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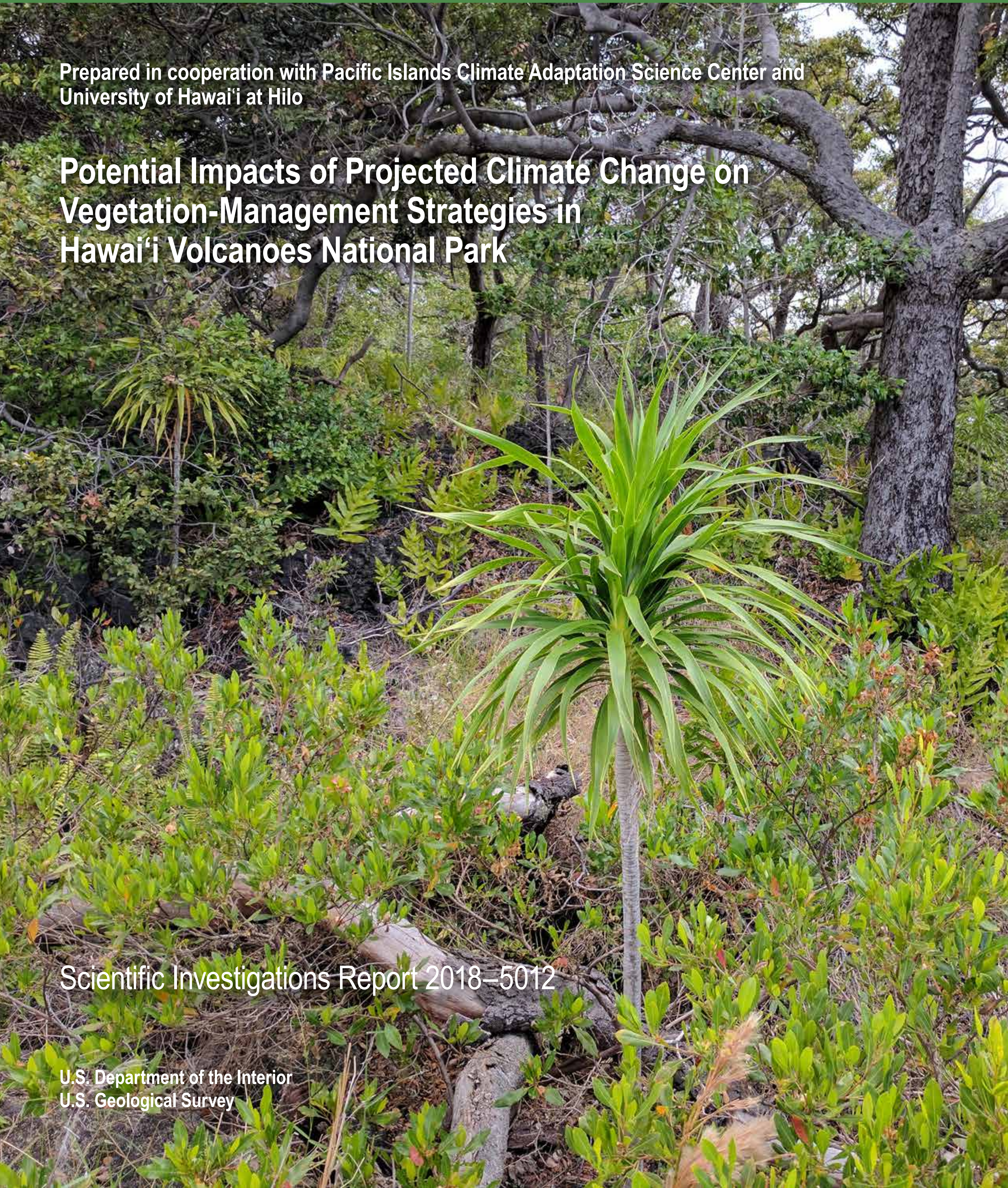

Prepared in cooperation with Pacific Islands Climate Adaptation Science Center and University of Hawai‘i at Hilo

Potential Impacts of Projected Climate Change on Vegetation-Management Strategies in Hawai‘i Volcanoes National Park

Scientific Investigations Report 2018–5012

U.S. Department of the Interior
U.S. Geological Survey

Cover. View of Kealakomo Special Ecological Area, located in lowland dry-forest habitat in Hawaiʻi Volcanoes National Park, Hawaiʻi. This plant community is dominated by native shrub and tree species, including a young Halapepe (*Chrysodracon hawaiiensis*) tree growing in foreground. Photograph by Mark Wasser, National Park Service.

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RYAN K. ZINKE, Secretary

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Conversion Factors

Inch/Pound to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
yard (yd)	0.9144	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare (ha)
acre	0.004047	square kilometer (km^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as °F = (1.8 × °C) + 32.

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as °C = (°F – 32) / 1.8.

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude and elevation, as used in this report, refer to the distance above mean sea level.

Abbreviations

A1B	IPCC emission scenario, which assumes rapid economic growth, global population that peaks midcentury, and balanced energy sources
asl	Above mean sea level
C-CAP	Coastal Change Analysis Program
CMIP3	Coupled Model Intercomparison Project, phase 3
DEM	Digital elevation model
DOFAW	Hawai‘i Division of Forestry and Wildlife
ENSO	El Niño–Southern Oscillation
FWS	U.S. Fish and Wildlife Service
GCM	Global Circulation Model
GIS	Geographic information system
HAVO	Hawai‘i Volcanoes National Park
HRCM	Hawai‘i Regional Climate Model
IPCC	Intergovernmental Panel on Climate Change
IPRC	International Pacific Research Center
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
PICASC	Pacific Islands Climate Adaptation Science Center
PDO	Pacific Decadal Oscillation
RACH	Rainfall Atlas and Climate of Hawai‘i
SEA	Special Ecological Area
SRES	Special Report on Emissions Scenarios
TMA	Three Mountain Alliance
WGS84	World Geodetic System 1984

Potential Impacts of Projected Climate Change on Vegetation-Management Strategies in Hawai‘i Volcanoes National Park

By Richard J. Camp,[1,2] S. Paul Berkowitz,[1] Kevin W. Brinck,[1] James D. Jacobi,[2] Rhonda Loh,[3] Jonathan Price,[4] and Lucas B. Fortini[2]

Abstract

Climate change is expected to alter the seasonal and annual patterns of rainfall and temperature in the Hawaiian Islands. Land managers and other responsible agencies will need to know how plant-species habitats will change over the next century in order to manage these resources effectively. This issue is a major concern for resource managers at Hawai‘i Volcanoes National Park (HAVO), where currently managed Special Ecological Areas (SEAs) for important plant species and communities may no longer provide suitable habitats in the future as the climate changes. Expanding invasive-species distributions also may pose a threat to areas where native plants currently predominate.

The objective of this project was to combine recent climate-modeling efforts for the state of Hawai‘i with existing models of plant-species distribution in order to forecast suitable habitat ranges under future climate conditions derived from the Coupled Model Intercomparison Project, phase 3 (CMIP3) global circulation model that was dynamically downscaled for the Hawaiian Islands by using the Hawai‘i Regional Climate Model (HRCM). The HRCM uses the A1B emission scenario (a median future climate projection) from the Special Report on Emissions Scenarios (SRES). On the basis of this model, maps showing projected plant-species ranges were generated for four years as snapshots in time (2000, 2040, 2070, 2090) and for three different trajectories of climate change (gradual, linear, rapid) between the present and future.

We mapped probabilistic surfaces of suitable habitat for 39 plant species (both native and alien [nonnative]) identified as being of interest to HAVO resource managers. We displayed these surfaces in terms of change relative to present conditions, whether the range of a given plant species was expected to contract, expand, or remain the same in the future. Within HAVO, approximately two-thirds (18 of 29) of the modeled native plant species were projected to contract in range, whereas one-third (11 of 29) were projected to increase. Most of the HAVO SEAs were projected to lose most of the native plant species modeled. Within HAVO, all alien plant species except *Lantana camara* were projected to contract in range within the park; this trend was observed in most SEAs, including those at low, middle, and high elevations. Congruence was good in the “current” (2000) distribution of plant-species richness and SEA configurations; however, the congruence between species-richness hotspots and SEAs diminished by the projected “end-of-century” (2090) distribution. Over time, the projected species-richness hotspots increasingly occurred outside of the currently configured SEA boundaries.

Introduction

Changing global climate conditions, which include, but are not limited to, increasing global temperatures, changing circulation and precipitation patterns, increasing ocean acidification, and rising sea level, are “unequivocally linked to human activities” (Intergovernmental Panel on Climate Change, 2014). These changing conditions result in changes to physical, biological, and human-managed systems. Future climate conditions are projected with global circulation models (GCMs), using atmospheric and oceanographic factors. Because GCMs have a coarse horizontal resolution of 100 km or more, they do not adequately represent the small-scale topographic features and climate variations of the Hawaiian Islands (Giambelluca and others, 1986). Accurate characterization of diverse and complex island microclimates requires downscaling of the GCM’s grid to regional (Timm and Diaz, 2009) and local scales. Dynamic downscaling is a technique that uses the large-scale conditions provided by GCMs to drive a local-scale meteorological model that has a much higher resolution (Gutmann and others, 2012). The International Pacific Research Center (IPRC), located in the School of Ocean and Earth Science and Technology at the University of Hawai‘i at Manoa, recently completed a dynamic downscaling of GCMs for the present and for the end of the 21st century (Zhang and others, 2012).

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Changes in climate conditions will drive changes in biotic systems and species distributions, resulting in changes to the composition of plant communities (Price and others, 2012). These changes can have direct negative impacts on some plant species by making environmental conditions less favorable for their persistence (Krushelnycky and others, 2011) or by changing hydrological processes (Oki, 2004; Bassiouni and Oki, 2013). A study by Fortini and others (2013), which examined climate-based species-distribution shifts in the context of habitat area, quality, and distribution, indicated that many native Hawaiian plant species may be particularly vulnerable to climate change. Results from that assessment predict major changes in the range of many Hawaiian plant species that are due to climate change. Many plant species face a reduced potential to persist in low-elevation microrefugia, owing to habitat degradation and conversion to urban, exurban, and agricultural land uses, as well as a decreased opportunity to expand upslope, owing to reduced high-elevation habitat and faster warming upslope (Giambelluca and others, 2008). Furthermore, other research studies (for example, Foden and others, 2013; Fortini and others, 2013) determined that the Hawaiian plant species that are most vulnerable to climate change also tend to be the ones most susceptible to existing nonclimatic threats (for example, competition with, or predation by, invasive plant species and habitat loss owing to changing land uses), suggesting that conservation challenges for these species will become increasingly difficult over time.

One important consequence of these projected climate-change effects is that plant species targeted for protection may shift their range outside of currently prioritized conservation areas, possibly decreasing the effectiveness of conservation efforts (Hannah and others, 2007). Future changes in temperature or available moisture may make a current habitat unsuitable for a particular plant species; conversely, climate change may expand the potential range of a species toward currently unfavorable habitats. Individual plant species may respond differently and at different rates. The community composition associated with existing biomes may also shift as climate change creates new habitats for currently coexisting plant species or allows species to coexist where they do not today. Simultaneously, climate change may allow nonnative invasive plant species to spread into areas where they do not exist today. Indeed, invasive plant species, which generally have higher growth, fecundity, and dispersal rates, may respond faster to changes in temperature and available moisture than do established native plant species (Byers, 2002). As a result of climate change, resource managers at Hawaiʻi Volcanoes National Park (HAVO) have considered the need to adjust the boundaries of current focal conservation areas in order to ensure that important plant species and communities continue to be protected in the future.

To manage plant species effectively, HAVO resource managers require information on how climate change may affect plant distributions, as well as on the variables that control plant growth and fitness. Current vegetation-management strategies within HAVO are focused on Special Ecological Areas (SEAs; fig. 1), which are largely configured to protect representative or otherwise important plant species and communities by controlling the most invasive incipient plant and animal species (Loh and others, 2014). Climate change and concomitant shifts in habitat distribution may cause mismatches in the plant species and communities currently protected within SEAs. Park managers, therefore, want to know whether the current configuration of SEAs will continue to provide protection for plant species and communities of concern in the future, as well as what new and possibly novel communities may in the future reside within, and adjacent to, the currently configured SEA boundaries. The answers to these questions are likely to prompt revisions to their vegetation-management strategies for future management and protection of HAVO's important plant species.

Methods

Figure 2 illustrates the modeling process used to project plant-species ranges by combining current (Giambelluca and others, 2013, 2014) and future (Zhang and others, 2012) climatic conditions. The focus of our study was to model current and future species-range maps for selected plant species in HAVO, starting by modeling the ranges for these species statewide, then focusing in on their ranges relative to the SEAs. Price and others (2012) developed geographic-range models for 1,100 Hawaiian plant species that are based on climate envelopes defined by the minimum and maximum values of climate boundaries (that is, physiological thresholds) around species occurrences; they used elevation as a surrogate for mean annual temperature and a moisture-zone index as a surrogate for plant-available moisture. These models used historical and current species-occurrence records to describe the "current" (ca. 2000) geographic range of each plant species in terms of environmental and climatic factors.

We associated the four environmental factors in Price and others' (2012) models (volcano boundaries, elevation, upland area, and presence on young lava flows) with both current and future (projected) rainfall and temperature values to model current and projected species ranges. We obtained current rainfall and temperature data from the Rainfall Atlas and Climate of Hawaiʻi (RACH) (Giambelluca and others, 2013, 2014), which represents the current temperature and rainfall in Hawaiʻi during a 30-year climatological averaging period (1978–2007). For future (projected) values, we used the projected changes in rainfall and temperature variables that are based on the difference between "end-of-century" (2080–99; hereafter, referred to as "2090") and "current" (1990–2009; hereafter, referred to as "2000") dynamically downscaled climate models from the Hawaiʻi Regional Climate Model (HRCM) (Zhang and others, 2012). The HRCM relies on the Coupled Model Intercomparison Project, phase 3's (CMIP3's) global circulation model (GCM) and the United Nations Intergovernmental Panel on Climate Change's (IPCC's) A1B emission scenario as described in the Special Report on Emissions Scenarios (SRES). The A1B

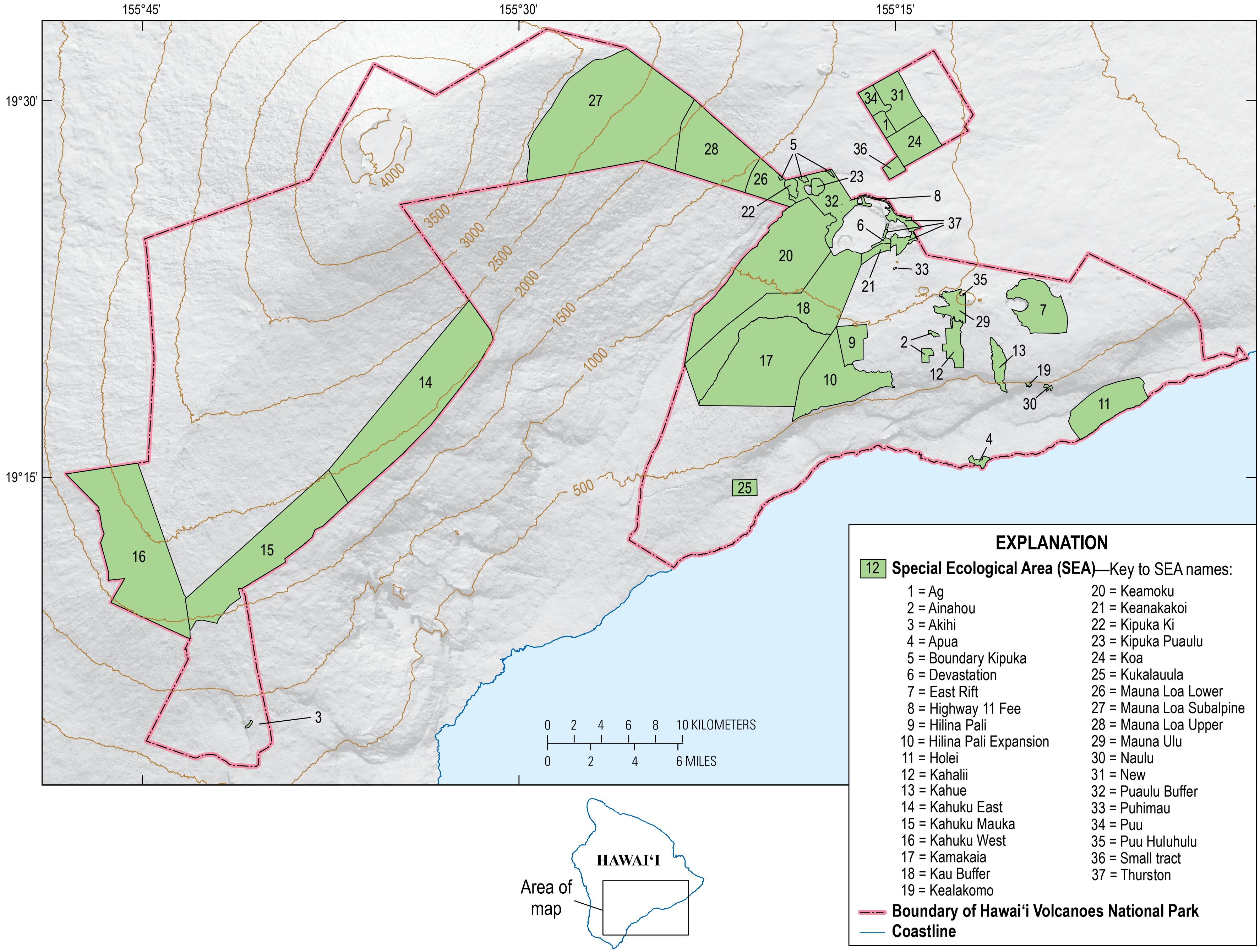

Figure 1. Map of southeastern part of Island of Hawai'i, showing locations of Special Ecological Areas (SEAs) within Hawai'i Volcanoes National Park (HAVO). SEA boundaries (as of 2015; D. Benitez, unpub. data, 2015) and HAVO boundary from National Park Service's National Geospatial Data Asset (National Park Service, unpub. data, 2014). Shaded-relief base map, contours (contour interval, 500 m), and coastline from U.S. Geological Survey's National Elevation Dataset (U.S. Geological Survey, 2014), World Geodetic System 1984 (WGS84).

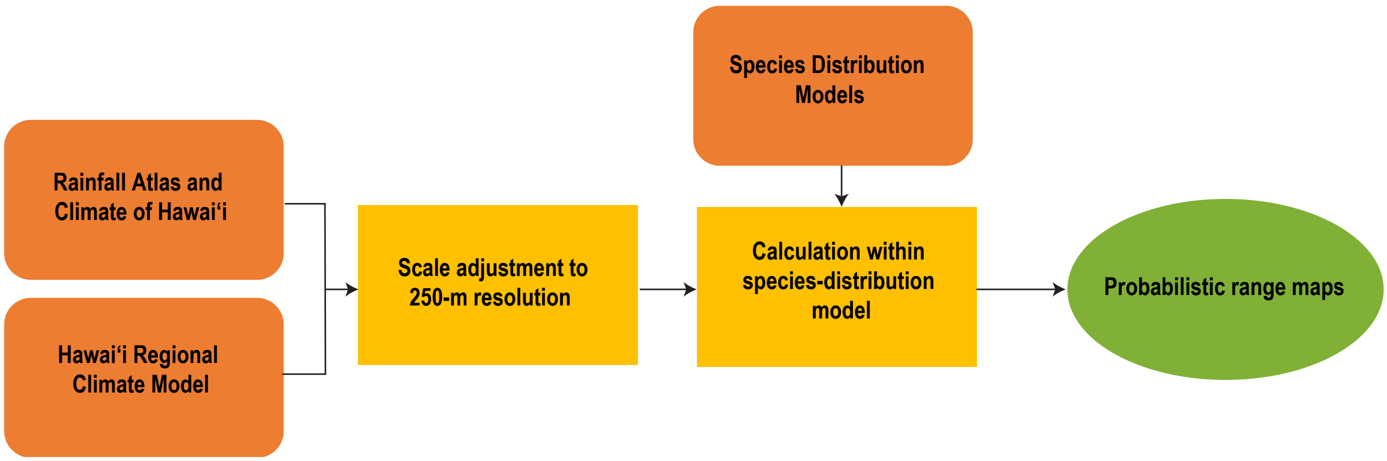

Figure 2. Flow chart depicting climate-envelope model used to produce probabilistic species-range maps. Round-edged rectangles represent input data: present climate data (Rainfall Atlas and Climate of Hawai‘i; Giambelluca and others, 2013, 2014); projected future climate data (Hawai‘i Regional Climate Model; Zhang and others, 2012); and plant species occurrence records (Price and others, 2012; J. Price, unpub. data, 2014). Square-edged rectangles represent processing steps (scale adjustment to 250-m resolution; calculation within species-distribution model) used to produce probabilistic species-range maps. Oval represents output (probabilistic species-range maps). Species-range maps, which were generated from 400 modeled climate-change-projection iterations at 80-percent-threshold values, are based on different starting and ending climatic conditions.

emission scenario represents a single forcing of greenhouse gasses and anthropogenic sources in the GCM that is based on the assumptions of (1) rapid economic growth, (2) global population that peaks midcentury, and (3) balanced use across all energy sources. This approach allowed us to project the geographic ranges of Hawaiian plant species for the year 2090 (“end-of-century”) by using this specific climate-change scenario. Following Morrison and Hall (2002), we define “species range” as the spatial arrangement of suitable habitats and “species distribution” as the subset wherein each species could be expected to be found. Our projections, therefore, represent both current and future (projected) species ranges.

We modeled the statewide ranges of the 39 plant species that are identified as being influential in the formulation of vegetation-management strategies for ecologically sensitive areas (SEAs) in HAVO (R. Loh and J. Price, oral commun., 2014; table 1). On the basis of the HRCM, we interpolated projected temperature and rainfall for four years that are appropriate for resource management (“beginning-of-century” [2000; also referred to as “current”], 2040, 2070, and “end-of-century” [2090]), following three potential climate-change trajectories (rapid, linear, gradual) between the present and the future. We then used the species-climate-envelope approach of Price and others (2012) to project the range of each of our target plant species for each time interval and trajectory (for a total of eight range projections: 2000, 2090, and three each at 2040 and 2070).

Climate models exhibit considerable uncertainty (Lauer and others, 2013) in their projections, which presents complications when using them to make ecological forecasts. Conroy and others (2011) emphasized the role of climate-forecast uncertainty in resource-management decisions. Models that incorporate the inherent uncertainty of climate projections provide a way to incorporate the uncertainty and feedback into the decisionmaking process. As described below, we compiled different combinations of between-year variability in the climate-projected differences from 2000 to 2090 to create pseudoprobability surfaces to describe the chance that a given pixel on the landscape is suitable for a given plant species in the future. We used an 80-percent-threshold cutoff to obtain species ranges for the present and future (Epstein and Axtell, 1996). We then calculated the change in species range between “beginning-of-century” and each future modeled year.

We modeled the changes in plant-species range (both contraction and expansion) on the basis of physiological thresholds of suitable habitat as a function of climate change. For each island, we clipped the downscaled rainfall and temperature projections and baseline data to the coastline, then added a narrow (1–2 cells wide) buffer of ocean.

We obtained plant-species threshold values from Price and others (2012) and reproduced each species-range model by using a series of aligned covariate raster datasets on which logical and mathematical operations could be performed across grids. To enable these raster operations, we resampled and aligned all covariate grids to match the cell size and layout of the RACH, which had a cell size of 0.00225 decimal degrees (~250 m) and used the World Geodetic System (WGS) of 1984 as the spatial reference. The Network Common Data Form (NetCDF) files for all islands had an initial grid-cell size of 3 km, except for Maui, which had higher resolution data of 1-km cells. We processed the following five covariate grids (three physical and two climatic): volcano boundaries; young substrates suitable for pioneering plant species; elevations; temperatures; and moisture zones.

Table 1. Status and importance of 39 plant species identified as being influential in formulation of vegetation-management strategies for ecologically sensitive Special Ecological Areas in Hawai‘i Volcanoes National Park.

[Status codes: N, native species; I, invasive species. Importance codes: B, native-bird resource; C, cultural resource; D, dominant species; I, invasive species]

Scientific name	Hawaiian or common name	Status	Importance
	Native species		
Acacia koa	Koa	N	B, C, D
Alyxia stellata	Maile	N	C
Cheirodendron trigynum	‘Ōlapa	N	D, B
Cibotium spp.	Hāpu‘u	N	D
Coprosma ernodeoides	Kūkaenēnē	N	D
Coprosma montana	Mountain Pilo	N	D
Coprosma spp.	Pilo	N	D, B
Dicranopteris linearis	Uluhe	N	D
Diospyros sandwicensis	Lama	N	D
Dodonaea viscosa	‘A‘ali‘i	N	D
Freycinetia arborea	‘Ie‘ie	N	B
Ilex anomala	Kāwa‘u	N	D, B
Leptecophylla tameiameiae	Pukiawe	N	D
Metrosideros polymorpha	‘Ōhi‘a lehua	N	D, B, C
Myoporum sandwicense	Naio	N	D
Myrsine lessertiana	Kōlea lau nui	N	D, B
Nestegis sandwicensis	Olopua	N	D
Osteomeles anthyllidifolia	‘Ulei	N	D
Pandanus tectorius	Hala	N	D
Pipturus albidus	Māmaki	N	D, B, C
Pisonia spp.	Pāpala kēpau	N	D, B
Psychotria hawaiiensis	Kōpiko ‘ula	N	D, B
Psydrax odorata	Alahe‘e	N	D
Rubus hawaiensis	‘Ākala	N	D, B
Sadleria cyatheoides	‘Ama‘u	N	D
Santalum spp.	‘Iliahi	N	D
Sophora chrysophylla	Māmane	N	D, B
Vaccinium calycinum	‘Ōhelo kau lā‘au	N	D, B
Vaccinium reticulatum	‘Ōhelo	N	D, B, C
	Alien (nonnative) species		
Clidemia hirta	Coster’s Curse	I	I
Falcataria moluccana	Albizia	I	I
Hedychium gardnerianum	Kahili Ginger	I	I
Lantana camara	Lantana	I	I
Miconia calvescens	Miconia	I	I
Morella faya	Faya Tree	I	I
Passiflora tarminiana	Banana Poka	I	I
Psidium cattleianum	Strawberry Guava	I	I
Rubus ellipticus	Himalayan Raspberry	I	I
Schinus terebinthifolius	Christmas Berry	I	I

Physical Covariates

The first of the three physical covariates describes 17 different bioregions that cover the following seven Hawaiian islands: Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Kaho‘olawe, Maui, and Hawai‘i. We converted the original volcano-boundary vector data (that is, polygon outlines) from Price and others (2012) into raster data, using the raster-conversion tool in ArcGIS 10.2.2 (Environmental Systems Research Institute, 2014). In general, these bioregions delineated potential plant habitats by using the boundaries between volcanoes and, to a lesser extent on Mauna Loa volcano, the areas that represent the somewhat-natural breaks in climate and geology. Three islands (Kaua‘i, Lāna‘i, Kaho‘olawe) are composed of a single volcano or bioregion; three (O‘ahu, Moloka‘i, Maui) contain two adjacent volcanoes; and one (Hawai‘i) is formed from five distinct volcanoes. Owing to its size and diversity, Price and others (2012) further subdivided Mauna Loa volcano on Hawai‘i into four subregions, which enabled them to confine historical plant-species records more precisely within the subregions. Because many Hawaiian plant species (1) evolved in isolation, (2) have limited geographic distributions, and (3) cannot easily move between, or adapt to, different islands, volcanoes, or regions, the species models of Price and others (2012) used the 17 bioregions and subregions as a means of restricting projected plant-species ranges on the basis of the documented historical occurrences for each species. Without such a restriction, we likely would overestimate the projected range for many plant species.

Our second physical covariate is a binary indicator that depicts the presence or absence of young lava substrates that are capable of being colonized by early seral (pioneer) vegetation. As described by Price and others (2012), whether or not young lava substrates can support sparse to no vegetation is dependent on the substrate age combined with the moisture zone; in effect, lava substrates in wetter climates are capable of supporting well-developed vegetation far sooner (within 200 years of eruption) than those in drier areas, where the process can require as long as 5,000 years. We acquired a version of Price and others’ (2012) 30-m grid, which depicts the distribution of young lava substrates, and we then resampled it to 250-m cells in ArcGIS, using a majority sampling technique. On the basis of the values contained in this grid, we restricted the modeled range of numerous plant species that are incapable of surviving on young lava substrates.

The third physical covariate is a digital elevation model (DEM) that serves as the basis for deriving threshold temperatures; the DEM then goes directly into the species-range models to restrict suitable habitats. We obtained elevation data as a high-resolution (10-m cell size) DEM, originally compiled by the U.S. Geological Survey as part of the National Elevation Dataset (U.S. Geological Survey, 2014), a seamless mosaic of elevation data that represent the highest quality available. To resample these data into larger cells, we took the mean elevation of the about 625 (25×25) 10-m input cells within each 250-m output cell and assigned that mean value as the output-cell value. The number of 10-m input cells nested within each 250-m output cell varied slightly because the different cell-alignment and spatial-reference systems prevented the grids from nesting perfectly. We performed this procedure sequentially, using focal neighborhood functions and nearest-neighbor methods in ArcGIS, while simultaneously aligning the DEM to the RACH grids and transforming the datum to WGS 1984.

Climatic Covariates

The two climatic covariates that we used to project the range of each plant species are temperature range and moisture zone. Our models incorporated temperature in two different ways. First, we used temperature as a means of differentiating between upland (referred to as “montane” in Price and others, 2012) and lowland areas, which are climatologically distinct. Price and others’ (2012) model used the 1,250-m-elevation contour as the cutoff between upland and lowland areas, primarily to differentiate wet and dry areas, respectively. Second, on J. Price’s (oral commun., 2014) advice, we used the 1,250-m-elevation contour as the temperature boundary as well. For example, Price and others’ (2012) models might have defined suitable habitat for a certain species as upland (that is, colder than the upland temperature threshold) and dry (that is, arid, very dry, or moderately dry). When fitting the models, any plant species that had a minimum elevation below 100 m was considered as having no maximum temperature.

Price and others (2012) also used elevation as a proxy for temperature to define upper and lower temperature limits for suitable habitats. We derived an acceptable temperature range for each plant species that is based on the elevations of historical and contemporary species-occurrence records. We converted the elevation parameter in Price and others’ (2012) models to temperature by deriving a regression relation between elevation and temperature. Using the 250-m temperature grid from Giambelluca and others (2013) and the 250-m elevation grid (the third physical covariate described above), we fit a suite of linear-regression models using “island” as a categorical predictor and linear and quadratic combinations of elevation, plus interaction terms (fig. 3), performed in program R (R Core Team, 2014). The preferred model (with 100 percent of the model weight by Akaike information criterion) was the following:

$$T = 23.58 - 0.00773e + 0.000000734e^2 \qquad (1)$$

where

T is temperature, in degrees Celsius; and

e is elevation, in meters.

A critical component of Price and others’ (2012) species-envelope models was the inclusion of a moisture-zone grid that defined seven levels of moisture availability across the seven modeled Hawaiian Islands as a function of rainfall and elevation. The landscape was classified into the following seven categories: arid, very dry, moderately dry, seasonal mesic, moist mesic, moderately wet, and very wet. We further extended

Price and others' (2012) moisture zones to the highest upland elevations and to the higher maximum rainfalls projected by the climate models (fig. 4). Price and others (2012) adjusted these zones to reflect potential evaporation and cloud cover. We did not incorporate such additional factors into our projected moisture zones.

Summarizing Downscaled Data

The dynamically downscaled climate projections of Zhang and others (2012) are in the NetCDF format, having predicted rainfall and temperature in 5-minute intervals for each cell in a 3-km-resolution grid (1 km-resolution on Maui). We began with the monthly summaries (Fortini and others, 2013) of rainfall and minimum and maximum temperature that cover the "current" (1990–2009) and "end-of-century" (2080–99) time periods. We calculated the annual rainfall values by summing the monthly rainfall by year, and the annual temperatures by splitting the difference between monthly minimum and maximum temperatures; we then took the mean of those values during all months within each year.

To calculate future rainfall and temperature from the downscaled model, we used a procedure that, in climate modeling, is called the "delta method" (Snover and others, 2013), which accounts for model bias by subtracting modeled "present" conditions from modeled "future" conditions, creating the "delta," and then adding this delta value to observed present conditions (we used Giambelluca and others' [2013, 2014] meteorological atlas to obtain observed present conditions). The delta values (on either a 3- or 1-km grid) were then downsampled by bilinear regression to a 250-m grid, which matches present-day meteorological data.

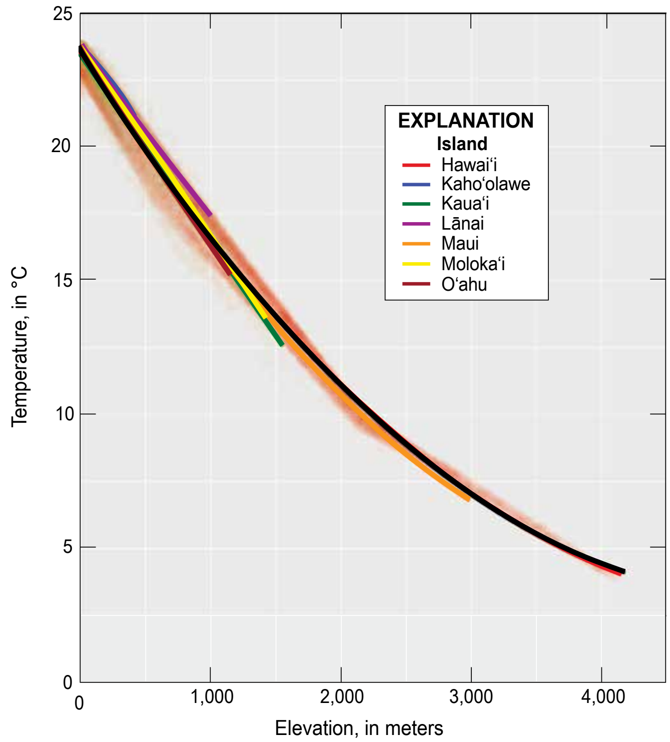

Figure 3. Graph showing modeled quadratic relation between temperature and elevation within 250-m cells across seven islands in the state of Hawai'i. Black line shows preferred relation as indicated by general model (that is, not including island as covariate) used to derive quadratic relation in Hawaiian Islands. Individual landscape pixels plot as near-transparent dots, resulting in diffuse colored shading; shading is dominated by largest Hawaiian island, Hawai'i.

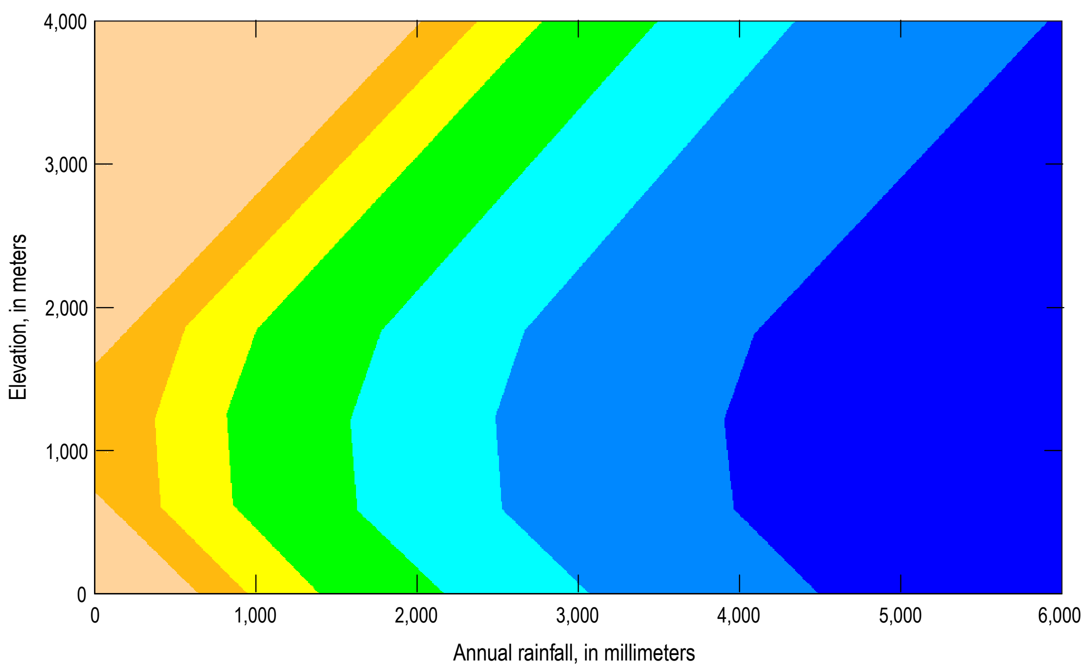

Figure 4. Graph showing relation of elevation to precipitation (rainfall), used to derive moisture zones in climate models. Color indicates range of moisture availability, from low (pale orange) to high (dark blue).

Interpolating Climate Change

Although we calculated the results of climate change statewide and at a decadal interval, we focused primarily on the results of interest to HAVO resource managers and at three particular future years (2040, 2070, 2090), as well as the "current" year (2000) (R. Loh, oral commun., 2014). However, how climate change will progress over the century is unknown; therefore, at the two intermediate years (2040, 2070), we examined three possible trajectories of change (rapid, linear, gradual), even though all three change trajectories converge at the same point in 2090. We calculated linear change as a straight-line interpolation between 2000 and 2090. For the rapid trajectory, we assumed a scenario in which one-half of the total change occurs linearly during the first one-quarter of the time span and then linearly again for the remainder of the time span. For the gradual trajectory, the change levels were reversed: one-half of the change occurs (linearly) during the first three-quarters of the time span, and the remainder occurs (linearly) afterward (fig. 5). From a resource-management perspective, the rapid trajectory has the greatest negative influence because nearly one-half of the current management cycle has already occurred, putting managers in a reactionary position of potentially needing to make up a lot of lost ground for the next management cycle. Conversely, if the changing climate follows either the linear or gradual trajectory, resource managers have more time to implement precautionary actions in anticipation of projected change.

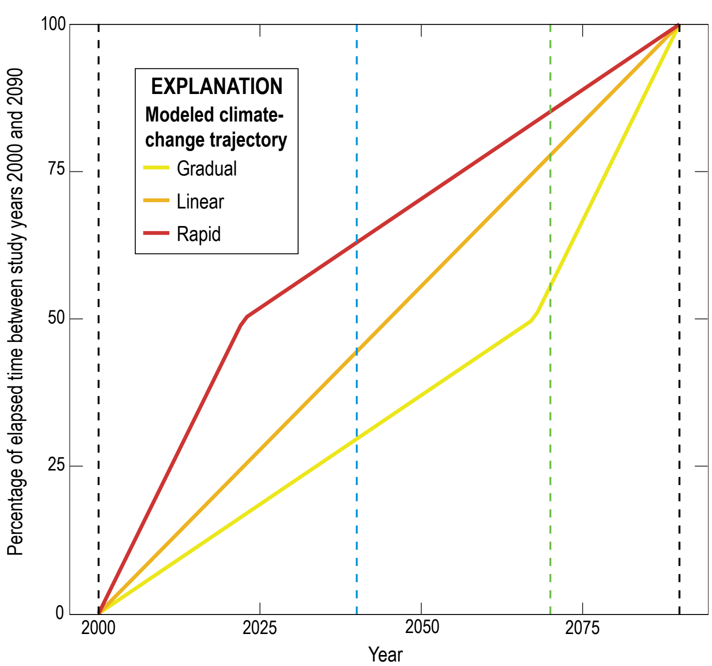

Figure 5. Graph showing hypothetical amounts of rainfall and temperature as interpolated between "current" (2000) and "end-of-century" (2090) study years for three modeled trajectories of change (rapid, linear, gradual). Dashed lines highlight values at beginning (2000), end (2090), and two intermediate (blue line, 2040; green line, 2070) years of study.

Estimating Uncertainty

Models of climate change incorporate uncertainty in different ways and on multiple levels. The GCMs differ in their projections both by their inherent mechanics and by various emissions scenarios. Once a GCM (or combination of GCMs) is chosen, it may need to be downscaled to incorporate local-scale topography to yield projections on a spatial scale that is relevant to a single plant or animal species. Different downscaling techniques and models may vary in their projections, even when they are based on the same GCM. An individual downscaling model may produce explicit estimates of uncertainty from either empirical statistical methods or bootstrap simulation. Although Zhang and others' (2012) dynamic downscaling did not report explicit uncertainties in its projection of future climate, we have attempted to approximate its uncertainty by incorporating the variability of its modeled weather.

Climate is essentially the long-term average of observed weather, and so a point estimate of future conditions as projected by Zhang and others' (2012) model can be calculated as the average of the projected weather in its 20-year time span. We estimated the uncertainty of that point estimate by a delta-method calculation of annual precipitation and temperature for each combination of years in the "current" and "end-of-century" time periods, yielding a total of 400 (20 years "current" by 20 years "end-of-century") deltas. We then used each of these 400 climate projections to estimate the potential range of each plant species. For each pixel on the landscape, we took the proportion of projected climates where the pixel was a suitable habitat as a measure of the likelihood (ranging from 0 percent [= never] to 100 percent [= always]) that a location on the landscape would be a suitable habitat in the future (fig. 6*A*).

From a perspective of plant-species adaptation and survival, the rapid-trajectory scenario has the greatest potential to influence species distribution because this scenario exhibits the largest percentage of change in rainfall and temperature during the shortest time interval. More specifically, because our species models predict potential range and not actual distribution, the rate of climate change will influence whether plant species (1) can disperse quickly enough into new suitable habitats, (2) can adapt rapidly in place to changing climate, and (3) can compete effectively, given changes in climate and species composition. All of these factors, along with their uncertainties, will determine whether an actual species distribution approaches its projected future range. The primary end product was a series of species-range maps and tabulations for eight different climate scenarios: 2000 ("current" range), 2040 and 2070 (three trajectories each, rapid, linear, and gradual), and 2090 (projected "end-of-century" range).

In other sciences, varying confidence levels have been suggested as appropriate bases for decisionmaking. For example, in sea-level-rise and -inundation mapping, the National Oceanic and Atmospheric Administration (2010) suggested that 80-percent confidence is a reasonable level for decisions in the face of potential coastal inundation (fig. 6*B*). We used an 80-percent-confidence threshold to produce maps of species ranges; a pixel was considered to fall within a species range if it had an 80 percent or higher pseudoprobability of being a suitable habitat, meaning that it was considered to be suitable in at least 320 of the 400 interannual differences.

All output rasters and probability surfaces were brought into ArcGIS and mapped in multipanel layouts to allow for the clear visualization of projected species ranges. To highlight the changes in range rather than the ranges themselves, we generated similar map layouts for each species that show only the projected changes in range. Furthermore, we tabulated these changes in suitable plant-species habitat to quantify shifts in species range at the SEA, island, and statewide levels.

In 2015, HAVO resource managers provided a recently updated geographic information system (GIS) file that contained 147 SEA blocks within HAVO. Each block constituted an SEA subdivision used for weed control, ungulate control, plant monitoring, and resource management. For the purposes of this study, these original 147 SEA blocks represented too small a unit in which to examine changes in plant-species range. On the basis of discussions with HAVO resource managers, we

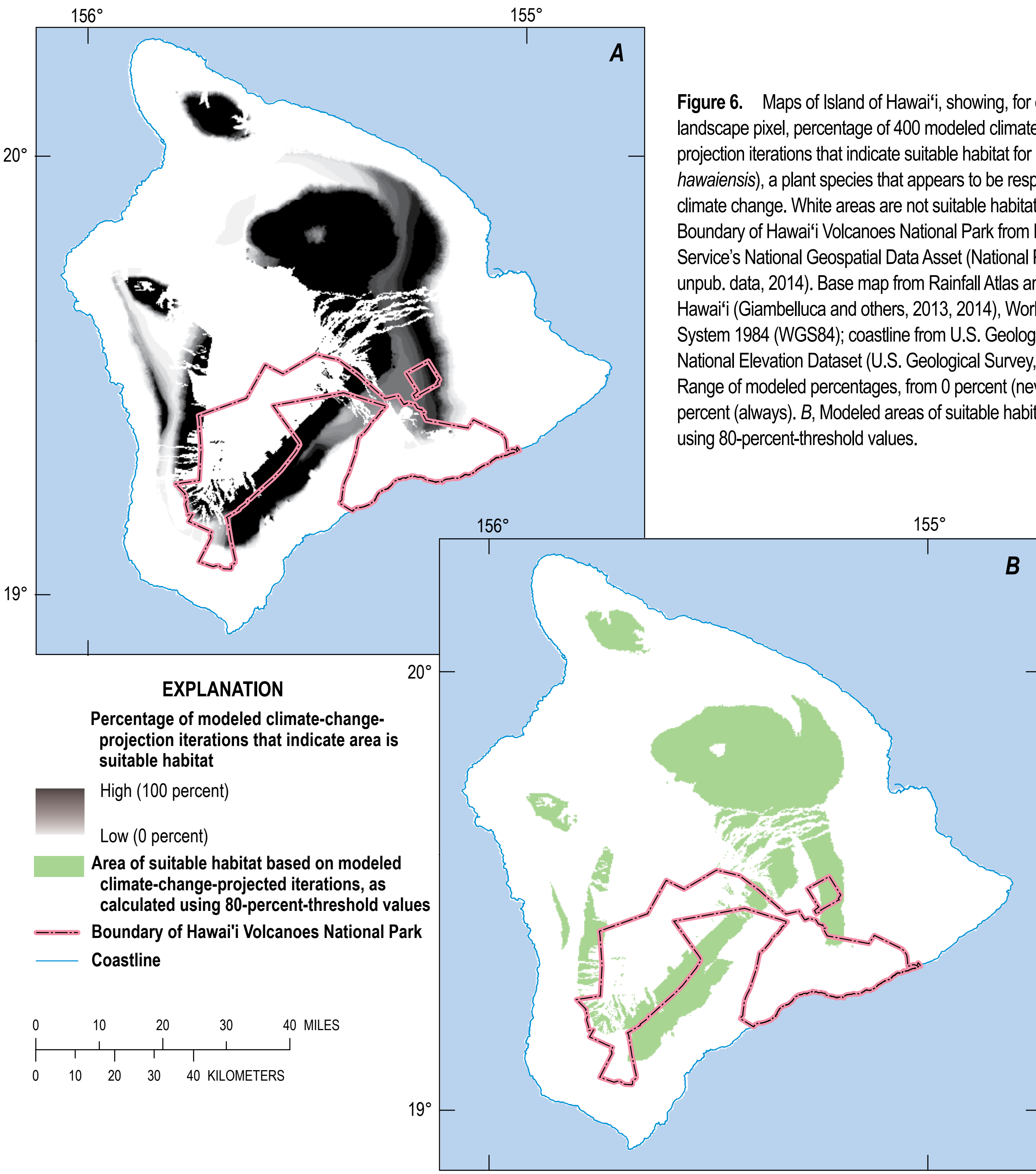

Figure 6. Maps of Island of Hawaiʻi, showing, for each landscape pixel, percentage of 400 modeled climate-change-projection iterations that indicate suitable habitat for ʻĀkala (*Rubus hawaiensis*), a plant species that appears to be responsive to climate change. White areas are not suitable habitat for ʻĀkala. Boundary of Hawaiʻi Volcanoes National Park from National Park Service's National Geospatial Data Asset (National Park Service, unpub. data, 2014). Base map from Rainfall Atlas and Climate of Hawaiʻi (Giambelluca and others, 2013, 2014), World Geodetic System 1984 (WGS84); coastline from U.S. Geological Survey's National Elevation Dataset (U.S. Geological Survey, 2014). *A*, Range of modeled percentages, from 0 percent (never) to 100 percent (always). *B*, Modeled areas of suitable habitat, calculated using 80-percent-threshold values.

aggregated these 147 blocks into 37 SEAs that represent units more appropriately sized for analyzing changes in plant-species range (fig. 1). Although some of the aggregated SEAs still have limited geographic extents, they are useful management units for HAVO resource managers. We used ArcGIS 10.2.2 to dissolve the boundaries between blocks, giving us the final SEA configuration for analysis.

We characterized the net percentage of change in a plant-species range, as well as the amounts of its contraction or expansion, as either minimal, moderate, or substantial. On the basis of the linear ("middle") trajectory of climate change, we set minimal contraction or expansion amounts at 20-percent change or less; moderate contraction or expansion, more than 20-percent change but less than or equal to 50-percent change; and substantial contraction or expansion, more than 50-percent change. The most desirable levels of change for native plant species are minimal contraction and substantial expansion, whereas, for alien plant species, the reverse (substantial contraction and minimal expansion) is preferred.

SEA Evaluation

We evaluated each SEA by calculating the change in richness (expressed as the number of native-plant species projected to be present, out of 29 studied) between the "current" (2000) and "end-of-century" (2090) time periods. We considered an SEA that maintained or increased its native-plant-species richness as being optimally suited for future (projected) conditions, whereas an SEA that lost one-half or more of its current native-plant-species richness may benefit from additional investigation. Conversely, a substantial loss of alien-plant-species richness by the "end-of-century" year was considered to be a positive outcome.

Results

State, Island, and HAVO-Wide Species-Range Patterns

Across the seven main Hawaiian Islands, all but three native plant species—*Dodonaea viscosa*, *Myoporum sandwicense*, and *Santalum* spp.—were projected to undergo a net loss in species range, contracting either moderately (that is, a species-range contraction of more than 20 percent but less than or equal to 50 percent) or substantially (that is, a species-range contraction of >50 percent; see appendixes 1, 2, 3); these three species were projected to expand but only minimally (by 3–10 percent). This pattern of net loss in native species range was projected for all the main Hawaiian Islands below the 1,600-m elevation and for Maui at all elevations (appendixes 1, 2).

In addition to the three species mentioned above, the following five native plant species were forecast to have a net increase in suitable habitat on Hawaiʻi: *Diospyros sandwicensis*, *Nestegis sandwicensis*, *Osteomeles anthyllidifolia*, *Pandanus tectorius*, and *Psydrax odorata*. However, except for *Diospyros sandwicensis*, which was expected to expand moderately (by 25 percent), these species were projected to expand only minimally (that is, by ≤20 percent). In general, most plant species were expected to contract at lower elevations and at the periphery of their range, whereas any expansions were projected to occur at upper elevations around the volcano summits.

Within HAVO, the net percentage of change in suitable habitat during the 21st century was projected to increase for the following 11 of the 29 native plant species (table 2; appendixes 2, 3): *Alyxia stellata*, *Coprosma montana*, *Diospyros sandwicensis*, *Dodonaea viscosa*, *Metrosideros polymorpha*, *Myoporum sandwicense*, *Nestegis sandwicensis*, *Osteomeles anthyllidifolia*, *Pandanus tectorius*, *Psydrax odorata*, and *Santalum* spp. Our models projected minimal to moderate range expansion for 10 of these species, whereas the range of *Diospyros sandwicensis* was expected to increase substantially (by 75 percent; table 2). In contrast, 8 native plant species within HAVO were expected to contract in range minimally to moderately, and 10 more showed a substantial contraction (that is, by >50 percent decrease in range). At statewide and islandwide scales, most plant species were expected to contract in range at lower elevations, and any expansions in range are projected to occur at higher elevations.

Statewide patterns for the 10 alien (nonnative) plant species revealed that all 10 of them may contract in range at least minimally on all seven modeled Hawaiian Islands: most contracted substantially (8 of 10 species by >50 percent); 1 species, minimally; and 1 species, moderately (see appendixes 1, 2, 3). Except on Hawaiʻi, all 10 alien plant species were projected to contract in range moderately to substantially and many to expand in range by 1 to 2 percent. On Hawaiʻi, *Lantana camara* was projected to increase in range moderately (by 29 percent) by "end-of-century," whereas all other alien plant species were projected to contract in range moderately to substantially. Within HAVO, 8 of the 10 alien plant species were projected to contract in range substantially (that is, by >50 percent); *Schinus terebinthifolius*, to contract in range minimally; and *Lantana camara*, to expand in range substantially (table 2; appendixes 2, 3). Both of these species, which were in the lower to middle elevations of HAVO at "current" year (2000), were projected to contract in range at the lowest elevations but expand in range upslope by "end-of-century" (2090).

Patterns of Change in Plant Species Range Relative to SEAs

Overall, the net percentage of change in native-plant-species range was negative within the 37 SEAs in HAVO (appendixes 1, 3). In 15 SEAs, native plant species contracted in range substantially, including the SEAs around the lower part of Mauna Loa Strip tract[5] (consists of Boundary Kipuka, Kipuka Ki, and Mauna Loa Lower SEAs) and around Kīlauea Crater (consists of Devastation, Highway 11 Fee, Kau Buffer, Keamoku,

[5]Tracts are sections or parts of HAVO.

Table 2. Projected changes in suitable-habitat range for 39 focal native and alien (nonnative) plant species in Hawai‘i Volcanoes National Park, as projected using middle- (linear-) climate-change trajectory.

[Average areal percentages of Hawai‘i Volcanoes National Park (HAVO) that have suitable habitat for years 2000 (“current”) and 2090 (projected “end-of-century”) are listed in columns 2 and 9, respectively. Amounts of contraction and expansion of suitable habitat over three projected time periods (2000–2040, 2000–2070, 2000–2090), as percentages of change from 2000, are listed in columns 3 through 8. Average areal percentage of suitable habitat was calculated as area of species-specific suitable habitat (that is, area that remained suitable + area of expansion) in HAVO, divided by area of HAVO, × 100. Net percentage of change between 2000 and 2090, listed in column 10, was calculated as difference in percentage of HAVO that is suitable between 2090 and 2000, divided by percentage of HAVO that is suitable in 2000, × 100. Any numerical differences are due to rounding of reported values]

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	change (%)
Native species									
Acacia koa	16	0	22	19	25	39	26	13	–13
Alyxia stellata	22	0	14	3	28	10	31	27	21
Cheirodendron trigynum	23	26	0	69	0	87	0	3	–87
Cibotium spp.	20	19	8	60	0	80	0	4	–80
Coprosma ernodeoides	70	14	11	41	20	48	20	51	–27
Coprosma montana	42	4	17	10	31	15	31	49	16
Coprosma spp.	25	9	12	43	13	61	13	13	–48
Dicranopteris linearis	49	32	3	72	0	87	0	6	–87
Diospyros sandwicensis	8	1	34	4	60	10	85	14	75
Dodonaea viscosa	82	0	11	0	17	0	22	100	22
Freycinetia arborea	16	12	3	56	3	77	1	4	–77
Ilex anomala	22	20	3	64	0	82	0	4	–82
Leptecophylla tameiameiae	91	7	9	22	9	37	9	66	–27
Metrosideros polymorpha	72	3	18	13	28	20	32	81	13
Myoporum sandwicense	86	0	9	0	16	0	16	100	16
Myrsine lessertiana	55	37	0	75	0	88	0	6	–88
Nestegis sandwicensis	11	0	29	3	42	7	46	15	38
Osteomeles anthyllidifolia	60	3	27	15	42	24	49	75	26
Pandanus tectorius	15	13	29	59	69	80	96	17	16
Pipturus albidus	47	31	4	71	0	86	0	6	–86
Pisonia spp.	17	2	7	21	6	48	6	10	–43
Psychotria hawaiiensis	18	17	7	60	2	79	0	4	–79
Psydrax odorata	9	0	20	3	30	9	37	11	28
Rubus hawaiensis	25	17	0	47	0	59	0	10	–59
Sadleria cyatheoides	59	20	25	53	40	68	47	47	–20
Santalum spp.	78	0	13	0	20	0	27	99	27
Sophora chrysophylla	23	3	6	7	10	15	12	22	–4
Vaccinium calycinum	30	74	0	92	0	97	0	1	–97
Vaccinium reticulatum	80	12	6	36	6	42	6	51	–36
Alien (nonnative) species									
Clidemia hirta	8	10	29	45	26	71	16	3	–55
Falcataria moluccana	4	87	57	100	42	100	22	1	–78
Hedychium gardnerianum	13	57	0	83	0	93	0	1	–93
Lantana camara	8	1	34	4	57	10	73	13	63
Miconia calvescens	6	59	12	84	14	96	10	1	–86
Morella faya	47	31	2	75	2	89	1	5	–88
Passiflora tarminiana	15	43	5	93	1	100	0	0	–100
Psidium cattleianum	13	10	14	50	4	73	0	4	–72
Rubus ellipticus	5	72	0	92	0	100	0	0	–100
Schinus terebinthifolius	6	4	41	14	50	41	30	5	–11

Keanakakoi, and Puaulu Buffer SEAs). Both of these areas (Mauna Loa Strip tract and around Kīlauea Crater) are areas of intense visitor pressure, and they both also are important areas for cultural practitioners. Native plant species contracted in range minimally, moderately, and substantially in 6 SEAs; about evenly between minimally and substantially in 14 SEAs (12 of which are below 1,200 m elevation); and minimally in 2 SEAs (East Rift and Puu Huluhulu SEAs). Native plant species showed minimal to no range expansions within all but five SEAs (appendixes 1, 3), and two to seven native plant species showed mixed but predominately substantial range expansions in four SEAs (Hawaii 11 Fee, Kahuku Mauka, Mauna Loa Subalpine, and Thurston SEAs).

Most alien (nonnative) plant species were projected to contract in range in all 37 SEAs; the exceptions were *Lantana camara* and *Schinus terebinthifolius*, which showed mixed results that range from substantial contractions to substantial expansions in several SEAs. The Apua SEA was not a suitable habitat for any of the selected alien plant species during any time period. We expect to see similar results for other alien plant species, most of which show a minimal expansion in range under future conditions. However, we note that our projected ranges for alien plant species probably are conservative estimates because many of these invasive, alien species have not yet come to equilibrium within the habitats in Hawai‘i that they can occupy.

Rate of Change in Species Range

The degree of contraction and expansion of range for a given plant species at some point in the future depends upon the trajectory of climate change. In this section, we report the results of species-range contractions and expansions that are based on the middle, linear trajectory.

We observed two main patterns of species-range contraction or expansion: either the change occurred gradually to the "end-of-century" as the habitat became progressively more or less suitable, or the change occurred suddenly and rapidly. Examples of each pattern included *Leptecophylla tameiameiae* in the Kahuku West SEA and *Acacia koa* in the Ag SEA, respectively (figs. 7*A*, *B*). A third pattern, although observed less frequently than the first two, occurred where conditions in unsuitable habitats became more favorable initially, facilitating species-range expansion, before returning to an unsuitable state and long-term contraction by "end-of-century" (for example, *Psychotria hawaiiensis* in Kahuku Mauka SEA; see fig. 7*C*).

