Managing for Climate Change within Protected Area Landscapes

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Steward's Circle

Managing for Climate Change within Protected Area Landscapes

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ABSTRACT: Protected area managers should aim to help the greatest number of species and habitats that presently occur within their parks to adapt and persist in the face of climate change, and ensure that the novel ecosystems that emerge are diverse and resilient. A practical and cost-effective approach to achieve these goals is to focus management efforts on habitat corridors along natural environmental gradients (that is, adaptation corridors embedded within larger natural landscapes) and keystone habitats that provide critical resources within existing protected areas.

Index terms: adaptation, climate change, corridors, management, Mediterranean ecosystem, protected areas, Southern California

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INTRODUCTION

Favorable environments for many terrestrial species are predicted to shift spatially and temporally as global warming drives climate change (Walther et al. 2002; Root et al. 2003; Parmesan 2006). More vagile animals may simply move to a more suitable environment, while other species may adapt *in situ* to new conditions or slowly shift their distribution over generations (Pearson and Dawson 2003; Smith and Bernatchez 2007). However, climate change may be occurring more quickly than most taxa can effectively respond to through local adaptation or large-scale migration across landscapes or through corridors (Peters and Darling 1985; Hobbs and Hopkins 1991; Hannah et al. 2002; Araújo 2004; Hannah et al. 2005). Assisted migration has been proposed to facilitate range shifts (Root and Schneider 1991), but it typically is costly, problematic, and often translocates a trivial portion of a species population or local biodiversity. For these reasons, we believe that efforts to facilitate adaptation of terrestrial species and natural communities to climate change must be focused within existing protected areas and their local natural landscapes (generally at a scale < 300 km^2).

Adaptation corridors

Protected area strategies, work plans, and budgets should target management activities within local-scale corridors of contiguous natural habitat along natural environmental continuums, such as elevation, soils, or precipitation gradients (Hobbs and Hopkins 1991; Hannah et al. 2002; Hannah et al. 2005). Such corridors are embedded within natural landscapes and provide room to move and favorable conditions for local adaptation rather than acting as connectors.

Managers should strive to keep these corridors in as good a condition as possible through effective control of invasive species, maintenance of natural fire regimes, restoration of habitat, removal of barriers to contiguous habitat (for example, paved roads), and assurance that corridors are of adequate width to reduce edge effects (for example, invasive ants, encroaching weeds, feral cats, light, and moisture gradients associated with edges). Adaptation corridors dominated by healthy natural vegetation maximize the ability of the ecosystem to retain moisture and to provide mesic and thermal refugia for species and assemblages. Assumedly, this will improve their chances of persisting, successfully shifting their distribution over short distances, or adapting locally to new conditions (Harris et al. 2006). Corridor boundaries should be delineated to encompass multiple habitat types and populations of species to act as source biodiversity. In some situations, acquiring new land adjacent to existing protected areas may be important to encompass new source populations or provide greater area to sustain present populations. Habitat adjacent to existing protected areas may also help to increase reserve heterogeneity through additional gradients, establish protection for contiguous habitat along gradients, or permit shifting of species ranges to higher latitudes or elevations.

This management approach is being applied to the protected wildlands of the northern Santa Ana Mountains (managed and/or owned by California State Parks, California Department of Fish and Game, County of Orange, U.S. Forest Service, The Irvine Company, and the Irvine Ranch Conservancy) that conserve chaparral, sage scrub, native grasslands, oak-sycamore woodlands (*Quercus agrifolia* Née-*Platanus racemosa* Nuttall), and riparian habitats characteristic of Southern California. Mediterranean-climate ecosystems, including those of California, are predicted to become hotter and drier as a result of climate change (Galbraith et al. 2003; Lenihan et al. 2003; Hayhoe et al. 2004; Cayan et al. 2006; Seager et al. 2007; Diffenbaugh et al. 2008; Hall et al. 2008).

Within the Irvine Ranch wildlands of the Santa Ana Mountains, two priority climate change corridors have been identified that run along three environmental gradients, namely, thermal and precipitation gradients associated with elevation, coastal fog precipitation (that is, the distance from the Pacific Ocean and associated exposure to coastal fog) (Weathers 1999), and watershed gradients (that is, variations in groundwater, shading, slope, soil, etc. associated with location within a watershed) (Figures 1-3).

