Science Feature

Assessing the effects of ungulates on natural resources at Assateague Island National Seashore

By Mark Sturm

UNGULATES ARE A THREAT to many of the natural resources at Assateague Island National Seashore (Maryland and Virginia). Feral horses (*Equus caballus*) (fig. 1), Asiatic sika deer (*Cervus nippon*) (fig. 2), and native white-tailed deer (*Odocoileus virginianus*) (fig. 3) roam the barrier island, competing for resources and disrupting natural processes that maintain habitat for a diverse array of plant and animal species of conservation concern. These include the piping plover (*Charadrius melodus*), a shorebird, and seabeach amaranth (*Amaranthus pumilus;* see sidebar, fig. 4), a fleshy-leaved plant. Though these species are threatened with extinction, management of ungulates to help protect them is a complex challenge owing to historical and ecological factors and multiple management jurisdictions.

Assateague Island is located on the highly developed mid-Atlantic coast of the United States. The Maryland portion of the island, 21.7 miles (35 km) long, is managed primarily as Assateague Island National Seashore, while a roughly 1.8-mile (3 km) section is managed by the Maryland Department of Natural Resources as Assateague State Park.

Feral horses have continuously occupied Assateague Island for more than three centuries. Though the origin of the horse

Figure 1. Symbol of Assateague Island National Seashore, feral horses grew in number from 28 in 1968 to a high of 179 in 2002. A successful contraceptive program has reduced the population to 134 individuals in 2008.

NPS PHOTO

population is unclear, by the time the national seashore was established in 1965 the horses had long since become an important regional icon, and they remain very popular among visitors today. Given the horses' historical and cultural significance the National Park Service identified them as a desirable species in 1982 and manages them as wildlife. However, in order to control the size of the population, the park employs a contraceptive program developed for the national seashore (Kirkpatrick 1995) that has reduced the species' numbers from a high of 179 in 2002 to its current size of 134.

Sika deer were introduced to the island in the 1920s by a private landowner (Flyger 1960). Since then, this "deer" species, which is actually a small Asiatic elk, has become naturalized on the island. Both nonnative sika and native white-tailed deer are subject to a congressionally authorized hunting season to control their abundance. Despite considerable annual hunting pressure, sika deer have continued to maintain a sizable population, and at

Figures 2 and 3. Population estimates indicate that nonnative sika deer (top) outnumber native white-tailed deer (bottom) by about three to one on Assateague Island. Both deer species occur throughout the island and are frequently observed in marsh, forest, shrub, and dune habitats.

B. EMERSON (TOP); NPS PHOTO (BOTTOM)

this time their elimination from the island may not be feasible.

For more than two decades scientists have been studying the effects of the three ungulate species on island vegetative communities and natural processes. This article summarizes that program of research and its implications for effective ungulate management strategies.

Initial studies

Growing concern about the ever-increasing horse population and its impacts on vegetation led to initial studies in the 1980s and 1990s. The research focused on the effects of foraging in island dune and low (i.e., lowest-elevation) salt-marsh habitats, since horses spend much of their time in these areas. Stribling (1989) found, for example, that horse grazing altered nutrient cycling in low salt marshes, while Furbish (1990) and Furbish and Albano (1994) discovered that horse grazing reduced aboveground biomass, altered low salt-marsh plant and animal species composition, and at high intensities may change the phenotypic expression (i.e., increased stem density or lower growth form) of cordgrass (*Spartina alterniflora*), the dominant grass species of the low salt marsh. Similarly, Seliskar (1997) found that horse herbivory reduced the abundance of American beachgrass (*Ammophila bevigulata*), a dominant grass species in island dune systems. De Stoppelaire's (2002) research supported this finding, and further revealed that horse herbivory interrupted dune formation and maintenance processes, which are essential to the long-term health and sustainability of the barrier island. All of these findings were attributable only to horses since deer impacts were ubiquitous throughout the treatment areas of all these studies.