Evaluation of Protection Provided by Currently Configured SEAs

In only two SEAs (East Rift and Koa) were native plant species projected to increase in richness, and in only one SEA (Kahuku Mauka) were they projected to maintain their current richness. Most other SEAs (24 of 37, or 65 percent) may lose more than one-half of the native plant species modeled here, and the rest (10 SEAs) could lose as much as one-half of their native-plant-species richness by "end-of-century" (table 3). Thus, most

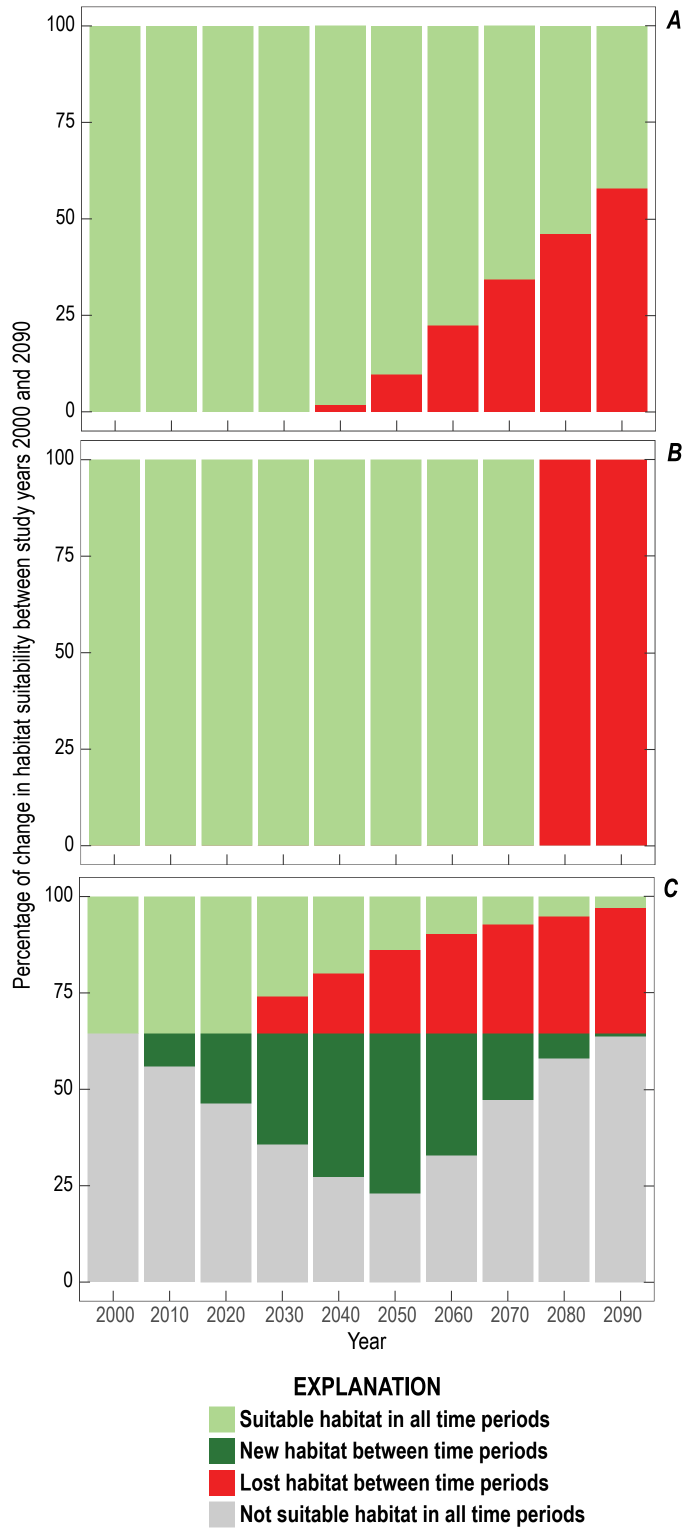

Figure 7. Charts showing percentages of change in habitat suitability, as projected using middle- (linear-) climate-change-trajectory, by decade for certain species in particular Special Ecological Areas (SEAs) within Hawai‘i Volcanoes National Park (see fig. 1 for locations). *A*, Gradual shift for *Leptecophylla tameiameiae* in Kahuku West SEA. *B*, Sudden shift for *Acacia koa* in Ag SEA. *C*, Transition from unsuitable to suitable and back to unsuitable for *Psychotria hawaiiensis* in Kahuku Mauka SEA.

Table 3. Native-plant-species richness in Special Ecological Areas of Hawai‘i Volcanoes National Park.

[Species richness (Rich) expressed as number of native-plant species projected to be present, out of 29 studied). Special Ecological Areas (SEAs) listed in order (from greatest gains to greatest losses) of amount of change in native-species richness (Δ rich), which is based on amount of change between "current" (2000) and projected "end-of-century" (2090) richness. Also provided for each SEA are total area, average areal percentage of suitable habitat for all native-plant species present (Average area suitable), and amount of change between "current" and "end-of-century" average areal percentages of suitable habitat (Δ average area suitable). Average areal percentage of suitable habitat was calculated as area of species-specific suitable habitat (that is, area that remained suitable + area of expansion), divided by area of SEA, × 100. See figure 1 for SEA locations]

SEA	Area (ha)	2000		2090		Change	
		Rich	Average area suitable (%)	Rich	Average area suitable (%)	Δ rich	Δ average area suitable (%)
East Rift	1,111	22	88	26	66	4	–22
Koa	771	22	100	25	40	3	–60
Kahuku Mauka	3,629	26	78	26	48	0	–30
Puu Huluhulu	1	21	100	20	100	–1	0
Akihi	11	26	100	24	71	–2	–29
Mauna Ulu	335	26	52	24	33	–2	–19
Apua	66	7	96	3	96	–4	0
Kahue	261	27	88	23	60	–4	–27
Kahuku East	5,230	22	69	17	88	–5	19
Mauna Loa Subalpine	7,296	21	40	15	75	–6	34
Kahuku West	5,119	25	60	18	43	–7	–17
Holei	1,234	11	95	3	99	–8	4
Mauna Loa Upper	2,277	26	79	17	52	–9	–27
New	764	22	100	12	71	–10	–29
Kamakaia	3,776	25	52	13	50	–12	–2
Kealakomo	10	24	93	12	84	–12	–9
Ag	162	22	100	9	92	–13	–8
Ainahou	83	26	85	13	84	–13	–1
Kahalii	340	26	96	13	93	–13	–3
Kau Buffer	3,358	25	52	12	45	–13	–7
Kukalauula	202	16	52	3	100	–13	48
Naulu	16	23	93	10	94	–13	1
Puhimau	2	25	100	12	100	–13	0
Small Tract	143	22	100	9	100	–13	0
Hilina Pali	467	26	62	12	54	–14	–8
Hilina Pali Expansion	1,954	27	51	13	55	–14	4
Puu	245	22	100	8	100	–14	0
Devastation	34	25	94	10	94	–15	0
Keanakakoi	127	25	92	10	92	–15	0
Thurston	296	25	90	10	99	–15	9
Boundary Kipuka	39	26	92	10	91	–16	–1
Hwy 11 Fee	20	26	87	10	100	–16	13
Keamoku	4,244	27	48	11	48	–16	–1
Puaulu Buffer	926	27	86	11	84	–16	–1
Kipuka Ki	92	26	77	9	76	–17	–1
Mauna Loa Lower	634	27	92	10	80	–17	–13
Kipuka Puaulu	93	26	98	9	100	–17	2

SEAs may not even provide suitable habitats for one-half of their current native-plant-species richness by “end-of-century.”

A total of 29 SEAs were projected to lose more than one-half of their alien (nonnative) plant species, and 5 may lose as much as one-half of their alien plant species (table 4). Apua and Kahuku Mauka SEAs were projected to have no change in alien-plant-species richness; only 1 SEA (East Rift) was projected to show an increase in alien-plant-species richness by the “end-of-century,” and the increase was only by 2 species.

Projected Species Richness and Areas that Need Protection as an SEA

At year 2000 (“current”), good congruence exists between native-plant-species richness and SEA locations (table 3; fig. 8*A*). Areas that have a high number of native plant species (that is, hotspots that have at least 23 species) are located in the Mauna Loa Southwest Rift (Akihi SEA), Mauna Loa Strip (Boundary Kipuka, Kipuka Ki, and Mauna Loa Lower SEAs), and East Rift (Ainahou, East Rift, Kahalii, Kahue, Mauna Ulu, and Puu Huluhulu SEAs) tracts. Only one small SEA is located in the Mauna Loa Southwest Rift tract, whereas extensive SEAs currently are located in both the Mauna Loa Strip and East Rift tracts. The congruence, however, was projected to break down over time, and, by the “end-of-century,” many existing SEAs will be located in areas that have a suitable habitat for only a limited number of native plant species (table 3; fig. 8*B*). Of particular interest were the forecasted remnant hotspots on the east edge of the Mauna Loa Southwest Rift tract, the eastern part of the Olaa tract, and the southern and eastern areas of the East Rift SEA, areas projected to remain relatively species rich (that is, at least 19 overlapping native plant species).

Patterns of Culturally Important Species

Although most native plants were important to early Hawaiians, we modeled five species that are particularly important to cultural practitioners today. “End-of-century” projections for these plant species showed mixed changes in their ranges, resulting in varying overlap with current collection areas within HAVO. Ranges of maile (*Alyxia stellata*) and ´ōhi´a lehua (*Metrosideros polymorpha*) should remain relatively consistent (table 2), and they may expand upslope more than they contract at lower elevations. Climate-driven changes for the other three modeled plant species may not be as favorable: koa (*Acacia koa*), māmaki (*Pipturus albidus*), and ´ōhelo (*Vaccinium reticulatum*) were projected to contract in range moderately to substantially, with minimal to no projected expansion in species range within HAVO (table 2).

Discussion

Climate is a key determinant of species distribution. Geophysically explicit species-range modeling offers a powerful option for evaluating plant-species response to future climatic conditions. On the basis of relations of current climatic conditions in which a species has been observed, models can be used to predict species responses to forecasted climates (Chen and others, 2011). Projected species ranges may be used to focus vegetation-management efforts on maintaining plant species where climate change is projected to threaten their existence, as well as to facilitate the establishment of SEAs at HAVO in areas where plant species may be expected to shift. Our “end-of-century” projected plant-species ranges were consistent with other species-range-modeling efforts in Hawai‘i (Price and others, 2012, 2015; Fortini and others, 2013) in which plant-species ranges depend largely on climate (that is, rainfall and temperature), substrate age, and historic distribution. Assuming an “A1B” emission scenario, the HRCM dynamically downscaled “end-of-century” climatic conditions are projected to have generally warmer temperatures and more variable precipitation amounts. Species-range contractions generally occurred in coastal and lower elevation environments, whereas expansion of suitable conditions occurred primarily in upper elevation montane and subalpine habitats. Our projections can be useful for making initial inferences about the potential effects of climate change on the 39 plant species that we modeled.

Within HAVO, approximately two-thirds (18 of 29) of the native plant species were projected to contract in range, whereas about one-third (11 of 29) were projected to expand in range (table 2). The plant species that showed the largest contractions typically have restricted bioclimate envelopes under current conditions. Because of the predominance of range contractions and the limited number of range expansions, most currently configured SEAs were projected to lose most of the 29 native plant species that we modeled, especially those SEAs that lie below 1,200 m.

Net range expansion typically occurred for the few pioneer species that may colonize young lava flows in areas where subalpine and alpine environments were projected to become suitable habitats under future rainfall and temperature regimes, that is, when bioclimatic-envelope and climate-change metrics matched (Garcia and others, 2016). Contraction in low (<100 m) elevation areas might not reflect the full physiological limits of native plant species because these species may be able to persist in areas that have temperatures higher than what has been recorded. However, from a modeling perspective, these areas would be “novel” environments and so were eliminated from consideration.

Within HAVO, the projected extent of range contraction exceeded that of expansion for all but one alien (nonnative) plant species, *Lantana camara*. The contractions were expected to occur in most SEAs and at all (low, middle, and high) elevations. Suitable habitats for only 4 of the 10 alien plant species (*Clidemia hirta*, *Lantana camara*, *Morella faya*, and *Schinus terebinthifolius*) will likely persist throughout most HAVO SEAs. These results may (1) help resource managers by reducing the need for control measures for this set of alien plant species and (2) benefit some native plant species by reducing competition. However, any interpretation of projected range changes for alien plant species should be done cautiously. The projected ranges are based on presently observed plant distributions in Hawai‘i and, thus, might not reflect the full physiological limits of these species. For

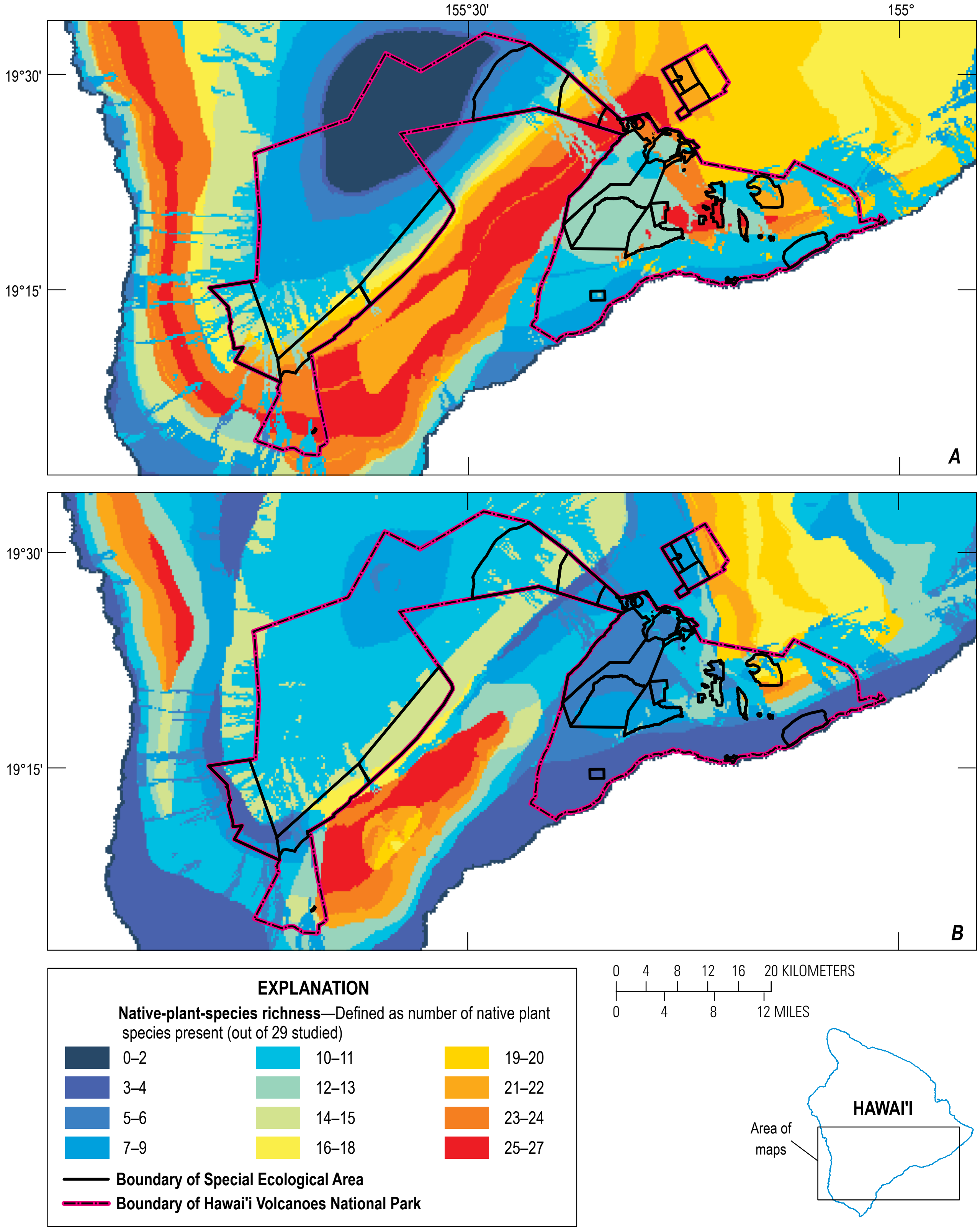

Figure 8. Maps showing native-plant-species richness (defined as number of native plant species projected to be present, out of 29 studied) in southern part of Island of Hawaiʻi in general and in Special Ecological Areas (SEAs) within Hawaiʻi Volcanoes National Park (HAVO) in particular. SEA boundaries (as of 2015; D. Benitez, unpub. data, 2015) and HAVO boundary from National Park Service's National Geospatial Data Asset (National Park Service, unpub. data, 2014). Approximate shoreline from U.S. Geological Survey's National Elevation Dataset (U.S. Geological Survey, 2014), World Geodetic System 1984 (WGS84). *A*, At year 2000 ("current"), distribution of species-richness hotspots (that is, areas that have high species-richness values) within HAVO aligns well with SEA boundaries. *B*, At year 2090 ("end-of-century"), projected native-plant-species richness predominately recedes from HAVO, resulting in fewer species-richness hotspots within SEA boundaries.

Table 4. Alien-plant-species richness in Special Ecological Areas of Hawai‘i Volcanoes National Park.

[Species richness (Rich) is expressed as number of alien- (nonnative-) plant species projected to be present, out of 10 studied). Special Ecological Areas (SEAs) are listed in order (from greatest gains to greatest losses) of amount of change in alien-species richness (Δ rich), which is based on amount of change between "current" (2000) and projected "end-of-century" (2090) richness. Also provided for each SEA are total area, average areal percentage of suitable habitat for all alien-plant species present (Average area suitable), and amount of change between "current" and "end-of-century" average areal percentages of suitable habitat (Δ average area suitable). Average areal percentage of suitable habitat was calculated as area of species-specific suitable habitat (that is, area that remained suitable + area of expansion), divided by area of SEA, × 100. See figure 1 for SEA locations]

SEA	Area (ha)	2000		2090		Change	
		Rich	Average area suitable (%)	Rich	Average area suitable (%)	Δ rich	Δ average area suitable (%)
East Rift	1,111	6	76	8	42	2	–34
Apua	66	0	0	0	0	0	0
Kahuku Mauka	3,629	3	64	3	3	0	–61
Akihi	11	6	100	5	59	–1	–41
Holei	1,234	1	0	0	0	–1	0
Kahuku West	5,119	2	35	1	5	–1	–30
Koa	771	4	88	3	29	–1	–60
Puu Huluhulu	1	4	100	3	100	–1	0
Ag	162	3	100	1	100	–2	0
Kahuku East	5,230	2	42	0	0	–2	–42
Mauna Loa Subalpine	7,296	2	4	0	0	–2	–4
Mauna Loa Upper	2,277	3	71	1	5	–2	–66
Puu	245	3	100	1	100	–2	0
Boundary Kipuka	39	4	70	1	83	–3	14
Devastation	34	4	91	1	88	–3	–3
Kipuka Ki	92	4	56	1	51	–3	–4
Kukalauula	202	3	14	0	0	–3	–14
Mauna Loa Lower	634	4	74	1	84	–3	10
New	764	4	75	1	98	–3	23
Kipuka Puaulu	93	4	89	1	100	–3	11
Small Tract	143	4	97	1	100	–3	3
Hwy 11 Fee	20	5	72	1	100	–4	28
Kahue	261	9	79	5	47	–4	–32
Kau Buffer	3,358	5	21	1	2	–4	–19
Keanakakoi	127	5	80	1	83	–4	4
Mauna Ulu	335	9	16	5	8	–4	–8
Puaulu Buffer	926	5	69	1	86	–4	17
Puhimau	2	5	100	1	100	–4	0
Thurston	296	6	65	1	99	–5	34
Ainahou	83	8	73	2	65	–6	–8
Kahalii	340	8	92	2	91	–6	–1
Kamakaia	3,776	8	13	2	0	–6	–12
Kealakomo	10	8	95	2	55	–6	–40
Hilina Pali	467	8	34	1	25	–7	–9
Hilina Pali Expansion	1,954	9	18	2	6	–7	–11
Keamoku	4,244	8	13	1	2	–7	–11
Naulu	16	8	89	1	87	–7	–3

example, the observed upper elevation limit of a recent plant-species arrival in the islands may not be due to temperature but, instead, may merely reflect the limit of how far that species has been able to expand since its introduction. Additionally, other alien plant species besides the 10 that were modeled in this study are expected to continue to occupy these habitats, and their range may either expand or contract in response to climate change (Vorsino and others, 2014).

Vegetation-Management Implications

Projected shifts in suitable habitats for native plant species will assist HAVO resource managers in assessing the configuration of, and the prioritizing of future work in, SEAs (Watson and others, 2013). Potential changes to SEAs could include altering the boundaries of existing SEAs, establishing new SEAs, or expanding existing SEAs to incorporate future species-richness hotspots in areas not currently managed by HAVO staff. A good congruence exists between "current" (2000) native-plant-species richness and SEA configuration (table 3; fig. 8). However, our results suggest that substantial shifts in plant-species range may occur across HAVO under modeled "end-of-century" climate projections, in which drier areas become drier, wetter areas become wetter, and temperatures increase everywhere but more so at higher elevations (Elison Timm and others, 2011; Zhang and others, 2012). As such, most SEAs were projected to contain suitable habitats for as many as 12 of the modeled native plant species at the "end-of-century" (2090). Thus, the congruence between species-richness hotspots and SEAs diminishes over time, so that, by the "end-of-century," many projected species-richness hotspots (including the east edge of the Mauna Loa Southwest Rift tract [Akihi SEA], the eastern part of the Olaa tract [Koa and New SEAs], and the southern and eastern parts of the East Rift tract [Kahue and Ease Rift SEAs]) will be outside current SEA boundaries.

In addition to informing HAVO-wide vegetation- and habitat-management priorities, the results from this modeling will assist HAVO resource managers who are working with adjoining landowners and partner agencies to prioritize conservation efforts islandwide. As a member of the Three Mountain Alliance (TMA), HAVO collaborates with several federal, state, and private landowners to protect more than a million acres of watershed on the Island of Hawaiʻi. Protection of native-plant-species richness and invasive-plant-species management are among the TMA activities that would benefit directly from this modeling effort and its forecasted shifts in species range. For example, our models projected that most of the most plant-species-rich habitats currently in the Kahuku East, Kahuku West, and Kahuku Mauka SEAs will have been lost by "end-of-century" (2090), yet suitable habitats for these plant species are projected to remain in the adjacent Kaʻu Forest Reserve.

Although current resource-management actions (for example, fencing and control of ungulates, invasive-species control, and outplanting restoration) will continue to be critical for the conservation of plant species and communities, the rate of climate change is also a factor that will affect habitat suitability. If, for example, climate change is very rapid, the predicted changes in suitable habitat for some native plant species might grossly underestimate the realized changes in future distribution if these native species cannot adapt rapidly to changing climate conditions or compete effectively with alien plant species in order to realize their potential. Assisted colonization, which is the translocation of organisms to areas outside their historically documented range in anticipation of more suitable future conditions, may be a conservation option in the Mauna Loa Southwest Rift tract. Candidate plant species for assisted colonization include those that have long generation times and low fecundity, lack the dispersal capability needed to track rapidly changing climate conditions, or are found close to their physiological limits (Chauvenet and others, 2013; Rout and others, 2013; Gallagher and others, 2015). From our models, four plant species (*Diospyros sandwicensis*, *Nestegis sandwicensis*, *Pandanus tectorius*, and *Psydrax odorata*) were projected to have new suitable habitats by "end-of-century" in the Mauna Loa Southwest Rift tract. Once these species have been established, additional resource-management actions, such as supplementing introduced plant populations, may be needed to maintain viable plant populations and communities (Moir and others, 2012).

The Tropics have a relatively small range of natural climatic variation (Mora and others, 2013; Power, 2014). In our models, however, the suitable-habitat ranges of most plant species changed substantially by "end-of-century," with the three different climate trajectories (rapid, linear, gradual) for the "A1B" emission scenario resulting in changes in the timing of these species-range shifts. These changes can be seen in the eight-panel species-projection maps (see appendix 3). In general, projections of the rapid climate trajectory in 2040 were most similar to those of the gradual climate trajectory in 2070, whereas projections of the 2070 middle (linear) and rapid climate trajectories were most similar (fig. 5). We anticipated these similarities because our approach to modeling future climate change provided overlapping scenarios as a means of discerning which trajectory of climate change is being followed as the century unfolds. On the basis of which trajectory seems to be occurring, resource managers can update their decisions at intermediate management cycles (Stephenson, 2014).

We expect that plant-species habitats will become suitable or unsuitable gradually as the climate changes, regardless of which future climate trajectory unfolds. In some places, however, a sudden change in habitat suitability could occur when the envelope threshold of a species is crossed. Smaller SEAs may be more likely to undergo this sudden shift because any changes in climatic conditions would be expected to more quickly encompass the entire SEA. In our model, rainfall and temperature were the main drivers affecting the patterns of species-range expansion and contraction. These drivers interacted in various ways (including synergistically, orthogonally, and in opposition to one another) to influence the projected ranges. For example, the drivers initially may facilitate habitat suitability but later may work against each other, resulting in habitat contractions. *Psychotria hawaiiensis* in the Kahuku Mauka SEA represents one such case where the SEA initially became more favorable (suitable) before returning to an unsuitable state. Understanding the species-specific influence of each driver will help to identify microsite suitability within a matrix of unsuitable habitats (Chapin and others, 2002).

Plant-Community Structure

Climate change will also affect plant communities by potential changes in vegetation structure, as well as in plant-species composition, distribution, and abundance (Price and others, 2012, 2015) and in flowering phenology, nectar and pollen production, and fruit production (Menzel and others, 2006). The projected changes in mean annual surface temperature and rainfall suggest that substantial changes will occur in HAVO vegetation and flora. Furthermore, both variations in climate and extreme climatic events will likely have a greater influence on flowering phenology than indicated in mean climate projections (Garcia and others, 2014); climatic drivers of such effects include the El Niño–Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) events (Chu and Chen, 2005). Thus, climate change will have cascading effects on ecosystem structure, ecological functions, and ecosystem services (Permesan, 2006; Butt and others, 2015).

Many Hawaiian forest birds could also be adversely affected by changing availability of resources (Banko and Banko, 2009), which could further threaten many declining Hawaiian bird species (Gorresen and others, 2009). Climate-driven variations in Hawaiian plant-species distributions and also their flower and fruit production have obvious direct effects on nectarivorous and frugivorous birds (Woodworth and Pratt, 2009). Most insect-species ranges are regulated by climatic conditions (temperature and moisture), food resources, and host plants (Leblanc and others, 2013; Vorsino and others, 2013). Thus, changes in climatic conditions and in plant-species distributions will change insect-species distributions, which could adversely affect insectivorous birds through changes in prey resources (Woodworth and Pratt, 2009). In addition to shifting plant- and animal-species distributions, changing climatic conditions may stress species, resulting in either extinction, rapid evolution, or, more likely, a mix of these two extremes. In general, species that tend to be specialists will face a greater probability of extinction, whereas generalist species may be better able to adapt and evolve to novel climatic and environmental conditions (Banko and Banko, 2009).

Potential Impacts of Climate Change on Cultural Resources

Much current literature exists on the relation between anthropology and climate change, describing the perceptions and impacts of climate change on indigenous and local peoples (for example, Crate and Nuttall, 2009; Intergovernmental Panel on Climate Change, 2014). Indigenous cultures still closely tied to local landscapes are already well aware of changing climatic conditions and the resulting changing environmental conditions (Crate and Nuttall, 2009). A long history of interactions between humans and nature results in species-assemblage and -composition patterns that have high cultural significance (Rossler, 2006). Thus, climate-driven changes in culturally significant landscapes have far-reaching effects on languages, habits, rituals, opinions, values, norms, and world views (Shadid, 2007), resulting in changes in cultural practices and activities and in the strength of ties to the environment. Historically, Hawaiians have been intimately connected to a dynamic environment influenced not only by geologic forces such as volcanism, seismic activity, and tsunamis, and by cyclical climate fluctuations such as the El Niño and La Niña phases of the ENSO cycle, and the PDO. In addition, they have been aware of the pronounced differences between the windward and leeward aspects of most Hawaiian Islands, which result in sharp spatial and temporal gradients in temperature and rainfall, as well as in lowland and upland plant communities.

In traditional Hawaiian culture, natural resources—the land, forests, and ocean, as well as the plants, animals, and inanimate objects—all are integral to all aspects of human life. We may reasonably assume that Hawaiians have been using all available resources, including plants, in the many *ahupua´a* (a traditional Hawaiian land division) both within and adjacent to present-day HAVO. Hawaiians have been intimately related to, and knowledgeable of, the land, forests, and ocean, thus establishing a deep respect of place and the identity connected to place (Kapā‘anaokalāokeola Oliveira, 2014). ´Ōhi´a lehua (*Metrosideros polymorpha*), a dominant tree throughout the islands, has been used widely in many cultural practices, including religious purposes, as well as for making ornaments, musical instruments, weapons of war, and canoes (Krauss, 1993). Koa (*Acacia koa*), another dominant tree, has been the preferred wood for making Hawaiian voyaging canoe hulls, along with thwarts and paddles, as well as for dyes and medicine (Krauss, 1993). Hawaiians have used the leaves, flowers, fruits, seeds, and seed capsules of maile (*Alyxia stellata*; a vine or liana), māmaki (*Pipturus albidus*; a tall shrub), and ´ōhelo (*Vaccinium reticulatum*; a short shrub) for ornaments, dyes, apparel, medicine, and food (Krauss, 1993).

The Hawaiian cultural renaissance has increased traditional practices that include plant collection. Generally speaking, these collections are used for *ho´okupu* to Pele (that is, as contributions to the religious practice) and for hula performances. Thus, it remains critical for HAVO resource managers to help maintain the cultural significance of the landscapes (Martin and Carter Schuster, 2003). Plant collection for cultural purposes is likely to continue, at the same time that these same species are adjusting to changing climatic conditions and shifting habitat suitability. Plant collection for cultural purposes in HAVO is currently focused along roadways and in the vicinity of Kīlauea Caldera (C. Langlas, written commun., 2003). If Hawaiian cultural practitioners are to continue to collect plants, suitable collection sites may have to be relocated in order to track shifts in plant-species ranges that are due to climate change.

Modeling Limitations and Opportunities for Improved Models

Reliable projections of climatically and environmentally suitable areas for plant species under future climatic conditions rely on the quality of the global circulation models (GCMs), emission scenarios, dynamically downscaled modeling, species-distribution data, and bioclimatic-envelope models. The dynamic-downscaling model used to forecast mean annual temperature and precipitation is based on a single forcing of a GCM; however, the large uncertainties that remain around all climate models are not adequately captured within a single forcing of a GCM. Such uncertainties complicate management decisions for both near- and long-term planning. In addition, downscaling of GCM projections to a local scale that is suitable for inference to species-habitat suitability introduces yet another layer of uncertainty, and different downscaling methods may, in turn, predict different small-scale effects, even within the same GCM and forcing scenario.

Although in our study we used a single forcing and a single downscaling model, some measure of uncertainty still exists in the climate change projected by the downscaling model, such that, in some areas (for example, the midelevation areas around Mauna Kea), the 80-percent-threshold range of predicted increase in rainfall extends down either to no change or to a decrease in precipitation. The uncertainty in the climate delta then creates further uncertainty in the response of such plant species as ʻĀkala (*Rubus hawaiensis*). Moisture limits of ʻĀkala range from moderately dry to very wet; in addition, within the areas that surround Mauna Kea where ʻĀkala currently exists (figs. 6, 9), a significant probability exists of drying down to a level unsuitable for ʻĀkala, despite the mean projection from the HRCM in that area as increasing in rainfall. Further refinements to downscaling models may allow for reduced uncertainties and improved projections in species ranges, but our current projections should be used cautiously for detailed on-the-ground management decisions.

The climatic variables available for use in this study were also quite general. For example, mean temperature fails to capture short-term heat and freezing limitations, whereas mean annual precipitation does not adequately incorporate drought or the extreme-rainfall events that limit species ranges. Additional limitations exist in the temperature and precipitation source data identified by Price and others (2012) and Giambelluca and others (2013, 2014), including geographic representation across large landscapes that have few weather stations. Our use of the more current "Rainfall Atlas and Climate of Hawaiʻi" (Giambelluca and others, 2013, 2014), which is derived from weather-station data collected from 1978 to 2007, better agrees with the currently observed weather patterns. Nonetheless, limitations in categorically based factors such as moisture, upland area, bioregions, and substrate-age cutpoints still persist. The long-term temporal and widespread geographic scales of our modeling effort should capture general patterns of species ranges but will miss many weather-related and environmental nuances that influence plant-species distributions, as is evident in our models in which some species were projected to extend to the highest elevations on the three highest volcanoes in the state (Mauna Loa, Mauna Kea, and Haleakala). Although our modeled climatic conditions (rainfall and temperature) may become favorable in these high-elevation areas, these areas also currently contain unweathered substrates (volcanic lava) that have little or no soil and, thus, do not support vegetation. Additionally, although average temperatures may increase at higher elevations, they will still be subject to extended periods of below-freezing temperatures during winter months, which may exclude some plant species.

The scale of climate projections used in this study was chosen to minimize deviation from weather data and to maximize model performance. Standardizing resolution—that is, grid size—among climatic and environmental variables can be accomplished through interpolation and resampling to match the desired resolutions. This approach allows for grid size to vary independently, thus avoiding the need to match scale across all biotic and abiotic factors of climatic and environmental variables used to model plant-species ranges. However, problems can arise when resolutions vary widely, such as when combining GCM projections at 10,000-km^2 scale with hydrology at 0.25-km^2 scale. Downscaling procedures can help alleviate these types of scale disparity and also can more adequately represent important physiological drivers at biologically relevant scales as resolutions become more similar.

To meet HAVO's objectives of determining SEA effectiveness under future climatic conditions, the 250-m grid resolution of the "Rainfall Atlas and Climate of Hawaiʻi" (Giambelluca and others, 2013, 2014) appears to adequately capture the influences of environmental and climatic factors in controlling species-habitat suitability. Although increasing resolution may better approximate the variations in plant-species ranges, localized conditions become greater influences on species ranges as grid size decreases; that is, the presence or absence of a species within physiologically suitable environments and climate projections is controlled by local-scale factors not captured by this model, such as aspect, slope, soil type, evapotranspiration, and the presence of competitive species. As long as interpolation and resampling methods are valid for rescaling grids, modeling efforts could benefit from additional species-occurrence data that better parameterize climate envelopes, and they also could incorporate more forcing variables at greater spatial resolutions to better capture future climatic uncertainty.

A direct application of our projections is that they can be used to identify places where major changes in habitat conditions are predicted (for example, transition from a more stable wet habitat, across a mesic habitat, to a dry habitat), as well as where plant species are projected to respond to future climatic conditions. We addressed this by calculating the differences in species richness between "current" (2000) and "end-of-century" (2090) projections (fig. 8) to generate a map that distinguishes areas predicted to have low to high amounts of species turnover (fig. 10). Areas that have high species turnover are where the climate-change signal is strongest, indicative of areas projected to undergo the greatest amount of climate change. Within

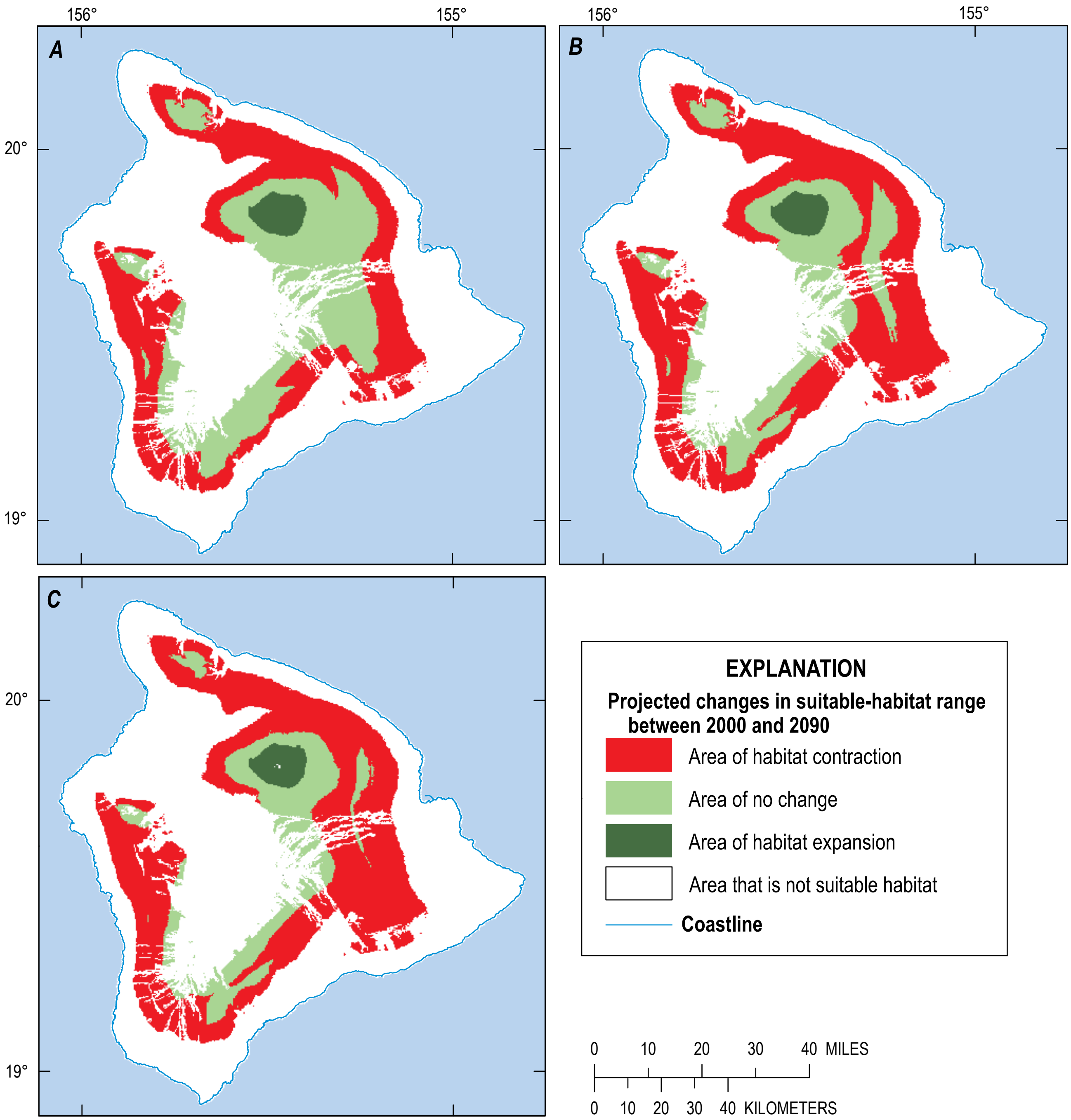

Figure 9. Maps of Island of Hawai‘i, showing projected changes in suitable-habitat range of ‘Ākala (*Rubus hawaiensis*), a plant species that appears to be responsive to climate change, between “current” (2000) and “end-of-century” (2090) for three different confidence levels, which represent percentages from 400 modeled climate-change-projection iterations. White areas are not suitable habitat for ‘Ākala. Base map from Rainfall Atlas and Climate of Hawai‘i (Giambelluca and others, 2013, 2014), World Geodetic System 1984 (WGS84); coastline from U.S. Geological Survey’s National Elevation Dataset (U.S. Geological Survey, 2014). *A*, 50-percent-confidence threshold. *B*, 80-percent-confidence threshold. *C*, 95-percent-confidence threshold.

HAVO, these areas include the western parts of the Kahuku tract, Southwest Rift tract, and Mauna Loa Strip tract, as well as scattered locations in the East Rift tract. Obtaining additional species-habitat data in these areas—for example, by deploying more weather stations—will help resource managers understand the trajectory and extent of future climatic changes, whereas vegetation monitoring will provide information on how plants are responding to these changing conditions.

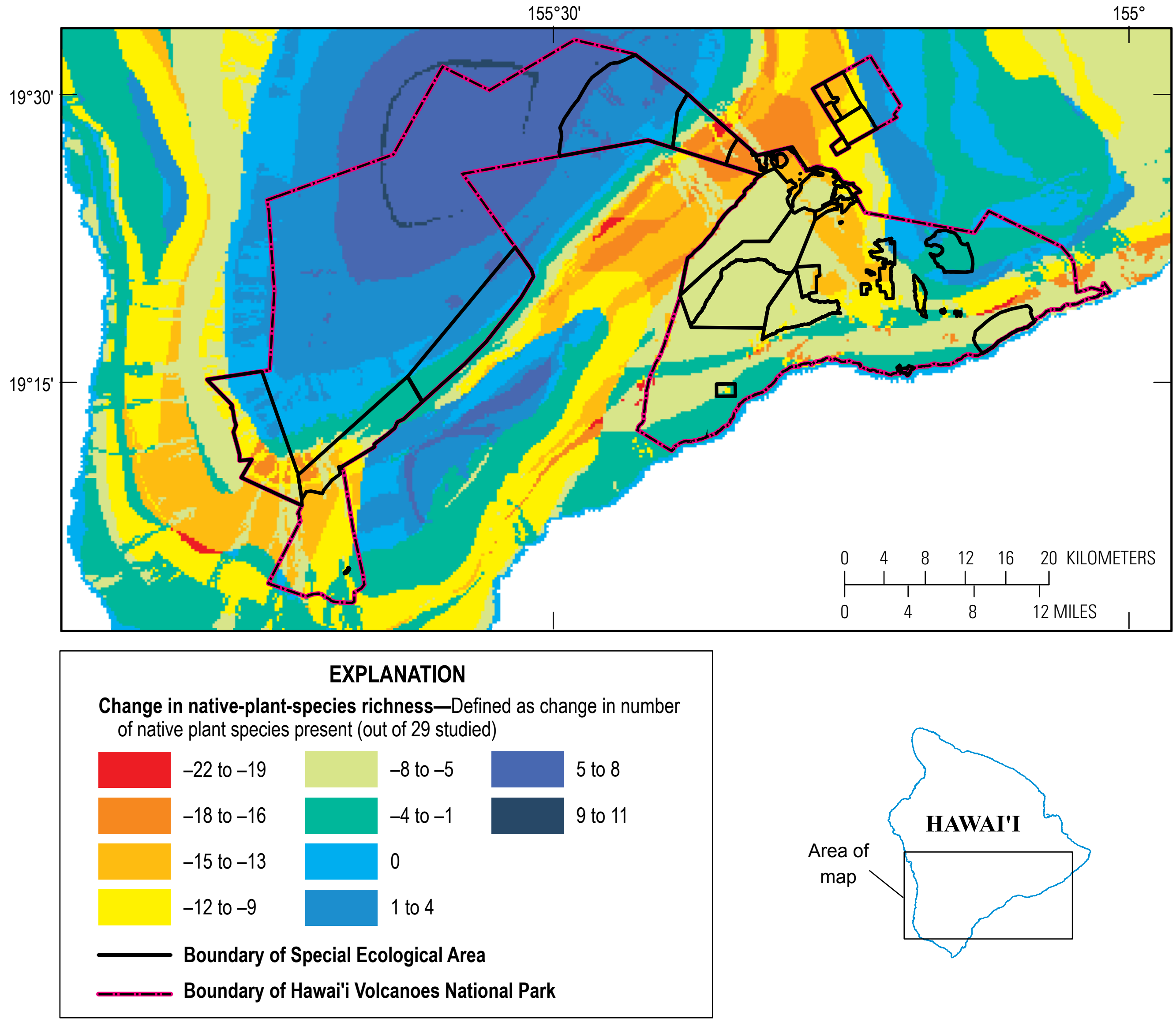

Figure 10. Map showing change in native-plant-species richness (defined as change in number of native plant species projected to be present, out of 29 studied) from “current” (2000) to “end-of-century” (2090) in southern part of Island of Hawaiʻi in general and in Special Ecological Areas (SEAs) within Hawaiʻi Volcanoes National Park (HAVO) in particular. Negative values represent decrease in suitable habitat by year 2090; positive values, increase during same time period. SEA boundaries (as of 2015; D. Benitez, unpub. data, 2015) and HAVO boundary from National Park Service’s National Geospatial Data Asset (National Park Service, unpub. data, 2014). Approximate shoreline from U.S. Geological Survey’s National Elevation Dataset (U.S. Geological Survey, 2014), World Geodetic System 1984 (WGS84).

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Appendixes 1–3

Appendix 1. Projected changes in suitable-habitat range for 39 focal native and alien (nonnative) plant species, as projected using middle- (linear-) climate-change trajectory, by state, Hawaiian island, or Special Ecological Area

[Average areal percentages of state, Hawaiian island, or Special Ecological Area (SEA) that have suitable habitat for years 2000 (“present”) and 2090 (projected “end-of-century”) are listed in columns 2 and 9, respectively. Amounts of contraction and expansion of suitable habitat by species over three projected time periods (2000–2040, 2000–2070, 2000–2090), as percentages of change from 2000, are listed in columns 3 through 8. Average areal percentage of suitable habitat was calculated as area of species-specific suitable habitat (that is, area that remained suitable + area of expansion) in the state, island, or SEA, divided by area of the state, island, or SEA, × 100. Net percentage of change between 2000 and 2090, listed in column 10, was calculated as difference between 2090 and 2000 percentages of the state, island, or SEA that is suitable, divided by 2000 percentage of state, island, or SEA that is suitable, × 100 (any numerical differences are due to rounding of reported values)]

Contents of Appendix 1

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
1. State of Hawai‘i									
Native species									
Acacia koa	53	18	4	37	6	52	6	28	–46
Alyxia stellata	65	7	6	18	11	28	13	51	–21
Cheirodendron trigynum	35	33	0	61	0	74	0	9	–74
Cibotium spp.	43	20	1	44	0	60	0	18	–60
Coprosma ernodeoides	42	23	3	46	5	59	5	20	–52
Coprosma montana	21	17	3	31	3	41	3	15	–29
Coprosma spp.	42	28	3	53	4	67	5	16	–61
Dicranopteris linearis	49	21	1	47	0	63	0	18	–63
Diospyros sandwicensis	41	13	8	28	14	40	17	35	–15
Dodonaea viscosa	92	0	24	0	38	0	43	95	4
Freycinetia arborea	41	19	3	44	3	60	1	17	–57
Ilex anomala	44	20	2	46	2	62	0	18	–61
Leptecophylla tameiameiae	80	15	11	33	11	48	7	44	–45
Metrosideros polymorpha	83	8	23	19	31	29	31	65	–21
Myoporum sandwicense	93	0	23	0	35	0	35	95	3
Myrsine lessertiana	51	23	2	50	2	66	0	18	–64
Nestegis sandwicensis	40	12	9	29	13	39	10	31	–23
Osteomeles anthyllidifolia	60	10	17	24	27	35	28	50	–16
Pandanus tectorius	33	17	10	38	17	53	20	29	–13
Pipturus albidus	48	21	2	46	0	62	0	18	–62
Pisonia spp.	53	18	3	36	3	51	2	27	–50
Psychotria hawaiiensis	31	17	1	43	0	62	0	12	–62
Psydrax odorata	33	15	5	33	8	45	9	24	–26
Rubus hawaiensis	30	30	1	54	1	68	1	10	–65
Sadleria cyatheoides	60	19	10	42	15	58	18	32	–46
Santalum spp.	81	0	22	0	36	0	44	89	10
Sophora chrysophylla	37	23	3	36	4	45	4	23	–38
Vaccinium calycinum	25	49	0	73	0	84	0	4	–84
Vaccinium reticulatum	49	24	1	46	1	58	1	21	–56
Alien (nonnative) species									
Clidemia hirta	29	21	5	44	6	61	6	16	–47
Falcataria moluccana	14	38	3	73	4	83	4	6	–58
Hedychium gardnerianum	30	30	1	61	1	72	0	9	–69
Lantana camara	36	14	7	31	13	43	14	30	–17
Miconia calvescens	20	32	4	65	5	76	3	8	–59
Morella faya	37	39	4	73	5	86	2	7	–80
Passiflora tarminiana	12	56	1	88	0	95	0	1	–92
Psidium cattleianum	36	20	4	42	4	58	3	17	–53
Rubus ellipticus	11	49	0	80	0	93	0	1	–92
Schinus terebinthifolius	27	28	6	51	8	66	4	12	–54

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
2. Island of Kaua‘i									
Native species									
Acacia koa	84	17	0	34	0	44	0	47	–44
Alyxia stellata	90	9	2	22	2	31	2	63	–31
Cheirodendron trigynum	41	39	0	58	0	69	0	13	–69
Cibotium spp.	68	25	1	40	1	49	1	35	–49
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	43	39	0	58	0	69	0	14	–69
Dicranopteris linearis	68	25	0	40	0	49	0	35	–49
Diospyros sandwicensis	74	11	16	27	27	38	33	55	–26
Dodonaea viscosa	96	0	0	0	0	0	0	96	0
Freycinetia arborea	67	25	2	41	3	50	3	35	–48
Ilex anomala	68	25	0	40	0	49	0	35	–49
Leptecophylla tameiameiae	84	17	0	34	0	44	0	47	–44
Metrosideros polymorpha	91	9	0	22	0	31	0	63	–31
Myoporum sandwicense	96	0	0	0	0	0	0	96	0
Myrsine lessertiana	68	25	0	40	0	49	0	35	–49
Nestegis sandwicensis	64	12	3	31	6	44	8	39	–39
Osteomeles anthyllidifolia	64	12	3	31	6	44	8	39	–39
Pandanus tectorius	60	13	21	31	31	44	36	48	–20
Pipturus albidus	68	25	1	40	1	49	1	35	–49
Pisonia spp.	83	17	3	34	5	44	5	47	–43
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	64	12	4	31	7	44	9	39	–39
Rubus hawaiensis	22	40	0	61	0	74	0	6	–74
Sadleria cyatheoides	68	25	0	40	0	49	0	35	–49
Santalum spp.	87	0	12	0	17	0	19	89	3
Sophora chrysophylla	29	51	1	69	2	75	2	9	–70
Vaccinium calycinum	25	38	0	63	0	76	0	6	–76
Vaccinium reticulatum	29	41	0	60	0	71	0	8	–71
Alien (nonnative) species									
Clidemia hirta	55	29	8	45	12	54	12	31	–44
Falcataria moluccana	23	32	5	55	8	68	9	14	–39
Hedychium gardnerianum	42	24	1	43	1	55	1	20	–53
Lantana camara	63	13	7	32	10	45	12	39	–38
Miconia calvescens	31	27	4	46	5	56	5	17	–45
Morella faya	51	50	3	70	4	83	5	11	–78
Passiflora tarminiana	9	61	1	91	1	100	0	0	–100
Psidium cattleianum	63	27	8	43	11	53	11	34	–46
Rubus ellipticus	15	51	1	80	1	90	1	2	–85
Schinus terebinthifolius	54	26	6	52	9	65	7	22	–60

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
3. Island of O‘ahu									
Native species									
Acacia koa	69	22	0	40	0	50	0	34	–50
Alyxia stellata	84	14	0	29	0	41	0	49	–41
Cheirodendron trigynum	26	58	0	81	0	89	0	3	–89
Cibotium spp.	46	27	0	44	0	52	0	22	–52
Coprosma ernodeoides	3	75	0	92	0	97	0	0	–97
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	29	57	0	80	0	89	0	3	–89
Dicranopteris linearis	46	27	0	44	0	52	0	22	–52
Diospyros sandwicensis	79	15	3	31	5	44	6	45	–42
Dodonaea viscosa	93	0	0	0	0	0	0	93	0
Freycinetia arborea	46	27	0	44	0	52	0	22	–52
Ilex anomala	46	27	0	44	0	52	0	22	–52
Leptecophylla tameiameiae	69	22	0	40	0	50	0	34	–50
Metrosideros polymorpha	84	14	0	29	0	41	0	49	–41
Myoporum sandwicense	93	0	0	0	0	0	0	93	0
Myrsine lessertiana	46	27	0	44	0	52	0	22	–52
Nestegis sandwicensis	70	16	3	35	6	50	8	37	–46
Osteomeles anthyllidifolia	70	16	3	35	6	50	8	37	–46
Pandanus tectorius	72	16	23	34	33	48	37	48	–34
Pipturus albidus	46	27	0	44	0	52	0	22	–52
Pisonia spp.	69	22	0	40	0	50	0	34	–50
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	70	16	3	35	6	50	8	37	–46
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	46	27	0	44	0	52	0	22	–52
Santalum spp.	88	0	5	0	8	0	10	89	1
Sophora chrysophylla	26	75	1	91	0	96	0	1	–95
Vaccinium calycinum	11	62	0	85	0	94	0	1	–94
Vaccinium reticulatum	11	65	0	88	0	96	0	0	–96
Alien (nonnative) species									
Clidemia hirta	45	28	1	44	1	53	1	22	–51
Falcataria moluccana	19	28	4	43	5	53	6	14	–28
Hedychium gardnerianum	25	24	0	35	0	43	0	14	–43
Lantana camara	69	16	4	35	6	50	8	37	–46
Miconia calvescens	24	24	1	36	1	44	1	14	–41
Morella faya	35	51	1	80	1	92	1	4	–90
Passiflora tarminiana	1	80	0	93	0	97	0	0	–97
Psidium cattleianum	46	27	0	44	0	52	0	22	–52
Rubus ellipticus	5	69	0	93	0	99	0	0	–99
Schinus terebinthifolius	54	28	2	51	4	64	6	22	–59

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
4. Island of Moloka‘i									
Native species									
Acacia koa	44	15	0	27	0	34	0	29	–34
Alyxia stellata	53	14	0	25	0	33	0	35	–33
Cheirodendron trigynum	28	32	0	53	0	65	0	10	–65
Cibotium spp.	35	15	0	31	0	43	0	20	–43
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	29	30	0	52	0	63	0	11	–63
Dicranopteris linearis	35	15	0	31	0	43	0	20	–43
Diospyros sandwicensis	61	26	9	42	13	52	14	35	–43
Dodonaea viscosa	63	0	0	0	0	0	0	63	0
Freycinetia arborea	35	15	0	31	0	43	0	20	–43
Ilex anomala	35	15	0	31	0	43	0	20	–43
Leptecophylla tameiameiae	44	15	0	27	0	34	0	29	–34
Metrosideros polymorpha	67	24	0	38	0	47	0	36	–47
Myoporum sandwicense	63	0	0	0	0	0	0	63	0
Myrsine lessertiana	35	15	0	31	0	43	0	20	–43
Nestegis sandwicensis	55	29	6	46	8	58	10	28	–49
Osteomeles anthyllidifolia	41	18	4	32	6	43	8	28	–32
Pandanus tectorius	33	22	9	40	14	52	18	28	–16
Pipturus albidus	35	15	0	31	0	43	0	20	–43
Pisonia spp.	44	15	0	27	0	34	0	29	–34
Psychotria hawaiiensis	35	15	0	31	0	43	0	20	–43
Psydrax odorata	55	29	6	46	8	58	10	28	–49
Rubus hawaiensis	13	45	0	71	0	85	0	2	–85
Sadleria cyatheoides	35	15	0	31	0	43	0	20	–43
Santalum spp.	63	0	0	0	0	0	0	63	0
Sophora chrysophylla	27	52	3	72	4	80	4	8	–69
Vaccinium calycinum	18	39	0	70	0	84	0	3	–84
Vaccinium reticulatum	19	38	0	61	0	74	0	5	–74
Alien (nonnative) species									
Clidemia hirta	29	19	5	37	7	51	8	20	–32
Falcataria moluccana	11	45	3	73	4	84	4	5	–50
Hedychium gardnerianum	25	28	0	55	0	69	0	8	–69
Lantana camara	55	29	6	46	9	58	11	28	–49
Miconia calvescens	18	35	4	61	4	74	3	7	–62
Morella faya	33	24	0	43	0	56	0	14	–56
Passiflora tarminiana	6	56	1	85	1	97	1	1	–82
Psidium cattleianum	34	16	2	32	2	44	2	20	–41
Rubus ellipticus	9	67	0	91	0	97	0	0	–97
Schinus terebinthifolius	33	28	5	43	7	53	9	21	–36

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
5. Island of Lāna‘i									
Native species									
Acacia koa	37	50	0	80	0	90	0	4	–90
Alyxia stellata	72	17	0	42	0	53	0	34	–53
Cheirodendron trigynum	2	100	0	100	0	100	0	0	–100
Cibotium spp.	2	100	0	100	0	100	0	0	–100
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	2	100	0	100	0	100	0	0	–100
Dicranopteris linearis	2	100	0	100	0	100	0	0	–100
Diospyros sandwicensis	72	17	0	42	0	53	0	34	–53
Dodonaea viscosa	93	0	0	0	0	0	0	93	0
Freycinetia arborea	2	100	0	100	0	100	0	0	–100
Ilex anomala	2	100	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	37	50	0	80	0	90	0	4	–90
Metrosideros polymorpha	72	17	0	42	0	53	0	34	–53
Myoporum sandwicense	93	0	0	0	0	0	0	93	0
Myrsine lessertiana	2	100	0	100	0	100	0	0	–100
Nestegis sandwicensis	72	17	0	42	0	53	0	34	–53
Osteomeles anthyllidifolia	72	17	0	42	0	53	0	34	–53
Pandanus tectorius	63	20	16	47	21	60	23	34	–47
Pipturus albidus	2	100	0	100	0	100	0	0	–100
Pisonia spp.	37	50	0	80	0	90	0	4	–90
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	72	17	0	42	0	53	0	34	–53
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	2	100	0	100	0	100	0	0	–100
Santalum spp.	93	0	0	0	0	0	0	93	0
Sophora chrysophylla	61	66	0	91	0	95	0	3	–95
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	2	100	0	100	0	100	0	0	–100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	72	17	0	42	0	53	0	34	–53
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	2	100	0	100	0	100	0	0	–100
Passiflora tarminiana	2	100	0	100	0	100	0	0	–100
Psidium cattleianum	2	100	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	37	50	0	80	0	90	0	4	–90

