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ISSUES – FIGURE SET

What Are the Impacts of Introduced Species?

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Brown tree snake, *Boiga irregularis*
photo © G. H. Rodda, USGS
{biology.usgs.gov/s+t/
imagefiles/x181w02.htm}

THE ISSUE:
Introduced species are changing ecosystems throughout the world.

ECOLOGICAL CONTENT:
life history, competition, biogeography, trophic dynamics, predation, multispecies interactions, and parasitoids

STUDENT-ACTIVE APPROACHES:
turn-to-your-neighbor, guided class discussion, think-pair-share, informal groupwork, paired think aloud, and jigsaw

STUDENT ASSESSMENTS:
essay quiz, rebuttal essay, essay from website, drawing of interactions

OVERVIEW OF THE ECOLOGICAL BACKGROUND

In this Issue, students will examine published data that address the ecological consequences of introduced species. Activities engage students in data analysis and hypothesis testing and will increase their understanding of the complexities of ecological phenomena. This Issue focuses on ecological consequences of introduced species using several case studies - zebra mussels, brown tree snakes, fire ants, and gypsy moths. There are many, many more examples of introduced species; faculty looking for others can use links in the resources section and this Issue for ideas about how to help students think about this complex and controversial topic. Note that the ESA Issues in Ecology No. 5 is called Biotic Invasions: Epidemiology, Global Consequences and Control (http://www.esa.org/sbi/sbi_issues/). As with all TIEE Issues the teaching approaches suggested here are just that - suggestions. Adopt and modify as suits your needs.

As the ecology of introductions become better understood, ecological information about this phenomenon can help address management issues and perhaps mitigate ecological disruption from species introductions in the future. Decreasing the rate and impacts of introduced species is considered by many as important to maintaining the natural biodiversity and ecosystem functioning which, in turn, provide goods and services for humans (see ESA's Issues in Ecology No. 2: Ecosystem Services and No. 4: Biodiversity and Ecosystem Functioning; http://www.esa.org/sbi/sbi_issues/). As expected, ecologists disagree about effects of introductions, including the relationship between diversity of introduced species and native ones (Rejimanek 2003).
The relocation of organisms across geographical boundaries occurs naturally by various means. Since humans began exploring the globe, however, the rate of new species being introduced into regions has greatly increased. In some cases, humans have dispersed species on purpose; for instance, many plants were transported from Europe to North America for agricultural and ornamental purposes. Others were transported accidentally by ship, train, airplane - even on the shoes of hikers. Some species may be introduced and not be able to survive in their new habitat. Others may find optimal conditions for growing, reproducing, and adapting to the new environment, and their populations soar. For instance, lack of predators may contribute to their rapid population increases.

Not surprisingly, there is much controversy about the topic of introduced species. This includes debate about the terms "invasive", "exotic", "introduced" and "native". If a plant such as Kentucky bluegrass was introduced to Illinois 200 years ago, is it native or introduced (http://www.invasivespecies.gov/, http://www.farmlandinfo.org/fic/states/il/grass/kentuckybluegrass.html)? What about organisms that "invade" new volcanic islands like Krakatoa? Are they native?

One way to clarify the terminology is to consider the effects of the species. Introduced species that have profound effects on their new ecosystems have been termed *invasive* species. These effects include out competing native species, sometimes causing their extinction, and altering ecosystem functioning.

The activities presented in this Issue investigate the ecological disturbances created by four introduced species and the research conducted to better understand their ecology and effects.

The zebra mussel (*Dressena polymorpha*) is perhaps the most widely known example of an aquatic invader in the U.S.. Transported to the Great Lakes from Europe in ballast water, the zebra mussel has successfully found a niche, out competing other filter feeders. The US Geological Survey hosts a network specifically for this invasive species (http://nas.er.usgs.gov/zebra.mussel/). The problem has increased awareness to avoid other species introductions through ballast water.

The brown tree snake (*Boiga irregularis*) is an invasive that has taught scientists much about the impact of introduced species on islands. The invasion has created significant ecological problems; it is an aggressive predator, causing the extinction of local species, and it has impacts on human health.

The red fire ant (*Solenopsis invicta*) from South America, has had wide spread impact in the southeastern region of the U.S. and is expected to widen its range. These ants out compete other ants and impact crops and humans. Scientists are investigating the interaction of the phorid fly with fire ants as a possible means of control.

The gypsy moth (*Lymantria dispar*), introduced approximately 100 years ago, had caused significant disturbances in forest ecosystems in the U.S. The caterpillar feeds on a large number of tree species, defoliating them; if defoliation continues over many years, these trees likely die. Scientists have formed networks to coordinate and communicate research to learn more about gypsy moth ecology and ways to manage this species.