Isolating the effects of ungulates

To better understand the effects of herbivory by all three island ungulate species, we decided in 2002 to study the individual influences of horses and deer in island vegetative communities believed to be most commonly used by deer. Previous research using fecal analysis had identified a number of plant taxa consumed by sika and white-tailed deer (Kochenberger 1982; Keiper and Tzilkowski 1983). Using this information we developed a study of ungulate herbivory. We identified multiple potential study sites that had comparable abundance of plant species known to be consumed by both deer species, and then selected four at random in both maritime forest and shrub habitats.

Each study site consisted of three treatments: (1) a horse and deer exclosure (fig. 5), (2) a horse exclosure (deer entered freely) (fig. 6), and (3) a control area where both deer and horses foraged. The exclosures were constructed in fall 2002 and the treatment areas measured 66 × 98 feet (20 × 30 m). Given this design, data from treatment areas excluding both horses and deer reflected the vegetative response to "rest" from all ungulate herbivory, whereas data from treatments that allowed only deer to enter reflected the vegetative response to herbivory by both deer species in the absence of horses.

From 2003 to 2005 we collected data in both the early (spring) and late (summer) growing seasons. We used an adapted pin-sampling technique that sampled from 0 to 4.9 feet (0 to 1.5 m) aboveground, which reflects the range where the vast majority of deer and horse herbivory occurs. We measured and monitored changes in plant species mean height, diversity, evenness, richness, and abundance. We conducted analysis of variance (ANOVA) and Tukey tests on each of these parameters. Also, with help from

Figure 4. Assateague Island preserves some of the only remaining habitat for plants and animals of management concern on the mid-Atlantic coast, including the seabeach amaranth. This threatened annual plant species is vulnerable to trampling and herbivory by ungulates.

NPS PHOTO

Figure 5. With the goal of better understanding the ecological role of ungulates at Assateague Island National Seashore, managers conducted research beginning in 2002 to isolate the influences of horses and deer on park vegetation and ecosystem processes such as invasion by exotic plant species. Exclosures like this kept horses and deer out, allowing scientists to study vegetation without pressure from ungulates.

NPS PHOTO

Figure 6. Used in recent studies, exclosures like this prevented horses from eating and trampling vegetation. Scientists were thus able to isolate the effects of deer on park vegetation.

NPS PHOTO

the NPS Northeast Coastal and Barrier Island Network, we used species relative abundance estimates to conduct analysis of similarity (ANOSIM), a nonparametric technique used to analyze community data. Significant ANOSIM results led us to further conduct similarity percentage analysis (SIMPER), which assesses the level of similarity among areas. We used a protected experiment-wise error rate (α_e) of 0.05 throughout these analyses, which revealed patterns of influence that were directly attributable to deer or horse herbivory, or to the combination of both (see examples in table 1).

Results and discussion

This research has given us a new level of understanding of the role of horse and deer herbivory in the development of Assateague Island's maritime forest and shrub communities. For example, we found that deer primarily limit red maple (*Acer rubrum*) sapling recruitment (table 1). The ecological implications of this effect are great, since it restricts the reproductive capacity of red maple, which today is an important component of many Assateague Island habitats. We also learned that deer herbivory significantly increases the abundance of phragmites (*Phragmites australis*), a nonnative, invasive plant species (table 1). Phragmites apparently compensates for herbivory by increasing the number of shoots and runners it produces; therefore, deer are affecting the rate at which native plant communities are being replaced by homogeneous stands of this invasive exotic. In addition to having important biological ramifications, this finding is significant financially, since we are currently preparing to implement a costly phragmites treatment program.

Horse herbivory was similarly found to be influencing the growth and development of maritime forest and shrub habitats. For example, horses significantly reduced overall species diversity during the summer in forest understory habitats. This is likely the result of foraging combined with other destructive behaviors such as trampling and rubbing. In areas of the forest understory where horses were excluded, plant diversity quickly increased regardless of whether deer were present; however, we found the highest plant species diversity in forest treatments where both horses and deer were excluded. This research also confirmed the finding of Seliskar (1997) and De Stoppelaire (2002) that horse herbivory reduces American beachgrass abundance. Understanding this aspect of the influence of horse herbivory is key because of the important role American beachgrass plays in dune development and maintenance. Table 1 reveals further examples of many other important results that were attributable to horse or deer herbivory.

