APPROACHES TO CONSERVING BEE POLLINATORS

With

Three Case Studies in
Europe, Africa, and North America

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Bombus mixtus photo by Mace Vaughan

EXECUTIVE SUMMARY

Concerns about the worldwide decline of pollinators have gained the interest of many countries and resulted in the formation of specific initiatives related to pollinator conservation. Both managed and wild pollinators play important roles in ecosystem services, food security, and the economy. Bees are particularly important pollinators for many agricultural crops and their absence often results in lower yields and less marketable products.

Although the importance of pollinators is well validated, remarkably little is known about the life history, habitat requirements, and population dynamics of many species. There is also a lack of taxonomic resources available to identify pollinators to the species level. Professionals across the world have recognized the need to gather this information and incorporate it into the conservation of both wild and managed pollinators.

Initiatives and efforts to implement management of pollinators have many similar objectives and often stem from the goals of the International Pollinator Initiative (IPI). The Plan of Action for the IPI aims to promote coordinated efforts worldwide to monitor pollinator decline, address the lack of taxonomic information on pollinators, assess the economic value of pollination and the economic impacts of a decline in pollination services, and promote the conservation, restoration and sustainable use of pollinator diversity in agriculture and related ecosystems. The IPI provides an opportunity to integrate and further develop the science and practice of pollination, and bring pollinators to the forefront of international agricultural policy. It has also brought experts from around the world together and served as a framework for the formation of initiatives taking place in many countries. The European Pollinator Initiative, for example, is an effort that incorporates many of the same goals, as well as specific objectives for pollinators in Europe. The African Pollinator Initiative also addresses the IPI's Plan of Action, and has incorporated additional objectives that consider socioeconomic contexts and integration of indigenous knowledge into monitoring and management.

Lastly, the North American Pollinator Protection Campaign has pushed for political action and incorporation of pollinator conservation into federal and state land policies. The status of pollinators in North America has been on the agenda due to the dramatic declines of managed honey bees, placing pollinator conservation as a critical issue within political, social, and environmental discussions.

The efforts of these organizations illustrates the growing need for more information on pollinators in order to sustain one of the world's most important economic and environmental actors relative to their individual size.

LITERATURE REVIEW

Importance of Pollinators

Pollinating organisms play key roles in ecosystem processes. More than 20,000 pollinating bee species exist in the world, as well as numerous other insect and vertebrate pollinators (Eardley et al. 2006). These pollinators are vital to maintaining ecological integrity and diversity.

The dominating group of pollinators in a region may vary according to climate (Faegri and Van der Pijl 1971) and pollination syndromes, which are characterized by the method a flower uses to attract the pollinating agent. More than 90% of wild flowers depend on biotic pollinators for their reproduction (Potts 2000). Some plant-pollinator relationships are highly specialized, such as the complex relationship between Brazil nut trees (*Bertholletia excelsa*) and long-tongued orchid bees (*Euglossa spp*.) (Mari 2000). The nectar is found deep within the flower, requiring a long tongue to access it. While the bee reaches its long proboscis toward the nectar, pollen is dusted on the abdomen and thorax, and later transferred to the stigma of another flower resulting in seed formation.

Many plant species depend on pollinators to maintain genetic diversity through cross-pollination. In this method a pollinating agent transfers pollen grains between the flowers of different plants of the same species, which can reduce the effects of inbreeding depression (Ramsey and Vaughton 1996). Furthermore, some plant species are self-infertile and are completely dependent on cross-pollination either by abiotic (e.g. wind) or biotic transfer. Cross-pollination can enhance desirable characteristics of plants that are capable of self-fertilization. For example, Arabica coffee (*Coffea arabica)*, which can self-pollinate, yields increased fruit mass or seed sets when exposed to pollinating honey bees (Roubik 1997).

Pollinators are also a vital factor in agricultural systems throughout the world and are necessary contributors to improved livelihoods, increased income, and food security (Figure 1). One-third of the world's crops rely on pollination to produce seeds and fruits and the majority is pollinated by various bee species (Yang 2006). Among domestic crops in North America, almonds and alfalfa are completely dependent on insect pollination, and most others are enhanced by pollinator interactions (e.g. blueberries, broccoli, cucumbers, and most fruit trees). The estimated annual economic value of pollinators worldwide is between $40 billion and $100 billion (Pimental et al. 1997).