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
6. Island of Kaho‘olawe									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	25	53	0	81	0	95	0	1	–95
Cheirodendron trigynum	0	0	0	0	0	0	0	0	0
Cibotium spp.	0	0	0	0	0	0	0	0	0
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	0	0	0	0	0	0	0	0	0
Dicranopteris linearis	0	0	0	0	0	0	0	0	0
Diospyros sandwicensis	25	53	0	81	0	95	0	1	–95
Dodonaea viscosa	82	0	0	0	0	0	0	82	0
Freycinetia arborea	0	0	0	0	0	0	0	0	0
Ilex anomala	0	0	0	0	0	0	0	0	0
Leptecophylla tameiameiae	0	0	0	0	0	0	0	0	0
Metrosideros polymorpha	0	0	0	0	0	0	0	0	0
Myoporum sandwicense	82	0	0	0	0	0	0	82	0
Myrsine lessertiana	0	0	0	0	0	0	0	0	0
Nestegis sandwicensis	0	0	0	0	0	0	0	0	0
Osteomeles anthyllidifolia	25	53	0	81	0	95	0	1	–95
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	0	0	0	0	0	0	0	0	0
Pisonia spp.	0	0	0	0	0	0	0	0	0
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	25	53	0	81	0	95	0	1	–95
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	0	0	0	0	0	0	0	0	0
Santalum spp.	82	0	0	0	0	0	0	82	0
Sophora chrysophylla	17	100	0	100	0	100	0	0	–100
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	25	53	0	81	0	95	0	1	–95
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	0	0	0	0	0	0	0	0	0
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
7. Island of Maui									
Native species									
Acacia koa	63	31	8	60	11	81	12	17	–74
Alyxia stellata	69	16	7	40	15	57	19	36	–49
Cheirodendron trigynum	36	36	0	71	0	89	0	4	–88
Cibotium spp.	43	34	1	73	1	89	0	5	–88
Coprosma ernodeoides	37	25	0	53	0	67	0	12	–67
Coprosma montana	11	16	1	28	1	36	0	7	–34
Coprosma spp.	41	29	5	62	7	79	7	13	–70
Dicranopteris linearis	44	34	1	73	0	89	0	5	–89
Diospyros sandwicensis	45	24	6	61	8	75	10	17	–62
Dodonaea viscosa	94	0	4	0	4	0	4	95	0
Freycinetia arborea	40	34	2	73	2	89	1	5	–88
Ilex anomala	44	34	1	73	0	89	0	5	–89
Leptecophylla tameiameiae	69	29	0	56	0	74	0	18	–74
Metrosideros polymorpha	76	15	6	37	7	53	7	37	–50
Myoporum sandwicense	95	0	0	0	0	0	0	95	0
Myrsine lessertiana	46	36	0	74	0	89	0	5	–89
Nestegis sandwicensis	43	25	4	59	3	68	4	16	–63
Osteomeles anthyllidifolia	51	22	7	53	9	63	9	23	–54
Pandanus tectorius	33	33	10	76	14	92	11	10	–70
Pipturus albidus	44	34	1	73	1	89	0	5	–88
Pisonia spp.	55	36	3	66	2	86	1	8	–85
Psychotria hawaiiensis	31	37	1	82	1	97	0	1	–97
Psydrax odorata	41	27	4	63	5	73	7	15	–63
Rubus hawaiensis	31	25	0	54	0	66	0	11	–66
Sadleria cyatheoides	51	29	6	64	8	79	8	14	–72
Santalum spp.	79	0	9	0	14	0	19	83	5
Sophora chrysophylla	37	30	2	48	3	56	3	18	–51
Vaccinium calycinum	25	37	0	83	0	93	0	2	–93
Vaccinium reticulatum	37	25	0	53	0	67	0	12	–67
Alien (nonnative) species									
Clidemia hirta	29	41	4	81	4	94	2	3	–88
Falcataria moluccana	12	71	3	99	1	100	0	0	–96
Hedychium gardnerianum	31	40	1	86	1	94	0	2	–93
Lantana camara	40	27	4	64	5	74	7	14	–64
Miconia calvescens	19	54	3	95	2	98	1	1	–95
Morella faya	28	56	2	86	1	94	0	2	–93
Passiflora tarminiana	7	84	0	98	0	100	0	0	–99
Psidium cattleianum	35	36	4	75	2	91	2	4	–88
Rubus ellipticus	15	51	1	93	0	98	0	1	–96
Schinus terebinthifolius	30	56	2	85	1	94	1	2	–93

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
8. Island of Hawai‘i									
Native species									
Acacia koa	46	13	5	31	7	47	7	28	–38
Alyxia stellata	59	3	7	7	12	16	14	56	–6
Cheirodendron trigynum	38	28	0	57	0	71	0	11	–71
Cibotium spp.	42	15	2	39	0	59	0	17	–59
Coprosma ernodeoides	61	23	7	45	11	57	11	30	–50
Coprosma montana	32	17	5	31	6	41	6	23	–29
Coprosma spp.	46	23	4	48	6	63	7	21	–55
Dicranopteris linearis	50	17	1	45	0	63	0	18	–63
Diospyros sandwicensis	28	6	8	12	15	25	19	34	25
Dodonaea viscosa	92	0	42	0	65	0	75	98	6
Freycinetia arborea	38	14	3	37	2	56	1	17	–55
Ilex anomala	43	15	0	41	0	60	0	17	–60
Leptecophylla tameiameiae	88	12	17	27	19	42	19	53	–40
Metrosideros polymorpha	85	4	31	10	48	19	56	77	–9
Myoporum sandwicense	94	0	45	0	68	0	68	98	4
Myrsine lessertiana	53	20	0	47	0	65	0	18	–65
Nestegis sandwicensis	30	5	10	11	14	18	11	33	8
Osteomeles anthyllidifolia	60	6	26	14	40	26	41	61	1
Pandanus tectorius	23	15	8	30	15	48	20	27	18
Pipturus albidus	49	17	2	43	0	62	0	18	–62
Pisonia spp.	48	13	4	28	4	46	2	27	–43
Psychotria hawaiiensis	41	14	2	38	1	58	0	17	–58
Psydrax odorata	18	7	5	16	9	25	10	22	20
Rubus hawaiensis	38	30	1	53	2	68	2	14	–64
Sadleria cyatheoides	67	16	18	39	27	57	32	39	–41
Santalum spp.	81	0	31	0	51	0	62	93	15
Sophora chrysophylla	40	9	4	20	6	30	6	32	–22
Vaccinium calycinum	29	51	0	73	0	83	0	5	–83
Vaccinium reticulatum	64	21	3	42	3	54	3	30	–53
Alien (nonnative) species									
Clidemia hirta	24	11	5	35	7	60	7	15	–38
Falcataria moluccana	13	35	3	80	5	92	4	5	–64
Hedychium gardnerianum	31	31	0	59	0	71	0	9	–71
Lantana camara	23	7	9	15	15	24	16	30	29
Miconia calvescens	19	30	3	64	4	77	4	8	–58
Morella faya	38	34	4	70	5	83	2	8	–79
Passiflora tarminiana	17	53	1	87	1	94	1	1	–92
Psidium cattleianum	33	13	4	35	4	55	3	17	–48
Rubus ellipticus	12	46	0	76	0	91	0	1	–91
Schinus terebinthifolius	18	19	7	40	9	58	5	11	–36

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
9. Ag SEA									
Native species									
Acacia koa	100	0	0	0	0	100	0	0	–100
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	100	0	100	0	0	–100
Cibotium spp.	100	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	24	24	24
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	100	0	100	0	0	–100
Ilex anomala	100	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	0	0	89	0	100	0	100	100	100
Osteomeles anthyllidifolia	0	0	89	0	100	0	100	100	100
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	100	0	0	0	0	100	0	0	–100
Psychotria hawaiiensis	100	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	0	0	89	0	100	0	100	100	100
Vaccinium calycinum	100	72	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	72	0	100	0	100	0	0	–100
Lantana camara	0	0	0	0	87	0	100	100	100
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	86	0	0	0	0	0	0
Psidium cattleianum	0	0	100	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
10. Ainahou SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	70	0	0	0	0	0	0	70	0
Cheirodendron trigynum	70	0	0	61	0	100	0	0	–100
Cibotium spp.	70	0	0	61	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	70	0	0	61	0	100	0	0	–100
Dicranopteris linearis	100	0	0	49	0	100	0	0	–100
Diospyros sandwicensis	70	0	0	0	0	0	0	70	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	70	0	0	61	0	100	0	0	–100
Ilex anomala	70	0	0	61	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	49	0	100	0	0	–100
Nestegis sandwicensis	70	0	0	0	0	0	0	70	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	75	75	75
Pipturus albidus	100	0	0	49	0	100	0	0	–100
Pisonia spp.	70	0	0	0	0	0	0	70	0
Psychotria hawaiiensis	70	0	0	61	0	100	0	0	–100
Psydrax odorata	70	0	0	0	0	0	0	70	0
Rubus hawaiensis	70	67	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	49	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	70	0	0	0	0	0	0	70	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	70	0	0	61	0	100	0	0	–100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	70	100	0	100	0	100	0	0	–100
Lantana camara	70	0	0	0	0	0	0	70	0
Miconia calvescens	70	100	0	100	0	100	0	0	–100
Morella faya	100	0	0	49	0	100	0	0	–100
Passiflora tarminiana	70	27	0	100	0	100	0	0	–100
Psidium cattleianum	70	0	0	61	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	70	0	0	0	0	13	0	61	–13

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
11. Akihi SEA									
Native species									
Acacia koa	100	0	0	0	0	0	0	100	0
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	0	0	69	0	31	–69
Cibotium spp.	100	0	0	0	0	69	0	31	–69
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	0	0	69	0	31	–69
Dicranopteris linearis	100	0	0	0	0	69	0	31	–69
Diospyros sandwicensis	100	0	0	0	0	0	0	100	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	0	0	69	0	31	–69
Ilex anomala	100	0	0	0	0	69	0	31	–69
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	0	0	69	0	31	–69
Nestegis sandwicensis	100	0	0	0	0	0	0	100	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	31	0	100	100	100
Pipturus albidus	100	0	0	0	0	69	0	31	–69
Pisonia spp.	100	0	0	0	0	0	0	100	0
Psychotria hawaiiensis	100	0	0	0	0	69	0	31	–69
Psydrax odorata	100	0	0	0	0	0	0	100	0
Rubus hawaiensis	100	100	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	0	0	69	0	31	–69
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	100	0	0	0	0	0	0	100	0
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	100	0	0	0	0	69	0	31	–69
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	100	0	0	0	0	0	0	100	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	0	0	69	0	31	–69
Passiflora tarminiana	100	67	0	100	0	100	0	0	–100
Psidium cattleianum	100	0	0	0	0	69	0	31	–69
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	100	0	0	0	0	0	0	100	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
12. Apua SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	0	0	0	0	0	0	0	0	0
Cheirodendron trigynum	0	0	0	0	0	0	0	0	0
Cibotium spp.	0	0	0	0	0	0	0	0	0
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	0	0	0	0	0	0	0	0	0
Dicranopteris linearis	0	0	0	0	0	0	0	0	0
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	96	0	0	0	0	0	0	96	0
Freycinetia arborea	0	0	0	0	0	0	0	0	0
Ilex anomala	0	0	0	0	0	0	0	0	0
Leptecophylla tameiameiae	96	100	0	100	0	100	0	0	–100
Metrosideros polymorpha	96	56	0	100	0	100	0	0	–100
Myoporum sandwicense	96	0	0	0	0	0	0	96	0
Myrsine lessertiana	0	0	0	0	0	0	0	0	0
Nestegis sandwicensis	0	0	0	0	0	0	0	0	0
Osteomeles anthyllidifolia	96	56	0	100	0	100	0	0	–100
Pandanus tectorius	96	56	0	100	0	100	0	0	–100
Pipturus albidus	0	0	0	0	0	0	0	0	0
Pisonia spp.	0	0	0	0	0	0	0	0	0
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	0	0	0	0	0	0	0	0	0
Santalum spp.	96	0	0	0	0	0	0	96	0
Sophora chrysophylla	0	0	0	0	0	0	0	0	0
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	0	0	0	0	0	0	0	0	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	0	0	0	0	0	0	0	0	0
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
13. Boundary Kipuka SEA									
Native species									
Acacia koa	83	0	0	100	0	100	0	0	–100
Alyxia stellata	83	0	0	0	0	0	0	83	0
Cheirodendron trigynum	83	0	0	100	0	100	0	0	–100
Cibotium spp.	83	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	98	100	0	100	0	100	0	0	–100
Coprosma spp.	83	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	1	0	80	80	80
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	83	0	0	100	0	100	0	0	–100
Ilex anomala	83	0	0	0	0	0	0	83	0
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	83	0	0	0	0	0	0	83	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	83	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	83	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	83	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	83	0	0	0	0	0	0	83	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	83	100	0	100	0	100	0	0	–100
Lantana camara	0	0	25	0	83	0	83	83	83
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	83	0	0	100	0	100	0	0	–100
Psidium cattleianum	12	0	81	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
14. Devastation SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	88	0	0	0	0	0	0	88	0
Cheirodendron trigynum	88	0	0	100	0	100	0	0	–100
Cibotium spp.	88	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	88	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	88	0	88	88	88
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	88	0	0	100	0	100	0	0	–100
Ilex anomala	88	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	88	0	0	0	0	0	0	88	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	88	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	88	0	0	100	0	100	0	0	–100
Psydrax odorata	88	0	0	0	0	0	0	88	0
Rubus hawaiensis	88	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	88	0	0	0	0	0	0	88	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	88	100	0	100	0	100	0	0	–100
Lantana camara	0	0	88	0	88	0	88	88	88
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	88	0	0	100	0	100	0	0	–100
Psidium cattleianum	88	0	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
15. East Rift SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	76	0	0	0	0	0	0	76	0
Cheirodendron trigynum	76	0	0	0	0	0	0	76	0
Cibotium spp.	76	0	0	0	0	0	0	76	0
Coprosma ernodeoides	100	0	0	47	0	90	0	10	–90
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	76	0	0	0	0	0	0	76	0
Dicranopteris linearis	100	0	0	0	0	0	0	100	0
Diospyros sandwicensis	65	0	30	0	30	0	30	76	16
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	76	0	0	0	0	0	0	76	0
Ilex anomala	76	0	0	0	0	0	0	76	0
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	0	0	0	0	100	0
Nestegis sandwicensis	0	0	0	0	4	0	11	11	11
Osteomeles anthyllidifolia	0	0	0	0	4	0	11	11	11
Pandanus tectorius	0	0	0	0	6	0	48	48	48
Pipturus albidus	100	0	0	0	0	0	0	100	0
Pisonia spp.	76	0	0	0	0	0	0	76	0
Psychotria hawaiiensis	76	0	0	0	0	0	0	76	0
Psydrax odorata	0	0	0	0	4	0	11	11	11
Rubus hawaiensis	76	70	0	98	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	0	0	0	0	100	0
Santalum spp.	95	0	100	0	100	0	100	100	5
Sophora chrysophylla	0	0	0	0	4	0	11	11	11
Vaccinium calycinum	100	0	0	32	0	83	0	17	–83
Vaccinium reticulatum	100	0	0	47	0	90	0	10	–90
Alien (nonnative) species									
Clidemia hirta	66	0	28	0	28	0	28	76	14
Falcataria moluccana	0	0	10	0	35	0	24	24	24
Hedychium gardnerianum	76	0	0	27	0	73	0	21	–73
Lantana camara	0	0	0	0	4	0	11	11	11
Miconia calvescens	66	0	28	31	28	83	28	21	–69
Morella faya	95	0	100	0	100	0	100	100	5
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	76	0	0	0	0	0	0	76	0
Rubus ellipticus	76	67	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	4	0	8	8	8

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
16. Highway 11 Fee SEA									
Native species									
Acacia koa	1	0	0	100	0	100	0	0	–100
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	100	0	100	0	0	–100
Cibotium spp.	100	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	1	100	0	100	0	100	0	0	–100
Coprosma spp.	100	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	10	0	100	100	100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	100	0	100	0	0	–100
Ilex anomala	100	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	32	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	51	0	100	0	100	0	100	100	95
Osteomeles anthyllidifolia	51	0	100	0	100	0	100	100	95
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	100	0	0	32	0	100	0	0	–100
Psychotria hawaiiensis	100	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	99	0	99	0	99	99	99
Rubus hawaiensis	100	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	51	0	100	0	100	0	100	100	95
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	100	0	100	0	100	0	0	–100
Lantana camara	0	0	99	0	100	0	100	100	100
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	51	0	100	100	0	100	0	0	–100
Psidium cattleianum	60	0	100	100	0	100	0	0	–100
Rubus ellipticus	49	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
17. Hilina Pali SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	25	0	0	0	0	0	0	25	0
Cheirodendron trigynum	25	0	0	100	0	100	0	0	–100
Cibotium spp.	25	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	25	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	25	0	0	0	0	0	0	25	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	25	0	0	100	0	100	0	0	–100
Ilex anomala	25	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	86	0	14	–86
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	25	0	0	0	0	0	0	25	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	10	10	10
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	25	0	0	0	0	100	0	0	–100
Psychotria hawaiiensis	25	0	0	100	0	100	0	0	–100
Psydrax odorata	25	0	0	0	0	0	0	25	0
Rubus hawaiensis	25	9	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	25	0	0	0	0	0	0	25	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	25	0	0	100	0	100	0	0	–100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	25	100	0	100	0	100	0	0	–100
Lantana camara	25	0	0	0	0	0	0	25	0
Miconia calvescens	25	100	0	100	0	100	0	0	–100
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	25	0	0	100	0	100	0	0	–100
Psidium cattleianum	25	0	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	25	0	0	0	0	100	0	0	–100

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
18. Hilina Pali Expansion SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	7	0	0	0	0	0	0	7	0
Cheirodendron trigynum	7	1	0	57	0	100	0	0	–100
Cibotium spp.	7	0	0	57	0	100	0	0	–100
Coprosma ernodeoides	100	35	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	7	0	0	57	0	100	0	0	–100
Dicranopteris linearis	100	0	0	39	0	100	0	0	–100
Diospyros sandwicensis	7	0	0	0	0	0	0	7	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	7	0	0	57	0	100	0	0	–100
Ilex anomala	7	0	0	57	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	8	0	92	–8
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	39	0	100	0	0	–100
Nestegis sandwicensis	7	0	0	0	0	0	0	7	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	19	0	68	0	89	89	36630
Pipturus albidus	100	0	0	39	0	100	0	0	–100
Pisonia spp.	7	0	0	0	0	5	0	7	–5
Psychotria hawaiiensis	7	0	0	57	0	100	0	0	–100
Psydrax odorata	7	0	0	0	0	0	0	7	0
Rubus hawaiensis	3	100	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	39	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	7	0	0	1	0	31	0	5	–31
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	35	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	7	0	0	57	0	100	0	0	–100
Falcataria moluccana	13	100	0	100	0	100	0	0	–100
Hedychium gardnerianum	7	100	0	100	0	100	0	0	–100
Lantana camara	7	0	0	0	0	0	0	7	0
Miconia calvescens	7	100	0	100	0	100	0	0	–100
Morella faya	100	0	0	39	0	100	0	0	–100
Passiflora tarminiana	4	100	0	100	0	100	0	0	–100
Psidium cattleianum	7	0	0	57	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	7	0	0	0	0	14	0	6	–14

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
19. Holei SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	0	0	0	0	0	0	0	0	0
Cheirodendron trigynum	0	0	0	0	0	0	0	0	0
Cibotium spp.	0	0	0	0	0	0	0	0	0
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	0	0	0	0	0	0	0	0	0
Dicranopteris linearis	88	100	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	99	0	0	0	0	0	0	99	0
Freycinetia arborea	0	0	0	0	0	0	0	0	0
Ilex anomala	0	0	0	0	0	0	0	0	0
Leptecophylla tameiameiae	99	70	0	100	0	100	0	0	–100
Metrosideros polymorpha	99	1	0	100	0	100	0	0	–100
Myoporum sandwicense	99	0	0	0	0	0	0	99	0
Myrsine lessertiana	88	100	0	100	0	100	0	0	–100
Nestegis sandwicensis	0	0	0	0	0	0	0	0	0
Osteomeles anthyllidifolia	99	1	0	100	0	100	0	0	–100
Pandanus tectorius	99	1	0	100	0	100	0	0	–100
Pipturus albidus	88	100	0	100	0	100	0	0	–100
Pisonia spp.	0	0	0	0	0	0	0	0	0
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	88	100	0	100	0	100	0	0	–100
Santalum spp.	99	0	0	0	0	0	0	99	0
Sophora chrysophylla	0	0	0	0	0	0	0	0	0
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	0	0	0	0	0	0	0	0	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	0	100	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
20. Kahalii SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	91	0	0	0	0	0	0	91	0
Cheirodendron trigynum	91	0	0	0	0	100	0	0	–100
Cibotium spp.	91	0	0	0	0	100	0	0	–100
Coprosma ernodeoides	100	2	0	73	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	91	0	0	0	0	100	0	0	–100
Dicranopteris linearis	100	0	0	0	0	100	0	0	–100
Diospyros sandwicensis	91	0	0	0	0	0	0	91	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	91	0	0	0	0	100	0	0	–100
Ilex anomala	91	0	0	0	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	0	0	100	0	0	–100
Nestegis sandwicensis	91	0	0	0	0	0	0	91	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	18	0	59	59	59
Pipturus albidus	100	0	0	0	0	100	0	0	–100
Pisonia spp.	91	0	0	0	0	0	0	91	0
Psychotria hawaiiensis	91	0	0	0	0	100	0	0	–100
Psydrax odorata	91	0	0	0	0	0	0	91	0
Rubus hawaiensis	90	76	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	0	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	91	0	0	0	0	0	0	91	0
Vaccinium calycinum	100	99	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	2	0	73	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	91	0	5	0	5	100	0	0	–100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	91	100	0	100	0	100	0	0	–100
Lantana camara	91	0	0	0	0	0	0	91	0
Miconia calvescens	91	100	0	100	0	100	0	0	–100
Morella faya	100	0	0	0	0	100	0	0	–100
Passiflora tarminiana	91	36	0	100	0	100	0	0	–100
Psidium cattleianum	91	0	0	0	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	91	0	0	0	0	0	0	91	0

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
21. Kahue SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	87	0	0	0	0	0	0	87	0
Cheirodendron trigynum	87	5	0	23	0	96	0	4	–96
Cibotium spp.	87	0	0	5	0	78	0	19	–78
Coprosma ernodeoides	86	43	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	87	3	0	17	0	85	0	13	–85
Dicranopteris linearis	100	0	0	9	0	77	0	23	–77
Diospyros sandwicensis	87	0	0	0	0	0	0	87	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	87	0	0	5	0	78	0	19	–78
Ilex anomala	87	0	0	5	0	78	0	19	–78
Leptecophylla tameiameiae	100	0	0	0	0	4	0	96	–4
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	9	0	77	0	23	–77
Nestegis sandwicensis	87	0	0	0	0	0	0	87	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	14	0	21	0	82	0	100	100	637
Pipturus albidus	100	0	0	9	0	77	0	23	–77
Pisonia spp.	87	0	0	0	0	0	0	87	0
Psychotria hawaiiensis	87	0	0	5	0	78	0	19	–78
Psydrax odorata	87	0	0	0	0	0	0	87	0
Rubus hawaiensis	52	100	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	9	0	77	0	23	–77
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	87	0	0	10	0	17	0	72	–17
Vaccinium calycinum	91	53	0	100	0	100	0	0	–100
Vaccinium reticulatum	86	43	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	87	0	0	5	0	78	0	19	–78
Falcataria moluccana	22	100	15	100	0	100	0	0	–100
Hedychium gardnerianum	87	56	0	100	0	100	0	0	–100
Lantana camara	87	0	0	0	0	0	0	87	0
Miconia calvescens	87	56	0	100	0	100	0	0	–100
Morella faya	100	0	0	9	0	77	0	23	–77
Passiflora tarminiana	70	96	0	100	0	100	0	0	–100
Psidium cattleianum	87	0	0	5	0	78	0	19	–78
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	87	0	0	0	0	0	0	87	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
22. Kahuku East SEA									
Native species									
Acacia koa	56	0	95	0	95	0	95	98	75
Alyxia stellata	15	0	46	0	46	0	98	98	565
Cheirodendron trigynum	50	29	0	29	0	100	0	0	–100
Cibotium spp.	2	0	26	0	26	100	0	0	–100
Coprosma ernodeoides	100	0	0	0	0	0	0	100	0
Coprosma montana	100	0	0	0	0	0	0	100	0
Coprosma spp.	67	0	94	0	94	0	94	98	47
Dicranopteris linearis	15	0	26	0	26	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	0	0	0	0	0	0	0	0	0
Ilex anomala	21	0	18	0	18	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	76	51	0	51	0	100	0	0	–100
Nestegis sandwicensis	0	0	0	0	0	0	9	9	9
Osteomeles anthyllidifolia	97	0	100	0	100	0	100	100	3
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	1	0	26	0	26	100	0	0	–100
Pisonia spp.	0	0	0	0	0	0	2	2	2
Psychotria hawaiiensis	0	0	7	0	7	0	0	0	0
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	98	0	0	0	0	0	0	98	0
Sadleria cyatheoides	84	0	100	0	100	0	100	100	19
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	98	0	0	0	0	0	0	98	0
Vaccinium calycinum	41	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	0	0	0	0	100	0
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	0	0	0	0	0	0	0	0	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	33	6	9	98	0	100	0	0	–100
Passiflora tarminiana	50	30	0	99	0	100	0	0	–100
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
23. Kahuku Mauka SEA									
Native species									
Acacia koa	85	0	0	15	0	26	0	63	–26
Alyxia stellata	81	0	20	0	20	5	20	81	0
Cheirodendron trigynum	85	19	0	71	0	96	0	4	–96
Cibotium spp.	62	25	59	63	3	94	0	4	–94
Coprosma ernodeoides	100	3	0	27	0	43	0	57	–43
Coprosma montana	100	3	0	28	0	52	0	48	–52
Coprosma spp.	85	3	0	23	0	39	0	52	–39
Dicranopteris linearis	94	25	100	73	0	96	0	4	–96
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	5	94	13	100	18	100	4	4	–29
Ilex anomala	84	19	7	71	0	95	0	4	–95
Leptecophylla tameiameiae	100	0	0	14	0	32	0	68	–32
Metrosideros polymorpha	100	0	0	0	0	4	0	96	–4
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	24	0	74	0	96	0	4	–96
Nestegis sandwicensis	7	0	26	0	56	0	69	71	897
Osteomeles anthyllidifolia	100	0	0	0	0	4	0	96	–4
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	70	34	100	68	10	95	0	4	–95
Pisonia spp.	7	0	26	89	45	100	39	36	401
Psychotria hawaiiensis	35	44	58	80	27	92	1	4	–89
Psydrax odorata	0	0	0	0	4	0	10	10	10
Rubus hawaiensis	85	3	0	23	0	39	0	52	–39
Sadleria cyatheoides	100	3	0	27	0	43	0	57	–43
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	85	0	0	0	0	5	0	81	–5
Vaccinium calycinum	65	98	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	3	0	27	0	43	0	57	–43
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	8	97	1	100	0	100	0	0	–100
Lantana camara	0	0	0	0	0	0	4	4	4
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	24	100	74	0	96	0	4	–96
Passiflora tarminiana	85	19	0	71	0	97	0	2	–97
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
24. Kahuku West SEA									
Native species									
Acacia koa	55	3	2	42	2	65	2	20	–64
Alyxia stellata	45	0	20	22	21	57	21	31	–31
Cheirodendron trigynum	25	100	0	100	0	100	0	0	–100
Cibotium spp.	22	100	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	8	0	35	0	58	0	42	–58
Coprosma montana	100	8	0	35	0	58	0	42	–58
Coprosma spp.	56	8	0	42	0	64	0	20	–64
Dicranopteris linearis	43	100	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	4	100	0	100	0	100	0	0	–100
Ilex anomala	25	100	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	2	0	34	0	58	0	42	–58
Metrosideros polymorpha	100	0	0	12	0	41	0	59	–41
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	44	100	0	100	0	100	0	0	–100
Nestegis sandwicensis	6	0	21	0	5	0	4	10	67
Osteomeles anthyllidifolia	100	0	0	12	0	41	0	59	–41
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	37	100	0	100	0	100	0	0	–100
Pisonia spp.	6	65	2	100	0	100	0	0	–100
Psychotria hawaiiensis	17	100	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	5	0	10	10	10
Rubus hawaiensis	56	8	0	42	0	64	0	20	–64
Sadleria cyatheoides	100	8	0	35	0	58	0	42	–58
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	56	0	0	18	0	45	0	31	–45
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	100	8	0	35	0	58	0	42	–58
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	0	0	0	0	1	0	5	5	5
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	44	100	0	100	0	100	0	0	–100
Passiflora tarminiana	25	100	0	100	0	100	0	0	–100
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
25. Kamakaia SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	0	0	0	0	0	0	0	0	0
Cheirodendron trigynum	0	0	0	0	0	100	0	0	–100
Cibotium spp.	0	0	0	0	0	100	0	0	–100
Coprosma ernodeoides	100	14	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	0	0	0	0	0	100	0	0	–100
Dicranopteris linearis	100	0	0	62	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	0	0	0	0	0	100	0	0	–100
Ilex anomala	0	0	0	0	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	31	0	69	–31
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	62	0	100	0	0	–100
Nestegis sandwicensis	0	0	0	0	0	0	0	0	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	1	0	50	0	83	83	83
Pipturus albidus	100	0	0	62	0	100	0	0	–100
Pisonia spp.	0	0	0	0	0	0	0	0	0
Psychotria hawaiiensis	0	0	0	0	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	100	0	0	62	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	0	0	0	0	0	0	0	0	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	14	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	100	0	0	–100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	100	0	100	0	100	0	0	–100
Lantana camara	0	0	0	0	0	0	0	0	0
Miconia calvescens	0	100	0	100	0	100	0	0	–100
Morella faya	100	0	0	62	0	100	0	0	–100
Passiflora tarminiana	0	100	0	100	0	100	0	0	–100
Psidium cattleianum	0	0	0	0	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
26. Kau Buffer SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	2	0	0	0	0	0	0	2	0
Cheirodendron trigynum	2	100	0	100	0	100	0	0	–100
Cibotium spp.	2	100	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	30	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	2	100	0	100	0	100	0	0	–100
Dicranopteris linearis	100	27	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	2	0	2	0	2	2	2
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	2	100	0	100	0	100	0	0	–100
Ilex anomala	2	100	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	39	0	96	0	4	–96
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	27	0	100	0	100	0	0	–100
Nestegis sandwicensis	2	0	0	0	0	0	0	2	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	17	0	31	31	31
Pipturus albidus	100	27	0	100	0	100	0	0	–100
Pisonia spp.	2	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	2	100	0	100	0	100	0	0	–100
Psydrax odorata	2	0	0	0	0	0	0	2	0
Rubus hawaiensis	2	100	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	27	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	2	0	0	0	0	0	0	2	0
Vaccinium calycinum	86	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	30	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	1	100	0	100	0	100	0	0	–100
Lantana camara	2	0	0	0	0	0	0	2	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	27	0	100	0	100	0	0	–100
Passiflora tarminiana	2	100	0	100	0	100	0	0	–100
Psidium cattleianum	2	100	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	2	0	0	0	0	0	0

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
27. Kealakomo SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	93	0	0	0	0	0	0	93	0
Cheirodendron trigynum	93	82	0	100	0	100	0	0	–100
Cibotium spp.	93	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	93	82	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	93	0	0	0	0	0	0	93	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	93	0	0	100	0	100	0	0	–100
Ilex anomala	93	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	76	0	24	–76
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	93	0	0	0	0	0	0	93	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	100	0	0	0	0	0	0	100	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	93	0	0	0	0	82	0	17	–82
Psychotria hawaiiensis	93	0	0	100	0	100	0	0	–100
Psydrax odorata	93	0	0	0	0	0	0	93	0
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	93	0	0	100	0	100	0	0	–100
Vaccinium calycinum	22	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	93	0	0	100	0	100	0	0	–100
Falcataria moluccana	100	100	0	100	0	100	0	0	–100
Hedychium gardnerianum	93	100	0	100	0	100	0	0	–100
Lantana camara	93	0	0	0	0	0	0	93	0
Miconia calvescens	93	100	0	100	0	100	0	0	–100
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	93	0	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	93	0	0	0	0	82	0	17	–82

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
28. Keamoku SEA									
Native species									
Acacia koa	1	0	0	73	0	100	0	0	–100
Alyxia stellata	2	0	0	0	0	0	0	2	0
Cheirodendron trigynum	2	71	0	100	0	100	0	0	–100
Cibotium spp.	2	71	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	46	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	2	71	0	100	0	100	0	0	–100
Dicranopteris linearis	100	46	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	2	0	2	2	688
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	2	71	0	100	0	100	0	0	–100
Ilex anomala	2	71	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	68	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	46	0	100	0	100	0	0	–100
Nestegis sandwicensis	2	0	0	0	0	0	0	2	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	1	0	14	14	14
Pipturus albidus	100	46	0	100	0	100	0	0	–100
Pisonia spp.	2	0	0	91	0	100	0	0	–100
Psychotria hawaiiensis	2	71	0	100	0	100	0	0	–100
Psydrax odorata	2	0	0	0	0	0	0	2	10
Rubus hawaiensis	2	74	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	46	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	2	0	0	0	0	0	0	2	0
Vaccinium calycinum	82	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	46	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	100	0	100	0	0	–100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	2	100	0	100	0	100	0	0	–100
Lantana camara	1	0	2	0	2	0	2	2	324
Miconia calvescens	0	100	0	100	0	100	0	0	–100
Morella faya	100	46	0	100	0	100	0	0	–100
Passiflora tarminiana	2	71	0	100	0	100	0	0	–100
Psidium cattleianum	2	71	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	31	0	100	0	0	–100

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
29. Keanakakoi SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	83	0	0	0	0	0	0	83	0
Cheirodendron trigynum	83	43	0	100	0	100	0	0	–100
Cibotium spp.	83	43	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	36	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	83	43	0	100	0	100	0	0	–100
Dicranopteris linearis	100	36	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	48	0	83	0	83	83	83
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	83	43	0	100	0	100	0	0	–100
Ilex anomala	83	43	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	36	0	100	0	100	0	0	–100
Nestegis sandwicensis	83	0	0	0	0	0	0	83	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	36	0	100	0	100	0	0	–100
Pisonia spp.	83	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	83	43	0	100	0	100	0	0	–100
Psydrax odorata	83	0	0	0	0	0	0	83	0
Rubus hawaiensis	83	43	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	36	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	83	0	0	0	0	0	0	83	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	36	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	5	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	83	100	0	100	0	100	0	0	–100
Lantana camara	48	0	68	0	68	0	68	83	72
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	36	0	100	0	100	0	0	–100
Passiflora tarminiana	83	43	0	100	0	100	0	0	–100
Psidium cattleianum	83	43	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	48	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
30. Kipuka Ki SEA									
Native species									
Acacia koa	51	0	0	100	0	100	0	0	–100
Alyxia stellata	51	0	0	0	0	0	0	51	0
Cheirodendron trigynum	51	0	0	100	0	100	0	0	–100
Cibotium spp.	51	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	82	100	0	100	0	100	0	0	–100
Coprosma spp.	51	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	6	0	32	32	32
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	51	0	0	100	0	100	0	0	–100
Ilex anomala	51	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	51	0	0	0	0	0	0	51	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	51	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	51	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	51	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	51	0	0	0	0	0	0	51	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	51	100	0	100	0	100	0	0	–100
Lantana camara	0	0	26	0	51	0	51	51	51
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	51	0	0	100	0	100	0	0	–100
Psidium cattleianum	19	0	40	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
31. Kipuka Puaulu SEA									
Native species									
Acacia koa	100	0	0	100	0	100	0	0	–100
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	100	0	100	0	0	–100
Cibotium spp.	100	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	51	100	0	100	0	100	0	0	–100
Coprosma spp.	100	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	47	0	100	100	100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	100	0	100	0	0	–100
Ilex anomala	100	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	100	0	0	0	0	0	0	100	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	100	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	100	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	100	0	0	0	0	0	0	100	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	100	0	100	0	100	0	0	–100
Lantana camara	0	0	91	0	100	0	100	100	100
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	100	0	0	100	0	100	0	0	–100
Psidium cattleianum	56	0	100	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
32. Koa SEA									
Native species									
Acacia koa	100	0	0	0	0	65	0	35	–65
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	34	0	95	0	5	–95
Cibotium spp.	100	0	0	34	0	95	0	5	–95
Coprosma ernodeoides	100	0	0	34	0	95	0	5	–95
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	34	0	95	0	5	–95
Dicranopteris linearis	100	0	0	34	0	95	0	5	–95
Diospyros sandwicensis	0	0	0	0	40	0	100	100	100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	34	0	95	0	5	–95
Ilex anomala	100	0	0	34	0	95	0	5	–95
Leptecophylla tameiameiae	100	0	0	0	0	65	0	35	–65
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	34	0	95	0	5	–95
Nestegis sandwicensis	0	0	3	0	53	0	77	77	77
Osteomeles anthyllidifolia	0	0	3	0	53	0	77	77	77
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	34	0	95	0	5	–95
Pisonia spp.	100	0	0	0	0	65	0	35	–65
Psychotria hawaiiensis	100	0	0	34	0	95	0	5	–95
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	34	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	34	0	95	0	5	–95
Santalum spp.	91	0	100	0	100	0	100	100	10
Sophora chrysophylla	0	0	3	0	53	0	77	77	77
Vaccinium calycinum	100	0	0	97	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	34	0	95	0	5	–95
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	3	0	4	4	4
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	0	0	97	0	100	0	0	–100
Lantana camara	0	0	0	0	53	0	77	77	77
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	91	0	100	83	100	100	0	0	–100
Passiflora tarminiana	0	0	3	0	0	0	0	0	0
Psidium cattleianum	63	0	100	20	43	91	0	5	–91
Rubus ellipticus	100	90	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
33. Kukalauula SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	12	0	0	100	0	100	0	0	–100
Cheirodendron trigynum	0	0	0	0	0	0	0	0	0
Cibotium spp.	0	0	0	0	0	0	0	0	0
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	0	0	0	0	0	0	0	0	0
Dicranopteris linearis	20	100	0	100	0	100	0	0	–100
Diospyros sandwicensis	12	0	0	100	0	100	0	0	–100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	0	0	0	0	0	0	0	0	0
Ilex anomala	0	0	0	0	0	0	0	0	0
Leptecophylla tameiameiae	100	99	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	24	0	100	0	100	0	0	–100
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	20	100	0	100	0	100	0	0	–100
Nestegis sandwicensis	12	0	0	100	0	100	0	0	–100
Osteomeles anthyllidifolia	100	24	0	100	0	100	0	0	–100
Pandanus tectorius	100	24	0	100	0	100	0	0	–100
Pipturus albidus	20	100	0	100	0	100	0	0	–100
Pisonia spp.	12	100	0	100	0	100	0	0	–100
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	12	0	0	100	0	100	0	0	–100
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	20	100	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	0	0	0	0	0	0	0	0	0
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	12	0	0	100	0	100	0	0	–100
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	20	100	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	12	100	0	100	0	100	0	0	–100

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
34. Mauna Loa Lower SEA									
Native species									
Acacia koa	92	0	0	100	0	100	0	0	–100
Alyxia stellata	92	0	0	0	0	0	0	92	0
Cheirodendron trigynum	92	0	0	100	0	100	0	0	–100
Cibotium spp.	92	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	90	84	0	100	0	100	0	0	–100
Coprosma spp.	92	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	7	0	20	20	20
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	92	0	0	100	0	100	0	0	–100
Ilex anomala	92	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	92	0	0	0	0	0	0	92	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	92	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	92	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	1	0	1	0	1	1	200
Rubus hawaiensis	92	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	92	0	0	0	0	0	0	92	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	92	100	0	100	0	100	0	0	–100
Lantana camara	0	0	13	0	61	0	84	84	84
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	92	0	0	100	0	100	0	0	–100
Psidium cattleianum	11	0	56	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
35. Mauna Loa Subalpine SEA									
Native species									
Acacia koa	5	0	14	0	21	0	21	24	406
Alyxia stellata	1	0	4	0	16	0	23	23	2375
Cheirodendron trigynum	4	100	0	100	0	100	0	0	–100
Cibotium spp.	0	100	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	0	0	0	0	100	0
Coprosma montana	100	0	0	0	0	0	0	100	0
Coprosma spp.	7	0	15	0	19	0	19	24	275
Dicranopteris linearis	2	100	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	91	0	100	0	100	0	100	100	10
Freycinetia arborea	0	0	0	0	0	0	0	0	0
Ilex anomala	1	100	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	43	0	100	0	100	0	100	100	135
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	14	100	0	100	0	100	0	0	–100
Nestegis sandwicensis	0	0	0	0	0	0	0	0	0
Osteomeles anthyllidifolia	31	0	86	0	100	0	100	100	227
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	1	100	0	100	0	100	0	0	–100
Pisonia spp.	0	0	0	0	0	0	0	0	0
Psychotria hawaiiensis	0	0	0	0	0	0	0	0	0
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	24	0	0	0	0	0	0	24	0
Sadleria cyatheoides	18	0	63	0	100	0	100	100	441
Santalum spp.	82	0	100	0	100	0	100	100	23
Sophora chrysophylla	24	0	0	0	0	0	0	24	0
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	100	0	0	0	0	0	0	100	0
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	0	0	0	0	0	0	0	0	0
Lantana camara	0	0	0	0	0	0	0	0	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	5	100	0	100	0	100	0	0	–100
Passiflora tarminiana	4	100	0	100	0	100	0	0	–100
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
36. Mauna Loa Upper SEA									
Native species									
Acacia koa	86	0	0	40	0	61	0	34	–61
Alyxia stellata	77	0	40	0	40	31	40	62	–19
Cheirodendron trigynum	86	71	0	100	0	100	0	0	–100
Cibotium spp.	67	62	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	40	0	62	0	38	–62
Coprosma montana	100	2	0	40	0	63	0	37	–63
Coprosma spp.	86	0	0	42	0	62	0	32	–62
Dicranopteris linearis	90	69	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	15	0	13	100	0	100	0	0	–100
Ilex anomala	80	68	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	39	0	61	0	39	–61
Metrosideros polymorpha	100	0	0	0	0	29	0	71	–29
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	72	0	100	0	100	0	0	–100
Nestegis sandwicensis	19	0	37	0	53	0	12	29	51
Osteomeles anthyllidifolia	100	0	0	0	0	29	0	71	–29
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	78	64	0	100	0	100	0	0	–100
Pisonia spp.	19	0	37	100	0	100	0	0	–100
Psychotria hawaiiensis	52	52	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	86	0	0	42	0	62	0	32	–62
Sadleria cyatheoides	100	0	0	40	0	62	0	38	–62
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	86	0	0	0	0	28	0	62	–28
Vaccinium calycinum	37	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	40	0	62	0	38	–62
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	30	100	0	100	0	100	0	0	–100
Lantana camara	0	0	0	0	0	0	5	5	5
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	96	71	0	100	0	100	0	0	–100
Passiflora tarminiana	86	71	0	100	0	100	0	0	–100
Psidium cattleianum	0	0	0	0	0	0	0	0	0
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
37. Mauna Ulu SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	10	0	0	0	0	0	0	10	0
Cheirodendron trigynum	10	0	0	0	0	87	0	1	–87
Cibotium spp.	10	0	0	0	0	87	0	1	–87
Coprosma ernodeoides	100	0	0	0	0	78	0	22	–78
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	10	0	0	0	0	87	0	1	–87
Dicranopteris linearis	100	0	0	0	0	78	0	22	–78
Diospyros sandwicensis	4	0	6	0	6	0	6	10	147
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	10	0	0	0	0	87	0	1	–87
Ilex anomala	10	0	0	0	0	87	0	1	–87
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	0	0	78	0	22	–78
Nestegis sandwicensis	8	0	1	0	1	0	1	9	11
Osteomeles anthyllidifolia	43	0	58	0	83	0	92	96	123
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	0	0	78	0	22	–78
Pisonia spp.	10	0	0	0	0	0	0	10	0
Psychotria hawaiiensis	10	0	0	0	0	87	0	1	–87
Psydrax odorata	8	0	1	0	1	0	1	9	11
Rubus hawaiensis	10	0	0	98	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	0	0	78	0	22	–78
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	8	0	1	0	1	0	1	9	11
Vaccinium calycinum	100	18	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	0	0	78	0	22	–78
Alien (nonnative) species									
Clidemia hirta	2	0	8	0	8	100	1	1	–44
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	10	70	0	100	0	100	0	0	–100
Lantana camara	8	0	1	0	1	0	1	9	11
Miconia calvescens	2	100	3	100	0	100	0	0	–100
Morella faya	100	0	0	0	0	78	0	22	–78
Passiflora tarminiana	8	0	1	56	0	100	0	0	–100
Psidium cattleianum	10	0	0	0	0	87	0	1	–87
Rubus ellipticus	2	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	5	0	4	0	5	0	4	8	81

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
38. Naulu SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	87	0	0	0	0	0	0	87	0
Cheirodendron trigynum	81	100	0	100	0	100	0	0	–100
Cibotium spp.	87	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	0	0	0	0	0	0	0	0	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	87	100	0	100	0	100	0	0	–100
Dicranopteris linearis	100	6	0	100	0	100	0	0	–100
Diospyros sandwicensis	87	0	0	0	0	0	0	87	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	87	0	0	100	0	100	0	0	–100
Ilex anomala	87	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	6	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	6	0	100	0	100	0	0	–100
Nestegis sandwicensis	87	0	0	0	0	0	0	87	0
Osteomeles anthyllidifolia	100	0	0	0	0	6	0	94	–6
Pandanus tectorius	100	0	0	0	0	6	0	94	–6
Pipturus albidus	100	6	0	100	0	100	0	0	–100
Pisonia spp.	87	0	0	0	0	100	0	0	–100
Psychotria hawaiiensis	87	0	0	100	0	100	0	0	–100
Psydrax odorata	87	0	0	0	0	0	0	87	0
Rubus hawaiensis	0	0	0	0	0	0	0	0	0
Sadleria cyatheoides	100	6	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	87	63	0	100	0	100	0	0	–100
Vaccinium calycinum	0	0	0	0	0	0	0	0	0
Vaccinium reticulatum	0	0	0	0	0	0	0	0	0
Alien (nonnative) species									
Clidemia hirta	87	0	0	100	0	100	0	0	–100
Falcataria moluccana	94	100	0	100	0	100	0	0	–100
Hedychium gardnerianum	87	100	0	100	0	100	0	0	–100
Lantana camara	87	0	0	0	0	0	0	87	0
Miconia calvescens	87	100	0	100	0	100	0	0	–100
Morella faya	100	6	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	87	0	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	87	0	0	0	0	100	0	0	–100

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
39. New SEA									
Native species									
Acacia koa	100	0	0	0	0	96	0	4	–96
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	63	0	100	0	0	–100
Cibotium spp.	100	0	0	63	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	63	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	63	0	100	0	0	–100
Dicranopteris linearis	100	0	0	63	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	43	43	43
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	63	0	100	0	0	–100
Ilex anomala	100	0	0	63	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	96	0	4	–96
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	63	0	100	0	0	–100
Nestegis sandwicensis	0	0	16	0	83	0	98	98	98
Osteomeles anthyllidifolia	0	0	16	0	83	0	98	98	98
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	63	0	100	0	0	–100
Pisonia spp.	100	0	0	0	0	96	0	4	–96
Psychotria hawaiiensis	100	0	0	63	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	63	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	63	0	100	0	0	–100
Santalum spp.	100	0	100	0	100	0	100	100	0
Sophora chrysophylla	0	0	16	0	83	0	98	98	98
Vaccinium calycinum	100	9	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	63	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	9	0	100	0	100	0	0	–100
Lantana camara	0	0	0	0	56	0	98	98	98
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	100	100	100	100	0	0	–100
Passiflora tarminiana	0	0	9	0	0	0	0	0	0
Psidium cattleianum	0	0	100	0	37	100	0	0	–100
Rubus ellipticus	100	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
40. Puaulu Buffer SEA									
Native species									
Acacia koa	47	0	0	0	0	0	0	47	0
Alyxia stellata	86	0	0	0	0	0	0	86	0
Cheirodendron trigynum	86	19	0	100	0	100	0	0	–100
Cibotium spp.	86	19	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	22	0	100	0	100	0	0	–100
Coprosma montana	16	100	0	100	0	100	0	0	–100
Coprosma spp.	86	19	0	100	0	100	0	0	–100
Dicranopteris linearis	100	22	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	71	0	85	85	85
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	86	19	0	100	0	100	0	0	–100
Ilex anomala	86	19	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	100	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	22	0	100	0	100	0	0	–100
Nestegis sandwicensis	86	0	0	0	0	0	0	86	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	22	0	100	0	100	0	0	–100
Pisonia spp.	86	0	0	100	0	100	0	0	–100
Psychotria hawaiiensis	86	19	0	100	0	100	0	0	–100
Psydrax odorata	16	0	27	0	27	0	27	39	141
Rubus hawaiensis	86	19	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	22	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	86	0	0	0	0	0	0	86	0
Vaccinium calycinum	94	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	22	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	86	100	0	100	0	100	0	0	–100
Lantana camara	1	0	78	0	86	0	86	86	11113
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	22	0	100	0	100	0	0	–100
Passiflora tarminiana	86	19	0	100	0	100	0	0	–100
Psidium cattleianum	72	22	49	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000 Average area suitable (%)	2000–2040 Contraction	2000–2040 Expansion	2000–2070 Contraction	2000–2070 Expansion	2000–2090 Contraction	2000–2090 Expansion	2090 Average area suitable (%)	Net change (%)
41. Puhimau SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	100	0	100	0	0	–100
Cibotium spp.	100	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	100	0	100	0	100	100	100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	100	0	100	0	0	–100
Ilex anomala	100	0	0	0	0	0	0	100	0
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	100	0	0	0	0	0	0	100	0
Osteomeles anthyllidifolia	100	0	0	0	0	0	0	100	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	100	0	0	0	0	100	0	0	–100
Psychotria hawaiiensis	100	0	0	100	0	100	0	0	–100
Psydrax odorata	100	0	0	0	0	0	0	100	0
Rubus hawaiensis	100	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	100	0	0	0	0	0	0	100	0
Vaccinium calycinum	100	100	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	67	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	100	0	100	0	100	0	0	–100
Lantana camara	100	0	0	0	0	0	0	100	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	100	0	0	100	0	100	0	0	–100
Psidium cattleianum	100	0	0	100	0	100	0	0	–100
Rubus ellipticus	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius	0	0	0	0	100	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
42. Puu SEA									
Native species									
Acacia koa	100	0	0	30	0	100	0	0	–100
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	100	0	100	0	0	–100
Cibotium spp.	100	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	0	0	0	0	0
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	100	0	100	0	0	–100
Ilex anomala	100	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	30	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	0	0	99	0	100	0	100	100	100
Osteomeles anthyllidifolia	0	0	99	0	100	0	100	100	100
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	100	0	0	30	0	100	0	0	–100
Psychotria hawaiiensis	100	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	0	0	99	0	100	0	100	100	100
Vaccinium calycinum	100	96	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	96	0	100	0	100	0	0	–100
Lantana camara	0	0	0	0	5	0	100	100	100
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	64	0	0	0	0	0	0
Psidium cattleianum	0	0	77	0	0	0	0	0	0
Rubus ellipticus	100	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
43. Puu Huluhulu SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	0	0	0	0	100	0
Cibotium spp.	100	0	0	0	0	0	0	100	0
Coprosma ernodeoides	100	0	0	0	0	0	0	100	0
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	0	0	0	0	100	0
Dicranopteris linearis	100	0	0	0	0	0	0	100	0
Diospyros sandwicensis	0	0	100	0	100	0	100	100	100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	0	0	0	0	100	0
Ilex anomala	100	0	0	0	0	0	0	100	0
Leptecophylla tameiameiae	100	0	0	0	0	0	0	100	0
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	0	0	0	0	100	0
Nestegis sandwicensis	0	0	0	0	0	0	0	0	0
Osteomeles anthyllidifolia	0	0	0	0	0	0	0	0	0
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	0	0	0	0	100	0
Pisonia spp.	100	0	0	0	0	0	0	100	0
Psychotria hawaiiensis	100	0	0	0	0	0	0	100	0
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	0	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	0	0	0	0	100	0
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	0	0	0	0	0	0	0	0	0
Vaccinium calycinum	100	0	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	0	0	0	0	100	0
Alien (nonnative) species									
Clidemia hirta	0	0	100	0	100	0	100	100	100
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	0	0	100	0	100	0	0	–100
Lantana camara	0	0	0	0	0	0	0	0	0
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	0	0	0	0	100	0
Passiflora tarminiana	0	0	0	0	0	0	0	0	0
Psidium cattleianum	100	0	0	0	0	0	0	100	0
Rubus ellipticus	100	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

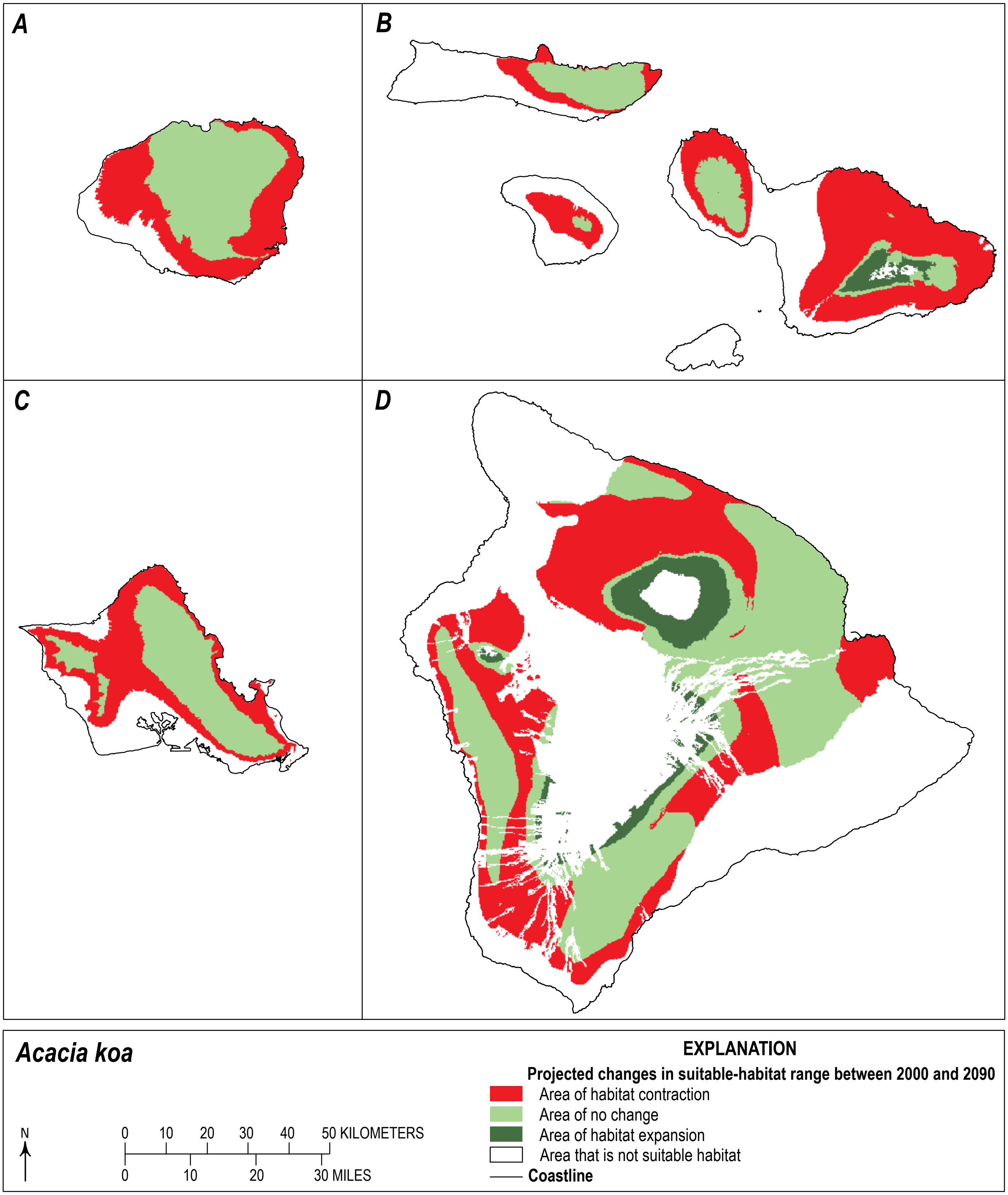
Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
44. Small Tract SEA									
Native species									
Acacia koa	100	0	0	0	0	100	0	0	–100
Alyxia stellata	100	0	0	0	0	0	0	100	0
Cheirodendron trigynum	100	0	0	100	0	100	0	0	–100
Cibotium spp.	100	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	100	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	0	0	2	0	100	100	100
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	100	0	0	100	0	100	0	0	–100
Ilex anomala	100	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	0	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	0	0	70	0	100	0	100	100	100
Osteomeles anthyllidifolia	0	0	70	0	100	0	100	100	100
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	100	0	0	0	0	100	0	0	–100
Psychotria hawaiiensis	100	0	0	100	0	100	0	0	–100
Psydrax odorata	0	0	0	0	0	0	0	0	0
Rubus hawaiensis	100	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	0	0	70	0	100	0	100	100	100
Vaccinium calycinum	100	11	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	100	11	0	100	0	100	0	0	–100
Lantana camara	0	0	53	0	100	0	100	100	100
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	0	0	70	0	0	0	0	0	0
Psidium cattleianum	87	0	100	100	0	100	0	0	–100
Rubus ellipticus	100	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	0	0	0	0	0	0	0

