level of understanding school officials, administration, and building managers have in regards to pest management and control options (EPA, 2012a). The results of this study will be given to the Georgia Department of Agriculture Division for distribution and their discretional use. In addition, this study created a model Integrated Pest Management contract for school officials which will be provided to the Georgia Department of Agriculture commissioners to distribute. The purpose of this SIPM criteria survey project was to investigate what IPM strategies, if any, schools in Georgia are using by examining a variety of schools near Athens, Georgia. In this survey, we specifically visited schools and observed classrooms, cafeterias, food preparation areas, restrooms, and the immediate exterior areas of the buildings.

Methods

<u>Determining Schools:</u>

Schools of varying economic statuses, location, sizes, and age groups were sought out. We initially wanted to complete the SIPM criteria walk-through survey in five to ten schools. A comprehensive list of eighteen schools near or in Clarke County was compiled. Specifically, schools both with and without Title 1 assistance were contacted and of the eighteen schools, eleven were Title 1 Schools that are Title 1 receive government financial assistance for having high numbers or percentages of children from low income families to help insure that all children meet state academic standards (US Department of Education, 2014). Initially, we considered including a private school in the survey as well; however, since SIPM would be government mandated, private schools would be exempt, therefore it was removed. Location was also considered and schools from the following eight counties (Table 2.1). In addition we selected schools from varying age demographics including elementary, middle, and high schools. We also were interested in the relative size and number of students the schools enrolled. We selected six elementary schools, five middle schools, five high schools, and initially one private high school that had preschool students to high school students. These schools had student populations varying between five hundred and two thousand students.

Numerous attempts were made by phone and email to contact the relevant school personnel, including the board of educations, super intendants, principals, vice- or assistant-principals, and facility managers. However, none of the schools responded to our request to conduct the on-site SIPM criteria survey. Reasons for their unwillingness to participate are unknown. During conversations with the staff we could contact, many people did not seem to know what IPM is, or were suspicious about the intent of the survey. School administrators were not interested in reviewing nor knowledgeable about their own pest control practices. Furthermore, as we later found out, school pest control is primarily managed from a top down perspective. That is, the buildings manager is often hired at the county level and is responsible for hundreds of buildings in multiple schools. This individual will check up on the school buildings and is ultimately responsible for hiring people for pest control whether it is the school's janitors or a pest control company. Therefore we partnered with the Georgia Department of Agriculture: Structural Pest Division. With the inspectors' help, we were able to visit four schools in two counties; Catoosa and Coweta. A third county, Gordon County, was contacted but declined to participate in the walk-through survey. In addition, a school from Bartow County contacted University of Georgia personnel with a pest problem. In return for investigating their issue, permission was granted for the survey to be conducted.

Table 2.1: The initial list of schools that were contacted for the walkthrough consisting of five elementary schools, six middle schools, and five high schools including one private preschool-high school.

Schools	School Type	Title 1	#Students	County
School 1	Elementary	yes	734	Morgan
School 2	Elementary	yes	431	Oconee
School 3	Elementary	yes	547	Oglethorpe
School 4	Elementary	yes	791	Cobb
School 5	Elementary	yes	583	Clarke
School 6	Middle	yes	799	Barrow
School 7	Middle	no	2406	Gwinnett
School 8	Middle	no	776	Morgan
School 9	Middle	no	1900	Gwinnett
School 10	Middle	yes	804	Oconee
School 11	Middle	yes	568	Oglethorpe
School 12	PK-High	No -private	935	Clarke
School 13	High	yes	1535	Clarke
School 14	High	no	1011	Morgan
School 15	High	yes	1506	Clarke
School 16	High	no	1008	Oconee
School 17	High	yes	710	Oglethorpe

The five schools we visited included one primary school, two elementary schools, one middle school, and one high school (Table 2.2 and Figure 2.1). All schools are public and three of them are Title 1.

Table 2.2: The list of schools where the walkthrough was conducted.

Schools	School Type	Title 1	#Students	County
School A	Primary	Yes	500	Catoosa
School B	Elementary	Yes	733	Bartow
School C	Elementary	No	745	Coweta
School D	Middle	Yes	892	Coweta
School E	High	No	800	Catoosa

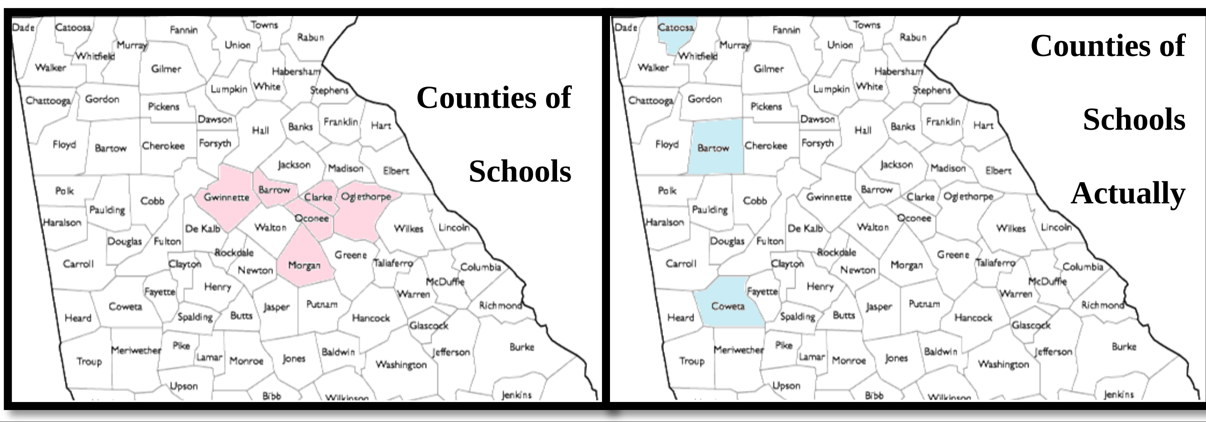


Figure 2.1: Depicted on the left are the counties where the initial targeted school were located. On the right are the counties of the schools we actually visited.

<u>The SIPM Criteria Survey:</u>

The walk-through survey (Appendix B) that was used is the same survey used to determine if Florida schools are upholding their 2008 mandated SIPM. The survey has several criteria listed that encompass IPM practices. The criteria include both internal and external regions of the school can be rated from 1-5; 1 being poor and 5 being excellent. The walkthrough also presents questions ab out observable pest presence, which are also ranked from 1-5; 1 being infested and 5 having no evidence of pests. The total number of points that can be obtained on the walk-through is five hundred. This raw score is then calculated into a percentage, where <69% is considered unsatisfactory, 70-79% is average, 80-89% is above average, and 90-100% is excellent.

The survey has a comprehensive list of both indoor and outdoor areas of the school and grounds. The survey specifically targets food preparation areas, food preparation appliances, cafeteria and food preparation equipment, furniture, cafeteria and food areas, food storage areas, teacher lounges, classrooms, and restrooms. As for the grounds, the survey specifically targets garbage areas, landscaping, and the status of the structures. The survey also requests the school's demographic information. It includes the name of the principal, the director of operations, the IPM specialist, the grounds supervisor, the contractual custodian supervisor (if applicable), kitchen manager, school nurse, pest management company, waste management company, age of the schools, square footage of the schools, number of teachers, students, and custodians, and if there are any perceived observed pests. Only two of the five schools fully completed the demographic section of the survey. The basic information about the three schools that did not provide this information, including number of students, was obtained from public records (Table 3). Furthermore, the walk-through also inquires about the school IPM program status including if the school has an IPM coordinator, if the school has an IPM policy, and if the school has an IPM committee. However, since none of the schools we visited had an integrated pest management plan, this section of the survey was omitted.

Results

Each of the five schools that we visited received scores higher than a 90% (Table 2.3) on the survey and all schools had at least one pest sightings log book which was filled out by the employees. The Coweta County Schools perform their pest control in house, while the other schools we visited contracted their pest management to a company. Many of the schools had similar shortcomings in their pest management schemes; these were accounted for in the survey. Of the one hundred criteria examined on the list only twenty were problematic, receiving less than a 5 by any one school (Table 2.4). The first was that dry and nonperishable foods should not be stored in the original cardboard containers, but should instead be stored in plastic containers with fitted lids. All five of the schools stored their unopened dry and nonperishable food products in the original cardboard boxes. The schools all had cardboard in the food preparation area as well. Three of the schools did keep any dry food that had been previously opened in closed, tightly fitted plastic containers for overnight storage. Two of the schools had some cardboard or clutter in the inspection aisles. In addition, in three of the five schools the garbage dumpsters were not located an adequate distance from the entrance to the building. In two of the schools, the dumpster lids were not closed. Three of the five schools did not have their bulletin boards in the cafeteria caulked to the wall, and two of the five schools did not have the bulletin boards caulked to the wall in the teachers' lounge. In one school, the metal piping in the cafeteria furniture did not have endcaps. Some of the metal piping did have caps covering the ends of the cafeteria furniture, but it appeared that students pulled them off, or they were old and damaged. One school had a clogged gutter leaking water directly outside of one of the exits. The dripping had caused excess moisture and several invertebrates (slugs, pill bugs, and earwigs) were noted in the areas inside and outside the exit door. Several other minor criteria were noted in at least one of the schools and are depicted in Table 2.4.

School Name	Raw Score	%
School A	463	92.6
School B	466	93.2
School C	475	95.0
School D	458	91.6
School E	478	95.6
Average	**468**	**93.6**

Table 2.3: The schools that were visited and their scores on the IPM walkthrough. The scores were calculated by rating each of the one hundred criteria from 1 (poor/infested) to 5 (excellent/no evidence). The scores were added to calculate the raw score out of five hundred. The percentage of the raw score was then calculated.

Discussion

IPM vs Green Management:

Overall, the schools we visited were in very good standing and had already initiated several IPM practices despite the differences in economic status, size of the school, counties, and if the pest control was done in house or managed by a pest control company. Despite each of the schools clearly practicing some form of IPM, school officials, grounds members, and building directors did not know the meaning of the term IPM when questioned. Of the supervisors that were familiar with the pest control practices utilized in their school, many referred to the strategies as “Green Management.” The Georgia Structural Pest Control Commission (GSPCC, 2014) defines green pest management to be “a service that employs an IPM approach while utilizing fewer of the earth’s resources as part of a larger effort to reduce human impacts on the environment. We are uncertain if schools using “Green Management” are comprehensively following the Georgia Department of Agriculture practice.

All schools had a pest sightings log, which indicated that all the schools were monitoring for pests, and all the schools building managers stated that pest control with pesticides was done when needed. Otherwise, basic sanitation, monitoring, and maintenance was used for most of their pest control. If a pest problem continued or worsened, then the schools all said they used baiting and trapping as their next strategy.

Table 2.4: The problematic criteria noted of the one hundred IPM criteria noted in the survey. The scoring system is ranked on a scale from 1 (poor/infested with pests) to 5 (excellent/no evidence of pests).

Criteria	School A	School B	School C	School D	School E
Exterior Garbage Areas					
Dumpsters sealed properly with tightly fitting lids	5	3	5	4	5
Dumpsters located adequate distance from doors	5	4	5	3	1
Exterior Landscaping					
Adequate visibility between buildings (18in)	5	5	5	5	3
Exterior Building Features					
Air ventilation intakes screened, unobstructed	5	5	3	5	5
Gutters cleared of debris	5	5	2	5	5
Evidence of bees/wasps	5	5	4	5	5
Food Preparation Area Ceiling, Walls, and Floors					
Permanent bulletin boards (etc...) caulked (Cafeteria)	5	1	5	1	1
Food preparation Area Appliances, Equipment, Furniture					
Surfaces in food preparation and serving areas free from grease	5	5	4	5	5
Kitchens appliances/fixtures are pest resist design	5	5	4	5	5
Food preparation areas are free of cardboard (even storage)	1	1	1	1	1
Food and Product Storage Areas					
Floors are clean by end of day, especially under storage areas	5	5	4	5	5
Floor and sink drains are clean and traps are kept full of water	5	5	4	5	5
Bulk stored products are stored on open wire racks and not in cardboard	1	1	1	1	1
Food items are stored in tightly closed containers overnight	1	1	4	5	5
Inspection aisles are maintained around bulk stored products	5	1	4	5	5
Mops and mop buckets are properly hung, dried, and stored	5	5	4	5	5

	School A	School B	School C	School D	School E
Teacher Lounges					
Refrigerators, microwaves, and food storage cleaned monthly	5	5	4	5	1
Bulletin boards (etc...) caulked (Teachers' lounge)	5	1	5	5	1
Classroom and Other Interior Areas					
Interior doors sealed tightly	5	5	4	5	1
Refrigerators (etc..) free of debris	5	5	4	5	5

Addressing Problematic Criteria:

The schools that we visited were managed well and strikingly clean. Informal conversations with kitchen staff and teachers revealed that they were delighted and proud to be working in the schools with clean working conditions and considerate, responsive pest management staff. Furthermore, when speaking with either the pest control representative or building managers, the pride that they took in their work and how proud they were of the results was apparent.

However some problems were apparent including the potential harborage of pests in the cardboard boxes in the food storage areas. This is problematic because cardboard boxes are a known cockroach harborage because they are dark inside and do not close tightly. Cardboard boxes should be replaced with plastic containers with tightly sealed lids. In addition, any leftover cardboard should be disposed of properly as it can also harbor pests. Furthermore, any permanent signage or boards on the walls in areas where food is prepared, stored, or eaten should be caulked to the wall to seal off areas of potential pest harborage. Following suit, it is important that all the furniture in the kitchen, food preparation areas, and cafeterias should be constructed in such a way that they cannot harbor pests. Most of the tables and chairs we saw in the schools had metal tubing at the bottom for support. If the metal tubing is not sealed properly, it can be a place where pests seek refuge and habitat. Kitchens and storage areas should be properly cleaned daily to remove food substances that could attract pests. Although some of the schools either had slightly dirty kitchen appliances or floors, the walk-throughs that were conducted were all done during the school day and just before, during, or after peak lunch hours and therefore were not considered representative of what their status would be at the end of the day. We provided these recommendations to the schools where necessary and were assured by the kitchen staff and building managers that everything would be cleaned by the end of the day.

While the building managers' pride for the current status of their schools was particularly notable, there was still a noticeable stigma and fear associated with pest management "inspections." The intentions of this study were clearly detailed to everyone that we interacted with, including the schools that never communicated with us after our initial requests. It became obvious that people had a distrustful attitude towards the project. This was particularly noticeable when we conducted the school visits.

One school, contacted the University of Georgia because of a perceived slug problem. In exchange for looking at their evidence, we were granted permission to conduct our study. After providing formal, written recommendations about their predicament, we asked permission from the buildings manager to conduct the same study in the other schools that he manages. However, he refused to return any of our communication. In the other four schools, we were only granted permission to be there if one of the staff from the Georgia Department of Agriculture conducted the walk-throughs with us and we were also always escorted by the buildings manager. In the last school that we visited, the principal followed us through the school as well.

<u>The Future of SIPM in Georgia:</u>

Determining pest management strategies used in Georgia schools is difficult because currently there is no federal mandate stating that the school admiration must allow for any kind of inspection or walk-through. In addition, the Georgia Department of Agriculture in the Structural Pest Division does not have enough staff for complete implementation and enforcement of SIPM in schools. Furthermore, the task of educating school administrators, buildings managers, and pest control companies on the practices and importance of IPM is beyond the scope of possibilities for this project. Instead, in addition to the simple walk-through that was conducted, a SIPM model contract was drafted so that it could be distributed throughout the school districts. Furthermore since education about pest management is important for everyone in the school community, educational materials were created for classrooms to enhance student learning and to instruct teachers on beneficial and simple pest management tactics that they can use in their own classrooms. By providing these tools we hope to increase IPM practices in schools in Georgia.

Georgia SIPM Model Contract

After conducting the walk-throughs in five schools in Georgia a model contract was constructed for the Georgia Department of Agriculture to distribute to school administrators throughout Georgia. This contract makes it easier for administrators to implement a SIPM program and ensures such a program will be comprehensive.

<u>The Need for a Model Contract:</u>

While it was generally assumed that schools in Georgia were not conducting IPM in their schools, a survey was distributed by the IPM Institute to school districts in Georgia asking schools about their IPM programs (IPM Institute, 2013). Of the 181 school districts in Georgia, 67 (37.0%) of the school districts responded, which is an average response rate (Evans, 1991). However, for specific questions regarding IPM coordinators or committees only the 23 (12.7%) school districts that had SIPM responded. Of the 67 districts that responded, only 11 (16.4%) of those had an IPM policy committing schools to use IPM and only 21 (31.3%) of participating districts had any written IPM plans for dealing with pests. Nine (13.4%) of the districts did not have a written plan, one district (1.5%) didn’t know and the other 36 (53.7%) districts used their pest control company recommendations. Finally, 23 (34.3%) of the districts that responded to the survey had an IPM coordinator while the remaining 44 (65.7%) districts either did not have an IPM coordinator or did not know (IPM Institute, 2013).

Furthermore, a more comprehensive study about the usage of IMP in schools was conducted at the University of Georgia in 2011. It was determined that many Project Management Professionals (PMPs) who are responsible for overseeing pest management at schools are not using IPM techniques. This assessment was determined based on average time for school visits when compared to average time needed to implement and manage IPM strategies in schools (Brannon, 2011). It was also found that 99% of pest management technicians in Georgia had instances of noncompliance with Georgia's regulations, although many of these violations were due to a lack of attention to detail in managing paperwork. Most of these violations were made by a few ill-informed or inadequate technicians (Brannon, 2011).

Between the two surveys (IPM Institute, 2013; Brannon, 2011), it is apparent that many schools do not have IPM policies and it could be inferred that many do not know what an IPM program is, how to form one, or how to obtain an IPM coordinator. A sample model IPM program was not created for this project because several easily adoptable SIPM programs are available online. Arguably the best model program is produced by California (Messenger *et al*. 2010). While this guidebook was created specifically to address the requirements of the Healthy Schools Act, passed in 2000 in California (Assembly Bill No. 2260, 2000), the guidebook still contains all the components a school would need to design an IPM program around their state's legislation. This model SIPM guidebook is comprehensive and includes sections on what IPM is, the importance of IPM, and how to adopt an IPM program, including formulating a policy, educating decision makers, and pest management roles and responsibilities. The model program guidebook also includes information about developing an IPM policy, IPM operations, proper notifications and postings, responsibilities of the IPM coordinator, the IPM decision making process, implementation of IPM, monitoring pests and damage, setting and reacting to injury and action levels, least hazardous pest control programs, selecting pesticides for the IPM program, and pesticide use and disposal. Finally, a glossary is included to help people understand the integrated pest management language (Messenger, 2000). However, like other texts it fails to teach the mindset of an IPM program (Greene and Breisch, 2002). In addition to providing this manual, alternate IPM training should be used to ensure that PMPs, pest control companies, and applicators understand how to approach pest control management.

The model SIPM guidebook, however, does not provide a contract to establish professional relations between the school administrators and the IPM contractor. This contact is necessary to establish what the IPM policy entails, how the IPM contractor will oversee the implementation of IPM in the school, the employees of the IPM contractor, and the areas of the grounds the coordinator is expected to take care of. While there are some model contracts available, the available contracts are of varying lengths, specifications, and quality. Also, contracts should directly reference the state's pesticide laws and therefore should be state specific.

Designing the Model Georgia Contract:

The model contract was designed based on state IPM contracts implemented in North Carolina (North Carolina, 2005), New Jersey (New Jersey Schools), Maryland (University of Maryland and Maryland Department of Agriculture), Iowa (IPM for Iowa Schools), and Vermont (Vermont SIPM Program). In addition, the pesticide laws of Georgia and the pesticide laws regarding use in schools for Georgia were also used when designing this contract (Georgia Structural Pest Control Commission). Furthermore, sample forms from the Maryland school IPM contract were used to design similar forms for the Georgia model contract (University of Maryland and Maryland Department of Agriculture).

The Georgia Model Contract (Appendix B) is divided into four main sections. The first is the general information which describes in detail the services to be provided to the school, the definition of IPM, the contractor service requirements, designating contact persons and school liaisons, routine services required, additional or special services, contractor licensing personnel, the IPM plan, and commercial pesticides applicator documentation. These sections outline what IPM is, what the contractor is expected to do, and how he is expected to do it. In this part of the contract, the IPM plan is fully articulated so that the expectations of the services to be provided are clear for all parties involved.

The second section, Pest Control, includes exactly how the contractor will manage pests depending on the type of pest and the population size. There are sections determining methods the contractor should take before using pesticides and what monitoring and trapping techniques the contractor should use before determining which pesticides to use. If pesticides are to be used the contract states what category of pesticides the contractor should use, where the pesticides should be administered, in what quantities the pesticides should be applied, and that all pesticides and uses are to comply with both state and federal laws. These conditions are stated for both arthropod and rodent pests.

The third part of the contract includes an evaluation program to determine the effectiveness and status of the current IPM program. This is important because the contractor can be replaced if the negotiations of the contract are not met or pest problems are not completed efficiently or effectively. Tools in place to determine effectiveness of the policy are inspection systems, checklists, quality control files, and the designations of inspectors. The contractor, contact person, school liaison, and school administrators all need to sign the contract.

The final part of the contract consists of supplementary model forms necessary for the enactment of IPM in schools. The forms include a pest sighting log, pesticide application records, cockroach trap records, landscape monitoring, weed monitoring, inspection checklist, and sample pesticide notices.

References:

1. Brannon SL. 2011. Integrated Pest Management (IPM) in Urban Entomology: Training, Regulation, and Education. University of Georgia, Athens GA.

2. Evans SWJ. 1991. Good surveys guide. *BMJ* 302: 302-303.

3. Georgia Structural Pest Control Commission (GSPCC). 2014. Green Management Definition. Retrieved November 13, 2014 from http://agr.georgia.gov/data/sites/1/media/ag_plantindustry/structural_pest_control/structural_pest_control_commission/files/definitions.pdf

4. Georgia Structural Pest Control Commission (GSPCC). Rules of Georgia Structural Pest Control Commission. Ch. 620-1-11.

5. Integrated Pest Management (IPM) for Iowa Schools. Sample Pest Control Contract. Retrieved Oct 31, 2014 from http://www.ipm.iastate.edu/ipm/schoolipm/sites/default/files/SamplePestControlContract.pdf

6. Integrated Pest Management (IPM) Institute of North America. Sample IPM Contract. Retrieved Oct 31, 2014 from http://www.ipminstitute.org/Articles/Model%20IPM%20Contract%20071807.doc

7. IPM District Survey. 2013. Georgia IPM School District Survey Summary Report.

8. Messenger B, Drlik T, Brattesani M, and Hanger A. 2000. *California School IPM Model Program Guidebook*. 3rd Edition. Retrieved from http://apps.cdpr.ca.gov/schoolipm/managing_pests/guidebook.cfm

9. New Jersey Schools. Integrated Pest Management Model Contract. Retrieved Oct 31, 2014 from http://www.nj.gov/dep/enforcement/pcp/bpc/ipm/model_contract.pdf

10. North Carolina. 2005. Sample Contract. Retrieved Oct 31, 2014 from http://schoolipm.ncsu.edu/documents/CONTRACT2005.doc

11. United States Department of Education. 2014. “Programs”. Retrieved November 16, 2014 from http://www2.ed.gov/programs/titleiparta/index.html

12. University of Maryland and Maryland Department of Agriculture. Bulletin 364. Integrated pest management in schools: Contracting guidelines for IPM services in Maryland public schools. Retrieved Oct 31, 2014 from http://mda.maryland.gov/plants-pests/Documents/ipmcontr.pdf.

13. Vermont School Integrated Pest Management (SIPM) Program. Sample School Integrated Pest Management Plan. Retrieved Oct 31, 2014 from http://www.uvm.edu/pss/pd/schoolipm/documents/sampleplan.doc

CHAPTER 3

INTEGRATING STUDENTS IN IPM CURRICULUM

Why Do We Need Integrated Pest Management Curriculum?

Education specifically related to School Integrated Pest Management (SIPM) is important because effective integrated pest management happens at all levels in the school and everyone is responsible for maintaining clean spaces. While it cannot be determined how many Georgia school districts are practicing IPM, data from the IPM Institute of North America (2013) suggest that most school districts are not performing any kind of IPM. The IPM Institute of North America found that only 23 of the 67 school districts that responded to the survey have an IPM program in schools. However, more strikingly is that of the 23 school districts that claim to have IPM practices, none of them have any sort of IPM curriculum (IPM Institute, 2013).

Teachers and students are responsible for maintaining clean classrooms and eating areas, which aid the official pest management applicators in maintaining pest free environments throughout the school grounds (Messenger *et al.* 2010). Many pest related issues can be prevented or rectified early if classroom space is properly maintained. Therefore, it is necessary to properly educate both students and school personnel about IPM practices if we hope to successfully implement SIPM.

Not only is involving school personnel and students in pest management practices important, but it is also important to teach people about arthropods and their biology. Because many people are afraid or dislike insects (Kellert, 1993, Lockwood, 2013) it is important to use education to curb the negativity people develop towards insects (Kellert, 1993).   Education can be a beneficial experience for fostering positive attitudes towards insects including arthropods predominantly seen as pests (Pitt and Shockley, 2014). If students and teachers know why insects and other arthropods are inhabiting human spaces, students and teachers can aptly alter their habits to make their areas less desirable for pests. Furthermore, it is important to encourage students to become involved in science and promote positive attitudes towards science to encourage more people to become involved in science in the future (Koballa and Crawley, 1985; Tai *et al*. 2006). Therefore, the second aspect of the SIPM project was to create materials focused on educating students on IPM in relation to habitat modification.

If We Want to Educate Students – The Students Have to Learn

For students to have positive notions about insects and the sciences, they must first learn about them. Learning is defined as knowing, understanding, and applying the gained knowledge to new situations (Handelsman *et al.* 2007). Students need to actively construct their own meanings and connect them to prior ideas to adequately apply previously gained knowledge. (Dewey 1916; Osborne and Wittrock 1983; 1985). There are three main aspects of learning. The first is metacognition, where students think about the goals that need to be obtained and how. The second is cognition, where students employ strategies to meet those learning goals. The third is that students acquire knowledge, which can include information, mental processes, or skills that are related to the learning strategies and goals (Marzano, 1998).

