November 28, 2018

Amber Crooks
Conservancy of Southwest Florida
1495 Smith Preserve Way
Naples, FL 34102

Dear Ms. Crooks:

This letter serves as a follow-up to the report entitled "Impacts to Panther Habitat from the Proposed Eastern Collier Multiple Species Habitat Conservation Plan: A Quantitative Analysis" (report) that I submitted to the Conservancy of Southwest Florida on October 7, 2018. The report describes the results of using a landscape-scale panther habitat model (Frakes et al. 2015) to predict and quantify damages to panther habitat that may result if the Eastern Collier Multiple Species Habitat Conservation Plan (ECMSHCP) is approved and implemented as proposed in the April 2015 draft document. An especially concerning finding of the study was the predicted narrowing and breaking of existing adult habitat corridors linking the main body of panther habitat to the south with the Corkscrew Swamp and Okaloacoochee Slough to the north.

A revised version of the ECMSHCP dated August 2018 was made available online by the U.S. Fish and Wildlife Service in conjunction with the opening of the public comment period. In this revised version it was noted that the "southern corridor" had been widened slightly by moving a small area from the Covered Activities to the Preservation/Plan-wide Activities. Since my previous analysis had predicted significant narrowing and breaks in this important habitat linkage, I agreed to reexamine the model output using this new configuration. Conservancy staff digitized the changed area and provided the layer as a shapefile.

The change to the southern corridor was contained entirely within just 3 grid cells of the study area (out of 895 total). The total area changed (from covered activities to preserve) was about 118 acres of mostly agricultural land cover. The change increased the width of the protected "corridor" from about 650 feet at its narrowest point to about 1690 feet. When I ran this change through the model it had the following effect on the 3 cells involved:

Cell	*P* before	*P* after	Change in *P*
11689	0.106	0.198	+0.092
11809	0.228	0.270	+0.042
11929	0.278	0.324	+0.046

As shown, all 3 cells increased slightly in adult habitat value (*P*), as would be expected when the amount of urban land cover is reduced. When these new values were imported into ArcMap and the maps were re-drawn, the change was almost imperceptible. The corridor near Summerlin Swamp and Highway 29 is still as fragmented and narrowed as it was before. Therefore, this particular change to the ECMSHCP has no effect on the conclusions in the report.

Sincerely,

Robert A. Frakes, Ph.D.

IMPACTS TO PANTHER HABITAT FROM THE PROPOSED EASTERN COLLIER MULTIPLE SPECIES HABITAT CONSERVATION PLAN: A QUANTITATIVE ANALYSIS

October 7, 2018

Prepared for:
Conservancy of Southwest Florida
1495 Smith Preserve Way
Naples, Florida 34102

Prepared by:
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EXECUTIVE SUMMARY

The Eastern Collier Multiple Species Habitat Conservation Plan (ECMSHCP or "Plan") proposes development of 45,000 acres in rural eastern Collier County within the current range of the endangered Florida panther. The Plan asserts that, using the USFWS Panther Habitat Assessment Methodology, preservation of 87,500 acres of existing (mostly agricultural) uses provides adequate compensation/mitigation for the loss of habitat from the proposed mining and residential/commercial developments, also known as "Covered Activities." However, the Panther Habitat Assessment Methodology is outdated and scientifically flawed.

The ECMSHCP is located entirely within the Rural Lands Stewardship Area (RLSA) in eastern Collier County. This study used a recently published landscape-scale panther habitat model to predict how adult panther breeding habitat and habitat linkages within the RLSA would be impacted by the proposed development(s). Model validation using GPS adult panther telemetry locations indicated high model accuracy (>97%) in this part of the panther's range.

Three scenarios were examined: existing conditions (pre-HCP); Scenario 1 (development as proposed by the ECMSHCP); and Scenario 2 (likely additional residential development, agricultural intensification, and mining beyond Scenario 1). To simulate development, changes were made to variables for human density, road density, landcover, and forest edge. Model outputs for pre- and post-development were then compared in order to quantify impacts to adult panther habitat.

The model predicted substantial losses of adult panther (breeding) habitat in terms of both habitat quantity (areal extent) and quality. Under Scenario 1 (proposed ECMSHCP), the model predicted that the RLSA will lose 16,779 acres (18%) of existing adult panther habitat. This figure increased to 21,425 acres (23%) under Scenario 2. Overall habitat quality within the RLSA (area-weighted average probability of presence, *P*) decreased by 16% and 23.4% under Scenario 1 and 2, respectively.

Nearly all of the existing panther habitat in the Covered Activities area will be destroyed by development under the proposed ECMSHCP. This area was predicted to lose 85.4 -90.9% of its existing adult panther habitat. Although mostly agricultural, the Covered Activities area is currently used by panthers as part of their home ranges. During the 10-year period from 2004 to 2013, the Covered Activities area contained parts of the home ranges of at least 17 adult panthers. With final average *P* values of 0.097 (Scenario 1) and 0.072 (Scenario 2), the Covered Activities area will be almost useless to panthers post-development.

It is important to note that even the proposed Preserve Areas will suffer considerable habitat losses. Under Scenario 1, the "Preservation/Plan-Wide Activities" area was predicted to lose 4753 acres (8.0%) of panther breeding habitat. Under Scenario 2, the predicted loss increased to 6744 acres (11.4%). These losses are approximately the same size as the town of Ave Maria. Any compensation calculation should take potential habitat impacts within the Preserve Areas into account.

Damages to north-south panther corridors within the RLSA were predicted, in spite of claims that these corridors would be preserved by the ECMSHCP. The model predicted that the northward extension of habitat on the western side of the RLSA (through Camp Keais Strand towards the Corkscrew Swamp) will be significantly narrowed and shortened. The fairly strong existing habitat connection on the eastern side of the RLSA (through Summerlin Swamp towards the Okaloacoochee Slough) will be narrowed and completely severed in some places, especially under Scenario 2. It is likely that the degraded/reduced habitat along these pathways will adversely impact north-south panther movements. In addition, new roads, especially those running east and west, will add to the fragmentation and loss of connectivity

The locations within the RLSA where the greatest impacts to adult panther habitat were predicted to occur are shown on the output maps. Minimization of effects (as required under the Endangered Species Act) could be achieved by relocating the Covered Activities boundaries to avoid these high impact areas. Further minimization could be achieved by requiring that current land uses in the Preserve Areas be maintained (i.e., no agricultural intensification).

Approval of the ECMSHCP as currently conceived would appreciably reduce the likelihood of survival and recovery of the Florida panther, due to significant habitat loss, fragmentation, and damage to dispersal corridors. The ECMSHCP provides little or no meaningful compensation for these adverse impacts and does not demonstrate minimization and mitigation to the maximum extent practicable.

INTRODUCTION

Historically occurring throughout the southeastern United States, the Florida panther (*Puma concolor coryi*) is now restricted to less than 5 percent of its historic range in one breeding population located in southern Florida. Recovery of the panther is dependent upon the survival of this small, isolated population and expansion of additional populations elsewhere in its historic range. Although the species was listed as endangered in 1967, loss of panther habitat due to development on private lands has continued unchecked since that time. Anticipated rampant development in south Florida remains the greatest threat to panther survival and recovery.

The Eastern Collier Multiple Species Habitat Conservation Plan (ECMSHCP or "Plan") proposes development of 45,000 acres in rural eastern Collier County within the current range of the panther (Stantec 2015). The Plan proposes to compensate for impacts to panther habitat through the protection of approximately 87,500 acres of "Preservation/Plan-Wide Activities" (Stantec 2015). The Plan asserts that, using the current U.S. Fish and Wildlife Service (USFWS) Panther Habitat Assessment Methodology (USFWS 2012), protection of these preservation areas provides adequate compensation/mitigation to offset the loss of habitat from the mining and residential/commercial developments, also known as "Covered Activities." However, the Panther Habitat Assessment Methodology is outdated, scientifically flawed, and does not provide accurate comparisons of panther habitat value on a landscape scale (Frakes et al. 2015).