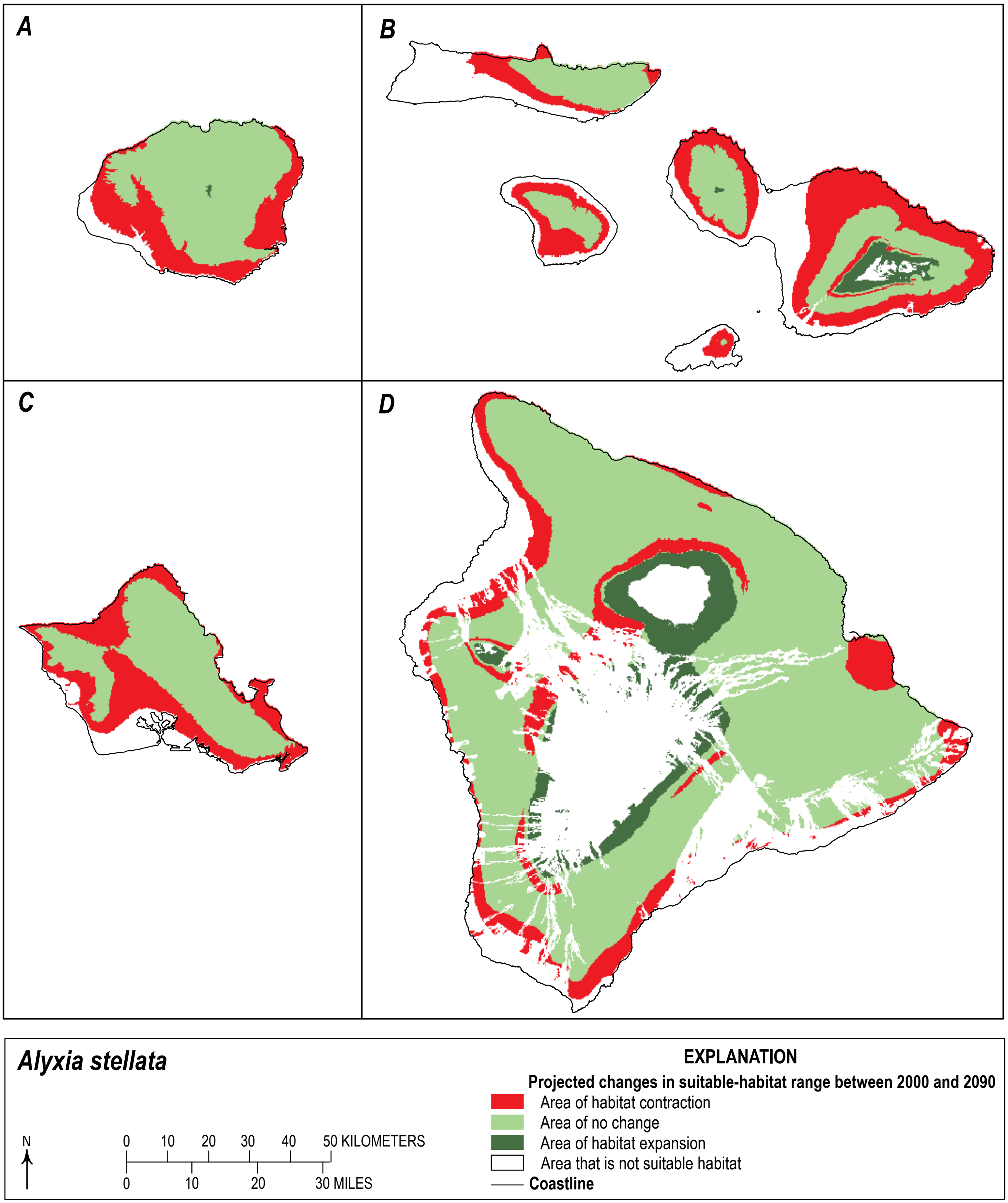
Scientific name	2000	2000–2040		2000–2070		2000–2090		2090	Net change (%)
	Average area suitable (%)	Contraction	Expansion	Contraction	Expansion	Contraction	Expansion	Average area suitable (%)	
45. Thurston SEA									
Native species									
Acacia koa	0	0	0	0	0	0	0	0	0
Alyxia stellata	99	0	0	0	0	0	0	99	0
Cheirodendron trigynum	99	0	0	100	0	100	0	0	–100
Cibotium spp.	99	0	0	100	0	100	0	0	–100
Coprosma ernodeoides	100	0	0	100	0	100	0	0	–100
Coprosma montana	0	0	0	0	0	0	0	0	0
Coprosma spp.	99	0	0	100	0	100	0	0	–100
Dicranopteris linearis	100	0	0	100	0	100	0	0	–100
Diospyros sandwicensis	0	0	1	0	78	0	99	99	99
Dodonaea viscosa	100	0	0	0	0	0	0	100	0
Freycinetia arborea	99	0	0	100	0	100	0	0	–100
Ilex anomala	99	0	0	100	0	100	0	0	–100
Leptecophylla tameiameiae	100	0	0	5	0	100	0	0	–100
Metrosideros polymorpha	100	0	0	0	0	0	0	100	0
Myoporum sandwicense	100	0	0	0	0	0	0	100	0
Myrsine lessertiana	100	0	0	100	0	100	0	0	–100
Nestegis sandwicensis	43	0	96	0	98	0	98	99	131
Osteomeles anthyllidifolia	44	0	98	0	100	0	100	100	127
Pandanus tectorius	0	0	0	0	0	0	0	0	0
Pipturus albidus	100	0	0	100	0	100	0	0	–100
Pisonia spp.	99	0	0	5	0	100	0	0	–100
Psychotria hawaiiensis	99	0	0	100	0	100	0	0	–100
Psydrax odorata	43	0	96	0	98	0	98	99	131
Rubus hawaiensis	99	0	0	100	0	100	0	0	–100
Sadleria cyatheoides	100	0	0	100	0	100	0	0	–100
Santalum spp.	100	0	0	0	0	0	0	100	0
Sophora chrysophylla	43	0	96	0	98	0	98	99	131
Vaccinium calycinum	100	77	0	100	0	100	0	0	–100
Vaccinium reticulatum	100	0	0	100	0	100	0	0	–100
Alien (nonnative) species									
Clidemia hirta	0	0	0	0	0	0	0	0	0
Falcataria moluccana	0	0	0	0	0	0	0	0	0
Hedychium gardnerianum	99	77	0	100	0	100	0	0	–100
Lantana camara	2	0	90	0	99	0	99	99	4167
Miconia calvescens	0	0	0	0	0	0	0	0	0
Morella faya	100	0	0	100	0	100	0	0	–100
Passiflora tarminiana	43	0	96	100	0	100	0	0	–100
Psidium cattleianum	90	0	86	100	0	100	0	0	–100
Rubus ellipticus	56	100	0	100	0	100	0	0	–100
Schinus terebinthifolius	0	0	1	0	27	0	0	0	0

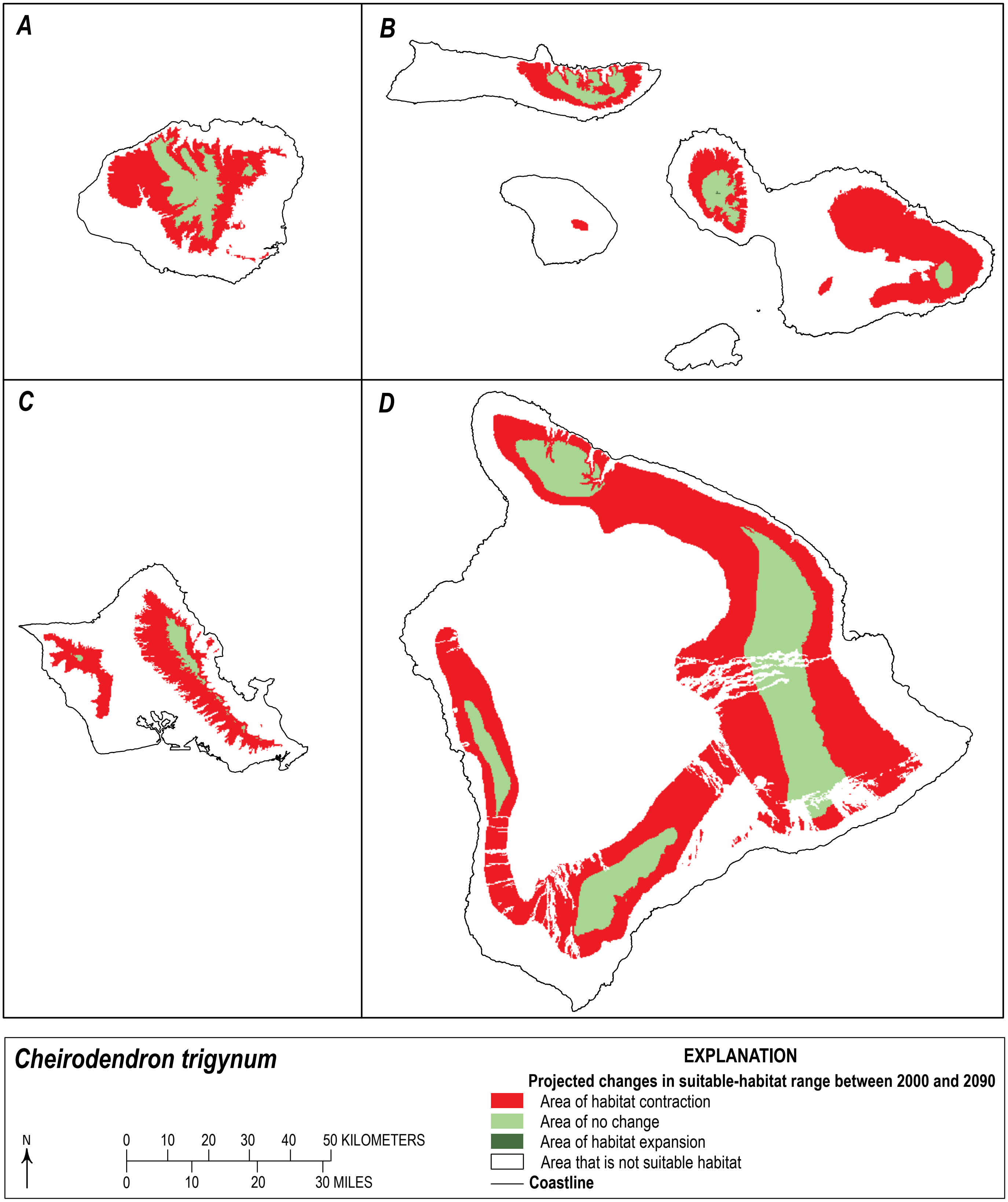
Appendix 2. Projected changes in suitable-habitat range, from “current” (2000) to “end-of-century” (2090), for 39 focal native and alien (nonnative) plant species across seven modeled islands in state of Hawai`i

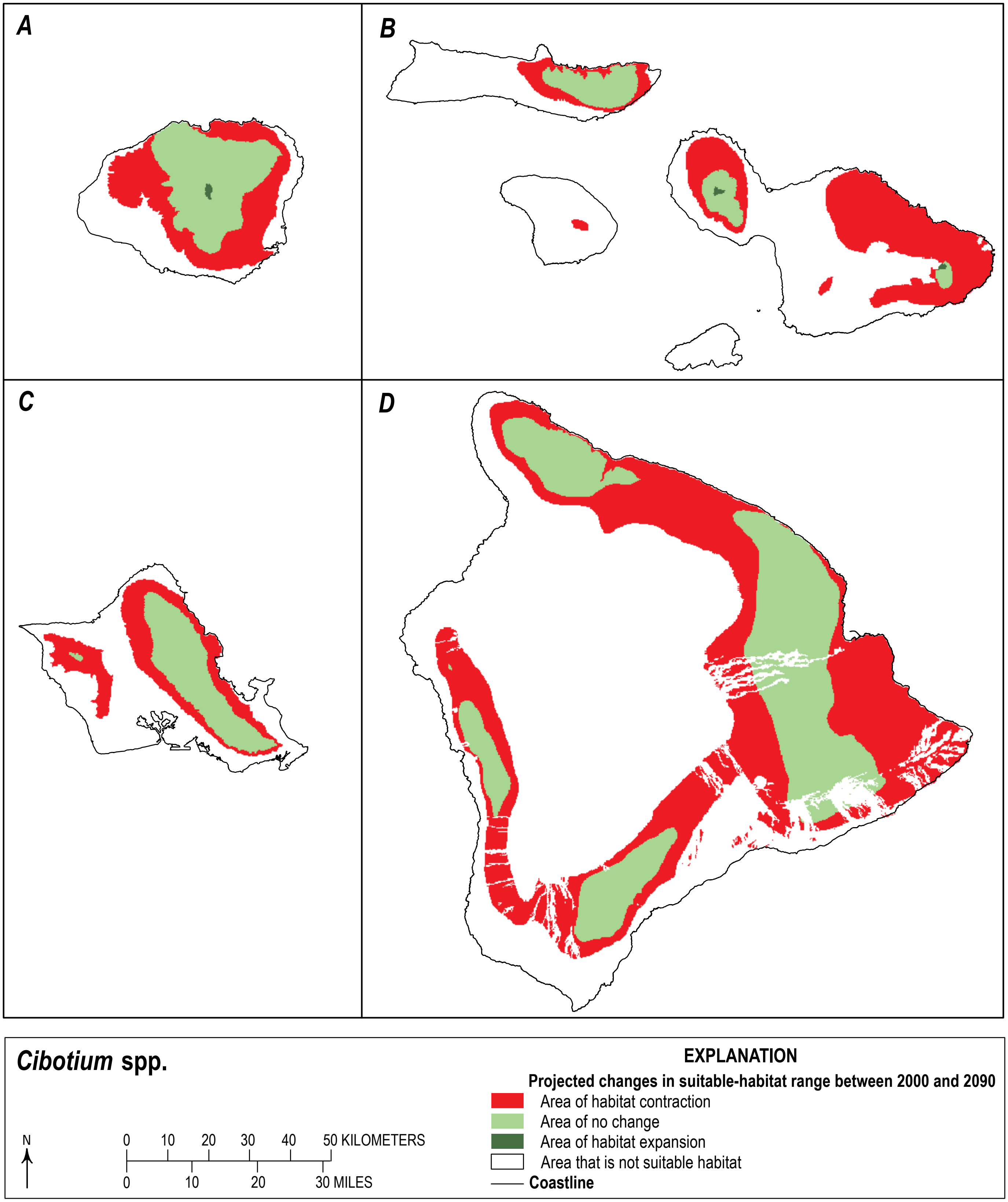
[Hawaiian islands shown in map panels: *A*, Kaua‘i; *B*, Moloka‘i, Maui, Kaho‘olawe, and Lāna‘i (listed clockwise from upper left corner); *C*, O‘ahu; *D*, Hawai‘i. Coastline from U.S. Geological Survey’s National Elevation Dataset (U.S. Geological Survey, 2014), World Geodetic System 1984 (WGS84)]

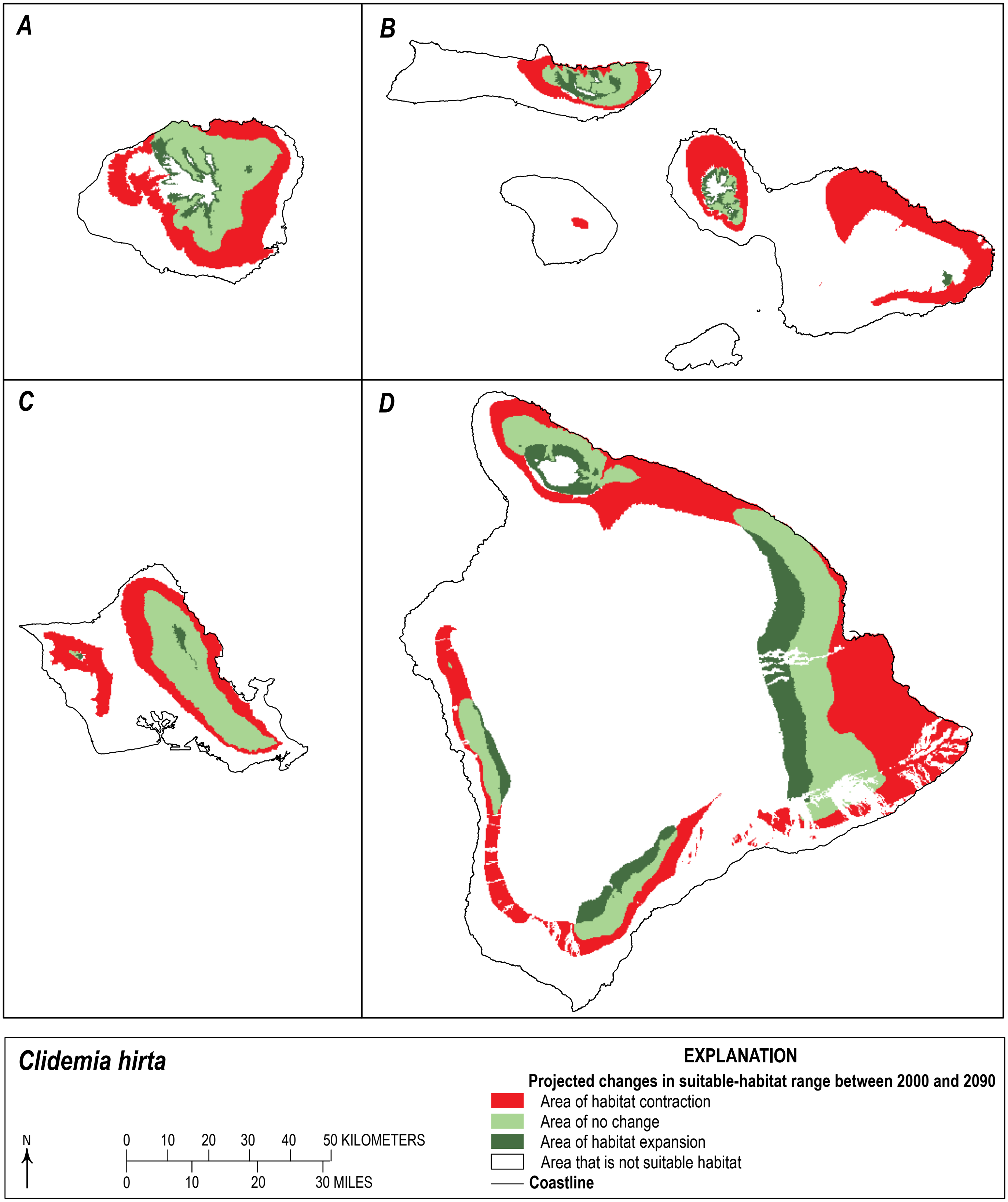
Contents of Appendix 2

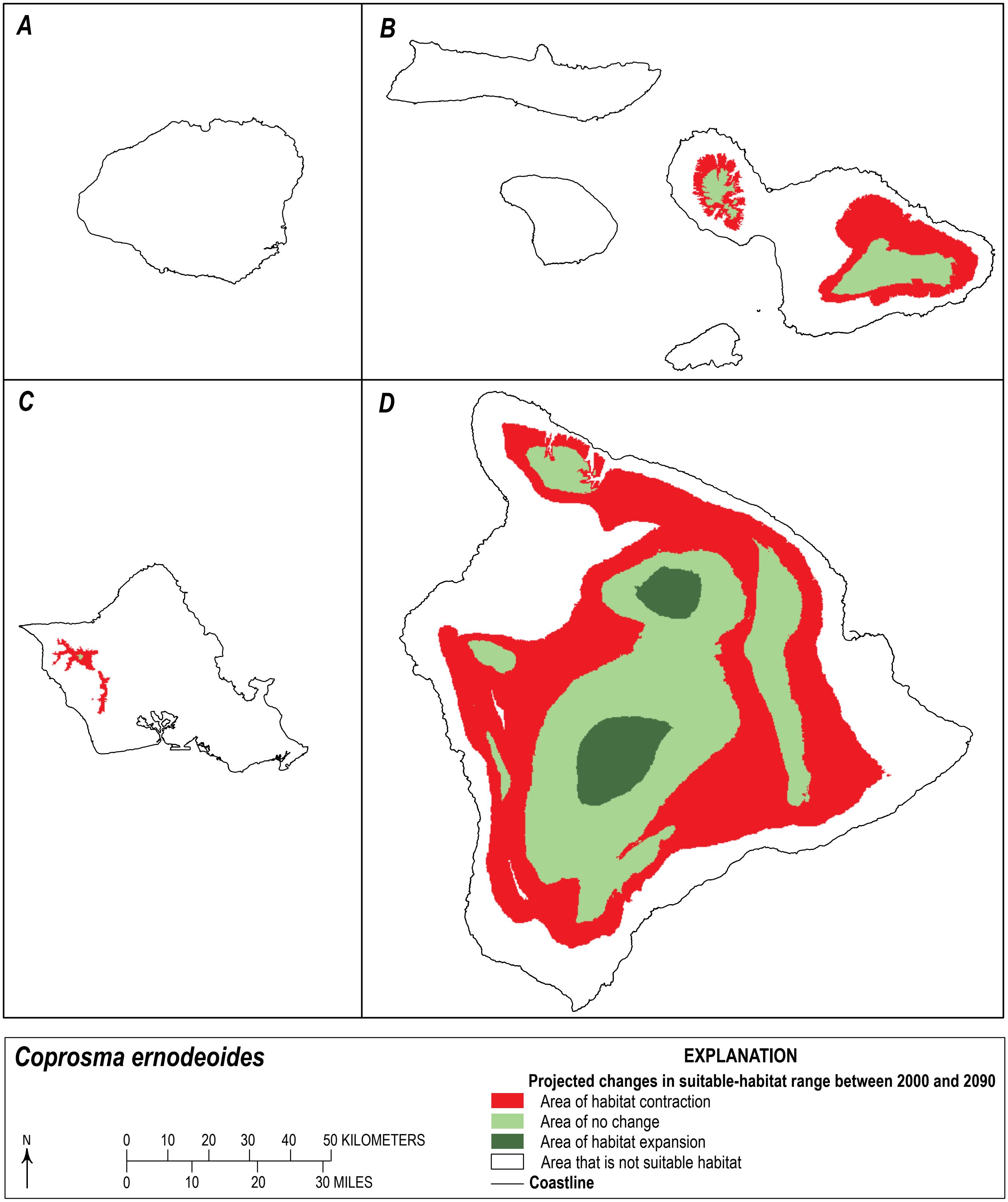

A
B
C
D
Acacia koa
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

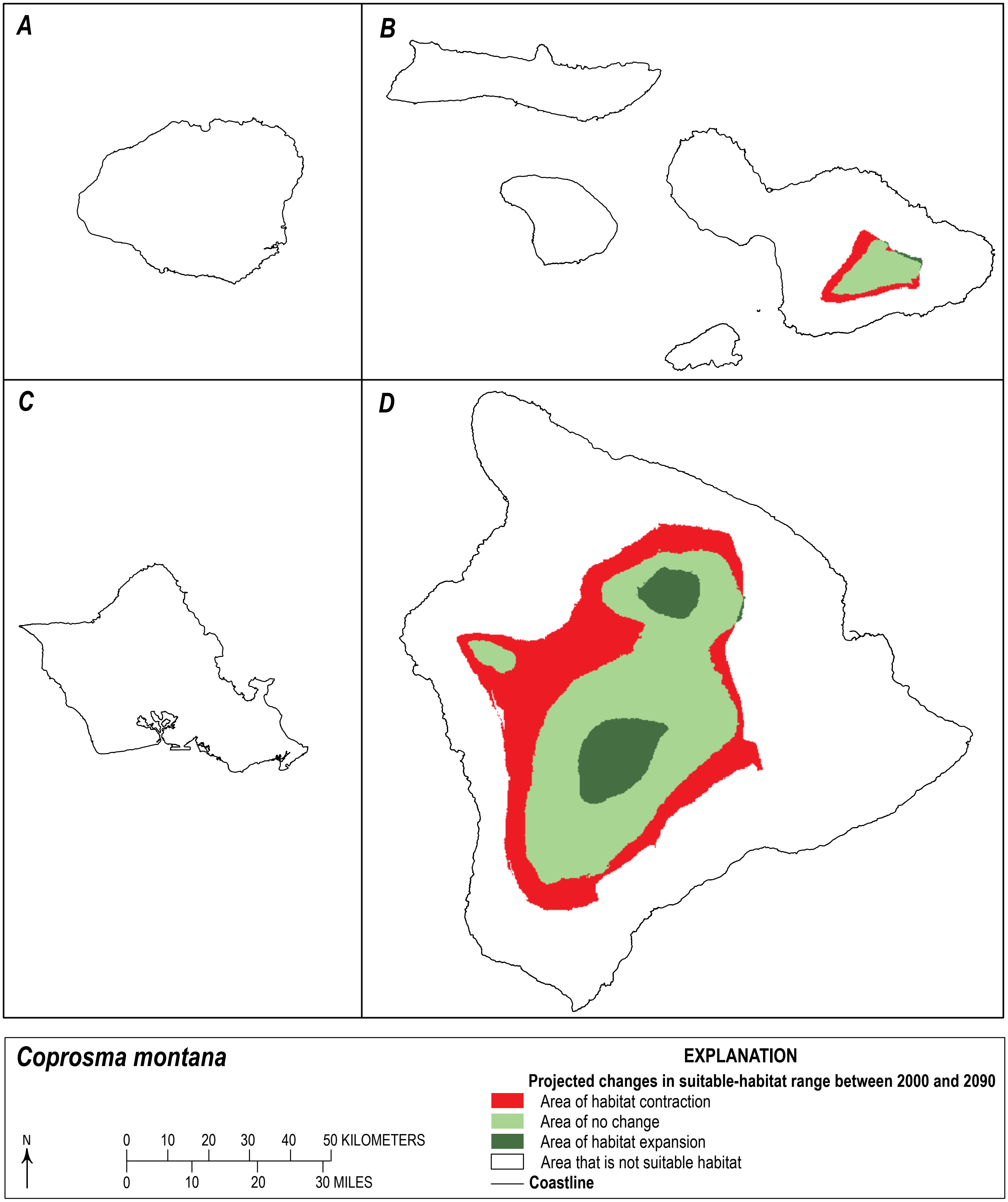

A
B
C
D
Alyxia stellata
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline

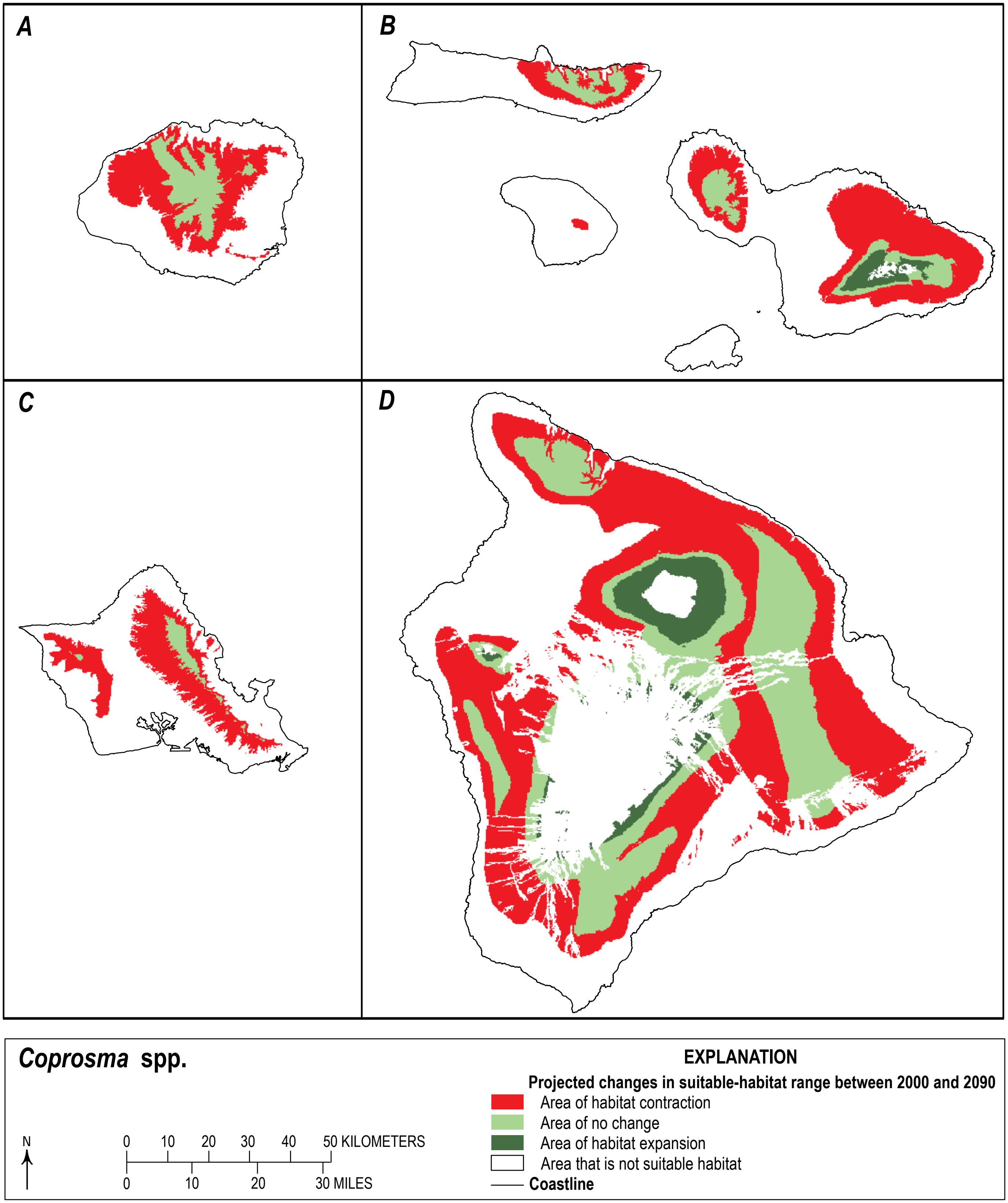

A
B
C
D
Cheirodendron trigynum
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

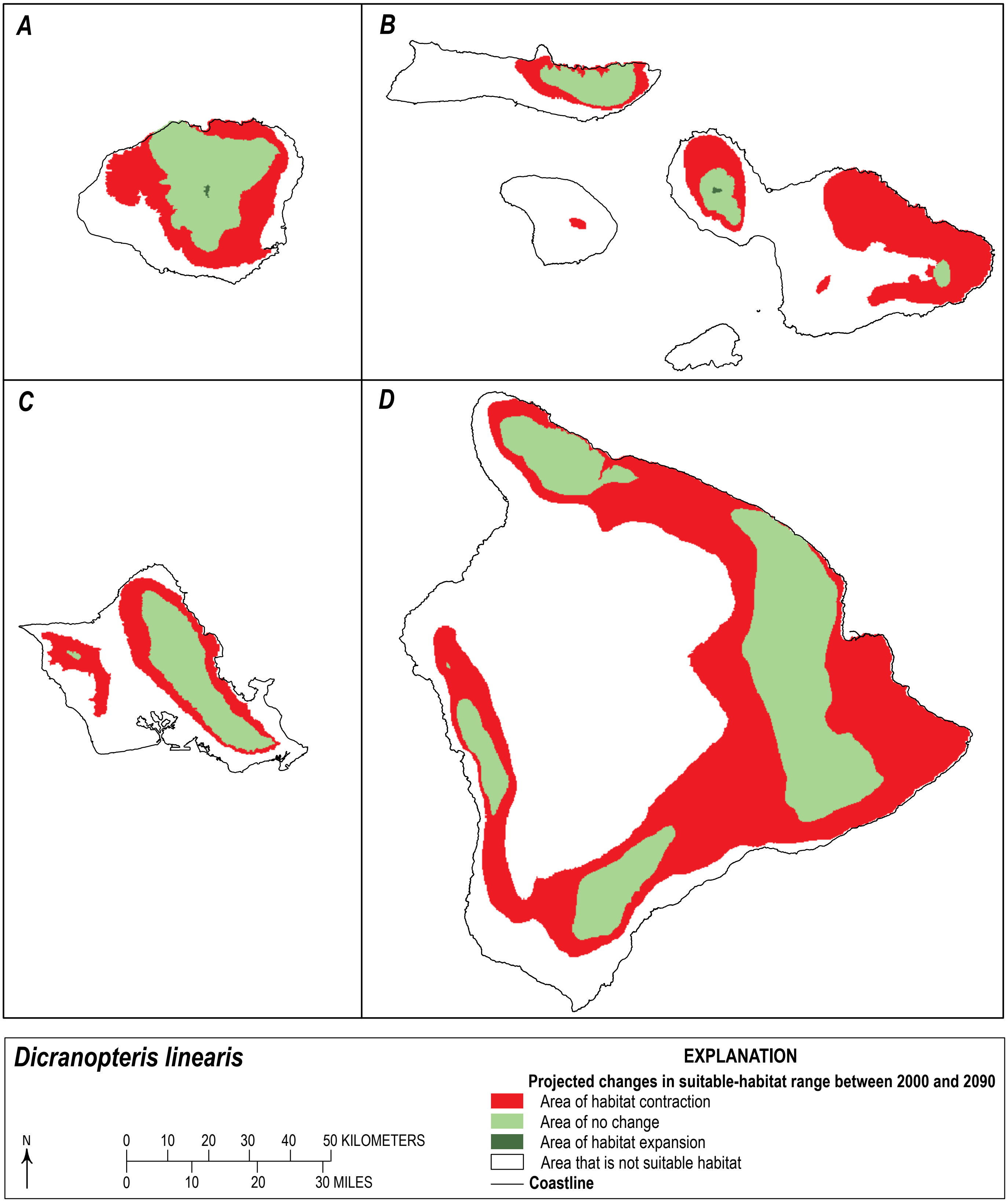

A
B
C
D
Cibotium spp.
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

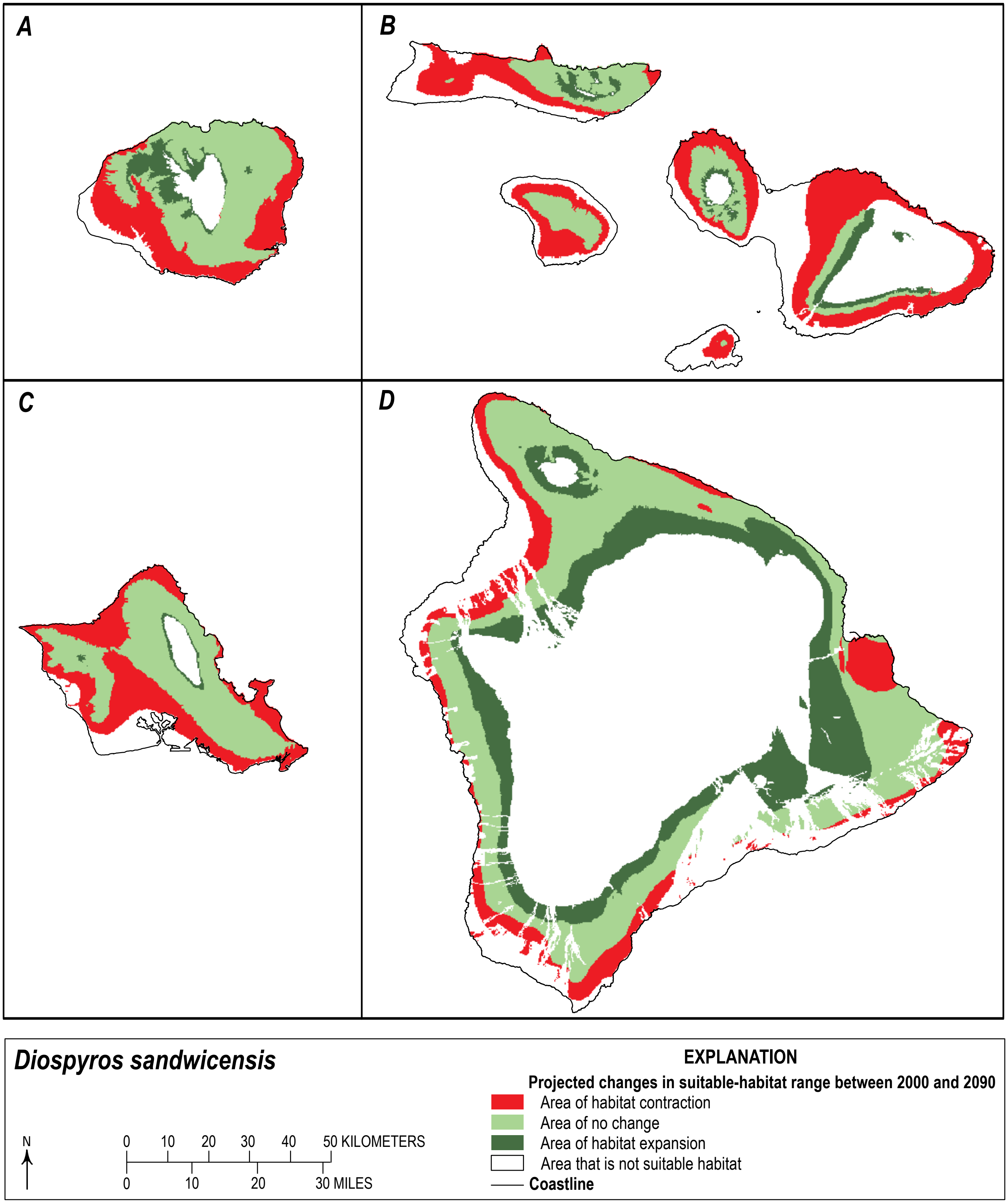

A
B
C
D
Clidemia hirta
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

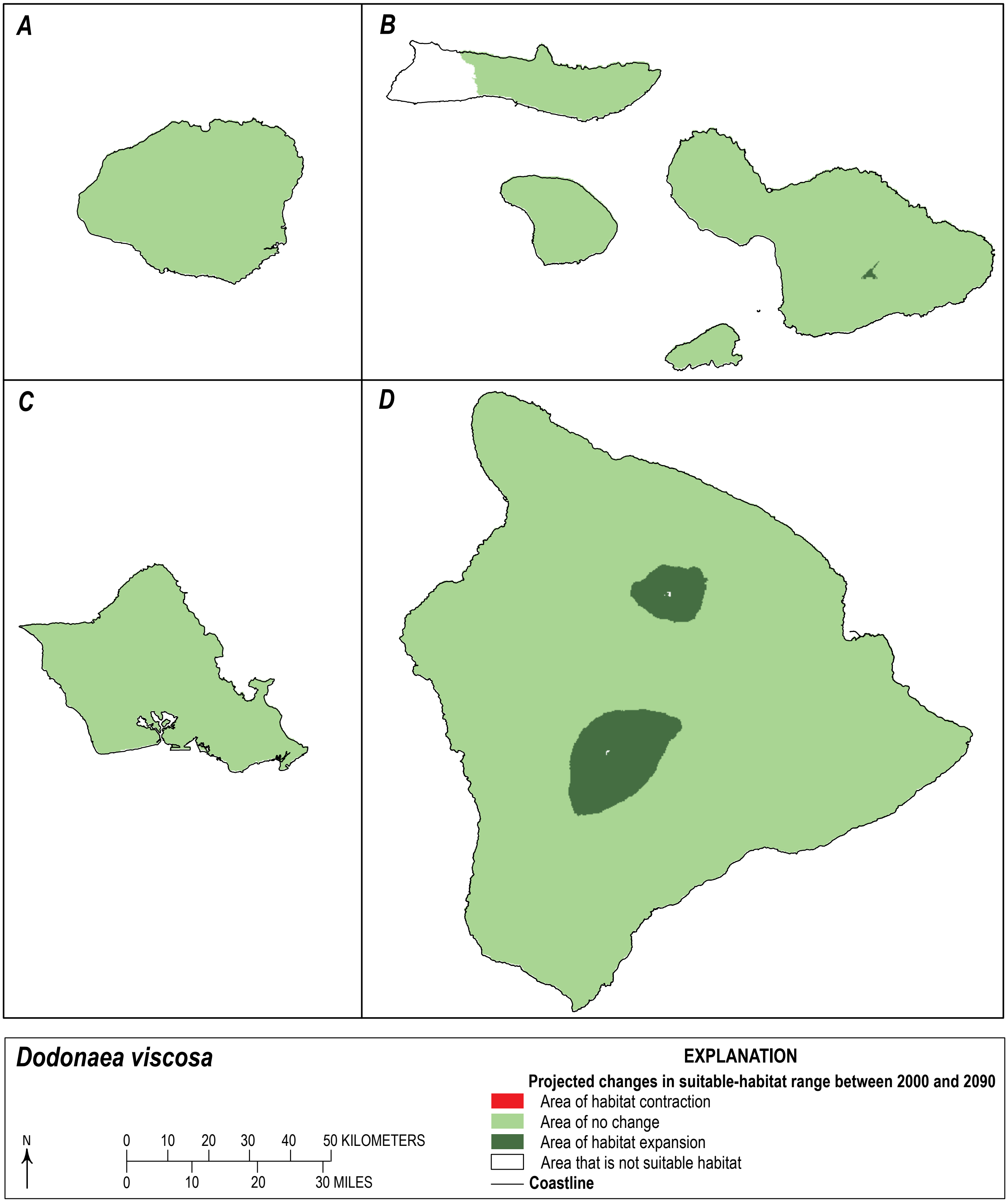

A
B
C
D
Coprosma ernodeoides
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

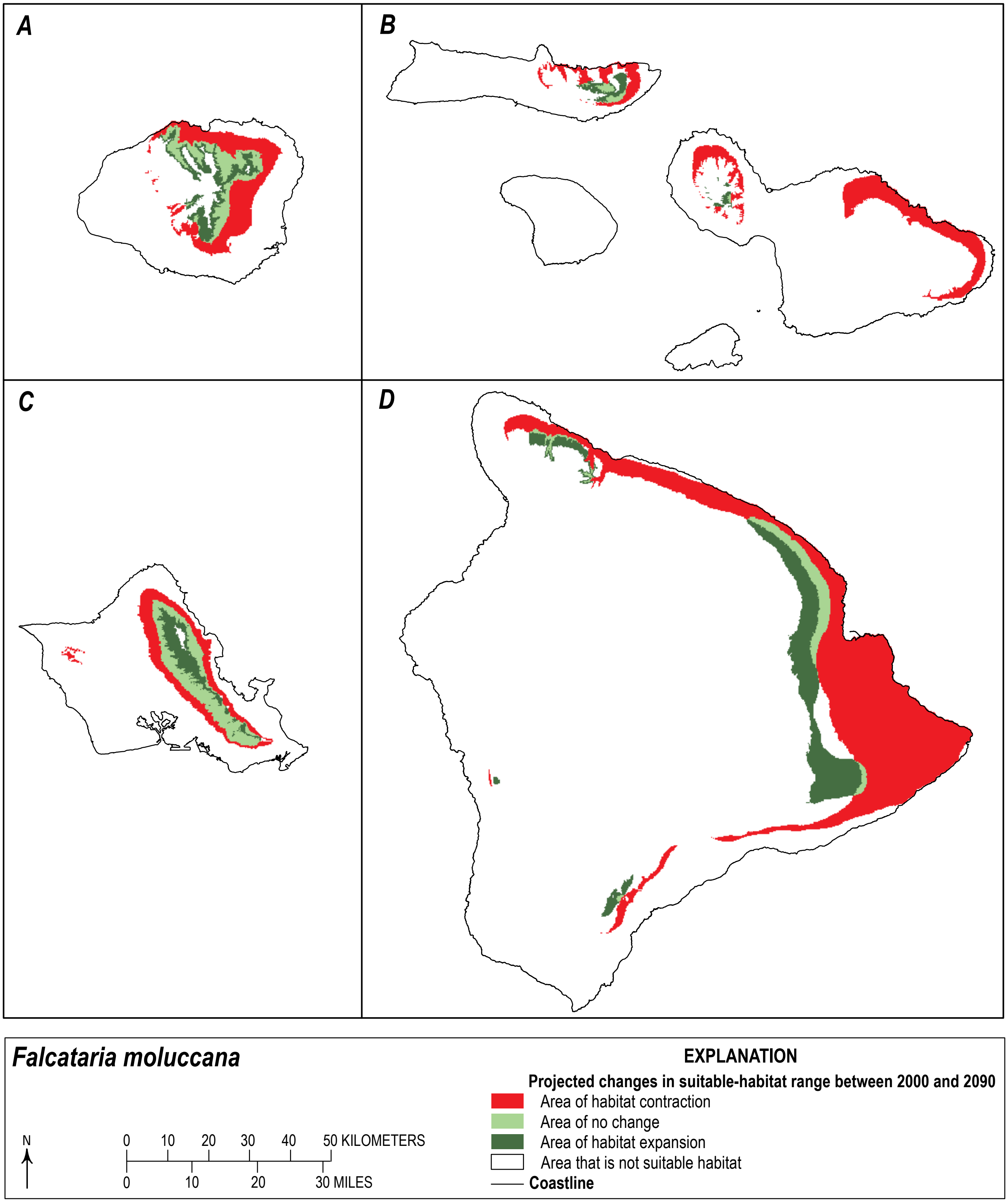

A
B
C
D
Coprosma montana
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

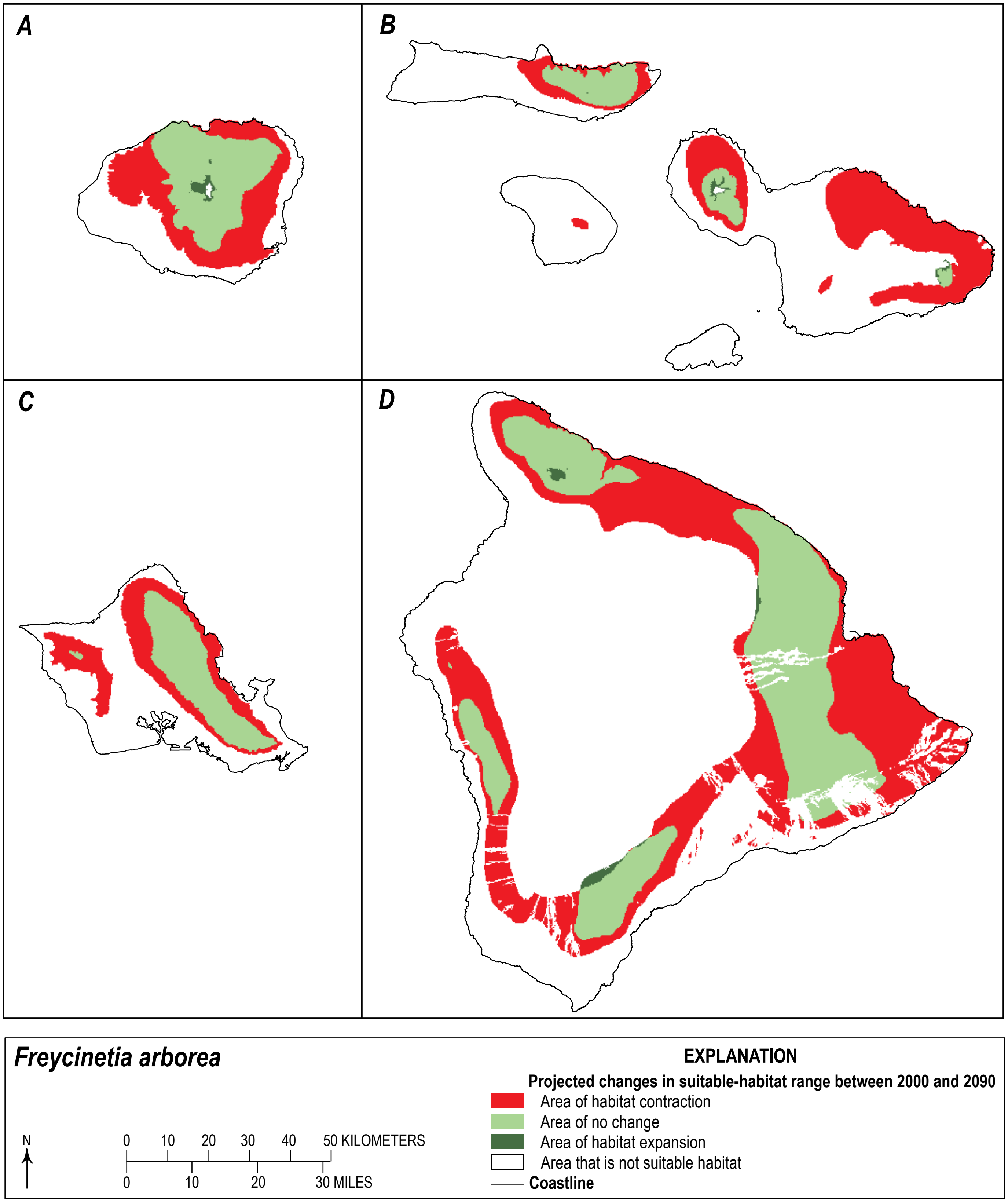

A
B
C
D
Coprosma spp.
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

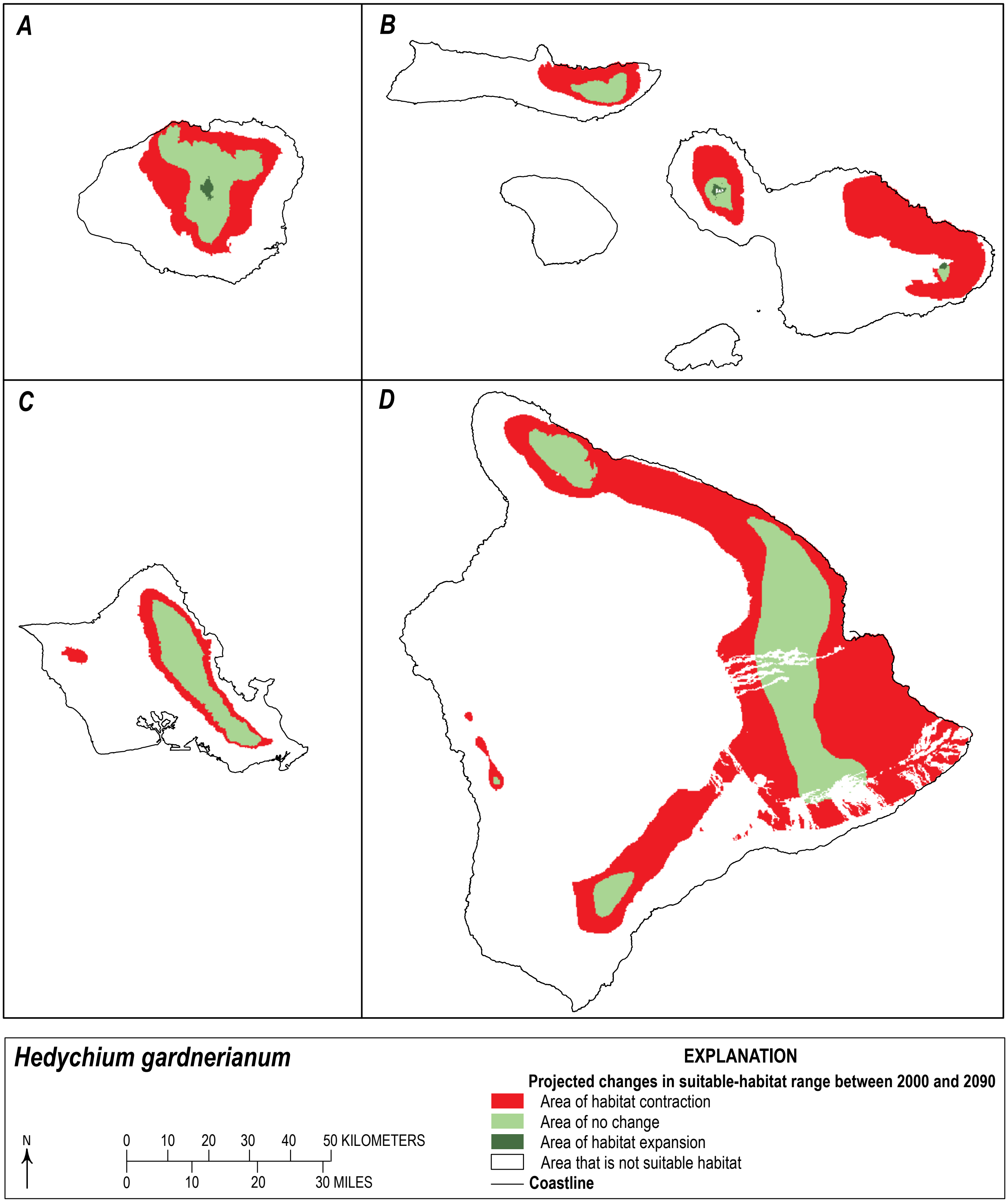

A
B
C
D
Dicranopteris linearis
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline

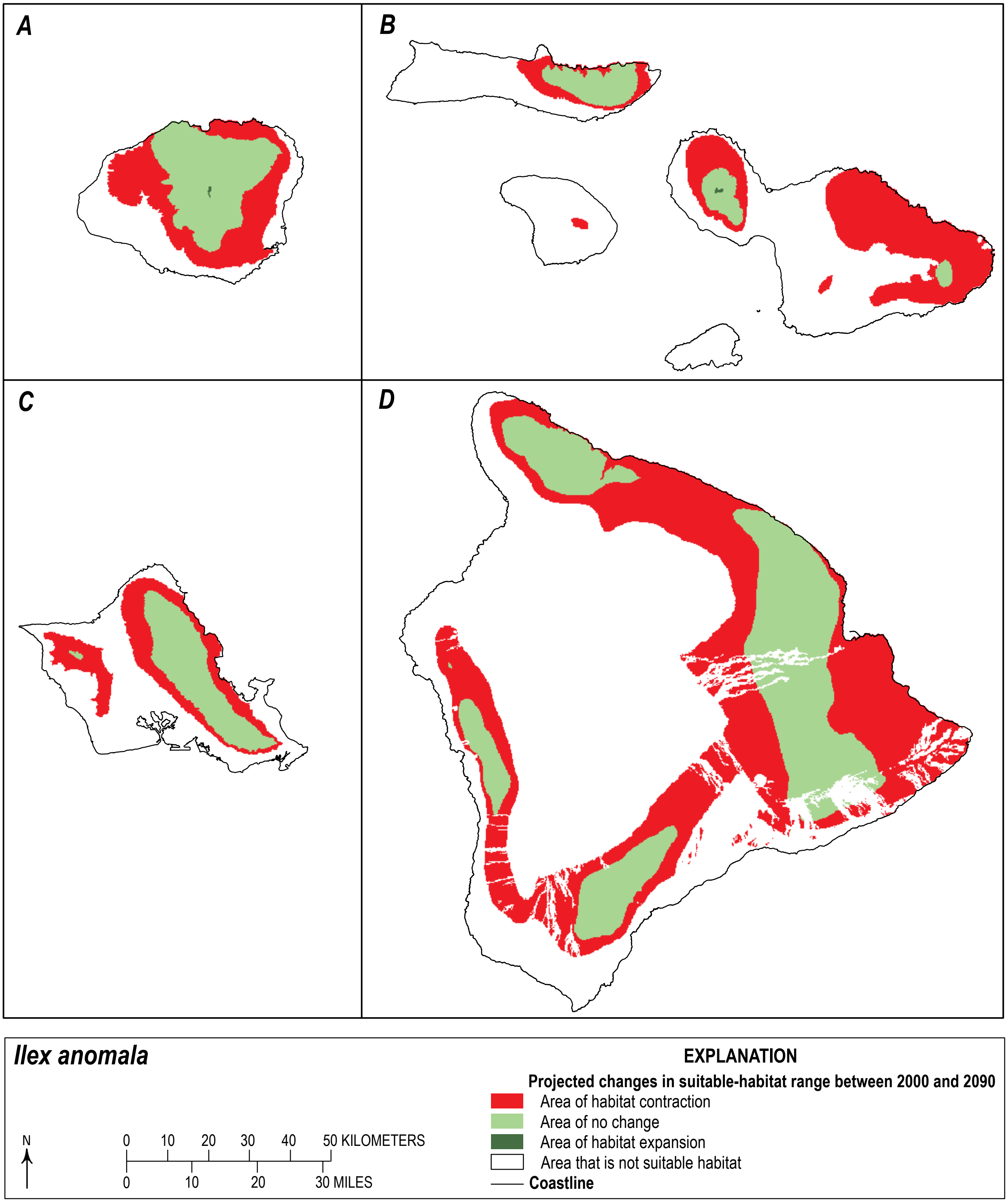

A
B
C
D
Diospyros sandwicensis
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

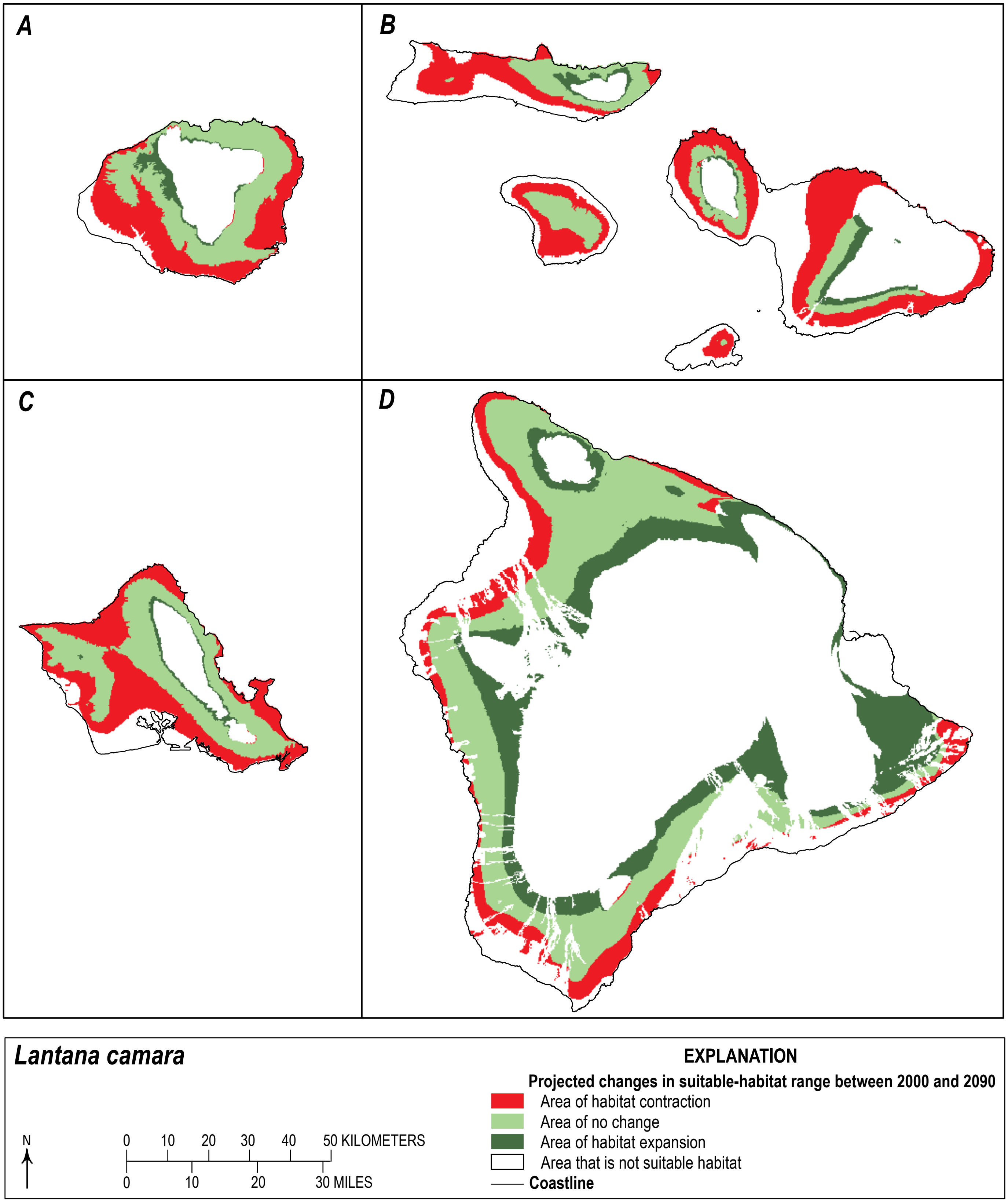

A
B
C
D
Dodonaea viscosa
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

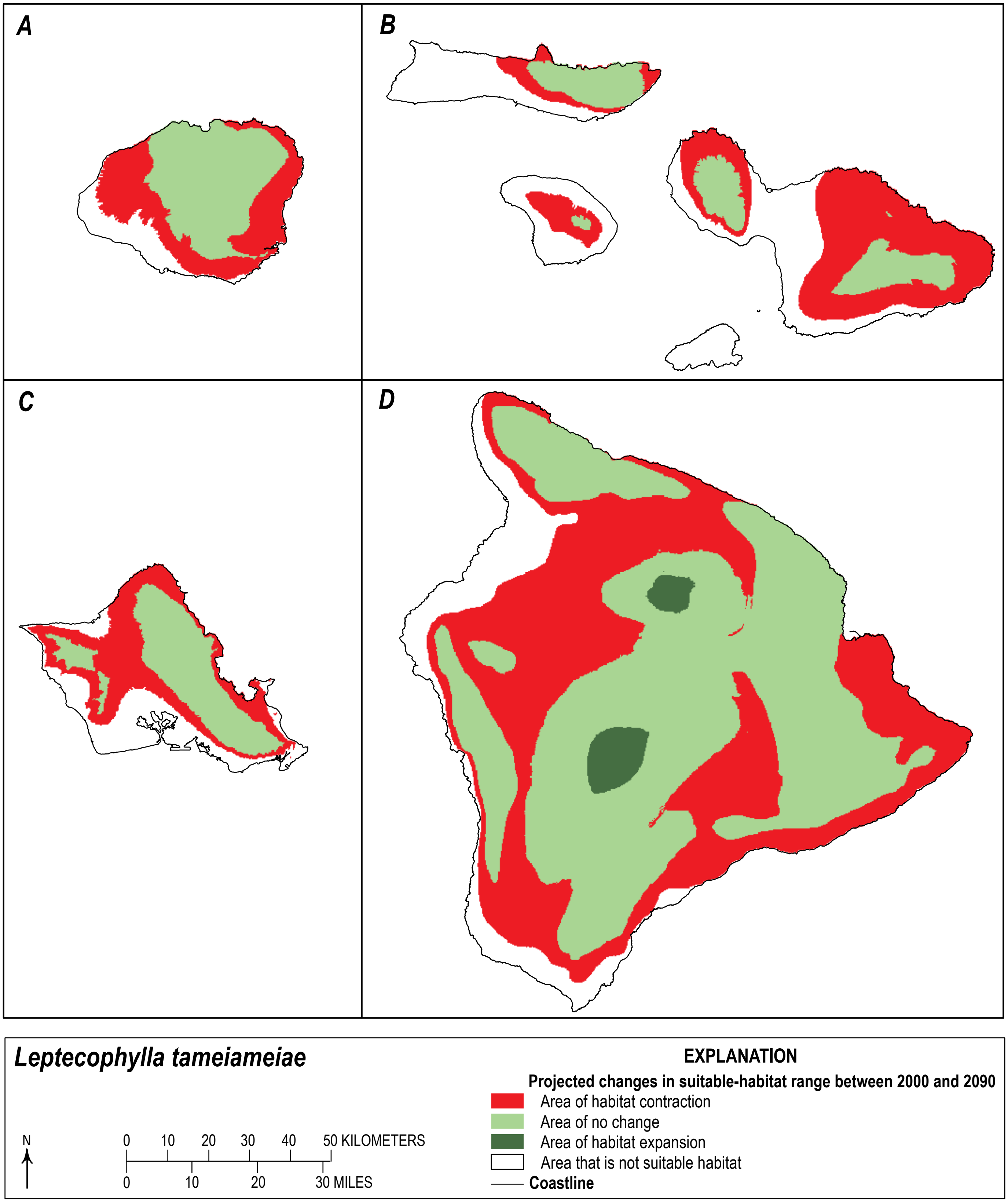

A
B
C
D
Falcataria moluccana
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