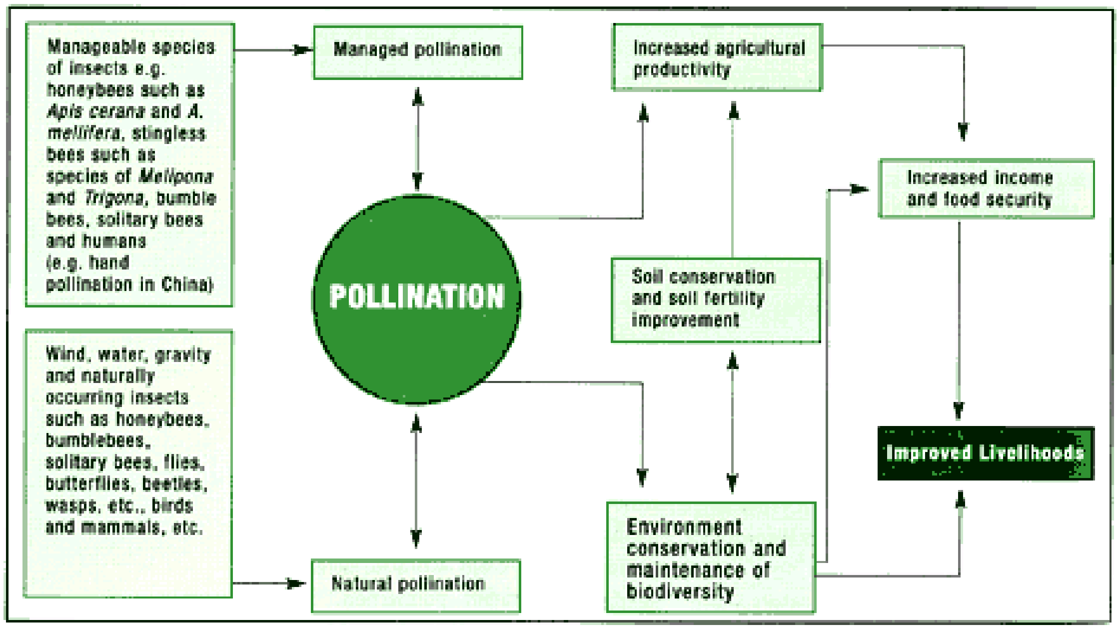

Figure 1: Flow chart illustrating the contribution of pollination to agricultural productivity and improving rural livelihood.
Source: FAO 2002

Crops also benefit from human-managed beehives. For the past few centuries many farmers across the United States and Europe have managed their pollination needs by using European honey bee colonies to pollinate their crops (Kremen et al. 2002). For example, almond orchards in California have a high demand for many pollinators during the mass blooming periods. The honey bees may be managed near the farm or transported by traveling beekeepers when the crop is in bloom. Sixty percent of the managed hives across the United States are required to pollinate approximately 750,000 acres of almond orchards (Blake 2008). Value added products from managed hives are also important agriculturally derived sources of money. Honey, beeswax, larvae, and royal jelly are all produced by honey bees, and to various extents are managed as commodities. Pollen is another product that can be harvested from a beehive, and is often used as a dietary supplement (Schmidt and Btichmann 1992).

Beekeeping is a practice found throughout the world, but many of the managed colonies are declining or disappearing. The number of commercially managed honey bee colonies in the United States have declined from 5.9 million in the 1940's to 2.7 million in 1995 (NAPPC 2008). Major declines of European honey bee colonies due to parasitism and Colony Collapse Disorder, for example, have created concerns about the reliability and future of these pollinators. The losses of colonies have in turn decreased the commodities that a beekeeper or community relies on for revenue and cultural practices. The Mayan society, for example, managed colonies of stingless bees for thousands of years, using the honey to produce mead (Buchmann 2005). This practice continues in Quintana Roo, Mexico, but both the cultural practice and the requisite pollinating species are in decline due to several factors (Science Daily 2005), including habitat loss, competition with African honey bees, and a loss of inherited knowledge from traditional beekeepers.

Status of Pollinators

As mentioned previously, declines of managed pollinators are occurring across the world. The most common species used for colony management is the European honey bee (*Apis mellifera)*, which has suffered major declines due to diseases, parasites, viruses, and, most recently, Colony Collapse Disorder (Stokstad 2006). The number of commercially managed honey bee colonies in the U.S. has declined from 5.9 million in the 1940's to 2.7 million in 1995 due to parasites and diseases (NAPPC 2008). These losses have occurred as demand for pollination services has soared, especially in relation to almonds, as well as various other fruit, nut and vegetable crops (Berenbaum 2007). Another threat to the management and sustainability of these colonies is hybridization with the African honey bee (*Apis mellifera scutellata*), an aggressive species that escaped from a study project in Brazil over 50 years ago (Sanford and

Hall 2005). Since its escape, African honey bees have migrated north and have been known to hybridize with some colonies of European honey bees. This has caused concerns to beekeepers in Southern Mexico and the Southeastern United States, because the hybridized offspring maintains the aggressive traits exhibited by the African species, making the colonies more difficult to manage.