The ECMSHCP is located entirely within the Rural Lands Stewardship Area (RLSA) in eastern Collier County. The RLSA contains many square kilometers of excellent panther habitat as well important linkages between the core panther population to the south and protected areas, such as Corkscrew Regional Ecosystem Watershed (CREW) and Okaloacoochee Slough State Forest, to the north. The purpose of this study was to use the best available science to predict how adult panther breeding habitat and habitat linkages within the RLSA would be affected by the proposed ECMSHCP, in terms of both habitat quantity and quality.

METHODS

The landscape-scale adult panther habitat model used in this study was identical to that described by Frakes et al. (2015). Briefly, habitat characteristics in 1-km^2 grid cells in south Florida were analyzed using the RandomForest package in R to predict the probability of panther presence (*P*) in each cell. The training dataset consisted of VHF telemetry locations of adult panthers collected by the Florida Fish and Wildlife Conservation Commission and the National Park Service from 2004 through 2013 (FWC 2014). See Frakes et al. (2015) for details on the model. It is important to note that the habitat model used in this report predicts the suitability of an area as habitat for adult, breeding panthers. Other areas not classified as adult panther habitat may still be important to transient, dispersing or immature panthers or as connections between areas of more valuable habitat. In this report the terms "habitat," "panther habitat," and "habitat quality" refer to adult, breeding panther habitat only.

The study area for this analysis was defined by overlapping the RLSA with the grid cells from the south Florida model (Frakes et al. 2015). Grid cells along the border that were bisected by

the RLSA boundary were included in the study area, to include complete grid cells and to ensure complete model coverage of the entire RLSA. This resulted in inclusion of 895 1-km^2 grid cells in the study area. These cells were run through the model under existing conditions (c. 2010), and again using various assumptions for variable values to depict conditions after development in the RLSA, as described in the draft ECMSHCP (Stantec 2015). To simulate development, changes were made to variables for human density, road density, landcover, and forest edge. The hydrology variables were held constant at existing conditions because no information on changes to hydrology due to Covered Activities development was available. Model outputs for pre- and post-development were then compared in order to quantify impacts to adult panther habitat.

ECMSHCP shapefiles showing Covered Activities, Preservation/Plan-Wide Activities, and other designations were obtained through U.S. Fish and Wildlife Service (USFWS) quarterly release of documents related to the Plan.[1] The shapefiles depict the designations proposed in the April 2015 draft ECMSHCP. All areal and geostatistical calculations for the RLSA, Covered Activities, and Preserve Areas were done in ArcMap® version 10.6. Interpolation (smoothing) between grid cells was accomplished using the kernel interpolation tool of the geostatistical analyst package in ArcMap®. Bandwidth was set at 1500 meters.

For the purposes of this analysis, habitat quality was assumed to be directly proportional to the probability of panther presence (*P*) as estimated by the model. The overall habitat quality of an area was characterized by the average and range of *P* values of the grid cells in that area. Loss of habitat quality due to development was estimated by comparing the average *P* value under existing conditions (pre-HCP) with the average *P* value predicted for the same area after development. To account for the fact that some cells were only partially contained within each area, area-weighted average *P* values were calculated.

A grid cell was classified as adult panther habitat when the model-predicted *P* value was > 0.34 (Frakes et al. 2015). Habitat quantity (areal extent) was calculated as the sum of the area of all grid cells or partial cells above that threshold.

The purpose of this study was to predict how the adult panther breeding habitat, as depicted in Frakes et al. (2015), would be affected by the proposed intensification from the ECMSHCP, in terms of both habitat quantity and quality. Scenario 1 is designed to reflect the applicants' submittal as found in the April 2015 draft ECMSHCP and associated plans, such as the Rural Lands West development application currently under review. Scenario 2 builds upon Scenario 1 by also including other likely effects and impacts associated with the addition of 45,000 acres of urban and mining development in the RLSA, including other parcels likely to be intensified due to the ECMSHCP.

Scenario 1

Land cover

Land cover is an important variable determining panther use of an area. Panther home ranges generally consist of a mixture of cover types. The model analyzes the mixture of cover types in

[1] ECMSHCP 2016 Quarter 1 release.

each grid cell as part of the process of calculating the probability of panther use. Land cover types used as variables in the south Florida model (Frakes et al. 2015) were based on the Florida Land Use and Cover Classification System (FLUCCS) (SFWMD 2009). Vegetative cover and land uses from the FLUCCS were combined into 10 major land cover categories for use as variables in the model. Fig. 1 shows the current distribution of the 9 land cover classes in the RLSA (one landcover type, saltwater wetland, was not present in the study area).

Areas depicted as Covered Activities under the ECMSHCP were described as "45,000 acres… of residential/commercial development and earth mining" (Stantec 2015). Under Scenario 1, these areas were reclassified from their original designation (mostly agricultural) to urban. The applicants' proposed Plan and associated shapefile depict a 49,848-acre envelope where the 45,000 acres of Covered Activities development is proposed to take place (Stantec 2015). Thus, this study selected 45,000 acres of the 49,848-acre envelope for designation as urban (Fig. 2a). The model as described in Frakes et al. (2015) includes mining as an urban land cover category. In order to evaluate the "worst case" for Scenario 1, the 45,000 acres of development was applied to the Primary Zone (Kautz et al. 2006) first. As presented in the ECMSHCP, Ave Maria at 5,027 acres (Primary and Secondary Zones) was mapped as urban and included in the 45,000 acres (Stantec 2015).

All of the Covered Activities areas, which may include internal open space, were reclassified as urban land cover because the proposed Plan describes these areas as part of the residential/commercial development (Stantec 2015). Additionally, since detailed site development plans were not available, it was not known if natural lands contained within the Covered Activities areas would be accessible to panthers, or if they would be used by panthers given the expected increase in human activity.

Population density

All areas reclassified as urban under Scenario 1 were assigned a new human population density value (people/km^2). The population density of future towns was based on the density of the existing town of Ave Maria, as well as the potential density for the proposed town known as Rural Lands West. By utilizing these known and proposed densities, the possible densities for future towns in the RLSA were extrapolated. The densities were assigned based on approximate locations of potential new towns (Stantec 2015), in which the center of the new town would have the highest density, with lower densities as one moves farther from the town center. The assigned densities ranged from 0.2 to 6 dwelling units per acre. The new densities were then converted to people/km^2 using a factor of 2.59 persons per dwelling unit[2] and integrated into the existing density layer for the entire RLSA.

These assumptions result in accommodating a future additional population of approximately 303,000 people in the RLSA in approximately 117,000 new dwelling units. Therefore, the assumed new population under Scenario 1 is conservative compared with a projected population estimate of up to 350,000 in this portion of Collier County.[3]

[2] https://www.census.gov/quickfacts/fact/table/colliercountyflorida/PST045217

[3] See https://www.naplesnews.com/story/opinion/2018/01/19/commentary-smart-growth-planning-collier-county/1034456001/ and http://www.winknews.com/2015/07/13/plans-moving-ahead-for-new-town-in-eastern-collier-county/