One of the major obstacles for teachers is that many variables can affect learning, some of which are beyond the teacher’s control. Student attitudes towards learning and school, prior knowledge, previous experiences, culture, upbringing, gender, race, ethnicity, and physical and psychological health all play important roles in how students learn. Furthermore, the physical space where learning happens including the human community can also affect how well students learn (National Research Council, 1999; Handelsman *et al.* 2007). Furthermore teachers should encourage and be receptive to student question as the types of questions students ask is indicative of student learning. Student questions that simply ask for clarification of facts indicate that the student is not fully engaging with the material. However if students ask more sophisticated questions then they are becoming more involved with and learning the material (Zoller, 1987; Watts, 1997).

Because science is often taught as rote facts, simple memorization, or cookie-cutter experimental procedures, students tend to accept science as simple facts instead of a dynamic entity (Entwistle and Ramsen, 1983; Marton 1983; Williams 1992). This approach encourages students to become surface learners. Surface learning is associated with accepting ideas without questioning, memorization without understanding underlying principles or patterns, and not understanding the relatedness between tasks and the rote memorization of facts (Entwistle and Ramsden 1983; Marton, 1983; Biggs, 1987; Williams, 1992). Rote learning is arbitrary, verbatim, and not related to experiences or events and lacks commitment on the part of the learner to relate new and old information (Novak, 1998). Students who surface learn are only interested in passing assessments and view curriculum as a demand to be met and often learn information for their own ego or for social approval (Dweck and Elliot; 1983; Marton, 1983; Nicholls, 1984; Biggs, 1987; Nolen, 1988). Students who surface learn tend to ask lower quality questions. There are three main types of questions; consolidation, exploration, and elaboration. Students who ask consolidation questions try and make sense of new ideas and clarify given information. Exploration questions are characterized when students seek to expand their current knowledge and test their ideas.

We Want Better Questions

Since the type of questions students can motivate and promote meaningful learning, it is necessary to encourage students to ask more complicated questions. Many factors can affect student questions. Student questions are affected by the student's age, prior knowledge, prior experiences, race, gender, culture, and also the classroom environment. The attitude of the teacher, teaching style, nature of the topics taught, reward structure, classroom evaluative climate, and social interaction patterns between peers and the students with the teacher all play a role in student questioning (Bidulph and Osborne, 1982).

Because learning is the ability to understand concepts and apply knowledge to new situations (Handelsman *et al.* 2007) teachers must understand how learning happens in order to promote learning. Learning happens in individuals when interactions occur with the natural and physical world and also practice communication with others whether it be their peers or with the teacher (Driver *et al.* 1994). Meaningful learning specifically is purposeful and the students monitor and reflect upon their learning process (Baird and White, 1982) and can be promoted through assessing prior knowledge and engaging the students in related, relevant learning tasks (Novak, 1998). Meaningful learning is associated with metacognitive thinking where students recognize problems, evaluate what they are learning, and reconstruct existing ideas with new knowledge (Gunstone, 1994).

Meaningful learning is associated with deep learning, which is learning with understanding (Boud, 1990). This is the kind of learning that educators want to see in students. Deep learning is associated with student learning because the tasks are fun and engaging. Therefore, the student learns because the student wants to learn and not simply to pass and assessment. Students who deep learn personalize the task, are interested in the content, and make the content meaningful to themselves (Biggs, 1987; Marton, 1983). This deep learning is especially important in science especially in terms of issues like genetically modified organisms (GMO's), vaccines, evolution, and climate change, science-related topics where people often hold strong opinions that may or may not be related to scientific evidence. Students must actively participate and learn the curriculum to determine to be able to understand and possible change prior belief about these issues with new information presented by either the teacher or the scientific community.

In addition, deeper learning strategies lead to more long-lasting and complete understanding of the subject material (Hegarty-Hazel and Prosser, 1991a, 1991b). If a student engages themselves in the material, the student will learn more deeply (Cavello and Schafer, 1994). Students who are deep learners accept the tasks at hand with a sense of purpose, relate the ideas presented to other topics, and relate phenomenon's of the world to scientific concepts (Laurillard, 1978; Entwistle and Ramsden, 1983). These students also interact critically with the contents and examine the logic of arguments as they relate to evidence (Entwistle and Ramsden, 1983; Marton, 1983; BouJaoude, 1992).

Similarly, the types of questions that students who deep learn ask are more sophisticated than surface learners. Deep learners ask exploration questions, seeking to expand their knowledge and test constructs, and elaboration questions which examine claims and counter claims (Watts *et al.* 1997). Deep learning students ask "wonderment" questions which focus on student curiosity, puzzlement, skepticism, and knowledge based speculation on a familiar topic (Scardamalia and Bereiter, 1992). Furthermore, students who are deep learners ask questions about predictions they have and try to resolve discrepancies between conflicting pieces of knowledge, and think ahead about causes and effects (Chin and Brown, 2000). Teachers must foster deep learning environments or else students, even students with the predisposition to deep learn, will resort to surface memorization (Roth, 1990). Students need to be encouraged to be curious in science because curiosity sparks the process of experimentation to explain natural phenomena. Furthermore, skepticism is an important quality to foster in students so they can think critically about information that is presented to them.

How Do We Encourage Students to Learn Deeply?

The burden for learning is placed solely on the leaner. The teacher cannot learn the information for the student. However, the teacher can encourage the student to want to learn. Many aspects affect learning (Handelsman *et al.* 2007; National Research Council. 1999) however students can have the predisposition to generally be one type of learner over another. These epistemological beliefs can affect the learning strategies the students use. Generally students just see science as rote facts to be learned and try not to solve problems whereas constructivists use activities to solve problems (Roth and Roychoudhury, 1994; 1994). However, just because students have predispositions not only in their epistemological beliefs but in their ability, personality, cognitive style, motivation, values and morals, does not mean that they cannot become deep learners (Biggs, 1987; Biggs, 1994). While it is noted that students can change, researchers argued that how much the students can change is also dependent on their predisposition to change which is further influenced by personal characteristics such as upbringing and learning styles (Entwistle, 1981; Biggs, 1987; Schmeck, 1988; Britner, 2008). Furthermore, student motivation and engagement in the tasks are rooted in past experiences, both positive and negative (Lumsden, 1994; Clark, 2003). However, several studies show that the classroom environment is equally as important to the learner and students will respond accordingly to their surroundings (Morton 1983; Ramsden, 1988). Students will modify their learning strategies based on different learning situations including relevance of the task at hand, attitude and enthusiasm of the teacher, and the expected forms of assessment (Beattie *et al.* 1997).

How Do We Engage Students?

Because students can have several learning styles and the rigidity of those learning styles are somewhat debated (Coffield *et al*. 2004) teachers must employ wide variety of tactics to engage all the students in the curriculum. Therefore, it is the burden of the teacher to positively affect motivation which can be difficult in the 21st century because of technology and social media. Students are now accustomed to instant gratification and maintaining their attention can be challenging (Friedman, 2006). However students, even unmotivated students can become motivated with engaging relevant tasks and a supportive learning community (Lumsden, 1994; Dev, 1997).

Students can be motivated with extrinsic or intrinsic methods. The first method is extrinsic which attempts to encourage students with assessment and grades (Dev, 1997; Ryan and Deci, 2000). Some researchers think that extrinsic motivation is detrimental to student learning (Deci *et al.* 1999; Kohn, 1994) while others suggest that extrinsic motivation is not detrimental if used properly (Cameron and Pierce, 1994; Cameron, 2001). Teachers should also have high expectations when utilizing assessments. High caliber assessments and lesson plans have learning gains for all students but especially for low achieving students (Black and William, 1998). Students will respond to teachers in the way that the students expect the teacher to behave. If teachers allow for mediocre work to be passed in, students will do mediocre quality work. If teachers set high expectations, students will rise to the challenge (Fergusten, 2002). High expectations in a supportive classroom can provide short term goals for students, provide challenging yet achievable tasks, and motivate students (Lurmsden, 1994; 1999). High classroom standards in conjunction with relevant and engaging tasks help students build self-esteem and increase confidence (Cotton 2003; Brophy 2008; 2010). When students build their confidence they are motivated to attempt and complete more challenging tasks and students rise to new standards or achievement (US Department of Education, 1992; NMSA, 2003). Furthermore, ongoing lesson plans and assessments help shape classroom standards and set a level of expectation for the students. Furthermore, assessments not only do assessments provide important feedback about the student learning, these ongoing assessments help the students also gauge their learning. These ongoing assessments allow for students to assess themselves and their peers though reflection and analyzing with specific markers for achievement (Black and William 1998). Reflection is an important part of motivating students to reassess prior ideas and make necessary changes to their understanding and knowledge of a topic (Bell *et al.* 2003). Therefore, the assessments help the students guide their own learning (Handelsman *et al.* 2007).

The second type of motivation is intrinsic motivation where students learn because they find learning or the subject matter fun and interesting (Dev, 1997; Ryan and Deci, 2000). Intrinsic learning is more closely linked to deep learning because if students are genuinely interested in the material, they will spend more time to become invested in it instead of simply memorizing information to pass assignments (Lee and Anderson, 1993; Lee and Brophy, 1996). When students are intrinsically motivated, they seek to understand the task, use deep cognitive and self-regulated strategies to help them learn conceptually (Meece *et al*. 1988; Ames and Archer, 1988; Nolen and Haladyna, 1990). Therefore it is generally agreed that it is better to have intrinsically motivated students since this type of motivation leads to deeper learning (Kohn, 1994 Deci *et al.* 1999).Obviously, not all students will be inherently interested in the subject matter when they first enter the classroom. However, students can be encouraged to learn intrinsically through immersive activities (Lee and Brophy, 1996). Teachers must maximize student motivation through the combination of assessment and engaging tasks to encourage students to deeply learn the material (Cameron and Pierce, 1994; Good and Brophy; 2000; Hidi and Harackiewicz, 2000).

Active Learning:

Engaging assessments can be created by using active learning. Active learning can only happen if the students are actively participating and are engaged in the learning experience. Active learning, also called “inquiry learning” or “problem based learning” captures the spirit of doing science in the classroom (Handelsman *et al.* 2007). While active learning is slowly starting to make its way throughout school curriculum, this process of engaging students in their own learning is not an new concept. Socrates and Plato used forms of active learning among their pupils and since then active learning has been used throughout the generations and in many cultures (Plato, 1901; Dewey, 1916; Swisher, 1990; Haynes and Gebreyesus, 1992; Jagers, 1992, Handelsman *et al*. 2007).

Active learning has been shown to be effective in all age groups of formal education. Undergraduate biology, (Okelbukola, 1986a; 1986b; Lazarowitz *et al.* 1998; Ebert-May *et al.* 2003) physical science (Smith *et al.* 1991; Beichner *et al.* 1999), and math (Dees, 1991; Duren and Cherrington, 1992) classes have effectively implemented active learning into their curriculum. Active learning has had a positive impact on high school students (Sandoval and Morrison, 2003; Hofstein *et al.* 2004; Taraban *et al.* 2007), middle school students (William and Gallagher, 1993; Gibson and Chase, 2002; Meece, 2003; Rivet and Krajcik, 2008) and elementary school students (Wiley, 1973; Wheeler and Frank, 1973; Stevens and Slavin, 1995;

Zumbach *et al.* 2004). Active learning has been reported to increase student engagement, encourage positive forms of motivation, promote higher order thinking, high processing skills, and students obtained more content knowledge. Furthermore, the classroom environment became more conducive for student learning. Teachers became more involved in the curriculum and interacted with the students which made the students feel like their voices were being heard and honored. This led to improved student communication and social skills and promoted cooperation among students. These improvements were also seen in handicapped students and specifically with active learning, women's attitudes towards science improved (Wiley, 1973; Stevens and Slavin, 1995; Dufresne *et al.*1996; Meece, 2003; Taraban *et al.* 2007).

Theoretical Background Employed in the Lesson Plans:

To determine whether or not students are deeply learning teachers must know if students understand the material. The six factors of understanding are explanation; interpretation, application, perspective, empathy, and self-knowledge. Explanation is where students can provide accounts of phenomena whereas interpretation is where students can relate those phenomena to personal or related events. Students apply their knowledge when they adapt their knowledge and use it in new contexts. Students have perspective when they critically analyze new information and see facts come together in a big picture. Students then can empathize when they can find value in what other people find strange or implausible. Finally, students have self-knowledge and become self-aware of their own positions on topics and their own learning styles (Wiggins and McTighe, 1998).

Teachers can encourage student understanding through established lexicons promoting more complicated student involvement with the material. One of these lexicons is Bloom's Taxonomy (Bloom and Krathwohl, 1956).

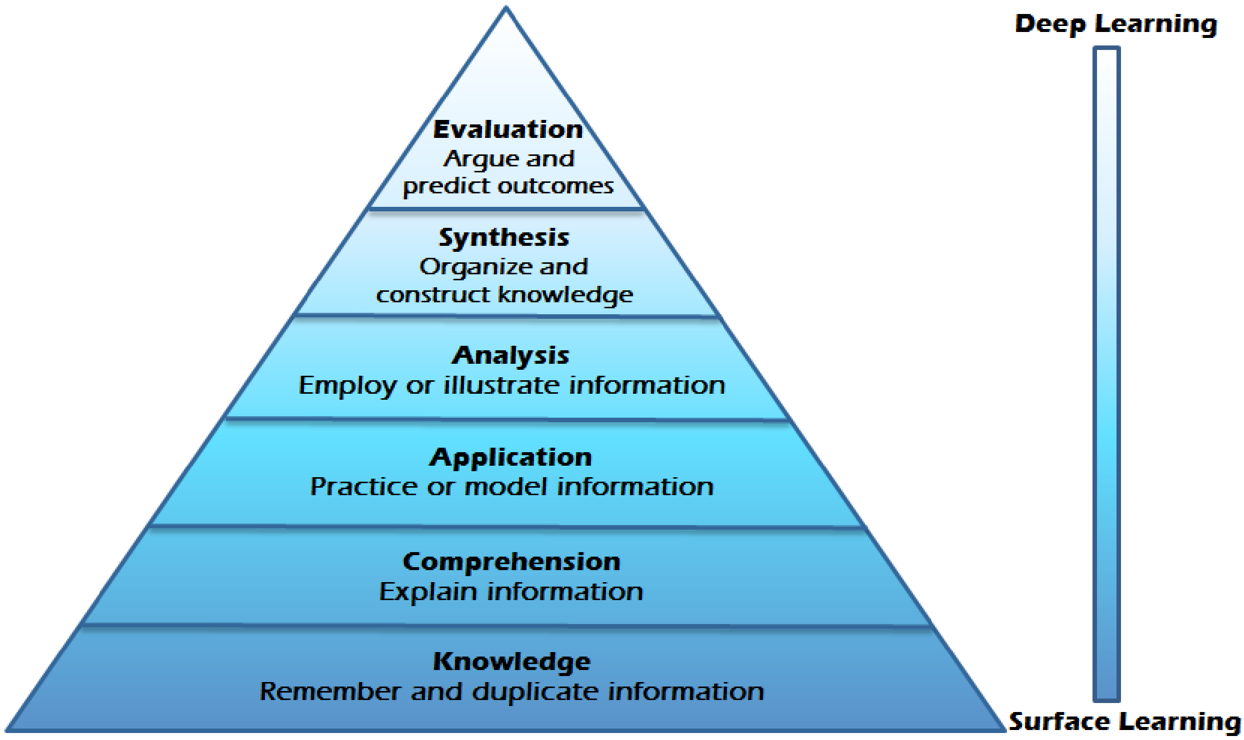


Figure 3.1: A representative pyramid of Bloom's Taxonomy showing the progression from simple surface leaning to more sophisticated deep learning.

Bloom's taxonomy is usually depicted as a pyramid the base represents more simple levels of learning and lead up to more challenging and demanding forms of learning (Bloom and Krathwohl, 1956) (Figure 3.1). Knowledge starts at the base of the pyramid because knowing facts and procedures provides a framework from which the rest of the higher orders of thinking can establish. After students know the basic facts they can classify, describe, discus and explain them demonstrating their basic comprehension. The lesson plans must promote higher levels of thinking. The lesson plans must encourage students to apply their knowledge to demonstrate, interpret, or illustrate more complicated ideas. In addition students must analyze what they are learning and critically assess the information. Students must then synthesize the information, organizing, collecting, and formulating the topics so the students can finally evaluate the information. This last form of learning and understanding is where students can argue, assess, compare, and evaluate the information (Bloom and Krathwohl, 1956).

While Bloom's Taxonomy provides an excellent framework for establishing lesson plans, it is important to remain grounded in reality and apply the theoretical framework to a physical space. Dewey (1902) stated the importance of social interaction with student learning and that students thrive when they become actively engaged with the curriculum. Dewey (1902) noted that the inactivity of the student leads to passive learning methods and the students do not invest themselves in the material. He promoted this idea by stating that students should collaborate with each other and the teacher though interactive, problem or experimental based scenarios (Dewey, 1916). By doing experimental or problem based learning students can be immersed in a constructivism approach. In constructivism, students learn by building their own knowledge on a scaffold of provided facts. From there, the rest of the student's knowledge and understanding is built through application and experimentation (Ausubel 1963; 2000). When students have a constructivist approach to learning, students become engaged in the activity, use more meaningful learning strategies, and learn deeply (Tsai, 1998). It is important to promote discovery and experimental procedures because students who think science is dynamic are more inclined to try challenging tasks and figure problems out, whereas students who think science is static with the rote memorization of facts will wait until someone else determines the answer.

Methods – Creating Engaging Lesson Plans

Teachable Units – Lesson Plan Design:

To guide both elementary, middle, and high school students and teachers through the scientific process, three full IPM-focused lesson plans were developed. Many elementary and middle school teachers are not science graduates and therefore may be unknowledgeable about the scientific process (Lawrenz, 1986; Ingersoll, 1999; Jeastrom *et al.* 2004). Teachable units in essence are fully developed lesson plans that engage students in learning, provide feedback to students and instructors, have learning goals that represent the nature of science with activities and assessments to achieve and assess those learning goals, and contains all the information that another teacher should need to repeat and teach the unit (Hendelsman *et al.* 2007). Teachable units teach the principles of the work to be completed by the students, what the student will learn and how, and provide a framework for collecting data and information (Hendelsman *et al.* 2007). Because these lesson plans are longer than what would fit in a class period, the teachable units are broken down into “tidbits” that provide convenient stopping points for the instructors roughly lined up with a 45-50 minute class period.

<u>Alignment to the Standards:</u>

These three teachable units were set to the standards in Georgia which follow closely in concept to the National Science Standards. Therefore, while these lesson plans were specifically set for the standards in Georgia, they could be easily modified to match the national standards or other states standards. The lesson plans were also aligned to the Next Generation Science Standards (NGSS) which was a state led effort but partnered with the National Research Council, National Science Teachers Association, and the American Association for the Advancement of Science. The NGSS are to help integrate the scientific process in all aspects of the science curriculum and the creators are pushing these to be adopted by schools in 2015 (NGSS, 2014). The standards should be viewed as guidelines and a basic framework from which to build the appropriate knowledge (Laursen, 2006; Dulan, 2008).

Backwards Design:

These lesson plans were created using the backwards design method. The backwards design is important because the creator must identify the desired learning goals and results first (Wiggins and McTighe, 1998). Because these lesson plans were specifically related to IPM and insect biology, it was important that the lesson plans were created around students understanding what the pest's biology so that students can understand how the organisms function in shared spaces.

The second aspect of backwards design to determine what assessments will be integrated in the lesson to evaluate the progress of the students' learning and understanding (Wiggins and McTighe, 1998). This was done in the lesson plans through series of homework assignments and final projects. All of these were designed to inform the teacher about the students' progress and allow the students to assess and self-reflect upon their own learning and work. These assessments were designed in the lesson to specifically outline what the students needed to do to complete the assessment in addition to the quality of work that was expected from them (Wiggins and McTighe, 1998).

The final aspect of backwards design is to include the factual information and actives the students will be using use as a framework to build their knowledge and understanding (Wiggins and McTighe, 1998). This was done in the lesson plans through a series of activities, experiments, and group discussion. Because students generate good, meaningful, and thoughtful answers to assessments by first asking productive questions (Shodell, 1995), the lesson plans really encourage students to reflect on their previous knowledge and use this to create questions that can be looked at experimentally. This is especially important because lower levels of questions are correlated with lower levels of achievement (Tisher, 1977). Therefore, many activities were designed in the lesson plans to help promote inquisitive thinkers and creative experimental designs to answer these questions. Furthermore, since knowledge and understanding can only be obtained when students interact with the natural world and communicate ideas with their peers (Driver *et al.* 1994). The lesson plans all urge students to look critically at the natural world and include group activities and presentations where students express their ideas and experimental findings.

Building Communication Skills:

Group work was an aspect that was specifically focused on in these lesson plans. This is because group work has been shown to be effective and enhance learning (Deutsch, 1949a; 1949b; Wheeler and Frank, 1973; Johnson *et al.* 1978; Johnson and Johnson, 1985, Handelsman *et al.* 2007). Unfortunately, group work has not been a focus of science learning in the past because many scientists and teachers feel that science is a competitive field and students should be prepared to work though problems themselves (Hendelsman *et al.* 2007). However, even the most competitive activities are more cooperative than competitive. People must work together as a team to adequately take on the challenge (Johnson *et al.* 1978; Johnson and Johnson, 1985). While people have to compete for places in schools or research labs, people within those frameworks must work together as a class or as a lab to run experiments.

Students who work together in groups indicate that they like the class and subject material more and they appreciate being to share and clarify information by talking with one another (Wheeler and Frank, 1973). Students not only like group work, but collaboration fosters learning (Johnson *et al.* 1978; Johnson and Johnson, 1985). Students who collaboratively worked had higher coordination effort, were more obligated to participate in the activities, and had higher attentiveness to other students in the class. Teachers had a wider diversity of contributors to the discussion and activities. Teachers noted there was more of a subdivision of labor and noticed an improvement in quality of the final products students produced for homework or assessments Students had a better understanding of the material and were better able to communicate their ideas when they worked collaboratively. Students felt a higher pressure to achieve and participate in the activities and therefore the students' productivity per unit time also increased (Deutsch, 1949a; 1949b).

Finally, in an attempt to encourage students to communicate their ideas in different formats, the lesson plans require a type of presentation. Presentations are important formats for which students can build, assess, and reflect upon their communication skills (Tucker and McCarthy, 2001). Furthermore, presentations help students organize and create enjoyable content from complicated ideas (Alshare and Hindi, 2004). Creating presentations can be difficult and students need guidance throughout the process to confidently and accurately express their ideas and findings to engage the audience (Collins, 2004). Presentation skills are not only important for engaging students in subject matter and assessing their learning, but to build communication skills that the students will need later in life. Regardless if students pursue science or not in their future, their ability to effectively engage audience members with presentations will help them obtain jobs and advance in those jobs (Curtis, 1989; Flatley; 1990; Roebuck *et al.* 1995; Warner, 1995; Cohen, 1999; Messmer, 1999; Chaney and Creen, 2002; Sherman, 2002). Many graduate students report feeling nervous and under prepared in their schooling to help them develop their communication skills (Hanson, 1987; Knight; 1999) but they realize that effective presentation skills are essential to career advancement (Chaney and Green, 2002; Sherman 2002). Students reported being nervous for presentations, however practice and positive reinforcement can help build student self-confidence which is an essential aspect of giving effective presentations (Reinsch and Shelby, 1996; McKeen *et al.* 2000; Tucker and McCarthy, 2001). Because good presentation skills are so important for career advancement, these skills should be developed early in school. Therefore, the lesson plans that were created focused heavily on student communication in a formal environment to their peers.

Experimentation and Model Building:

Experimentation, discovery, and observation are incredibly important in science education. Because science is often taught as rote facts (Handelsman *et al.* 2007) students obtain an inaccurate perception of how science is actually conducted. Some labs attempt to guide students though experiments however the outcome is previously decided and limit students' creative thinking (Tamir and Lunetta, 1998; Germann *et al.* 1998). These types of experiments are misleading because scientists develop experiments to determine an unknown answer. Failure to integrate inquiry and discovery based labs in relation to the current content taught undermine the purpose of the labs and makes the concepts and theories less relevant to the students (NRC, 2000). The ideas that the students are learning in class must be communicated, addressed, and reviewed in the experiments and activities in the lesson plans (Hodson, 1996; Hodson and Bencze, 1998).

The lesson plans that were developed specifically lead students though the thought processes of a scientist. These students and scientists first must hypothesize about a phenomenon using observations, research, and previous knowledge. Then the students must design an experiment to test their hypothesis and afterwards collect and analyze data. Then the students must develop explanation and focus on an explanation that is the most plausible to explain the outcome. Finally, students must communicate their findings and address how they would improve their experiments in the future (Hodson, 1996). Therefore, the lesson plans also focus heavily on observational biology and encourage students to critically think about their observations in terms of the arthropods' biology.

After students conduct their experiments or observations in the lesson plans, students are encouraged to create models describing their findings. Students must present their models to the class either as a stand along presentation or integrated into a larger presentation about their experiments. Modeling is important because models help people understand complicated, abstract ideas usually presented in science (Gilbert *et al*. 1998a). Models help students build relations between newly discovered information and past experiences. Furthermore, it helps students organize newly learned complex ideas into tangible and palatable contents (Wittrock, 1994). If modeling is not presented to students in a proper way, then students can possess naive ideas about the purpose of the modeling. They will try to simply replicate reality instead reconstructing and synthesizing information to create the model to test ideas and explain concepts (Grosslight *et al.* 1991). Therefore, in each of the lesson plans, students develop models based on their observations combined with research or experimentation to emphasize that models are an effective means of communicating several ideas at once.

Student Explanation:

These lesson plans guide students though the process of scientific explanation. As students work together in groups, build and practice their communication skills, conduct experiments, and design models, the students develop explanations to explain the phenomena they experimented for or observed. These lesson plans focus on two types of student explanation to focus on. The first is self-explanations where students conduct activities, observe, or research aspects of a fact or problem. Then the students themselves develop an explanation for why the phenomenon happened or how it happened. Self-explanations are linked to greater problem solving ability and deeper understanding of material (Chi *et al.* 1989, Chi *et al.* 1994). The second type of explanation type the lesson plans focused on is causal explanations. This is where students specifically look at the effects or outcomes of a situation and determine how or why they were caused. Students must have foresight and a deep understanding of the methods they employed to accurately assess cause and effect. Causal explanations have more explanatory power and are highly valued and are related to higher orders of student explanations (Woodruff and Meyer, 1997; Gilbert *et al.* 1998b,; Harwood, 1998). Students are encouraged in the lesson plans to produce causal explanations though research, observation, experimentation, and modeling.

