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**Introduction:**

The Nature Conservancy is an organization that for the past 52 years has been working with communities and businesses around the world to protect our natural landscapes. They have helped to protect 98 million acres of valuable lands and waters worldwide. Their success is deeply rooted in their commitment to working with small groups of people to educate and promote the conservation of our environment. “The Nature Conservancy is increasingly committed to exploring, for our mission of preserving Earth's biological diversity will succeed only if we can maintain the full benefits of that diversity for the well-being of humankind. And it is our belief that this can be achieved by working at the local level” (McCormick 2003;www.tnc.org). It is through the notion that humans and nature can co-exist and as we evolve we can learn to exist in a more sustainable way through the efforts of The Nature Conservancy and others who are making changes in our local communities. Steven McCormick, CEO of The Nature Conservancy states that, “If we can demonstrate to a logger's family or a fisherman's family, no matter where in the world they may live, that there is a way to protect their livelihood today and for years to come, they will sustain that idea perpetually. Sustainability—a concept we believe is limited only by our imaginations and
our courage to pursue it” (McCormick 2003: www.tnc.org). It is clear that The Nature Conservancy is devoted to protecting the natural environment and promoting a more sustainable relationship between man and nature.

The project that I worked on for the Nature Conservancy looked at the introduction of invasive species in the Kennebec River estuary and the role that humans have played in these invasions. The Kennebec Estuary is one of the most important estuary areas in the Northeast, “Six rivers, draining one-third of the state of Maine, converge in Merrymeeting Bay, and inland, freshwater, tidal delta. Below the outlet of the Bay, the salty, tidal waters of the Lower Kennebec River support an abundant community of animal and plant life” (2003: www.tnc.org). The unique attributes of this estuary make it one of the most productive areas that has supported a vast array of species for hundreds of years. Recently with the increase in human activities around the estuary some of the species have become threatened by the invasive species Purple Loosestrife (Lythrum Salicaria);

“The European purple loosestrife, which was introduced in the early nineteenth century as an ornamental plant, has been spreading at a rate of 115,000 hectares per year and is changing the basic structure of most wetlands it has invaded. Competitive strands of purple loostrife have reduced the biomass of 44 native plants and endangered wildlife including the bog turtle and several duck species, that depend on these native plants. Loosestrife now occurs in 48 states and costs $45 million per year in control costs and forage losses” (Pimentel et al 2000:54).

This estuary is home to many endangered and threatened species and The Nature Conservancy is concerned that these invasive species will disrupt the natural balance of this productive ecosystem. Invasive species are a problem because they, “May modify natural and semi-natural habitats, for example, by replacing a diverse system with single species strands, introducing a new life form to the habitat, altering the water or fire
regime, changing the nutrient status of the soil and humus, removing food source or introducing a food source where none existed before, or altering sedimentation processes” (Cronk et al 1995: 3). The Kennebec Estuary is only one of the many invasive species problems that The Nature Conservancy is addressing throughout the world.

**History of Invasive Species:**

The history of human involvement in the distribution of invasive species stretches back to the beginning of agrarian societies; “From the start of agriculture, whenever people have moved, plants have moved too, both through the deliberate spread of domesticated crops and the accidental associated spread of weeds and ruderals” (Cronk et al 1995: 3). As civilizations flourished in the sixteenth century the distribution of plants across continents has changed dramatically; “The expansion of the European colonial powers (notably Britain, France, Germany, the Netherlands, Portugal, and Spain) increased dramatically the transport of living material” (Cronk et al 1995: 19). These European settlers, “Sought to recreate the familiar conditions of home” (Mooney 2000:175), bringing with them nonindigenous plants and animals. Even more important in these changes was the “Opening of the tropics and the discovery of the New World that led a great wave of plant exchange or, as it has been called, ‘ecological imperialism’ (Cronk et al 1995: 19). The changes that were made as people and goods began to travel to distant places have only increased in recent years and continue to pose a threat to our natural environment.
Invasive species can enter the environment in a variety of different ways and humans play a major role in their introductions. Often times our own backyards provide the avenue through which invasive plants enter and spread into surrounding areas. As spring rolls around and we begin to think about what we want to plant in our gardens, the desire for something different emerges and we look to plant exotic plants that are not native to these environments; “Ever since the seventeenth century enthusiastic gardeners have, in increasing quantities, introduced exotic species to countries for their ornamental value” (Cronk et al 1995:22). Many times people do not deliberately spread these plants and therefore it is the goal of conservationists to educate people about the harmful effects that these ornamental plants can have on the environment.

