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Barnett A. Rattner
U.S. Geological Survey, brattner@usgs.gov

Betty K. Ackerson
U.S. Geologica Survey

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Barnett A. Rattner, U.S. Geological Survey, Patuxent Wildlife Research Center, Beltsville Laboratory, c/o BARC-East, Building 308, 10300 Baltimore Avenue, Beltsville, MD 20705; Brattner@usgs.gov

Betty K. Ackerson, U.S. Geological Survey, Patuxent Wildlife Research Center, Beltsville Laboratory, c/o BARC-East, Building 308, 10300 Baltimore Avenue, Beltsville, MD 20705

Introduction

Part of the mission of the National Park Service (NPS) entails preservation of natural resources, processes, systems, and associated values of its units in an unimpaired condition. Environmental contamination and pollution processes are well recognized stressors that can adversely affect park units and are addressed by NPS management policies and plans. Nonetheless, biota remain at risk to contaminants at many NPS units. One U.S. Department of the Interior activity that addresses pollution hazards is the Biomonitoring of Environmental Status and Trends project (Zylstra 1994). Its does so through active field monitoring and by use of decision support tools, including the Contaminant Assessment Process (Coyle et al. 1999) and the Contaminant Exposure and Effects-Terrestrial Vertebrates (CEE-TV) database (Rattner et al. 2005). A recent study using the CEE-TV database found that contemporary terrestrial vertebrate ecotoxicological data are lacking at 59 of 126 Park Service units located in coastal watersheds exhibiting serious water quality problems or high vulnerability to pollution. Based upon this finding, a study was undertaken at 23 Inventory and Monitoring (I&M) Program units in the National Capital Region and Mid-Atlantic networks to evaluate contaminant threats to terrestrial vertebrates. The specific objectives included compiling ecotoxicological data for terrestrial vertebrates (viz., amphibians, reptiles, birds and mammals) residing at these I&M units, using additional pollution data from various federal and state agencies to assess potential hazards at these sites, recommending management activities to mitigate risk, and prioritizing sites for potential contaminant biomonitoring activities.

Methods

Using Geographic Information System procedures, shapefiles were obtained for each park boundary and a 10-km buffer was created around each unit. Because of their proximity, Gettysburg National Military Park (NMP) and Eisenhower National Historic Site (NHS) were joined as one unit.

Potential pollution sources that could affect terrestrial vertebrates were compiled, including (1) National Priorities List (NPL) Superfund sites; (2) Clean Water Act Section 303(d) impaired waters for 2002; (3) pesticide and herbicide use at NPS units for 2004; (4) Toxic Release Inventory (TRI) sites for 1997 through 2003; (5) fish consumption advisories for 2004; (6) solid waste facilities; and (7) wastewater treatment sites. Extant terrestrial vertebrate contaminant exposure and/or effects information was obtained from the CEE-TV

database (Rattner et al. 2005). In an attempt to garner additional data, interviews were conducted with staff of each I&M unit using questions derived from the Contaminant Assessment Process guidance document (Coyle et al. 1999). All of these data were overlaid on the NPS unit boundary and buffer shapefiles.

Initially data were qualitatively reviewed (presence of contaminants in abiotic media and prey species, pesticide and herbicide use, presence of critical areas or sensitive species, and existing wildlife toxicology data). A semi-quantitative ranking scheme was then applied to rank contaminant threats at or near each national park unit (e.g., NPL sites, impaired waters, number of pesticides and relative toxicity, number of TRI sites and fish consumption advisories). A data richness metric was also derived that reflected the quantity and type of wildlife exposure and effects information. This data richness score in combination with known contaminant threats and size of the national park unit was examined to identify and rank relative contaminant monitoring/research needs of each park unit. For example, parks with low contaminant threats or a large number of terrestrial vertebrate ecotoxicological data were ranked low, while parks with high contaminant threats and relatively little terrestrial vertebrate data were identified as priority sites for study.