Each of the lesson plans will be distributed to the Georgia Department of Agriculture of distribution. Furthermore, these lesson plans will be integrated into the UGA Project Focus class. Project Focus is a class offered at the University of Georgia where undergraduate students employ active based science lessons in local Athens-Clarke County school systems. The University of Georgia has an online class in the Entomology Department named "Entomology for Teachers". In this class, students – both undergraduate and graduate – obtain necessary resources and skill sets to integrate science and entomology into their future classrooms. The lesson plans will be available as resources in this class. The lesson plans will also be released to the Entomological Society of America for use in their teacher's resources (http://www.entsoc.org/teachers).

Results

Elementary School Lesson Plan: (Appendix C)

This lesson plan introduces students to the concepts and procedures of science. In elementary school, reading, language arts, and math are focused on four times more than science

(Gruber *et al.* 2002). This is because there is not standardized testing for the sciences in elementary school. However, as Dewey (1902; 1916) noted science education should start at a very early age. Therefore, these lesson plans specifically focus on group work and the scientific process. Students' interest in science diminishes as the students age, therefore it is necessary to engage them in science immediately (Simpson and Oliver, 1990; Greenfield, 1996; Jovanovich and King, 1998). In addition to the lesson plan, an elementary outreach program was created and aligned to the elementary school science standards.

The National Standards for Science in elementary school focus on the characteristics of organisms and their needs for habitat (Dolan, 2008; Georgia Department of Education; 2013). The Georgia National Science Standards focus on the same aspects of organisms as the National Science Standards. The Next Generation Science Standards (NGSS) for elementary school specific focus on habitats and ecosystems and how the organisms found in those ecosystems relates who what those habitats provide for the organisms (NGSS, 2014). The common core standards were not used in these lesson plans because the common core science standards start in sixth grade (Common Core State Standards Initiative, 2014). This elementary school lesson plan was aligned to the following standards:

Georgia Performance Standards:

3rd Grade:

- Habits of Mind
  - **S3CS1:** Students will be aware of the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
  - **S3CS4:** Students will use ideas of system, model, change, and scale in exploring scientific and technological matters.
  - **S3Cs5:** Students will communicate scientific ideas and activities clearly.

- The Nature of Science
    - **S3CS7:** Students will communicate scientific idea and activities clearly.
    - **S3CS8:** Students will understand important features of the process of scientific inquiry.
- Life Science:
    - **S3L1:** Students will investigate the habitats of different organisms and the dependence of organism on their habitat
    - **S3L2:** Students will recognize the effects of pollution and humans on the environment.

4th Grade:

- Habits of Mind:
    - **S4CS1:** Students will be aware of the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
    - **S4CS3:** Students will use tools and instruments for observing, measuring, and manipulating objects in scientific activities utilizing sale laboratory procedures.
    - **S4CS5:** Students will communicate scientific ideas and activities clearly
    - **S4CS6:** Students will question scientific claims and arguments effectively.
- The Nature of Science:
    - **S4CS7:** Students will communicate scientific idea and activities clearly.
    - **S4CS8:** Students will understand important features of the process of scientific inquiry.
- Life Science:
    - **S4L1:** Students will describe the roles of organisms and the flow of energy within the ecosystem.

5th Grade:

- Habits of Mind:
    - **S5CS1:** Students will be aware of the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
    - **S5CS3:** Students will use tools and instruments for observing, measuring, and manipulating objects in scientific activities.
    - **S5CS5:** Students will communicate scientific ideas and activities clearly

    - **S5CS6:** Students will communicate scientific ideas and activities clearly
- <u>The Nature of Science:</u>
    - **S5CS7:** Students will communicate scientific idea and activities clearly.
    - **S5CS8:** Students will understand important features of the process of scientific inquiry.
- <u>Life Science:</u>
    - **S5L1:** Students will classify organism into groups and relate how they determined the groups with how and why scientists use classification.

(Georgia Department of Education, 2013)

Next Generation Science Standards Grades 3-5:

<u>Biological Evolution Unity and Diversity:</u>

- **2-LS4-1:** Make observations of plants and animals to compare the diversity of life in different habitats.
- **3-LS4-3:** Construct and argument with evidence that in a particular habitat some organism can survive well, some survive less well, and some cannot survive at all.
- **3-LS4-4:** Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

(NGSS, 2014)

In this elementary lesson plan it was important to stress the identification of insects and related arthropods while linking their biology to their habitat. It was also necessary to promote scientific inquiry though experimental procedures and observation. Therefore, this lesson plan focused on a student experiment using sticky traps (insect glue traps) to determine habitat for both pests and beneficial insects. This way the students learn to associate how to manipulate their habitat to promote beneficial insects while dissuading pest arthropods from entering the human environment.

Middle School Lesson Plan: (Appendix D)

This lesson plans specifically focus on conducting an experiment from start to finish. This is because middle school is a good time to expose students to the full scientific process and encourage them to consider science as a career path (Jeastrom *et al.* 2004). Eighth graders who wanted a degree in science in middle school were 1.9 times more likely to complete a BS in life science than their peers who had no interest (Tai *et al.* 2006). Therefore it is necessary to encourage middle school students to become the next generation of scientists. This can be particularly challenging to upkeep because middle schoolers are not usually particularly motivated to learn and tend to disengage in school activities and develop apathy towards learning (Honig, 1987; Anderman and Midgley, 1998; Balfanz, 2007). Middle school students are reported to not have an interest to engage in scientific activities when they enter high school however, many say that they want to pursue science as a career (Atwater *et al.* 1995). Teachers must address these concerns because students who experience academic failure in middle school have a higher likelihood of not graduating high school or going to college (Balfanz, 2007). Therefore, a conscious effort was placed in the creation of this lesson plan to give the students creative freedom to design their own experiment and become invested in the results.

The National and Georgia Performance Standards focus on the same aspects that students learned in elementary school however students are asked to apply these concepts of organismal life needs from the cellular level up to ecosystems as a whole (Dolan, 2008; Georgia Department of Education, 2013). The NGSS specifically focus on ecosystem function, health, and relation to human impacts (NGSS, 2014). The common core has very loose standards for science in middle school and is integrated as part of language art standards. Therefore students are mainly asked to analyze texts but are also asked to follow an experimental procedure. The experiment I designed specifically asks the students to monitor for arthropods in several different habitats both inside the academic buildings and out on the grounds. The middle school lesson plan was aligned to the following standards:

Georgia Performance Standards:

7th Grade:

- Habits of Mind:
  - **S7CS1:** Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
  - **S7CS3:** Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
  - **S7CS4:** Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.
  - **S7CS6:** Students will communicate scientific ideas and activities clearly
  - **S7CS7:** Students will questions scientific claims and arguments effectively
- The Nature of Science:
  - **S7CS8:** Students will investigate the characteristics of scientific knowledge and how that knowledge is achieved.
  - **S7CS9:** Students will investigate the features of the process of scientific inquiry.
- Co-Requisite – Content: - Life Science
  - **S7L1:** Students will investigate the diversity of living organisms and how they can be compared scientifically
  - **S7L4:** Students will examine the dependence of organisms on one another and their environments.

8th Grade:

- Habits of Mind:
  - **S8CS1:** Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
  - **S8CS3:** Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
  -
  - **S8CS4:** Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.

    - **S8CS6:** Students will communicate scientific ideas and activities clearly
    - **S8CS7:** Students will questions scientific claims and arguments effectively
- The Nature of Science:
    - **S8CS8:** Students will investigate the characteristics of scientific knowledge and how that knowledge is achieved.
    - **S8CS9:** Students will investigate the features of the process of scientific inquiry.

(Georgia Department of Education, 2013)

Next Generation Science Standards Grades 6-8:

Earth and Human Activity:

- **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.
- **MS-ESS3-4:** Construct and argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Ecosystems: Interactions, Energy, and Dynamics:

- **MS-LS2-1:** Analyze and interpret data to provide evidence for the effects of resource availability on an organism and populations of an organism in an ecosystem.
- **MS-LS2-4:** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- **MS-LS2-5:** Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

(NGSS, 2014)

Common Core Grades 6-8:

- **CCSS.ELA-LITERACY.RST.6-8.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
- **CCSS.ELA-LITERACY.RST.6-8.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
- **CCSS.ELA-LITERACY.RST.6-8.9:** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

(Common Core, 2014)

High School Lesson Plan: (Appendix E)

If students are not properly motivated throughout secondary school, students become more disengaged from school and related activities. The older students become, the less likely they are to take risks and engage themselves fully in the provided material (Brewster and Fager, 2000). Regrettably, many laboratory experiments or discovery based experiments are not available to all students (Freedman, 1997; NRC 2006). Of the labs that are in high schools, several do not promote science inquiry and do not promote students to ask questions (Germann *et al.* 1998). Furthermore, the science classes many students have in high school are often the last science classes students will have in their lifetime (Roey *et al.* 2001). Therefore, these lesson plans were specifically designed to lead students though internet research and applying knowledge to situations they may encounter in the future.

Georgia Performance Standards:

Biology Standards

- Habits of Mind:
    - **SCSh1:** Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
    - **SCSh3:** Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
    - **SCSh4:** Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.
    - **SCSh6:** Students will communicate scientific ideas and activities clearly.
- The Nature of Science:
    - **SCSh7:** Students will investigate the characteristics of scientific knowledge and how that knowledge is achieved.
    - **SCSh8:** Students will investigate the features of the process of scientific inquiry.
- Co-Requisite – Content:

- **SB2:** Students will analyze how biological traits are passed on to successive generations
- **SB3:** Students will derive the relationship between single-celled and multi-celled organisms and the increasing complexity of systems.
- **SB4:** Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.
- **SB5**: Students will evaluate the role of natural selection in the development of the theory of evolution.

Earth Systems

- Habits of Mind:
  - **SCSh1:** Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
  - **SCSh3:** Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
  - **SCSh4:** Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.
  - **SCSh6:** Students will communicate scientific ideas and activities clearly.
- The Nature of Science:
  - **SCSh7:** Students will investigate the characteristics of scientific knowledge and how that knowledge is achieved.
  - **SCSh8:** Students will investigate the features of the process of scientific inquiry.
- Co-Requisite – Content:
  - **SEC1:** Students will analyze how biotic and abiotic factors interact to affect the distribution of species and the diversity of life on Earth.
  - **SEC2:** Students will investigate factors influencing population density, dispersion, and demographics.
  - **SEC5:** Students will assess the impact of human activities on the natural world and research how ecological theory can address current issues facing our society, locally and globally.

Entomology

- Habits of Mind:
  - **SCSh1:** Students will explore the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
  - **SCSh3:** Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.

    - **SCSh4:** Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.
    - **SCSh6:** Students will communicate scientific ideas and activities clearly.
- <u>The Nature of Science:</u>
    - **SCSh7:** Students will investigate the characteristics of scientific knowledge and how that knowledge is achieved.
    - **SCSh8:** Students will investigate the features of the process of scientific inquiry.
- <u>Co-Requisite – Content:</u>
    - **SEN1:** Students will identify and analyze the roles of insects in ecosystems.
    - **SEN2:** Students will investigate the reasons for insect success.
    - **SEN3:** Students will investigate the impact of insects on the production of food and other products.
    - **SEN4:** Students will investigate the impact of insects on human and animal health.
    - **SEN5:** Students will evaluate methods for the management of insect populations for the benefit of humans.

(Georgia Department of Education, 2013)

Next Generation Science Standards Grades 9-12:

<u>Natural Selection and Evolution:</u>

- **HS-LS4-5:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

<u>Interdependent Relationships in Ecosystems:</u>

- **HS-LS2-1**: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- **HS-LS2-6:** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-7:** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- **HS-LS4-8:** Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

- **HS-LS4-6:** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

(NGSS, 2014)

Common Core Grades 9-10:

- **CCSS.ELA-LITERACY.RST.9-10.2:** Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- **CCSS.ELA-LITERACY.RST.9-10.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- **CCSS.ELA-LITERACY.RST.9-10.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.
- **CCSS.ELA-LITERACY.RST.9-10.7:** Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- **CCSS.ELA-LITERACY.RST.9-10.9:** Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Common Core Grades 11-12:

- **CCSS.ELA-LITERACY.RST.11-12.2:** Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **CCSS.ELA-LITERACY.RST.11-12.3:** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
- **CCSS.ELA-LITERACY.RST.11-12.4:** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
- **CCSS.ELA-LITERACY.RST.11-12.5:** Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

- **CCSS.ELA-LITERACY.RST.11-12.7:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- **CCSS.ELA-LITERACY.RST.11-12.8:** Evaluate the hypotheses, data, analyses, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- **CCSS.ELA-LITERACY.RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

(Common Core, 2014)

Conclusions:

The lesson plans were designed to encompass and teach a wide variety of cognitive and social skills to students of various ages. The teaching pedagogy used to craft the lesson plans was based solidly on theory and aligned to several state and national standards. However, these lesson plans should be tested and assessed in classrooms to ensure their quality and feasibility of implementation. The lesson plans were also designed to be flexible with sections that could be eliminated in the interests of time. Therefore, it would be beneficial to know which sections the teachers favored and why these sections in particular were selected. Overall, the lesson plans were based in sound theory and should be a beneficial addition to any classroom.

References

1. Alshare K and Hindi NM. 2004. The importance of presentation skills in the classroom: Students and Instructors perspectives. *Consortium for Computing Science in Colleges* 19(4): 6-15.

2. Ames C and Archer J. 1988. Achievement goals in the classroom: Student’s learning strategies and motivation processes. *Journal of Educational Psychology* 80: 260-267.

3. Anderman LH and Midgley C. 1998. *Motivation and middle school students* [microform]. ERIC Clearinghouse on Elementary and Early Childhood Education. Champaign IL. Retrieved Oct. 31, 2014 from http://purl.access.gpo.gov/GPO/LPS26550.

4. Ausubel D. 1963. *The Psychology of Meaningful Verbal Learning*. New York: Grume & Stratton.

5. Ausubel D. 2000. *The Acquisition and Retention of Knowledge: A Cognitive View*. Boston: Kluwer Academic Publishers.

6. Atwater MM, Wiggins J, and Gardner CM. 1995. A study of urban middle students with positive and negative attitudes towards science. *Journal of Research in Science Teaching* 32(6):665-677.

7. Aziz K. 1998. The key to perfect presentations. *Industrial and Communication Training* 30(6): 214-217.

8. Balfanz R. 2007. Preventing student disengagement and keeping students on the graduation path in urban middle-grades schools: Early identification and effective interventions. *Educational Psychologist* 41: 223-235.

9. Baird JR and White RT. 1982. A case study of learning styles in biology. *European Journal of Science Education* 4: 325-337.

10. Beattie V, Collins B, and McInnes B. 1997. Deep and surface learning: a simple or simplistic dichotomy? *Accounting Education* 6(1): 1-12.

11. Beichner RL, Bernold E, Burniston P, Dail R, Felder J, Gastineau M, Gjertsen, and Risley J. 1999. Case study of the physics component of an integrated curriculum. *Physics Education Research* 67: S16-S24.

12. Bell RL, Blair LM, Crawford BA, Lederman NG. 2003. Just do it? Impact of a science apprenticeship program on high school students' understanding of the nature of science and scientific inquiry. *Journal of Research in Science Teaching* 40(5): 487-509.

13. Biddulph F and Osborne R. 1982. Some issues relating of children's questions and explanations. LISP(P) Working paper no. 106, University of Waikato, New Zealand.

14. Black P and Wiliam D. 1998. Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan* 80(2): 139-148.

15. Bloom BS and Krathwohl DR. 1956. *Taxonomy of educational objectives: The classification of Educational Goals, by a Committee of College and University Examiners. Handbook 1: Cognitive domain.* New York: Longmans.

16. Boud D. 1990. Assessment and the promotion of academic values. *Studies in Higher Education* 15(1): 101-111.

17. BouJaoude SB. 1992. The relationship between students' learning strategies and the change in their misunderstandings during a high school chemistry course. *Journal of Research in Science Teaching* 29: 689-699.

18. Brewster C and Fager J. 2000. *Increasing Student Engagement and Motivation: From Time-on-task to Homework.* Retrieved Oct. 31, 2014 from http://educationnorthwest.org/sites/default/files/byrequest.pdf.

19. Britner SL. 2008. Motivation in high school science students: A comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching* 45(8): 955-970.

20. Brophy J. 2008. Developing students' appreciation for what is taught in schools. *Educational Psychologist* 43(3): 132-141.

21. Brophy J. 2010. *Motivating students to learn* (3rd ed.) New York, NY: Routledge.

22. Cameron J. 2001. Negative effects of reward on intrinsic motivation – a limited phenomenon: Comment of Deci, Koestner, and Ryan. *Review of Educational Research* 71(1): 29-42.

23. Common Core State Standards Initiative. 2014. English Language Arts Standards >> Science and Technical Subjects. *Common Core State Standards Initiative: Preparing*

America's Students for College and Career. Retrieved Nov 2, 2014 from http://www.corestandards.org/ELA-Literacy/RST/introduction/.

24. Cameron J and Pierce WD. 1994. Reinforcement, reward, and intrinsic motivation. A meta-analysis. *Review of Educational Research* 64(3): 363-423.

25. Cavallo AMN and Schafer LE. 1994. Relationships between students' meaningful learning orientation and their understanding of genetics topics. *Journal of Research in Science Teaching* 31: 393-418.

26. Chaney L and Green C. 2002. Presenter behaviors: Actions often speak louder than words. *Supervision* 63(5): 17-19.

27. Chi MTH, Bassok M, Lewis MW, Reimann P, and Glaser R. 1989. Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science* 13: 145-182.

28. Chi MTH, de Leeuw N, Chiu MH, and Lavancher C. 1994. Eliciting self-explanations improves understanding. *Cognitive Science* 18: 439-477.

29. Chin C and Brown DE. 2000. Learning in Science: A Comparison of Deep and Surface Approaches. *Journal of Research in Science Teaching* 37(2): 109-138.

30. Clark RE. 2003. Fostering the work motivation of individuals and teams. *Performance Improvement* 42: 21-29.

31. Coffield FD, Moseley D, Hall E, and Ecclestone K. 2004. *Learning Styles in Pedagogy in Post-16 Learning*: *A Systematic and Critical Review*. London: Learning and Skills Research Centre.

32. Cohen A. 1999. The right stuff. *Sales and Marketing Management* 151: 15.

33. Collins J. 2004. Education techniques for lifelong learning: Giving a Power-Point presentation: The art of communicating effectively. *RadioGraphics* 24: 1185-1192.

34. Cotton K. 2003. *Principles and Student Achievement.* Association for Supervision and Curriculum Development USA.

35. Curtis DB, Winsor JL, and Stephens RD. 1989. National Preferences in Business and Communication Education. *Communication Education* 38: 6-15

36. Dees RL. 1991. The role of cooperative learning in increasing problem-solving ability in a college remedial course. *Journal for Research in Mathematics Education* 22: 409-421.

37. Deutsch M. 1949a. An experimental study of the effects of cooperation and competition upon group process. *Human Relations* 2: 199-231.

38. Deutsch M. 1949b. A theory of cooperation and competition. *Human Relations* 2: 129-152.

39. Dev PC 1997. Intrinsic motivation and academic achievement: What does their relationship imply for the classroom teacher? *Remedial and Special Education* 18(1):12-19.

40. Dewey J. 1902. *The Child of the Curriculum.* Chicago: Chicago Press.

41. Dewey K. 1916. *Democracy and Education*. New York: Macmillan Co.

42. Dolan E. 2008. *Mentoring in Academia and Industry: Education Outreach and Public Engagement* New York, Springer.

43. Donaldson M. 1978. *Children's minds.* London: Falmer.

44. Driver R, Asoko H, Leach J, Mortimer E, and Scott P. 1994. Constructing scientific knowledge in the classroom. *Educational Researcher* 23: 5-12.

45. Dufresne RJ, Gerace WJ, Leonard WJ, Mestre JP and Wenk L. 1996. *Classtalk:* A classroom communication system for active learning. *Journal of Computing in Higher Education* 7(2): 3-47.

46. Duren PE and Cherrington A. 1992. The effects of cooperative group work versus independent practice on the learning of some problem-solving strategies. *School Science and Mathematics* 92: 80-83.

47. Dweck C, and Elliot ES. 1983. Achievement motivation. In E.M Hetherington (ed.), Handbook of child psychology: Vol 4. *Socialization, personality, and social development*. New York: Wiley.

48. Ebert-May D. Batzli J, and Lim H. 2003. Disciplinary research strategies for assessment of learning. *BioScience* 53: 1221-1228.

49. Elstgeest J. 1985. The right question at the right time. In W. Harlen (Ed.) *Primary Science: Taking the Plunge.* London. Heinemann.

50. Entwistle NJ and Ramsden P. 1983. *Understanding student learning*. London: Croom Helm.

51. Fagen AP, Crouch CH, Mazur E. 2002. Peer instruction: Results from a range of classrooms. *Physics Teacher* 40: 206-209.

52. Flatley M. 1990. Team presentation skills: Essential tools today. *Business Education Forum* 11: 19-21.

53. Freedman MP. 1997. Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching* 34: 343-357.

54. Friedman TL. 2006. *The World is Flat: A Brief History of the Twenty-First Century.* New York, NY: Farrar, Straus and Giroux.

55. Germann PJ, Haskins S, and Auls S. 1998. Analysis of nine high school biology laboratory manuals: Promoting scientific inquiry. *Journal of Research in Science Teaching* 33(5): 475-499.

56. Gibson HL and Chase C. 2002. Longitudinal impact of an inquiry-based science program on middle school students' attitude toward science. *Science Education* 86(5) 693-705.

57. Gilbert JK, Boulter C, and Rutherford M. 1998a. Models in explanations part 1: Horses for courses? *International Journal of Science Education* 20: 83-97.

58. Gilbert JK, Boulter C, and Rutherford M. 1998b. Models in explanations, part 2: Whose voice? Whose ears? *International Journal of Science Education* 20: 187-203.

59. Good TL and Brophy JE. 2000. *Looking in classrooms* (8^{th} ed.) New York, NY: Longman.

60. Greenfield TA. 1996. Gender, ethnicity, science achievement, and attitudes. *Journal of Research in Science Teaching* 33: 901-933.

61. Georgia Department of Education. 2013. Georgia Performance Standards. *GaDOE: Georgia Standards.org* Retrieved Nov 1, 2014 from https://www.georgiastandards.org/standards/Pages/BrowseStandards/BrowseGPS.aspx

62. Grosslight L, Unger C, and Jay E. 1991. Understanding models and their use in science: Conceptions of middle and high school students and experts. *Journal of Research in Science Teaching* 28: 799-822.

63. Gruber KJ, Wiley SD, Broughman SP, Strizek GA, Burian-Fitzgerald M. 2002. Schools and Staffing Survey, 1999-2000: Overview of the Data for Public, Private, Public Charter, and Bureau of Indian Affairs Elementary and Secondary Schools, NCES 2002-2313, U.S. Department of Education, National Center for Education Statistics, Washington DC.

64. Gunstone RF. 1994. The importance of specific science content in the enhancement of metacognition. In Fensham P, Gunstone R, and White R (Eds.) *The Content of Science: A Constructivist Approach to its Teaching and Learning*. London: Falmer.

65. Handelsman J, Ebert-May D, Beichner R, Bruns P, Chang A, DeHann R, Gentile J, Lauffer S, Stewart J, Tilghman SM, and Wood WB. 2004. Scientific Teaching *Science* 304: 521-522.

66. Handelsman J, Miller S, and Pfund C. 2007. *Scientific Teaching*. NY, New York: Freeman and Company.

67. Hanson G. 1987. The importance of oral communication in accounting practice. *CPA Journal* 57: 118-122.

68. Haynes NM. And Gebreyesus S. 1992. Cooperative learning: A case for African-American students. *School Psychology Review* 21: 577-585.

69. Hegarty-Hazel E and Prosser M. 1991a. Relationship between students' conceptual knowledge and study strategies – part 1: Student learning in physics. *International Journal of Science Education* 13: 303-312.

70. Hegarty-Hazel E. and Prosser M. 1991b. Relationship between student's conceptual knowledge and study strategies – part 2: Student learning in biology. *International Journal of Science Education* 13: 421-429.

71. Hennessey MG and Beeth ME. 1993, April. Student's reflective thoughts about science content: A relationship to conceptual change learning. Paper presented at the American Educational Research Association annual meeting, Atlanta, GA.

72. Hennessey S. 1993. Situated cognition and cognitive apprenticeship: Implications for classroom learning. *Studies in Science Education* 22: 1-41.

73. Hidi S and Harackiewics JM. 2000. Motivating the academically unmotivated: A critical issue for the 21st century. *Review of Educational Research* 70(2): 151-179.

74. Honig B. 1987. *Caught in the Middle: Educational Reform for Young Adolescents in California Public Schools*. Sacramento CA: Department of Education.

75. Horwood RH. 1988. Explanation and description in science teaching. *Science Education*, 72: 41-49.

76. Hodson D. 1996. Laboratory work as scientific method: Three decades of confusion and distortion. *Journal of Curriculum Studies* 28: 115-135.

77. Hodson D. 1998. Science fiction: the continuing misrepresentation of science in the school curriculum. *Journal of Curriculum Studies* 6: 191-216.

78. Hofstein A, Shore R, and Kipnis M. 2004. Providing high school chemistry students with opportunities to develop learning skills in an inquiry type laboratory: a case study. *International Journal of Science Education* 26(1): 47-62.

79. Ingersoll RM. 1999. The problem of underqualified teachers in American secondary schools. *Educational Research* 28(2): 26-37.

80. Jagers, RJ. 1992. Attitudes toward academic interdependence and learning outcomes in two learning contexts. *Journal of Negro Education* 61: 531-538.

81. Johnson DW and Johnson RT. 1975. *Learning Together and Alone: Cooperation, Competition, and Individualization.* NJ, Englewood Cliffs: Prentice Hall.

82. Johnson DW, Johnson RT, and Scott L. 1985. Classroom conflict: Controversy versus debate in learning groups. *American Education Research Journal* 22: 237-256.

83. Jovanovic J, King SS. 1998. Boys and girls in the performance-based science classroom: Who’s doing the performing? *American Educational Research Journal* 35:477-496.

84. Kellert SR. 1993. Values and perceptions of invertebrates. *Conservation Biology* 7: 845-855.

85. Knight JK and Wood WB. 2005. Teaching more by lecturing less. *Cell Biology Education* 4: 298-310.

86. Knight M. 1999. Management communication in US MBA programs: The state of the art. *Business Communication Quarterly* 62: 9-32.

87. Koballa TR and Crawley FE. The influence of attitude on science teaching and learning. *School Science and Mathematics* 85(3): 222-232.

88. Kohn A. 1994. *The Risks of Rewards* (Report No. EDO-PS-94-14). Champaign, IL: University of Illinois at Urbana. (ERIC Document Reproduction Service No. ED 376 990).