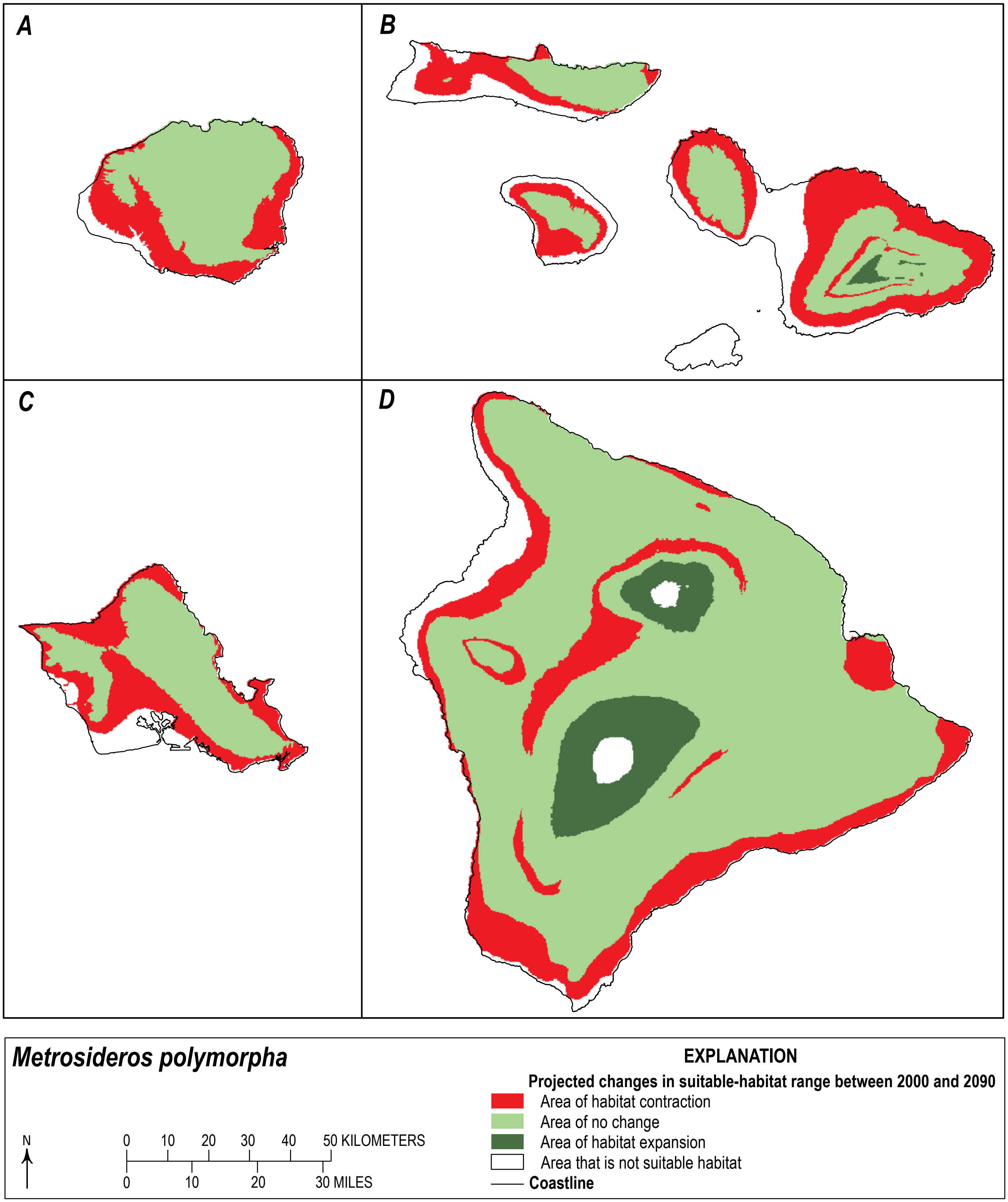

A
B
C
D
Freycinetia arborea
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Hedychium gardnerianum
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Ilex anomala
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline


A
B
C
D
Lantana camara
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Leptecophylla tameiameiae
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Metrosideros polymorpha
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
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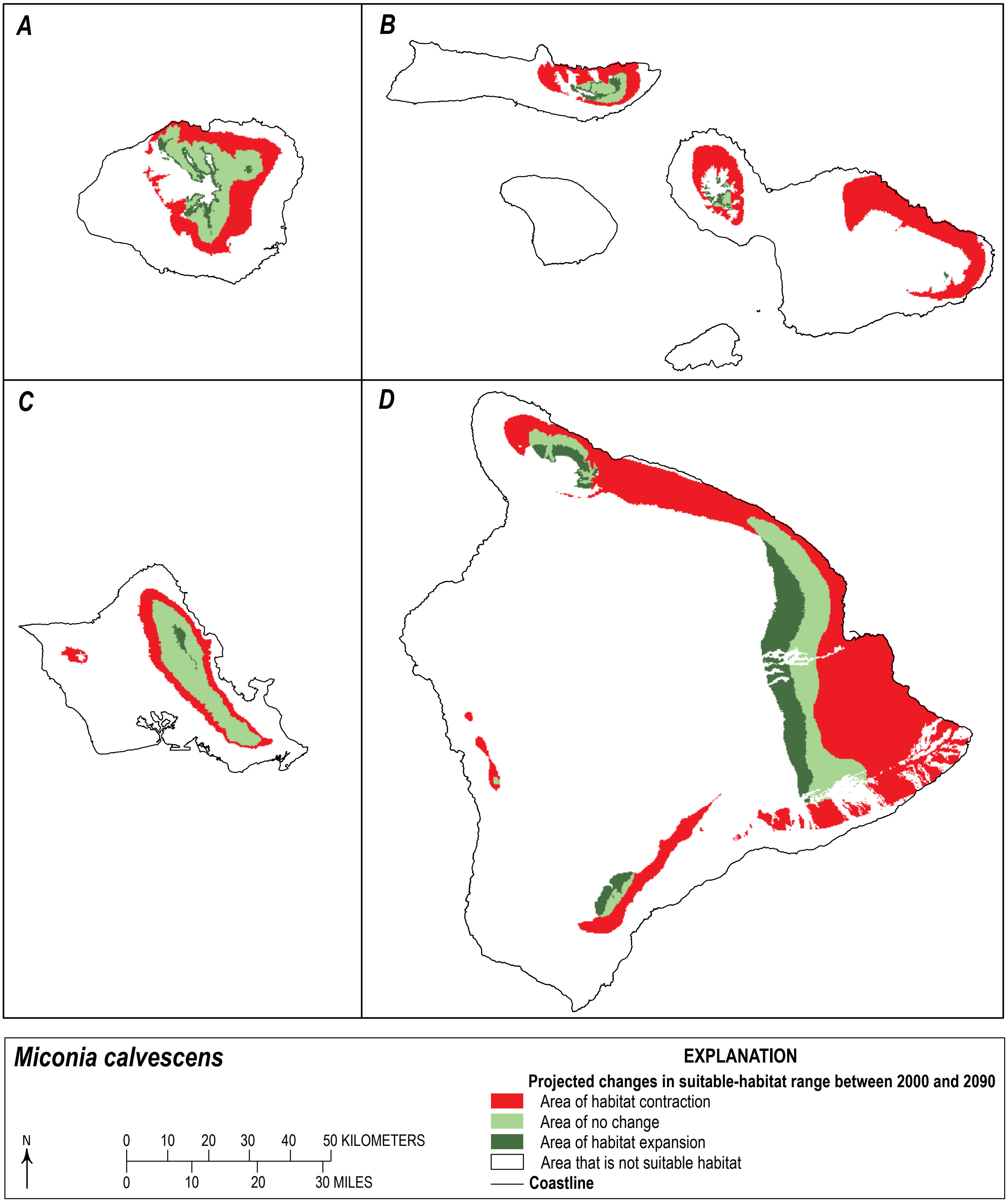
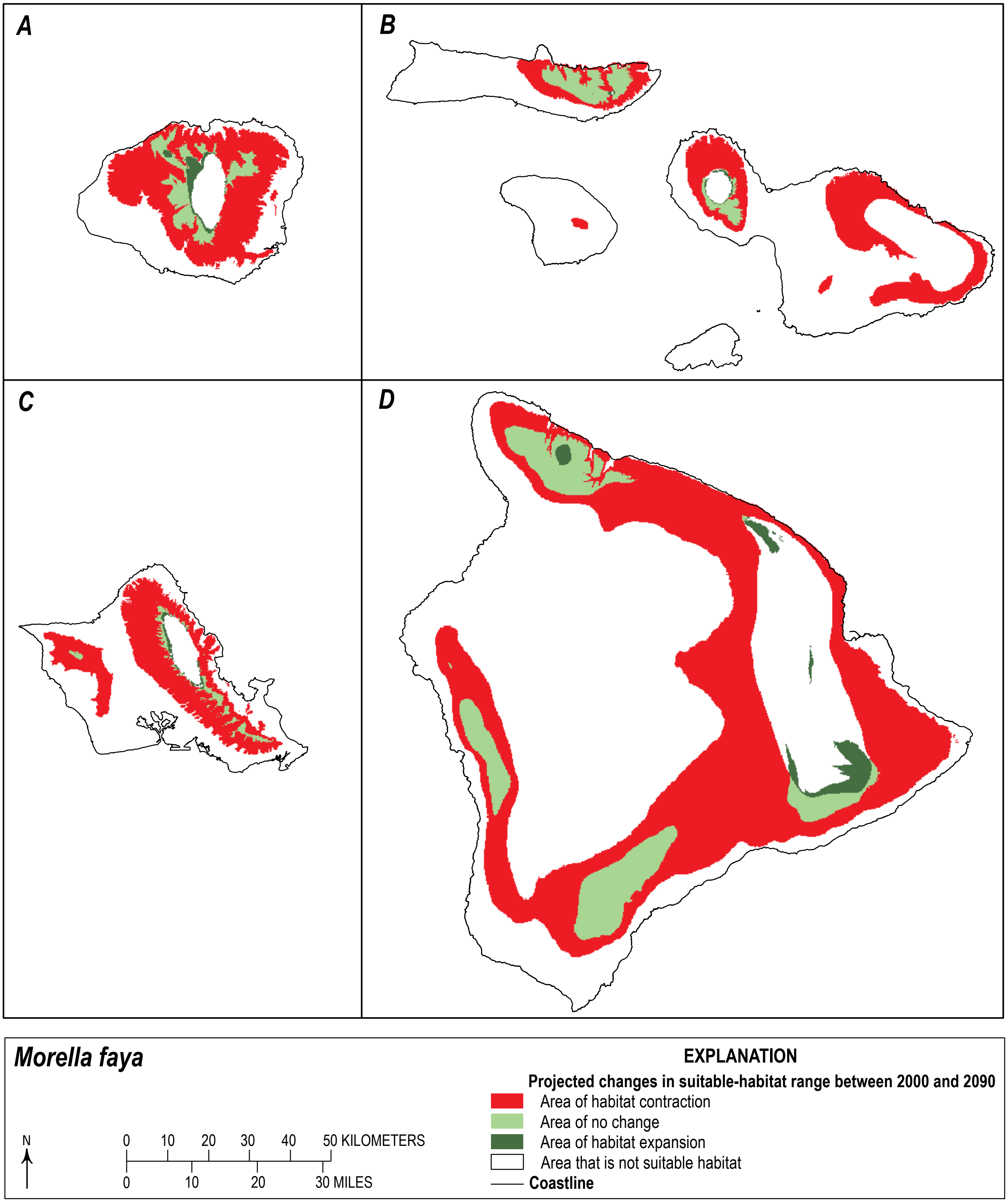
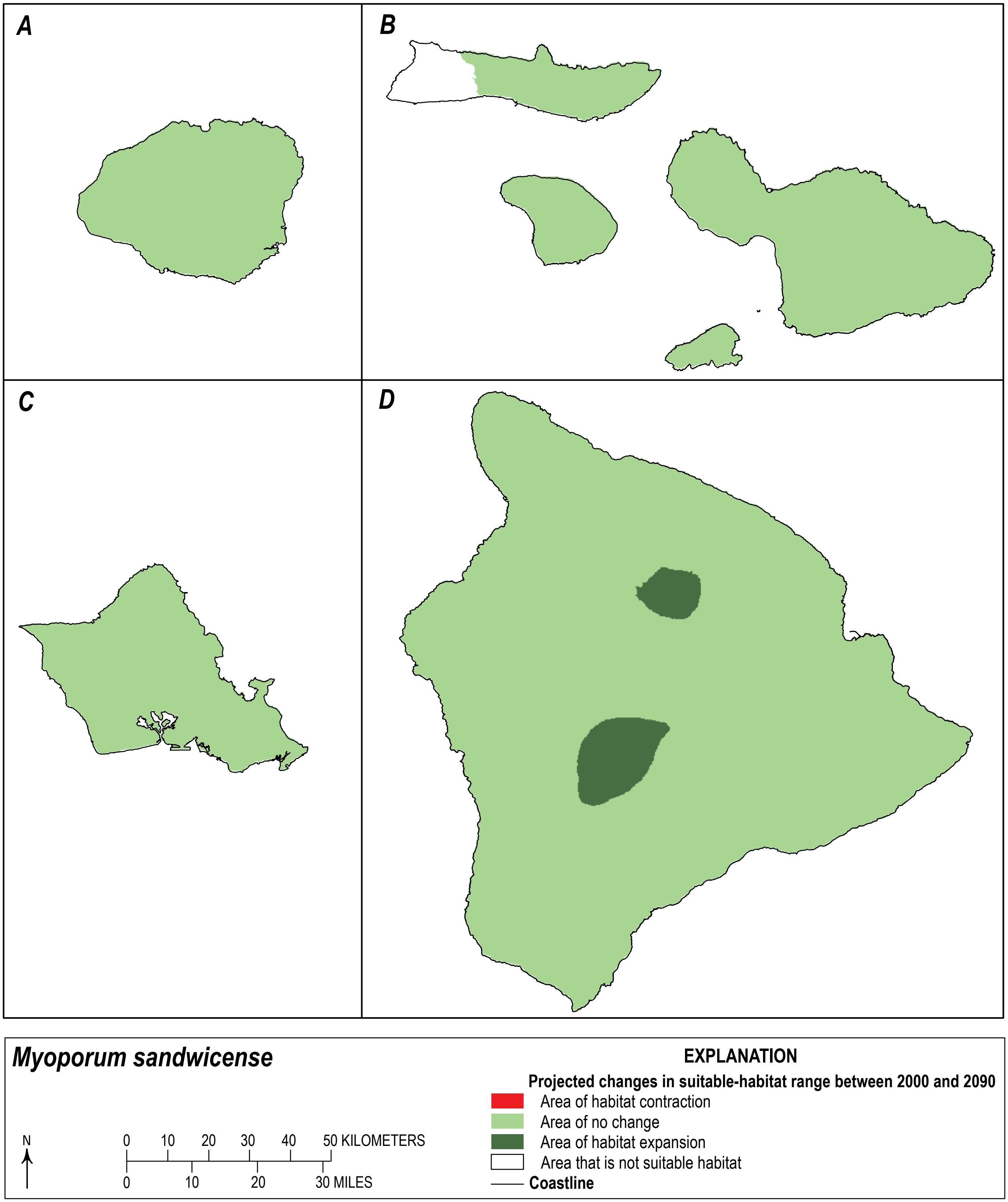
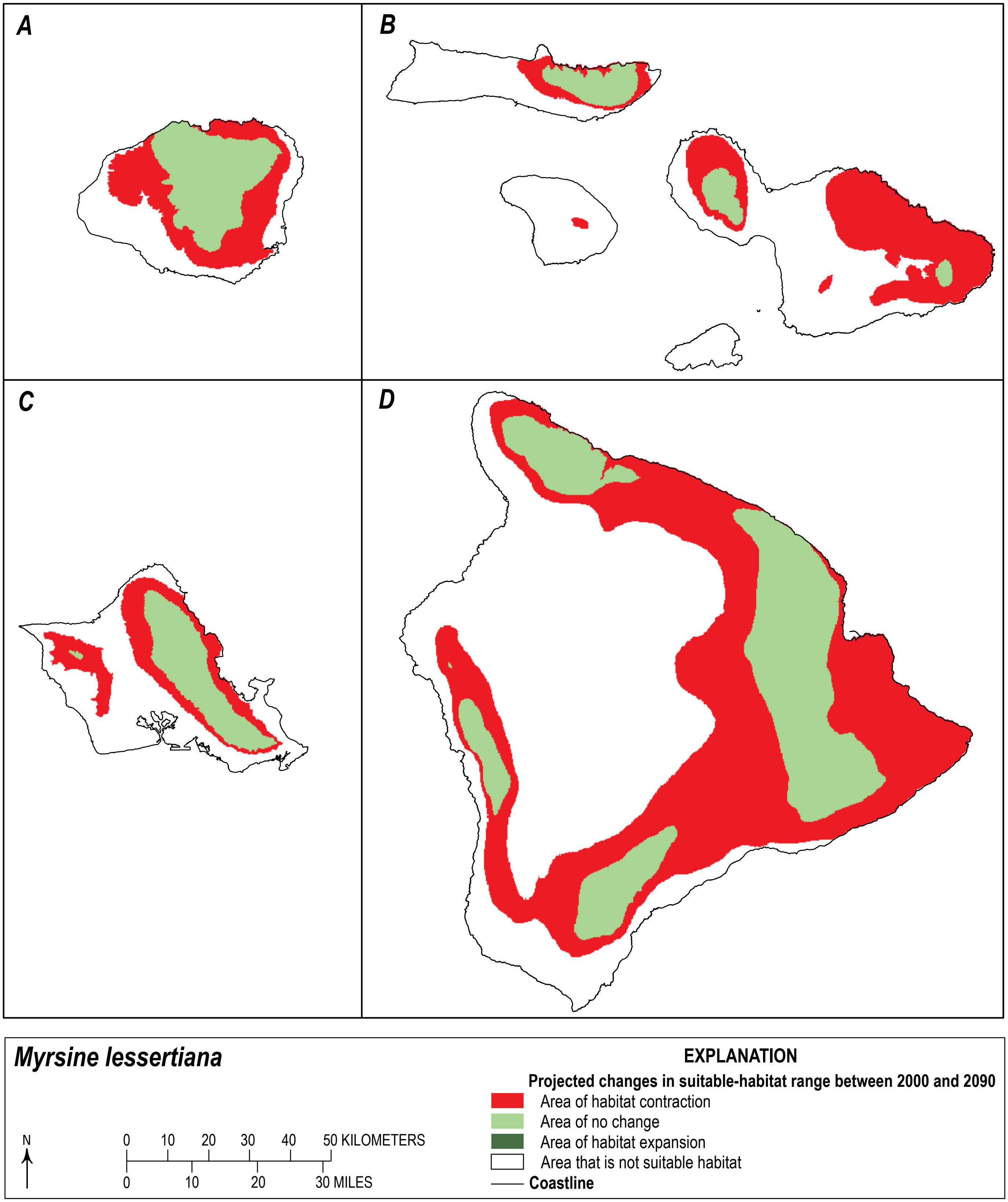

A
B
C
D
Miconia calvescens
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Morella faya
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Myoporum sandwicense
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
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C
D
Myrsine lessertiana
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
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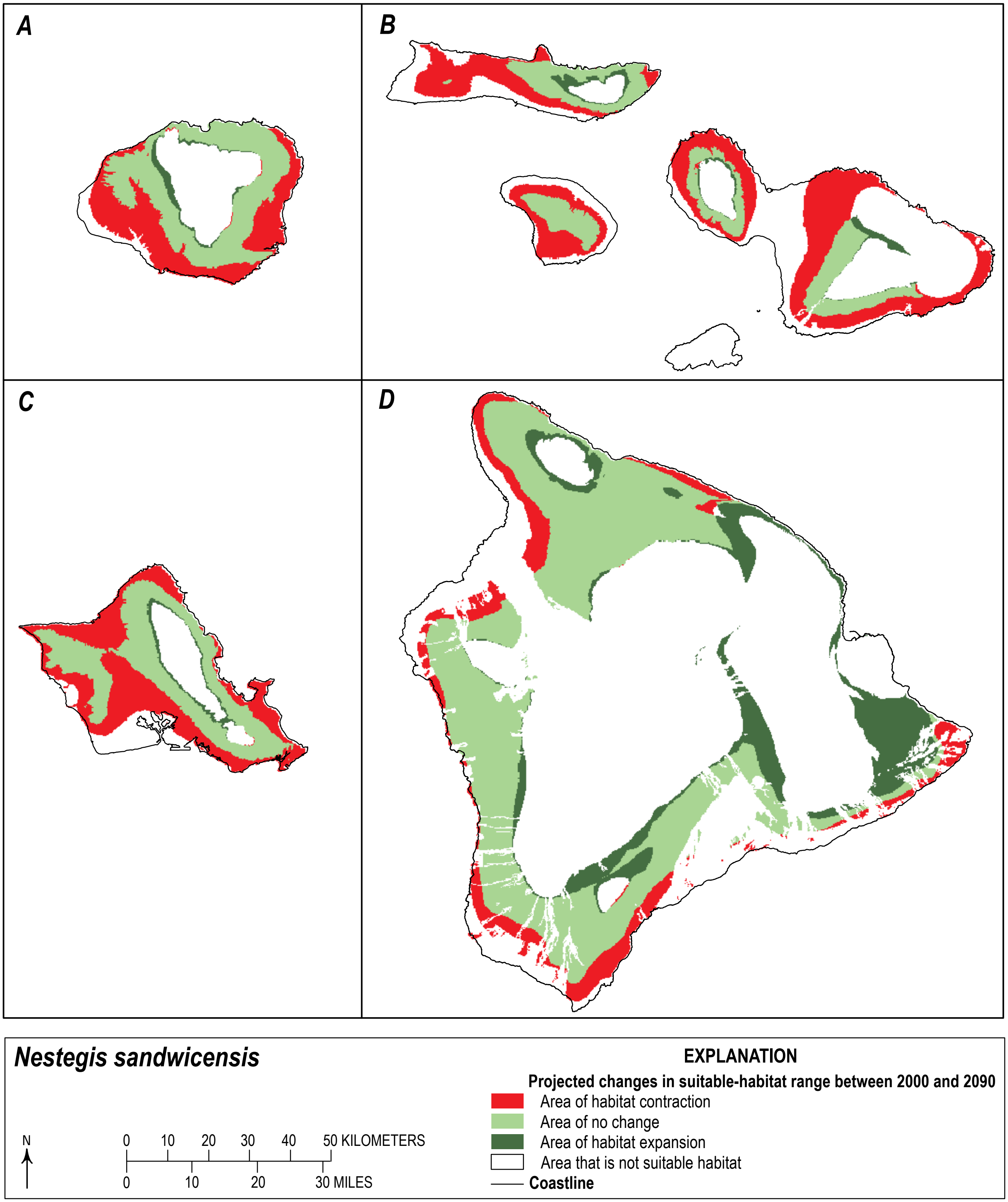
0 10 20 30 MILES


A
B
C
D
Nestegis sandwicensis
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
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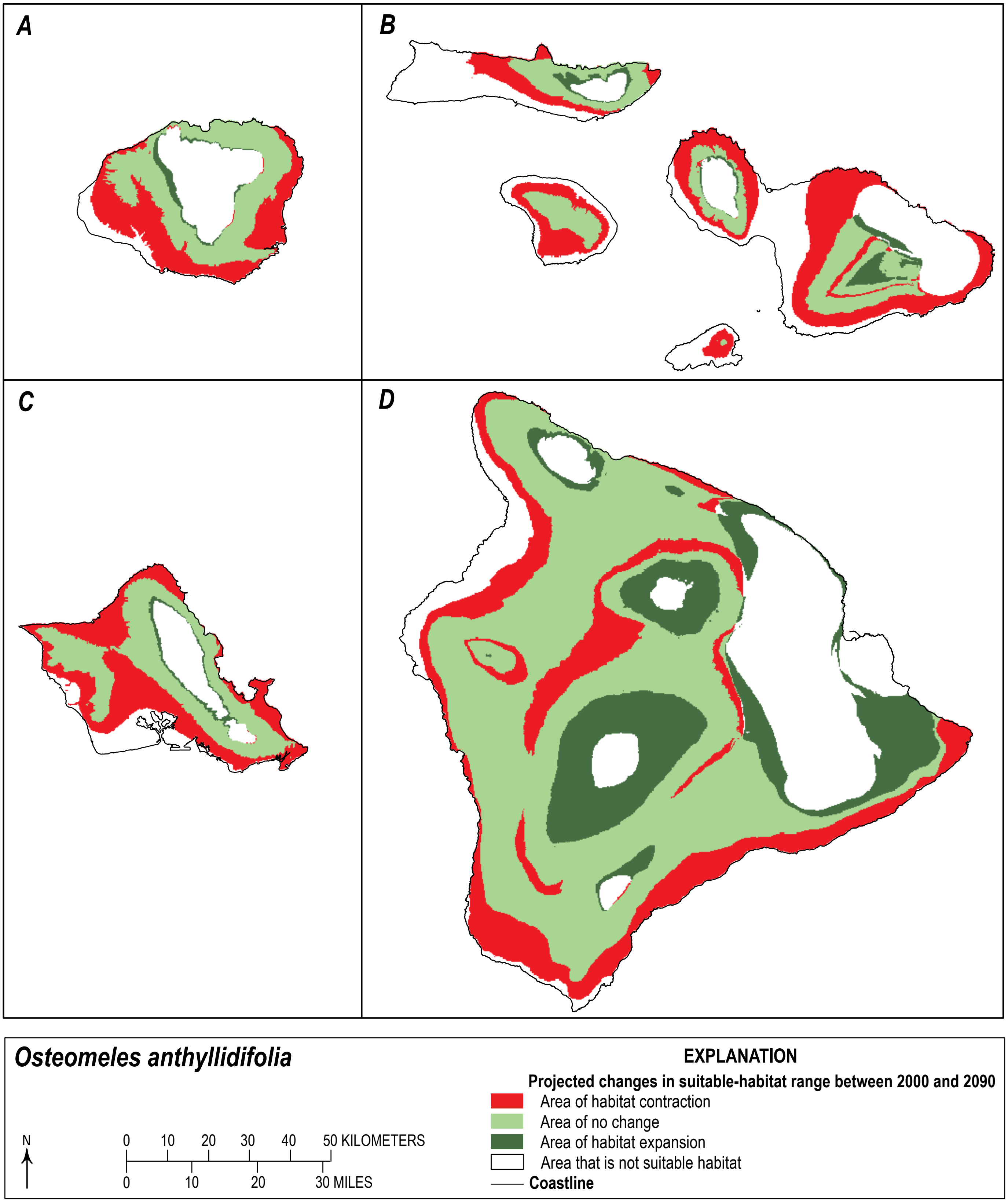
0 10 20 30 MILES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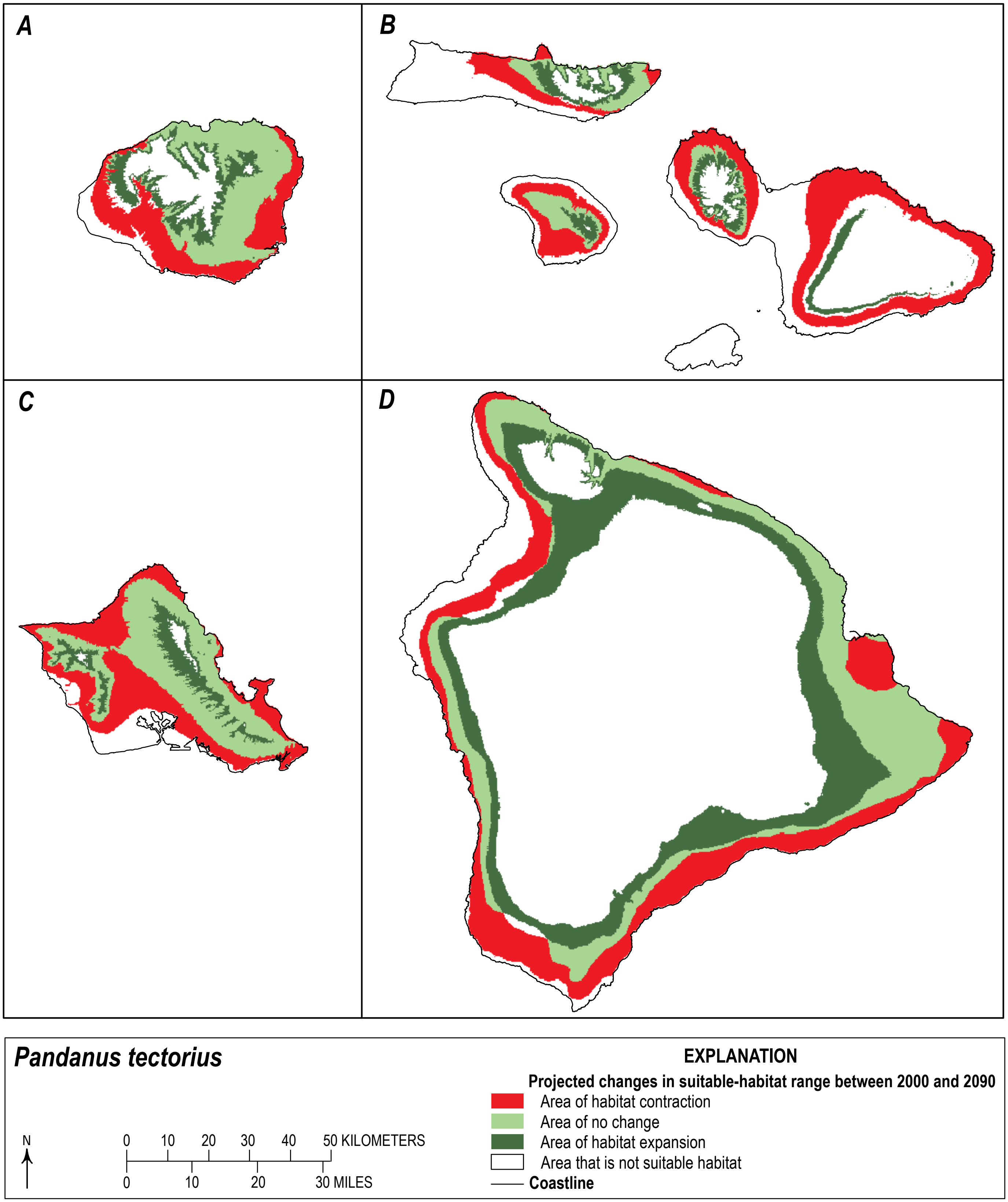
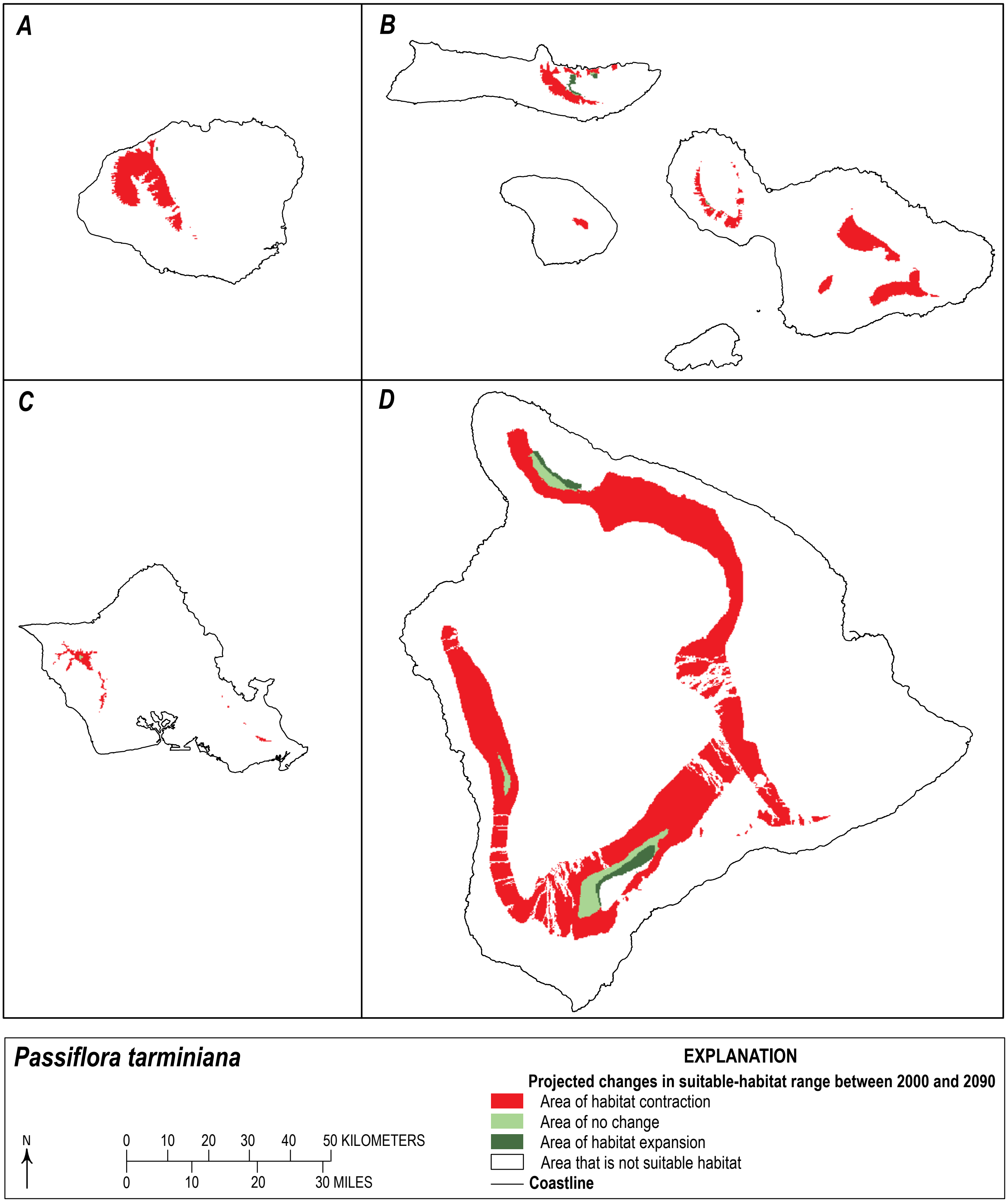
B
C
D
Osteomeles anthyllidifolia
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Pandanus tectorius
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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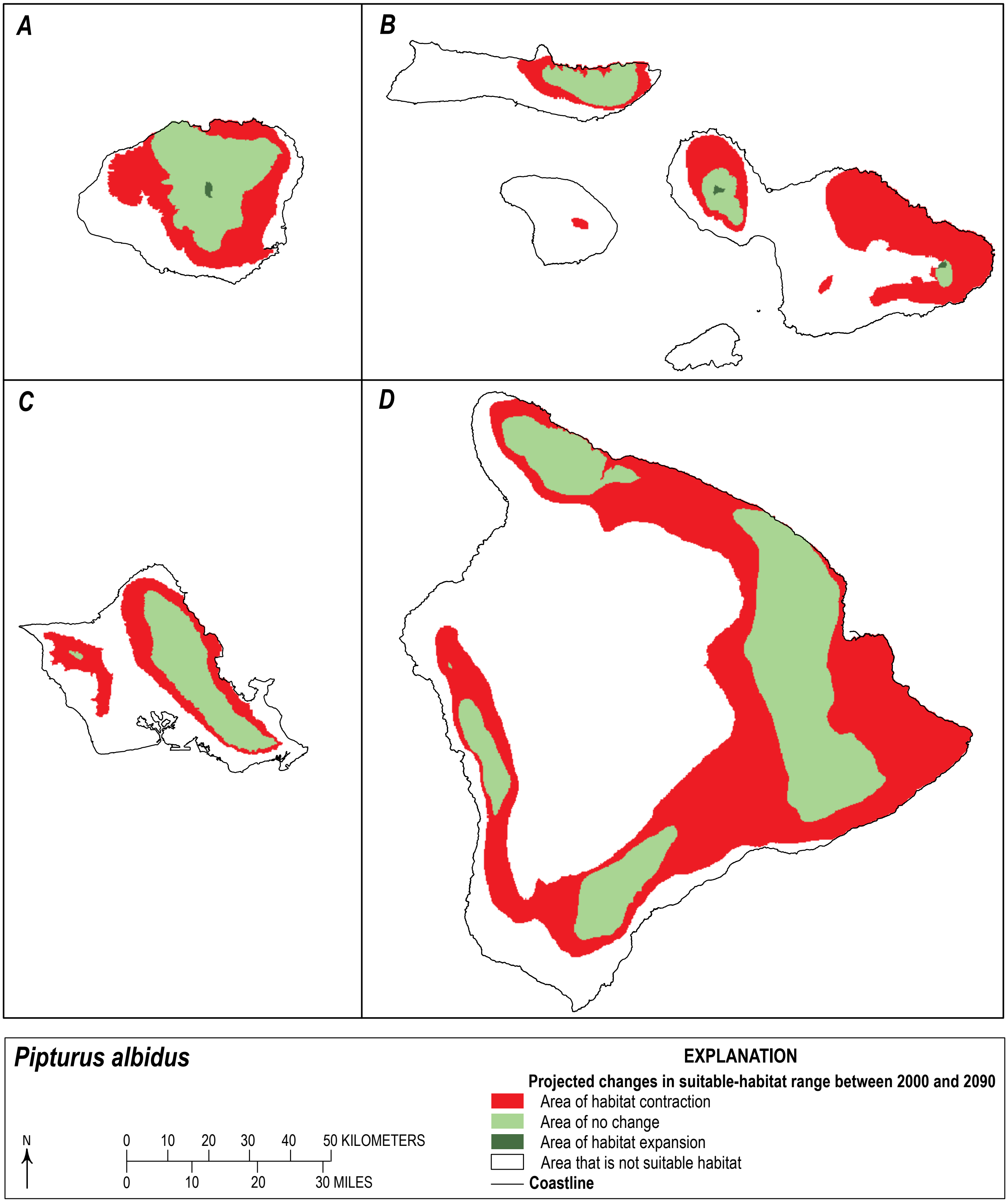
B
C
D
Passiflora tarminiana
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
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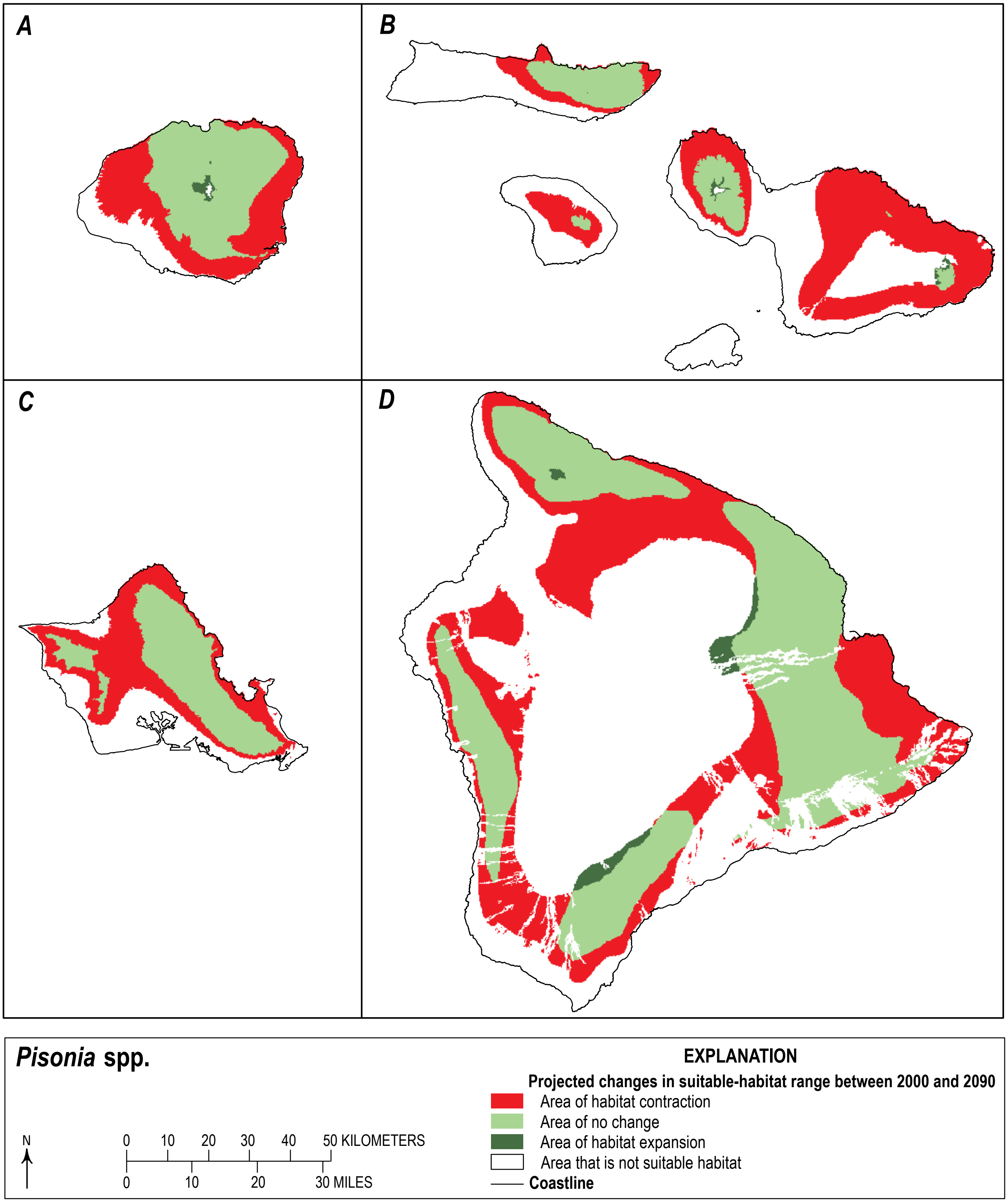
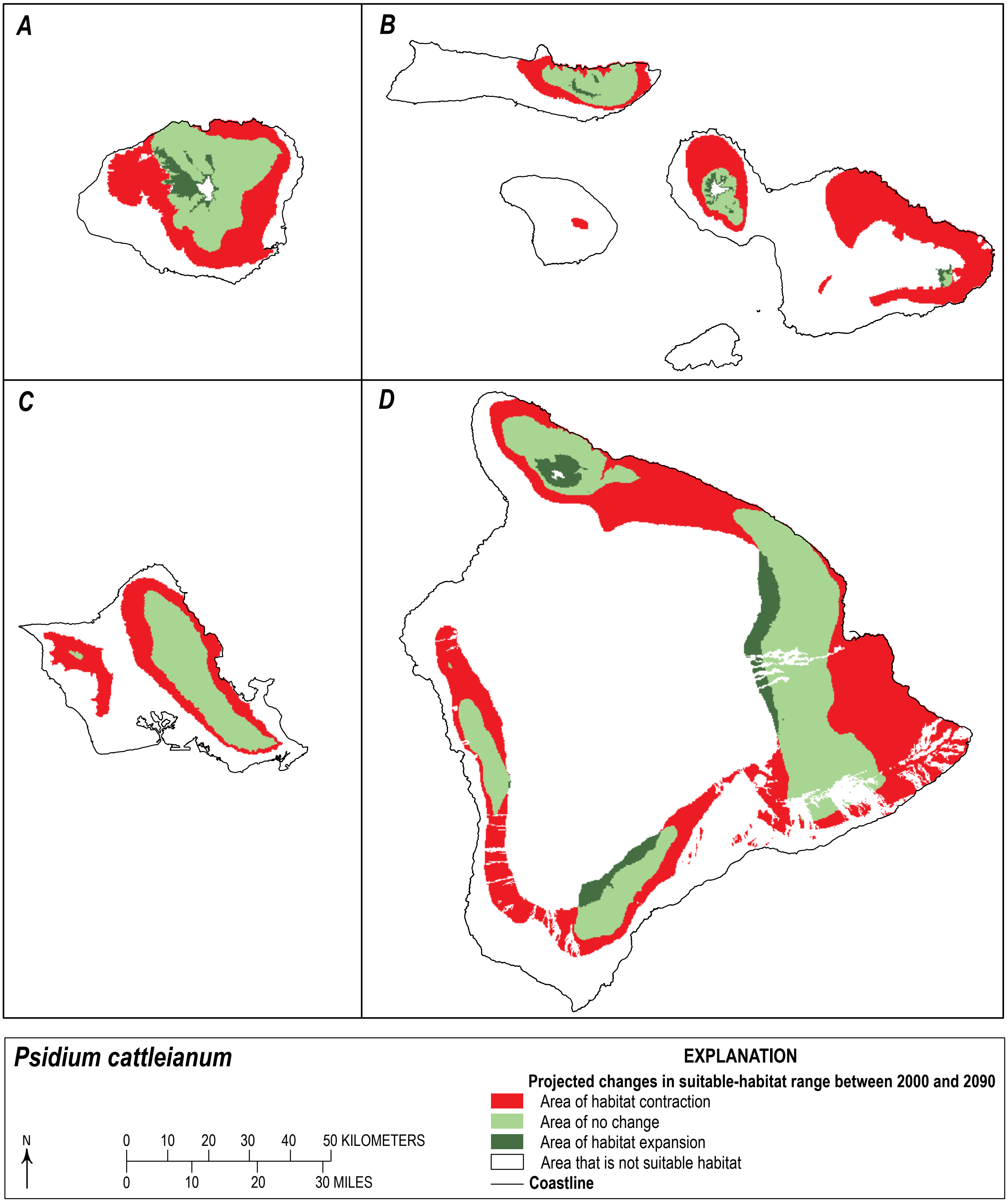
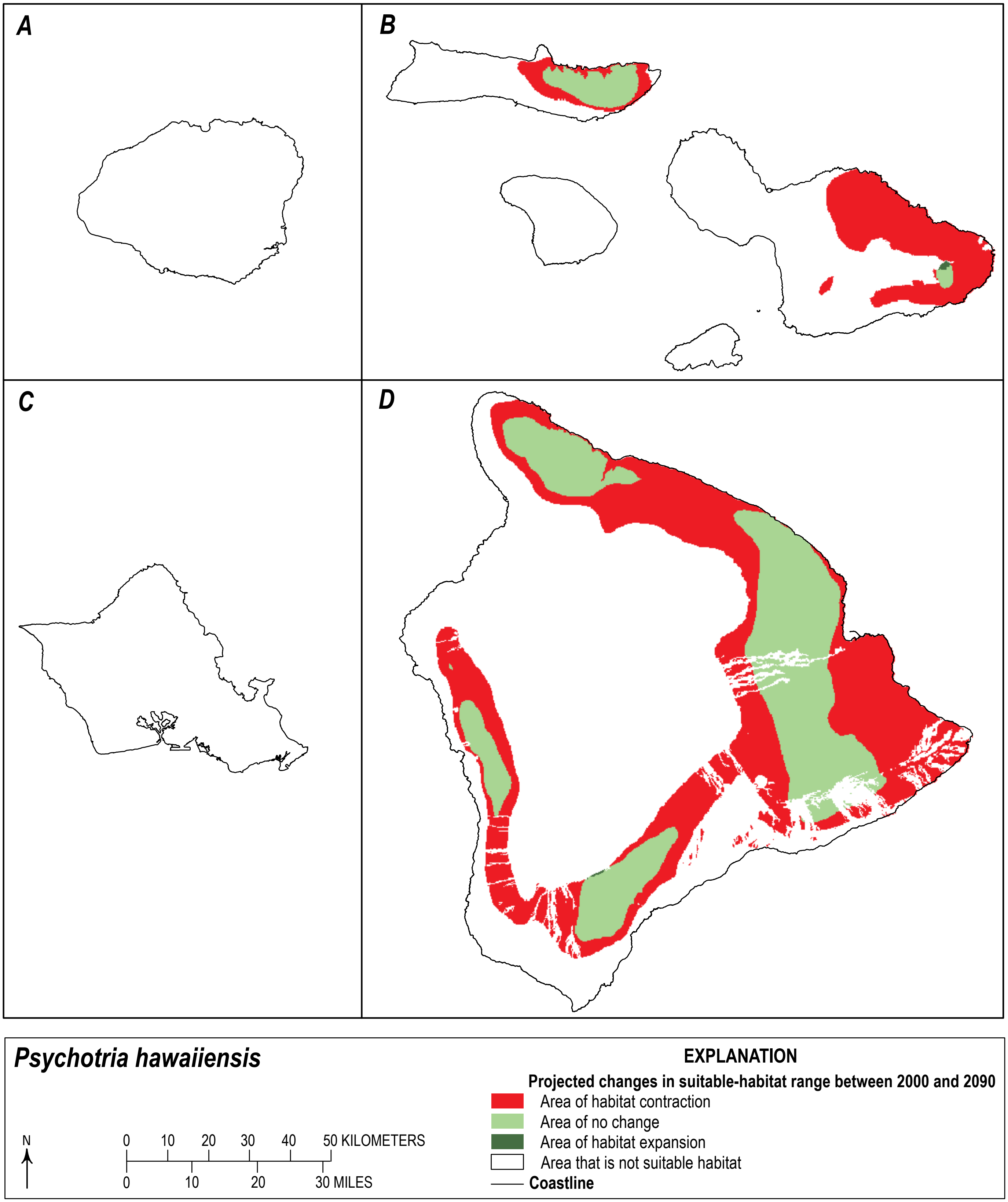
C
D
Pipturus albidus
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Pisonia spp.
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Psidium cattleianum
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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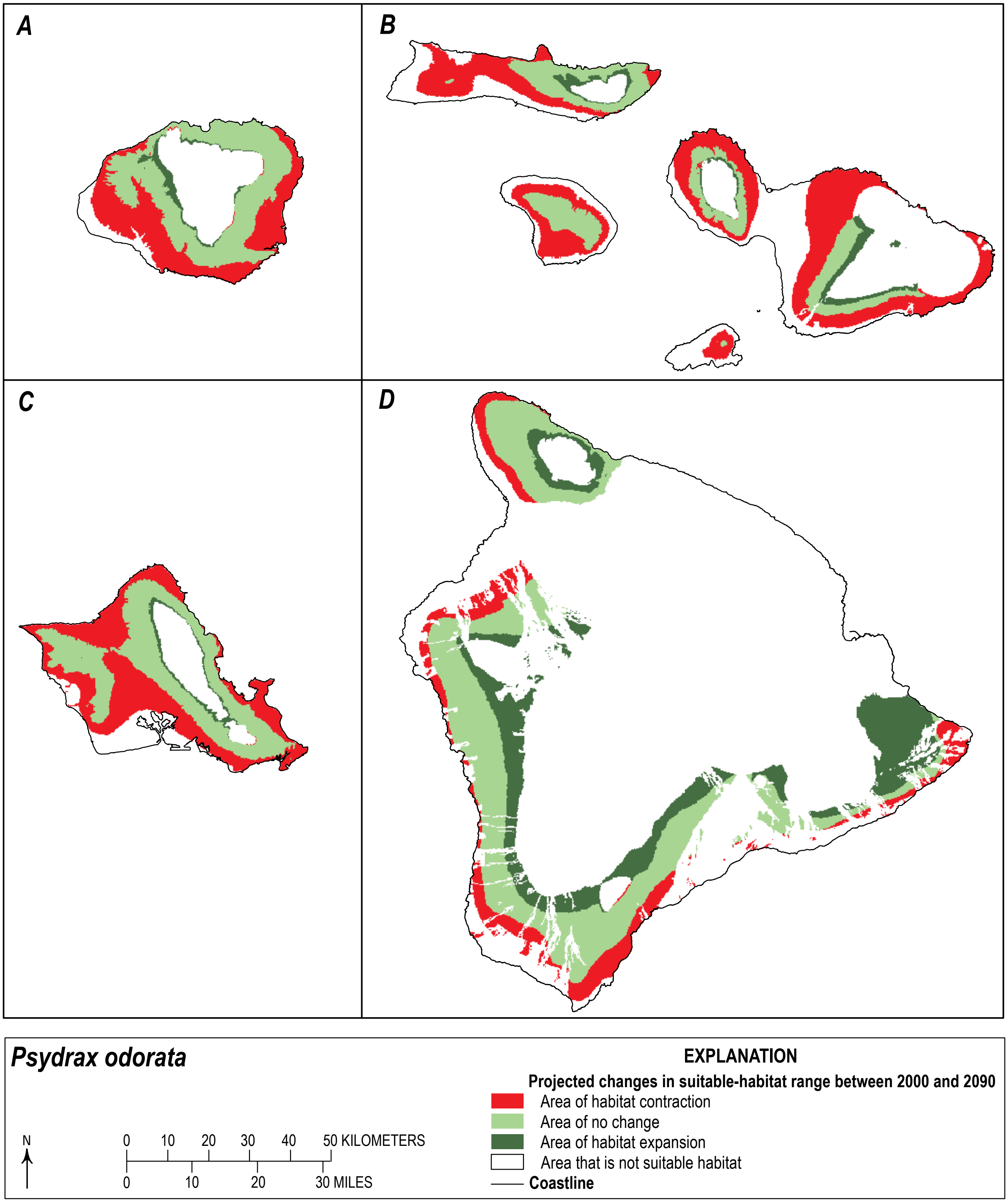
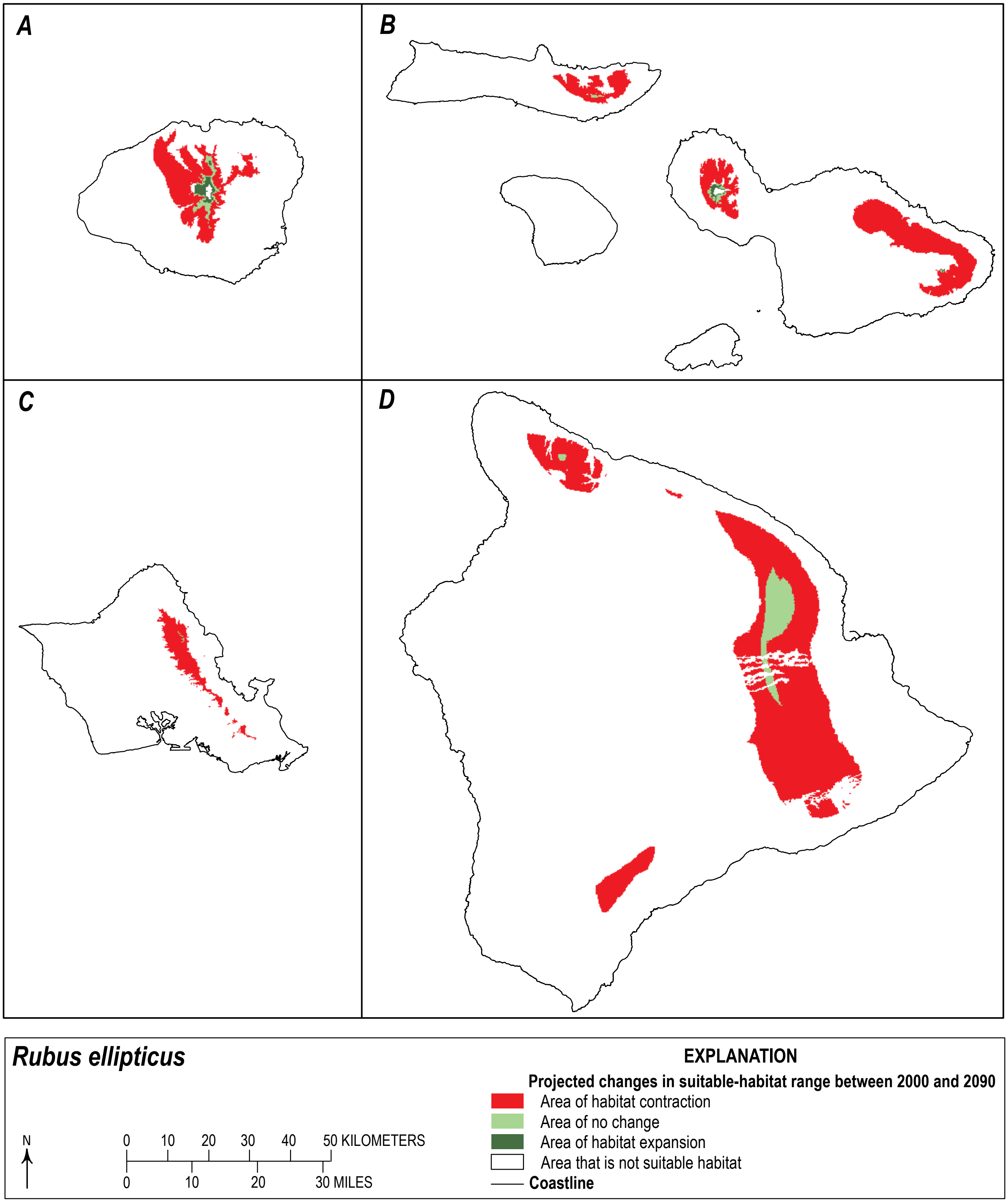
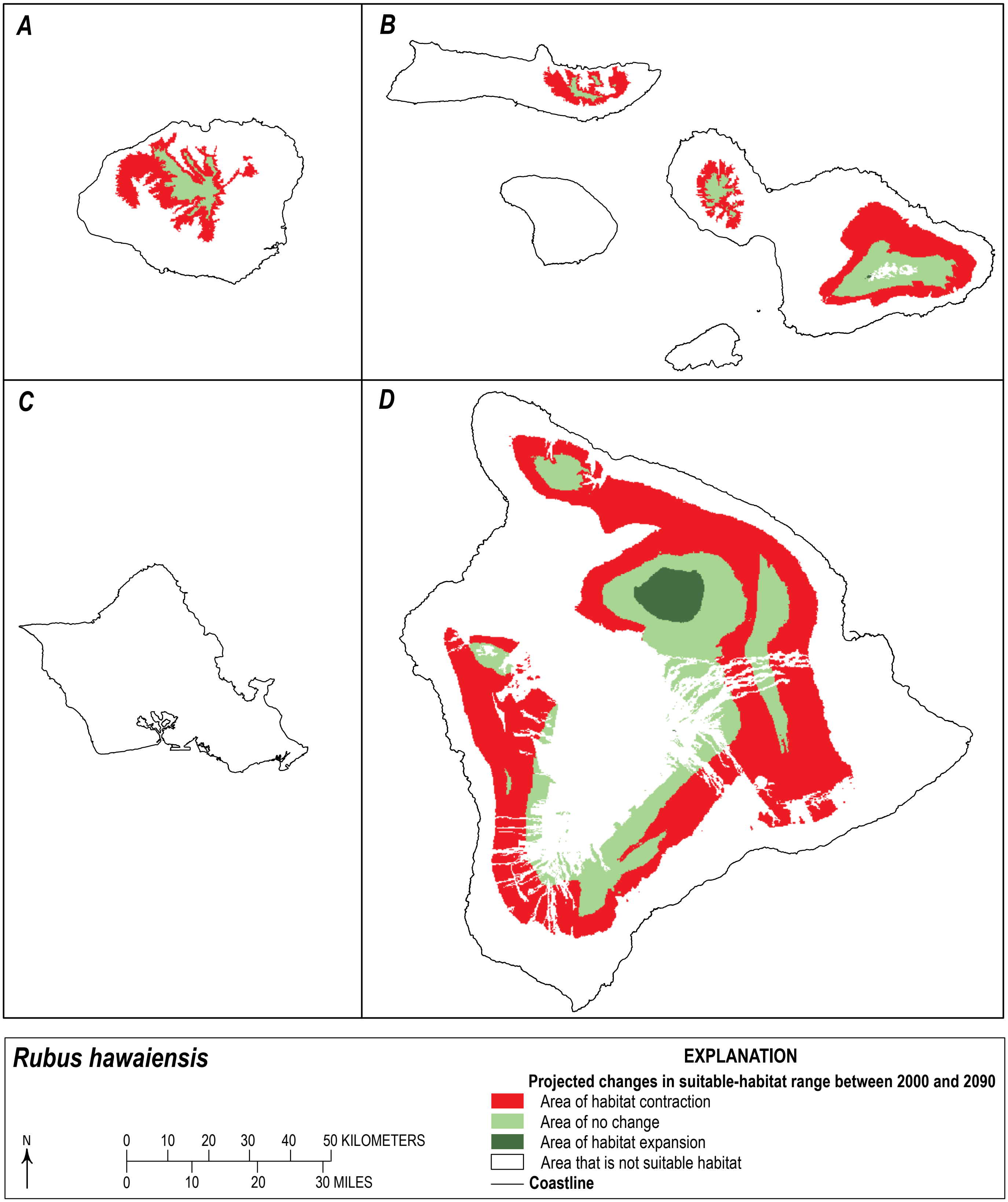
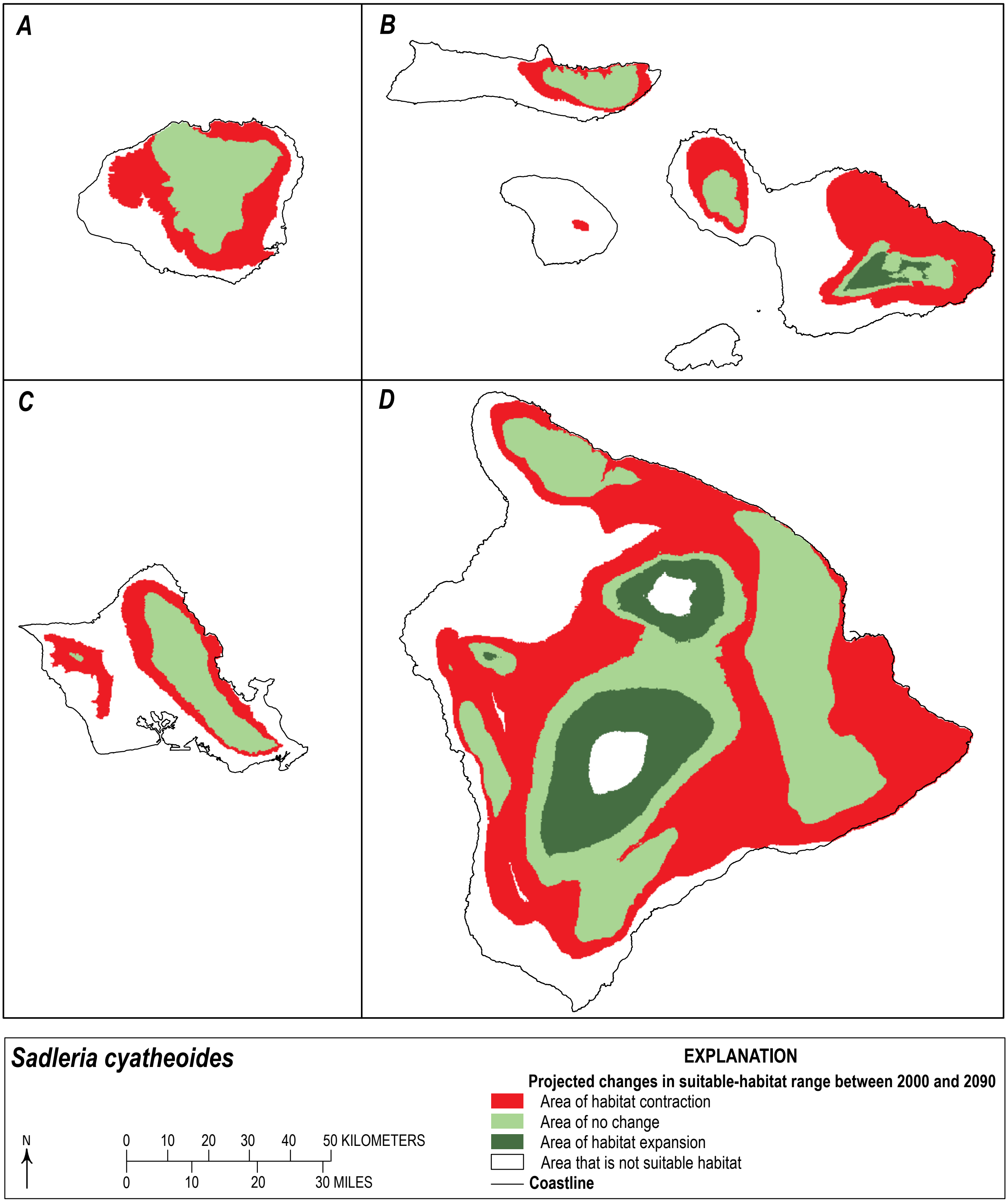
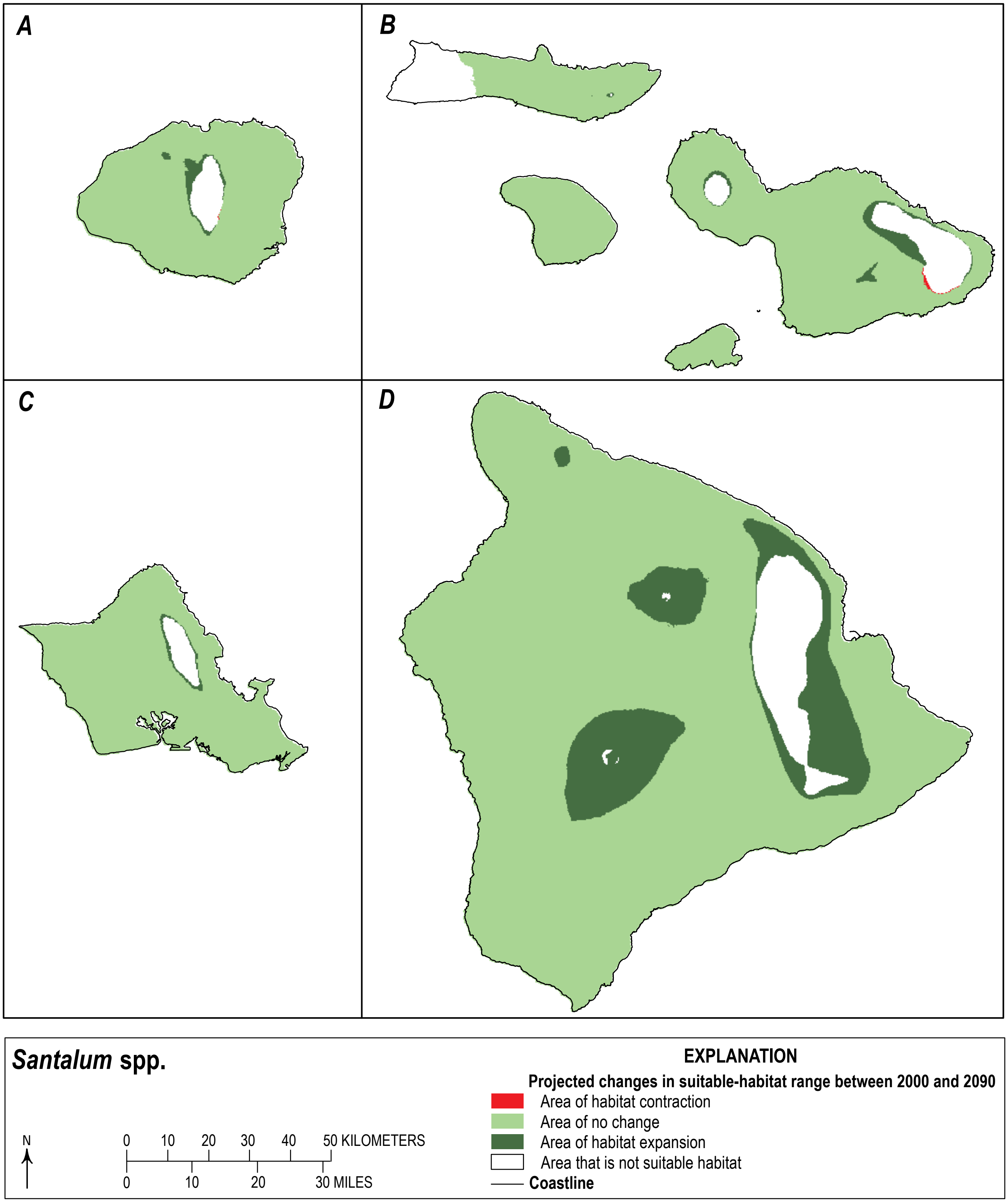
D
Psychotria hawaiiensis
N
0
10
20
30
40
50 KILOMETERS
0
10
20
30 MILES
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline

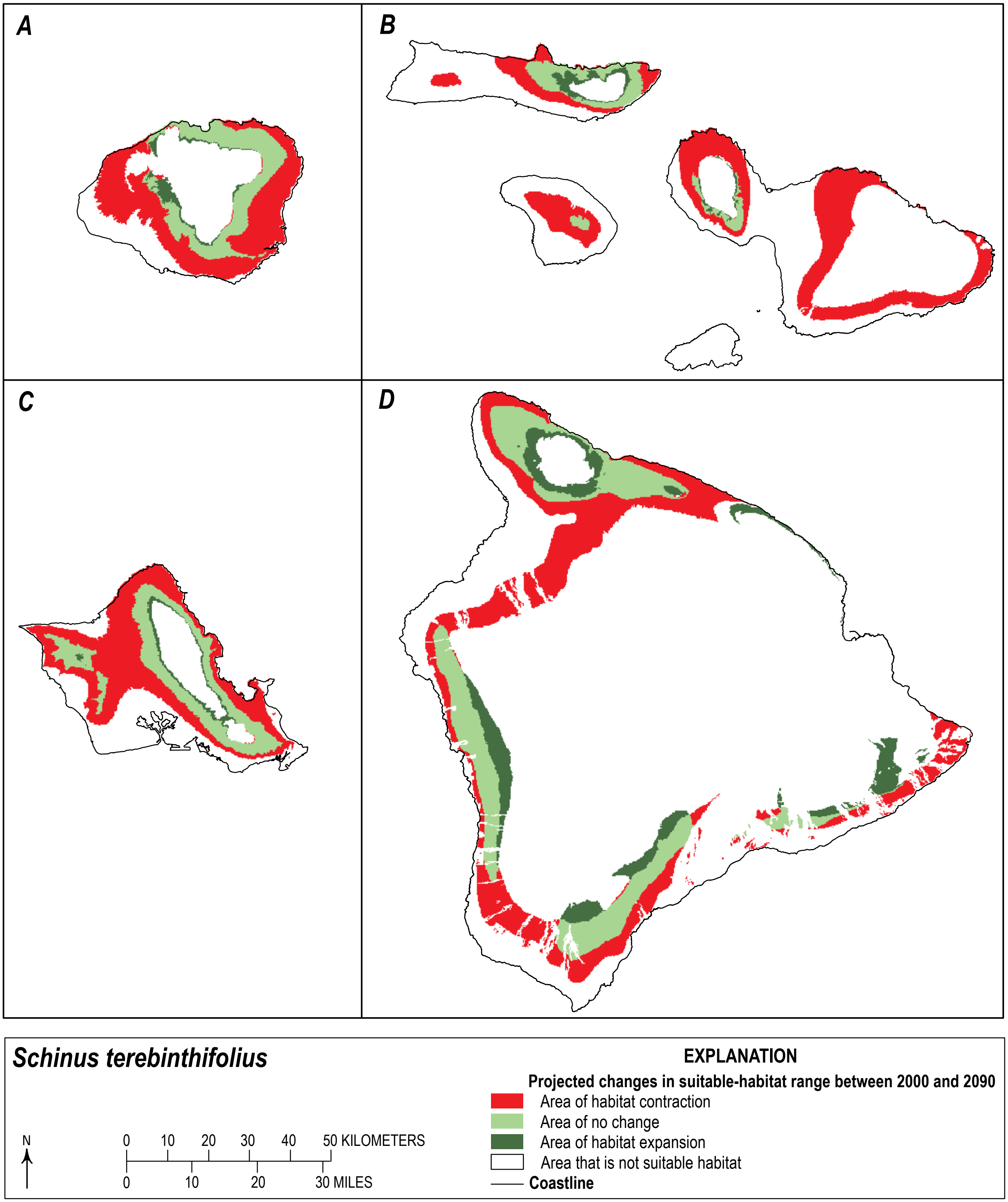

A
B
C
D
Psydrax odorata
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline

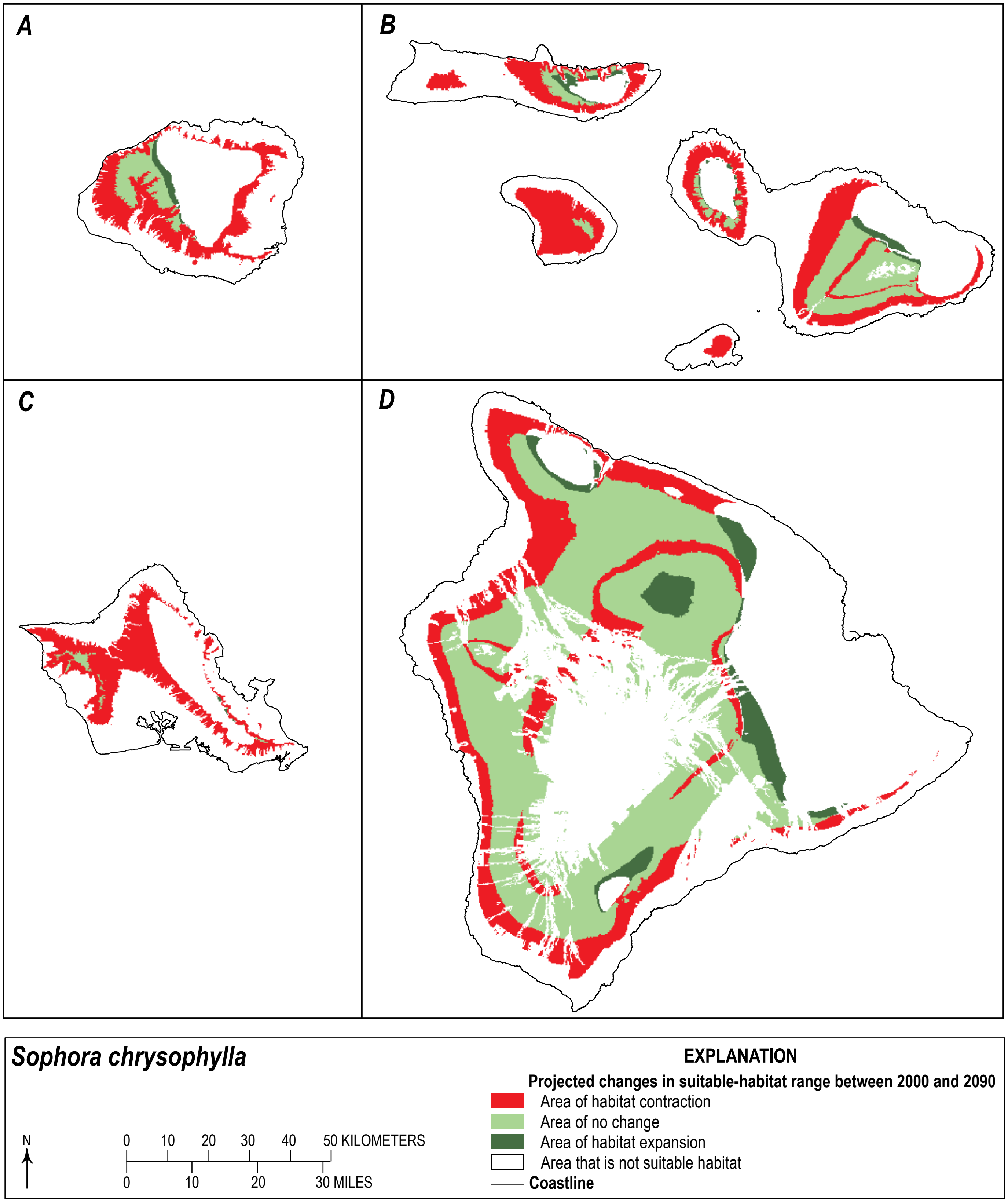

A
B
C
D
Rubus ellipticus
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

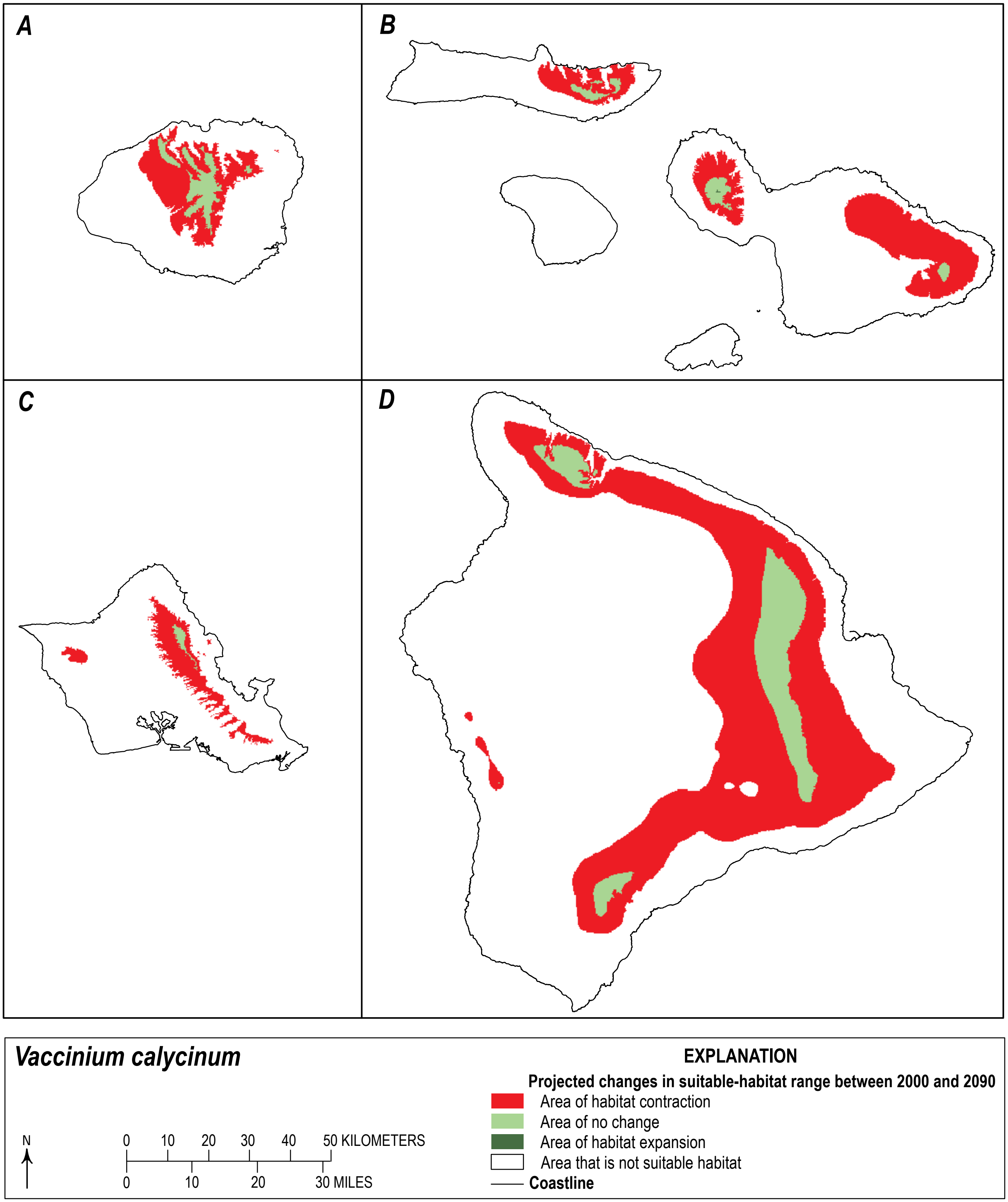

A
B
C
D
Rubus hawaiensis
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

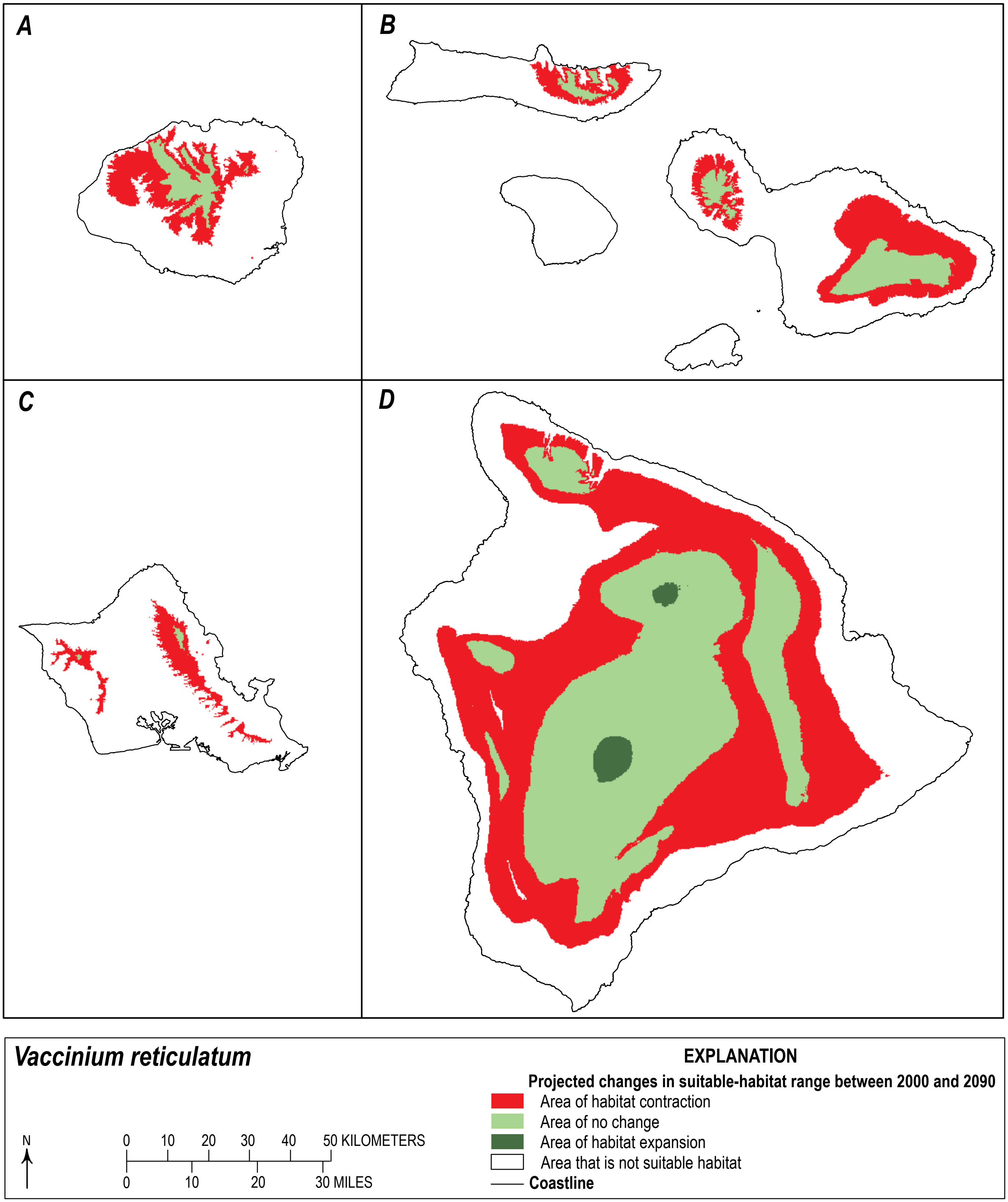

A
B
C
D
Sadleria cyatheoides
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Santalum spp.
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline


A
B
C
D
Schinus terebinthifolius
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A
B
C
D
Sophora chrysophylla
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

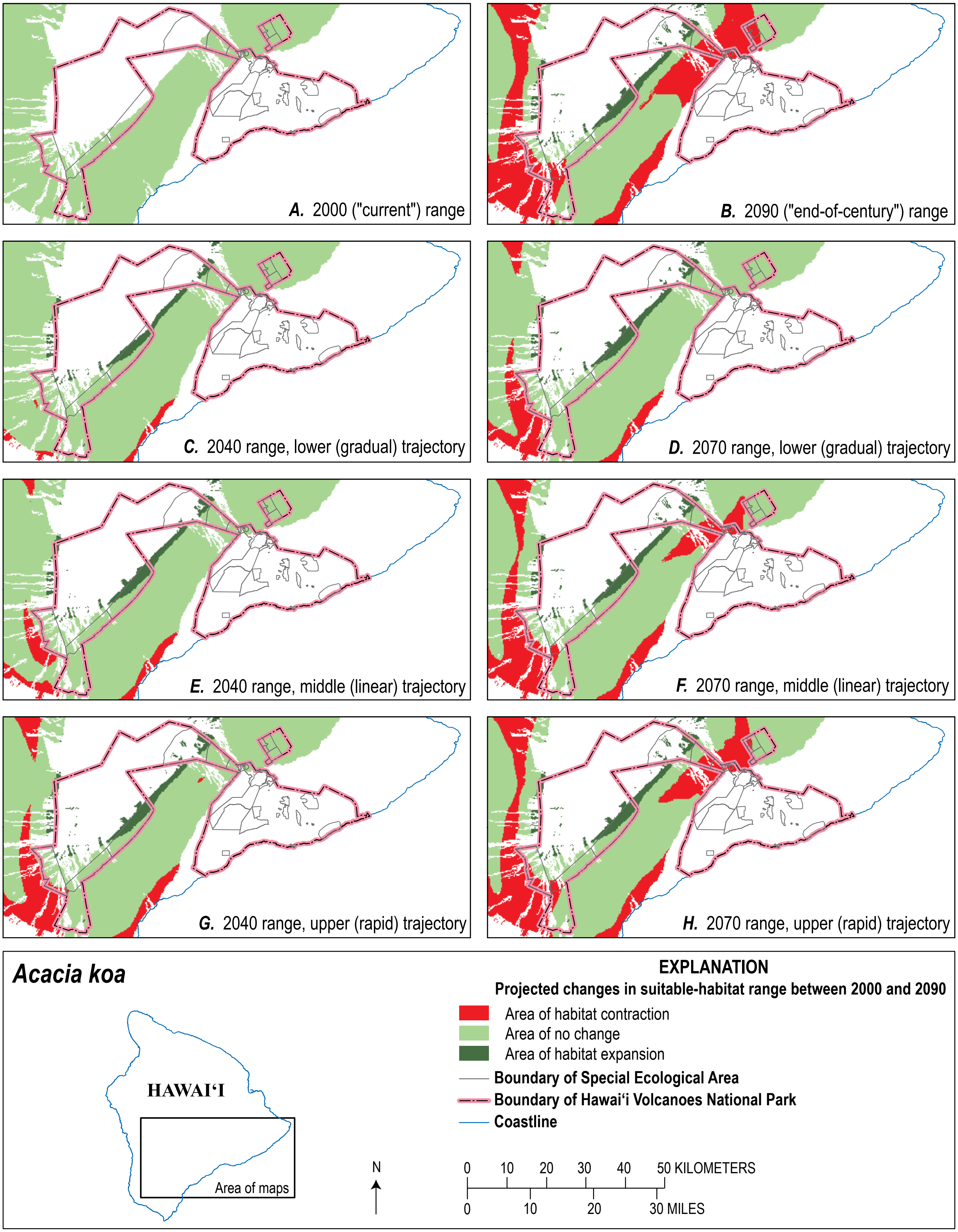

A
B
C
D
Vaccinium calycinum
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

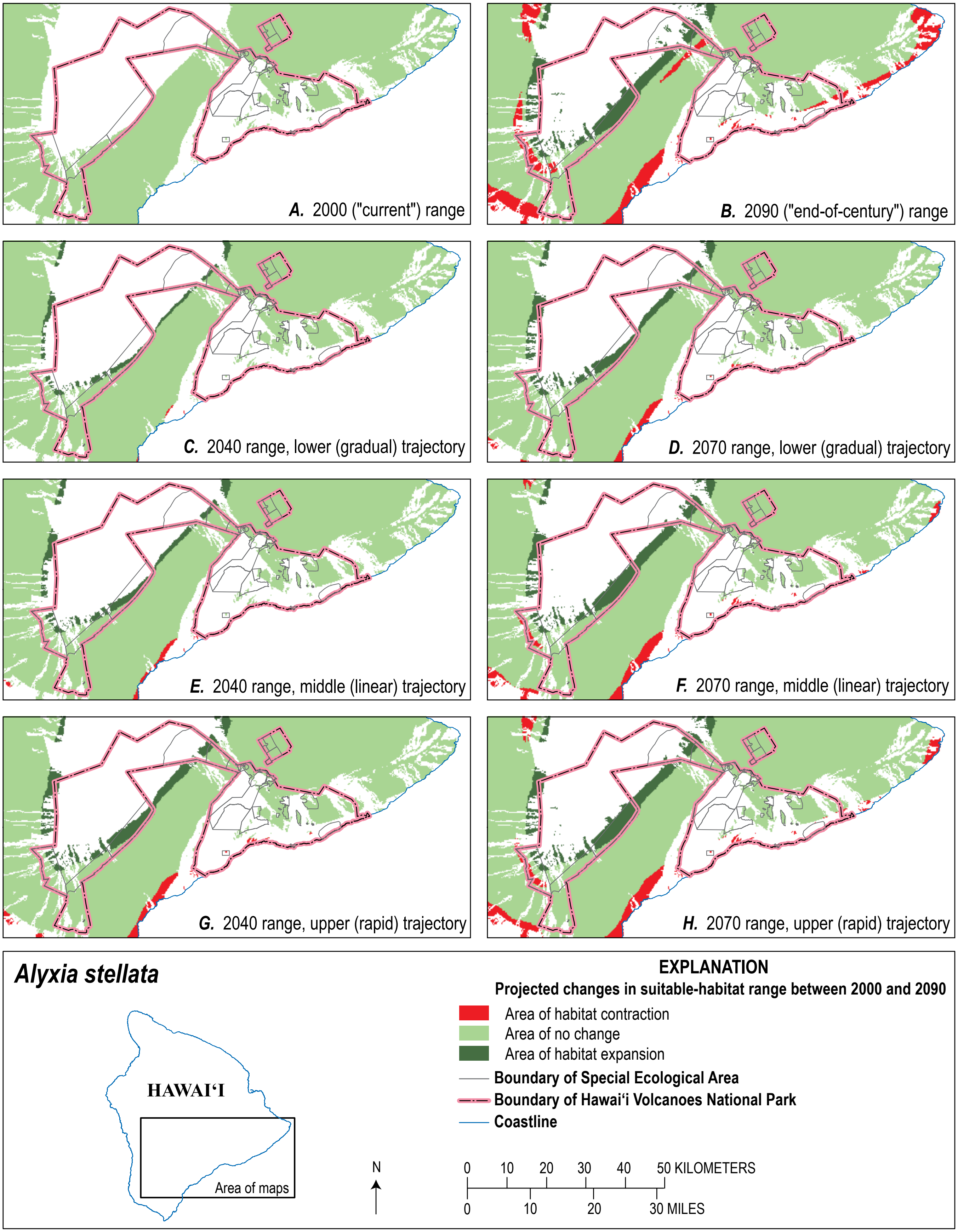

A
B
C
D
Vaccinium reticulatum
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Area that is not suitable habitat
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES

Appendix 3. Patterns of change in suitable-habitat range, from “current” (2000) to “end-of-century” (2090), for 39 focal native and alien (nonnative) plant species in and around Special Ecological Areas (SEAs) within Hawai‘i Volcanoes National Park (HAVO), as projected during several time periods and using multiple (lower [gradual], middle [linear], upper [rapid]) climate-change trajectories

[Areas that lack color indicate unsuitable habitat in all projected trajectories in every time period. Special Ecological Area (SEA) boundaries (as of 2015; D. Benitez, unpub. data, 2015) and Hawai‘i Volcanoes National Park (HAVO) boundary from National Park Service’s National Geospatial Data Asset (National Park Service, unpub. data, 2014). Coastline from U.S. Geological Survey’s National Elevation Dataset (U.S. Geological Survey, 2014), World Geodetic System 1984 (WGS84)]