Complementary studies

In addition to understanding vegetation impacts, we wanted to know more about horse and deer abundance and movements on the island to better understand the relative vegetative influence of each species. The horse population is relatively certain at any given time, since we closely monitor it as part of our contraceptive program to help control population growth. Estimating the size of the island's deer populations, however, was more problematic.

Both species of deer are secretive and their habitats are often dense, making the animals difficult to detect. Given these difficulties, we used distance sampling in part because this survey method could account for individuals that went undetected (Buckland et al. 2001). Using a stratified random sampling design, we established 35 cross-island transects each year from 2003 to 2006 to sample the island's diverse habitats for deer. We typically established the transects several weeks before they were surveyed in order to allow deer to become acclimated to them. We collected these data in February, after the hunting season yet before the birthing season, a time of year when both deer populations experience annual lows. Our estimates were fairly consistent from year to year and revealed an abundance of about 26 sika deer (95% confidence interval [CI]: 17–40) and 8 white-tailed deer (95% CI: 4–15) per square mile (Sturm 2007). This equates to 10.0 (95% CI: 6.6–15.4) sika and 3.1 (95% CI: 1.5–5.8) white-tailed deer per square kilometer.

Cooperators with the U.S. Geological Survey and Pennsylvania State University have also been investigating the movements and habitat use of sika and white-tailed deer using radiotelemetry in a related study that concluded in fall 2007 (Diefenbach 2005). The final report is pending; however, preliminary results reveal movement and dispersal differences between species.

Conclusion

This research has shed new light on the individual and combined effects of horse and deer herbivory on the maritime forest and shrub plant communities of As-

Table 1. Plant response to ungulate herbivory at Assateague Island National Seashore, 2003–2005

Common name	Scientific name	Habitat[1]	Horse or deer[2]
Increase in height			
Tapered rosette grass	*Dichanthelium acuminatum*	Shrub	Deer
Bayberry/waxmyrtle	*Morella* spp.	Shrub and forest	Deer
Greenbrier	*Smilax rotundifolia*	Forest	Horse
Increase in abundance			
Common reed[3]	*Phragmites australis*	Shrub	Deer
Common threesquare	*Schoenoplectus pungens*	Shrub	Both
Decrease in height			
Sand-heather	*Hudsonia tomentosa*	Shrub	Horse
Seaside goldenrod	*Solidago sempervirens*	Shrub	Deer
Decrease in abundance			
Red maple (saplings)	*Acer rubrum*	Forest	Deer
American beachgrass	*Ammophila breviligulata*	Shrub	Horse
Slender woodoats	*Chasmanthium laxum*	Forest	Horse
Bull thistle	*Cirsium* spp.	Shrub	Deer
Hyssopleaf thoroughwort	*Eupatorium hyssopifolium*	Shrub	Deer
Marsh fimbry	*Fimbristylis castanea*	Shrub	Horse
Beach pinweed	*Lechea maritima*	Shrub	Deer
Blackberry	*Rubus* spp.	Shrub	Deer
Seaside goldenrod	*Solidago sempervirens*	Shrub	Deer
Muscadine grape	*Vitis rotundifolia*	Shrub and forest	Deer

Note: Plant taxa include early- and late-season species, annuals and perennials, species that reproduce and disperse via various means, and species that respond differently to environmental stressors such as drought or periodic flooding.

[1]Habitat type where the response occurred (forest or shrub).

[2]Observed response attributable to horse or deer herbivory, or the combined effects of both.