89. Lazarowitz R, Hertz RL, Baird JH, and Bowlden V. 1988. Academic achievement and on-task behavior of high school biology students instructed in a cooperative small investigative group. *Science Education* 72: 67-71.

90. Laurillard DM, 1978. A study of the relationship between some of the cognitive and contextual factors involved in student learning. Unpublished doctoral dissertation, University of Surrey, UK.

91. Laursen SL. 2006. Getting unstuck: Strategies for escaping the science standards straightjacket. *Astronomy Education Review* 5: 162-177.

92. Lawrenz. 1986. Misconceptions of physical sciences concepts among elementary school teachers. *School Science and Mathematics* 86(8): 654-660.

93. Lee O and Anderson CW. 1993. Task engagement and conceptual change in middle school science classrooms. *American Educational Research Journal* 30: 586-60

94. Lee O and Brophy J. 1996. Motivational patterns observed in sixth-grade science classrooms. *Journal of Research in Science Teaching* 33: 303-318.

95. Lockwood J. 2013. *The Infested Mind: Why Humans Fear, Loathe, and Love Insects.* New York: Oxford University Press.

96. Lumsden LS. 1994. *Student motivation to learn* (Report No. EDO-EA-94-7). Washington, DCL Office of Educational Research and Improvement. (ERIC Document Reproduction Service No. ED 370 200).

97. Lumsden LS. 1999. *Student Motivation: Cultivating and Love of Learning*. Eugene, OR: ERIC Clearinghouse on Educational Management. (ERIC Document Reproduction Service No. ED 443 135).

98. Marton F. 1983. Beyond individual differences. *Educational Psychology* 3: 289-303.

99. Marzano RJ. 1998. *A Theory-Based Meta-Analysis of Research on Instruction*. Aurora, CO: Mid-continental Regional Educational Laboratory (McREL).

100. Maskill R and Pedrosa de Jesus H. 1997. Pupils' questions, alternative frameworks, and the design of science teaching. *International Journal of Science Education* 19: 781-799.

101. McKeen C, Bujaki M, and Burke R. 2000. Preparing business graduates for the real world – the role of the university. *Women in Management Review* 15(7): 356-369.

102. Meece J, Blumenfeld PC, and Hoyle R. 1998. Student's goal orientations and cognitive engagement in classroom activities. *Journal of Educational Psychology* 80: 514-523.

103. Meece J. 2003. Applying learner centered principles to middle school education. *Framework for Teaching* 42(2): 109-116.

104. Messmer M. 1999. Skills for a new millennium. *Strategic Finance* 81: 10-12.

105. National Research Council. 1996. National science education standards. National Academy Press, Washington DC.

106. National Research Council. 1999. *How People Learn: Brain, Mind Experience, and School*. Commission on Behavioral and Social Sciences and Education, Washington, DC: National Academies Press.

107. National Research Council. 2006. America's lab report: Investigations in high school science. In Singer SR, Hilton ML, Schweingruber HA (Eds.) *Committee on High School Science Laboratories: Role and Vision.* Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education, National Academies Press, Washington DC.

108. Next Generation Science Standards (NGSS). 2014. "The Next Generation Science Standards". Retrieved Oct 31, 2014 from http://www.nextgenscience.org/next-generation-science-standards.

109. Nicholls JG. 1984. Achievement motivation: Conceptions of ability, subjective experience, task choice, and performance. *Psychological Review* 91: 328-346.

110. Nolen SB. 1988. Reasons for studying: Motivational orientations and study strategies. *Cognition and Instruction* 5: 269-287.

111. Nolen SB and Haladyna TM. 1990. Motivation and studying in high school science. *Journal of Research in Science Teaching* 27: 115-126.

112. Novak JD. 1988. Learning science and the science of learning. *Studies in Science Education* 15: 77-101.

113. Okebukola PA. 1986a. Cooperative learning and students' attitudes to laboratory work. *School Science and Mathematics* 86: 582-590.

114. Okebukola PA. 1986b. The influence of preferred learning styles on cooperative learning in science. *Science Education* 70: 509-517.

115. Osborne RJ and Wittrock MC. 1983. Learning science: A generative process. *Science Education* 67: 489-508.

116. Osborne R and Wittrock M. 1985. The generative learning model and its implications for science education. *Studies in Science Education* 12: 59-87.

117. Pitt DB, Shockley MS. 2014. Don't fear the creeper: Do entomology outreach events influence how the public perceives and values insects and arachnids. *American Entomologist* 60(2): 97-100.

118. Pizzini EL and Shepardson DP. 1991. Student questioning in the presence of the teacher during problem solving in science. *School Science and Mathematics* 91: 348-352.

119. Plato. 1901. *The Republic*. New York: Colonial Press.

120. Prince M. 2004. Does active learning work? A review of the research. *Journal of Engineering Education* 93(3): 223-229.

121. Ramsden P. 1988. Context and strategy: Situational influence on learning. In Schemeck RR (Ed.) *Learning Strategies and Learning Styles*. New York: Plenum.

122. Reinsch L. and Shelby AN. 1996. Communication challenges and needs: Perceptions of MBA students. *Business Communication Quarterly* 59: 36-53.

123. Rivet AE and Krajcik JS. 2008. Contextualizing instruction: Leveraging students' prior knowledge and experience to foster understanding of middle school science. *Journal of Research in Science Teaching* 45(1): 79-100.

124. Roebuck DB, Sightler KW, and Brusch CC. 1995. Organizational size, company type, and position effects on the perceived importance of oral and written communication skills. *Journal of Managerial Issues* 7: 99-115.

125. Roey S, Caldwell N, Rust K, Blumstein E, Krenzke T, Legum S, Kuhn J, Waksberg M, Haynes J. 2001. The 1998 high school transcript study tabulations: comparative data on credits earned and demographics for 1998, 1994, 1990, 1987, and 1982 high school graduates, NCES 2001-2498 [Brown J, Project Officer]. US department of Education, National Center for Educational Statistics, Washington DC.

126. Roth KJ. 1990. Developing meaningful conceptual understanding in science. In Jones BF and Idols L (Eds.) *Dimensions of thinking and cognitive instruction*. Hillsdale, NJL: Erlbaum.

127. Roth WM and Roychoudhury A. 1993. The nature of scientific knowledge, knowing and learning: The perspectives of four physics students. *International Journal of Science Education* 15, 27-44.

128. Roth WM and Roychoudhury A. 1994. Physics students' epistemologies and views about knowing and learning. *Journal of Research in Science Teaching* 31: 5-30.

129. Ryan RM and Deci EL. 2000. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology* 25: 54-67.

130. Sandoval WA and Morrison K. 2003. High school students: Ideas about theories and theory change after a biological unit. *Journal of Research in Science Teaching* 40(4): 369-392.

131. Scardamalia M and Bereiter C. 1992. Text-based and knowledge-based questioning by children. *Cognition and Instruction* 9:177-199.

132. Schauble L, KlopferLE, and Raghavan K. 1991. Students transition from an engineering model to a science model of experimentation. *Journal of Research in Science Teaching*, 28: 859-882.

133. Seastrom MM, Gruber KJ, Henke R, McGrath DJ, Cohen BA. 2004. Qualifications of the public school teacher workforce: Prevalence of out-of-field teaching, 1987-88 to 1999-2000, NCES 2002-2603 Revised. US Department of Education, National Center for Educational Statistics, Washington DC.

134. Sherman R. 2002. 10 presentation skills top executives live by. *Business Credit* 104(6): 46-47.

135. Shodell M. 1995. The question-driven classroom. *The American Biology Teacher* 57:278-281.

136. Simpson RD and Oliver JS. 1990. A summary of major influences on attitude toward and achievement in science among adolescent students. *Science Education* 66(1): 1-18.

137. Smith ME, Hinckley CC, and Volk CG. 1991. Cooperative learning in the undergraduate laboratory. *Journal of Chemical Education* 68: 413-415.

138. Songer NB and Linn MC. 1991. How do students' views of science influence knowledge integration? *Journal of Research in Science Teaching* 28: 761-784.

139. Stepien W and Gallagher S. 1993. Problem-Based Learning: As authentic as it gets. *Authentic Learning* 50(7): 25-28.

140. Stevens RJ and Slavin RE. 1995. The cooperative elementary school: Effects on students' achievement, attitudes, and social relations. *American Educational Research Journal* 32(2): 321-351.

141. Swisher K. 1990. Cooperative learning and the education of American Indian/Alaskan native students: A review of the literature and suggestions for implementation. *Journal of American Indian Education* 29: 36-43.

142. Tai RH, Liu CQ, Maltese AV, Fan X. 2006. Planning early for careers in science. *Science* 312: 1143-1144.

143. Tamir P and Luntta VN. 1981. Inquiry-related tasks in high school science laboratory handbooks. *Science Education* 65(5): 477-484.

144. Taraban R, Box C, Myers R, Bowen CW. 2007. The effects of active-learning experiences on achievement, attitudes, and behaviors in high school biology. *Journal of Research in Science Teaching* 44(7): 960-979.

145. Tisher RP. 1977. Practical insights gained from Australian research on teaching. *Australian Science Teachers Journal* 23: 99-104.

146. Tucker ML and McCarthy AM. 2001. Self-Efficacy: Increasing communication skills through service learning. *Journal of Managerial Issues* 13(2): 227-244.

147. Warner KK. 1995. Business communication competencies needed by employees as perceived by business faculty and business professionals. *Business Communication Quarterly* 58: 51-56.

148. Watts M. Gould G, and Alsop S. 1997. Questions of understanding: Categorizing pupil's questions in science. *School Science Review* 79: 57-63.

149. Wheeler R and Frank RL. 1973. Effects of cooperation and competitive classroom environments on the attitudes and achievements of elementary school students engaged in social studies inquiry activities. *Journal of Educational Psychology* 65(3): 402-407.

150. White RT and Gunstone RF. 1989. Metalearning and conceptual change. *International Journal of Science Education* 11: 577-586.

151. Wiggins G and McTighe J. 1998. *Understanding by Design*. Alexandria, VA: Association for Supervision and Curriculum Development.

152. Williams E. 1992. Student attitudes towards approaches to learning and assessment. *Assessment and Evaluation in Higher Education* 17(1): 45-58.

153. Wittroch MC. 1994. Generative science teaching. In Fensham P, Gunstone R, and White R (Eds.) *The Content of Science: A Constructivist Approach to its Teaching and Learning.* London: Falmer.

154. Woodruff E and Meyer K. 1997. Explanations from intra- and inter-group discourse: Students building knowledge in the science classroom. *Research in Science Education* 27: 25-39.

155. Zoller U. 1987. The fostering of question-asking capability: A meaningful aspect of problem-solving in chemistry. *Journal of Chemical Education* 64: 510-512.

APPENDIX A – SIPM CRITERIA WALK –THROUGH SURVEY

Florida School IPM Walkthrough Date:_______

1. School Name and District:

2. Inspection Participants:

3. School Site Details (names, phone numbers, and/or e-mails):

• Principal: ____

• Age of School: ____

• Area (ft^2):____

• Number of Teachers: ____

• Number of Students: ____

• Director of Operations: ____

• IPM Specialist: ____

• Building Manager: ____

• Grounds Supervisor: ____

• Number of Custodians: ____

• Contractual Custodian Supervisor (if applicable): ___________________________

• Kitchen Manager: ____

• School Nurse: ____

• Pest Management Company: ____

• Waste Management: ____

• Perceived Pests: ____

• Observed Pests: ____

At a Glance Assessment - Key questions indicating an IPM program is in progress

Do you have an IPM coordinator? Y N

Do you have an IPM policy? Y N

Do you have an IPM committee? Y N

Are you a member of a state IPM coalition? Y N

Do you apply scheduled pesticide treatments? Y N

Do you have an inspection schedule? Y N

Do you have a monitoring program? Y N

Approximate number of monitors in place ________________

Do you use pest sighting logs? Y N

Do you provide continuing education regarding pest issues? Y N

Does your campus cook and prepare food on a daily basis? Y N

Graded IPM Inspection Check List

When you inspect each item on the checklist, place a mark in the appropriate box for each deficiency. Add the total points for each inspection area. Add the totals for Exterior and Interior inspection areas, add the two sections together, and then divide by the total amount of points (500) to get a final score:

0	**Starting Score**	**0**	**Starting Score**
	Add Points For All Exterior		**Add Points For All Interior**
	Final Score		**Final Score**
	Campus Total Score **Final Perfect Score (500)**		**Take final scores divide by 500 to get final percentage rank**

< 69 = Unsatisfactory; 70-79 = Average; 80-89 = Above Average; 90-100 = Excellent

EXTERIOR

Exterior Garbage Areas — **Grade**

In your score please consider the following features — **1= poor**

5 = excellent

Dumpsters sealed properly or with tightly fitting lids	
Dumpsters located adequate distance from doors	

Dumpsters on pest-proof pavement	
Area around dumpsters free from spillage	
Outdoor trash receptacles are self closing (e.g. do they have lids)	
Total	

Notes:

Pest Evidence in Exterior Garbage Areas **Grade**

In your score please consider the following features **1= infested**

5 =no evidence

Evidence of ants *(will depend on distance to dumpster to building if this can be an issue)*	
Evidence of rodents	
Evidence of cockroaches	
Evidence of flies	
Evidence of bees/wasps	
Evidence of other pests	
Total	

Notes:

EXTERIOR (Continued)

Exterior Landscaping | **Grade**

In your score please consider the following features | **1= poor**

5 = excellent

Adequate visibility between plantings and buildings (18 inches)	
Building free from direct contact with trees	
Building free from direct contact with shrubs/vines	
Building free of limbs overhanging roof	
Total	

Notes:

Exterior Building Features | **Grade**

In your score please consider the following features | **1= poor**

Note doors and windows will be reviewed twice – look for outside evidence here | **5 = excellent**

Doors sealed tightly – weather-stripping/door-sweeps are in place	
Windows and vents are screened or filtered	
Plumbing and electrical penetrations are properly sealed	
Walls-roof line free of cracks/openings	
Air ventilation intakes screened, unobstructed	
Adequate water drainage around foundation	
Awnings, breezeways, and other overhang structures free from bird nests	

Soil line below building siding or foundation or other conditions conducive to termites (e.g. for wood structures is there too much mulch)	
Gutters cleared of debris	
Total	

Notes:

Pest Evidence Around Exterior	**Grade**
In your score please consider the following features	**1= infested**
	5 =no evidence
Evidence of rodents	
Evidence of other pests (e.g. vertebrates, birds, bats)	
Evidence of bees/wasps	
Evidence of termites, termite tubes	
Total	

Notes:

INTERIOR KITCHEN, CAFETERIA AND FOOD AREAS

Food Preparation Area Ceiling, Walls and Floor **Grade**

In your score please consider the following features **1= poor**

5 = excellent

Ceiling tiles are in good condition (no openings or missing tiles)	
No signs of roof leaks (stained ceiling tiles or walls)	
Interior walls are free from cracks and crevices	
Plumbing and electrical penetrations are properly sealed	
Permanent bulletin boards, mirrors, electrical boxes and other wall fixtures in food preparation and serving areas are caulked	
Floors are clean (free of spillage) by end of day, especially under food preparation and serving areas	
Floor and sink drains are clean and traps are kept full of water	
Interior food preparation doors are sealed tightly, no daylight showing through bottom	
Dock receiving door is sealed – no daylight showing under door	
Total	

Notes:

INTERIOR KITCHEN, CAFETERIA & FOOD AREAS (Continued)

Food Preparation Area Appliances, Equipment and Furniture **Grade**

In your score please consider the following features **1= poor**

5 = excellent

Surfaces in food preparation and serving areas are regularly free of grease deposits	
Kitchen appliances and fixtures are of pest-resistant design (e.g. shelving with open areas, stainless steel, no wood)	
Vending machines are clean inside and out	
Cafeteria furniture does not provide pest harborage (e.g. metal tube frames are sealed, upholstered furniture not present)	
Food preparation areas are free of cardboard (even storage shelves)	
Trash cans are clean and lined with trash bags, daily	
Is there evidence of pest monitoring throughout the kitchen area	
Total	

Notes:

Grade

Pest Evidence in Food Preparation Area **1= infested**

In your score please observe & consider the following pests **5 =no evidence**

Evidence of rodents	
Evidence of roaches	

Evidence of ants	
Evidence of flies	
Evidence of other nuisance pests (e.g. stored product pests)	
Total	

Notes:

Food and Product Storage Areas **Grade**

In your score please consider the following features **1= poor**

5 = excellent

Ceiling tiles are in good condition (no openings or tiles missing)	
No signs of roof leaks (stained ceiling tiles or walls)	
Interior walls are free from cracks and crevices	
Plumbing and electrical penetrations are properly sealed	
Floors are clean (free of spillage) by end of day, especially under storage areas	
Floor and sink drains are clean and traps are kept full of water	
Bulk stored products are stored on open wire racks and not in original cardboard shipping containers	
Food items are stored in tightly closed containers overnight (e.g. bread, cookies, flour)	
Inspection aisles are maintained around bulk stored products	
Mops and mop buckets are properly hung, dried and stored	
Total	

Notes:

Pest Evidence in Food and Product Storage Areas **Grade**

In your score please observe & consider the following pests **1= infested**

5 =no evidence

Evidence of rodents	
Evidence of roaches	
Evidence of ants	
Evidence of other pests *(e.g. flies, stored product pests)*	
Total	

Notes:

Cafeteria Area ***(If this campus area is also used as auditorium be sure to check under and behind the stage)*** **Grade**

1= poor

In your score please consider the following features **5 = excellent**

Surfaces in cafeteria are cleaned regularly	
Fixtures are of pest-resistant design (e.g. shelving with open areas, stainless steel, no wood) *(if school has afterschool program be sure to check this area)*	
Vending machines are clean inside and out	
Cafeteria furniture does not provide pest harborage (e.g. metal tube frames are sealed, upholstered furniture not present)	
Ceiling tiles are in good condition (no openings or missing tiles)	

Trash cans are clean and lined with trash bags, daily	
Custodial closet - mops and mop buckets are properly dried and stored	
Total	

Notes:

INTERIOR GENERAL

Teacher Lounges **Grade**

In your score consider the following features **1= poor**

If campus has more than one lounge area – lump all together **5 = excellent**

Teachers' lounge cleaned daily	
Refrigerators, microwaves, and food storage located in teachers' lounge cleaned at least monthly	
Permanent bulletin boards, mirrors, electrical boxes and other wall fixtures in food preparation and serving areas are caulked	
Food items are kept in sealed storage containers free from pests	
Restrooms are free from water leaks and are cleaned daily	
Floor and sink drains are clean and traps are kept full of water	
Trash cans are cleaned daily and double lined with trash bags	
Total	

Notes:

Pest Evidence in Teacher Lounge Areas **Grade**

In your score please observe & consider the following pests **1= infested**

5 =no evidence

Evidence of rodents	
Evidence of roaches	
Evidence of ants	
Evidence of flies	
Evidence of other pests	
Total	

Notes:

Classrooms and Other Interior Areas **Grade**

In your score consider the following features **1= poor**

5 = excellent

Interior (vestibule) doors sealed tightly	
Interior walls, that form the exterior of the building, are free from cracks and crevices	
Ceiling plenums are accessible and are free of pest activity	
Ceiling tiles are in good repair (no chips, holes or other entry points)	
Classrooms free from clutter and cardboard	
Classrooms free from food *(food, if present, kept in pest resistant containers)*	
Indoor trash cans are clean and double lined with trash bags	

Storage closets (including janitorial) cleaned periodically and free from standing water, clutter and cardboard	
Restrooms free from water leaks	
Restrooms are cleaned daily	
Refrigerators, microwaves, and coffee pots in classrooms, free of debris, food and other attractants to pests	
Pets in classrooms – are cages cleaned weekly, area around cages are kept clean and tidy	
Pets in classrooms – food items are kept in locked storage containers free from pests	
Total	

Notes:

Pest Evidence in Classrooms and Other Interior Areas	**Grade**
In your score please observe & consider the following pests	**1= infested**
	5 =no evidence

Evidence of rodents	
Evidence of roaches	
Evidence of ants	
Evidence of flies	
Evidence of other pests	
Total	

Notes:

Additional Comments:

APPENDIX B – MODEL SIPM CONTRACT FOR GEORGIA

Georgia State School Integrated Pest Management Contract

1. General:

A. Description of Services:

This contract is part of a comprehensive Integrated Pest Management (IPM) program for the school buildings and other school affiliated areas specified in the contract.

B. IPM Definition:

Integrated Pest Management is a program established for achieving long term, environmentally sound pest suppression and prevention through a variety of strategies, including technological and management strategies. Control practices for an IPM program **are not** based on the routine application of pesticides, but on monitoring and inspecting for pests, modifying structures, improving sanitation, and changing personnel practices that can contribute to pest problems. Pest control is achieved in an IPM program by making accurate decisions as to when control measures are needed and the type of control measures that are appropriate.

Control Strategies Include:

- Facility inspections to identify pest harborage and favorable conditions for pests.
- Proper identification of pests and an understanding of pest biology and behavior.
- Structural and procedural changes to reduce access, harborage, water, and food for pests.

- Using pesticides only when needed based on trapping and monitoring techniques.
- Use of reduced-risk pesticide compounds, formulation, and selection of application methods that present a reduced potential hazard to humans and the environment.
- Coordination and communication among all facilities management programs that have a bearing on the pest control effort.

C. Contractor Service Requirements:

The Contractor shall furnish all labor and materials including supervision, labor, and equipment (except for major expense items unless requested by the contract administrator) necessary to accomplish the inspection, monitoring, trapping, pest management (including pesticide application if needed, but excluding sanitation and building maintenance), and pest removal components of the IPM program. The Contractor shall demonstrate an understanding of the concepts of IPM methods and of pest control. The Contractor shall provide detailed, site-specific recommendations for structural and procedural modifications to aid in pest prevention. The IPM program shall consist of the development and implementation of regularly scheduled pest management services; routine and special meetings among pest management personnel and school staff, routine and specifically scheduled training, and written reports describing program status and recommendations for the corrective actions that need to be implemented by the school, the Contractor, or the school board.

D. Contact Person and School Liaison:

School districts shall designate an IPM Contact Person for the school district and each individual school shall designated a School Liaison. The Contact Person will facilitate communication between the Contractor, IPM Liaison, and school administrators. The Contact

Person and School Liaison shall have the ability to address all pest management issues, regardless of the pest involved or the areas affected. The Contact Person shall participate in all decisions that may affect pest management. A list of the personnel designated as School Liaisons shall be provided to the Contractor by the school district. The School Liaison and the Contractor will

1. Identify and discuss specific problem areas in the landscape and turf areas.
2. Facilitate access to all management areas on school property.
3. Identify and discuss landscape features or maintenance practices that might contribute to pest infestations.
4. Discuss effectiveness of previous control efforts.
5. Notify pest management personnel of any new restrictions or special safety precautions.

E. Routine Services:

I. Initial Building and Grounds Inspections: The contractor shall complete a thorough, initial inspection of each building or site within ten (10) working days of the effective start date of the contract. The purpose of the initial inspection is for the Contractor to evaluate the pest control needs of all locations and to identify problem areas, structural features, equipment, or other conditions or management practices that are conducive or contributing to pest infestations. Access to building space shall be coordinated with the Contact Person. The Contact Person will inform the Contractor of any restrictions or areas requiring special scheduling.

II. Structural: Routine IPM services shall include control of all pests in and around the school buildings such as, but not limited to, rats, mice, cockroaches, silverfish, ants, flies, wasps, and any other arthropod pests not specifically excluded from the contract. Populations of these pests that are located outside of the specified buildings are included.

Populations of the following pests will be considered *special service*, separate from the specifications of this contract: (add to or subtract from the list as necessary)

- Birds, bats, snakes, and all other vertebrates other than commensal rodents
- Termites, carpenter ants, and other wood destroying organisms
- Mosquitoes
- Pests that primarily feed on outdoor vegetation
- Fleas and ticks

However, the following shall be controlled under the terms of the contract:

- Individuals of all the above pests that are invaders inside buildings
- Winged termite swarmers emerging indoors.

III. Grounds: Routine IPM services shall include the control of all landscape and turf pests such as, but not limited to, defoliating insects, sucking arthropods, wood-boring insects, leaf mining insects, gall forming arthropods, root feeding insects, diseases of ornamental landscape plants and turf grass, weeds, fungus, and vertebrate pests including voles, moles, other rodents, birds, and deer.

F. Additional, Special, and Emergency Services:

I. Structural: The school district reserves the right to negotiate with the Contractor for the purchase of related pest control services not specifically covered. These include, but are not limited to, subterranean and structural control of termites and other wood-boring insects, bird control, and to add or delete buildings or parts of buildings to or from the contract.

II. Grounds: The school district reserves the right to negotiate with the Contractor for the purchase of related pest control services not specifically covered, such as pruning, tree removal, and other plant maintenance practices, and to add or delete grounds or fields to or from the contract.

III. Special Service Request and Emergency Services for Structural and Grounds: On occasion, the Contractor may be contacted to perform corrective, special, or emergency services that are beyond routine service requests. The Contractor shall respond to these exceptional circumstances and complete the necessary work within an approved timeframe, which will minimize the disruption of the daily activities of the building.

The Contractor shall respond to a request for emergency services on the day of the request. In addition, the Contractor shall respond to special service requests within one (1) working day after receipt of request. If the special service or emergency service request entails the application of pesticides, applications will take place in the minimum time allowable by state and federal law. All emergency and special services shall be recorded in the school IPM log book. In the event that such services cannot be completed within the required time frame, the Contractor shall immediately notify the Contact Person and indicate an anticipated completion date.

G. Contractor Licensing:

Throughout the life of this contract, all Contractor personnel and employees providing on-site pest control service must meet state requirements for training, certification, and licensing as Commercial Pesticide Applicators in accordance to Chapter 620-3 of the Rules of the Georgia Structural Pest Control Commission. Uncertified individuals working under the supervision of a Certified Applicator will not be permitted to provide service under the terms of this contract.

H. Personnel:

The Contractor shall provide only qualified pest management personnel with adequate and verifiable experience with implementing IPM programs. All on-site personnel employed by the contractor must understand current pest management practices, hold valid state pesticide licenses, and be able to make decisions and field diagnoses regarding the use of IPM practices and techniques. The on-site personnel must understand and assess problems and solutions relating to general pest control, termite control, bird control, and rodent control and have IPM training. The proposal shall present a plan or method for assuring continuity of pest management personnel assigned to this contract, and the knowledge and sensitivity to the needs of the schools.