FIGURE SETS

These are published figures from peer-reviewed research journals and monographs that engage students in data analysis and critical thinking organized by teaching approach, Bloom's Taxonomy cognitive skills, and class size. The student-active approaches listed here are suggestions and examples; modify them as appropriate for your teaching. Note that there are two Figure Sets concerning zebra mussels.

Figure Set and Ecological Question	Student-Active Approach	Cognitive Skill	Class Size/Time
(1) Zebra Mussel Invasion (Mills et al. 1994)	think-pair-share	knowledge interpretation	any/ intermediate
(2) Zebra Mussels in the Hudson River (Strayer et al. 1999)	turn to your neighbor	comprehension anlysis	any/short
(3) Brown Tree Snakes and Bird Extinctions on the Island of Guam (Savidge 1987)	guided class discussion	knowledge comprehension application synthesis analysis	any/short
(4) Fire Ant Invasion and Control by a Parasitoid (Orr et al. 1995)	paired think-aloud	interpretation application	any/ intermediate
(5) Gypsy Moth Invasion and Links to Outbreaks of Lyme Disease (Jones et al. 1998)	jigsaw	comprehension intrepretation synthesis	medium/long

References:

Conry, P. J. 1988. High nest predation by brown tree snakes on Guam. Condor 90: 478-482.

Engbring, J., and F. L. Ramsey. 1984. Distribution and abundance of the forest birds of Guam: results of a 1981 survey. U.S. Fish and Wildlife Service FWS/OBS 84(20). 54 pp.

Engbring, J., F. L. Ramsey, and V. J. Wildman. 1986. Micronesian forest bird survey, 1982: Saipan, Tinian, Agiguan, and Rota. U.S. Fish and Wildlife Service, Honolulu, HI. 143 pp.

Fritts, T. H. 1988. The brown tree snake, *Boiga irregularis*, a threat to Pacific Islands. U.S. Fish and Wildlife Service Biological Rep. 88(31). 36 pp.

Moulton, M. P., and S. L. Pimm. 1986. Species introductions to Hawaii. Pages 231-249 *in* H. A. Mooney and J. A. Drake, eds. Ecology of biological invasions of North America and Hawaii. Springer-Verlag, New York.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. BioScience 50: 53-65

Rejimankek, M. 2003. The rich get richer - responses. Frontiers in Ecology and the Environment 3: 122-123.

Rodda, G. H., T. H. Fritts, and D. Chiszar. 1997. The disappearance of Guam's wildlife. BioScience 47: 565-574.

Savidge, J. A. 1988. Food habits of *Boiga irregularis*, an introduced predator on Guam. Journal of Herpetology 22: 275-282.

U.S. Department of the Interior. 1990. Endangered and threatened species recovery program. Report to Congress. Washington, DC. 406 pp.

Web Resources:

Zebra Mussels

- USGS http://nas.er.usgs.gov/zebra.mussel/
- Wayne State University http://sun.science.wayne.edu/~jram/zmussel.htm
- Army Corps of Engineering http://www.wes.army.mil/el/zebra/
- Sea Grant - huge list of online papers http://www.sgnis.org/update/zebra.htm
- Michigan Sea Grant http://www.msue.msu.edu/seagrant/sgezmans.html
- Minnesota Sea Grant http://www.seagrant.umn.edu/exotics/zmid.html
- Great Lakes Sea Grant http://www.seagrant.wisc.edu/greatlakes/glnetwork/exotics.html
- National Biological Information Infrastructure (NBII) http://www.invasivespecies.gov/profiles/zebramussel.shtml

Brown Tree Snakes

- USGS http://www.pwrc.usgs.gov/btree.htm
- National Biological Service http://biology.usgs.gov/s+t/noframe/x181.htm
- National Biological Information Infrastructure (NBII) http://www.invasivespecies.gov/profiles/bts.shtml
- USDA http://www.aphis.usda.gov/oa/pubs/bts.html
- Control Plan http://www.anstaskforce.gov/BTS%20Control%20Plan.htm
- Hawaii Garden Club http://www.gchonolulu.org/Conservation/Brown%20Tree%20Snake.htm
- FAQ http://www.dfw.gov.mp/newpage11.htm

Fire Ants

- Cooperative Agriculture Pest Survey Program http://www.ceris.purdue.edu/napis/pests/ifa/
- Texas A & M University http://fireant.tamu.edu/antfacts/
- USDA http://www.aphis.usda.gov/lpa/pubs/fsheet_faq_notice/fs_phifa.html

Gypsy Moths

- University of Wisconsin - Agricultural Education Classroom Activities http://www.uwrf.edu/ag-education/resource/
- Ohio State University Extension - Toledo Urban Forestry Commission http://lucas.osu.edu/gm/tufc.htm
- University of Connecticut Cooperative Extension - Links Between Acorns, Gypsy Moths, and Lyme Disease http://www.canr.uconn.edu/ces/forest/lyme.htm
- Vermont Community Foundation http://www.vermontcf.org/pdfs/deerticks.pdf