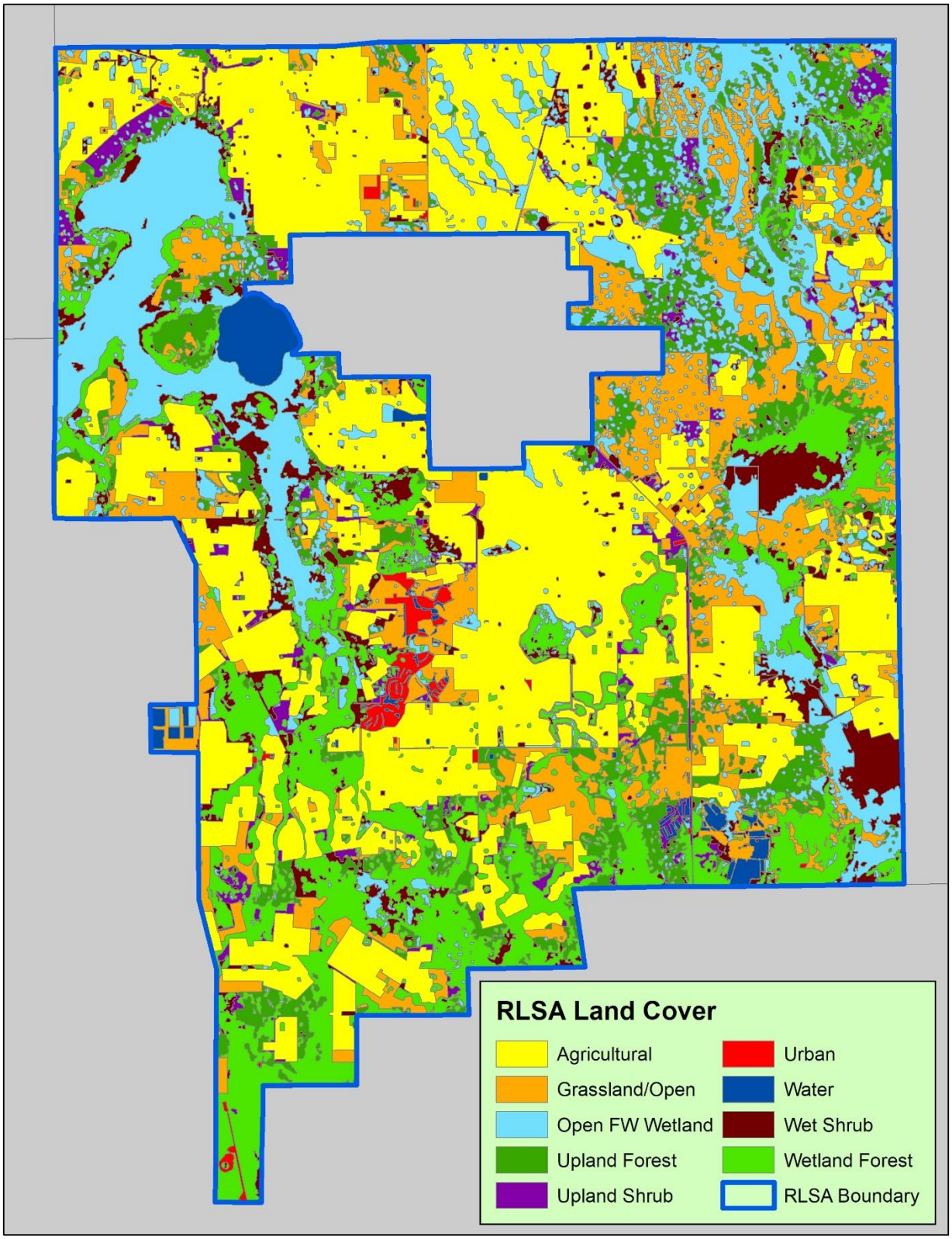

Figure 1. Current distribution of 9 major land cover categories within the RLSA, used as explanatory variables in the random forest model. Categories were distilled from the Florida Land Use and Cover Classification System (FLUCCS).

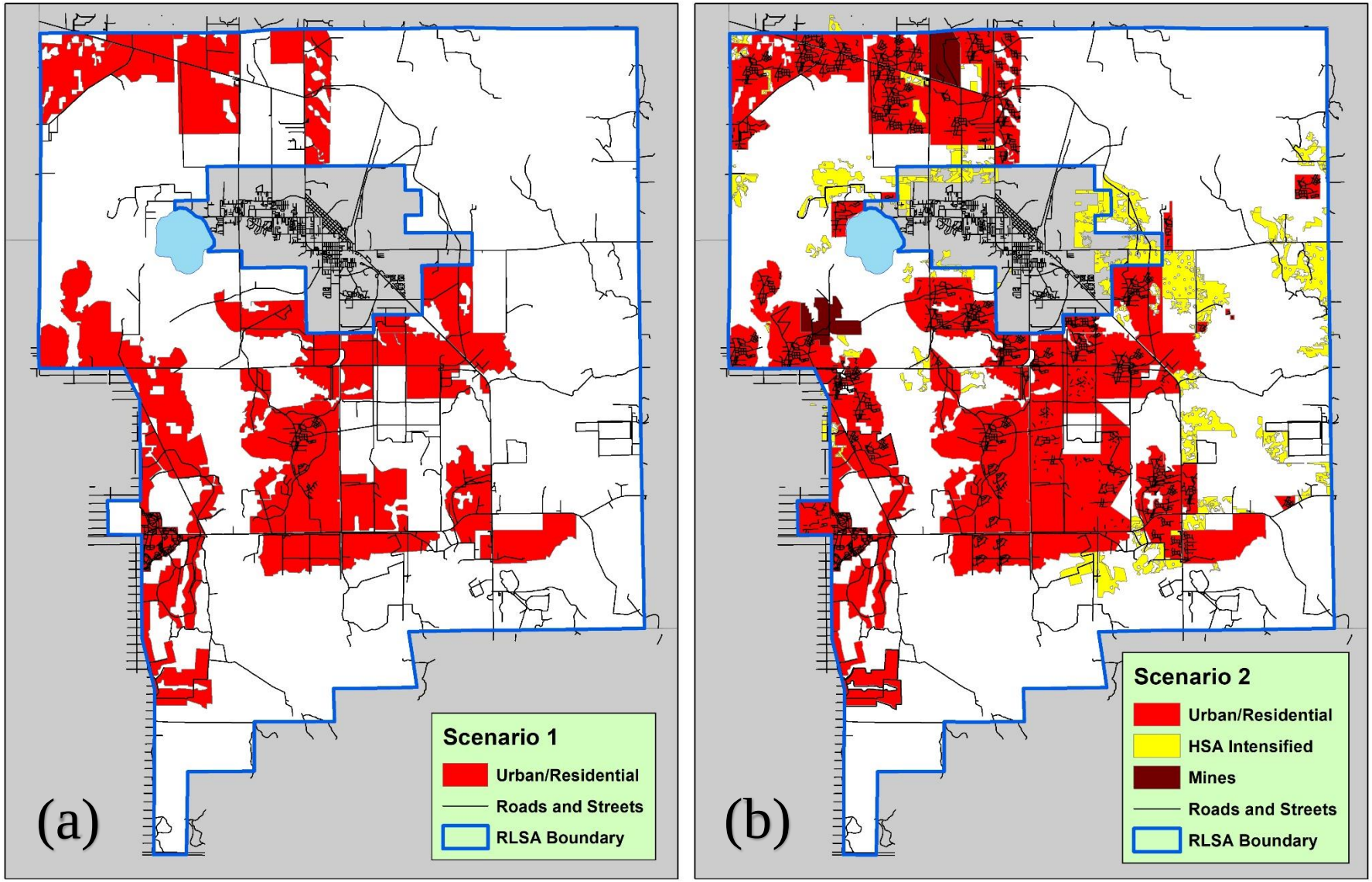

Figure 2. Landscape changes within the RLSA that are reasonably certain to occur if the ECMSHCP is approved. (a) Scenario 1 shows increased development and roads as proposed in the draft ECMSHCP. (b) Scenario 2 shows additional residential developments, intensified agriculture, new mines, and additional roads and streets that may occur beyond those proposed in the ECMSHCP.

Road density

The total length of roads in each cell in the study area for each of the three scenarios (existing conditions, Scenario 1, and Scenario 2) was calculated. The original road layer used in the south Florida model was based on the 2011 TIGER/Line shapefiles of Florida roads (U.S. Census Bureau 2011). Roads classified as four-wheel drive, bike trails, or pedestrian trails were excluded, because these probably do not represent enough disturbance to impact panther use of an area. An analysis provided to Collier County from Stantec of the road network needed to support 45,000 acres of development in the study area was used to estimate the road density under Scenario 1.[4] New roadways from this shapefile were added to the existing roads from the TIGER/Line 2011 shapefile as utilized in Frakes et al. 2015. Proposed internal roads from the Rural Lands West project were also digitized from plans submitted to Collier County and dated October 2017. The resulting roads layer (Fig. 2a) was then intersected with the study area grid to obtain road densities for each cell for Scenario 1.