Wild pollinators are also experiencing declines in many areas of the world. A study in United Kingdom and the Netherlands revealed that native pollinator populations and the plants they pollinate have been declining since 1980 (Stokstad 2006). Researchers have also found that wild bee diversity has fallen in almost 80% on studied sites over the past 25 years (Biesmeijer et al. 2006). Another study in South Africa examined the decline of a generalist pollinator in a community web, and found that five species of oil secreting plants decreased or disappeared with the absence of the associated pollinator (Pauw 2007). Some possible causes include habitat loss and alteration, climate change, and the use of certain insecticides. An example of impacts on bees related to chemicals is the effect of the pesticide fenitrothion, a DDT replacement more toxic to bees, used to treat insect pests on blueberry bushes in New Brunswick, Canada (Eardley et al. 2006). The fields that were treated with this pesticide had significantly lower blueberry yields than neighboring fields that were untreated, and since the ban of fenitrothion in the vicinity of blueberry fields, the yields as well as prevalence of wild bees, have increased (Kevan 1975; Kevan and Plowright 1995).

Landscape level changes and distance to undisturbed habitats can also influence the diversity of bees and crops requiring pollination. Agricultural intensification has had a negative impact on the diversity and abundance of native pollinators resulting in a reduced marketable watermelon crop in California (Kremen et al. 2004). The farms near natural habitats received the necessary level of pollination from wild bee communities while the more distant farms had to import managed bee colonies to attain desired yields (Kremen et al. 2004). Farmers that rely on transported bees have the additional expense of this service, which continues to increase due to the limited supply of healthy colonies as well as increased fuel prices (Lee 2008).

With the limited data on the life history of pollinators, it is difficult to determine when decline is taking place. For example, a long term documentation of pollinators in Carlinville, Illinois suggests that after 75 years in an agriculturally modified landscape the integrity of the pollinator community is still maintained (Marlin and LaBerge 2001). The researchers mention that this is possible because the agricultural matrix includes the nectar and habitat resources for these pollinators (Marlin and LaBerge 2001).Some long term research has documented cyclic trends of wild bees in North America and Central America (Marlin and LaBerge 2001; Roubik 2001). Another long term study in Panama found that the overall diversity of bees increased over a 21 year period, but that several of the species populations would cycle every four years (Roubik 2001). It is important to recognize the life history of pollinators because what may be perceived as a decline may actually be a natural cycle for the species.

The global issue of pollinator status is confounded by the significant lack of information in regards to social, ecological, and economic impacts. One important gap is the limited availability of taxonomists and resources to identify species in the field (IPI 2000). This issue is becoming more critical as initiatives have developed programs and goals to monitor pollinators, but lack the crucial taxonomical resources to identify and keep track of species. Lastly, there is a limited amount of recorded knowledge pertaining to indigenous groups and farming communities that have sustained native pollinators within their managed forests and gardens. Many indigenous communities may have a great potential to include traditional methods to help secure or enhance pollinator needs. The following section illustrates ways in which people have collaborated to address the possibility of pollinator decline and to study the potential for conservation of these important ecological and social actors.

Worldwide Initiatives

At the 1992 Earth Summit in Rio de Janeiro, 190 world leaders agreed on a comprehensive strategy for sustaining the world's biological diversity titled the "Convention on Biological Diversity" (CBD 2008). Three main goals of this convention included: "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources" (CBD 2008). One of the thematic issues is the "Conservation and Sustainable Use of Agricultural Biological Diversity", a program administered by Food and Agriculture Organization (FAO), which aims to reduce the negative impacts associated with agricultural systems on biodiversity, promote the conservation of genetic resources for food and agriculture, and promote fair access to utilizing these genetic resources (CBD 2008). These initiatives were further supported by scientists and agriculturists who were concerned that a worldwide decline of pollinator diversity was occurring and urged representatives from around the world to research the status and conservation policies of pollinators (Eardley et al. 2006).

In 2000, policymakers at the Fifth Meeting of the Conference of Parties of the Convention on Biological Diversity established the International Pollinators Initiative (IPI). The IPI was created in accordance with the recommendations from the Sao Paulo Declaration on Pollinators, a report specifically addressing the sustainable use of pollinators in agriculture (IPI 1999). The meeting was attended by several scientists from fifteen countries and six world organizations including the Convention on Biological Diversity (CBD), FAO, International Bee

Research Association, World Conservation Union, United Nations Development Program, and the Brazilian Council for Scientific and Technological Development. This meeting focused on six main areas of concern including: Reducing the Taxonomic Impediment on Pollinators; Monitoring the Decline of Pollinators; Identifying the Causes of Pollinator Decline; Quantifying the Economic Value of Pollinators to Agriculture; Conservation of Pollinator Diversity; and Sustainable Use of Pollinators (International Pollinators Initiative 1999).