The Santa Ana Mountains corridors are being targeted for habitat restoration, particularly for willow (*Salix* spp.) riparian communities and oak-sycamore woodlands, and control of high-impact invasive plants in riparian zones, such as *Tamarix ramosissima* Ledeb and arundo (*Arundo donax* Linnaeus), to boost mesic and thermal buffering in canyon bottomlands. Water retention and availability across the landscape (that is, within specific habitats, riparian areas, and groundwater) can also be improved through watershed-scale restoration of introduced annual grasslands to sage scrub and other native habitats that have greater retention capacity and narrower seasonal windows for fire risk.

Fire prevention and control can increase the proportion of late-successional vegetation for similar benefits. Fire management is a top priority in the Mediterranean-climate ecosystems of Southern California as fire intervals are currently very short (e.g., 5-15 years) compared to an estimated minimum interval of 60 years for natural ecosystems (Keeley and Fotheringham 2001), and the impacts of recurrent fires have profound and widespread ecological impacts (Zedler et al. 1983; Keeley and Fotheringham 2003).

The boundaries of these adaptation corridors largely follow those of watersheds to encompass their multiple biophysical gradients (Figure 1). The inclusion of entire watersheds within the corridors also helps capture a range of species characteristic of ridgeline, slope, or canyon habitats. Corridor boundaries diverge slightly from watersheds, in some cases, to encompass some populations of species of special concern deemed to have poor dispersal abilities, such as some plants, invertebrates, and reptiles.

Healthy keystone habitats

For some ecosystems, particularly those that experience drier conditions and more seasonal variability, managers should identify, map, and 'strengthen' (that is, carry out management activities to maintain the habitats in as good a condition as possible) keystone habitats that provide critical resources for a range of wildlife and species of special concern. For example, riparian habitats, palm canyons, and natural springs in desert areas are particularly important for the life histories and survival of numerous taxa and guilds, such as top carnivores, nesting birds, and pollinators. Wetlands, high productivity habitats such as acorn-producing oak woodlands, and important wildlife corridor bottlenecks are other temperate examples. Management activities for the Santa Ana Mountains are being focused on several keystone habitats including riparian, oak-sycamore woodlands, natural springs, and cactus scrub.

Change sensitivity profiles

Managers employing similar best practices for climate change management - targeted management of adaptation corridors and keystone habitats - will have to tailor their approach and corridors to the particularities of their specific ecosystems and species. Management teams should elucidate and characterize their parks' species, guilds, habitats, communities or assemblages, and ecological processes in terms of their relative sensitivity to potential changes in different environmental factors associated with climate change, such as temperature, precipitation, and seasonal water availability. Each would also be assessed in terms of their relative potential to benefit from adaptation corridors and keystone habitat management.

Sensitivity analyses will help managers design and manage adaptation corridors and target management activities. For example, in the Santa Ana Mountains, Tecate cypress (*Cupressus forbesii* Linnaeus) is considered sensitive to warming temperatures, and maintaining an adaptation corridor to higher elevations is a management priority for this endangered species. (Recurring fires pose a more immediate threat to this cypress population, however.)

In order for management decisions to be made with greater confidence, management teams should conduct such analyses as soon and cost-effectively as possible, using available information and expertise and identifying critical information gaps that may require further research or consultation. Documenting change and loss is important for revising sensitivity profiles and adaptive management, in general, but the majority of effort and resources should be directed towards on-the-ground activities that will facilitate local adaptation for the greatest number of native species and enhanced ecosystem resilience.

Facilitating adaptation

Clearly, the degree and rate of climate change may exceed the thresholds for persistence of many species and habitats despite efforts to enhance corridors or provide refugia. However, wildland managers should act to improve resilience to future change as best they can, guided by available information and first principles of ecology and conservation biology, or, at a minimum, ensure that the novel ecosystems that emerge have as many of the original species as possible (Halpin 1997; Hobbs et al. 2006; Preston et al. 2008).