Forest edge

As a possible measure of prey availability (i.e., panther hunting habitat), forest edge was an important variable in the south Florida model. Forest edge was calculated for each of the three scenarios (existing conditions, Scenario 1, and Scenario 2) based on the land cover layer for each scenario. See Frakes et al. (2015) for details on the calculation method. The values of the forest edge variable for existing conditions would be identical to Frakes et al. (2015). The amount of forest edge would be expected to decrease under Scenario 1, due to the increase of non-edge-forming residential and commercial (urban) areas.

Hydrology

Average dry and wet season water depths were important predictors of panther presence in the south Florida model. Because no information was available on potential changes in hydrology due to development in the RLSA, these variables were held constant (unchanged from existing conditions). However, large residential developments may produce significant changes in hydrology, both locally and possibly in downstream areas within and outside the RLSA. Therefore, the results of this exercise may be conservative in regards to the additive impact on the landscape from changes in hydrology, as well as climate change and sea level rise.

Scenario 2

Land cover

In addition to Scenario 1, reasonably foreseeable changes to land cover that may occur as a result of the proposed ECMSHCP were examined. Scenario 2 is a hypothetical worst-case scenario because specific information on changes that may occur in addition to those proposed in the ECMSHCP (Scenario 1) are lacking. As the RLSA program is an overlay, the study area includes lands that are not owned by the ECMSHCP applicants, and the applicants have proposed additional developments outside of the ECMSHCP process. Therefore, it is certainly reasonable to assume that additional development, intensification, road building, etc. will occur beyond what is proposed in Scenario 1, although these additional changes may not occur in the exact locations and extent as proposed here. The Scenario 2 analysis is presented as a

[4] Shapefiles entitled "RLSA_Buildout_RoadPlans" dated November 11, 2008 provided to the Conservancy of Southwest Florida by Collier County on December 8, 2008.

generalized example of possible indirect and cumulative effects that may occur beyond those specified in the ECMSHCP.

1. Scenario 2 assumes that Immokalee Sand Mine and Hogan Island Quarry will be mined, as is currently proposed (Fig. 2b).

2. Given the infrastructure that will be required to serve the proposed 45,000 acres of new towns and developments, the likelihood of adjacent development outside of the ECMSHCP Covered Activities area, either as dense urban developments or ranchettes, is increased. Thus, Scenario 2 assumes that the remaining 4,848 acres of lands identified as potential Covered Activities within the envelope provided by the applicants will be developed. Additionally, Scenario 2 assumes approximately 12,000 acres of adjacent lands owned by non-participants in the ECMSHCP may also be developed, as these landowners may apply for approval as an SRA or develop at the baseline one unit per five acres. The increase in urban/residential cover types assumed in Scenario 2 is shown in Fig. 2b.

3. Of the proposed Covered Activities, about 37,600 acres are row crops/groves and about 5,800 acres are pastures (Stantec 2015). To replace lost agriculture lands that will be converted to mines or rooftops, it is likely that intensification of natural and agricultural lands to active or more intense agriculture will occur. To account for this, the model assumes that approximately 13,000 acres of lands will be intensified. Largely, the areas assumed be intensified are in the RLSA Habitat Stewardship Areas (HSA). These lands may be intensified to pasture and row crops. The intensification was split equally between improved pasture and row crops, which have different land cover classes in the model. The intensification categorization was informed by surrounding and existing land uses; areas where grasslands were surrounded by or adjacent to existing agricultural operations were targeted as most likely locations for intensification or conversion. The assumed HSA intensification is shown in Fig. 2b.

Population density

All areas reclassified as additional urban land cover under Scenario 2 were assigned a new human population density value (people/km^2). The densities assigned to the new towns and villages are based on the proposed densities for Rural Lands West and the actual densities in Ave Maria. The additional residential areas under Scenario 2 added approximately 16,600 more people to the RLSA in approximately 6,400 new dwelling units. These additions brought the total population under Scenario 2 to approximately 319,600 in 123,400 new dwelling units.

Road density

Increasing road density can have a pronounced negative effect on adult panther use of an area (Frakes et al. 2015). Unfortunately, no information was available regarding projected road and street patterns following implementation of the residential developments proposed in the ECMSHCP. Therefore, the existing road density and patterns of the first town in the RLSA, Ave Maria, were replicated in likely town centers within the Covered Activities area. The new roads were added to the Scenario 1 road layer and used to compute estimated values for the road

density variable for Scenario 2. These new roads are approximations of what may be needed in order to support the residential densities proposed (Fig. 2b).

Forest edge

Forest edge was recalculated based on the assumed changes in land cover for Scenario 2. The amount of forest edge would be expected to decrease compared to Scenario 1, due to the addition of more urban, mining and agricultural areas. These non-natural cover types are not classified as edge-forming in the panther habitat model.

Hydrology

No change (see above).

RESULTS

Model Validation

The model was validated for the area in and surrounding the RLSA using GPS telemetry monitoring data supplied by the Florida Fish and Wildlife Conservation Commission (D. Onorato, pers. comm., 2018). All GPS locations of adult panthers (>3 years old) collected from 2005 to 2012 within approximately a 20 km radius of the RLSA boundary were used (33,318 locations). The GPS locations were not part of the training dataset. The model correctly predicted 97.7 percent of the GPS locations to be adult panther breeding habitat, indicating high model accuracy in this part of the panther's range (Fig. 3).

Effects on Quantity (Areal Extent) of Panther Habitat

Entire RLSA

The total area of the RLSA was calculated as 790.4 km^2 (195,300 ac). This area overlaps, wholly or in part, 895 grid cells from the south Florida panther habitat model (Frakes et al. 2015). During the 10-year period from 2004 through 2013, the RLSA contained parts of the home ranges of 27 radio-collared adult panthers (Fig. 4). Since only about half of panthers were collared during that time (Frakes et al. 2015), it is clear that the RLSA was (and is) extensively used by adult panthers as part of their breeding home ranges.

The areal extent of adult panther habitat in the RLSA as predicted by the model under existing conditions (pre-HCP) is shown in Fig. 5. Most of the habitat is south of County Road 858, adjacent to Florida Panther National Wildlife Refuge. There are also significant patches of habitat in the northeast and northwest corners of the RLSA, near the CREW and Okaloacoochee Slough, respectively. In addition, two narrow habitat corridors can be seen extending from south to north on each side of the RLSA.

The RLSA currently contains about 376.5 km^2 (93,000 ac) of adult panther breeding habitat (Table 1). This represents about 47.6 percent of the entire RLSA. Under Scenario 1 (proposed ECMSHCP), the model predicted that the RLSA will lose 67.9 km^2 (16,800 ac) of adult panther