Since the inception of the IPI, the CBD and FAO have united to strengthen this effort under the United Nation's Millennium Development Goals, with a target to reduce the loss of biodiversity by 2010 (CBD 2008). Many other initiatives have stemmed from this effort, including the European Pollinator Initiative, the Brazilian Pollinator Initiative; and three regional nodes were developed in Europe, South America and North America, supported by the International Network for Expertise in Sustainable Pollination (INESP) (CBD 2008). Other approaches, such as the North American Pollinator Protection Campaign (NAPPC) and the African Pollinator Initiative (API) are also currently underway.

These initiatives have strongly unified goals and objectives, but also are adapted to national contexts. The FAO and CBD have produced a framework for pollinator initiatives in other countries. For example, The Brazilian Pollinator Initiative (BPI) was established after the release of the Sao Paulo Declaration on Pollinators document, and keeps the core objectives of the IPI (Fonseca and Dias 2000). Additionally, in 2000, a group of researchers formed the European Pollination Initiative (EPI) at the International Pollination Symposium in Hungary (Potts 2000). The EPI has developed an action plan based on the Assessing Large Scale Risks to biodiversity with tested Methods (ALARM) project, which aims to quantify distribution shifts, determine the economic and ecologic risks associated with pollinator declines, and develop models to predict these declines (Potts and Roberts 2008).

Some initiatives in North America are approaching pollinator initiatives from a different angle than those of the aforementioned efforts. The NAPPC, for example, focuses on the implementation of research, protection, and social impacts associated with pollinators in the United States, Canada, and Mexico (NAPPC 2008). This campaign collaborates with existing projects to address specific pollinator habitats or migratory corridors that cross international boundaries. Examples of such plans are: Bat Conservation International’s Management Plan, the Plant Conservation Alliance’s Plan, and the Sao Paulo Declaration on Pollinators (NAPPC 2008). Efforts in the U.S. have also occurred at the federal level. The Senate has signed a resolution to help inform the public about the importance of pollinators through the implementation of “Pollinator Protection Week”, which has been celebrated across the U.S. (United States Senate 2006). The Senate Resolution 580 states:

> Recognizing the importance of pollinators to ecosystem health and agriculture in the United States and the value of partnership efforts to increase awareness about pollinators and support for protecting and sustaining pollinators by designating June 24 through June 30, 2007 as “National Pollinator Week.”

Initiatives in Africa have also been implemented in various ways. The African Pollinator Initiative (API), founded in 1999 at the Southern African Society for Systematic Biology, contributes by strengthening existing institutions (FAO 2002). The API has built a strong African regional network addressing existing initiatives such as the Global Taxonomy Initiative, the Global Biodiversity Initiative, and the Global Invasive Species Programme (GISP 2008). Like the NAPPC, the API has made a large investment in educating the public about the beneficial roles that pollinators play. They have targeted the public through schools and universities, as well as farmers, land managers NGO's and consumers through demonstration 'pollination gardens', management guides, workshops and media campaigns (FAO 2002).

With the many initiatives and campaigns taking place around the world, a central information portal was needed to allow researchers and the public to access resources. The Global Biodiversity Information Facility (GBIF) was created for this purpose, to allow free and open access to primary research data pertaining to biodiversity. One movement endorsed by GBIF is the Global Pollinator Species Campaign. This effort is led by the United States and supports pollinator conservation through the use of integrated taxonomic knowledge available through technological services. Five major information products are proposed: A World Checklist of Bees and other Pollinating Species, Searchable Digitized Records from Major Bee Collections and Observation Programs, Information on Plant and Pollinator Associations, Pollinator Identification Capability, and Status and Trends of Pollinators (GBIF 2008). The World Conservation Union (IUCN) is another important leader in recognizing the various needs to approach the issues of pollinator declines. The IUCN has created a Task Force on Declining Pollination that combines interdisciplinary expertise from several fields (e.g. botany, zoology, economics, social sciences) to address pollination sustainability at the global level (IUCN 2008).

Many countries have developed conservation strategies for pollinating bees that are both region specific and internationally recognized. There are documented declines in managed and wild populations of bees across the world, but long term data is limited and it is necessary to understand whether a decline is due to a natural life cycle, anthropogenic activities, or other factors. Gaps in knowledge include lack of information regarding life history of pollinating species, limited taxonomical resources, and limited knowledge on indigenous and small farm management of sustained populations of pollinators. Projects and initiatives are underway to address the status of pollinators and increase public awareness pertaining to their importance. The Sao Paulo Declaration on Pollinators was an important document that fueled the movement of many global initiatives, including the IPI, BPI, and EPI. Additionally, the NAPPC and API have benefited from the creation of IPI and these organizations are able to disseminate data through the GBIF and IUCN resources. These groups keep the doors of communication open for all interested parties, and encourage shared knowledge pertaining to biodiversity research on a global scale.

Conservation initiatives in Europe, Africa, and North America have made progress in many areas relating to pollinator research, health, and management. These continents share many challenges, such as incorporating pollinator conservation over a large area with language and cultural differences. Pollinator initiatives for these continents will be explored in greater depth as individual case studies in the following section.