Actions aimed at maintaining healthy climate change corridors and keystone habitats within protected areas offer managers one of the few practical means of buffering climate change impacts. These activities can easily make the jump from well-intentioned planning documents to field implementation as they constitute management actions - habitat restoration, invasive control, fire management - that would be carried out and budgeted for anyway, with climate change corridors given priority or added attention.

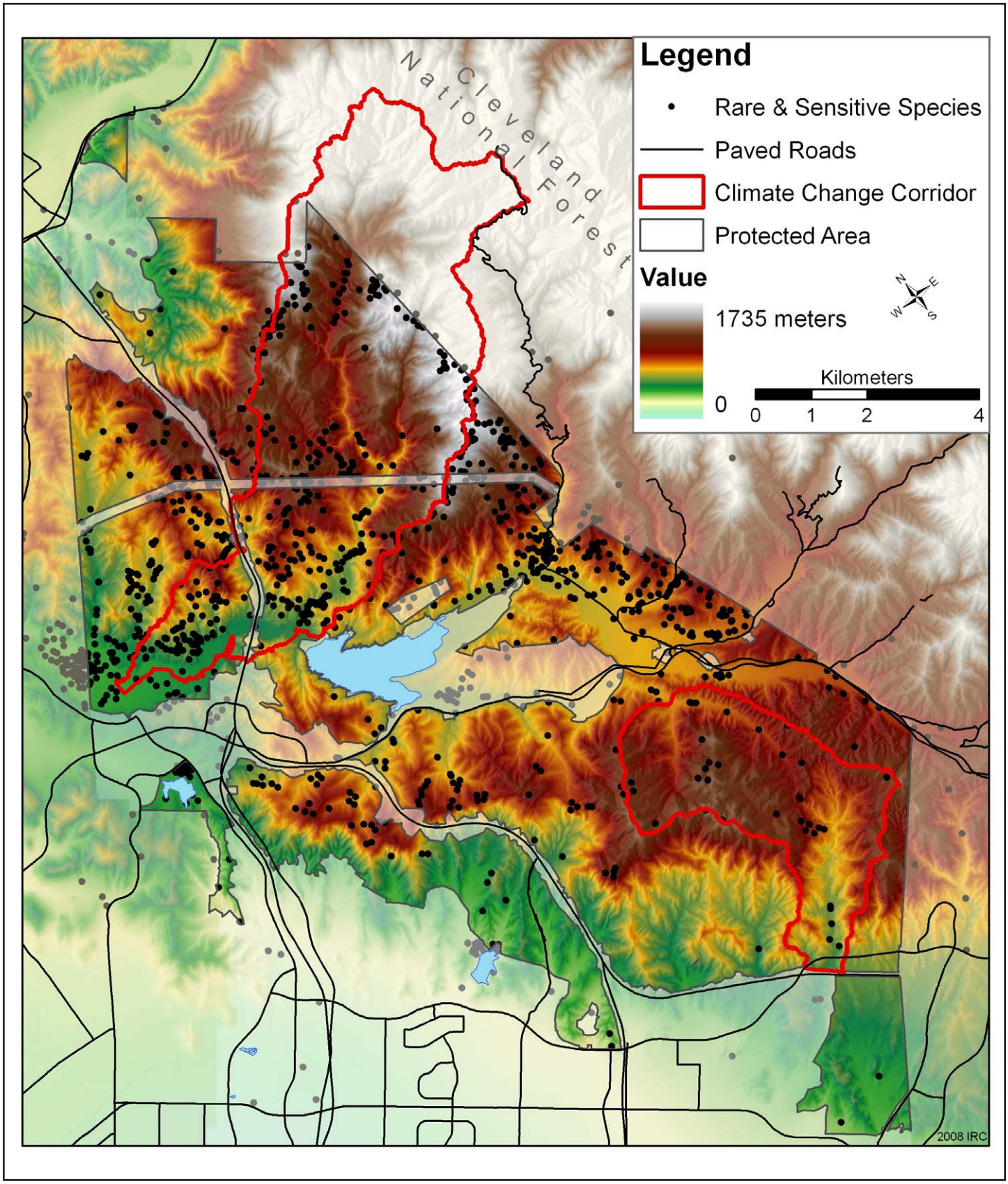

Figure 1. Two climate change corridors, both embedded within natural habitat, have been identified for protected areas of the Northern Santa Ana Range, Southern California. A priority management goal is to maintain these corridors that span elevation, fog precipitation, and watershed gradients in as good a condition as possible. The northern corridor has a 0.5 km wide underpass with natural vegetation under the highway.