[3]The significant increase in abundance by *Phragmites* was found after four years of data collection. All other results were significant after three years of data collection.

sateague Island. We have begun to understand how horses and deer, individually and collectively, influence the recruitment and expansion of dominant native and nonnative plant species. We are also learning how they directly and indirectly affect the survival and reproductive success of threatened and endangered species (see sidebar). Of great importance, we understand how they can interrupt essential barrier island processes such as dune formation. Finally, we have gained insights into the potential for interspecific competition between sika and white-tailed deer and better understand their relative influence on sensitive vegetative parameters.

The implications of this work are broad: We are moving toward holistic management of the island's horses, deer, and vegetative communities. We are developing monitoring protocols to measure vegetative parameters affected by ungulates. Ultimately, we plan to implement a robust yet conceivably simple adaptive management program designed to inform decisions pertaining to ungulate management and the preservation of the vegetative communities upon which they depend. Over the long term we anticipate that this approach will help us successfully manage Assateague Island National Seashore's horse and deer populations as well as the extent of their individual and combined effects on ecosystem health and integrity. With a little luck this program may one day serve as a model for monitoring, managing, and mitigating the effects of multiple cohabitating native and nonnative wild ungulate populations. The final project report (Sturm 2007) is available from http://www.nps.gov/nero/science/FINAL/ASIS_horsedeer/ASIS_horsedeer.htm.

References

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating the abundance of biological populations. Oxford University Press, New York, New York, USA.

De Stoppelaire, G. H. 2002. Impact of horse grazing on American beachgrass and dune geomorphology: Assateague Island National Seashore. Master's thesis. University of Florida, Gainesville, Florida, USA.

Diefenbach, D. 2005. Movements and habitat use of sika and white-tailed deer on Assateague Island National Seashore. A research proposal submitted by The Pennsylvania State University, College of Agricultural Sciences, School of Forest Resources to the National Park Service, Berlin, Maryland, USA.

Eggert, L. S., J. E. Maldonaldo, R. C. Fleischer, and D. M. Powell. 2005. An assessment of the genetic status of the feral horse population of Assateague Island National Seashore. Report to the National Park Service. Smithsonian Institution, Washington, D.C., USA.

Flyger, V. 1960. Sika deer on islands in Maryland and Virginia. Journal of Mammology 41:410.

Furbish, C. E. 1990. Factors affecting the distribution of *Distichlis spicata* in the *Spartina alterniflora* saltmarshes of Assateague Island, Maryland. Master's thesis. University of Maryland, College Park, Maryland, USA.

Furbish, C. E., and M. Albano. 1994. Selective herbivory and plant community structure in a mid-Atlantic salt marsh. Ecology 75:1015–1022.

Keiper, R. R., and W. M. Tzilkowski. 1983. A study of the behavior and ecology of the sika deer and white-tailed deer within the Assateague Island National Seashore. Division of Natural Sciences Research/Resources Management Report. U.S. National Park Service, Mid-Atlantic Regional Office, Philadelphia, Pennsylvania, USA.

Kirkpatrick, J. F. 1995. Management of wild horses by fertility control: The Assateague experience. National Park Service Scientific Monograph 95/26. National Park Service, Denver, Colorado, USA.

Kochenberger, D. R. 1982. Feeding habits of sika deer *(Cervus nippon)* on Chincoteague National Wildlife Refuge. Master's thesis. Millersville State College, Millersville, Pennsylvania, USA.

National Park Service. 1982. General management plan. Assateague Island National Seashore, Berlin, Maryland, USA.

Seliskar, D. 1997. The effect of grazing by feral horses on American beachgrass at Assateague Island National Seashore. Final Report. University of Delaware, Dover, Delaware, USA.

Stribling, J. M. 1989. Nutrient dynamics in *Spartina alterniflora*—effects of grazing. Master's thesis. University of Maryland, College Park, Maryland, USA.

Sturm, M. 2007. Assessment of the effects of feral horses, sika deer and white-tailed deer on Assateague Island's forest and shrub habitat. National Park Service Preliminary Research Final Report. Assateague Island National Seashore, Berlin, Maryland, USA.

About the Author

Mark Sturm *is an ecologist with Assateague Island National Seashore, Maryland. He can be reached at mark_sturm@nps.gov.*

PS