Results and discussion

The qualitative review of data revealed that over half of the national park units are near air pollution sources of concern, and lead, mercury and dioxins from TRI sites may be deposited at or near several of the national park units. Many priority pollutants (e.g., PCB, chlordane, mercury) were present in water ways within or near 12 national park units, and with the exception of Appomattox Court House National Historical Park (NHP), fish consumption advisories are in effect at or near 22 study units. Application of pesticides and herbicides at national park units is highly regulated, and with the exception of units with major agricultural leases (Antietam National Battlefield [NB], Gettysburg NMP, Fredericksburg & Spotsylvania NMP, and Monocacy NB), use on parks is minimal. Only 70 unique terrestrial vertebrate contaminant exposure and effects records were found, and these included 27 necropsy reports, 16 monitoring studies, and 27 hypothesis-driven investigations. Only 58 unique compounds were quantified, and the vast majority of these reports dealt with legacy organochlorine pesticides and PCBs, many of which are now banned. Other contaminants included organophosphorus and carbamate pesticides, rodenticides, petroleum hydrocarbons, and metals. Only one report (Rattner et al. 2004) addressed exposure to compounds of more contemporary concern (alkylphenols, perfluroinated compounds and brominated flame retardants).

Environmental contaminant threats appeared to be substantial at eight of the 22 study areas, while such threats were seemingly low at five park units (Table 1). Parks with the seemingly greatest threat of contamination were those near (1) impaired waters, (2) numerous TRI sites, and (3) TRI sites releasing large numbers of priority pollutants (i.e., Fort McHenry National Monument and Historic Shrine [NM & HS], Richmond National Battlefield Park [NBP], National Capital Parks-East, and Chesapeake & Ohio Canal NHP). Other units that appear to be moderately threatened by contaminants included Petersburg NB and Valley Forge NHP, principally because of their proximity to numerous TRI sites. In contrast, Shen-

Table 1. Rank of Overall Contaminant Threat to Mid-Atlantic and National Capital Region Network Park Units[a]

Park Name	NPL Sites	Percent Surface Waters Impaired	No. of Toxic Pesticides[b]	Relative Toxicity of Pesticides	No. of TRI Sites	No. TRI Sites Discharging POPs[c]	State Fish Consumption Advisories	Overall Contaminant Threat[d]
Antietam NB	0	1	2	2	1	0	1	7
Appomattox Court House NHP	0	0	2	1	1	1	0	5
Booker T Washington NM	0	0	1	1	0	0	2	4
Catoctin Mountain NP	0	0	1	1	1	0	1	4
Chesapeake & Ohio Canal NHP	2	0	1	1	4	3	2	13
Fort McHenry NM & HS	2	3	2	2	4	3	2	18
Fredericksburg & Spotsylvania NM	0	0	2	1	1	1	2	7
George Washington MP	1	0	0	0	2	1	2	6
Gettysburg NMP & Eishenhower NHS	0	0	3	2	1	0	1	7
Harper's Ferry NHP	0	0	3	2	1	1	2	9
Hopewell Furnace NHS	0	1	2	2	2	1	2	10
Manassas NBP	0	0	0	0	2	1	2	5
Monocacy NB	0	0	3	2	3	1	1	10
National Capital Parks-East	4	1	0	0	4	3	2	14
National Mall & Memorial Parks	1	1	0	0	2	1	2	7
Petersburg NB	0	1	1	1	4	2	2	11
Prince William FP	1	0	1	1	1	1	2	7
Richmond NBP	1	0	2	2	4	3	2	14
Rock Creek Park	1	1	2	2	2	1	2	11
Shenandoah NP	2	1	3	2	3	1	2	14
Valley Forge NHP	2	1	1	1	4	1	2	12
Wolf Trap NP for the Performing Arts	0	0	0	0	1	0	1	2

[a] Classification threat ranking scheme ranges from low (0) to high.

[b] Based on the toxicity classification scheme in Hill and Camardese (1986) and Smith (1987); pesticides classified as moderately toxic, highly toxic, and very highly toxic.

[c] Persistent organic pollutants.