I. Integrated Pest Management Plan and Service Schedule:

At the initiation of service, the Contractor shall become familiar with the school's site specific IPM Plan. If the school or school district does not have an IPM program that can be implemented one can be created or an existing model IPM can be modified to fit the needs of the school. Such an IPM program must be agreed upon by the Contractor and School district. If aspects of the Pest Control Plan are incomplete or managerially ineffective, then the Contractor shall have five (5) working days to submit suggested revisions to the plan.

The Plan shall consist of four (4) parts as follows.

1. Methods for Pest Identification, Monitoring, and Detection: The Contractor shall provide information on the procedures to be used to identify pests in addition to describing methods and procedures that will be used for identifying sites of pest harborage and access. The Contractor will also provide objective assessments of pest

population levels and determine the need to implement specific control measures throughout the term of the contract.

2. Description of Structural or Operational Changes That Would Facilitate the Pest Control Effort: The Contractor shall describe site-specific solutions for observed sources of pest food, water, harborage, access, or other conditions conducive to pest problems.

3. Proposed Materials and Equipment for Service: The Contractor will provide the following information:

A. A list of all pesticide products to be used. The list shall include each product’s brand name, the common name of the active ingredient, and the “signal word” (Caution, Warning, or Danger).

B. A list of the brand names of pesticide application equipment, rodent bait boxes, insect and rodent trapping devices, pest monitoring devices, pest detection equipment, and any other pest control devices or equipment that may be used to provide services.

C. The current label (and labeling) and Material Safety Data Sheet (MSDS) for each pesticide product on the list.

4. Commercial Pesticide Applicator Documentation: The Contractor shall provide the following documents:

A. The phone number for the currently designated state poison control center.

B. The names and phone numbers of at least two individuals who are designated as the primary and secondary 24-hour contacts for information concerning any aspects of the pest control service being provided.

C. A photocopy of the valid Georgia Commercial Pesticide Applicator License(s) under which all pest control is to be performed.

D. A photocopy of the Contractor’s valid Certificate of Insurance.

E. A list of all Contractor employees who will be performing on-site service under this contract. The list shall include the employee’s name and a statement of whether the employee is a licensee, certified applicator, or registered technician as described in the regulations of the Georgia Department of Agriculture, including the regulations of the Georgia Structural Pest Control Commission such as, but not limited to, Chapter 620-11 – Treatment of Schools. This document shall be updated in accordance to personnel changes to reflect the most accurate and up to date information.

The Contractor shall be responsible for carrying out work according to the approved IPM Plan.

J. <u>The Manner and Time To Conduct Pest Management Activities:</u>

The Contractor shall observe all safety precautions throughout the performance of this contract. Some areas may require special instructions for persons entering the building or area. Restrictions associated with these areas will be explained to the Contractor by the Contact Person. The Contractor shall adhere to these restrictions and incorporate them into the IPM Plan for the specific building or site.

All Contractor personnel working in or around buildings designated under this contract shall wear distinctive uniform clothing. The Contractor shall determine and provide additional personal protection equipment required for the safe performance of work. All protective clothing, equipment, and devices, as a minimum, must conform to the Occupational Safety and Health Administration (OSHA) standards for the products being used. All vehicles used by the Contractor shall be identified in accordance with safe and local regulations.

K. Record Keeping:

The Contractor shall be responsible for maintaining a pest management logbook for each building or site specified in this contract. These logbooks shall be kept on site and be accessible to all site staff. The Contractor shall maintain or update the contents of these logbooks on each visit. Each logbook shall contain at least the following items:

1. Integrated Pest Management Plan: A complete copy of the approved IPM plan.

2. Pest Sighting Log: A form that permits school personnel to record the location(s) of any pest sightings (**Appendix A**). Clear and concise records shall reflect the common names of the pests monitored in the school and grounds areas. The Contractor will review and approve the design of this form prior to its distribution and use in the facilities. The School Administration will be responsible for informing and educating all site staff about the methods for reporting pest observations in the log.

3. Contractor's Service Report: The Contractor shall document site-specific pest findings and subsequent control measures performed during the service visit. A separate form is not required if the Pest Sighting Form is designed to incorporate this information.

2. Pest Control

A. Insect and Other Arthropod Control:

1. Non-Pesticide Products and Use: The Contractor shall use non-pesticide methods of control wherever possible. For example:

A. Trapping Devices such as sticky traps, glue boards, and light traps shall be the standard methods to monitor insect pests including, but not limited to, silverfish, cockroaches, and flies and shall be fully integrated into the day-to-day operations.

B. Caulking and sealing pest harborages and pathways shall be used to block pest entrance into buildings. The Contractor shall make limited applications of approved sealants and other exclusion materials under sinks, as well as around cabinets, pipe chases, windows, doors, exterior areas, etc., in lieu of or to augment other pest management methods.

C. Portable vacuums rather than pesticide sprays shall be the standard method for initial removal of cockroach infestations and the control of spiders and other miscellaneous pests.

2. Pesticide Products and Use: All pesticides shall be applied according to need and not by schedule. Chemical control shall not be applied unless visual inspections or monitoring devices indicate the presence of pests in unacceptable abundances. Chemical pest management strategies will be initiated with Category III pesticides and the use of stronger pesticides (Category II and Category I) shall only be used when all other options have been exhausted.

A. Monitoring: Monitoring devices (sticky traps, light traps, etc.) shall be used to guide decisions on appropriate pest control measures and subsequently to evaluate the effectiveness of these measures. Proper identification of the insects or arthropods caught in the monitoring devices is essential for effective control of the pest.

B. Insecticide Bait Formulations: Non-volatile bait formulations shall be the first choice for cockroach and ant control. If possible, baits shall be applied or placed in areas that cannot be accessed by children or building occupants.

C. Application of Insecticides to Cracks and Crevices: The Contractor shall apply liquid or dry insecticide formulations in cracks and crevices, meaning that the formulated insecticides are applied to hidden or protected areas that are used as harborage sites by pests.

D. Application of Insecticides to Exposed Surfaces: Application of insecticides to exposed surfaces shall be restricted to exceptional circumstances where no alternative effective measures are practical. No surface application of space spray shall be made while the treatment site is occupied. The Contractor shall take all necessary precautions to ensure occupant and employee safety and all necessary steps to ensure the containment of pesticide to the site of the application.

E. Space Sprays: Application of pesticides as space sprays ("fogging") must allow the same restrictions outlined for surface prays. Space sprays must be timed to allow the specific treatment site to remain unoccupied for a minimum of 24 hours. The Contractor will be responsible for ventilating the treatment site in accordance with instructions on the product label before school personnel reenter the site. The Contractor may ask for assistance in securing the treatment site to prevent any unauthorized reentry to the area prior to ventilation or before any re-entry period specified on the product label. Additionally, the Contractor may ask for assistance to arrange for appropriate cleaning of exposed surfaces before the site is free for general use.

B. Rodent Control:

1. Non-Pesticide Products and Use: In general, rodent control inside all occupied buildings shall be accomplished with trapping devices only. All of these devices shall be concealed from the general view of the public and in protected areas so they are not affected by routine cleaning and other operations. Trapping devices shall be mapped and the location of each devices shall remain in the logbook or on file and updated as

necessary to maintain accuracy. The Contractor shall be responsible for disposing of all trapped rodents and rodent carcasses in an appropriate manner every 24 hours.

2. Pesticide Products and Use:

A. Use of Rodenticides: Rodenticides shall only be used in exceptional circumstances when they are deemed essential for adequate rodent control inside buildings. Only block (paraffin-based or other types) rodenticides shall be used. Pellet/pack bait formulations and packaging shall not be used in/around school buildings. All bait shall be placed in EPA-approved tamper-resistant bait boxes that can be secured to a surface and placed in areas that cannot be accessed by children or building occupants.

B. Use of Bait Stations: All bait stations shall be maintained in accordance with EPA and Georgia State pesticide regulations with an emphasis on the safety of non-target organisms. The Contractor shall adhere to the following five (5) points:

1. All bait stations shall be placed out of the general view, in locations where they will not be disturbed by routine operations.
2. The lids of all bait stations shall be securely locked or fastened shut.
3. All bait boxes shall be securely attached or anchored to the floor, ground, wall, or other immovable surface so that the station cannot be picked up or moved by unauthorized personnel.

4. Bait shall always be secured in the feeding chamber of the station and never placed in the runway or entryways of the stations where it could be removed or dislodged.

5. All bait stations shall be labeled with the Contractor's business name and address and dated by the Contractor's technician at the time of installation and each servicing.

C. Locations of All Trapping and Baiting Stations: The locations of the trapping and baiting stations will be recorded in the site's logbook. The Contractor shall receive record of all changes/additions to this information before leaving the site during each service visit. The Contractor will provide the Contact Person or School Administration with a key and instructions for opening bait stations in the event of an emergency.

3. Program Evaluation:

The School District, School, or School Administrators reserve the right to evaluate the progress of this contract in terms of its effectiveness and safety, and to require any changes as necessary. The Contractor shall take prompt action to correct all identified deficiencies.

1. Quality Control Program: The Contractor shall establish a complete quality control program to assure the requirements of the contract are provided as specified. Within five (5) working days prior to the starting date of the contract, the Contractor shall submit a copy of the program to the Contact Person.

The program shall include at least the following items:

A. Inspection System: The Contractor's quality control inspection system shall cover all the services stated in this contract. The purpose of the system is to detect and correct deficiencies in the quality of services before the level of performance becomes unacceptable or the deficiencies are identified.

B. Checklist: A quality control checklist shall be used in evaluating contract performance during both regularity scheduled and unscheduled visits. Every task shall be included on the checklist for every building or site serviced by the Contractor.

C. File: A quality control file shall contain a record of all inspections conducted by the Contractor and any corrective actions taken. The file shall be maintained throughout the term of
the contract and a copy provided to the Contact Person.

D. Inspector(s): The Contractor shall state the name(s) of the individual(s) responsible for performing the quality control inspections.

E. (Optional) The Contractor may use an electronic system of bar codes and scanning systems to record information concerning logs, employees, and service treatments. The use of electronic barcodes can facilitate the management and ease of access of the logs and staff information.

Contractor:

Name: ______________________________ (signed)   Date: ________________________

Contact Person:

Name: ______________________________ (signed)   Date: ________________________

School Liaison:

Name: ______________________________ (signed)   Date: ________________________

School Administrator(s):

Name: ______________________________ (signed)   Date: ________________________

Name: ______________________________ (signed)   Date: ________________________

Name: ______________________________ (signed)   Date: ________________________

Appendix A: Pest Sighting Log

Facility: ____

To be filled out by school official

To be filled out by the Contractor

Location of Sighting Bldg # and Specific Location	Type of Pest Sighted	Date	Action Taken	Technician's Name	Date

Appendix B: Pesticide Application Records

Name of Contractor				
Time and Date				
Customer Name				
Address of Property Treated				
Type of Application Employed				
Name of Target Pest				
Name of Pesticide (Common)				
EPA Req. No. of Pesticide(s) Used				
Rate & Concentration of Pesticides				
Total Amount of Pesticides				
Size of Treated Area				
Type of Application Equipment				
Wind Speed/Direction (if applicable)				
Additional Comments				

Appendix C: Cockroach Trap Monitoring

Building #: ___________ Name of Person Monitoring: __________________

Room or Area: _________

Trap #	Room # or Name	Date trap was Set	Read	Trap Missing?	Location Description	Number of Cockroaches Adults	Nymphs	Total

Appendix D: Landscape Monitoring:

Date: ___________________

Name of Person Monitoring: ______________________

Describe location of appropriate category:

Ornamental Beds: ______________________ Fence Lines: ________________________

Sport Turf: __________________________ Paved Areas: _______________________

Ornamental Turf: _____________________ Trees: _____________________________

Playground: _________________________ Other: _____________________________

Name of Plant	*Condition of Plant Excellent, Fair, Good, Poor	Name of Pest	†Abundance of Pests and Plant Damage Few, Common, Abundant, Innumerable	Presence of Natural Enemies	Management Activities	Comments

Use the following tables to help fill out the chart.

***Plant Condition Rating**

	Indicators of Plant Condition			
Plant Condition Rating	**Leaf Color**	**Amount/Size of Growth**	**Damaged Plant Parts**	**Presence of Pest Problems**
Excellent	Good	Adequate	None to few	No major ones
Good	Good	Slightly reduced	Few to common	A few minor ones
Fair	Poor	Much reduced	Common to abundant	Either major **or** minor ones occurring frequently
Poor	Poor	Severely Reduced	Innumerable	Both major and minor ones occurring frequently

Leaf Color: Note that there are healthy plants that don't have bright green leaves. Leaves can be of varying colors including purple, yellow, or mottled.

Amount/Size of Growth: This refers to the length of the new growth for the season as well as the number of new leaves, size of leaves, flowers, and fruit.

Damaged Plant Parts: Look at the whole plant and determine if there are leaves with holes, spots or discoloration, wilted or dead leaves, or dead twigs or branches.

Presence of Pest Problems: A major pest problem is one that has seriously affected or injured the plant and requires management. A minor pest problem may not require management.

†Pest and Plant Damage Abundance Chart:

Abundance Rating	Indicators of Abundance
Few	Organisms or plant damage occasionally found, but only after much searching.
Common	Organisms or plant damage easily found during typical searching.
Abundant	Organisms or plant damage found in large numbers. Organisms obvious without searching.
Innumerable	Organisms or plant damage extremely numerous. Organisms obvious without searching.

Appendix E: Pest Control Trouble Call Log

Trouble Calls					Pest Management Response			
Date	Bldg #	Problem Description	School Contact	Phone	Date	PCO Name	Action Taken	Materials* and amounts used

***Materials:** Pesticides, caulk, traps, etc...

Appendix F: Weed Monitoring Form for the Turf

Location of Turf: ______________________________ Date: ________________________

Data Collected by: ____________________________ Length of Pace: ______________

Distance between sampling points on transect:

____

Number of Transects: ___________________________ Length of Transects: ___________

Sketch of Location of Transects:

Transect A				Transect B			
Yes	No	Bare	Weed I.D.	Yes	No	Bare	Weed I.D.
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			

Average % Weed Growth ___________________________

Average % Bare Area ______________________________

Total the number of boxes marked "yes" in each column. Multiply this number by 100 and divide by the total number of samples taken. The result is the average percentage of weeds growing in the turf area. Follow the same produce to calculate the percentage of bare area.

Appendix G: IPM Cafeteria Inspection Checklist

This sample form can be edited and modified for other areas of the building.

School Name: ______________________ Date/Time of Inspection: ___________________

Inspector Name: _______________________

Building Exterior:	Satisfactory	Unsatisfactory	Comments for Maintenance
1. Garbage storage area	_________	___________	_______________________
2. Garbage handling system	_________	___________	_______________________
3. Perimeter walls	_________	___________	_______________________
4. Perimeter windows/openings	_________	___________	_______________________
5. Roof areas	_________	___________	_______________________
6. Parking lot/draining areas	_________	___________	_______________________
7. Weeds and surrounding landscape	_________	___________	_______________________
8. Rodent proofing	_________	___________	_______________________
9. Other: _________	_________	___________	_______________________

Building Interior			
1. Walls	_________	___________	_______________________
2. Floors	_________	___________	_______________________
3. Ceilings	_________	___________	_______________________

4. Floor drains ___________ _____________ ___________________________

5. Lighting ___________ _____________ ___________________________

6. Ventilation/air handling
   equipment ___________ _____________ ___________________________

7. Other: ________________ ___________ _____________ ___________________________

Food Storage:

1. Dry food storage area ___________ _____________ ___________________________

2. Damaged/poiled dry food ___________ _____________ ___________________________

3. Empty container storage ___________ _____________ ___________________________

4. Refrigerated areas ___________ _____________ ___________________________

5. Overall sanitation ___________ _____________ ___________________________

6. Other: _______________ ___________ _____________ ___________________________

Appendix H: Sample notice to parents, guardians, and staff of a pesticide application to school grounds.

Notification to Parents, Guardians, and Staff of a

Pesticide Application to School Grounds

Integrated pest management procedures such as inspections and monitoring are used to determine when to control pests and to identify conditions contributing to pest problems. The necessity for pest control, if warranted, is evaluated and one or more pest control methods including sanitation, structural repair, and nonchemical methods are utilized. Problem areas are identified where alternative pest control technologies can be incorporated in order to eliminate routine pesticide applications. When it is determined that nontoxic options are unreasonable or have been exhausted, the use of pesticides may be warranted to control the current pest problem. At this point in time, one of these occasions has occurred and it is necessary to apply pesticides.

School: ____

Common Name of Pesticide to be Applied: __________________________

Location(s) of Pesticide Application: _____________________________

Planned Date and Time of Application: ______________________________

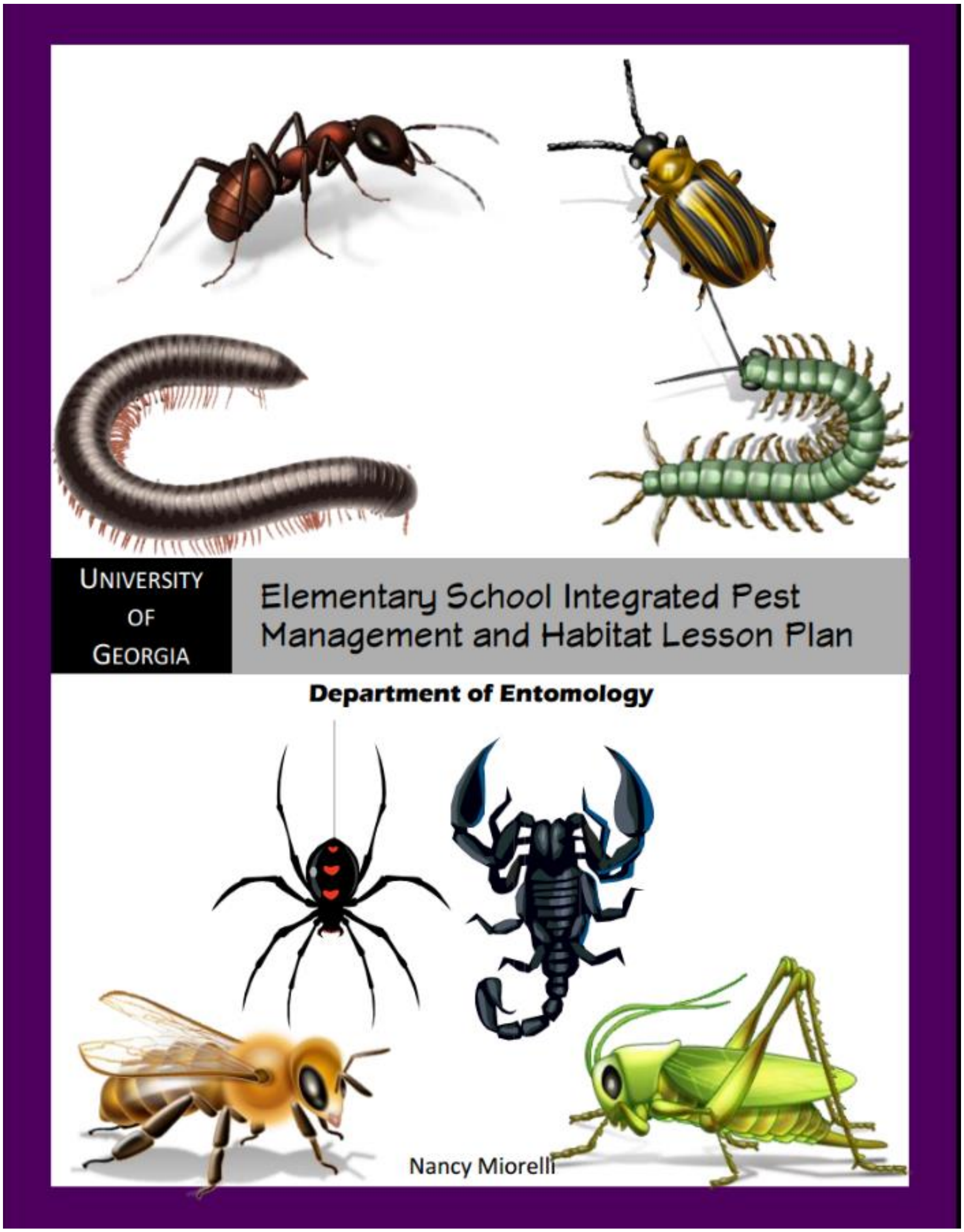
**If unfavorable weather conditions or other extenuating circumstance arise, the intended pesticide application may have to be delayed or postponed to later date(s). If the application is not be made within fourteen (14) days of the original planed date, a new notice will be issued.*

Areas of the grounds or buildings where pesticides will be applied will be clearly marked and all staff, students, parents, and guardians are expected to abide by all signage. In addition, infants (children less than two years old) and women who are pregnant should avoid any unnecessary pesticide exposure.

The following information regarding the potential adverse effects was taken from the material safety data sheet (MSDS) of the pesticide to be applied.

Should you with to receive additional information regarding this notice you can contact [*<u>Contact Person*</u>] at the following number (XXX)-XXX-XXXX.

APPENDIX C – ELEMENTARY SCHOOL IPM LESSON PLAN



Elementary School Lesson Plan

Integrated Pest Management and Habitat

Standards

Georgia Standards			Next Generation Science Standards
3rd Grade	4th Grade	5th Grade	Grades 3-5
Life Science: *S3L1, *S3L2	Life Science: *S3L1	Life Science: *S5L1	Biological Evolution Unity and Diversity: * 2-LS4-1, *3-LS4-3, *3-LS4-4
Habits of Mind *S3CS1 *S3CS4 *S3CS5	Habits of the Mind *S4CS1 *S4CS4 *S4CS5	Habits of the Mind *S5CS1 *S5CS4 *S5CS5	
The Nature of Science *S3CS7 *S3CS8	The Nature of Science * S4CS7 *S4CS8	The Nature of Science * S5CS7 *S5CS8	

List of Materials Needed:

In class Activities

- Arthropod Cutouts
- Sticky Traps

List of Suggested Materials

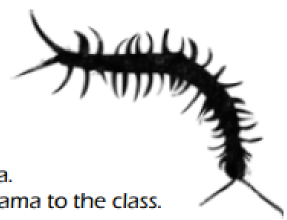
Student Diorama

- Shoebox
- Clay
- Plastic Insects
- Pipe Cleaners
- Paint/brushes
- Fake foliage
- Foam board
- Craft foam
- Glue
- Fabric/stuffing

Overview:

- What is an insect? What groups do other "buggy" animals fall into?
- Who are our friendly arthropods?
- Where do arthropods live? What is their habitat?
- How can we change our habitat to entice friendly arthropods and discourage pest arthropods?
- Diorama a bug and its habitat.

Objectives:



- Students learn to identify common arthropods.
- Students learn where arthropods live.
- Students learn how to reduce pest habitat
- Students learn about beneficial arthropods
- Students learn how to apply knowledge to create an insect diorama.
- Students gain presentation skills by presenting their arthropod diorama to the class.

Game Plan:

The parts can be done all at once, or broken up over several days.

- Part 1 – What is an Insect?
- Part 2 – Who's a friend and who's a foe?
- Part 3 – Where do these arthropods live?
- Part 4 – Create a diorama of a bug and is associated habitat.
- Part 5 – Altering our Space

Part 1 – What is an Insect?

Objectives:

- Students determine what insects, arachnids, and myriapods are.
- Students learn about taxonomic groupings.

Materials Needed:

- Arthropod cutouts. Available at the end of the document. (Extras available at http://www.scibugs.com/#!lesson-plans/c1g8k)

Plan:

Setup:

1. The instructor assembles the students into groups. The size of the group should be between two and four students.
   - Each group of students receives a pile of cutout arthropods.

Group Work:

2. The students, in their groups, organize the different arthropod together into three groups based on the characters they see fit.

Class Discussion:

3. After the students are given some time, the instructor brings the class back together for a class discussion.
   - **Taxonomy** (Grouping Organisms)**:**
     - The instructor should ask how different student groups organized their arthropods and what features the students used to generate those groups.
     - The instructor should lead the group to discuss how the different animals are grouped taxonomically using the definitions in the **vocabulary box**.
   - **Perception:**
     - Do students like these animals? Are their friends or families afraid of them? Were there bad experiences?

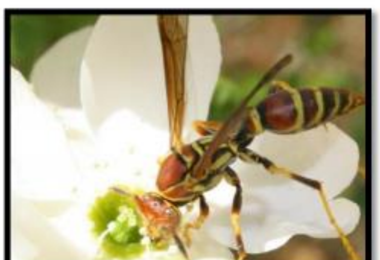
Vocabulary:

Taxonomy: is the science of classifying, grouping, and naming biological organisms.

Insect: A class of animals that includes arthropods with six legs and antennae.

Arachnid: A class of animals that includes arthropods with 8 legs and no antennae.

Myriapod: A subphylum of animals that have long bodies, many legs, and antennae.



This **wasp** is an **insect**. It has six legs and a pair of antennae.

This **spider** is an **arachnid**. It has eight legs and no antennae.

This **millipede** is a **myriapod**. It has many legs and a pair of antennae.

