Viewsheds: a complementary management approach to buffer zones

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Recreational activities may displace and disturb wildlife, as well as contribute to wildlife mortality (Knight and Gutzwiller 1995). Management actions currently used to reduce harmful effects of human activities are based on activity or access restrictions (Knight and Temple 1995). Land managers typically identify a species sensitive to disturbance, such as a bird-of-prey, and during sensitive periods (e.g., reproduction) create a spatial buffer zone within which human activities are restricted (Knight and Skagen 1988).

Wildlife may be disturbed prior to actual flight. McGarigal et al. (1991) developed the Dual Disturbance Threshold Model which categorized wildlife responses to disturbance at *agitation* and *flushing* distances (also see Anthony et al. 1995). This model acknowledges that wildlife respond to disturbances physiologically before they respond behaviorally. Heart rate increases and attention is diverted to human activities at a distance greater (the *agitation* point) than the distance where wildlife actually flee (the *flushing* distance). Spatial buffer zones, however, are implemented at the flushing distance.

The Nature Conservancy at Phantom Canyon Preserve, Colorado, regulates visitors and their activities but allows guided field trips, fishing, and work parties. Within the preserve are 2 occupied golden eagle (*Aquila chrysaetos*) territories. Given the importance of cliffs to nesting raptors and the relative lack of understanding of the effects of human activities on wildlife, we surveyed the cliff habitat used by nesting golden eagles at this preserve. Subsequently, using both a geographic information system (GIS) and a global positioning system (GPS), we developed a management scheme that considered spatial zones incorporating the viewshed from each nest. We defined a viewshed as the area visible across a landscape from a point location (nest site).

Methods

The Nature Conservancy's Phantom Canyon Preserve is located in Larimer County, Colorado, 40°N, 105°E, and comprises approximately 470 ha, including 8.5 km of the North Fork of the Cache la Poudre River. In addition, a contiguous 220-ha area and 1.5 km of the river form a conservation easement managed by The Nature Conservancy and considered part of the Phantom Canyon Preserve. The river bisects Phantom Canyon Preserve through the surrounding short grass prairie and foothills of the Rocky Mountains to form a canyon (approx 150 m below the rim).

Between 31 January and 26 February 1994, we searched all cliffs in the Phantom Canyon Preserve (including the Conservation Easement) for eagle nests. We found 6 nests and measured nest exposure and nest-site characteristics by rappelling into each nest. We determined the location of each nest using a GPS. The GPS used was the Trimble Scout (Trimble Navigation 1992, 1994). At each point, 3-dimensional fixes were obtained; however, due to the topography of the canyon, 2-dimensional fixes were used in some cases. The GPS was configured to register spatial data in North American Datum of 1927, a projection of UTMs and elevation in meters.

We digitized the boundary of the Phantom Canyon Preserve. Next we entered the cliff periphery points and eagle nest sites into Arc/Info, Version 6.1 (ESRI 1991) on a Sun Sparc workstation (Sun Microsystem, Mountain View, Calif.). For cliffs, arcs were added connecting the corners, thus creating cliff polygons.

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Nest and cliff coverages were based on field data that were spatially corrected. We used the Livermore Mountain Digital Elevation Model (DEM; U.S. Geol. Surv., electronic data, 1993), which contains the entire Phantom Canyon Preserve, for this project. For consistency each of the coverages was created or converted to the North American Datum of 1927, UTM-zone 13 projection in meters.

A buffer zone of a 333-m radius has been suggested for golden eagle nests when the birds are rearing young and exposed to a variety of human activities (Suter and Joness 1981). Accordingly, for each nest we generated a spatial buffer zone of a 333-m radius using Arc/Info (BUFFER algorithm, ESRI 1991). Arc/Info (VISIBILITY algorithm, ESRI 1991) and the DEM were used to generate the viewshed cover. No portion of the DEM was visible beyond a 3-km radius of a nest because nests were below the canyon rim. Therefore, we restricted each viewshed algorithm to sample for visible portions within a 3-km radius from each nest. This included lands within the preserve as well as private lands adjacent to the preserve. Buffer zones and viewsheds for each eagle nest were overlaid on a map of Phantom Canyon Preserve and the surrounding private lands.

Results

The total area that fell within the 333-m-radius buffer zones was 145 ha, while the area encompassed by the viewsheds was 434 ha (Fig. 1). One nest was located several meters above another; therefore, the projections overlaid each other and only 5 nest sites are apparent in Figure 1. The total area included within the 333-m-radius buffer zones that fell within Phantom Canyon Preserve and the private lands was 133 and 12 ha, respectively. The total area within the viewsheds that fell within Phantom Canyon Preserve and the private lands was 278 and 156 ha, respectively. Collectively, buffer zones and viewsheds comprised 48% (330 ha) of the Phantom Canyon Preserve, and 168 ha extended onto private land.