CASE STUDIES

European Pollinator Initiative

The purpose of the European Pollinator Initiative (EPI) is "to bring together interested parties to focus on a range of activities which will help conserve and manage pollinators to enhance the services they provide" (Potts 2000). These pollinator services include crop production, contributions to the diversity of managed and wild areas of flowering plants for aesthetic values, and the ecological role of pollinators in food webs. An estimated 84% of Europe's crops are directly dependant on insect pollination (Williams 1994), and honey bees alone contribute an estimated 4.25 billion Euros per year to the continent's economy (Borneck and Merle 1989).

Declines across many regions in Europe have been reported, including managed honey bee colonies in Austria, Germany, France, and Ireland. The declines in managed honey bees are similar to the afflictions occurring around the world, notably from varroa and tracheal mite parasitism and increased cases of diseases (Williams et. al 1991). Threats to wild pollinators across Europe includes: habitat loss from agricultural intensification and fragmentation (Osborne et al. 1991), the use of agrochemicals with negative effects on pollinators (Kevan 1975), changing fire and grazing regimes, competition between wild and managed pollinators, habitat changes due to climate change, and the introduction and spread of non-native plant species incapable of supporting pollinators (Potts 2000).

The overall mission of the EPI is to protect and enhance the biodiversity and economic value of pollinators throughout Europe by integrating and coordinating efforts on local, national, and international scales through projects and networking. In order to work towards this mission, EPI has created an action plan which includes four main elements: assessment, adaptive management, capacity building, and mainstreaming. Each of these elements is facilitated through an interim steering committee, which oversees the development of the network. Additionally, EPI has coordinated an effort across Europe to establish the fusion of local and regional interests (Figure 2).

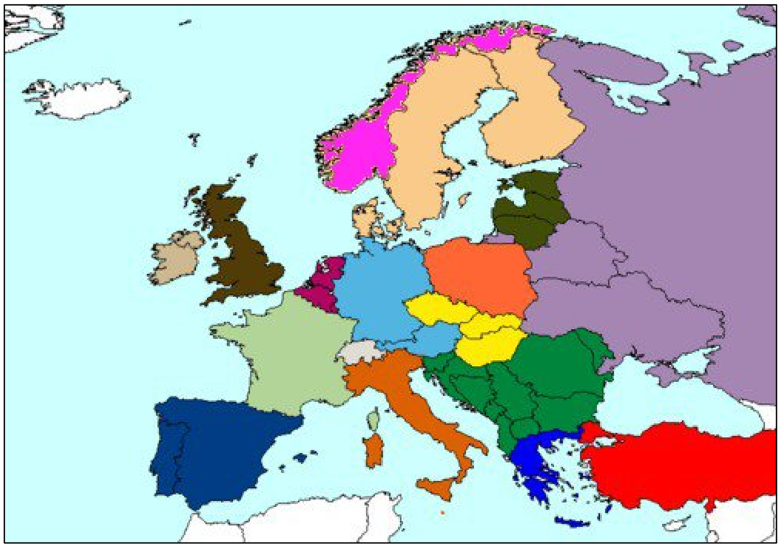

Figure 2: Regions across Europe collaborating through the EPI. Source: Potts 2000

Lastly, EPI has developed a series of working groups to focus on specific issues including: assessment of pollinator declines, pollinator taxonomy, honeybees, sustainable management of non-*Apis* pollinators, crop pollination, rare plant pollination, conservation and restoration, and communication (Potts 2000). Although the EPI has stated objectives, the management approach is flexible and considers that collaboration between various actions is the key to achieving their mission. The following statement illustrates EPI's commitment to multi-actor, integrated approaches to address the conservation of pollinators in Europe:

> Top down' and 'bottom up' approaches to managing ecosystems for pollinators are viewed as being complementary. For instance, EPI encourages and supports the adoption of wide-ranging agri-environmental schemes across Europe with broad centrally defined criteria set by the EU, while recognizing that these schemes need to be tailored and targeted at the national and local level in order to maximize effectiveness. Development of new management techniques relies heavily on farmers' guidance as to what is practically achievable and acceptable (Potts 2000).

Although each team has made significant contributions to the initiative, most of the current work has been done in relation to assessment of research needs and resources. The Assessment working group is pairing with Europe's ALARM project to quantify important pollinator distribution shifts across regions and develop models to help predict these changes.

This project is administered by the Centre for Agri-Environmental Research at the University of Reading in England. Several other universities have partnered in similar ways to connect efforts across the continent by conducting ‘Pollination Modules’ (CAER 2008). Standardized protocols for assessing pollinators will be utilized at each region for future analysis. The research collaboration between the EPI and ALARM projects are financially supported by the European Commission (CAER 2008).