Arthropod Relatedness

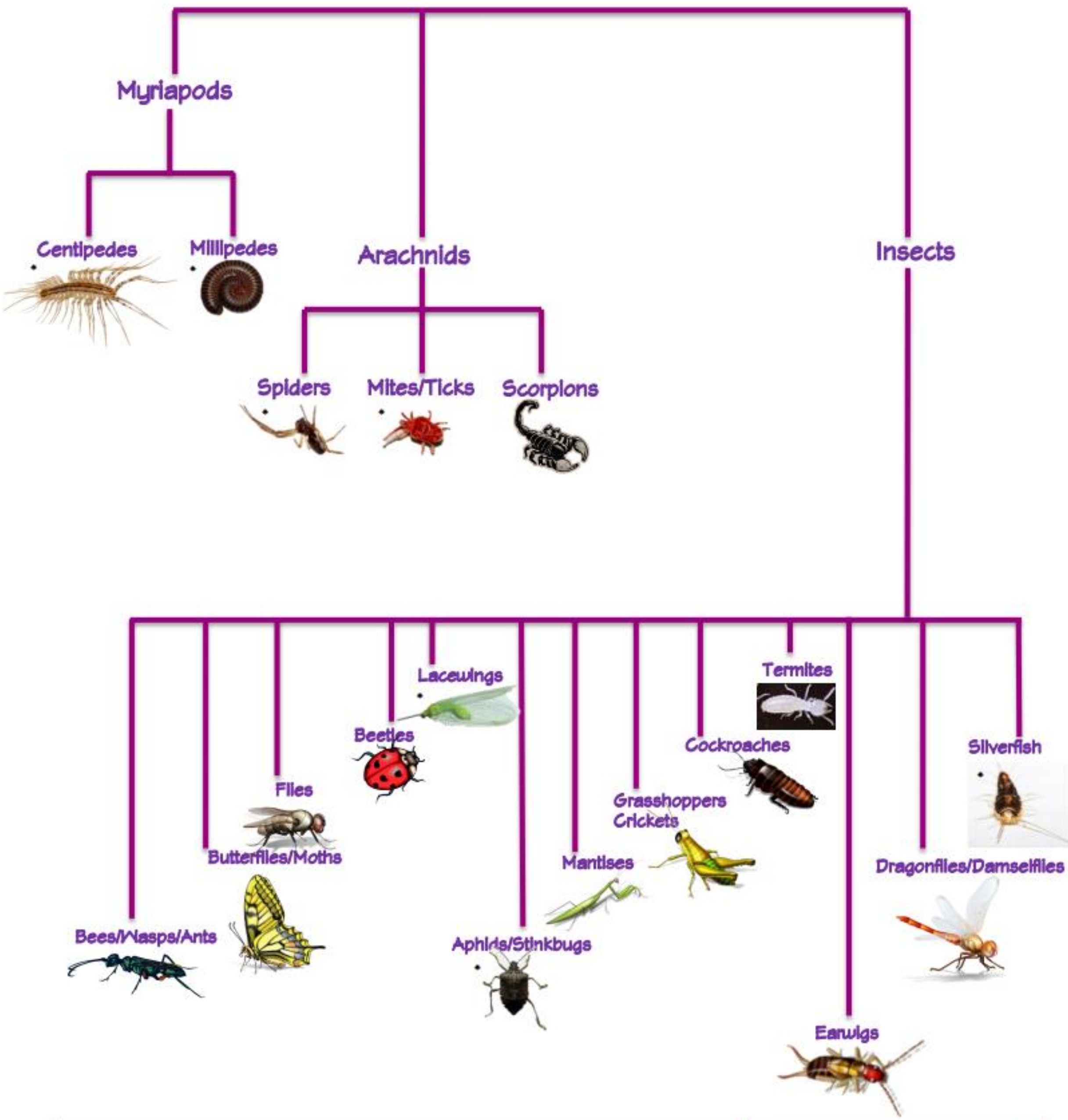


*Photo Credit: Bruce Marlin, Jud McCranie, Nancy Miorelli, Olei, Nancy Miorelli, Lildobe, Nancy Miorelli

Part 2 – Friend or Foe?

Objectives:

- Students can identify basic arthropod groups including insects, spiders, scorpions, centipedes, and millipedes.
- Students learn which arthropods are beneficial and which arthropods are pests.
- Students learn about specific pests; cockroaches, termites, ants, flies, and silverfish.

Materials:

- Insect cutouts of at least the following organisms: (available at the end of the document)
  (extras available at http://www.scibugs.com/#!lesson-plans/c1g8k)
  - butterfly
  - **bee
  - termite
  - aphid
  - **spider
  - cockroach
  - dragonfly
  - mosquito
  - **centipede
  - house fly
  - lacewing
  - mantis
  - **ant
  - silverfish
  - millipede
  - **wasp
  - **scorpion
  - ladybug

Plan:

Setup:

1. The instructor picks several arthropods of different groupings. These can be the same as in the previous activity.
2. The instructor assembles the students into groups of 2-4 students.
   - Each group receives a pile of the arthropods.

Group Work

3. The instructor asks the groups to place their arthropods into two piles, "Friend" or "Foe"

Class Discussion:

4. The instructor leads a discussion about why the students grouped their insects the way they did.
   - What arthropods did the students think were foes? Why?
     What arthropods did students think were friends? Why?

The Foes:

Aphids can cause significant damage to plants.

- Most insects are not pests, but here are a few to watch out for.
  1. Cockroaches – indoor pest
  2. Termites – structural pest
  3. **Ants – indoor pests (some carpenter ants can be structural)
  4. Aphids – garden/crop pests
  5. Mosquito – outdoor pest/transmit disease
  6. Silverfish – usually not a problem, but high populations can cause book damage
  7. House flies - spread diseases

The Beneficials:

- Many arthropods are very important to have around.
  1. **Bees/**wasps/butterflies pollinate
  2. **Wasps attack plant pests such as aphids
  3. Ladybeetles eat many plant pests such as aphids.
  4. **Spiders eat many pests both indoors and outdoors.
  5. **Scorpions eat many outdoor pests.
  6. Lacewings eat many outdoor pests.
  7. **Centipedes eat many pests including cockroaches
  8. Millipedes are harmless and are mainly decomposers.
  9. Dragonflies are predacious and eat mosquitoes
  10. Mantises eat many garden pests.

Those marked with an ** are beneficial, but can be dangerous if handled.

Instructors should, during this exercise, specifically mention the arthropods that can be harmful to the students.

A damselfly is related to dragonflies. It also eats mosquitoes and small gnats.

- Do the foes have any benefits? What might their purpose be in the ecosystem?
  - Ants/termites/silverfish break down dead trees and recycle nutrients back into the ground
  - Flies are important decomposers to decompose non-vegetative biological matter.

Part 3 – Where Do They Live?

Objectives:

- o Students learn about the arthropods and their habitat.
- o Students learn to hypothesize and justify their ideas.
- o Students record observations.

Materials Needed:

- o Sticky traps (provided)

Plan:

Setup:

1. The instructor should define habitat, or have students determine the definition
2. The instructor explains the purpose of a sticky trap.
    - A sticky trap is a sticky surface placed where pests normally navigate. The pests become stuck to the trap.

Class Discussion:

3. The instructor should lead a class discussion as to where to place sticky traps in the classroom.
    - Instructors should ask why the students want to place the traps where they do. Do the students think their spots are high traffic areas? If so, why?
4. The instructor should lead a class discussion as to where to place the sticky traps outside.
    - Instructors should ask why the students want to place the traps where they do. Do the students think their spots are high traffic areas? If so, why?

   The instructor should ask the students what arthropods they think they'll find both inside and outside.

Student Activity:

5. Place the traps in the predetermined places in the classroom.
6. The instructor brings the students outside
    - Students should place their sticky traps down in the areas that were discussed.
    - The students should look for other arthropods while while distributing the sticky traps noting the locations they find the insects. (Ex. Asphalt, mulch/dirt, grassy areas, flowers etc…)
7. Students are to bring a notebook outside and record the arthropods they see and where they saw the arthropods.

Class Discussion:

8. The instructor asks the students what were observed and where the students observed them.
9. The instructor makes a table of the arthropods and habitats the students found.

Group Work:

10. Students are to form groups between 2-4 students.
11. Students discuss why they think these arthropods can live where they do. How does the arthropod's body shape help it live and survive where it does?

Class Discussion:

12. The instructor asks the students to share their ideas. A list is made of common body forms.

Vocabulary:

Habitat: an environment or area in which an organism lives.

A cockroach's natural habitat is under tree bark.

This spider has long legs to help it live in its web.

This lacewing has long antennae to help it sense things in the dark.

Part 4 – Create a Diorama of an Arthropod and its Habitat

Objectives:

- Students learn about a particular arthropod and habitat.
- Students learn to physically show their ideas.
- Students learn research skills.
- Students learn presentation skills.

This gulf fritillary lives in sunny grasslands and is often found feeding on flowers.

Materials Needed:

- Shoe Box or a Shadow Box

Possible Materials:

- Clay
- Plastic Insects
- Pipe Cleaners
- Paint/brushes
- Colored paper
- Fake foliage
- Foam board
- Craft foam
- Glue
- Fabric/stuffing
- Tissue paper
- Felt
- Paper mâché
- Cellophane

Note: This was designed to be an individually led student research project; however it can modified to be done in a class period.

For an idea on how to make a diorama, visit here (http://www.wikihow.com/Make-a-Diorama).

Plan:

Homework:

1. Students research an arthropod that can be found in Georgia. Students learn the arthropod's name (common, scientific, or both), the habitat they are usually found in.
2. Students create a diorama depicting their arthropod and the arthropod's habitat.
   - It would be good for students to include what the arthropod feeds on.
3. Students determine if their arthropod is a friend or foe.

Class Presentation:

4. Students bring their dioramas to class and present them to the other students
5. Presentations should include the arthropods name, what the habitat is, how their diorama reflects the animal's habitat, and if their arthropod is a friend or foe.

Part 5 – IPM and Altering Our Space

Objectives:

- Students learn that changing our space encourages or discourages arthropods.
- Students learn how to change habitat to reduce pest numbers
- Students learn how to change habitat to increase beneficials.

American cockroaches can be very prolific. Reducing their access to food, water, and shelter will help coax them back outside.

Plan:

Setup:

1. The instructor should break the students into groups of 2-4 students.
2. The instructor should check the aforementioned sticky traps.

Group Work:

3. The instructor should ask students to think about what an organism needs in its habitat to survive. What makes a habitat suitable for any organism?
4. Groups of students look at the sticky traps and discuss where they were placed. Where were the sticky traps with the most arthropods placed? Which sticky traps had the most diversity (different kinds) of arthropods?

Class Discussion:

5. The instructor has the class discuss what animals need in an environment to survive.
   - Access to resources (food/water)
   - How individuals find each other.
   - Access to shelter
6. The instructor asks the students about the sticky traps.
   - What were general trends/what did students notice?
   - Which traps had the most "foe" arthropods?
   - Were sticky traps placed in dark corners or by trashcans more populated than sticky traps in other areas?
   - Why do the students think this is?
7. What does the presence/absence of arthropods on the sticky trap tell students about the presence of arthropods?
8. How can we as a group reduce the amount of "foes" seen in the classroom?
   - Removing food and water
9. How can we promote habitat for beneficial arthropods?
   - Providing shelter/ food (flowers/grasses)
     (To build your own insect hotel: http://bit.ly/MQhjkE)
   - Reducing chemical sprays

This is a parasitoid wasp attacking an aphid. Oftentimes, pests natural predators are suppressed more effectively by chemical than the pest.

This is a honeybee pollinating a magnolia flower. Planting flowering species is a good way to attract pollinators.

Bug Hotel built by the RHS Flower Show. This bug hotel is specifically designed to attract solitary bees and wasps that not only help pollinate but also eat common pests!

Insect Cutout Descriptions:
Pests ("Foes"):

Larger Insect cutouts are in a separate document
(http://www.scibugs.com/#!lesson-plans/c1g8k)

← The **German Cockroach** (Insect: *Blattella germanica*) is a common pest found in homes, restaurants, and hotels. It has two dark lines down its thorax and is relatively small measuring about a half inch long. Like most cockroaches, it prefers dark, tight, spaces to live in.

(Photo Credit: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

The **American Cockroach** (*Periplaneta americana)* is large measuring 1.5-2 inches. Like most cockroaches, it prefers dark, tight, spaces to live in.

(Photo Credit: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org) ↓

Termites (Insect: Isoptera/Termoitoidea) can cause severe structural damage to wooden buildings. Termites have a caste system which include winged reproductives, soldiers, and workers. Depicted below are the soldier termites which have hardened jaws for protecting the colony, and the workers which forage for food and take care of the colony.

(Photo Credit: Scott Bauer, USDA Agricultural Research Service, Bugwood.org) ↓

← **Silverfish** (Insect: Thysanura) are usually found in moist areas. While they usually go unseen, large numbers can cause damage to books as they will eat the paper.

(Photo Credit: Gary Alpert, Harvard University, Bugwood.org)

↑ **Fire Ants (Insect: *Solenopsis*) have recently been introduced into the United States where they have quickly become invasive. Fire ants make large mounds in sunny areas and eat many small insects.

(Photo Credit: Pest and Diseases Image Library, Bugwood.org)

↑ **Carpenter Ants** usually prefer damp wood to secure their colonies but one species in particular, the black carpenter ant (Insect: **Camponotus pennsylvanicus**), is a common pest species and can cause structural damage to wooden buildings.

(Photo Credit: Nancy Miorelli)

↑ **Pavement Ants** (Insect: *Tetramorium caespitum*) are commonly referred to as "sugar ants". They are a very small ant and can be usually found in large groups on sidewalks. Oftentimes they can get into buildings to forage for food.

(Photo Credit: Joseph Berger, Bugwood.org)

↑ **Bottle Flies** (Insect: *Calliphoridae*) are medium sized shiny green or blue flies. They are often attracted to garbage and rotting material.

(Photo Credit: Joseph Berger, Bugwood.org)

← **House Flies** (Insect: *Musca domestica*) are common pests found in public areas. House flies are usually attracted to garbage, rotting material, and exposed food items.

(Photo Credit: Pest and Diseases Image Library, Bugwood.org)

↑ **Aphids** (Insect: Aphididae) are plant pests which suck the plant's sap through their beak like mouthparts. Aphids are usually found in high numbers and can cause severe damage to ornamental plants.

(**Photo Credit**: Nancy Miorelli)

↑ **Green Stink Bug** (Insect: *Acrosternum hilare*) are plant pests which suck the plant's tissue through their beak-like mouthparts. These bugs can release an unpleasant odor when they're disturbed.

(**Photo Credit**: Susan Ellis, Bugwood.org)

↑ **Grasshoppers** (Insect: Acrididae) can sometimes cause ornamental plant damage They have big jumping legs for quickly escaping predators and are strong fliers.

(**Photo Credit**: Russ Ottens, University of Georgia, Bugwood.org)

Commensals (Neither "friend" nor "foe")

↑ **Camel Crickets** (Insect: Raphidophoridae) often get into people's homes but do not cause damage or allergic reactions.

(**Photo Credit**: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org)

↑ **Earwigs** (Insect: Dermaptera) can often be found in homes but do not cause any damage or allergic reactions.

(**Photo Credit**: David Cappaert, Michigan State University, Bugwood.org)

Beneficials ("Friends")

↑ **The European Mantis** (Insect: *Mantis religiosa*) is found throughout the United States and eats many garden pests.

(**Photo Credit:** Alvesgaspar)

↑ **The Chinese Mantis** (Insect: *Mantis religiosa*) is found throughout the United States and eats many garden pests. It was imported around 1895 as a biological control agent.

(**Photo Credit:** James Wheeler)

17

↑ **Monarch Butterflies** (Insect: *Danaus plexippus*) are important pollinators. Monarchs make a long migration from Mexico to the northern United States every year! Monarchs can be attracted with many flowering plants.

(Photo Credit: Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org)

18

↑ **Huminbird Moths** (Insect: Sphingidae) are important pollinators. They're often mistaken for bees because of their fuzzy appearance and clear wings. Since they are moths, they cannot bite or sting you.

(Photo Credit: David Cappaert, Michigan State University, Bugwood.org)

19

↑ **Dragonflies** (Insect: Anisoptera) are often found around bodies of water and are voracious predators. They eat many nuisance insects including mosquitoes and small gnats. Dragonflies look similar to damselflies but are more robust.

(Photo Credit: David Cappaert, Michigan State University, Bugwood.org)

20

↑ **Damselflies** (Insect: Zygoptera) are often found around bodies of water and are voracious predators. They eat many nuisance insects including mosquitoes and small gnats. Damselflies look similar to dragonflies but more slender and hold their wings over their back at rest.

(Photo Credit: Nancy Miorelli)

↑ Honey Bees (Insect: *Apis mellifera*) are important pollinators. Many are shipped around the country to help farmers pollinate their crops. Honey bees can be attracted with many brightly colored flowers but are sensitive to chemical sprays.

(**Photo Credit:** Joseph Berger, Bugwood.org)

↑ Bumble Bees (Insect: *Bombus*) are important pollinators. Bumble bees are fuzzy all over to collect pollen to bring pollen back to their young.

(**Photo Credit**: David Cappaert, Michigan State University, Bugwood.org)

↑ Thread Waisted Wasps (Insect: *Sphecidae*) not only pollinate flowers, but often predate on pests such as flies and caterpillars.

(**Photo Credit**: David Cappaert, Michigan State University, Bugwood.org)

↑ Paper Wasps (Insect: *Polistes*) not only pollinate flowers, but often predate on pests such as flies and caterpillars.

(**Photo Credit**: Nancy Miorelli)

↑ **Ladybugs** (Insect: Coccinellidae) eat many crop and ornamental plant pests such as aphids and white flies.

(**Photo Credit**: Nancy Miorelli)

↑**Tumbling Flower Beetles** (Insect: Mordellidae) are excellent pollinators. They get their name because when they're startled they'll play dead and fall off the flower.

(**Photo Credit**: Johnny N. Dell, Bugwood.org)

↑**Lacewings** (Insect: Neuroptera) are nocturnal predators that feed on small pest insects. Many have been used for biological control. As larvae, lacewings also feed on small insects such as aphis.

(**Photo Credit**: Nancy Miorelli)

↑Spiders come in all shapes and spiders. This **Crab Spider (Arachnid: Thomisidae) is an ambush predators. They'll wait for prey to come by and jump on it. They're harmless to people but eat many pests found in the garden.

(**Photo Credit**: Nancy Miorelli)

29

** ↑ **Wolf Spiders** (Arachnid: Lycosidae) are medium to large spiders that do not use webs to capture prey. Instead, wolf spiders chase down their prey. Female wolf spiders (as pictured above) have a parental care where the female carries the egg sac with her. They eat many pest species. They can

(Photo Credit: Ian Fieggen)

30

** ↑ **Zipper Spiders** (Arachnid: *Argiope aurantia*) are large spiders that make webs with a distinct zigzag pattern. They are harmless to humans but eat many garden pests.

(Photo Credit: Nancy Miorelli)

31

** ↑ The **Southern Unstriped Scorpion** (Arachnid: *Vaejovis carolinianus*) is commonly found in Georgia. It's a small scorpion that often finds its way into homes but feasts on small pests found inside and outside the home.

(Photo Credit: Warren Savary [2005] discoverlife.org)

32

↑ **North American Millipedes** (Myriapod: *Narceus americanus*) are large millipedes which can be found throughout Georgia. They are slow moving and feed on decaying matter. They are important decomposers in the ecosystem. When threatened, the millipede will curl into a ball and will sometimes release a brown liquid which is not harmful.

(Photo Credit: Gary Alpert, Harvard University, Bugwood.org)

33

** **Centipedes** (Myriapod: Chilopoda) are fast predators that use their first pair of modified legs to inject venom into their prey. Centipedes eat many pests species but should not be handled as they can bite humans. →

(**Photo Credit**: John Hill)

34

** ← **House Centipedes** (Myriapod: *Scutigera coleoptrata*) are commonly found inside people's homes. They don't bite unless provoked and are beneficial to have in the house. They eat many household pests including cockroaches and silverfish.

(**Photo Credit**: Bruce Marlin)

Elementary School Lesson Plan

Integrated Pest Management and Habitat

Insect Cutouts

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UGA1324064


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5380267


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UGA5314018

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UGA1242045


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UGA1236169

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UGA5343022


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UGA2131057

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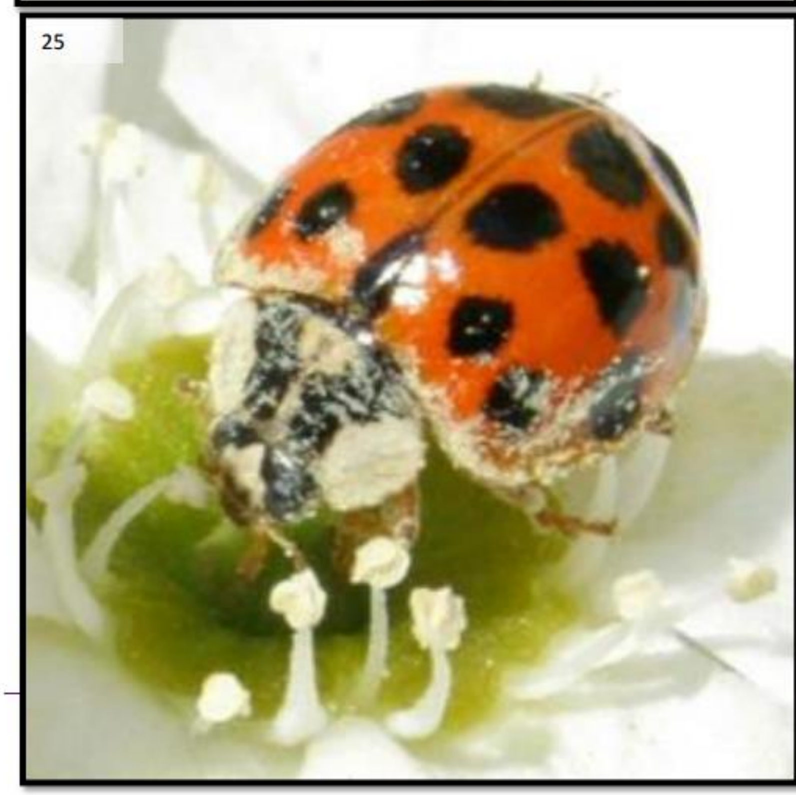

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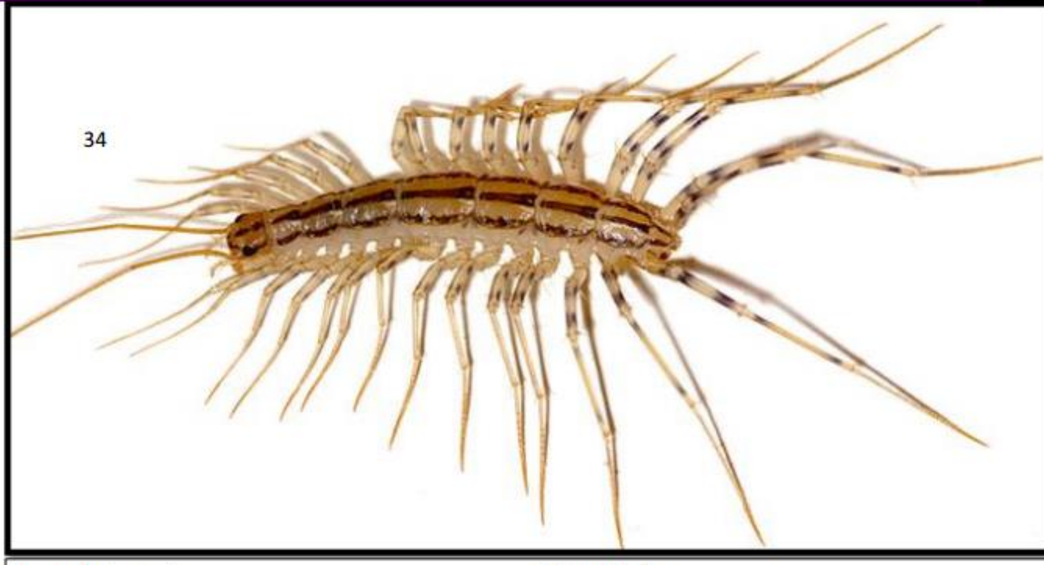
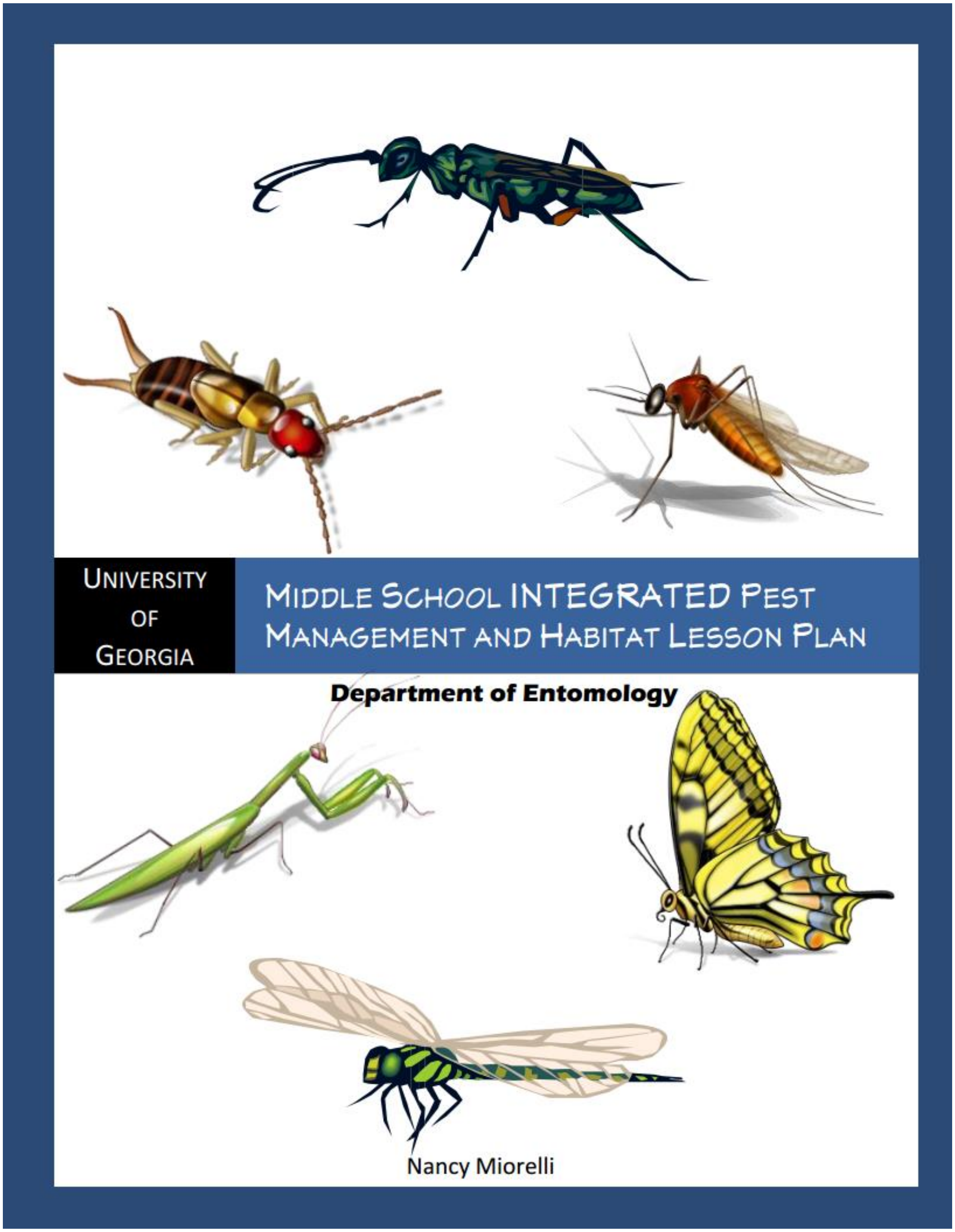


Insect/Arthropod:	Photo Credit:
1. German Cockroach	Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org
2. American Cockroach	Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org
3. Termites	Scott Bauer, USDA Agricultural Research Service, Bugwood.org
4. Silverfish	Gary Alpert, Harvard University, Bugwood.org
5. Fire Ant	Pest and Diseases Image Library, Bugwood.org
6. Carpenter Ant	Nancy Miorelli
7. Pavement Ant	Joseph Berger, Bugwood.org
8. Bottle Fly	Joseph Berger, Bugwood.org
9. House Fly	Pest and Diseases Image Library, Bugwood.org
10. Aphid	Nancy Miorelli
11. Green Stink Bug	Susan Ellis, Bugwood.org
12. Grasshopper	Russ Ottens, University of Georgia, Bugwood.org
13. Camel Cricket	Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org
14. Earwig	David Cappaert, Michigan State University, Bugwood.org
15. European Mantis	Alvesgaspar
16. Chinese Mantis	James Wheeler
17. Monarch Butterfly	Charles T. Bryson, USDA Agricultural Research Service, Bugwood.org
18. Hummingbird Moth	David Cappaert, Michigan State University, Bugwood.org
19. Dragonfly	David Cappaert, Michigan State University, Bugwood.org
20. Damselfly	Nancy Miorelli
21. Honey Bee	Joseph Berger, Bugwood.org
22. Bumble Bee	David Cappaert, Michigan State University, Bugwood.org
23. Thread Waisted Wasp	David Cappaert, Michigan State University, Bugwood.org
24. Paper Wasp	Nancy Miorelli
25. Ladybug	Nancy Miorelli
26. Tumbling Flower Beetle	Johnny N. Dell, Bugwood.org
27. Lacewing	Nancy Miorelli
28. Crab Spider	Nancy Miorelli
29. Wolf Spider	Ian Fieggen
30. Zipper Spider	Nancy Miorelli
31. Southern Unstriped Scorpion	Warren Savary [2005] discoverlife.org
32. North American Millipede	Gary Alpert, Harvard University, Bugwood.org
33. Centipede	John Hill
34. House Centipede	Bruce Marlin

APPENDIX D – MIDDLE SCHOOL IPM LESSON PLAN



Middle School Lesson Plan

Integrated Pest Management and Habitat

Georgia Standards		Next Generation Science Standards	Common Core
7th Grade	8th Grade	6-8th Grade	6-8th Grade
Habits of Mind *S7CS1 *S7CS3 *S7CS4 *S7CS6 *S7CS7	Habits of Mind *87CS1 *S8CS3 *S8CS4 *S8CS6 *S8CS7	Earth and Human Activity: *MS-ESS3-3 *MS-ESS3-4	CCSS.ELA-LITERACY.RST.6-8.3 CCSS.ELA-LITERACY.RST.6-8.4 CCSS.ELA-LITERACY.RST.6-8.9
The Nature of Science *S7CS8 *S7CS9	The Nature of Science *S8CS8 *S8CS9	Ecosystems *MS-LS2-1 *MS-LS2-4 *MS-LS2-5	
Co-requisite: *S7L1 *S7I4	Life Science: * S3L1		

This lesson plan should be completed during the Spring or Fall when insects are most active

List of Materials Needed:

In class Activities

- Sticky Traps (Found at Home Depot or similar) http://thd.co/1x1z3fe
- Colored plastic bowls (red, orange, yellow)
- Soapy Water

List of Suggested Materials

Optional

- Glow in the dark paint (for making bowls with UV patterns)
- Sharpies (for labeling)
- Insect Cutouts (for review)
- Ethyl alcohol (to store sample)

Overview:

- What kinds of habitats do insects and other arthropods live in?
- What insect and arthropod biodiversity is at the school?
- What do insects and arthropods need in their habitat?
- How does manipulation of habitat affect diversity, abundance, populations, and composition?
- What is the scientific method?
- What are proper scientific sampling techniques?