Contents of Appendix 3


A. 2000 ("current") range
B. 2090 ("end-of-century") range
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Acacia koa
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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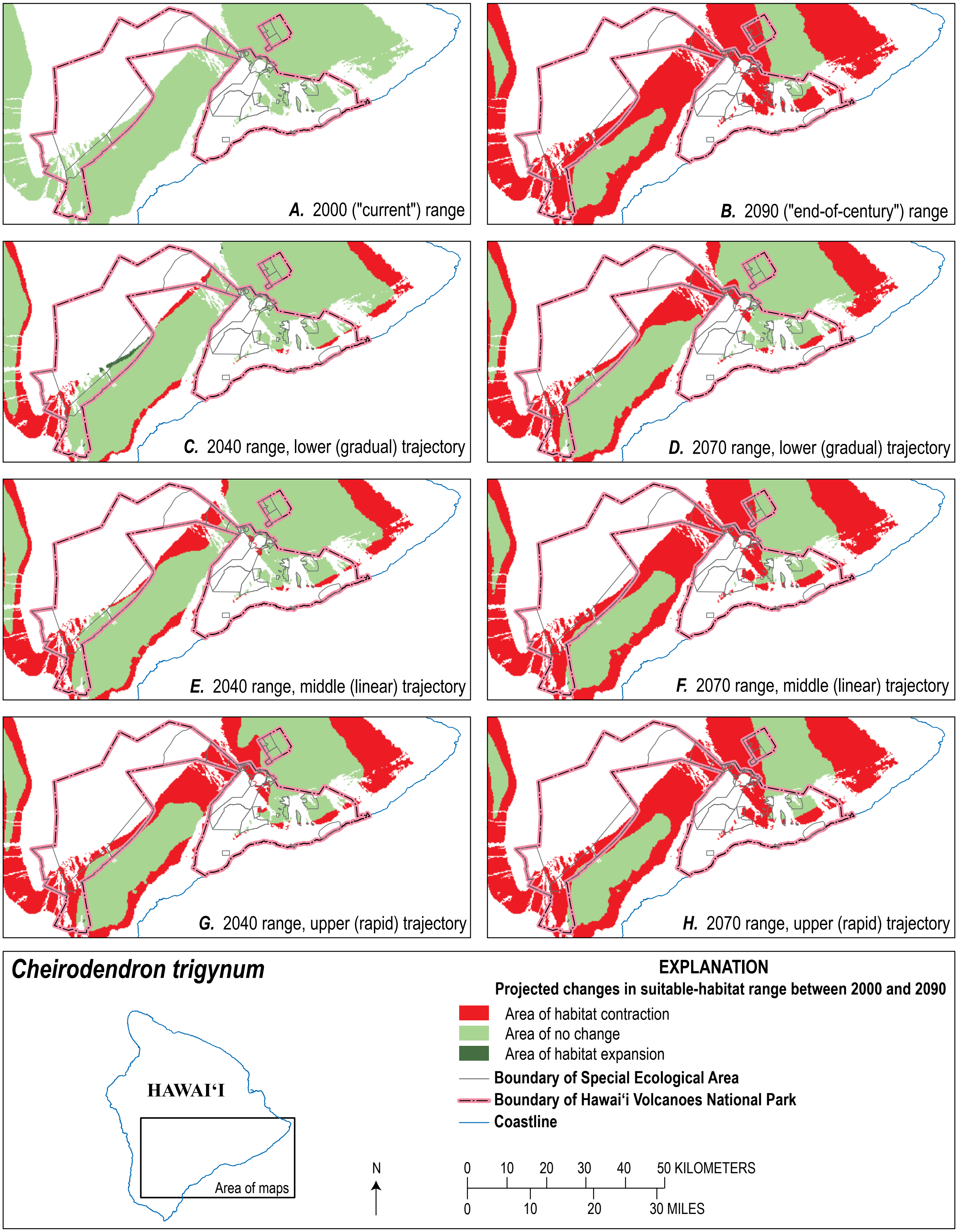
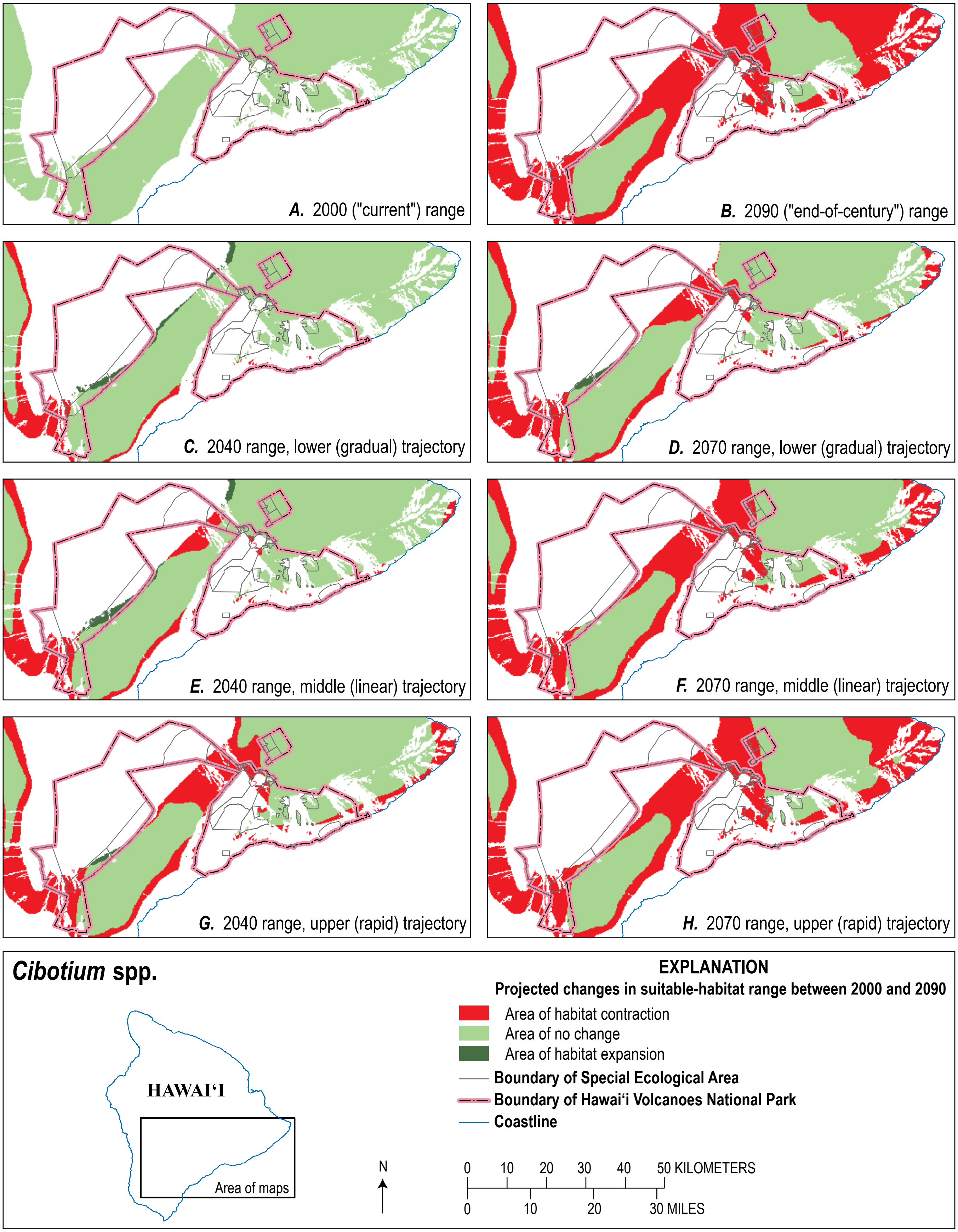
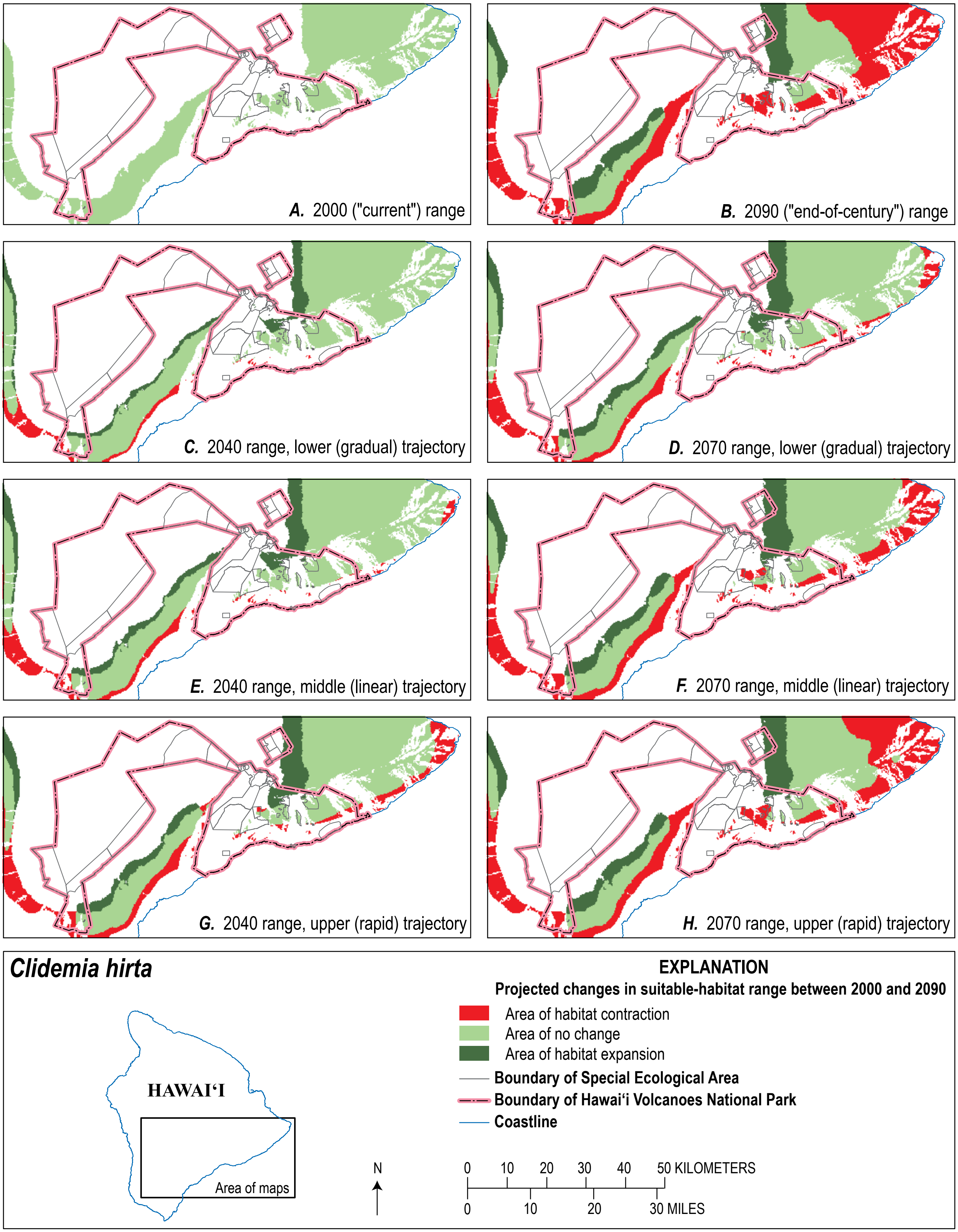
B. 2090 ("end-of-century") range
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Alyxia stellata
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A. 2000 ("current") range
B. 2090 ("end-of-century") range
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Cheirodendron trigynum
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A. 2000 ("current") range
B. 2090 ("end-of-century") range
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Cibotium spp.
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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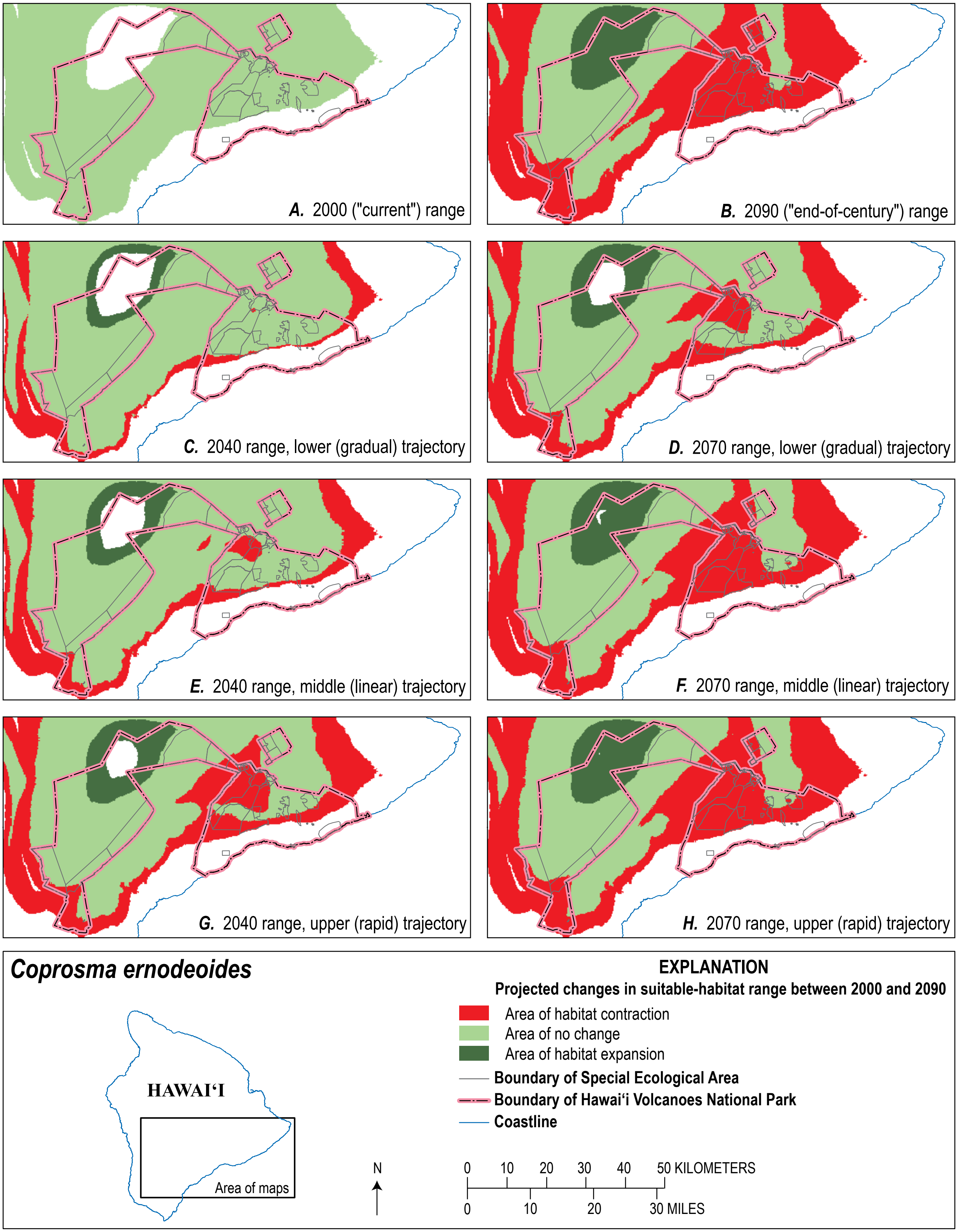
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Clidemia hirta
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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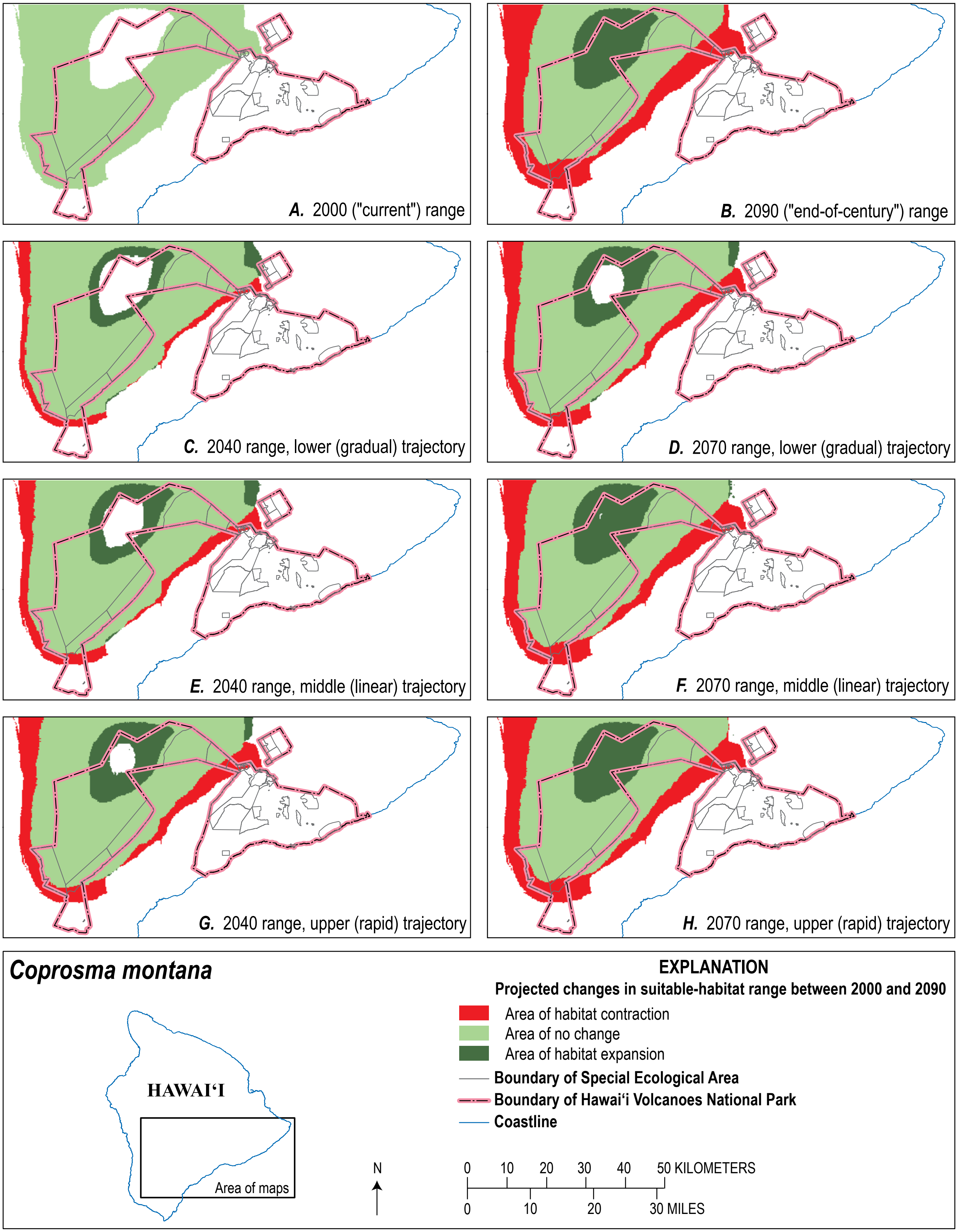
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Coprosma ernodeoides
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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B. 2090 ("end-of-century") range
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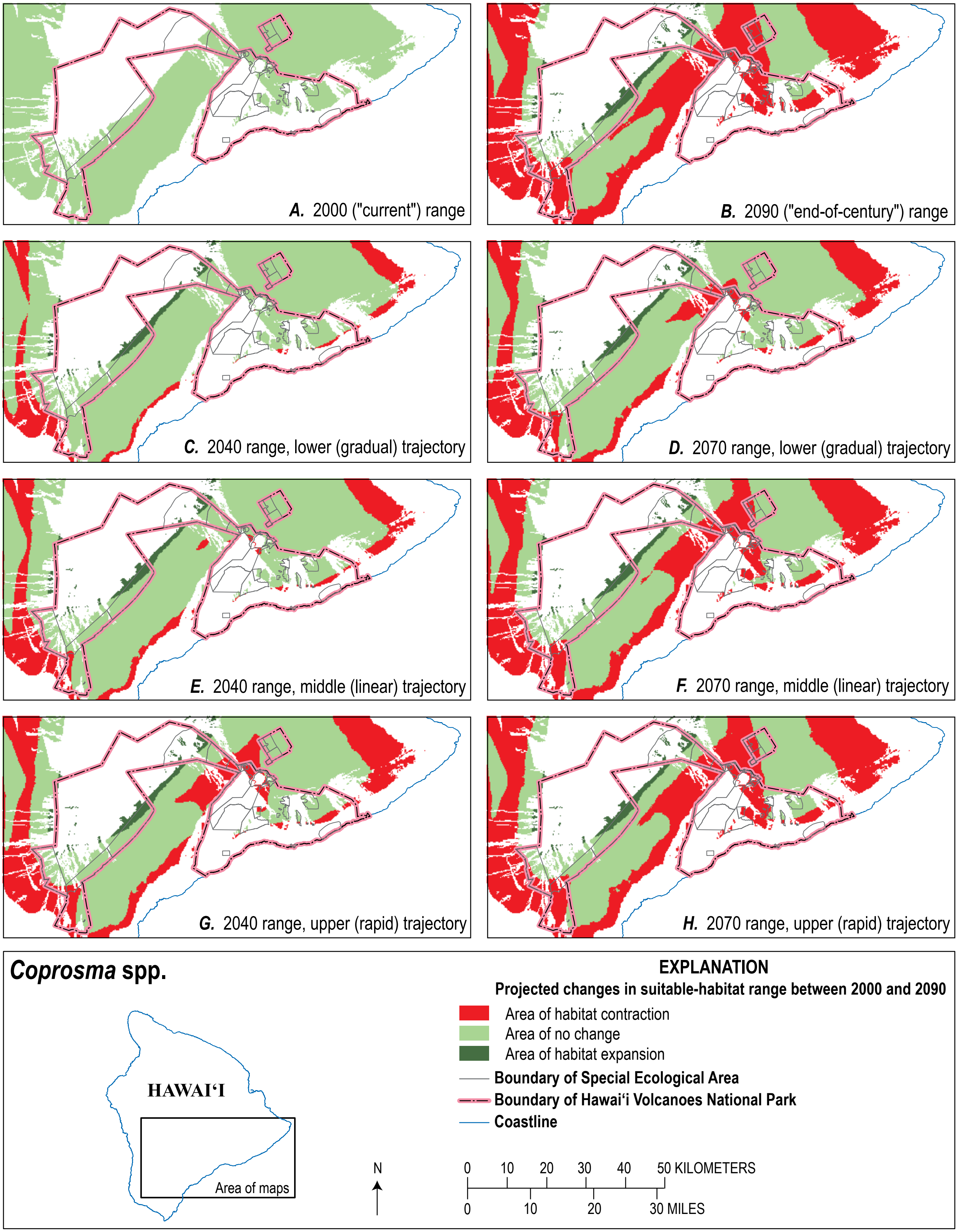
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Coprosma montana
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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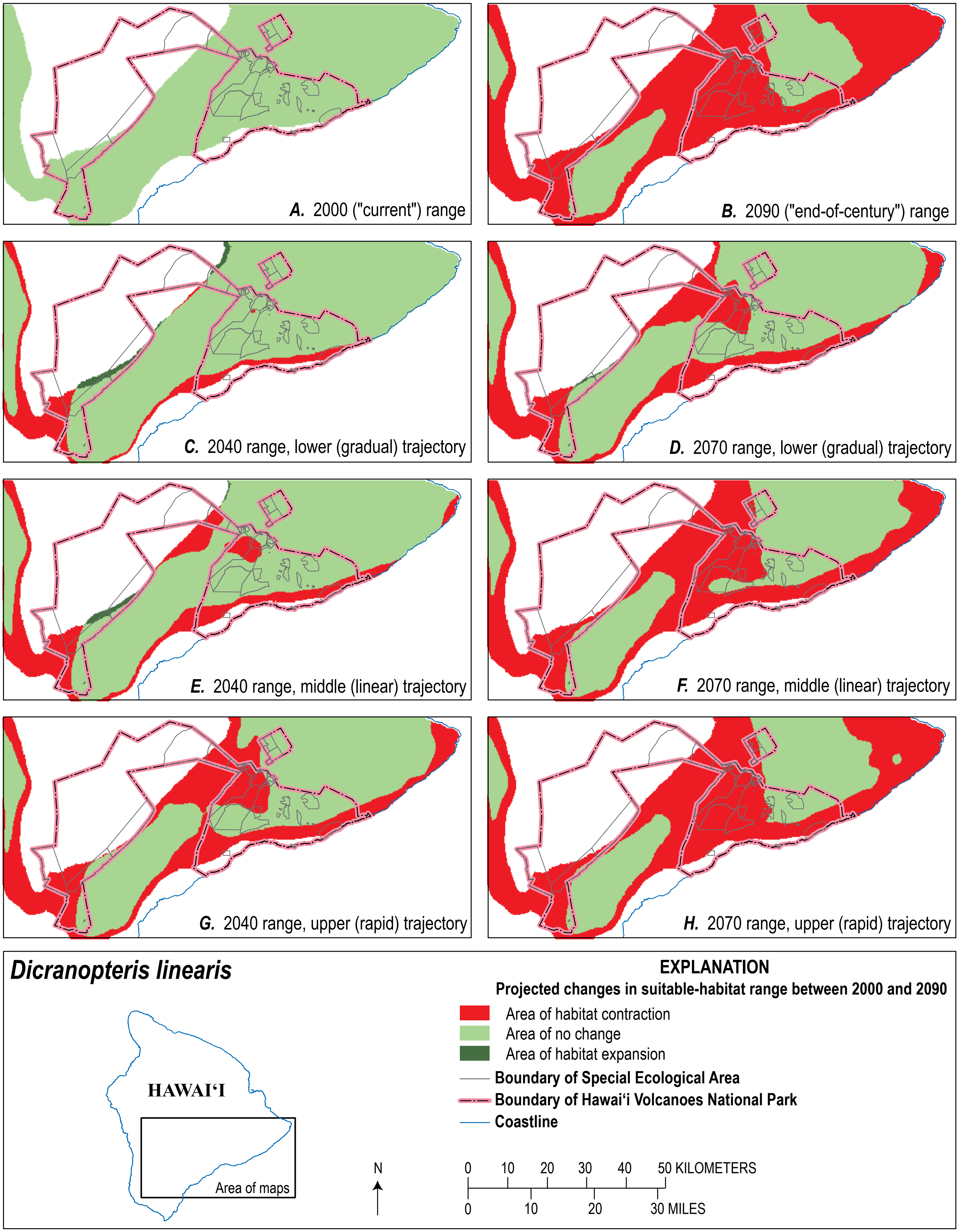
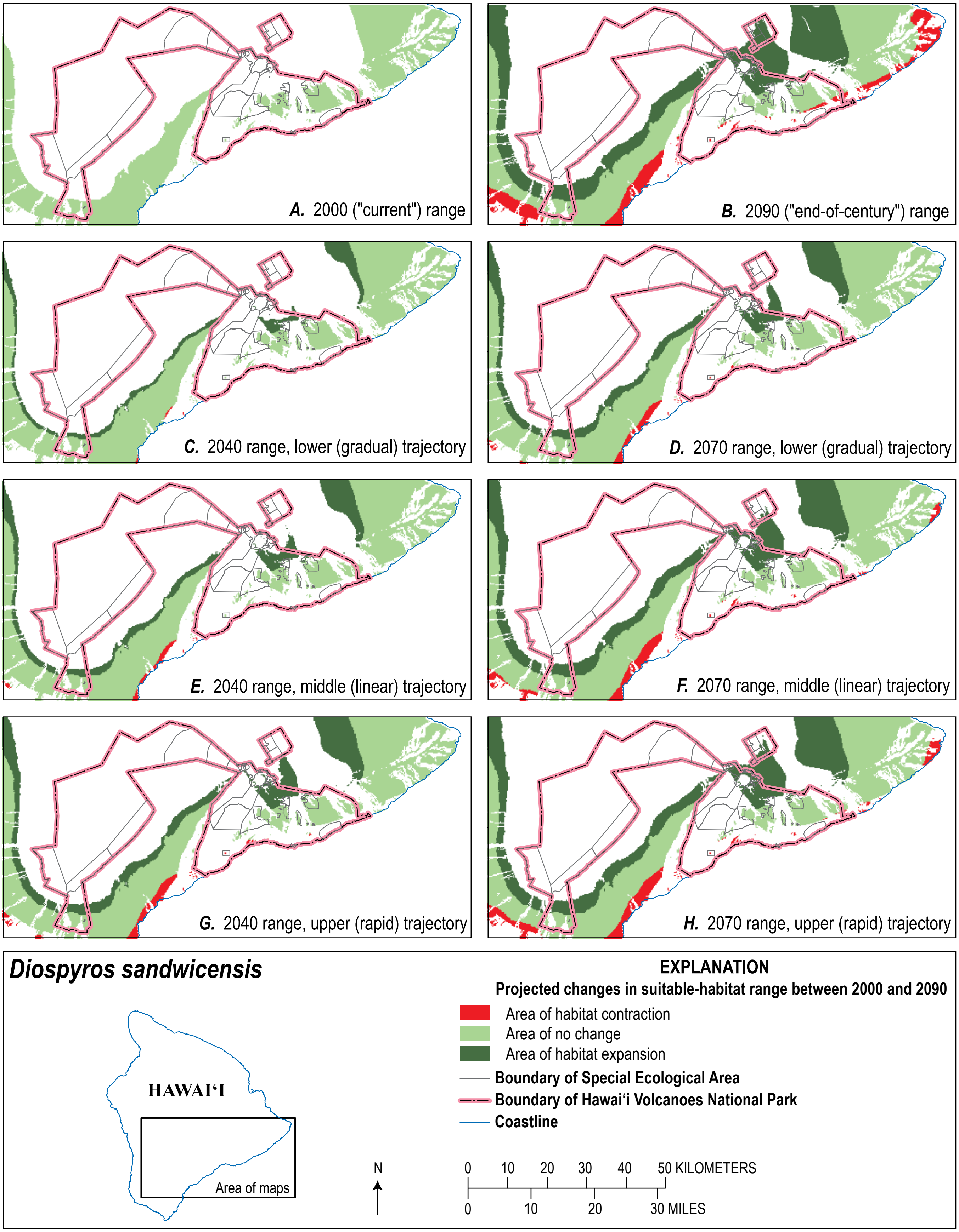
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Coprosma spp.
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A. 2000 ("current") range
B. 2090 ("end-of-century") range
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Dicranopteris linearis
HAWAI'I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai'i Volcanoes National Park
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Diospyros sandwicensis
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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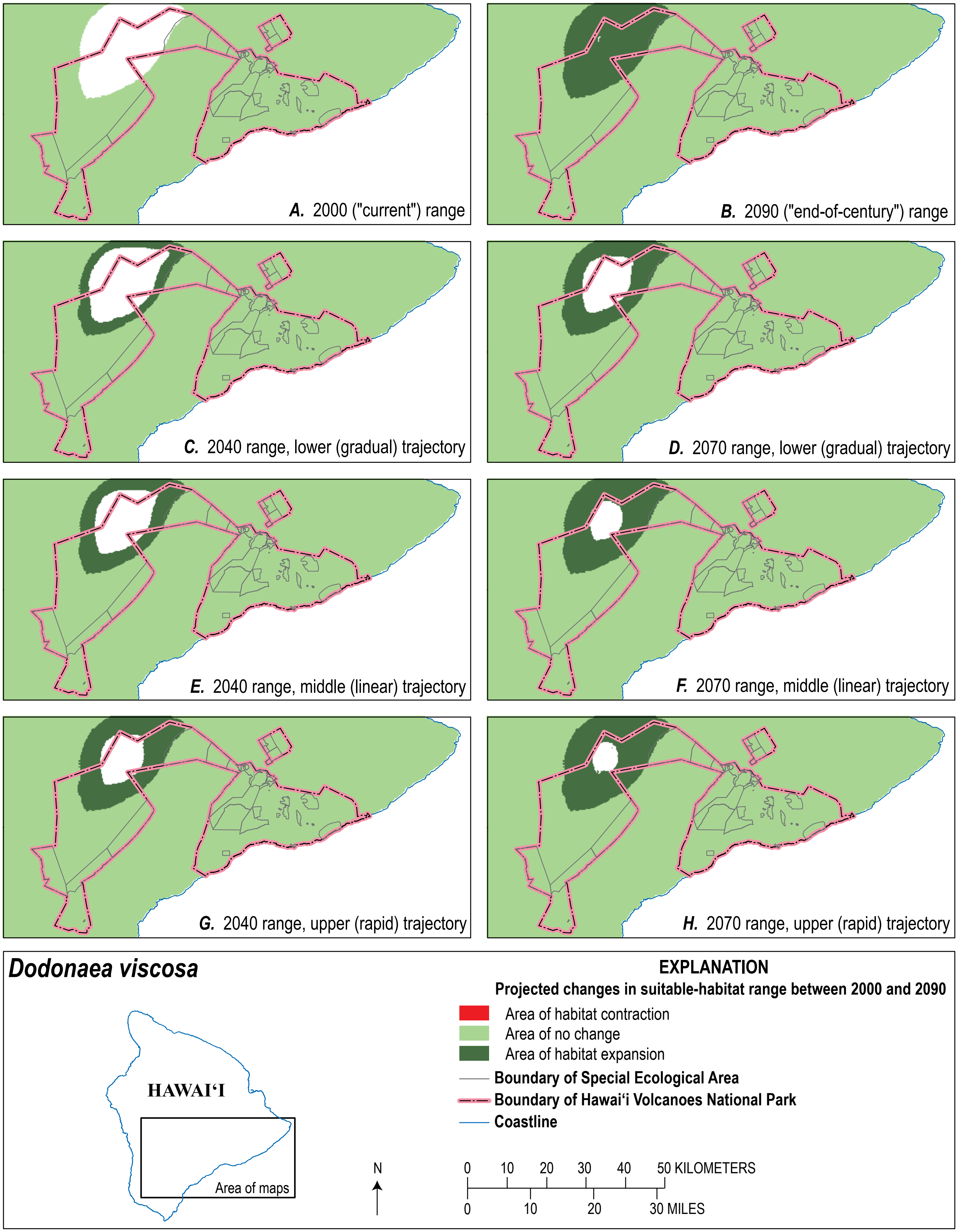
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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Dodonaea viscosa
HAWAIʻI
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawaiʻi Volcanoes National Park
Coastline
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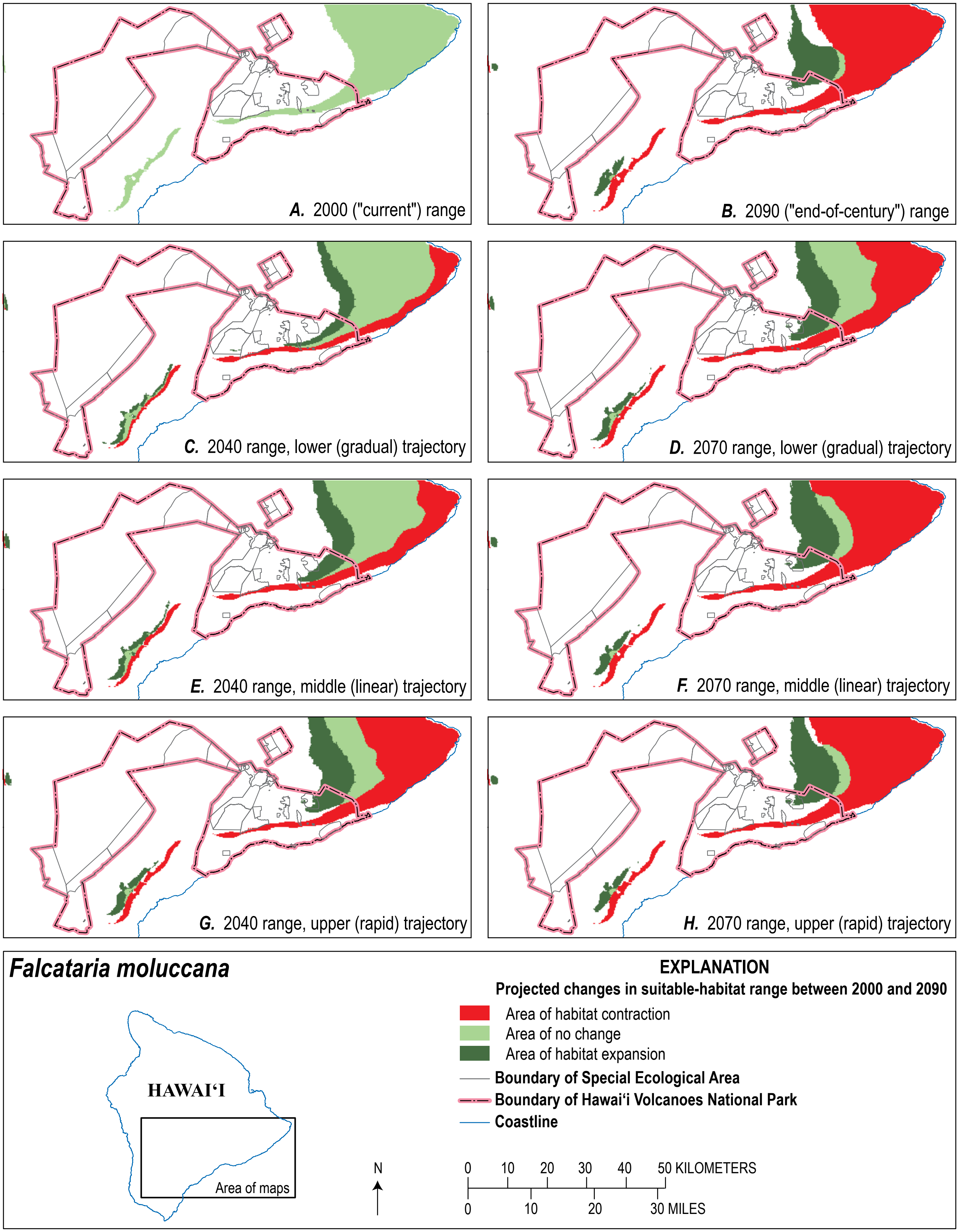
0 10 20 30 MILES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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Falcataria moluccana
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
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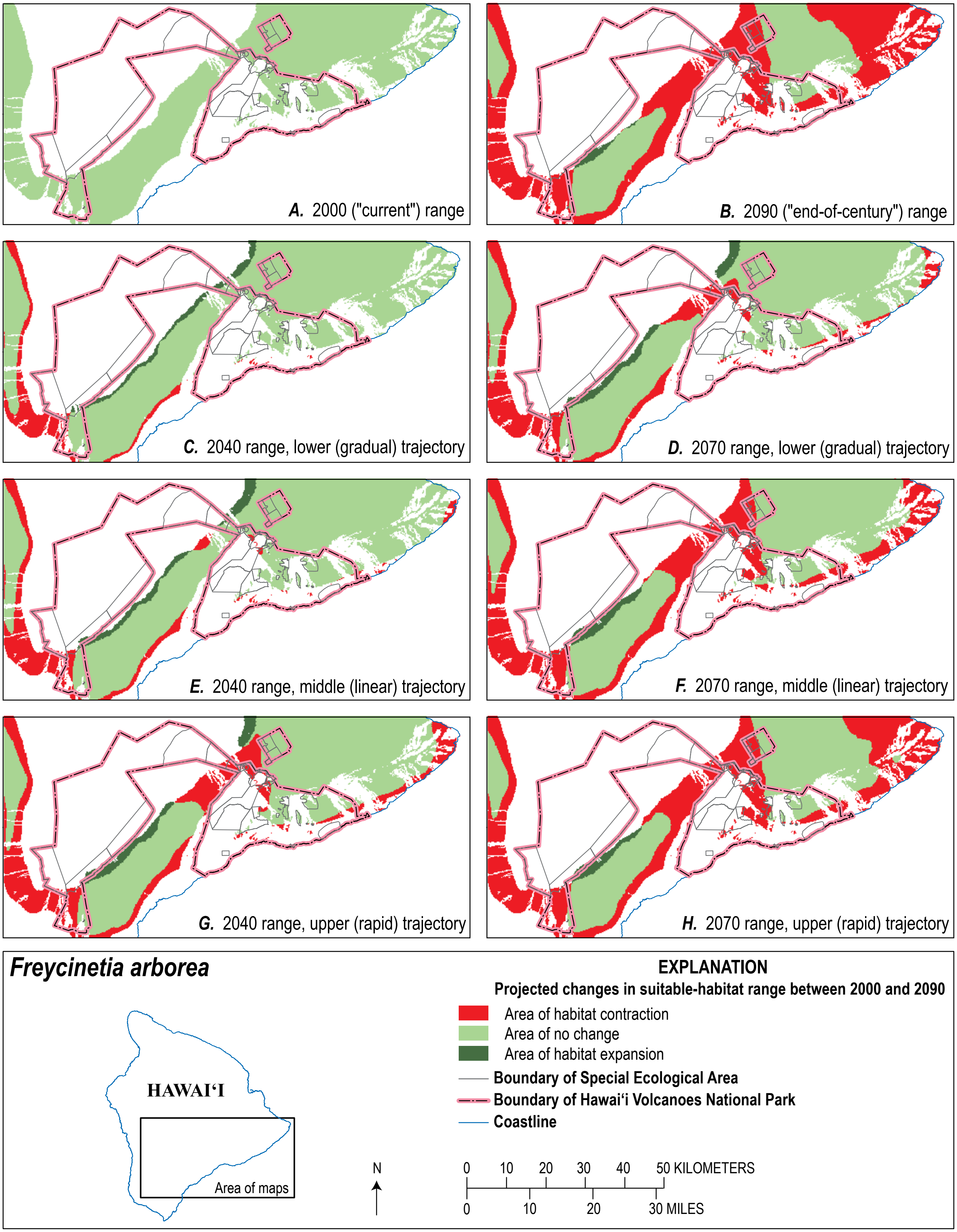
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Freycinetia arborea
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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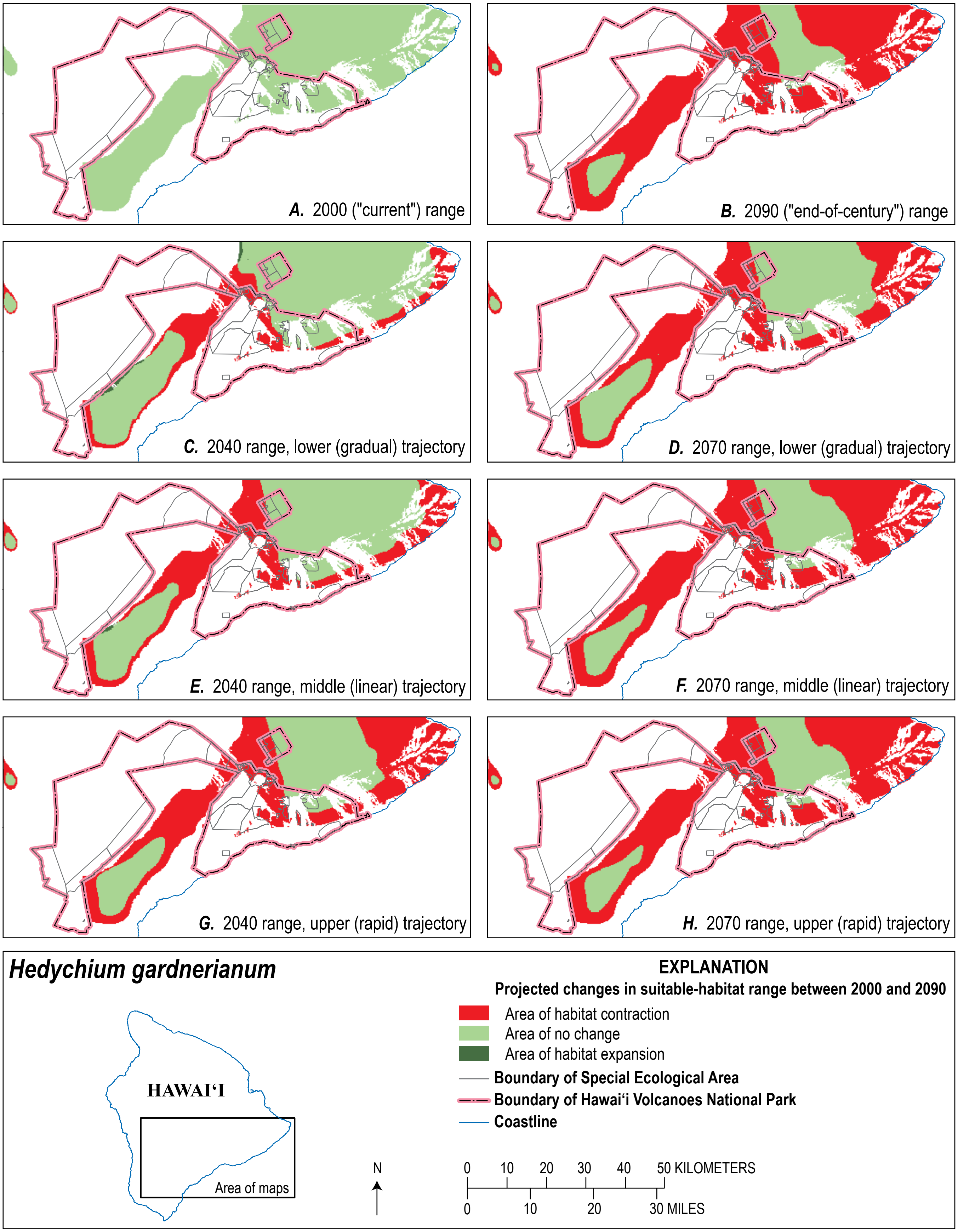
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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Hedychium gardnerianum
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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50 KILOMETERS
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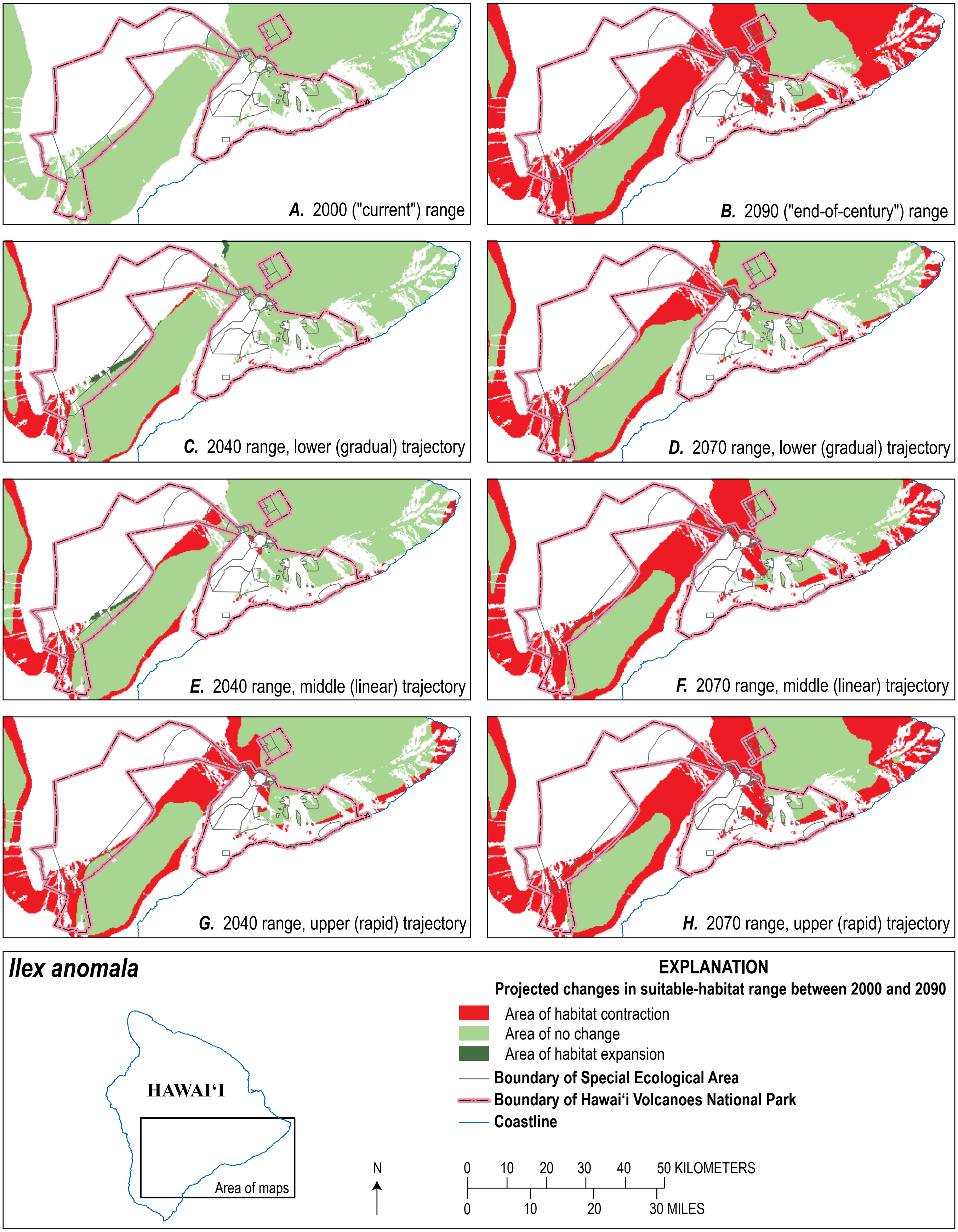
30 MILES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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Ilex anomala
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
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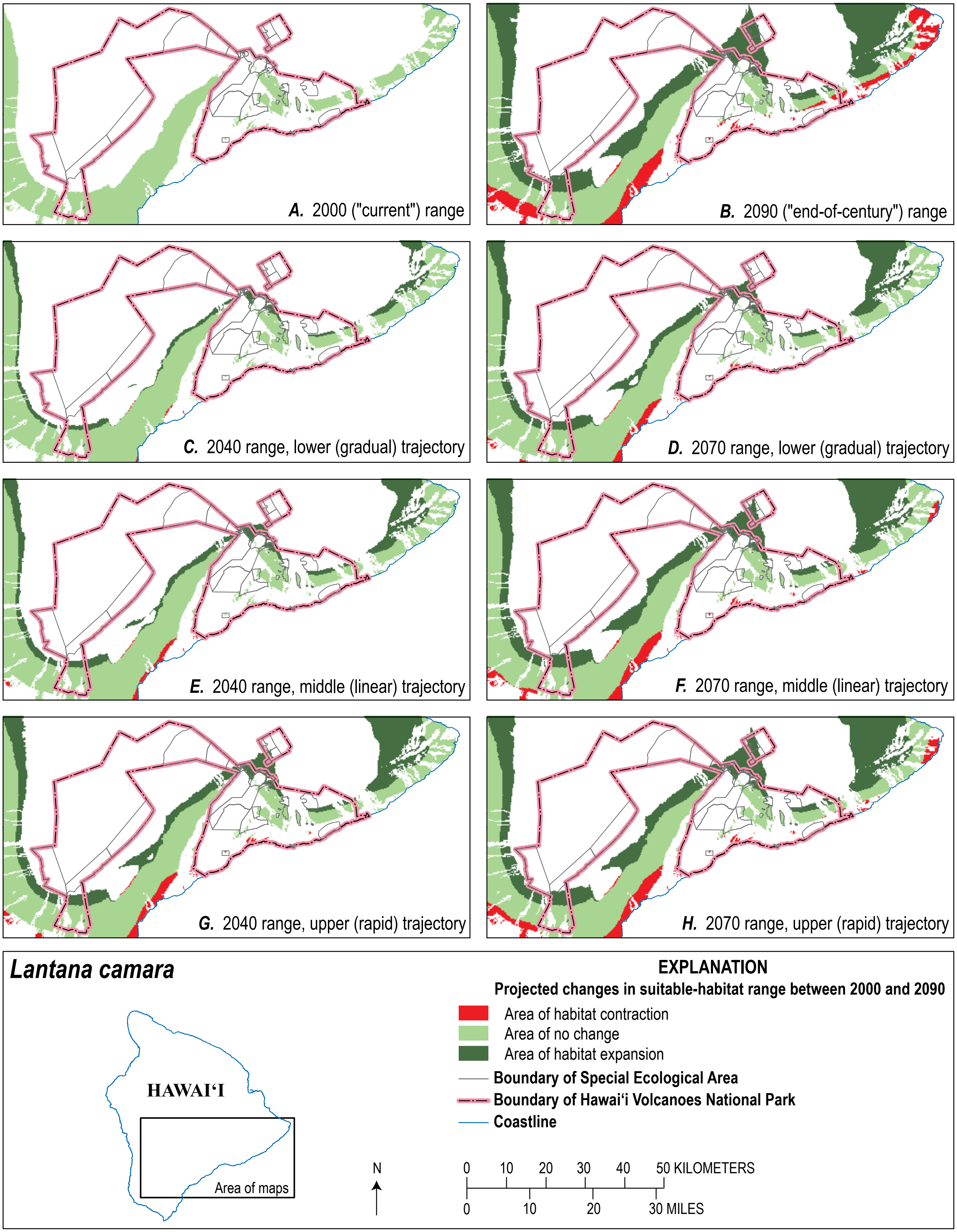
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Lantana camara
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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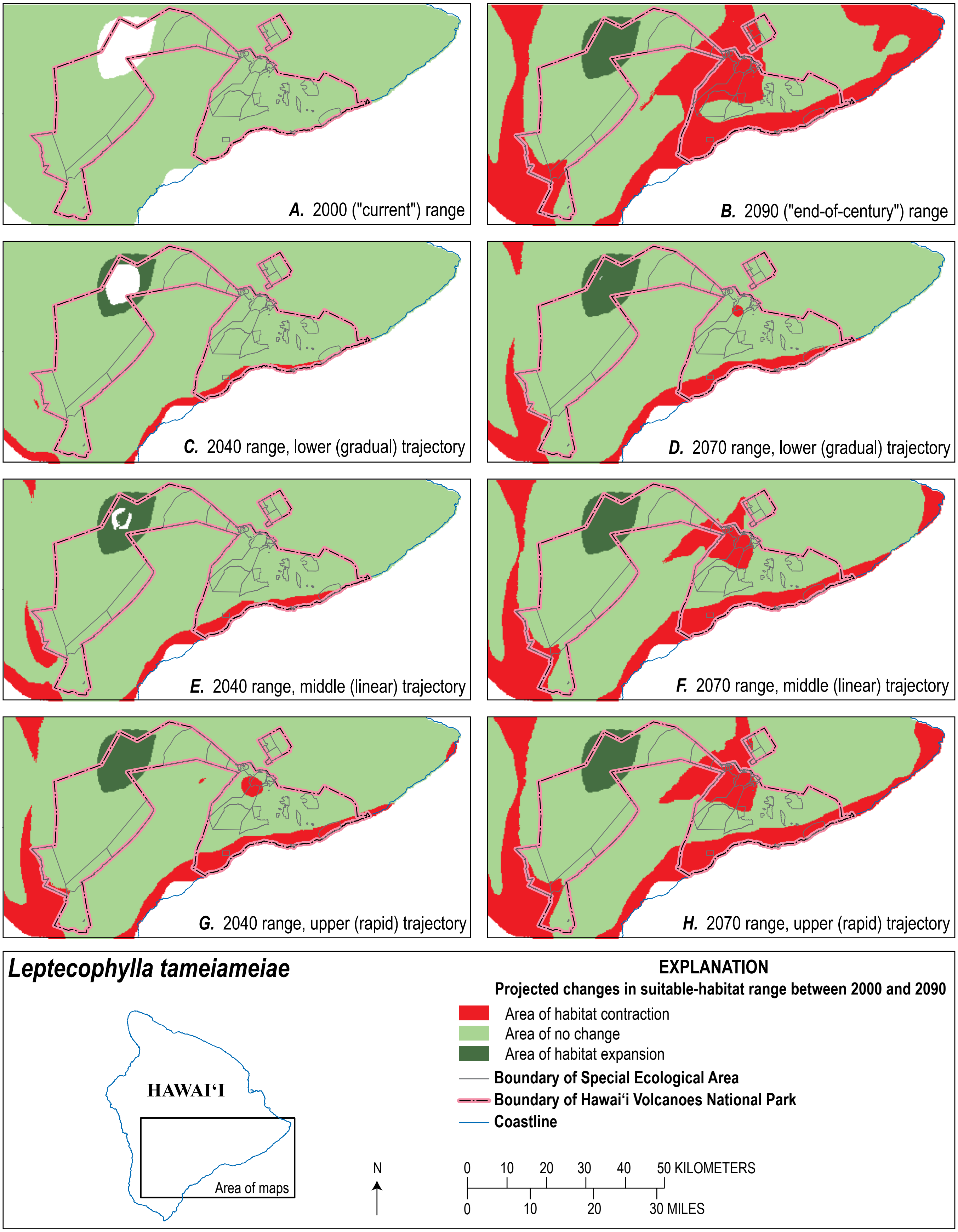

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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Leptecophylla tameiameiae
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
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Boundary of Special Ecological Area
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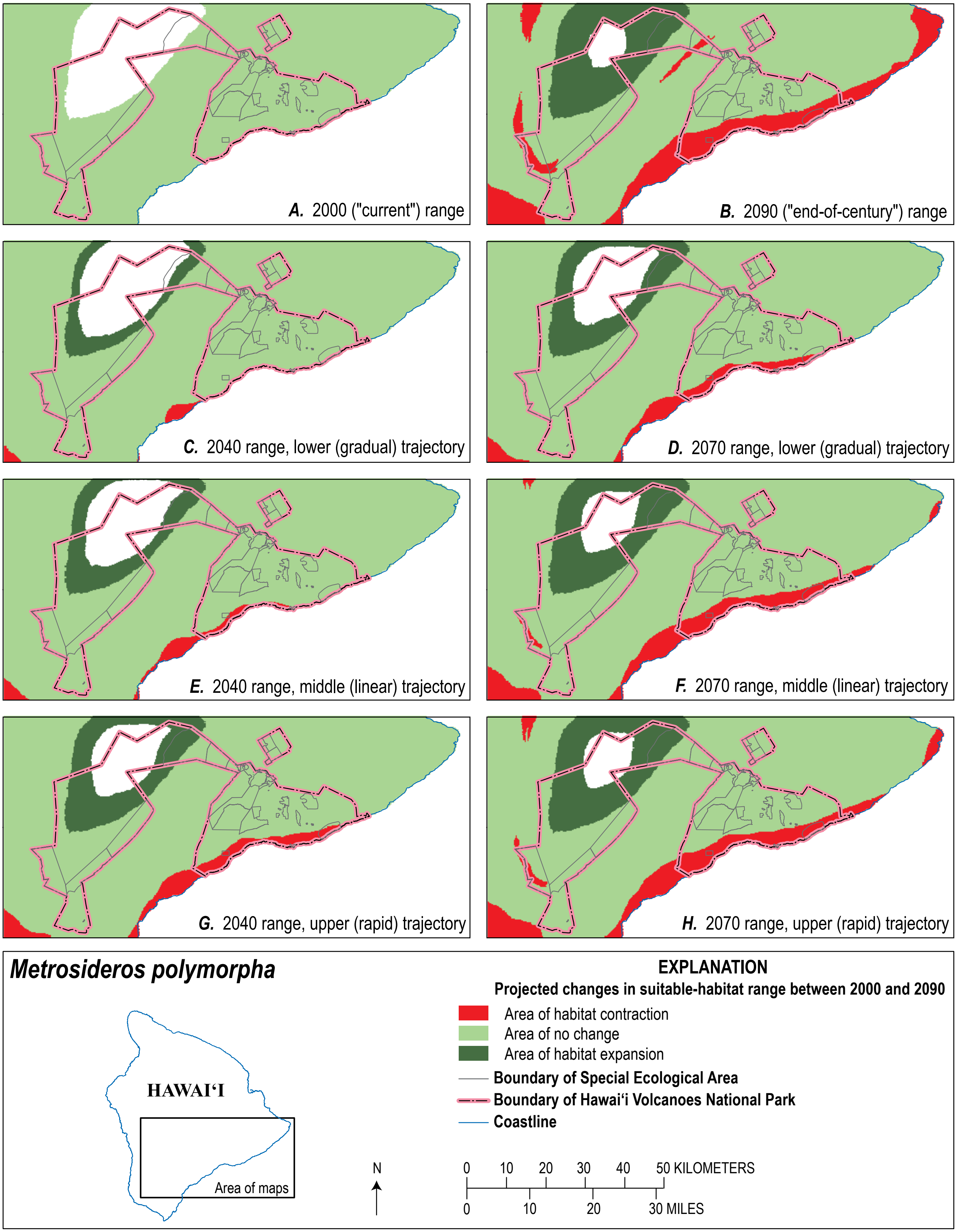
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Metrosideros polymorpha
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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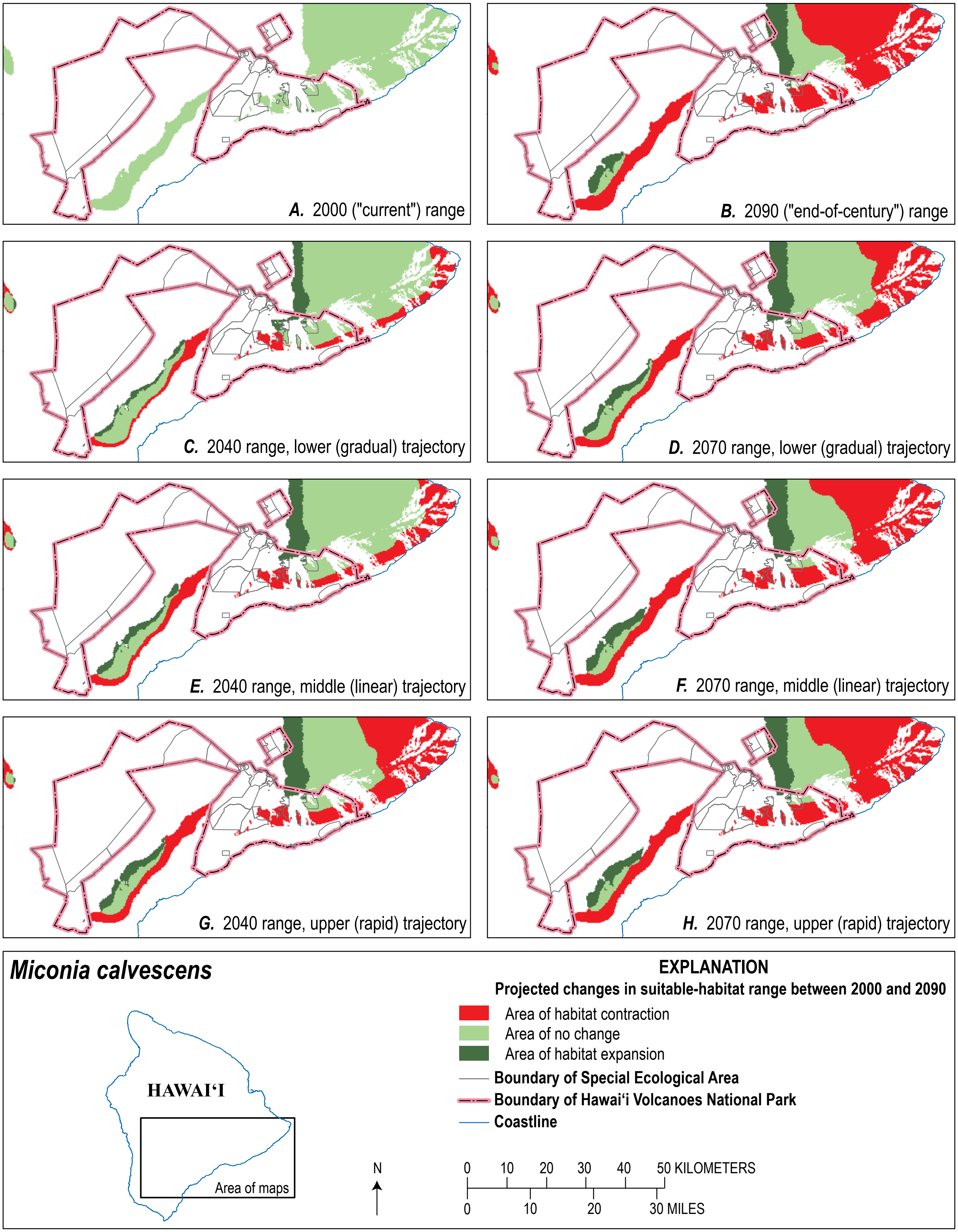
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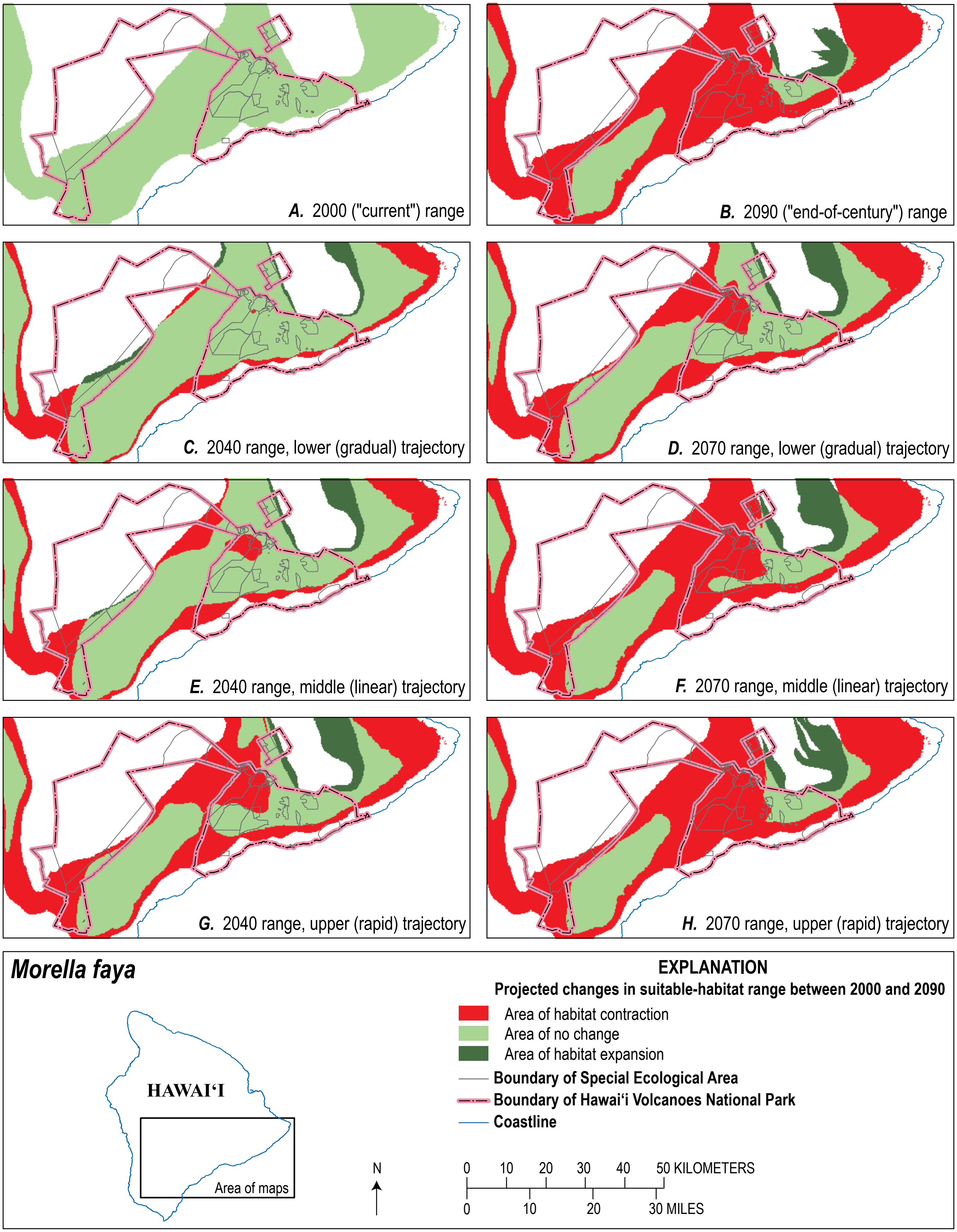
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Miconia calvescens
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Morella faya
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
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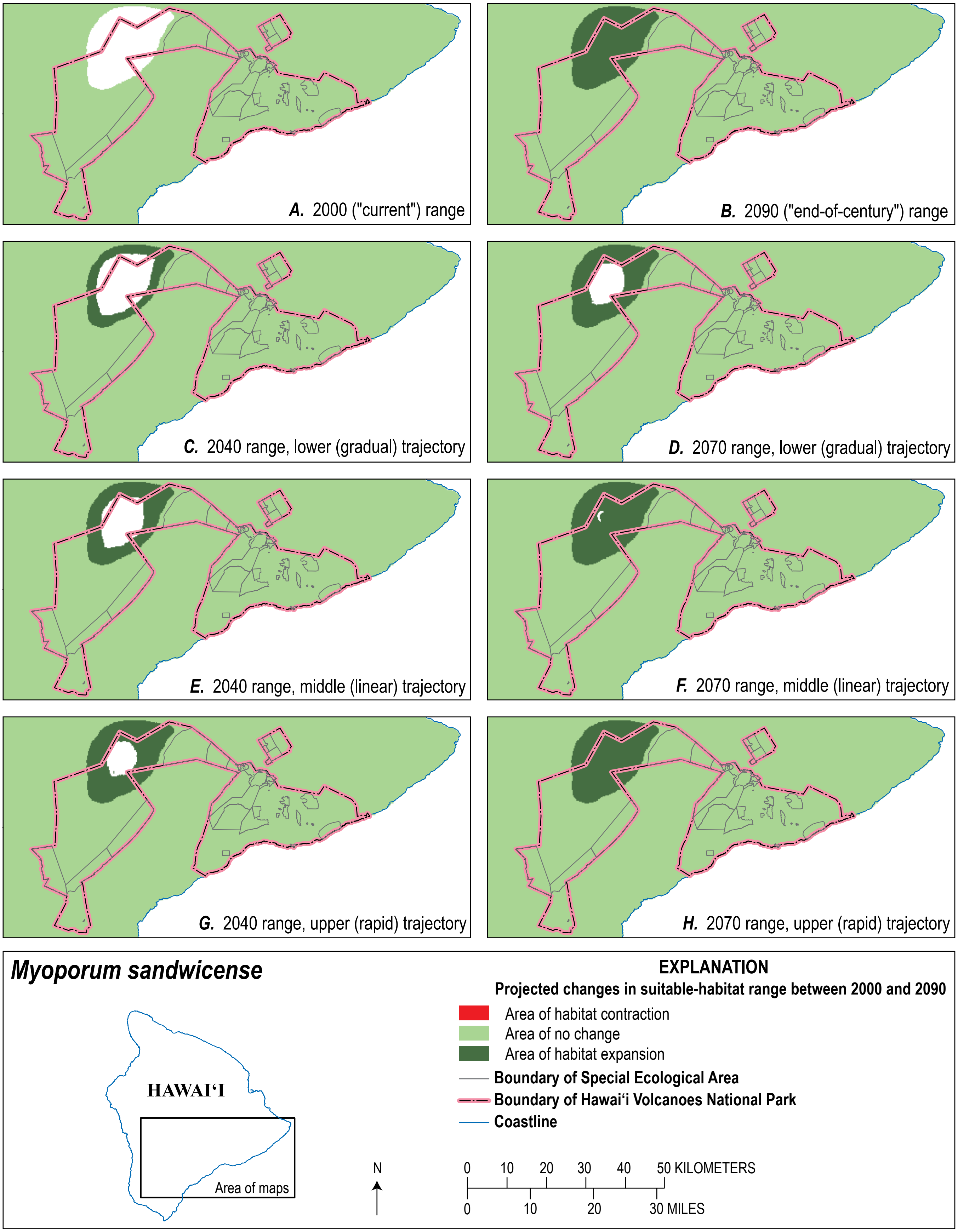
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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Myoporum sandwicense
HAWAI'I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai'i Volcanoes National Park
Coastline
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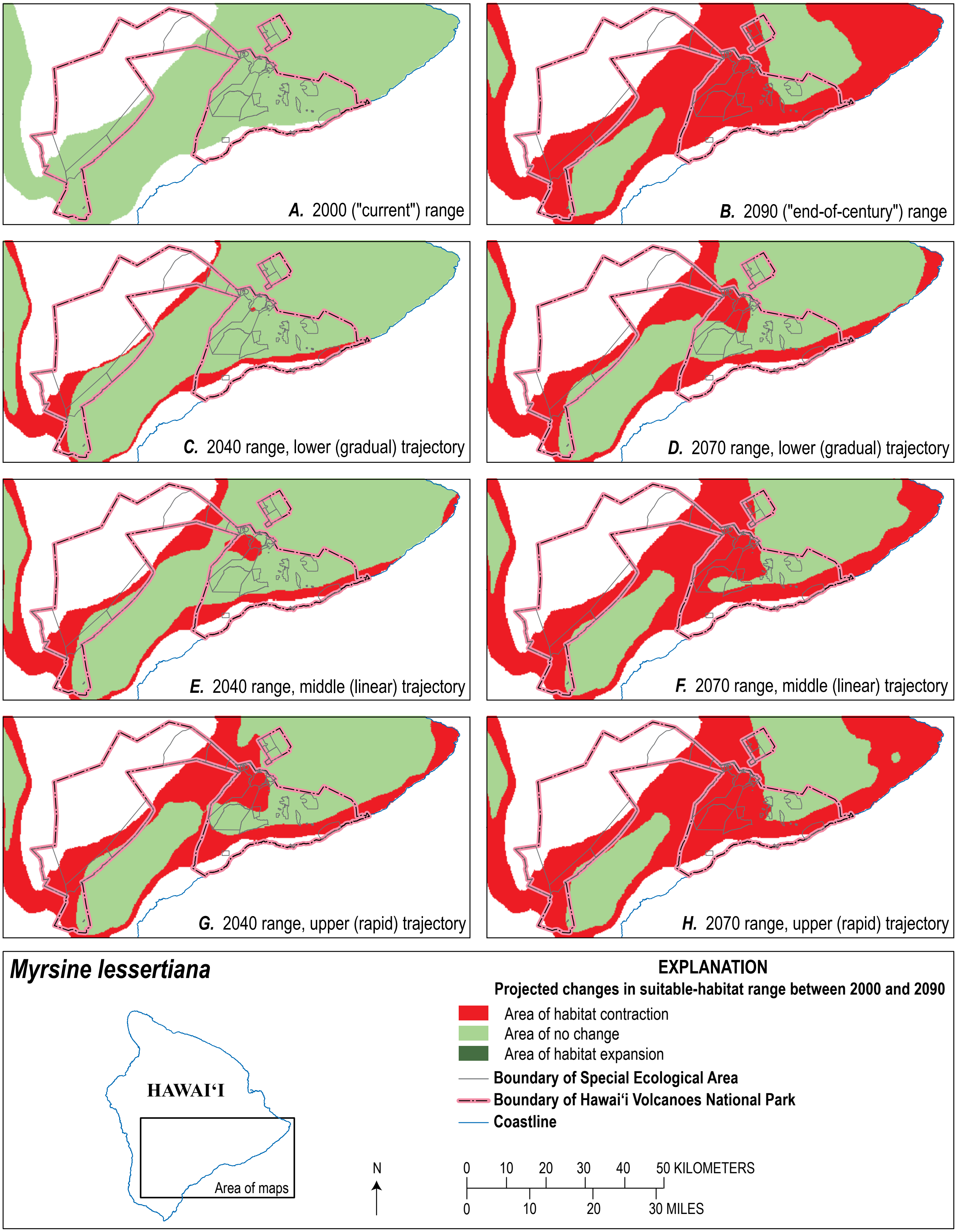
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Myrsine lessertiana
HAWAIʻI
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawaiʻi Volcanoes National Park
Coastline
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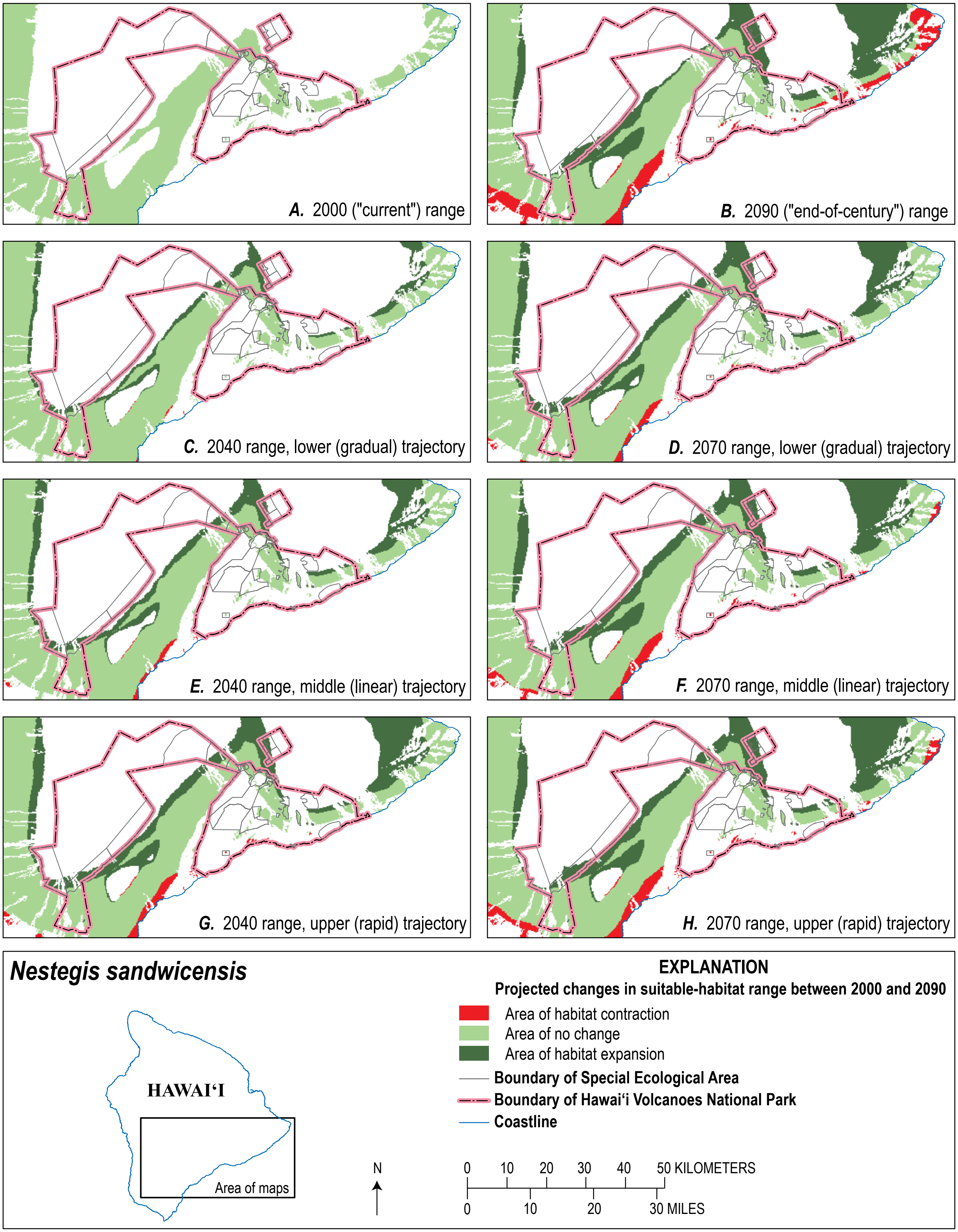
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Nestegis sandwicensis
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
N
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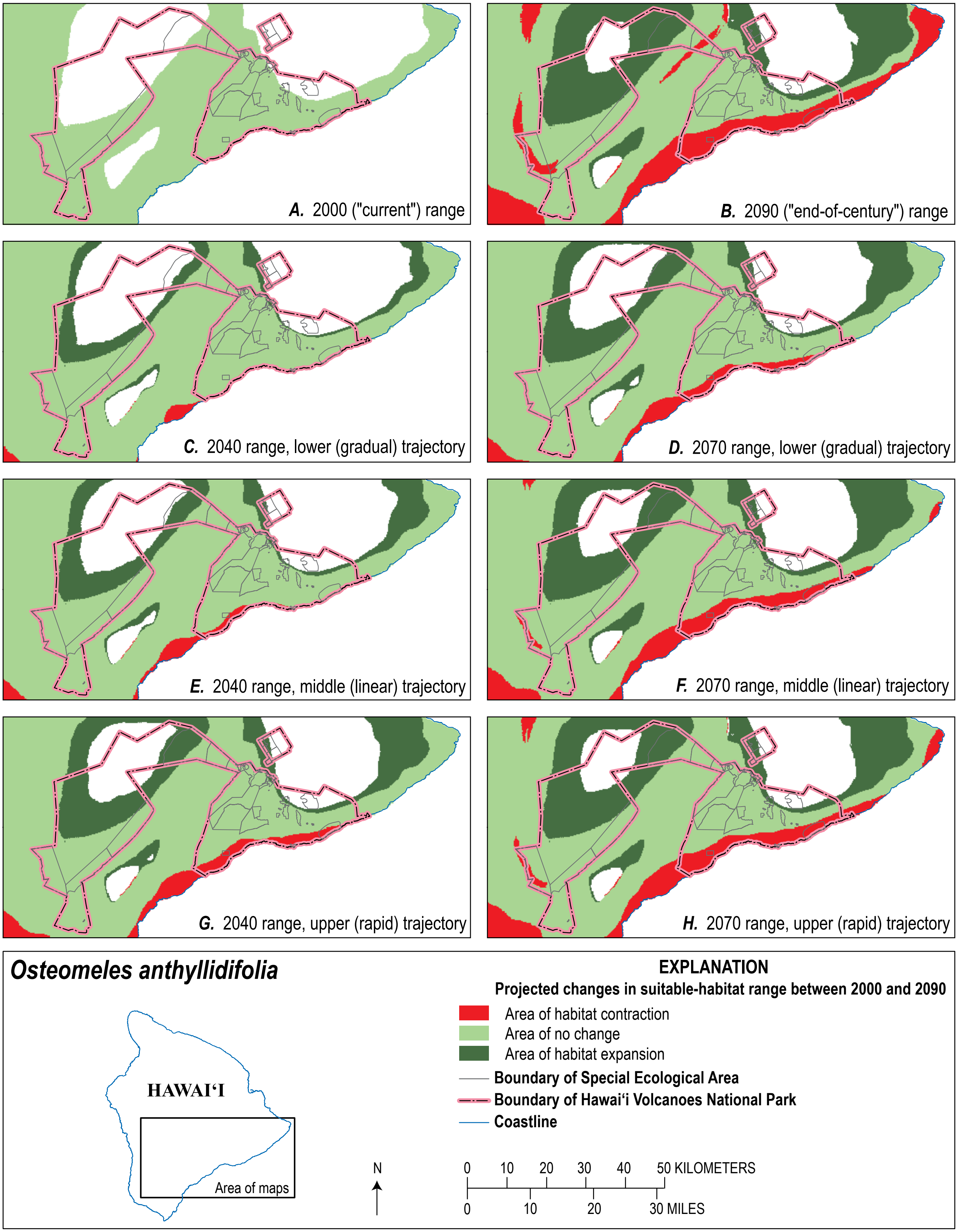
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Osteomeles anthyllidifolia
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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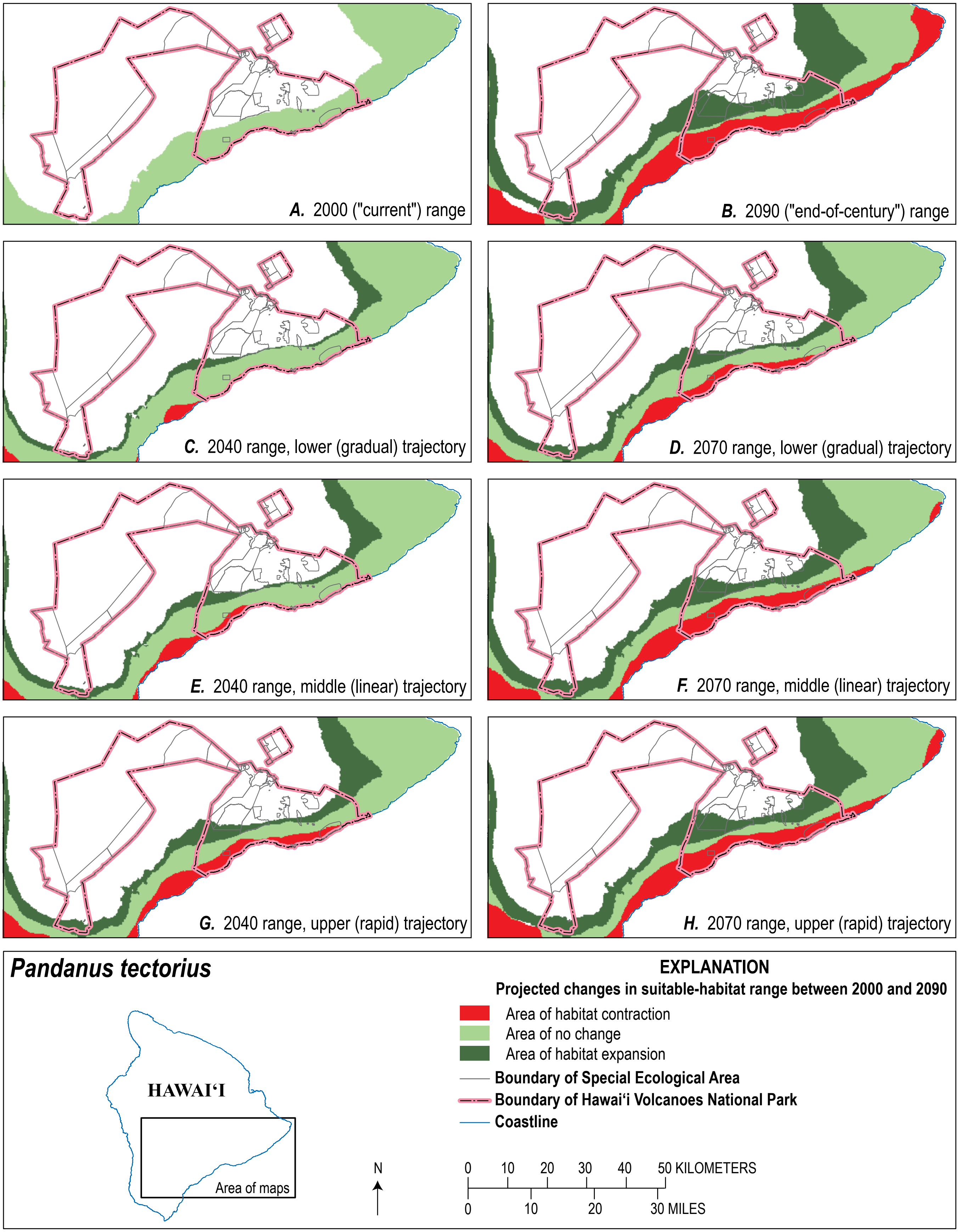
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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Pandanus tectorius
HAWAIʻI
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
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Boundary of Special Ecological Area
Boundary of Hawaiʻi Volcanoes National Park
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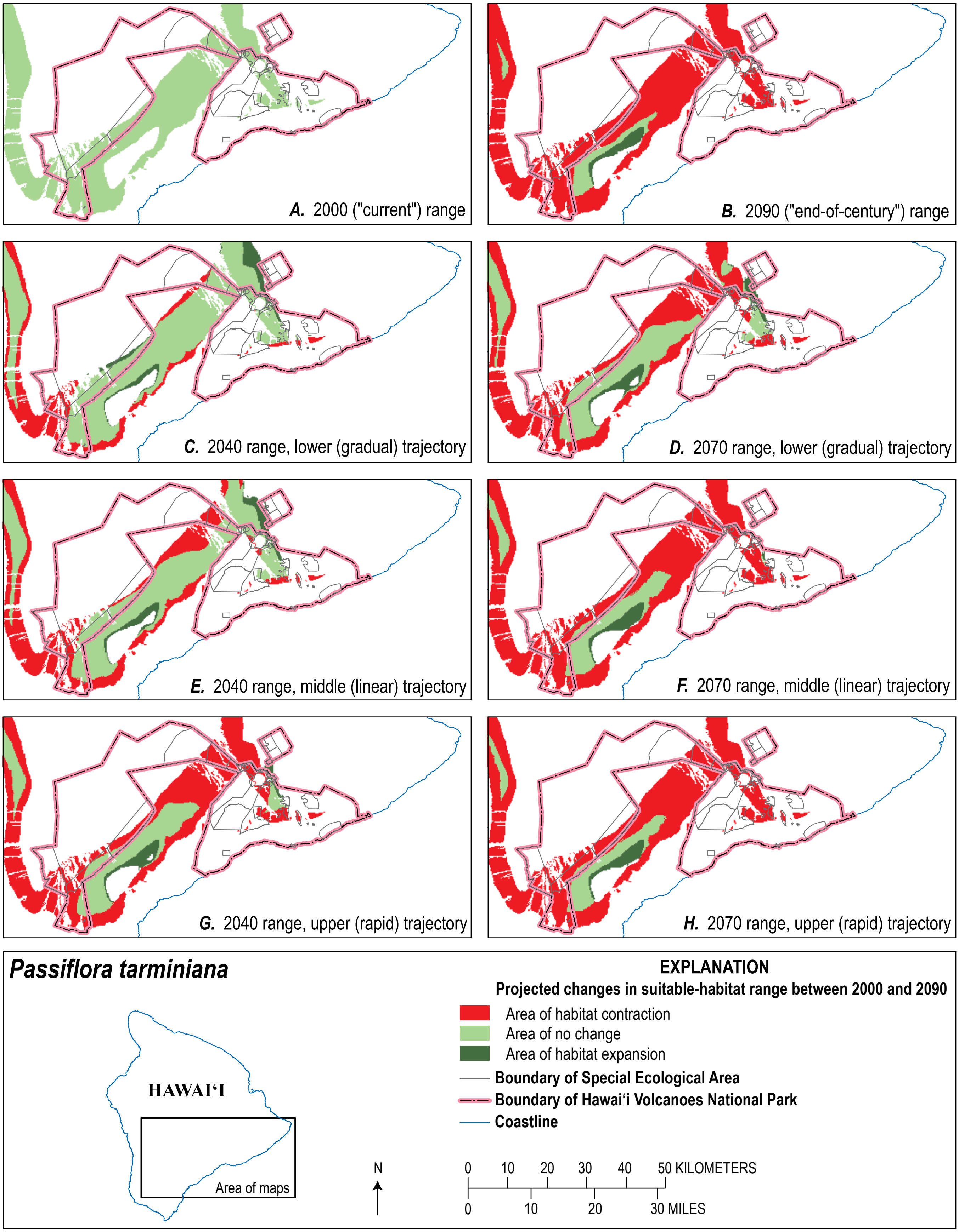
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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Passiflora tarminiana
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
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Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
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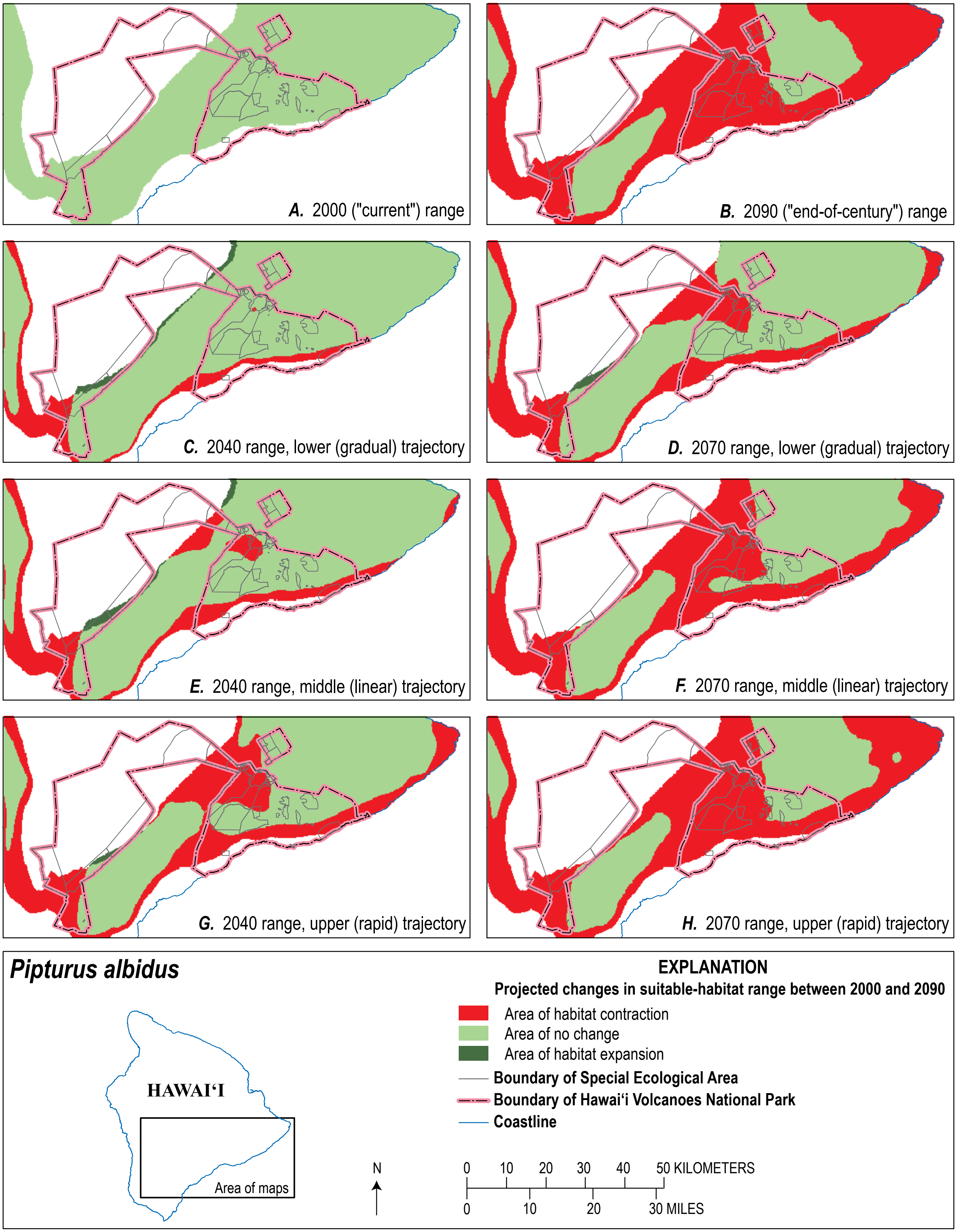
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Pipturus albidus
HAWAIʻI
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawaiʻi Volcanoes National Park
Coastline
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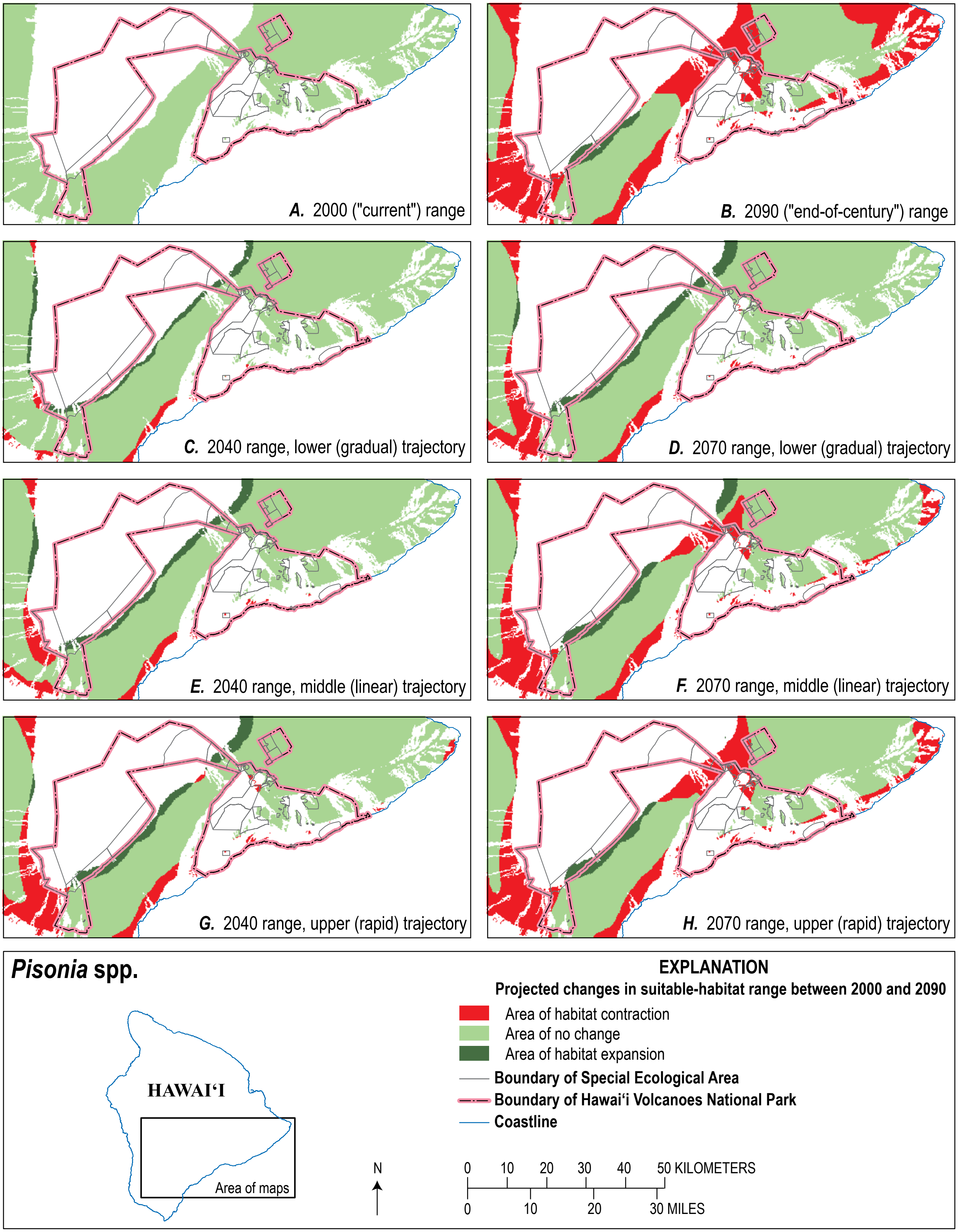
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Pisonia spp.
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
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Coastline
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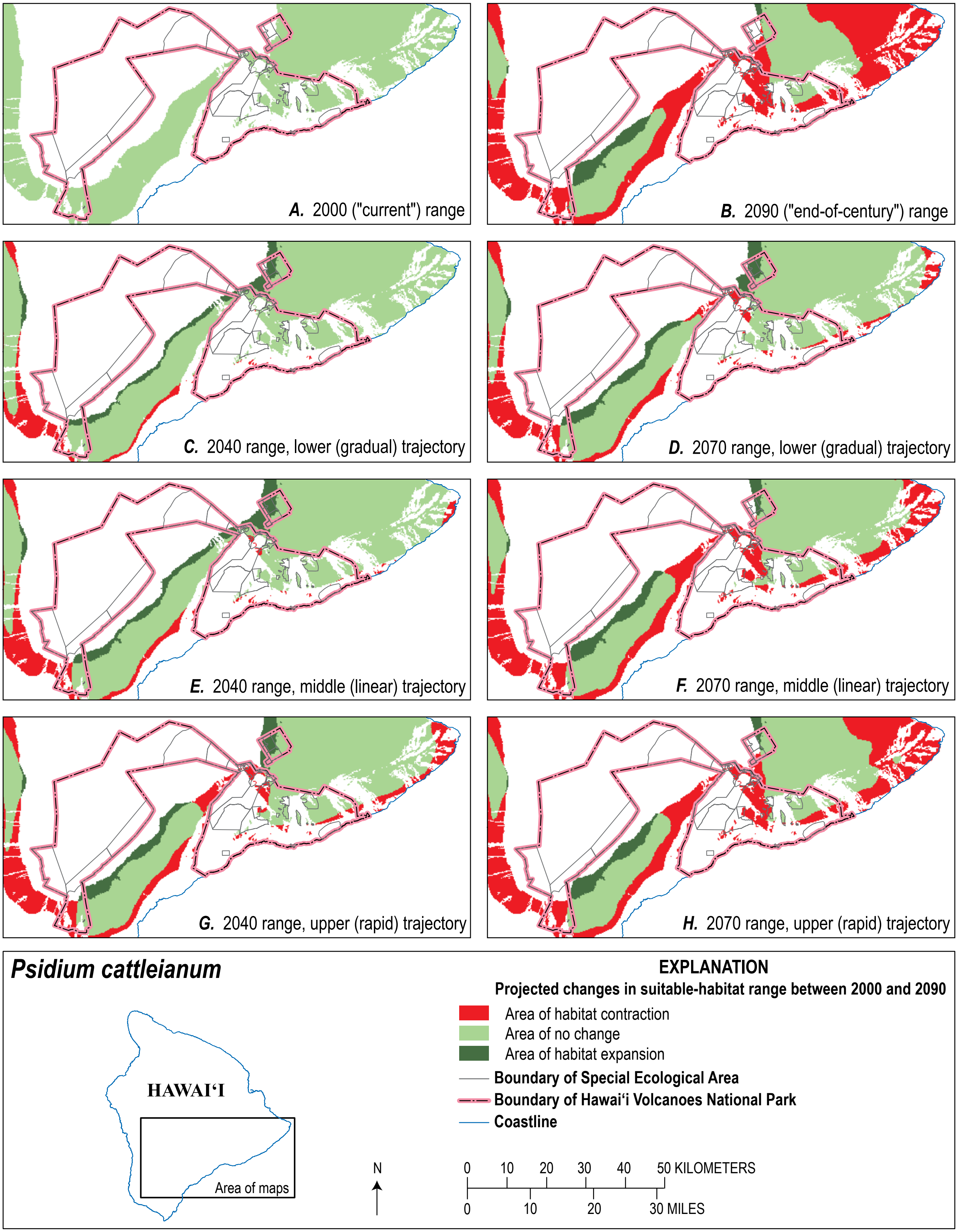