Although the EPI’s efforts are commendable, the initiative is nascent in its development and, given the large temporal and spatial scales it faces, there is a further need for future collaboration and information gathering. Through their plan to encourage capacity building and mainstreaming the EPI anticipates overcoming these obstacles. The success to date has relied largely on the activism of its participants which has established a necessary foundation for the EPI. The challenge now is to continue development to reach a larger audience. The major limitation to achieving this is the current lack of core funding to provide a dedicated team of workers to actively develop activities that engage the public about the EPI. The rate of future progress is likely to be limited by the finite resources current participants are able to contribute to the process (Potts 2000).

African Pollinator Initiative

The mission statement of the African Pollinator Initiative (API) is “to promote pollination as an essential ecosystem service for sustainable livelihoods and the conservation of biological diversity in Africa” (FAO 2002). Africa is a continent rich in biological and cultural diversity. However, many areas of the continent are experiencing widespread threats of poverty and disease (FAO 2002). This is an important consideration, because natural resource degradation may lead to food insecurity and inadequate diet, which can further undermine the immune system of vulnerable people (Hunter 2008). Consequently, native habitats have been largely converted to meet the food and fuel wood demands of people.

Pollinators in Africa are an important part of the equation of food security, poverty, and ecosystem health. The destruction and degradation of native habitats may affect pollinator populations, which, unlike in North America and Africa, are largely wild rather than managed. The API was formed with the recognition that pollinators could be in serious trouble, which translates into a wide range of effects related to food security and biodiversity protection on the continent.

The API is a regional network that supports the implementation of the International Pollinator Initiative. API's action plan includes the following objectives: collect and document baseline information on pollination and pollinators; conduct scientific research and survey traditional knowledge on pollinators; build capacity and create public awareness on the importance of pollinators to the ecosystem; mainstream this information into national policies, and share information between member countries (Kwapong 2007). Members of the API come from every region of the continent and have specific positions to manage scientific research. The bulk of literature and research pertaining to pollinators and plant-pollinator relationships are from Southern Africa, and one of the major goals of API is to expand this knowledge across the entire continent.

Increasing public awareness and education is the highest priority on API's list of objectives. In 2002, biologists at an API workshop concluded that no amount of science and research will successfully achieve the API's goals without the support of the public (FAO 2002). Many people, including farmers, recognize that bees provide important resources such as honey and wax, but do not understand they play a vital role in pollination (FAO 2002). Some examples of awareness strategies are included on the following table:

Table 1. Public Education and Awareness: Plan of Action for the African Pollinator Initiative.

Public Education and Awareness: Plan of Action		
Who?	**How or What?**	**Why?**
Public	Media campaigns, including targeting the general public, and specialized publics through newsletters/brochures.	To inform the public, both general and specialized.
Schools, Universities	Lectures, posters	To interest younger generations and current science managers in the importance of pollination.
Farmers, Land managers	Information, demonstration "pollinator gardens", simple management guides, posters	To increase the specific understanding of those most close to the resource.
NGO's	Workshops, documents	To provide advocacy materials for modifying land management practices to support pollinator conservation.
Consumers	Media campaigns, public information	To inform and influence consumer choices.

Source: FAO 2002

Traditional knowledge pertaining to pollinators and pollinator management will also be incorporated in the API framework. One example of this is The Bwindi Impenetrable forest, located in Uganda. This forest is home to indigenous groups such as the Batwa pygmie tribe (Byarugaba 2003). The Batwa people harvest honey and wax from two genera of stingless bees that live in the forest, and have their own classification system for recognizing six separate species. Although the classification is not Linnaean, the Batwa have effectively described morphological differences among the bees that are similar to scientific taxonomy. The API recognizes the importance of traditional knowledge such as this, and plans to better understand how pollinators have been successfully managed in indigenous communities throughout Africa in order to conserve the rich cultural and biological diversity that exists.

API intends to increase capacity through strengthening existing institutions. It has focused on using existing African networks, such as Nature Kenya, to meet objectives in the action plan. To make API a distinct effort among existing initiatives, distinct nodes of activity will be used to network information about overlapping issues that other organizations are addressing. Among the groups that will collaborate with the API are the Global Taxonomy Initiative, the Global Biodiversity Information Facility and the Global Invasive Species Programme (GISP 2008). The first API workshop, focused on approaches to effective pollinator conservation strategies in specific regions, and also described how the API will collaborate with international and regional partners (FAO 2002). For example, the API will be in close contact with FAO's Millennium Ecosystem Assessment of its data on pollinator declines within Africa (FAO 2002).

The API is strengthened by the collaboration of partners involved at the local, regional, and international scales. Furthermore, the four components of the action plan: education and awareness; placing pollination in the mainstream; conservation and restoration; and capacity building, have been designed to interact and reinforce each other, and to be applicable at both national and regional levels (FAO 2002). API is additionally supported by involving the public, policy makers, scientists, and existing organizations to fully implement the objectives in a multi-dimensional manner.