Another one of the ways that invasive species enter our environments is through land-use changes. As “Natural forests are cut or burned, meadows plowed or paved, wetlands drained or filled, and roads cut through formerly wild ecosystems, environmental conditions change, providing new opportunities for both native generalists and weedy invaders”(Baskin 1998: 789). When an area is cleared erosion increases changing the soil chemistry and altering the cycling of nutrients. This allows only certain species to take root and excludes those who cannot withstand the new conditions. Areas are often cleared for agricultural purposes and humans often introduce new non-native crops into these areas. Soon after the areas surrounding the land are unrecognizable and the biological diversity of these local ecosystems has been lost. The rapid urbanization of our natural landscapes is also a major contributing factor in the introduction of non-native species. The “Human modification has led in many cases to increasing degradation of ecosystem components, resulting in a decline in the value of the
ecosystem either for production or conservation services” (Mooney 2000: 56). As areas are transformed into housing developments the habitat area that is available to native species is severely reduced. Development “Produces some of the greatest local extinction rates and frequently eliminates the large majority of native species” (McKinney 2002: 883). During development it is common for developers “To remove most vegetation and even topsoil. This reduces construction costs by allowing equipment ready access to the construction site” (McKinney 2002: 888). It is clear that “While disturbance is a natural part of ecosystem dynamics in many systems, human alteration of disturbance regimes and the introduction of novel disturbances produce changed system settings and increased opportunities for invasion” (Mooney 2000:59).

Another major factor contributing to invasive species is the globalization of the world market. In recent years an accelerated world trade economy, “A phenomenon that connects the remotest region to global markets by truck, train, ship and air plane, [have] served as avenues for the movement of plants, pests, pathogens, disease vectors and other organisms” (Baskin 1998:792). Today, “The office of Technological Assessment (OTA) (1993), in a comprehensive review, concludes that about 4,500 exotic species occur in free-ranging condition in the United States, and that about 20 percent of them have caused serious economic or ecological harm” (Mooney 2000:176). The global market has clearly been a major factor in the transport of nonindigenous species and as our world economy becomes even more globalized it is important for strict regulations and studies to be conducted on materials being brought into the United States.

Global climate change is another human induced factor that is attributing to invasions. In recent years scientists have shown the humans have played a major role in
global climate changes, “Human activities are having a discernable impact on the climate- primarily through the burning of fossil fuels, which is increasing the amount of carbon dioxide in the air and thereby contributing to the so-called greenhouse effect” (Mooney 2000: 177). Air temperature and moisture changes will effect both native and non-native species differently and will either prevent or promote alien invasions. As climate changes in areas, it disrupts the natural balance that exists in ecosystems and allows for native plants to be out competed by alien invaders. It is believed that “Climate change could well promote the interests of invasive species, especially since invasives are especially likely to become established in habitats disturbed by human or other factors” (Mooney 2000:177). Humans have direct and indirect impacts on the introduction of nonindigenous species and therefore more information and regulations need to be set up to help prevent these disturbances to native ecosystems, so that we can maintain the natural biodiversity of this planet.

Effects:

Invasive species have tremendous environmental impacts in the United States and throughout the world. One of the most detrimental costs is associated with the loss of biodiversity; “Biodiversity serves humanity in producing goods and services for fundamental human needs such as clean air, fresh water, food, medicines, and shelter. It also provides people with essential recreation and spiritual enjoyment” (Abeyratne 2001: 1). As non-native species enter an environment they are more likely to be unaffected by the predators that prey on the native species and their populations will flourish rapidly. The new species also brings about new competition between the native species, “400 of
the 958 species that are listed as threatened or endangered under the Endangered Species Act are considered to be at risk primarily because of competition with and predation by nonindigenous species” (Pimentel et al 2000:53). Often times people do not realize how important plants and animals are in our everyday lives. Today, “About 25% of drugs prescribed in the U.S. include chemical compounds derived from wild organisms, and billions of people world-wide rely on plant- and animal-based traditional medicine for their primary health care” (Tuxill et al 1999:31). As these alien species enter an ecosystem and disrupt the balance, native species can sometimes not adjust or compete and fall victim to the invasive species. These losses greatly reduce the complex biodiversity that exists between each local ecosystem. It is clear that invasive species are threatening our environment and destroying those resources that we may someday need to fight off diseases. Human actions are the major contributing factor in alien invasions and in the long run we will be the ones who will be greatly affected by these losses. We cannot know what the future will hold, but by trying to preserve our native species we can hopefully hold onto species that may someday be beneficial to our society.