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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Psidium cattleianum
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
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Coastline
0 10 20 30 40 50 KILOMETERS
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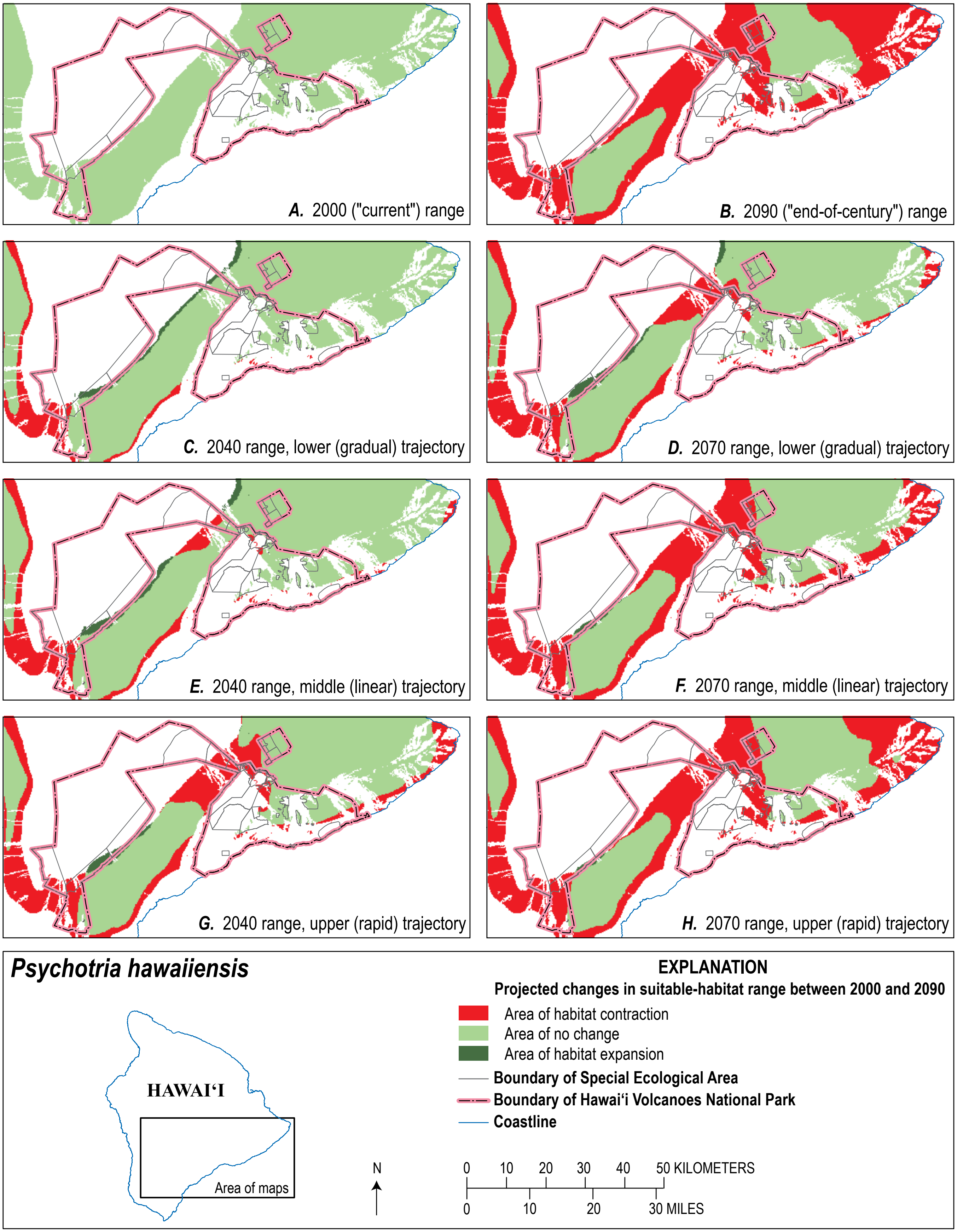
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Psychotria hawaiiensis
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
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Boundary of Special Ecological Area
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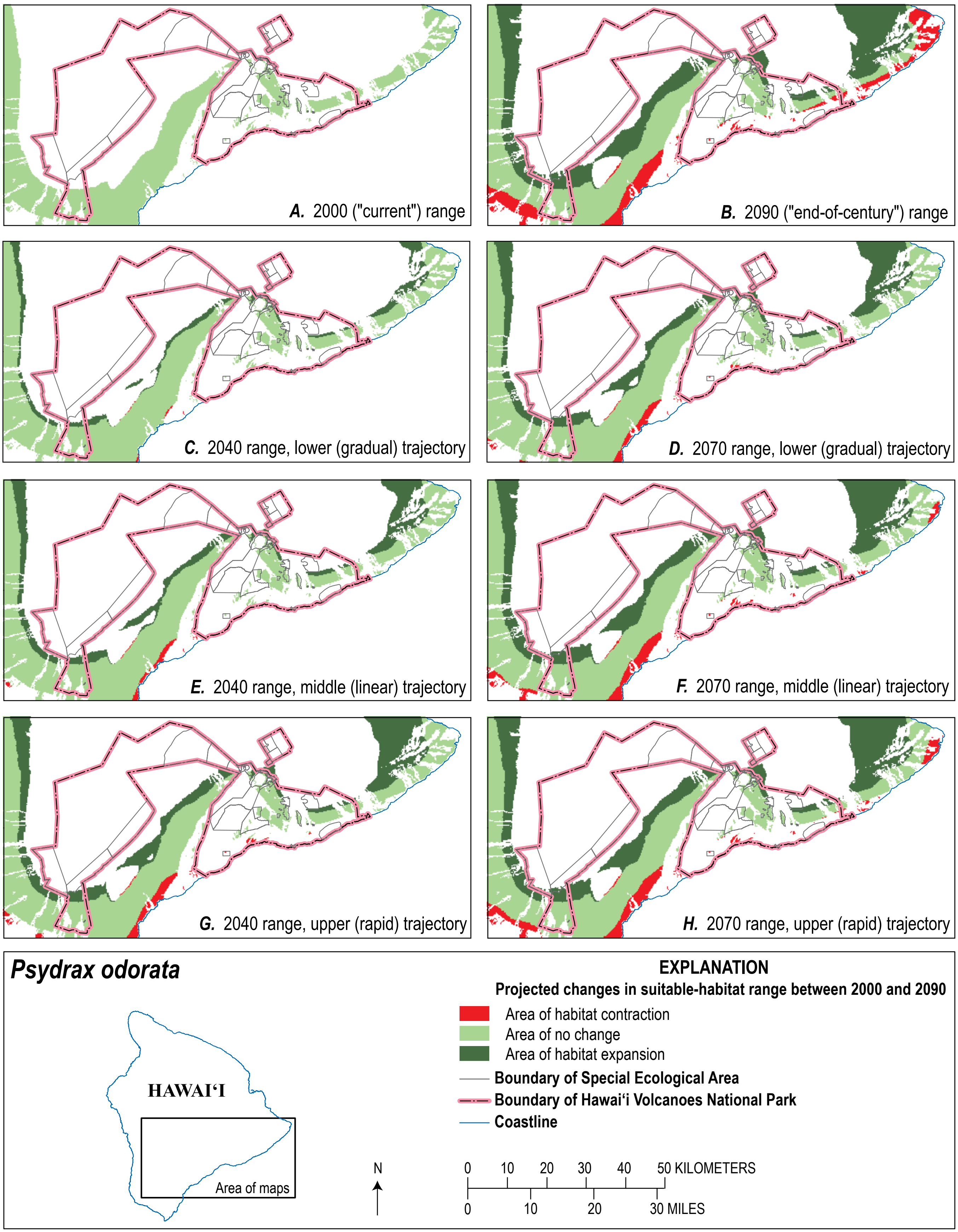
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H. 2070 range, upper (rapid) trajectory
Psydrax odorata
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
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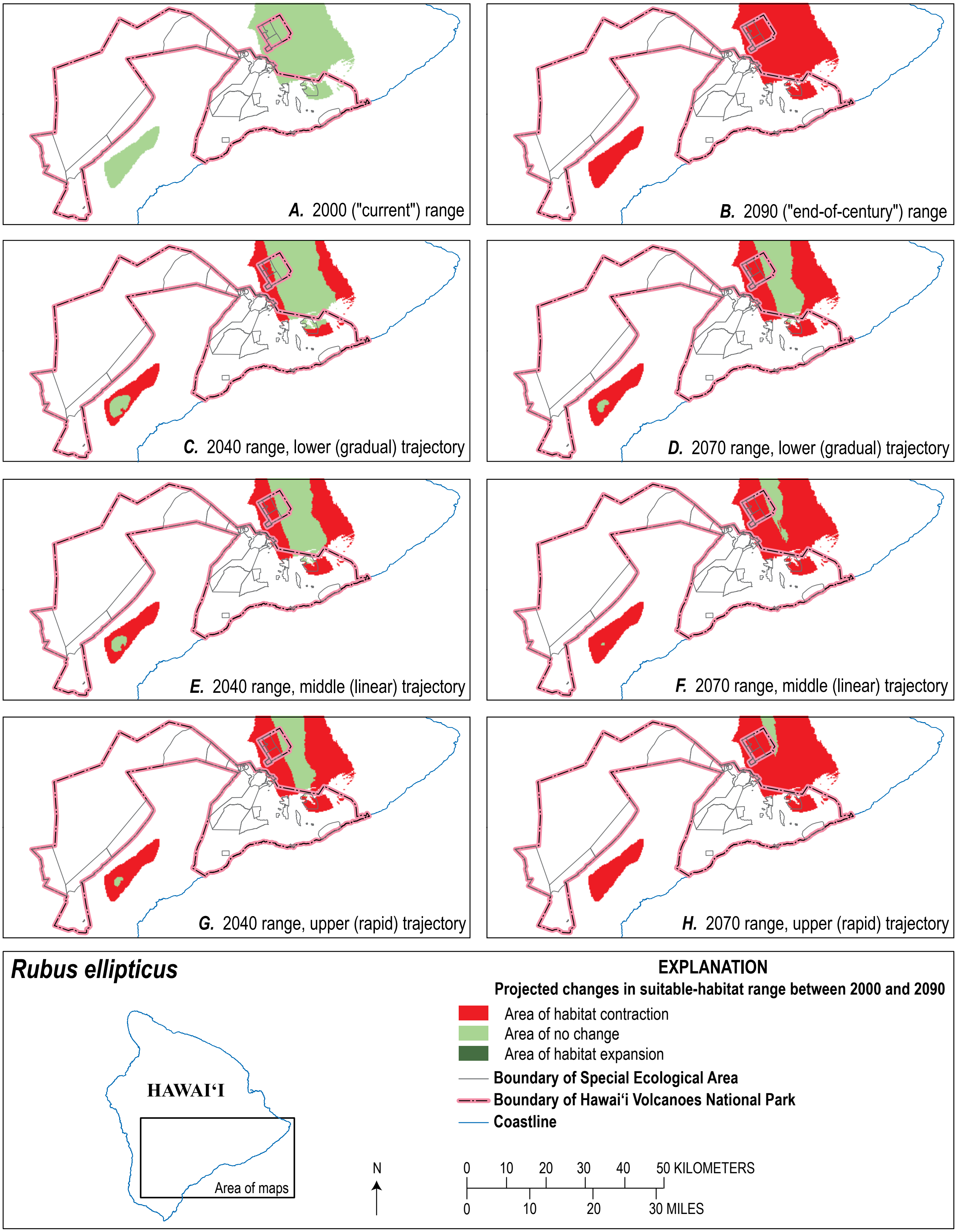
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Rubus ellipticus
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
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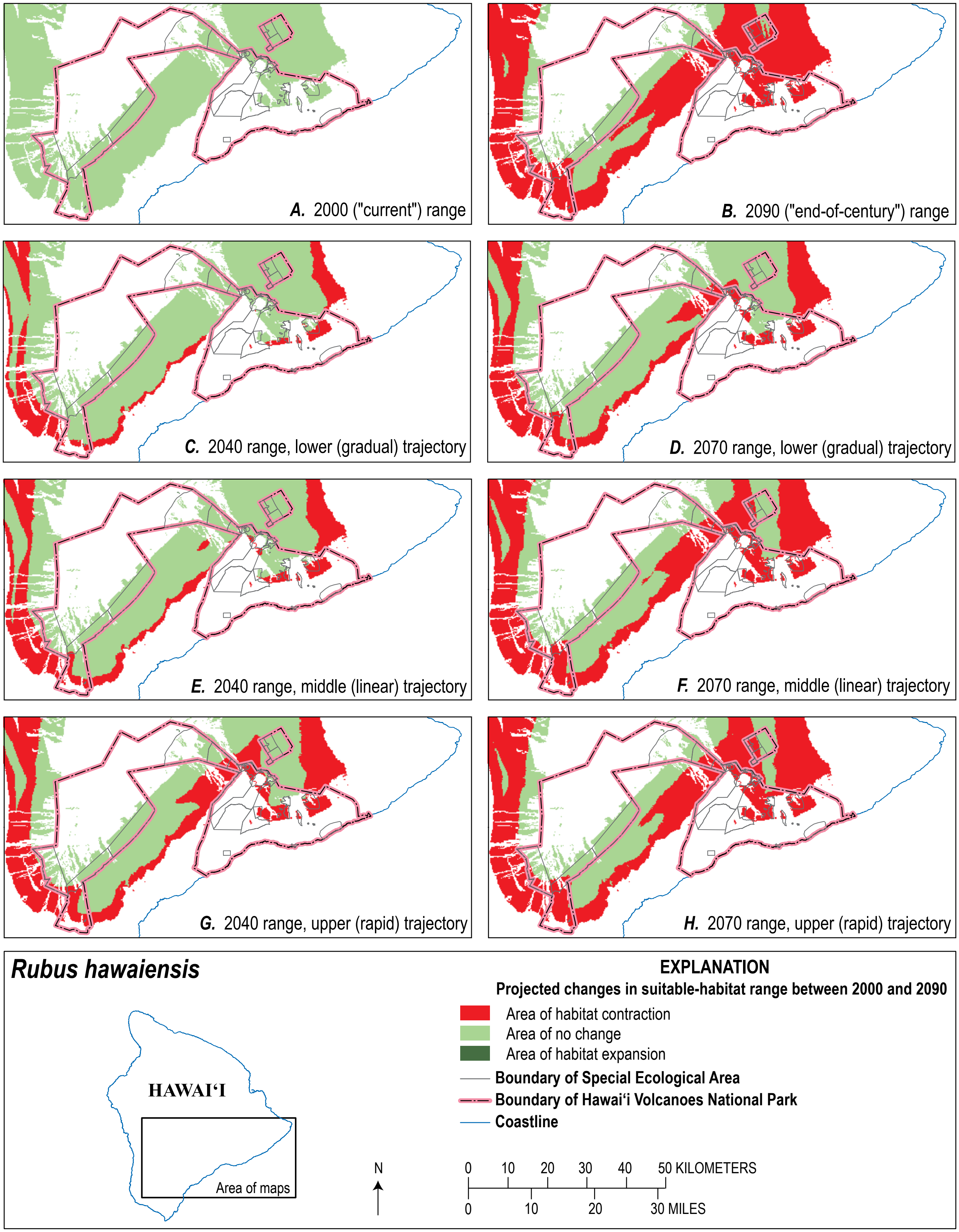
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Rubus hawaiensis
HAWAI‘I
Area of maps
N
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
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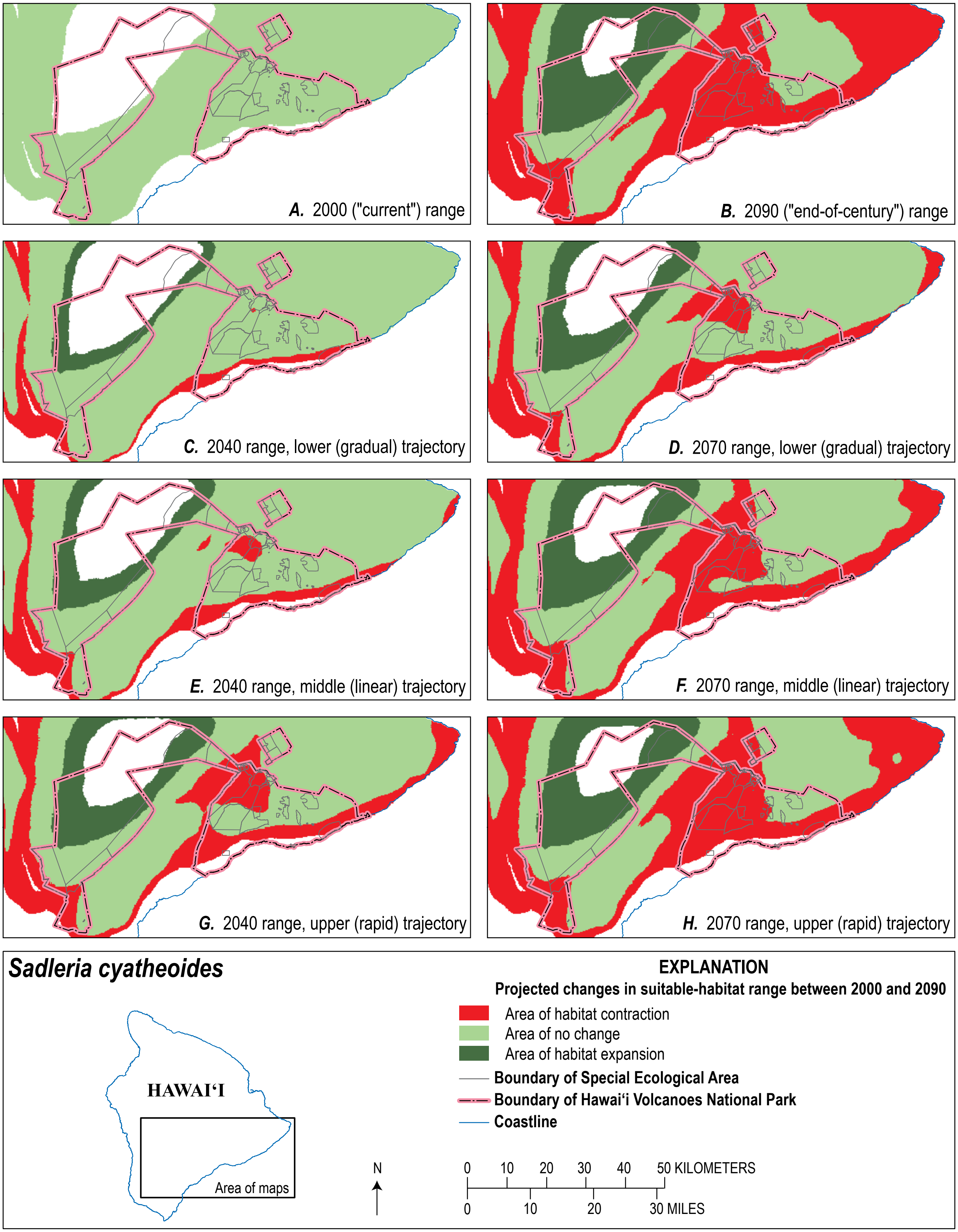
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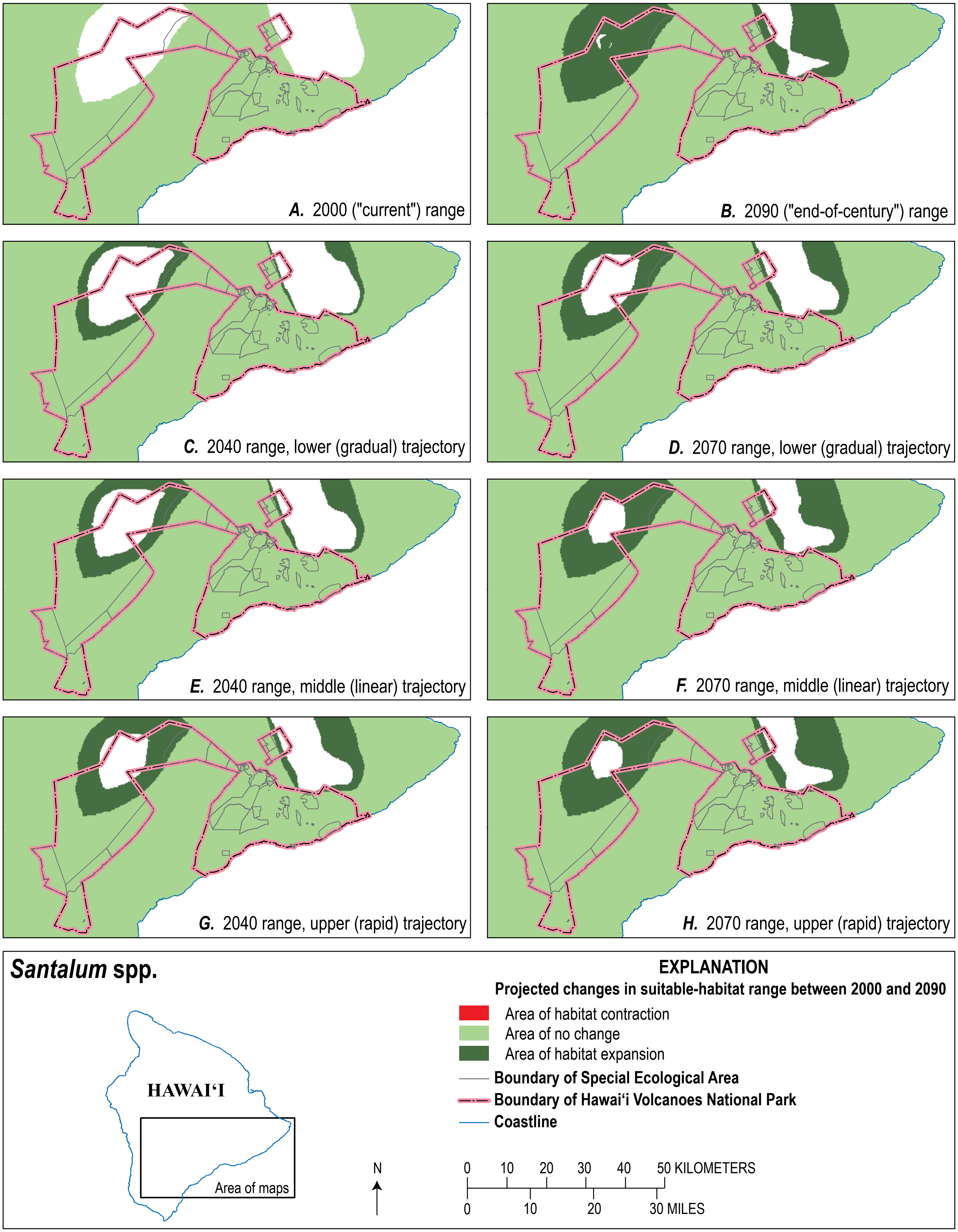
H. 2070 range, upper (rapid) trajectory
Sadleria cyatheoides
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
Area of habitat contraction
Area of no change
Area of habitat expansion
Boundary of Special Ecological Area
Boundary of Hawai‘i Volcanoes National Park
Coastline
N
0 10 20 30 40 50 KILOMETERS
0 10 20 30 MILES


A. 2000 ("current") range
B. 2090 ("end-of-century") range
C. 2040 range, lower (gradual) trajectory
D. 2070 range, lower (gradual) trajectory
E. 2040 range, middle (linear) trajectory
F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Santalum spp.
HAWAI‘I
Area of maps
EXPLANATION
Projected changes in suitable-habitat range between 2000 and 2090
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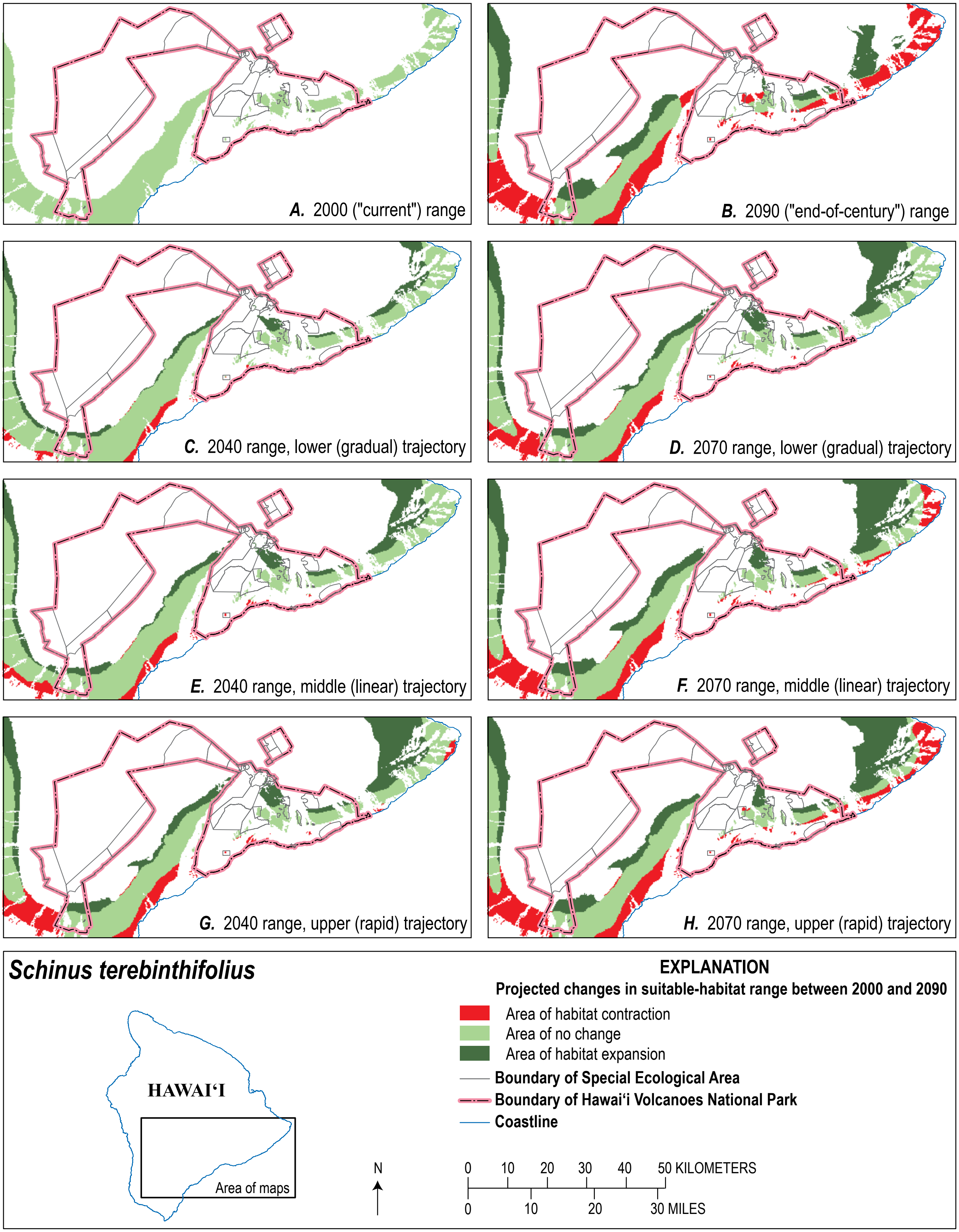
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H. 2070 range, upper (rapid) trajectory
Schinus terebinthifolius
HAWAI‘I
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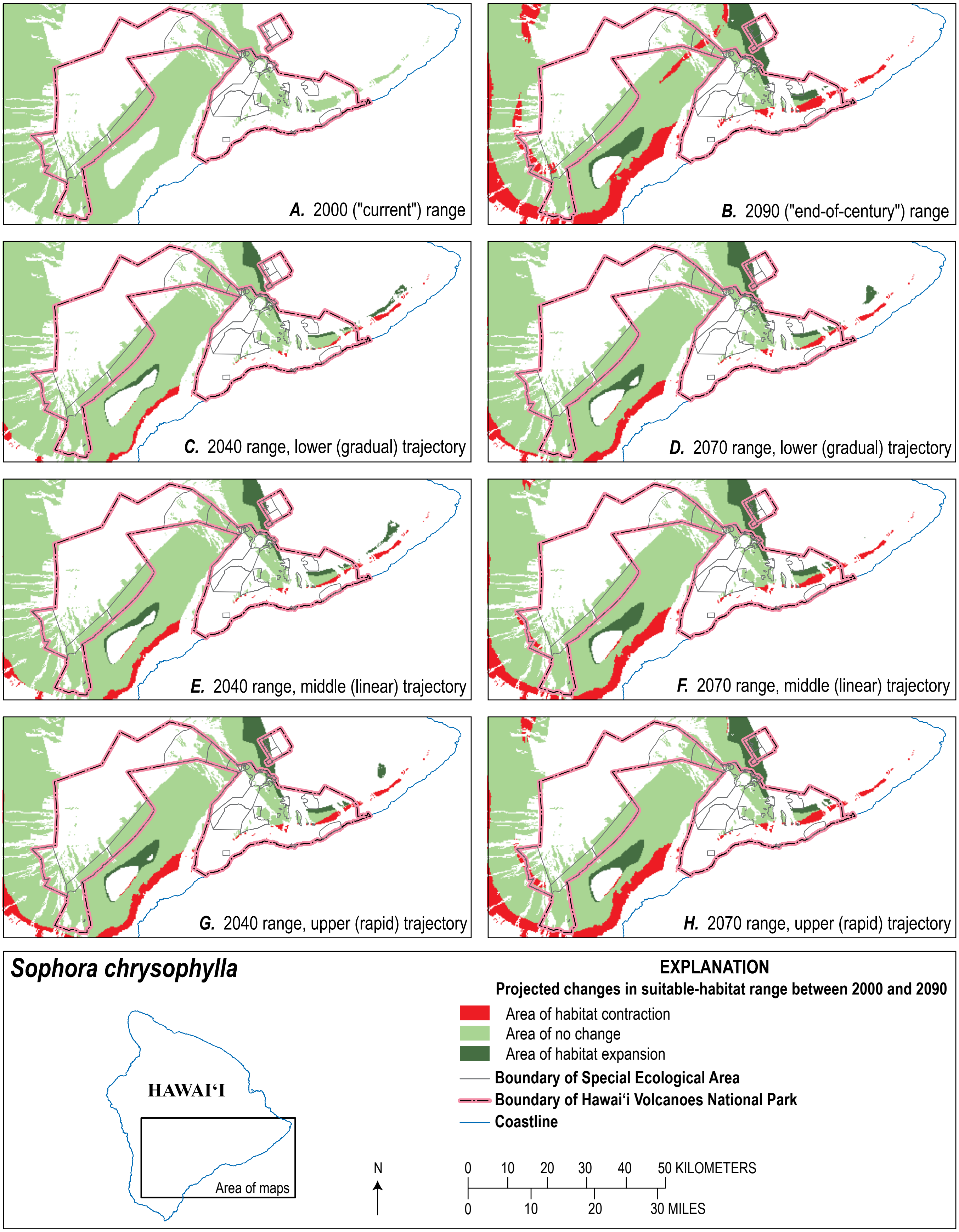
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H. 2070 range, upper (rapid) trajectory
Sophora chrysophylla
HAWAI‘I
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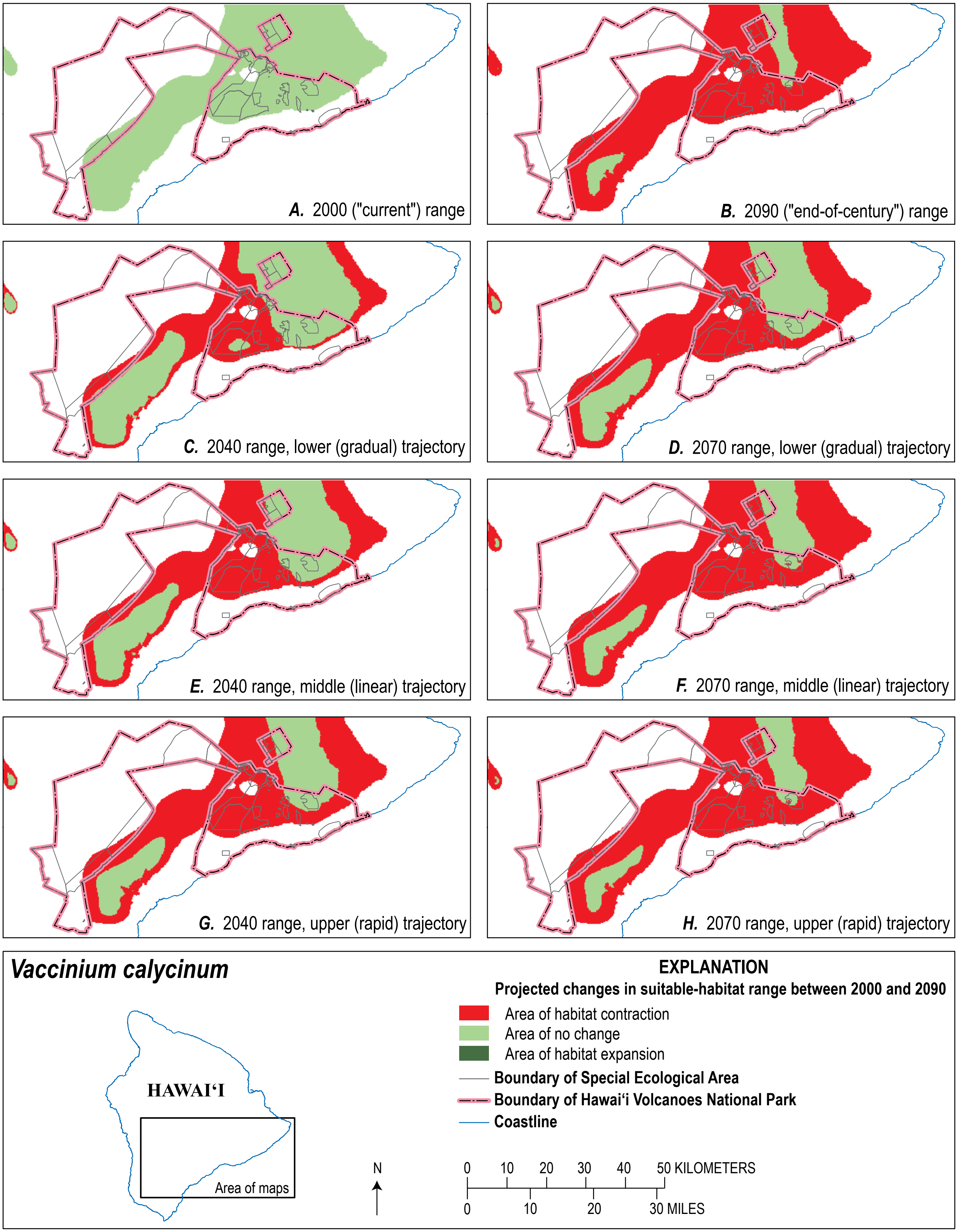
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F. 2070 range, middle (linear) trajectory
G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Vaccinium calycinum
HAWAIʻI
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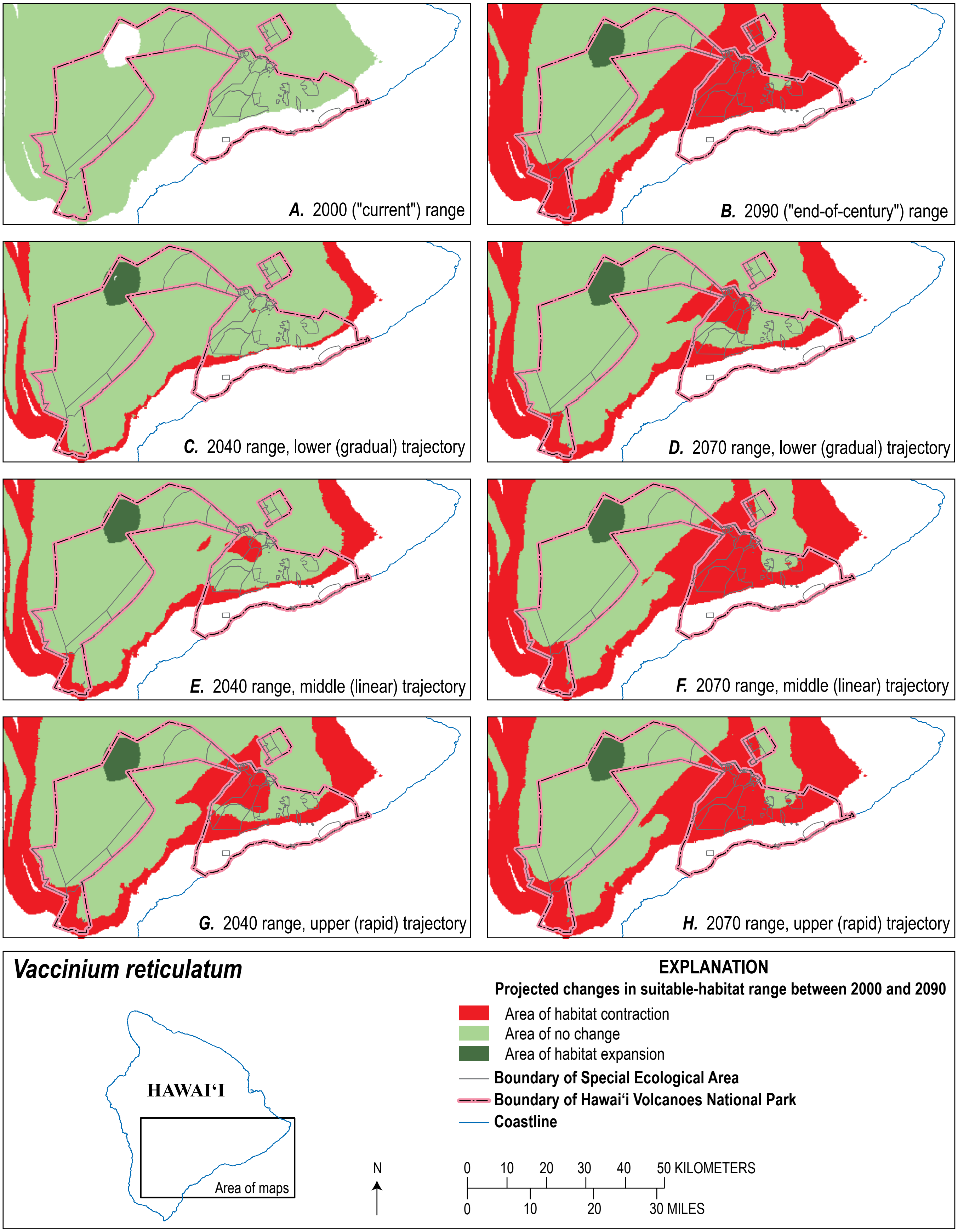
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G. 2040 range, upper (rapid) trajectory
H. 2070 range, upper (rapid) trajectory
Vaccinium reticulatum
HAWAI‘I
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