Objectives:

- Students learn to identify arthropods and insects.
- Students see, observe, and understand what can affect biodiversity.
- Students learn about arthropod natural history.
- Students determine how humans modify environments.
- Students learn how habitats can be modified for our benefit.
- Students associate habitat modification with pest control.
- Students learn scientific sampling methods and the importance of repeatability.
- Students learn to communicate scientific procedures, results, and concepts.

Game Plan:

The parts can be done all at once, or broken up over several days.

- Optional Overview – Arthropods Friend or Foe
- Part 1 – Determining Insects
- Part 2 – Designing an Experiment
- Part 3 – Conducing the Experiment
- Part 4 – Identifying Arthropods and Data Collection
- Part 5 – The Write Up
- Part 6 – Student Presentations
- Part 7 – Altering Habitat and IPM

For an electronic copy of this document, please visit:
http://www.scibugs.com/#!lesson-plans/c1g8k

Optional Overview – What is an Insect?

Objectives:

- Students determine what insects, arachnids, and myriapods are.
- Students learn about taxonomic groupings.

Materials Needed:

- Arthropod cutouts. Please see the elementary school lesson plan (Extras available at http://www.scibugs.com/#!lesson-plans/c1g8k)

Plan:

Setup:

1. The instructor assembles the students into groups. The size of the group should be between two and four students.
    - Each group of students receives a pile of cutout arthropods.

Group Work:

2. The students, in their group, organize the different arthropod together into three groups based on the characters they see fit.

Class Discussion:

3. After the students are given some time, the instructor brings the class back together for a class discussion.
    - **Taxonomy** (Grouping Organisms)**:**
        - The instructor should ask how different student groups organized their arthropods and what features the students used to generate those groups.
        - The instructor should lead the group to discuss how the different animals are grouped taxonomically using the definitions in the **vocabulary box**.
    - **Perception:**
        - Do students like these animals? Are their friends or families afraid of them? Were there bad experiences?

Vocabulary:

Taxonomy: is the science of classifying, grouping, and naming biological organisms.

Insect: A class of animals that includes arthropods with six legs and antennae.

Arachnid: A class of animals that includes arthropods with 8 legs and no antennae.

Myriapod: A subphylum of animals that have long bodies, many legs, and antennae.

This **wasp** is an **insect**. It has six legs and a pair of antennae.

This **spider** is an **arachnid**. It has eight legs and no antennae.

This **millipede** is a **myriapod**. It has many legs and a pair of antennae.

Arthropod Relatedness

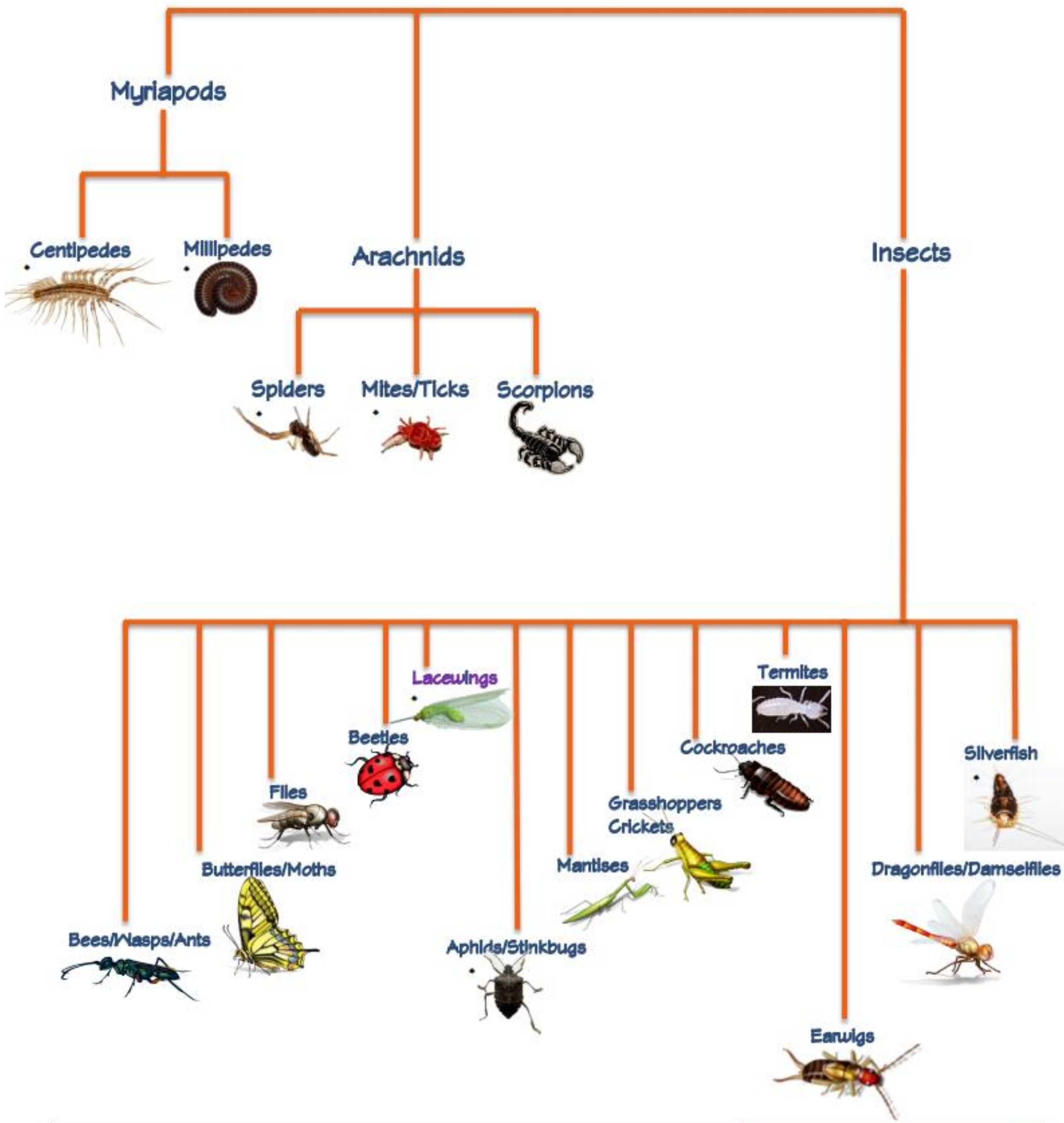


*Photo Credit: Bruce Marlin, Jud McCranie, Nancy Miorelli, Olei, Nancy Miorelli, Lildobe, Nancy Miorelli

Part 1 – Determining Habitats for Arthropods

Objectives:

- Students determine what habitat is and what it needs to contain to harbor organisms.
- Students determine life needs for insects.
- Students develop hypotheses to test in an experiment

Plan:

1. **Teacher Led Class Discussion:**
   The instructor leads a class discussion covering the following topics
   - What are things that all organisms need to survive?
   - Ask students to name insects or arthropods they know of. Where do the students think these animals live?

2. **Group Work**
   The instructor divides the students in groups of 2-4 students. These students will work together for the remainder of the project.
   - Students are told they will conduct a project determining arthropod diversity and composition in different habitats.
   - Each group of students should determine where they expect to find which kinds of arthropods. Students should be able to explain their reasoning. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
     - Students should consider available food and water sources in addition to shelter.

3. **Class Discussion:**
   The instructor asks each of the student groups their hypotheses and reasoning behind their hypothesis.

Vocabulary:

Habitat: an environment or area in which an organism lives.

A cockroach's natural habitat is under tree bark.

Photo Credit: Nancy Miorelli

Grassy, weed fields support a wide range of arthropod diversity including spiders, grasshoppers, and pollinators.

Photo Credit: Public Domain

Lakes, ponds, and small bodies of water can host a multitude of arthropods including spiders, dragonflies, water skimmers, beetles, and flies. Many immature insects develop in water both standing and running.

Photo Credit: Nancy Miorelli

s

Part 2 – Designing an Experiment

> A **Hypothesis** is a testable idea that objective and empirical evidence collection could support or reject the proposed idea.

Objectives:

- Students assess the feasibility of their hypothesis
- Students determine how to test their hypothesis
- Students design an experiment

Materials:

- Groups will be given pan traps and sticky traps, so the instructor should mention them. Good pan trap colors include red, orange, and yellow.
- Many insects can see UV, teachers can provide glow in the dark or black light paint for students to utilize.

Notes:

1. Teachers may either encourage
   a) Groups to design their own experiment for discussion about experimental design and method while allowing creative freedom
      i. Ex. Some groups could test different location or use different colored pan traps
   b) The class to design one experiment and group tests a different facet.
      i. Ex. The class wants to test different locations and each group will take a location to put their traps
2. There are many variables that can be assessed in this lesson plan. The instructor should decide what is most logical for the students to focus on given the available locations for sampling and what the instructor sees fit for the curriculum.
3. Generally, orange and yellow pan traps are effective for collecting pollinators (bees, wasps, beetles, butterflies) around sunny floral areas. Generally sticky traps are effective in dark, moist, and protected areas and usually collect pest species (silverfish, cockroaches)

Instructions for Trapping:

1. Pan traps are specifically for outdoors near flowers
2. Pan traps are typically used for collecting pollinators because the pollinators are attracted to the colors
3. Most insects cannot see red light, but can see from orange to ultra violet
4. Sticky traps are usually used indoors to catch pests. If used outside, make sure they are weighed down.
5. Sticky traps collect information about what is present by random chance and not by attraction.

Plan:

1. The instructor should determine which setup he or she wants the students to complete.
2. **If the instructor wants each group to determine their own project**
   a. Break the students into groups of 2-4 students.
   b. Students should discuss in their groups
      i. What color pan traps they want to use.
         1. Students should hypothesize about what they'll find and why
      ii. Where the pan traps should be used (at least two locations)
         1. Consider open areas, flowers, turf, shady areas, sunny areas etc…
         2. Students should hypothesize about what they'll find in each location and why
      iii. Where the sticky traps should be placed
         1. Students should pick at least two locations put the sticky traps. For the purposes of this experiment, the sticky traps should be placed indoors. However, extra sticky traps can be handed out if students are interested in placing the sticky traps elsewhere.

Part 2 – Designing an Experiment (Cont)

2. Students should hypothesize in which locations they expect to find more insects and *why*.
    a. More can be in terms of diversity or numbers of individuals. However the students should be clear with their predictions.

iv. Students should hypothesize which kinds of traps they expect to collect what kind of insects. Students are encouraged to base these hypothesizes on personal experience and research.

c. The instructor should bring the students back together so each group can propose their ideas and hypothesis. The instructor and other groups should make comments about good aspects of their idea and possible improvements.

3. If the instructor wants the class to determine a project together, the instructor should start a class discussion
    a. **Class Discussion:**
        i. The instructor can either propose several options to test, or have the students discuss possibilities together.
        ii. Students should agree on a project that the class will do together. There should be multiple aspects to test.
            1. Several locations to put the pan traps and sticky traps
                a. Pan traps placement should include different outdoor areas including near flowers, grass, turf, sunny and shady areas
                b. At least some of the sticky traps must be placed inside. Students can decide where to put them.
            2. What color pan traps to use
            3. Student should hypothesize what they'll find in the different colored traps in the different locations
        iii. Students should then divide the work among the groups
            1. Ex. Each group can test different locations, or each group can test a different color pan trap and a different sticky trap location
    b. **Group Work:**
        i. Each of the groups should discuss together about the methods of their portion of sampling
        ii. Each group should make hypothesis about what they think they will find, why, and how their results might compare to other groups.
        iii. The instructor should walk around and help the students develop their methods.

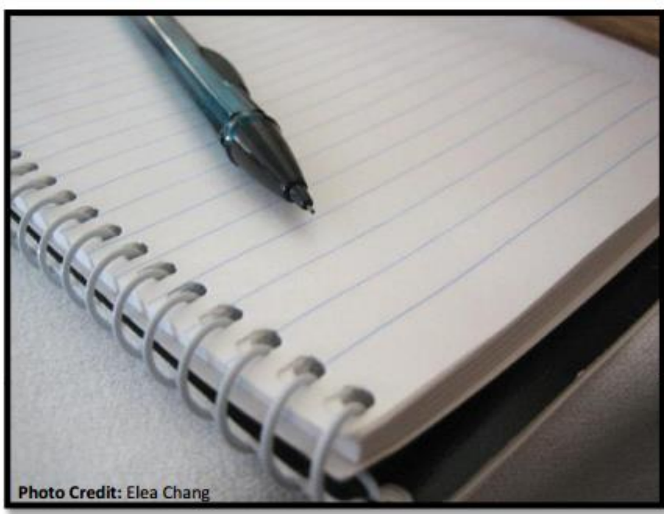


Photo Credit: Elea Chang

Part 3 – Conducting the Experiment

Objectives:

- Students conduct an experiment
- Students record their methods.
- Students learn the importance of organization and labeling.

Materials:

- Different colored pan traps (plastic bowls). Enough for six pan traps per group
- Soapy water
- Sticky traps. Enough for four sticky traps per group
- Sharpies for labeling

Instructions for Trapping:

1. **Pan Traps**
    a. Check the weather of the week that you are planning on conducting the experiment. Pan traps can be left outside overnight, but heavy rainfall can make the traps floor and strong winds can blow them over.
    b. Fill the colored bowls half way with some soapy water. Soapy water breaks the water's surface tension so the insects become captured.
    c. The pan traps work best on warm sunny days
2. **Sticky Traps:**
    a. Sticky traps can be laid inside or outside, but are usually used to capture indoor pests.
    b. Keep sticky traps in areas that are untraveled and where they cannot be tampered with. They can either be hung on the wall or placed on the floor.

The Plan:

1. Students should put their traps in the areas agreed upon in their experimental setup.
2. Students should take notes about their experimental setup
    a. Label all traps with
        i. Their name
        ii. Date/time
        iii. Location
    b. Students should take notes about
        i. The weather (sunny, cloudy, hot, cold...)
        ii. Observational notes about the location (examples below)
            1. Types or how many flowers/other vegetation
            2. Cleanliness of the area
            3. Types or how many insects
            4. How well travelled the area is
3. If possible, encourage students to take pictures of their set up to include in their presentation.

A typical pan trap setup. Visit here for further instructions http://blog.insectmuseum.org/?p=989


A typical sticky trap

Part 4 – Identifying Arthropods

Objectives:

- Students learn data collection
- Students learn to record results
- Students learn arthropod identification

Materials:

- Trap samples
- If identification takes longer than one class period, insects can be stored in ethyl alcohol. Or the contents of the pan trap can be strained, and the insects stored in a freezer.

Notes:

- Students may want to take pictures of their traps.
- For additional help identifying arthropods visit http://bit.ly/1ulkXzA, www.bugguide.net and www.discoverlife.org
    - It is unlikely that students will be able to identify most of their insects beyond the order classification (Ex. Beetles, butterflies, spiders... etc.)

Plan:

1. Students should break into their groups and identify their arthropods.
2. Students should make notes about
    a. Which arthropods they found
    b. How many arthropods they found
    c. From what locations
3. Students should discuss general trends they've discovered among their group
4. **Class Discussion** - the instructor can choose to have a class discussion. This would be important if the class decided to design an experiment as a whole.
    a. Groups should briefly state their experimental setup
    b. Groups should state any problems they've had or are having
    c. Groups should state if they they their hypothesis is, or will be supported by their preliminary data.
5. The instructor can request the data for the students and make a comprehensive chart.

This Jumping Spider is an arachnid an in the order "Araneae". Photo Credit: Nancy Miorelli

This carpenter bee is an insect and is in the order "Hymenoptera". Photo Credit: Nancy Miorelli

Part 5 – The Write Up

Objectives:

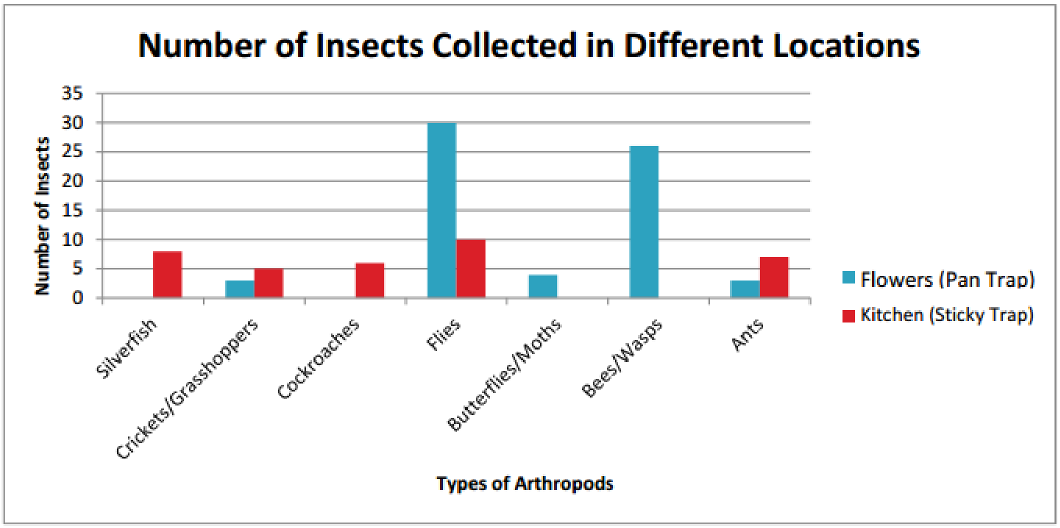
- Students practice writing a formal laboratory report
- Students learn to make conclusions from data

Notes:

- Students can write a lab report as a group or as individuals. It is up to the instructor's digression.
- This would be a homework assignment, but instructors can assign checkpoints or drafts.
- If the class designed an experiment as a whole, students should have access to all the data for the write-up.

What Goes in the Report:

1. Introduction
    a. Usually this includes background information. This can be included but is not necessary
    b. The student's hypothesis and reasoning for formulating the hypothesis.
2. Methods
    a. What did the students use?
    b. What did the students do?
    c. What was the reasoning behind their methods
3. Results
    a. How many insects were found in each of the traps in each of the locations?
    b. Charts can be included (All charts should include a title, legend, and labeled axes [if applicable])
4. Discussion
    a. Did their results match their hypothesis
        i. If so – why do they think that?
        ii. If not – why do they think that
    b. Do they think the experiment could have been conducted better?
        i. What problems did they have?
        ii. How do they think the problems could be resolved?
    c. Why do they think they got the results they did? What do the results suggest about the locations?



Sample chart showing example data. This may not be representative of what the class finds.

Part 6 – Student Presentations

Objectives:

- Students practice presenting information
- Students create presentation
    - This can be like a science fair presentation
    - This can be a PowerPoint
- Students evaluate information presented and ask questions
- Students practice answering questions from their peers
- Students learn time management in a presentation
- Students can use this practice if they plan on entering the science fair

Plan:

1. The presentation should be 10-15 minutes
2. The presentation should include the same parts and information as the report
    a. Introduction/Hypothesis
    b. Methods
    c. Results/Data
    d. Discussion of hypothesis and results
3. Students should take notes on the other students' presentation.
    a. What places did presenters sample?
    b. What color traps did they use?
    c. Generally what did the students find?
4. The instructor should take notes on the general findings of the class as a whole.

Optional Class Discussion:

1. If each group designed their own experiment
    a. How could each of the groups improve their experiment?
    b. What would happen if the groups had more traps, more colors, or more locations?
    c. Were some traps more effective at collecting arthropods? (Most arthropods/most diversity)
        i. Do the students think this was random chance?
        ii. Do the students think that there was a way to fix this?
2. If the class decided on an experiment as a whole
    a. How could the experiment be improved?
    b. Which traps had the most arthropods/diversity overall
        i. Did some traps have more than others? (even of the same type in the same location?)
        ii. Do the students think this was random chance?
        iii. Do the students think that the amount of traps placed gave them an understanding of the situation?

Part 7 – Altering our Habitat

Objectives:

- From the experiment, students determine that habitat affects
  - Populations
  - Abundance
  - Diversity
- Students learn about how habitat are important for abundance of organism and diversity of organisms,
- Students lean that habitats can be modified to attract beneficials or discourage pests
- Students use the data they collected to determine how they can help alter habitat to suppress the abundance of pests

Notes:

1. If the instructor has compiled the class data into charts, they should be displayed for the class
2. The students should understand that by keeping their area clean, it dissuades pests from staying because there is no food/shelter for them.
3. The students should understand that not all insects are pests and to use pesticides when necessary and other control measures can be effectively employed as well.