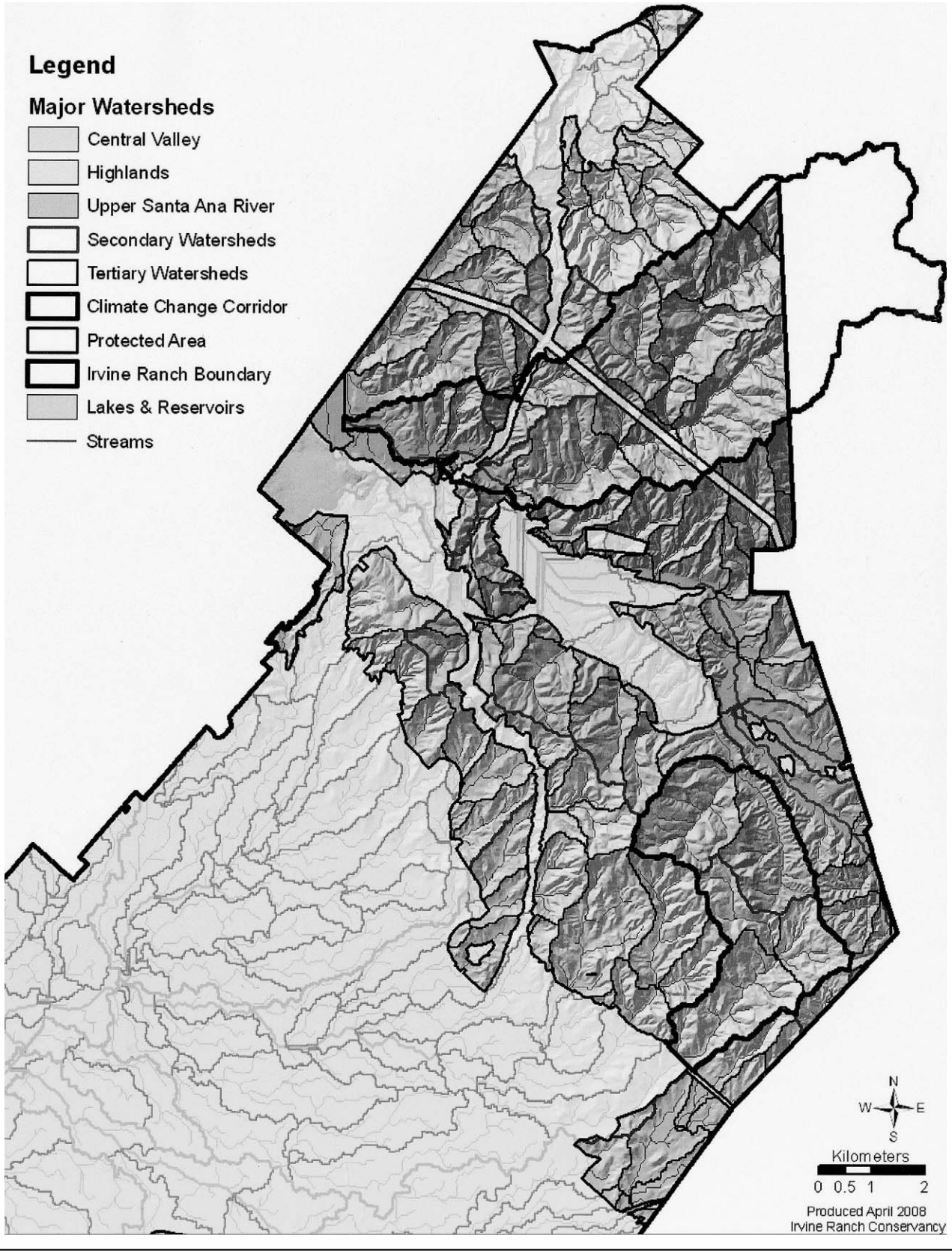

Figure 2. Watersheds of the protected areas of the Northern Santa Ana Range, Southern California. Watersheds are characterized by multiple environmental gradients.