[d] Overall contaminant threat score was derived as the sum of individual contaminant threat categories (2, low; 7, moderate; 18, serious).

andoah National Park (NP), located in a rural forested area, also ranked high in this scheme, due to the use of a large number of pesticide formulations containing active ingredients that are suspected to be highly toxic to amphibians (Birge et al. 2000). National park units with apparently lowest contaminant threats were located in areas with no NPL Superfund sites, few TRI sites, and a low percentage of impaired waters (e.g., Wolf Trap NP for the Performing Arts, Catoctin Mountain Park, and Appomattox Court House NHP). Some of the parks with seemingly low contaminant threats either contain or are close to affected waterways. For example, Smith Mountain Lake and the Roanoke River have fish consumption advisories due to elevated PCB burdens, and are within two kilometers of Booker T. Washington NM. Fish consumption advisories due to PCBs exist for Bull Run, a stream that runs through the northeastern portion of Manassas NBP.

Terrestrial vertebrate ecotoxicological data derived from hypothesis-driven studies are available at or near several park units (e.g., National Capital Parks-East, Fort McHenry NM & HS, Petersburg NB). However, there are a number of study units for which there are no contemporary exposure and effects information for terrestrial vertebrates (e.g., Hopewell Furnace NHS, Antietam NB, Harpers Ferry NHP, and Catoctin Mountain Park).

Those national park units with the most significant monitoring or research priority are sites with the greatest contaminant threat *and* little or no terrestrial vertebrate ecotoxicological data. Units that match this criterion include Shenandoah NP, Richmond NB, Valley Forge NHP, Hopewell Furnace NHS, Monocacy NB, and Harpers Ferry NHP (Table 2). Although the threat of contaminants to terrestrial vertebrates is great at Fort McHenry NM & HS, National Capital Parks-East, and Chesapeake & Ohio Canal NHP, a number of necropsy, monitoring, and research study reports are available for these sites. However, the Chesapeake & Ohio Canal NHP and its buffer constitute the largest study area in this investigation, and based upon its size deserves special consideration. The hazard of contaminants to terrestrial vertebrates at Wolf Trap NP, Booker T. Washington NM, and Catoctin Mountain Park appears to be minimal, but little if any terrestrial vertebrate ecotoxicological data are available at these sites.

Conclusions

Based upon these and other findings, ecotoxicological monitoring and research investigations of terrestrial vertebrates are warranted at several national parks in the National Capital Region and Mid-Atlantic Networks. These include Shenandoah NP, Richmond NBP, Chesapeake & Ohio Canal NHP, Valley Forge NHP, Hopewell Furnace NHS, Monocacy NB, and Harpers Ferry NHP. The types of investigations vary according to the species present at these parks and potential contaminant threats, but should focus on contemporary pesticides and herbicides, PCBs, mercury, lead, and perhaps, emerging contaminants including antibiotics, flame retardants, pharmaceuticals, and surfactants. Other management recommendations include additional training for natural resource staff members in the area of ecotoxicology, inclusion of terrestrial vertebrate contaminant monitoring and the Contaminant Assessment Process into the NPS Vital Signs Program, development of protocols for handling and toxicological analysis of dead or seemingly affected wildlife, consideration of some alterna-

Table 2. Prioritization of ecotoxicological research and monitoring needs at NP units

Park Name	Area, inc. buffer (km^2)	Data Richness Score[a]	Overall Contaminant Threat[b]
Shenandoah NP	4042.3	1	14
Richmond NBP	1311.3	1	14
Valley Forge NHP	482.6	1	12
Hopewell Furnace NHS	403.5	0	10
Harper's Ferry NHP	560.4	0	9
Monocacy NB	438.8	1	10
Antietam NB	503.5	0	7
Chesapeake & Ohio Canal NHP	5088.4	3	13
Fort McHenry NM & HS	331.0	4	18
National Capital Parks-East	1826.0	4	14
Rock Creek Park	542.8	3	11
Fredericksburg & Spotsylvania NM	1467.9	1	7
Gettysburg NMP/Eishenhower NHS	666.5	1	7
Catoctin Mountain NP	563.3	0	4
Petersburg NB	1190.2	3	11
Prince William FP	673.9	1	7
Appomattox Court House NHP	491.7	1	5
Manassas NBP	544.7	1	5
National Mall & Memorial Parks	524.8	3	7
George Washington MP	1013.1	3	6
Booker T Washington NM	359.5	1	4
Wolf Trap NP for the Performing Arts	341.0	1	2

[a] 0, low; 4,high.
[b] 2, low; 7, moderate; 18, serious.

tive methods and compounds for pest management and weed control, and use of non-toxic fishing tackle by visitors.

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