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Maintaining the Biological Integrity, Diversity, and Environmental Health of the National Wildlife Refuge System

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Section 4(a) of the National Wildlife Refuge System Improvement Act of 1997 states that, in administering the National Wildlife Refuge System, the secretary of the interior shall “ensure that the biological integrity, diversity, and environmental health of the System are maintained for the benefit of present and future generations of Americans.” This clause, hereinafter called the “biological integrity and environmental health clause,” provides one of the philosophical cornerstones of refuge system management. A policy to implement the clause was published in the *Federal Register* (U.S. Fish and Wildlife Service 2001). The policy constitutes Part 601, Section 3 of the Fish and Wildlife Service Manual and is hereinafter called “601 FW 3.”

In 601 FW 3, biological diversity is defined as “the variety of life, including the variety of living organisms, the genetic differences among them, and the communities in which they occur.” Biological integrity refers to “biotic composition, structure, and functioning at genetic, organism, and community levels consistent with historic conditions, including the natural biological processes that shape genomes, organisms, and communities.” Environmental health means “abiotic composition, structure, and functioning of the environment consistent with historic conditions, including the natural abiotic processes that shape the environment.” For the purposes of this article, the phrase “ecological integrity” will be used to represent the summation and integration of biological integrity, diversity, and environmental health.

In the process of implementing 601 FW 3, refuge managers are required to:

1. Ascertain the purposes of the refuge.
2. Ascertain historic conditions for the refuge. Historic conditions are defined as “composition, structure, and functioning of ecosystems resulting from natural processes that we believe, based on sound professional judgment, were present prior to substantial human related changes to the landscape.”
3. Assess current conditions and compare them with historic conditions to determine the degree to which ecological integrity has been compromised.
4. Determine the refuge’s importance to local, regional, national, and international ecological integrity, and identify refuge-specific roles and responsibilities within that context.
5. Consider the relationships among biological diversity, biological integrity, and environmental health, and integrate the application of these concepts.
6. Consider the purposes of the refuge and employ management techniques in pursuit of ecological integrity, phasing out techniques that compromise ecological integrity.

Scope of the biological integrity and environmental health clause

The biological integrity and environmental health clause applies to the entire refuge system, but the extent to which it applies to individual refuges varies with each one's purposes, which are provided in the legal instruments used to establish them (such as acts of Congress and executive orders). Where the purposes of a refuge may conflict with ecological integrity—for example, when they include domestic livestock grazing or other activities that are inconsistent with historic, natural conditions—refuge management adheres to the guidelines provided by 601 FW 3 to the maximum extent practicable.

Maintaining or restoring biological integrity, biological diversity, and environmental health

Refuge managers consider the relationships among biological diversity, biological integrity, and environmental health, and integrate these concepts in management decisions, as described in the next section. Nevertheless, it is essential to understand what is required to maintain each of the three components in order to integrate the maintenance of each.

Biological diversity. Refuge managers strive to maintain populations that are numerically viable and sufficiently functional to maintain genetic diversity. They minimize fragmentation and loss of connectivity within and between blocks of habitats. They maintain or restore corridors to facilitate movement of terrestrial wildlife and provide for the breeding, migrating, and wintering needs of migratory species.

Refuge managers develop estimates of species richness and, if possible, relative abundance as measures of biological diversity. They also manage for biological diversity at other taxonomic levels, including class, order, family, genus, subspecies, and distinct populations. At the community level, refuge managers monitor biological diversity using indicators of plant community composition, typically based on the National Vegetation Classification System.

Biological integrity. Refuge managers maintain or restore biological integrity by maintaining, restoring, or mimicking the natural environmental and evolutionary processes that shape ecosystem composition (including species) over time. These processes include plant community succession, the evolution of species, and disturbance regimes such as fire and flooding. Refuge managers mimic natural processes—for example, by using water control structures to simulate natural hydrological functioning—to contribute to the restoration of biological integrity.

Maintaining or restoring biological integrity is not the same as maximizing biological diversity. Managing the refuge system for the conservation of biological integrity may entail managing for a single species or community at some refuges and for combinations of species or communities at other refuges.

Environmental health. Corresponding to the genetic level of biological integrity, refuge managers maintain or restore environmental health by preventing contamination that interferes with reproductive physiology and mutation rates. Such contamination includes carcinogens and other toxic substances that are released within or outside of refuges.