Invasive species have significant economic impacts on agricultural practices in the United States. Today, “With the introduction of about 50,000 nonnative species into the United States, economic damages are approximated at $137 billion per year. Beyond these economic considerations, many of the world’s ecosystems have suffered severe ecological damage-upon which no monetary value can be placed following the introduction of exotic species” (Ludsin 2001: 780). The introduction of nonindigenous weed species in US agriculture, “Caused an overall reduction of 12% in crop yields, which represents approximately $32 billion in lost crop production annually (Pimentel et
al 2000:60). There are also significant secondary costs from the invasions, once these species have been introduced the US has to spend billions of dollars in pest control. “Control of weed species in lawns, gardens, golf courses makes up a significant proportion of the total management costs for lawns, gardens, and golf courses of approximately $36 billion per year (Pimentel et al 2000:60). These pest control practice can pose serious health risks for humans and other organisms in the environment and therefore measures must be taken to protect of environment from these alien invasions.

Some solutions:

Invasive species are clearly a major problem in the United States and humans have played a pivotal role in these invasions. We have reached a crucial point in our relationship with the environment, one that demands actions to be taken to ensure the survival of our natural world for future generations. Many environmental groups, like The Nature Conservancy have realized the threat that these invasions pose to our natural environment and have started to take action. The solutions to these problems will require people from all areas of the globe to realize that these invasions are a serious threat to our way of life. Countries, governments, states, communities and individuals all have to make a conscious effort to recognize and act on this problem because, “The loss of species touches everyone, no matter where or how they live. Earth’s endowment of species provides humanity with food, fiber, and many other products and “natural services” for which there is no substitute” (Tuxill et al 1999:53). One of the most important tools that organizations like The Nature Conservancy can use is education; “Education is essential in order to minimize accidental introduction of species.
Education should foster awareness of the potential threat that alien species pose to natural ecosystems and awareness that plant introductions should be accompanied by assessment of their potential to spread and cause damage” (Cronk et al 1995:35). The knowledge that the people at The Nature Conservancy gain from volunteers and students like myself can be used to help spread a more awareness throughout communities and hopefully help reduce the number of invasions in Maine as well as throughout the world.

**Project Description:**

In our ever increasing globalized world scientists and citizens alike are starting to realize the benefits that electronic databases and especially the internet can serve in understanding the changes to our environment. There is a large amount of information relevant to invasive species throughout the world but access to this information can be hard to obtain as it is tied up in many different disciplines in areas across the globe. Today times have changed and the increasing number of electronic databases allows more access to this information and in turn a better understanding of the local, regional and global problems that invasive species are causing. The project that I am working on is in fact one of these local databases that will allow scientists and citizens alike to examine a region along the Maine coast and better understand the effects that the invasive plant, Purple Loosestrife (*Lythrum Salicaria*) is having on this area. This invasive plant is native to Eurasia and “Was first reported from the northeastern coast of North America in 1814” (Bender et al 2003: 2). Purple loosestrife is a threat to the Kennebec Estuary because “Once purple loosestrife becomes established in a wetland it displaces endemic vegetation through rapid growth and heavy seed production. L. Salicaria has a
detrimental impact on native wetland vegetation and associated wildlife” (Bender 2000; 4). This invasive plant has a unique ability to spread rapidly and this project will help to identify and monitor this invasive species to help prevent the loss of native plant diversity. This project will be a stepping-stone in the quest to electronically link all of these independent databases to create a global information system for invasive species throughout the world; “Through a coordinated body, the global system we envision could provide standards for new invasive species databases that would reduce overlap, increase technical compatibility, and ensure the consistent usage of nomenclature and tabular data” (Ricciardi 2000:241). A databases system like this would allow people to better understand invasive species on a local, regional and global level and promote the prevention of these nonindigenous species.

The work I have done for The Nature Conservancy will hopefully help them to monitor and understand the impacts that humans have had on the introduction of Purple Loosestrife into the Kennebec Estuary. Over this past summer volunteers from the community were involved in gathering field data on the invasive species throughout the estuary. These volunteers identified and described some fifty different sites where Purple Loosestrife was found. The Nature Conservancy needed this data to be transformed into a more useful database that could be accessed easily. I took the data that was gathered and using ArcView 3.3, I created a GIS map of the Kennebec estuary that shows the areas of nonindigenous invasion. This map will allow the Nature Conservancy to assess the possible causes of these invasions and serve as a way to monitor the spread of these species over time. The map shows any possible human activities such as roads, culverts, streams, and ponds. With the knowledge provided from
the map I hope The Nature Conservancy can work to educate the local communities about invasive species and the role that they as individuals play in these invasions and the ways that they can prevent them. With my efforts and those of others, now and in the future, the likelihood that invasive species will enter the Kennebec estuary will hopefully decrease significantly. If we can begin to understand the impacts of invasive species on our own community environments than hopefully this knowledge will spread and help reduce the number of invasions throughout the world.

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