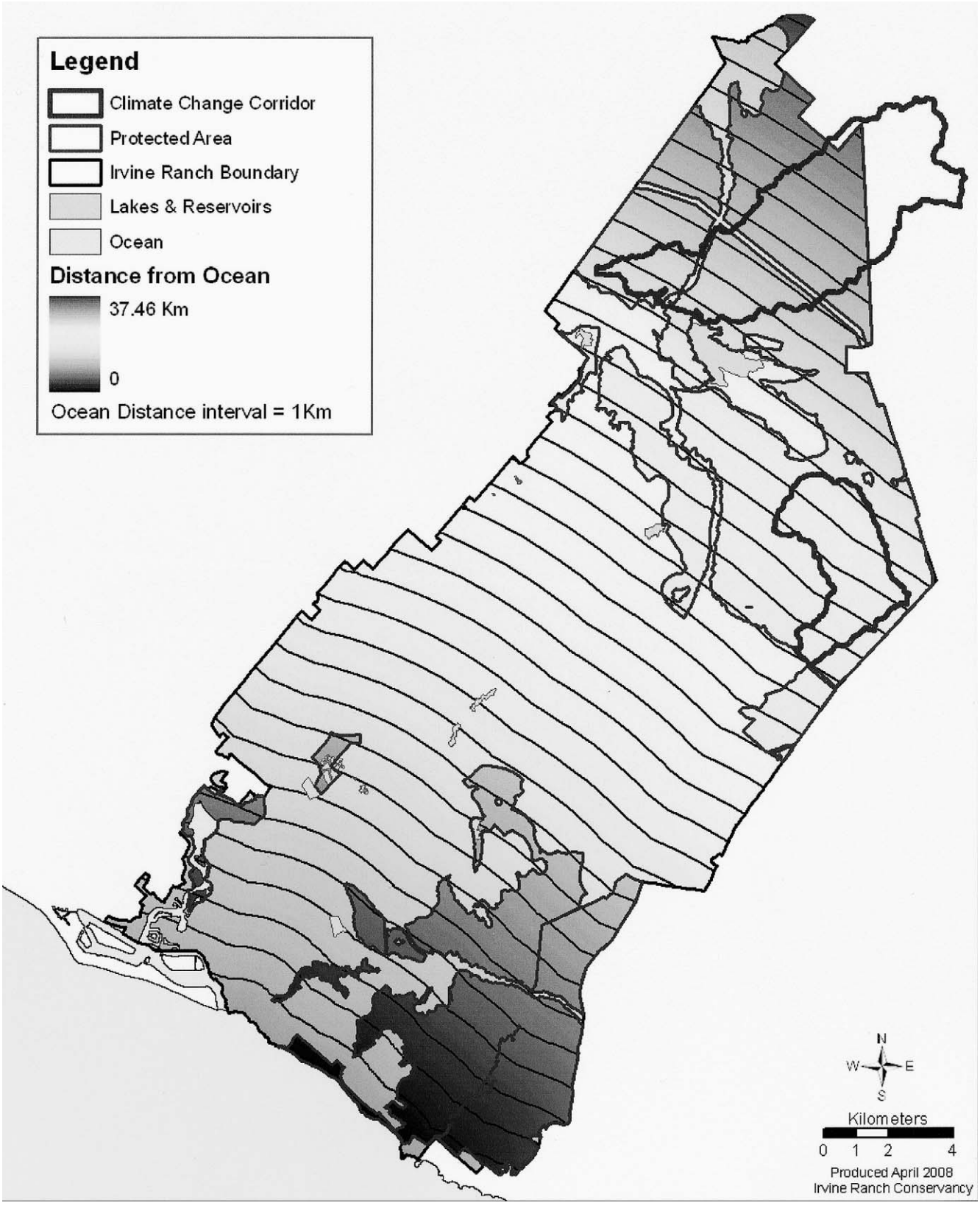

Figure 3. A coastal fog precipitation gradient was approximated using distance from the Pacific Ocean.

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