At the population and community levels, refuge managers consider the habitat compo-

nents of food, water, cover, and space. Food and water may become contaminated with chemicals that are not naturally present. Security or thermal cover may be modified by activities such as logging and mining or by structures such as fences and water tanks. Security is also compromised by unnatural noise and light pollution. Space may be displaced by unnatural physical structures, including buildings, reservoirs, infrastructure, and fences. Refuge managers construct new facilities and maintain existing facilities only when necessary to accomplish the purposes of a refuge or to contribute to overall ecological integrity. Facility construction and maintenance is designed to minimize impacts on environmental health.

At the ecosystem level, the major physical components and structures include topography, geological formations, soils, hydrology, and airsheds. Physical functions include soil formation, water cycles, nutrient cycles, and temperature regulation. Environmental health is diminished when the natural condition of these physical components, structures, and functions are modified by unnatural processes associated especially with industrial activities or industrialized agricultural and extractive activities. Refuge managers avoid the unnatural modification of the physical components of natural habitats and ecosystems and strive to restore natural physical components.

Integrating biological diversity, biological integrity, and environmental health

Considered independently, biological integrity, biological diversity, and environmental health can be conflicting goals. The integration of these properties produces ecological integrity (Pimentel et al. 2000). Refuge managers manage for ecological integrity in an integrated and holistic manner by maintaining, restoring, and mimicking historic, natural conditions. Refuge managers thus reduce the divergence between current and historic conditions.

Refuge managers do not always attempt to maximize ecological integrity at a particular refuge, because they are also concerned with ecological integrity at the ecosystem, national, and international levels. With regional and national guidance, they focus on natural communities, species, and ecological processes that are rare, declining, or unique. For example, they may contribute most to the ecological integrity of the refuge system by managing a particular refuge for a single vegetative community such as a nationally significant saltmarsh, desert, or coniferous forest, or by managing for a single species or group of species.

Unless sound professional judgment indicates that a species was present in the area of a refuge under historic conditions, managers do not introduce or maintain the presence of that species for the purpose of biological diversity. They may make exceptions where areas are essential for the conservation of a threatened or endangered species and suitable habitats are not available elsewhere. Cases may also arise where biological diversity has become unnaturally high. For example, small-scale agriculture in the midst of undeveloped lands may result in unnaturally high levels of biological diversity due to increased edge effect.

In fragmented landscapes, physical structures may be necessary to maintain biological integrity; for example, water control structures to maintain and restore natural hydrological cycles. While these structures compromise environmental health because they are unnatural physical alterations, they are essential to maintaining the biological integrity of the refuge and are usually considered appropriate.

Determining the historic conditions of a refuge

Management for biological integrity and environmental health requires a frame of reference. For refuge management purposes, the frame of reference is “historic conditions,” or those “resulting from natural processes” and “present prior to substantial human related changes to the landscape” (601 FW 3). Although humans played a significant role in shaping American flora and fauna throughout the Holocene epoch, “substantial” human-related changes are generally interpreted to have begun with the early stages of the American industrial revolution, circa 1800.

Refuge managers must also determine how much prior to substantial human-related changes should be considered in the frame of reference for historic, natural conditions. The draft version of 601 FW 3 circulated for public review cited the advent of the Medieval Warm Period (circa 800 AD) as the beginning of an ecologically and evolutionarily relevant frame of reference for natural conditions (U.S. Fish and Wildlife Service 2000). The precise starting point is not as important as avoiding the use of a “snapshot in time,” such as conditions as they occurred precisely in 1799, for example. The full range of an area’s natural plant community succession should be considered as indicated below. However, it is also important to avoid the use of irrelevantly ancient time periods (such as the Pleistocene epoch or earlier).

In some areas the industrial revolution did not commence until much later than 1800, especially in Alaska. In these areas, refuge managers may extend the frame of reference for historic, natural conditions beyond 1800 based on historical information and sound professional judgment.

Information on conditions prior to substantial human-related changes may be historical, archaeological, or paleoecological (including fossils, packrat middens, pollen cores, and tree ring data). Refuge managers obtain information on these conditions from their own investigations and from their partners in academia, conservation organizations, and other government agencies.

Consideration of successional stages in determining historic conditions

Refuge managers ensure that their management activities result in the establishment of a community that fits within the natural successional series. For example, if they determine that an area in question was aspen parkland in 1750, they may manage for aspen parkland or any other community that fits within the natural successional series, with a focus on natural communities and ecological processes that are rare, declining, or unique for the sake of conserving biodiversity. They may choose to maintain nonclimax communities pursuant to refuge purposes. They favor techniques such as fire that mimic or result in natural processes to maintain these nonclimax communities. However, where not precluded by refuge goals and objectives, they allow or, if necessary, encourage natural successional processes.