North American Pollinator Protection Campaign

The mission of the North American Pollinator Protection Campaign (NAPPC) is "to encourage the health of resident and migratory pollinating animals in North America." The NAPPC is a collection of experts and scientists from federal agencies, non-governmental organizations, and private citizens working to protect pollinators and raise awareness of pollinator issues. Coordination of NAPPC efforts is directed by the Coevolution Institute, a non-profit organization that supports the protection of biodiversity. Through the NAPPC, the

Coevolution Institute has worked with other organizations to bring information about pollinators to a variety of stakeholders (NAPPC 2008). The major goal of this is to develop and implement an action plan to: coordinate local, national, and international action projects in the areas of pollinator research, education and awareness, conservation and restoration, policies and practices, and special partnership initiatives; facilitate communication among stakeholders, build strategic coalitions, and leverage existing resources; and demonstrate a positive measurable impact on the populations and health of pollinating animals within five years (NAPPC 2008). The NAPPC also coordinates with existing initiatives that address specific pollinator conservation objectives, including the International Pollinator Initiative.

While this initiative has some international collaboration, the NAPPC focuses its efforts in the United States, Mexico, and Canada. Each of these countries has experienced decline of managed and wild pollinators. For example, declines in native and commercial bee populations have been documented in the United States and Canada (Stokstad 2006). Beekeepers of the Maya zone in Quintana Roo state, southeastern Mexico, have noticed a dramatic decrease in the native stingless bee, *Melipona beecheii* (Villanueva et al. 2005).

There are many contributing factors to the declines of honeybees in North America, including: habitat loss, exotic species introductions, parasitism and Colony Collapse Disorder (Stipp 2007). One area of particular concern to both the U.S. and Mexico is the introduction of the African honeybee. Competition with the introduced African honeybee has resulted in an increasing feral population of this species that has expanded north from South America. One study by Clarke et al. (2002) found a massive hybridization event between the feral African honeybees and resident European honeybees. This has negative consequences for beekeepers because the feral hybrids are more aggressive and defensive, making it difficult to manage hives.

Villanueva et al. (2005) note that “for the last 14 years the stingless bee keepers have been losing about 22 colonies each year…by the year 2008 there will be no domesticated colonies at all.”

Declines due to disease and parasitism have also had dramatic consequences for commercial bees in North America. In the last fifty years, mites have caused major declines of the common honeybee, *Apis mellifera*, cutting the colonies by 50% across the United States (Doebler 2000). Colony Collapse Disorder (CCD) is characterized by worker bees from a beehive or commercial honeybee colony abruptly disappearing from the hive (Penn State University College of Agricultural Sciences 2007). CCD was originally found in honeybee colonies in western North America in late 2006, and has since been observed in bee colonies in Europe and Taiwan (Wikipedia contributors 2007). The decline has economic consequences because bee colonies currently pollinate California's US$1.4-billion almond crop, which is 100% dependent on bee pollination (Lovgren 2007).

The NAPPC has responded to these declines by bringing awareness and alert to policy makers about the need to protect pollinators in North America. Professor May Berenbaum, Chair of the committee on the Status of Pollinators in North America, conveyed the importance of pollinator stability to the United States House of Representatives with the following quote:

> …as to the effects of losing the pollination services of individual species, most ecosystems depend on pollinators for food web stability. Few plant species rely on a single pollinator and many are visited by different suites of pollinator species over the course of a season. When entire suites decline, as has been the case for long-tongued bees in Europe, significant losses within the wild flora dependent upon these suites are likely. Unfortunately, missing markets make it difficult to estimate the economic value of changes to pollination services in natural communities. The economic cost of complete loss of all pollination services cannot be estimated because ecological and human adjustments to such extreme change would be radical (Barenbaum 2007).

Due to the collaboration and effort of many participants in the NAPPC, progress in the political sector has been continuing. The implementation of “Pollinator Protection Week” by the

U.S. Senate is a recent example of bringing public attention to pollinators (United States Senate 2006). Another effort by the Coevolution Institute is to incorporate native pollinator needs into the Farm Bill, directing United State Department of Agriculture (USDA) agencies to improve and build upon current pollinator conservation efforts, and recommend that pollinator protection be designated as a "Priority Resource Concern." Laurie Adams, co-director of the Coevolution Institute stated "Modest changes in Farm Bill conservation programs can be highly effective in helping agricultural producers protect pollinators and their habitat" (Pollinator Partnership 2008).