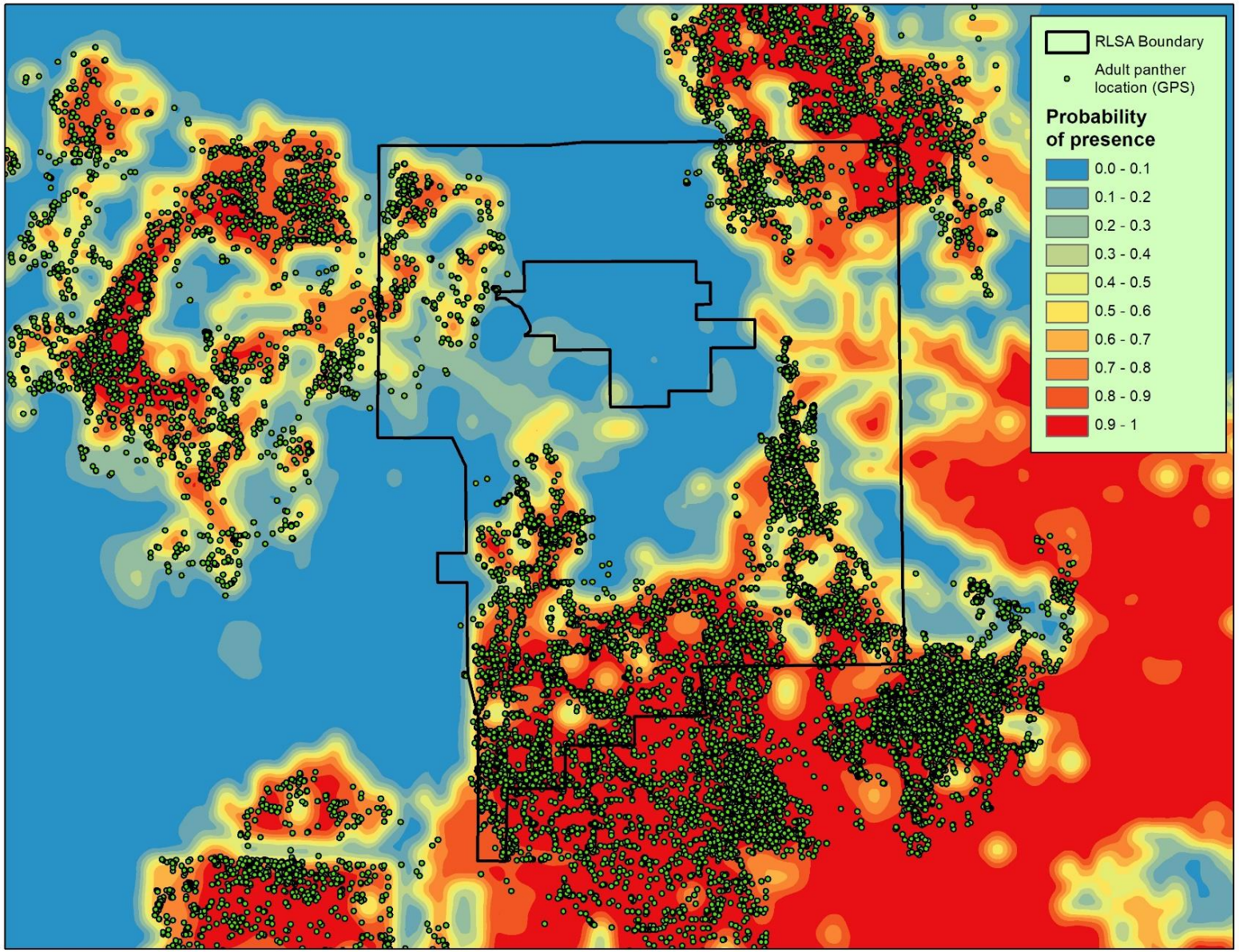

Figure 3. Model validation using GPS data (2005-2012) for adult panthers in the RLSA and surrounding area. Greater than 97 percent of GPS locations fell within areas classified by the model as adult panther habitat.

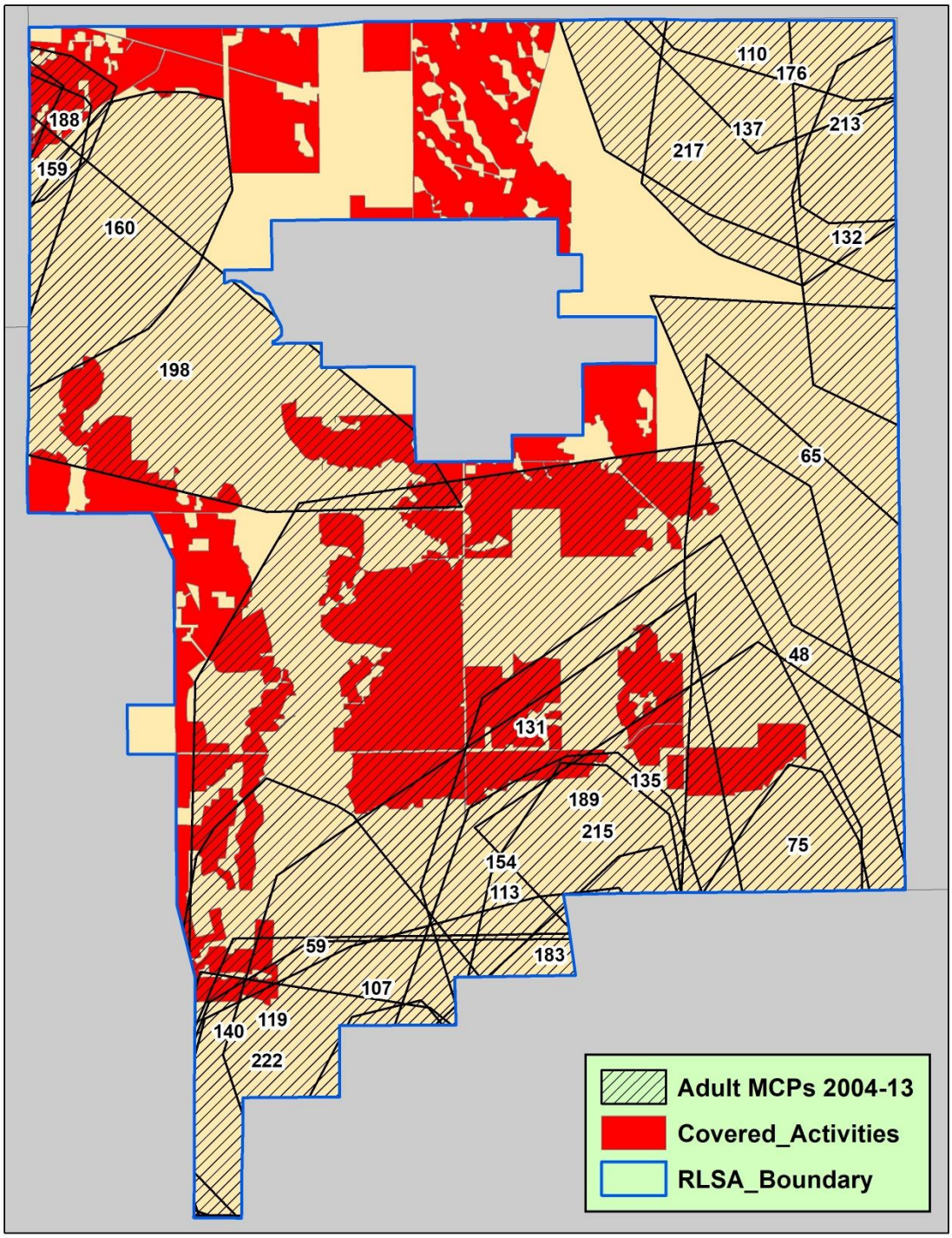

Figure 4. Minimum convex polygon adult panther home ranges within the RLSA in 2004-2013. Figure shows the minimum historical use of the RLSA by adult panthers. Actual use may be greater because panther numbers have increased in recent years and many adult panthers were not radio-collared.