If there is evidence that certain successional stages were naturally precluded, refuge managers generally do not attempt to manage for those stages. For example, if a volcanic eruption in the 12th century impounded water that flooded a forest, creating a lake in the process, refuge managers would not drain the lake to reproduce the forest. Reproducing conditions that naturally ceased to exist compromises ecological integrity.

However, some relatively natural disturbance events warrant restoration efforts, especially more recent events that may have been exacerbated by unnatural conditions. For example, if an intense forest fire resulted in the sterilization of soils on a refuge, and forested habitats were required for fulfilling refuge purposes, it would be appropriate to fertilize and otherwise restore conditions conducive to forested habitats, especially if the fire's intensity resulted from an unnaturally modified fire regime. This example illustrates the need for a holistic perspective and sound professional judgment in implementing the biological integrity and environmental health clause.

Managing populations to maintain and restore ecological integrity

Population management strategies on the refuge system are designed to support accomplishing refuge purposes and system objectives while maintaining or restoring ecological integrity. When consistent with refuge purposes, refuge goals and objectives for population management are formulated to maintain natural densities, social structures, and dynamics.

On some refuges, including many of those having the purpose of migratory bird conservation, managers establish objectives to maintain densities higher than those that would naturally occur because of the loss of surrounding habitats. By maintaining higher densities at the refuge level, refuge managers more closely approximate natural levels at larger scales. Refuge managers also consider population parameters such as sex ratios and age class distributions, objectives for which may be set within the range of values occurring under historic, natural conditions.

Refuge managers support the reintroduction of native species that have been extirpated. They do not introduce species outside their historic range or introduce species that were naturally extirpated, unless such introduction is essential for the survival of a species and is prescribed in an endangered species recovery plan. They detect and control populations of invasive species.

Habitat management

Refuge managers manage habitats to meet refuge objectives using strategies that promote ecological integrity by maintaining or mimicking natural ecosystem functions. For example, prescribed burning to maintain natural fire regimes or water level management to mimic natural hydrological cycles is often necessary to maintain natural plant and animal communities in fragmented landscapes. Farming, haying, logging, and livestock grazing are appropriate habitat management practices only when they are prescribed in plans to meet wildlife or habitat management objectives, and only when more natural methods such as prescribed fire or grazing by native herbivores are not feasible.

Refuge managers do not authorize land uses or management practices that result in the maintenance of nonnative plant communities unless they determine that there is no other feasible alternative for accomplishing refuge objectives. Where farming is practiced, refuge managers develop integrated pest management strategies that consider the effects on ecological integrity. Where farming is practiced but not prescribed in plans to support accomplishing refuge purposes, refuge managers may cease farming and strive to restore natural habitats.

Maintaining and restoring ecological integrity at the system level

Refuge managers maintain and restore ecological integrity on individual refuges and contribute to the maintenance and restoration of ecological integrity at broader landscape scales. Refuge, regional, and national personnel evaluate how individual refuges contribute to accomplishing national, regional, flyway, and ecosystem goals.

For example, on the Alaska Maritime National Wildlife Refuge, biological integrity includes a high density of nesting Aleutian Canada geese. The wintering grounds in California, however, have been usurped to a large extent by agriculture and other developments. Only if refuges on the wintering grounds, including the Sacramento and San Luis National Wildlife Refuge Complexes, are managed intensively can a goose population conducive to historic conditions on the Alaska Maritime Refuge be supported. Intensive management includes mechanized crop production, which compromises biological integrity and environmental health. With national and regional input, refuge managers therefore compromise some of the ecological integrity of the southern refuges to pursue the ecological integrity of the Alaskan refuge and of the system as a whole.

Ecological integrity in the context of climate change

With the global climate changing as a function of industrial production, maintaining or restoring historic, natural conditions will become more difficult. Global warming and sea-level rise pose particularly salient challenges to the ecological integrity of the refuge system, especially in coastal areas where many refuge properties will be submerged or transformed into different habitats in the current century. Maintenance or restoration of historic, natural conditions will not be possible in such scenarios. However, ecological integrity will remain relevant to managers. Regardless of how far conditions may differ from the baseline of ecological integrity, management prospects may always be viewed in terms of their propensity to drive an area closer to or further from historic, natural conditions and to mimic natural processes.

Summary

The biological integrity and environmental health clause of the Refuge Improvement Act provides one of the philosophical cornerstones for refuge system management. With a focus on historic, natural conditions, management will generally be less intrusive and will be designed to mimic natural processes. Ecological integrity may never be entirely restored, but the U.S. Fish and Wildlife Service and its managers will strive to maintain existing levels of ecological integrity and will achieve a degree of success in restoring what has been lost. The result will be a refuge system that more accurately represents the wildlife heritage of the nation.

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