Discussion

Cliffs concentrate a unique group of biologically diverse species, including raptors (Camp and Knight 1997). A variety of raptor species are either obligate cliff nesters or nearly so (Newton 1979). The wild-

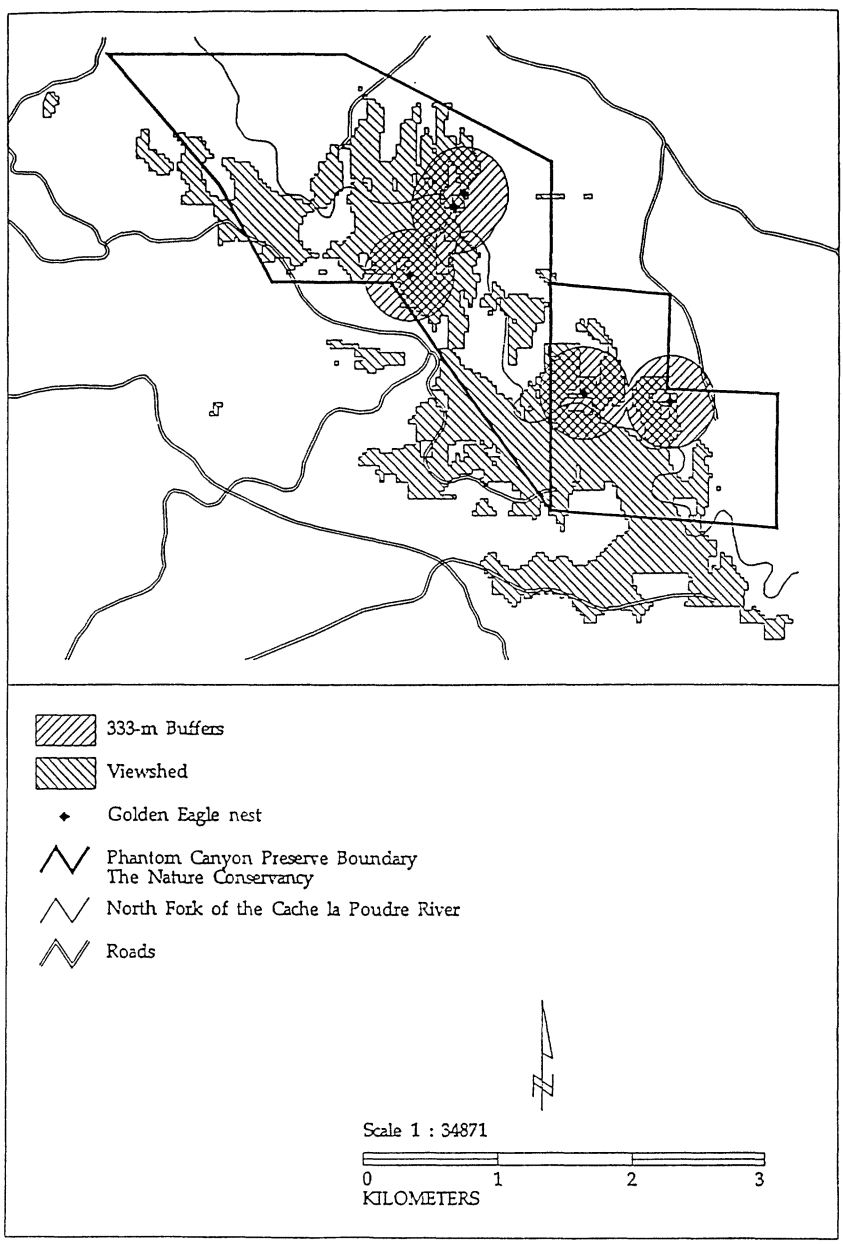

Fig. 1. Viewshed and buffer zones for golden eagle nests in Phantom Canyon, Colorado, 1994. One nest was located several meters above another; therefore, only 5 nests are apparent in the figure.

life-viewing public seeks out cliffs specifically to observe raptors and expects land managers to preserve these species. The viewsheds from all of the nests and 2 of the buffer zones in the Phantom Canyon Preserve fell outside the preserve boundary. Within the preserve, access to the river from the canyon rim is restricted to 1 trail, which descends through an eagle viewshed. Visitors at the river continue to be within sight of nesting birds as the viewsheds overlap and include most of the canyon floor.

Proactive management plans can be developed to minimize human activities potentially disturbing to eagles. If breeding eagles are flushed from the nest, eggs or young may experience adverse temperature changes and predation. Disturbance may also disrupt feeding of the young and result in increased nestling mortality (Knight and Skagen 1988). Viewshed management provides a more accurate assessment of birds' needs at individual nests. When birds are shielded from disturbances by vegetation (Stalmaster and Newman 1978) or topographical features such as cliffs, flushing distances are reduced. The use of viewsheds provides a manager with a realistic understanding of spatial requirements. Indeed, a viewshed approach to spatially managing disturbance may require less protected area than buffer zones, although this was not the case in our study.

We suggest that a more comprehensive approach to protecting wildlife from disturbance may include both a buffer zone and a viewshed. This dual approach may restrict activities potentially harmful to birds within the buffer zone, or flushing area, as well as mitigating wildlife responses to activities within the viewshed, or agitation area (McGarigal et al. 1991, Anthony et al. 1995). By creating viewsheds for sensitive species, managers may be better able to locate trails, panoramic sites, and tours, so as to minimize disturbances from these kinds of activities and regulate human activities during specific seasons. In addition, a viewshed database is dynamic in response to changes in wildlife distribution and proposed land-use projects. Newly located as well as recently inactive wildlife sites and proposed management activities can be incorporated into the existing database to assess potential impacts on wildlife.

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