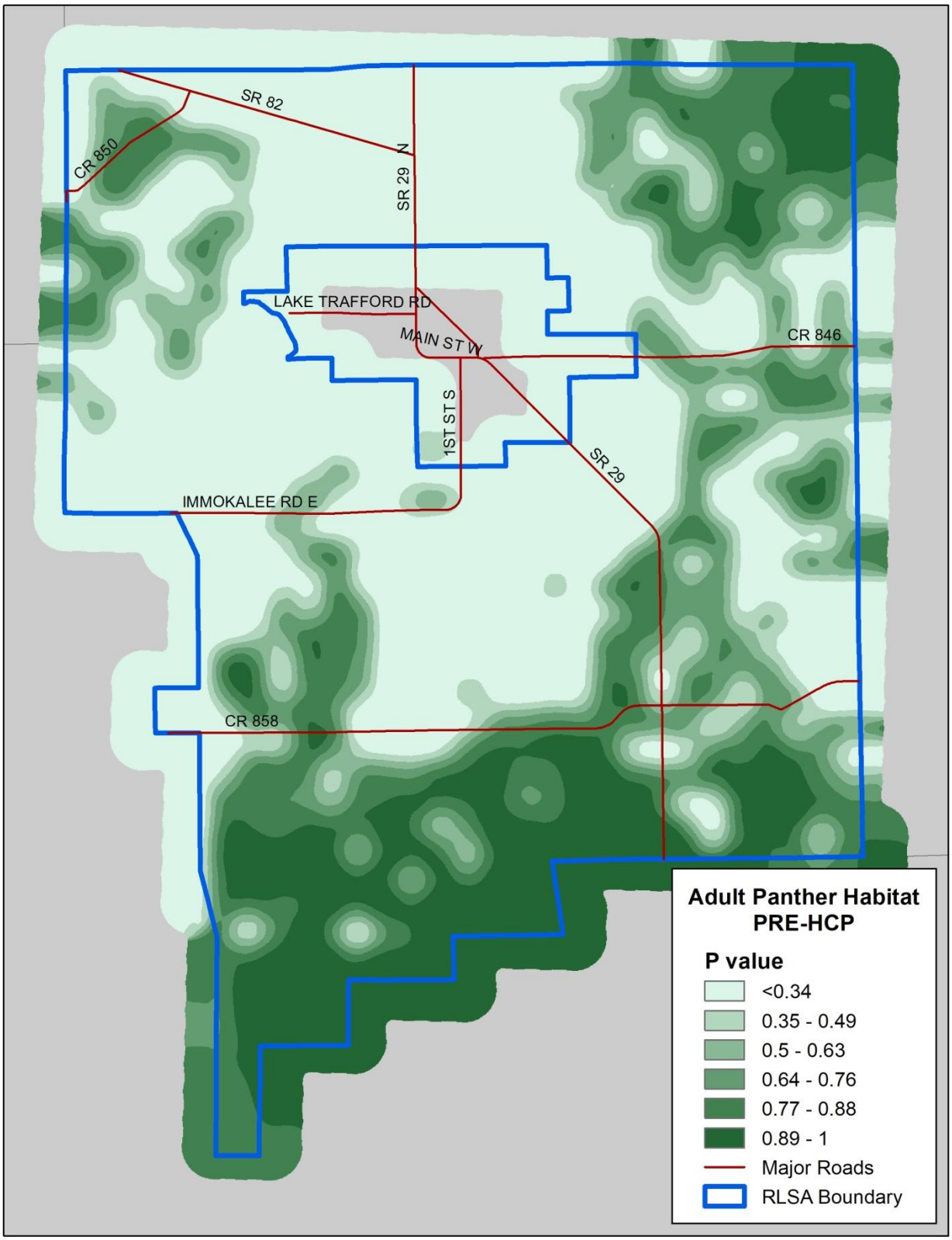

Figure 5. Areal extent of adult panther habitat within the RLSA under existing (pre-HCP) conditions. Areas with $P > 0.34$ are considered to be adult (breeding) panther habitat.

breeding habitat. This represents 18 percent of the remaining habitat within the RLSA (Fig. 6, Table 1). Impacts to panther habitat were considerably greater under Scenario 2. The RLSA was predicted to lose an additional 18.8 km^2, bringing the total habitat loss under Scenario 2 to 86.7 km^2 (21,400 ac). This represents a loss of 23.0 percent of the existing breeding habitat within the RLSA (Fig. 7, Table 1).

Covered Activities

The total area of the Covered Activities (CA) envelope presented in the draft ECMSHCP was 201.8 km^2 (49,900 ac). This area impacted, wholly or in part, 386 grid cells from the south Florida model (Table 1). During the 10-year period from 2004 to 2013, the CA area contained parts of the home ranges of 17 radio-collared adult panthers (Fig. 4). Since only about half of panthers were radio-collared during that time (Frakes et al. 2015), it is clear that the CA area was (and is) extensively used by adult panthers as part of their breeding home ranges. During the same time period, 60.4 percent of the CA area overlapped with the minimum convex polygon (MCP) home ranges of adult panthers. Development within the CA area may cause shifts in many home ranges, resulting in increased competition for prey and possibly intraspecific aggression among males.

Although the CA area is mostly agricultural land, it does overlap with a significant number of cells classified as adult panther habitat by the model. Under existing (pre-HCP) conditions, the CA area currently contains about 50.6 km^2 (12,500 ac) of adult panther breeding habitat (Table 1). This represents about 25.1 percent of the CA lands. Nearly all of the existing panther habitat in the CA area will be destroyed by development under the proposed ECMSHCP. Under Scenario 1, the CA area was predicted to lose 43.2 km^2 (85.4 percent) of its existing adult panther habitat. Nearly all of these losses are on the southern and western areas of the CA. Under Scenario 2 assumptions, the model-predicted losses were 46.0 km^2 (90.9 percent) of existing habitat (Table 1).

Preserve Areas

The proposed "Preservation/Plan-Wide Activities" (PA) lands of the draft ECMSHCP measured 396.1 km^2 (97,900 ac) and overlapped all or parts of 686 grid cells from the south Florida model (Table 1). The PA area contains a large amount of adult panther habitat (239.0 km^2) (59,100 ac), which makes up 60.3 % of the total area.

Since the PA lands are located outside the area proposed for development, direct habitat losses in the PA area under Scenarios 1 and 2 would be expected to be small. Nevertheless, considerable habitat losses were predicted to occur there because of the proximity of parts of the PA to the CA areas, new roads in the PA area, and reasonably foreseeable agricultural intensification under Scenario 2. Under Scenario 1, the PA area was predicted to lose 19.2 km^2 (4753 ac) (8.0%) of panther breeding habitat. Under Scenario 2, the predicted loss increased to 27.3 km^2 (6744 ac) (11.4%) (Table 1). These losses are approximately the same size as the town of Ave Maria. The draft ECMSHCP erroneously assumed no loss of habitat function or extent within the PA lands and counted the entire area as compensation for impacts in the Covered Activities area. Any compensation calculation should take potential habitat impacts within the PA area into account.

Table 1. Direct impacts to adult panther habitat quantity and quality under Scenario 1 and Scenario 2. Totals are shown for the entire RLSA, Covered Activities envelope, and Plan-Wide/Preserve areas proposed under the ECMSHCP.

Area	Total area		Cells	Adult habitat extent[a]		Habitat extent loss			Overall habitat	Habitat quality
Scenario	(km^2)	(acres)	impacted	(km^2)	(acres)	(km^2)	(acres)	(%)	quality (ave. *P*)[b]	loss (%)
RLSA, total	790.4	195315	895							
Existing conditions				376.5	93040	-	-	-	0.454	-
Scenario 1				308.6	76261	67.9	16779	18.0	0.382	16.0
Scenario 2				289.8	71615	86.7	21425	23.0	0.348	23.4
Covered Activites	201.8	49856	386							
Existing conditions				50.6	12495	-	-	-	0.246	-
Scenario 1				7.4	1822	43.2	10673	85.4	0.097	60.5
Scenario 2				4.6	1137	46.0	11358	90.9	0.072	70.7
Preserves	396.1	97884	686							
Existing conditions				239.0	59069	-	-	-	0.578	-
Scenario 1				219.8	54315	19.2	4753	8.0	0.520	10.0
Scenario 2				211.8	52324	27.3	6744	11.4	0.494	14.4

[a]Habitat extent is the total area of all cells with $P > 0.34$.

[b]Overall habitat quality of an area was based on the area-weighted average *P* for all cells.