Educating professionals as well as the public about the status of pollinators in North America has been an ongoing effort of the NAPPC. In 2007, *The Status of North American Pollinators* was published by the National Research Council's Committee, providing an assessment of pollinating animals in the United States, Canada, and Mexico. Educational outreach through a variety of means has strengthened the goals of the NAPPC. The Pollinator Partnership is an online resource sponsored by NAPPC and the Coevolution Institute provides interactive tools for teachers, as well as an extensive digital library for gardeners, farmers, consumers, and concerned advocates (Pollinator Partnership 2008). The Xerces Society is another international nonprofit organization dedicated to protecting biological diversity through invertebrate conservation. This group has incorporated pollinator conservation efforts through habitat management guides for farmers, gardeners, educators, and the general public (Xerces Society 2008).

CRITIQUE

The European Pollinator Initiative, African Pollinator Initiative, and North American Pollinator Protection Campaign are still relatively new initiatives. Each initiative has progressed to varying extents based on resource availability, financial support, and unforeseen barriers. The Plan of Action for each initiative includes components that are on-going, dynamic, and require a long time span for implementation and goal achievements. Pollinator conservation requires participation and collaboration from many different sectors, including the general public, academics, professionals, legislative bodies, natural resource managers, farmers, and trained extension personnel.

A common challenge the EPI, API, and NAPPC face is the lack of taxonomical resources available. This is an important consideration, because an insufficient body of knowledge pertaining to pollinators will impede many of the other objectives that these initiatives have created. Addressing this challenge relies on funding for equipment, personnel, and, most importantly, time. Resource availability vary among the EPI, API, and NAPPC. However, until a detailed key of pollinators in each of the regions is available, it will be difficult for conservation efforts to progress.

One different aspect between the initiatives is top-down versus bottom-up approaches to pollinator conservation integration into local practices. The API's bottom-up approach to making public education and participation a priority will help make their efforts sustainable. This approach has worked well in other circumstances, such as agricultural practices and could serve to teach individuals about the role of pollinators in each of the respective regions. For example, the practice of using velvet bean as a source of green manure mulch in Benin began with just a few farmers, but soon spread to over a hundred-thousand farmers in a short period of time (Stocking et al. 2003). Such initiatives that empower the locals with knowledge and experimental observation using pollinator gardens can have the same promising effect.

The NAPPC has incorporated a top-down approach working with lobbyists to make legal changes to which resource managers and farmers must abide, as well as a bottom-up approach through the collaboration and involvement of non-profit organizations, such as the Xerces Society. Likewise, the EPI incorporates both a bottom-up and top-down philosophy in their initiative. As public interest and research funds wax and wane, having both management styles will make the EPI's initiative more flexible and successful in the short and long-term.

An aspect that will help make the EPI, API, and NAPPC initiatives move forward and steadfast is their strategies of networking. The EPI's creation of pollinator modules will allow each region to better communicate and collaborate on current projects. Their standardization of monitoring pollinators also unifies the individual efforts and allows the information to be incorporated and compared in research analysis. This is an important consideration, because the EPI may be able to detect local and regional declines more readily with this information.

The API has added pollinator conservation goals to institutions that already exist, rather than creating new organizations. This can be seen as both a successful and questionable approach. Collaborating with existing institutions also allows the API and NAPPC to take advantage of reputable organizations with dedicated individuals. On the other hand, the goals of pollinator conservation for both the API and NAPPC may become overshadowed with other items of concern.

Another concern that could impede the goals of the API and EPI is the potential language and cultural barriers. Since these initiatives span across several distinct nations, it will be important for the working groups to translate the strategies in a clear, effective manner that local citizens can understand and become involved with pollinator conservation efforts. The NAPPC faces similar barriers in the United States, Mexico, and parts of Canada.

Lastly, the ability of each of these initiatives to captivate and include a wide audience will be a key to sustaining their goals. This includes creating many avenues for reaching people of all ages, education levels, and professions. The API has accomplished this in part through the use of pollinator gardens to attract attention and provide hands on experimentation with local farmers. The NAPPC has created a user-friendly website with educational materials ranging from elementary to high school that teachers can utilize in the classroom. The EPI's Plan of Action incorporates mainstreaming, with plans to introduce awareness of pollinators in education and educate land managers, farmers, and conservationists. Keeping education at the forefront of projects and goals will be a key to sustaining the EPI, API, and NAPPC initiatives.

Opportunely, pollinator conservation in general can be readily assimilated into other conservation areas. Due to the overlapping needs of pollinators and other conservation areas (i.e. soil, wildlife, ecosystem conservation), the initiatives each have ingrained hope for inclusive endeavors. Some opportunities for collaboration include habitat restoration and promoting biodiversity within landscapes. For example, hedgerows can provide cover for wildlife and nectar sources for pollinators.

Each of these initiatives is significant contributors to the conservation and understanding of our planets pollinators. Their vital role in food security and ecosystem processes places these important organisms in a position demanding attention. The EPI, API, and NAPPC are three important actors in this global effort.

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