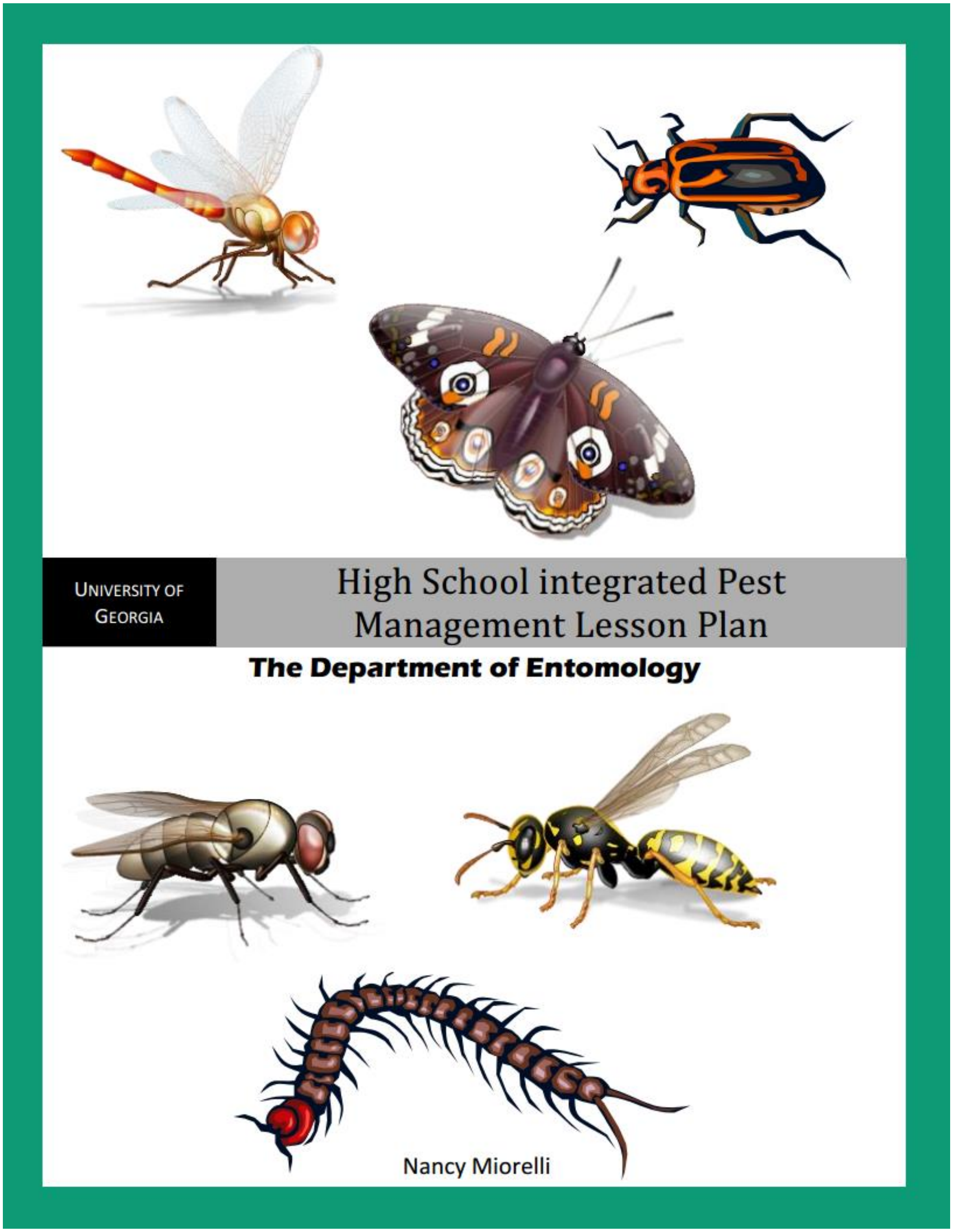
Plan:

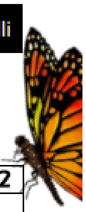
1. **Class Discussion:** The instructor should prompt the class to answer the following
   a. About their experiments
      i. Where were the most arthropods found?
      ii. Where was the most diversity?
   b. What habitats did pollinators seem to prefer?
   c. What habitats did pests seem to prefer
   d. Why do you think the arthropods preferred these habitats?
   e. How can we promote beneficial arthropods by modifying our environment?
   f. How can we suppress pest species by modifying our environment?
   g. If beneficial insects are found near our school building, what affect do you think spaying pesticides might have on them?
2. The class should make a short list of things that they can do to help promote a cleaner space that is undesirable for pests

Classrooms and other spaces that students use should be kept clean, but it's everyone's responsibility to keep the area tidy.

This hover fly (Diptera) is a pollinator and can be found in sunny areas with flowers. The use of pesticides could be detrimental to its survival so it's key to practice responsible pest management strategies.

APPENDIX E – HIGH SCHOOL IPM LESSON PLAN





Standards

Georgia Standards		9-12	Next Generation Science Standards 9-12
Biology Standards	**Ecology**	**Entomology**	
Habits of Mind • SCSh1 • SCSh3 • SCSh4 • SCSh6	Habits of Mind • SCSh1 • SCSh3 • SCSh4 • SCSh6	Habits of Mind • SCSh1 • SCSh3 • SCSh4 • SCSh6	Natural Selection and Evolution: • HS-LS4-5
The Nature of Science • SCSh7 •SCSh8	The Nature of Science • SCSh7 •SCSh8	The Nature of Science • SCSh7 •SCSh8	Interdependent Relationships in Ecosystems • HS-LS2-1 • HS-LS2-6 • HS-LS4-7 • HS-LS2-8 • HS-LS4-6
Co-Requisite Content • SB2 • SB3 • SB4 • SB5	Co-Requisite Content • SEC1 • SEC2 •SEC5	Co-Requisite Content • SEN1 • SEN2 • SEN3 • SEN4 • SEN5	

Common Core 9-10	**Common Core 11-12**
• CCSS.ELA-LITERACY.RST.9-10.2 • CCSS.ELA-LITERACY.RST.9-10.3 • CCSS.ELA-LITERACY.RST.9-10.4 • CCSS.ELA-LITERACY.RST.9-10.7 • CCSS.ELA-LITERACY.RST.9-10.9	CCSS.ELA-LITERACY.RST.11-12.2 CCSS.ELA-LITERACY.RST.11-12.3 CCSS.ELA-LITERACY.RST.11-12.4 CCSS.ELA-LITERACY.RST.11-12.5 CCSS.ELA-LITERACY.RST.11-12.7 CCSS.ELA-LITERACY.RST.11-12.8 CCSS.ELA-LITERACY.RST.11-12.9

Overview:

- What are some of the adaptations that arthropods have to survive in their respective environments?
- How do arthropod organ systems compare to mammalian organ systems?
- How do genetics and play a role in resistance?
- How can we modify our practices for effective pest management control?

Objectives:

- Students learn about arthropod anatomy and organ systems.
- Students learn how the arthropods are adapted to live in their respective environments.
- Students hone observation skills.
- Students learn to identify arthropod groups.
- Students learn about pesticide use throughout history and their associated effects.
- Students use their knowledge to analyze and provide solutions for case studies.

Game Plan:

The parts can be done all at once, or broken up over several days or weeks.

- Optional Overview – Arthropod General Introduction
- Part 1 – Arthropod Sketches
- Part 2 – The Inside of Arthropods
- Part 3 – Model an Arthropod
- Part 4 – Genetic Variability and Insecticide Resistance
- Part 5 – Arthropod Control through Varying Methods and Integrated Pest Management
- Part 6 – Case Studies

Optional Overview – Arthropod General Overview

The instructor should determine if this is necessary based on the level of the class

Objectives:

- Students review different types of arthropods
- Misconceptions about basic understanding and identification of groups are addressed

Plan:

Setup:

1. The instructor should create an activity either with insect cutouts (http://www.scibugs.com/#!lesson-plans/c1g8k) or a PowerPoint with pictures (www.bugguide.net).The goal should be for students to adequately place the arthropods into one of the following groups: Insects, Arachnids, or Myriapods.

Class Discussion:

2. After (or during depending on the preference of the instructor) the students should be led in a class discussion.
    - **Where are the arthropods are typically found?** Do the students even recognize some of the arthropods provided? What types of habitats do the students think the arthropods dwell in? What do they think the arthropods need in their different habitats?
    - If the instructor wants more in depth activity, the "Determining Habitats or Arthropods" as part of the Elementary School Lesson Plan can be used. (http://www.scibugs.com/#!lesson-plans/c1g8k)
2. **Perception:**
    - Do students like these animals? Are their friends or families afraid of them? Were there bad experiences?

Vocabulary:

Taxonomy: is the science of classifying, grouping, and naming biological organisms.

Insect: A class of animals that includes arthropods with six legs and antennae.

Arachnid: A class of animals that includes arthropods with 8 legs and no antennae.

Myriapod: A subphylum of animals that have long bodies, many legs, and antennae.

This **wasp** is an **insect**. It has six legs and a pair of antennae.

This **spider** is an **arachnid**. It has eight legs and no antennae.

This **millipede** is a **myriapod.** It has many legs and a pair of antennae.

Arthropod Relatedness

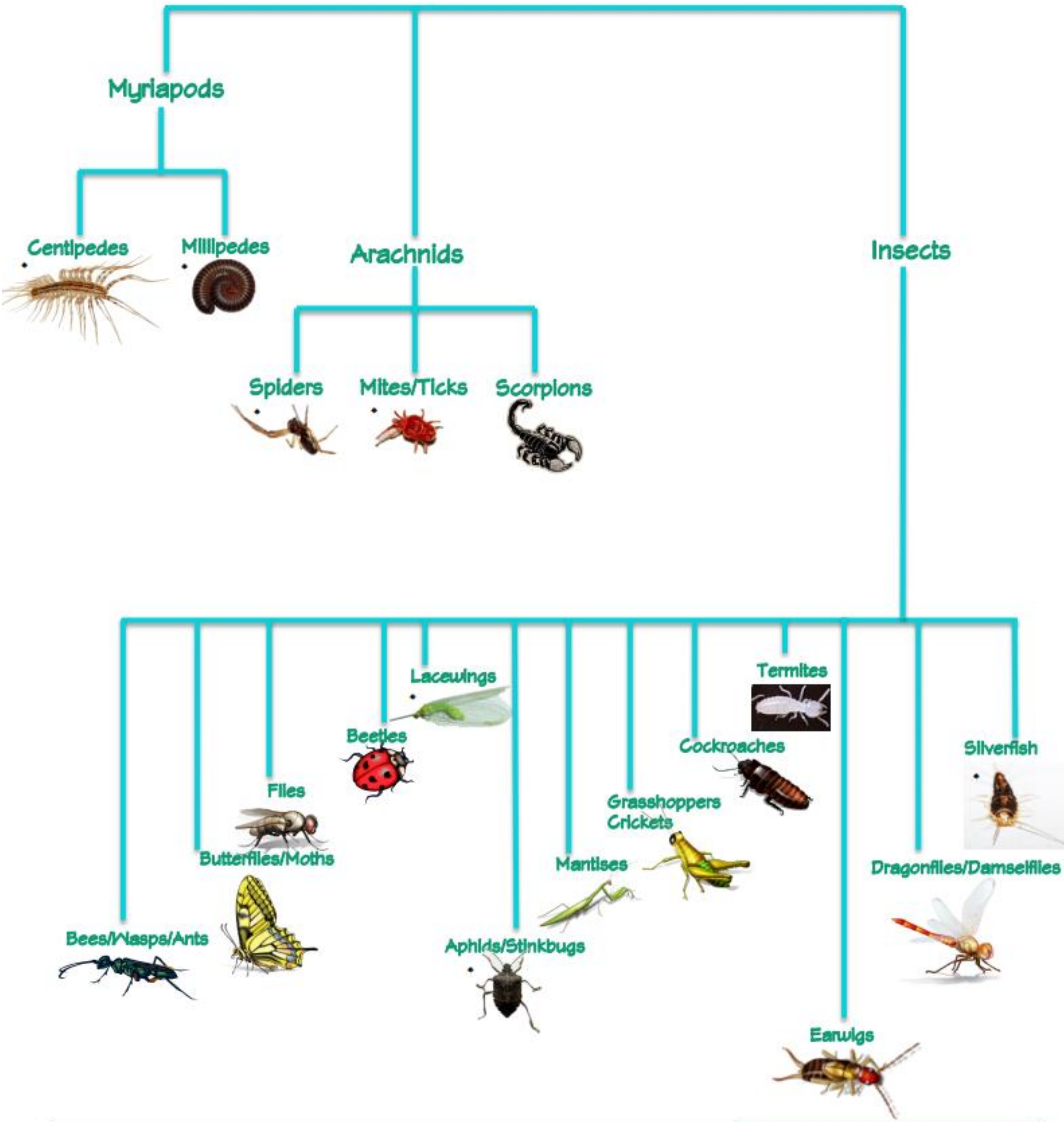


*Photo Credit: Bruce Marlin, Jud McCranie, Nancy Miorelli, Olei, Nancy Miorelli, Lildobe, Nancy Miorelli

Part 1– Arthropod Sketches

Objectives:

- Students observe arthropods in their natural environment
- Students note behavior and external adaptions that aid the animal in their environment.
- Students strengthen their observation and critical reasoning skills.

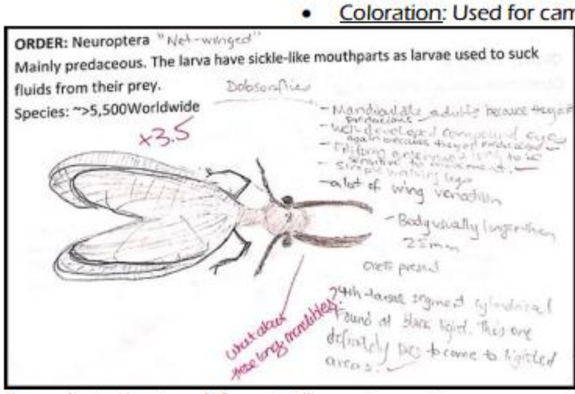
Plan:

Setup:

1. The instructor either decides or leads a group discussion where the students decide where they will observe their arthropods. This arthropod observation can either be done in class, or be assigned for homework.

Activity:

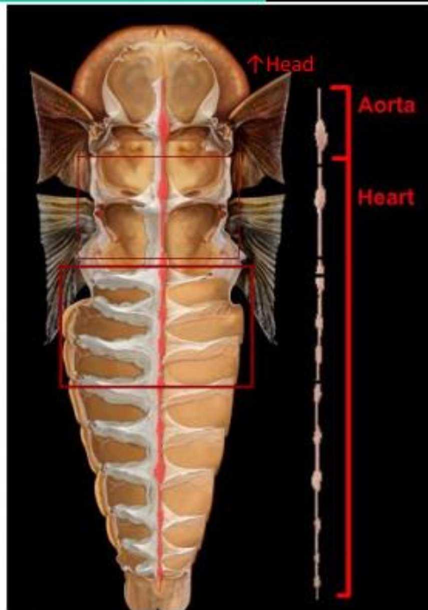
2. Students pick at least two environments in which to observe arthropods.
3. Students provide detailed annotated sketches of **three** arthropods of choice. These sketches should include
    a. The location (habitat type in which the arthropod was found). These locations can include inside buildings, ponds, fields, gardens, leaf litter, forests etc…
    b. An identification of their arthropod as an **Insect**, **Arachnid**, or **Myriapod**. Students should identify their arthropod to order. (www.bugguide.net) (http://keys.lucidcentral.org/key-server/player.jsp;jsessionid=BF6550703B3E21E68ED018FF90B22251?keyId=1).
    c. Students should label adaptations the arthropod has to aid it in its habitat including anatomical and behavioral.
    d. In addition to labeling the adaptions, students should reason as to why this helps the organism.
        - Students are encouraged to look at the shapes of certain features. For instance, many insects have wings but they are different shapes and colors. Students should reason as to why those features evolved in this way.
        - **Example Adaptations**:
            - Exoskeleton – water balance/protection
            - Antennae – sensing the environment. Generally long antennae gather more sensory information than short antennae
            - Eyes – Visual sensory information. Most insects can see orange to ultraviolet light. Large eyes with more lenses detect more information than little eyes.
            - Legs – Insect legs have been modified for many different purposes including jumping, catching prey, swimming, and digging.
            - Wings – Allow for dispersal. Dragonflies with narrow wings are built for speed whereas butterfly wings are used to signal potential mates.
            - Mouthparts: Arthropods eat a wide variety of material. Spiders have fangs which inject venom into the prey. Beetles tend to have strong mouthparts to chew through wood. Butterflies have proboscises to drink nectar.
            - Coloration: Used for camouflage, mimicry, or to warn of toxicity.



Example student work for a similar assignment

Praying Mantises are insects that have forelegs for capturing prey. They have four wings; the outer most are slightly hardened for protection. The praying mantis's large eyes indicate that it is a visual predator.

Part 2– The Inside of Arthropods



The circulatory system of the cockroach. Alary muscles are connected to the heart and the aorta. Hemolymph (the blood) bathes the internal organs and the heart is responsible for circulating the blood.

Objectives:

- Students learn about how the insides of arthropods work
- Students compare and contrast human organ systems to arthropod organ systems
- Students present scientific information to their peers.

Plan:

Setup:

1. This part of the lesson plan starts with the physiology of insects. If the instructor wishes to know more about the basic physiology of the insects, he or she may want to watch the following YouTube video.
   http://youtu.be/Dh5uAOAwKJw
   [www.youtube.com/scibugs Physiology]
2. The instructor should access "The Virtual Roach" (http://www.orkin.com/cockroaches/virtual-roach/)
3. Alternatively, the instructor can lead a dissection lab using lubbers for the dissection.
   a. To buy lubbers: http://www.hometrainingtools.com/grasshopper-lubber-large/p/PM-GRASHOP/#review-sec
   b. Lubber Anatomy and Dissection: http://www.hometrainingtools.com/grasshopper-dissection-guide/p/DE-GDGRASS/

Activity

4. The instructor should outline a class discussion including the following
   a. Do the students think insects have hearts, nerves, brains, lungs, and veins like we do? Why or why not?
   b. Have students heard of the notion that "Cockroaches can live for a week with their head cut off?" How do students think this could be possible? What do students think the cockroaches die from? (Answer, starvation).
5. The instructor either leads the lubber dissection or the virtual roach demonstration.
   a. The instructor should cover the following systems: **Digestive, Excretory, Circulatory, Respiratory, and Nervous.** Optional: (**Reproductive**)
   b. The important things to note are
      i. Insects have open respiratory and circulatory systems. Meaning blood and oxygen are not transported through the body like in people. The insects blood (**Hemolymph**) bathes the organs and the heart is responsible for moving blood around the body. Likewise, air enters small holes on the sides of the insect's body (**Spiracles**). Oxygen travels through several series of tubes and diffuses into the cells.
   c. After viewing the respective systems, the instructor should break the students into groups. Each group will get an organ system to research and give a 10 minute presentation including the following:
      i. What the organ system's main responsibility is
      ii. How the organ system works
      iii. A comparable organ system in mammal (Ex. The circulatory system in Insects vs. the circulatory system in humans)
      iv. A brief explanation as to how the organ systems are different in humans and arthropods.

Part 3– Arthropod Models

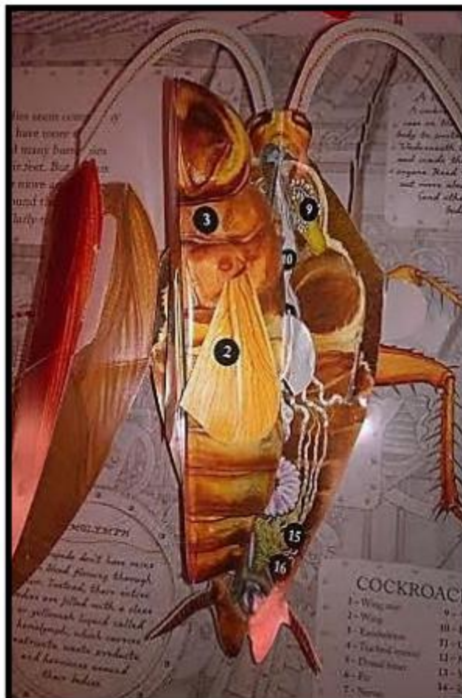
Objectives:

- Students build a model arthropod.
- Students present their model to their peers in a presentation.

Possible Sample Mediums

- Legos
- Minecraft (or similar)
- 3D Printing
- Puppets/Dolls
- Clay
- Paper

Students should not feel limited by the kinds of materials or medium that they wish to use when creating this model.



A paper model of a cockroach with labeled parts

Model by Jim Kay and Richard Ferguson
George McGavin. 2013. *Bugs*. Somerville Massachusetts: Candlewick

Homework Assignment

1. This model should be done for homework.
2. The students create a model insect based on one of the three arthropod drawings they did.
3. This model should represent that external anatomical features that were annotated in the sketch and the organ systems mentioned in class.
   a. The instructor may provide a list of internal structures that the students can include, but the students do not have to include all of them.

Activity:

4. The models should be put on display so all the students can see them
5. Each student should talk about their model to the class including
   a. The order of the arthropod and if it's an Insect, Arachnid, or Myriapod
   b. Where they found the arthropod and what it's behavior was at the time
   c. The anatomical adaptations they noted and how the student thinks these adaptations would be helpful for the arthropod.
   d. The internal anatomy they included
   e. What materials they used to construct their arthropod and some of the challenges that were posed making it.

Part 4– Genetic Variability and Insecticide Resistance

The Public Domain

Objectives:

- o Students understand that insects have a short generation time and produce a lot of offspring
- o This aspect of insect biology means that insect resistance can appear readily
- o Insect resistance and pesticide use is looked at throughout history

Plan:

Setup:

1. The instructor should be familiar with the history of DDT and associated environmental impacts that it had.

Activity:

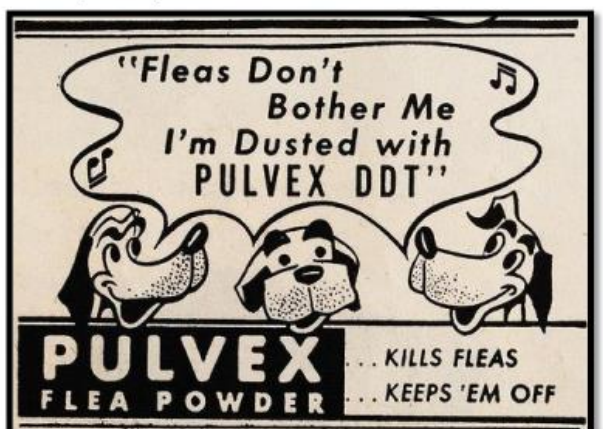
2. The instructor will present a brief history on the uses and environmental issues associated with DDT (dichlorodiphenyltrichloroethane).
    a. Synthesized in 1874 and its insecticidal properties were discovered in 1939. Paul Herman Müller was awarded a Nobel Prize in 1948 for this discovery.
    b. DDT was initially used in the military to control for mosquitos and typhus.
    c. It was subsequently used for agricultural use.
    d. Insect resistance.
    e. Rachel Carlson's book, *Silent Spring*, and its catalogue of environmental issues caused by DDT.
        i. Near extinction of raptors
        ii. Human health risks
    f. DDT's official ban in 1972.

3. The instructor should then start a class discussion including the following points
    a. How did we change the environment? How did populations change in response?
        i. How did these changes happen?
        ii. Why were insects able to cope with the environment faster than the apex predators?
            1. What adaptations do insects have to cope with the rapidly changing environment?
    b. What benefits did DDT have?
        i. It should be included that DDT eradicated malaria from the United States.
    c. What detrimental effects did DDT have?
    d. How could DDT have been used more responsibly?

410 The National Geographic Magazine

Flying and Biting Bugs on Jones Beach Die in a Cloud of DDT, New Insecticide

A truck-mounted fog generator squirts the poison, mixed with oil droplets, over a four-mile area of the New York City playground. Spread by Army and Navy planes and by hand sprays, DDT routed dangerous disease-bearing flies and mosquitoes on Pacific islands. Dusted on almost the entire population of Naples, it killed lice and halted a typhus epidemic. DDT has a drawback—it kills many beneficial and harmless insects, but does not kill all insect pests. Birds and fish which eat large numbers of DDT-poisoned insects may be casualties, too (page 408).



The Public Domain

Part 5– Arthropod Control in Varying Methods and Integrated Pest Management.

Objectives:

- Students learn about different methods of pest control and the history
- Students discuss how they can promote

Plan:

Setup:

1. The instructor should be familiar with how insects grow and develop (http://youtu.be/NoMBSm8Kkjl) [www.youtube.com/scibugs Growth and Development]
2. The instructor should be familiar with other methods of pest control (GMOs, Biocontrol, Targeted Insecticides)

Activity:

3. There were two take away messages from the use of DDT
   a. Regulated pesticide application
   b. A variety of methods need to be used to avoid pest resistance.

4. The instructor should have a short presentation that includes the following methods of pest control.
   a. **GMO**'s – Genetically Modified organisms come in all varieties from drought resistant wheat to corn that can produce a specialized, easily degradable insecticide called Bt.
   b. **BioControl** (Biological Control) – Many insects and arthropods have predators that either eat or parasitize them. These predators can be used to control pest populations. The first successful biological control effort was in Australia to control the Cottony Cushion Scale Insect.
   c. **Sanitation** – Many indoor pests can be dissuaded by just keeping the area clean and reducing habitat space for them. This includes throwing trash and food in the garbage cans, cleaning up spills, and reducing areas that could provide as shelter for the organisms.
   d. **Targeted Insecticides:** Many insecticides have come to market that degrade quickly in the environment, are targeted for specific insects and will not affect non target species. These can come in sprays, baits, and traps.

5. Integrated Pest Management
   a. IPM (Integrated Pest Management) does not condemn the use of pesticides. Instead it is a practice using all of the aforementioned techniques and using pesticides when there is a need for them.
   b. The instructor should lead a **Discussion** including the following topics
      i. What do the students think some of the biggest barriers to the IPM method is?
         1. Fear of pests
         2. People are uneducated about the options and control methods
            a. Not only that there are options, but people fear things like GMOs
      ii. How can we solve some of these problems?
      iii. How can we work together to promote IPM in our spaces?

Aphids can be an ornamental pest and an agricultural pest. The braconid wasp can be an effective biological control agent to reduce aphid numbers.

Part 6– Case Studies

Objectives:

- Students work though a case study using elements from this lesson plan.
- Students take previous knowledge and apply it to new situations

Plan:

Setup:

1. The instructor distributes the two case studies. The students can choose or the instructor can decide for the students.

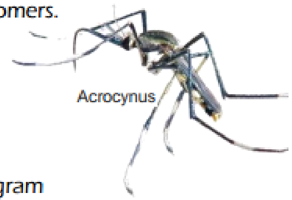
Cockroach Case Study

"Medio Italy" is a restaurant that opened last year. Despite producing wonderful Italian food and killer pizza, the management has come under scrutiny because of an alleged cockroach problem. You have been called in to help. You talk to the kitchen staff and they tell you that cockroaches scurry to their hiding spots when the staff enters the kitchen for the first time every morning. The staff tells you that they don't know of any current measures being used to treat the infestation. Looking around the kitchen for yourself, it does not look to be properly cleaned. The back door is usually propped ajar and a dumpster is only a few feet away with the lid opened. The owner of the restaurant asks you for help to save his restaurant.

Gary Alpert

Mosquito Case Study

"Windcrest Acers" is a farm that offers horseback riding lessons and boarding. They have an indoor and outdoor riding ring, four pastures for the horses, and three small ponds. The barn always had problems with flies, but this year they've had a particular problem with mosquitoes. You have been called to help investigate the situation. Upon your arrival you immediately notice the ponds are covered in a thick algae and investigation of the areas lead you to conclude that no fish or frogs are living in the ponds. Further investigation of the area several areas where stagnant water can build up particularly in some of the pastures where the large water buckets are only emptied and refilled every couple weeks. The grain room's door is usually kept shut but you find many flies in that room anyway. All mucked stalls remnants and waste is discarded in a compost pile at the edge of the property. The owner asks for your help for the safety of her animals and to keep her customers.



Acrocynus

Setup:

2. For each of the following cases the students must give:
   a. A brief background on their organism
      i. Basic adaptations it has to thrive in the given habitat
      ii. Basic growth and development of the insect including a life cycle diagram
      iii. Basic behaviors of the organism that apply to the given situation
      iv. Basic needs of the organism and how the current situation provides it to them
   b. A strategy for combating the current problem using various strategies.
      i. The instructor may want to encourage students to research particular pesticides or chemicals that are effective on these organisms and explain why those were decided upon.
   c. An educational system to help promote understanding of the pest's biology to both the owners and the staffs of these establishments.