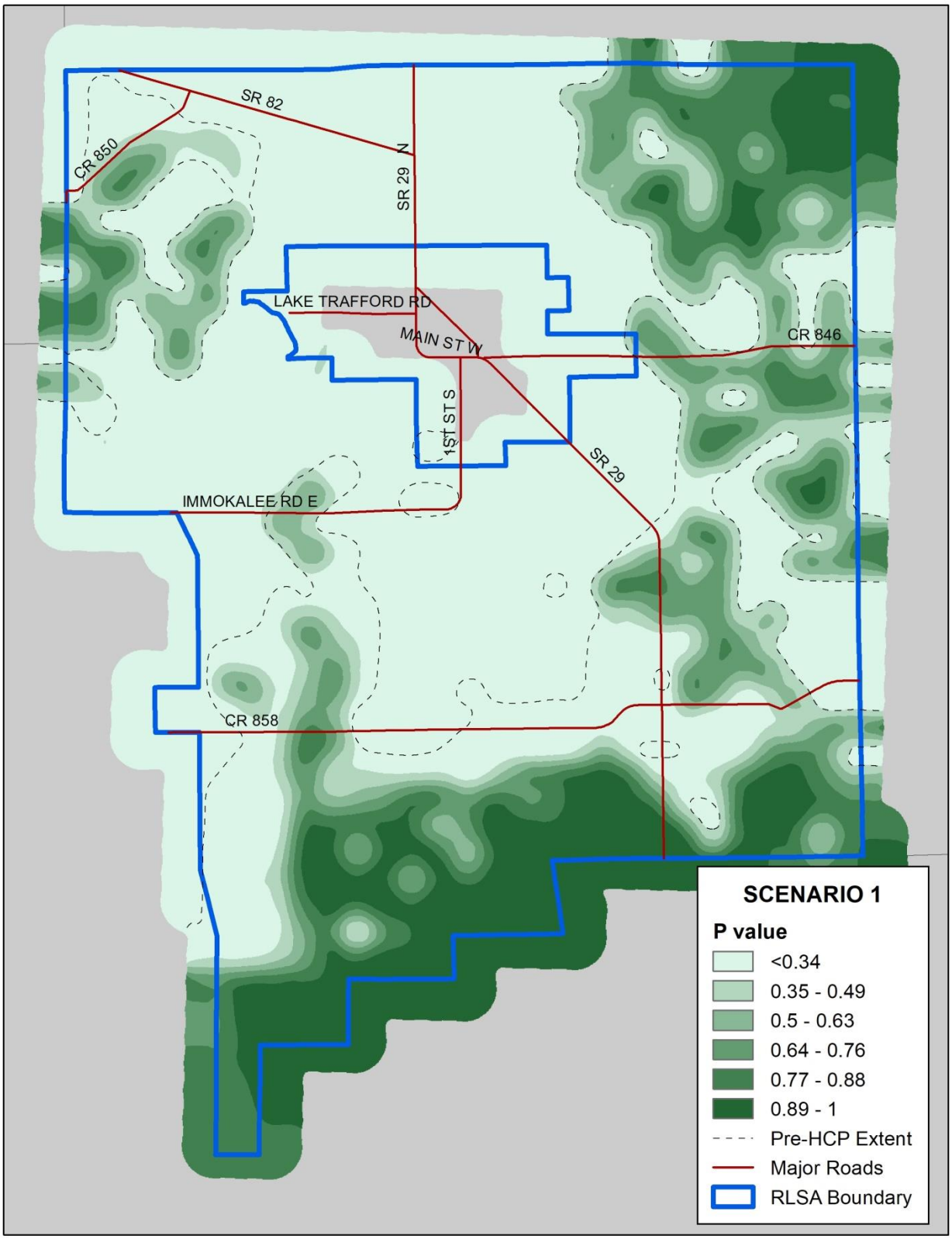

Figure 6. Areal extent of adult panther habitat within the RLSA under Scenario 1 (ECMSHCP as proposed). Areas with $P > 0.34$ are considered to be adult (breeding) panther habitat. For comparison, dashed line indicates panther habitat as it currently exists, showing the predicted loss in extent under Scenario 1.

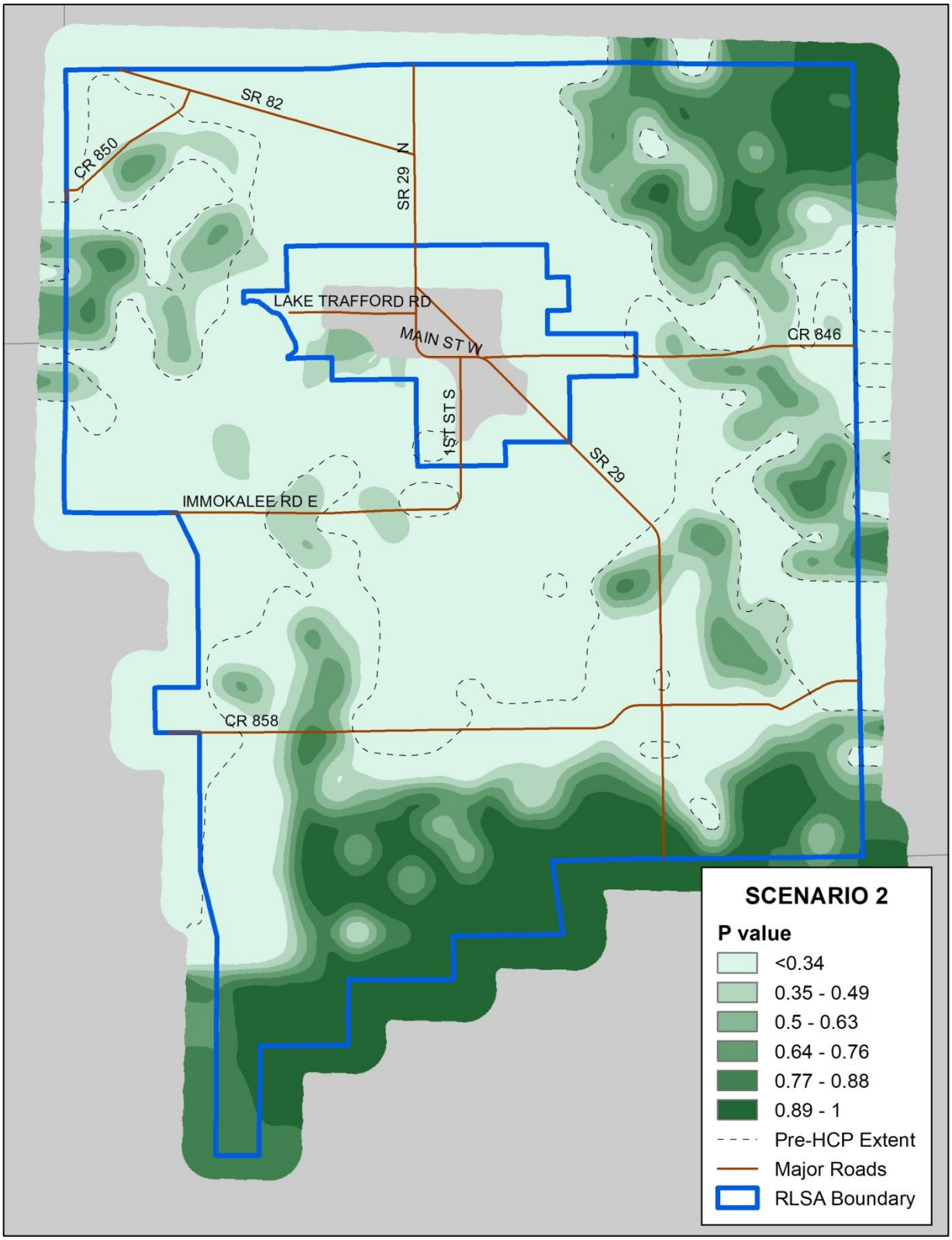

Figure 7. Areal extent of adult panther habitat within the RLSA under Scenario 2. Areas with $P > 0.34$ are considered to be adult (breeding) panther habitat. For comparison, dashed line indicates panther habitat as it currently exists, showing the predicted loss in extent under Scenario 2.

Effects on Panther Habitat Quality

Looking at panther habitat quality using averages over a large area can be misleading because habitat quality can vary tremendously depending on local conditions. For example, individual grid cells within the RLSA varied from $P = 0$ to $P = 0.99$. However, average values of P as reported in this section can give an idea of the overall decline in habitat function caused by a large development such as the ECMSHCP.

The area-weighted average P value of the RLSA under existing conditions was 0.454. This dropped to 0.382 under Scenario 1 (a 16% loss), and 0.348 under Scenario 2 (a 23.4% loss) (Table 1). For comparison, our previous study found that the minimum average value of home ranges of resident adult panthers was about 0.4 (Frakes et al. 2015). The most severe impacts under Scenario 1 were predicted in the southern and southwestern portions of the Covered Activities area (Fig. 8). Much of the additional impact under Scenario 2 was due to agricultural intensification projected to occur along the east central part of the RLSA (Fig. 9).

Although much of the CA area is of low-medium value to adult panthers, it does contain some high-quality habitat, particularly in the southern parts and along the edges. Approximately 25 percent of the CA lands were classified as adult panther habitat by this model. The area-weighted average P value of the entire CA area was only 0.246. However, habitat quality within the CA lands varied tremendously depending on location, which explains why many panthers included parts of the CA in their home ranges (Fig. 4). For example, CA lands south of County Road 858 (Oil Well Road) are mostly high-quality panther habitat (average $P = 0.658$).

The overall loss of habitat quality in the CA under Scenarios 1 and 2 was 60.5% and 70.7%, respectively. The area-weighted average P value dropped from 0.246 to 0.097 (Scenario 1) and 0.072 (Scenario 2), indicating that the CA area will be almost useless to panthers post-development under either scenario (Table 1). The portion of the CA known as Rural Lands West was especially damaging to the adjacent north-south habitat corridor (Camp Keais Strand). Covered Activities also damaged the north-south corridor near SR29 (Summerlin Swamp) (Figs. 10 and 11). Much of the loss in habitat function and extent could be avoided by limiting development to areas north of CR858.

The PA area under existing conditions has an area-weighted average P value of 0.578, making it suitable overall for use by breeding adult panthers as part of their home range. As with the other areas, individual grid cell values varied over a wide range from 0 to 0.99. Since the PA land is outside the area of proposed development, habitat quality losses were predicted to be relatively less than the other areas, but it was still affected for the reasons described above. The PA area was predicted to lose between 10.0 to 14.4 percent of existing habitat quality depending on which assumptions were modeled. The area-weighted average P value dropped from 0.578 to 0.520 (Scenario 1) and 0.494 (Scenario 2), suggesting that the PA area will still be useful to adult panthers post-development, provided no further intensification of land uses occurs (Table 1).

Minimizing Direct Impacts to Panther Habitat

The locations within the RLSA where the greatest impacts to adult panther habitat were predicted to occur are shown in Figs. 8 and 9. Fig. 8 shows the areas of greatest impact to

panther habitat that will result under the ECMSHCP as currently proposed (Scenario 1). The areas of greatest loss of habitat are shown in relation to the Covered Activities area identified in the Plan. Habitat loss is represented by the decrease in *P* before development (existing conditions) compared to after development (P_{existing} minus $P_{\text{scenario 1}}$).

As shown, some parts of the CA area caused a large loss of panther habitat value, while other areas caused less severe impacts. Impacts were greatest where existing high value panther habitat is slated for residential development. Minimization of effects (as required under the Endangered Species Act) could be achieved by simply relocating the CA boundaries to avoid the high impact areas shown in Fig. 8 (orange and red areas on the map).

Fig. 9 shows additional areas of habitat loss projected to occur under Scenario 2. Most of these additional losses are due to possible agricultural intensification projected under Scenario 2. These additional losses could be avoided/minimized by requiring that current land uses in those areas be maintained (i.e., no intensification in those parts of the Preservation/Plan-Wide Activities that have panther habitat value).

Without changes to the proposed ECMSHCP such as those recommended above, approval of the Plan will result in substantial losses of panther habitat quality scattered over a wide area of the RLSA, as shown in Figs. 8 and 9.

Impacts to Habitat Connectivity and Dispersal Pathways

The analysis shown in Figs. 10 and 11 was intended to examine potential impacts to connections between the main body of habitat to the south and the Okaloacoochee Slough and Corkscrew Swamp to the north. Adverse impacts to these connections may be even more damaging than direct habitat losses in certain areas, because they could block or hinder the movement of panthers between these areas of excellent habitat and impact the potential for panthers to disperse north across the Caloosahatchee River. Since dispersal of panthers across the Caloosahatchee River is a requirement for recovery, impacts to these pathways will reduce the likelihood of panther recovery.

As shown in Figs. 10 and 11, north-south pathways in the areas of the Camp Keais Strand and Summerlin Swamp within the RLSA may be broken or significantly narrowed by approval of the ECMSHCP. The model predicts that the northward extension of habitat on the western side of the RLSA (towards the Corkscrew Swamp) will be significantly narrowed and shortened (Fig. 10). This corridor was already a limited connection, which will be decimated even further by the proposed development. The fairly strong existing connection to the Okaloacoochee Slough through the eastern side of the RLSA will be completely broken, especially under Scenario 2 (Fig. 11).

Even though adult habitat connections to the north may be broken or narrowed, transient and dispersing panthers, which seem to be more tolerant of low quality habitat, may still be able to find their way north. However, it is likely that the degraded/reduced habitat along these pathways will adversely impact all north-south panther movements.

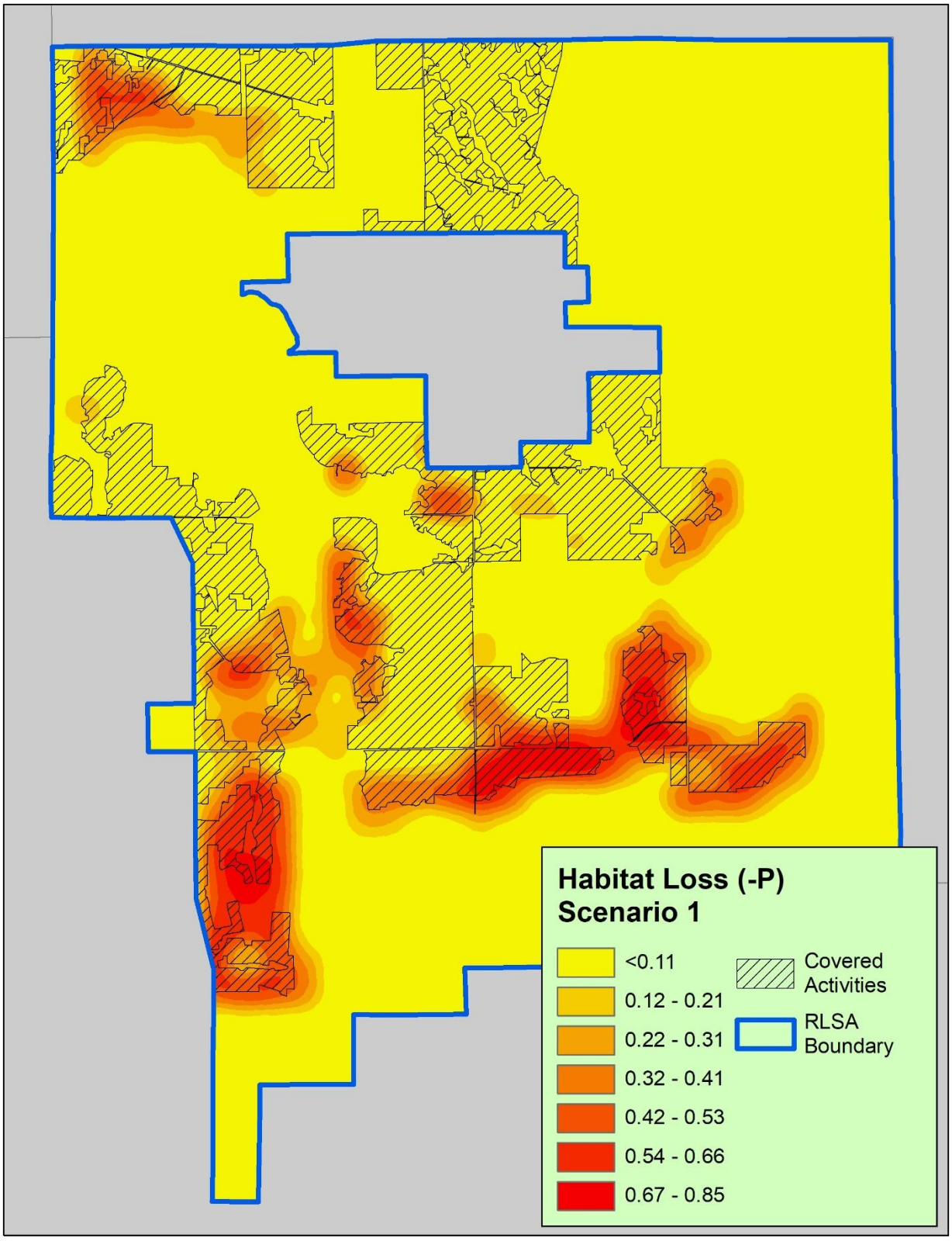

Figure 8. Losses to adult panther habitat quality (decrease in *P*) that are predicted to occur under the ECMSHCP (Scenario 1). Impacts to habitat are shown in relation to the Covered Activities area in the Plan.

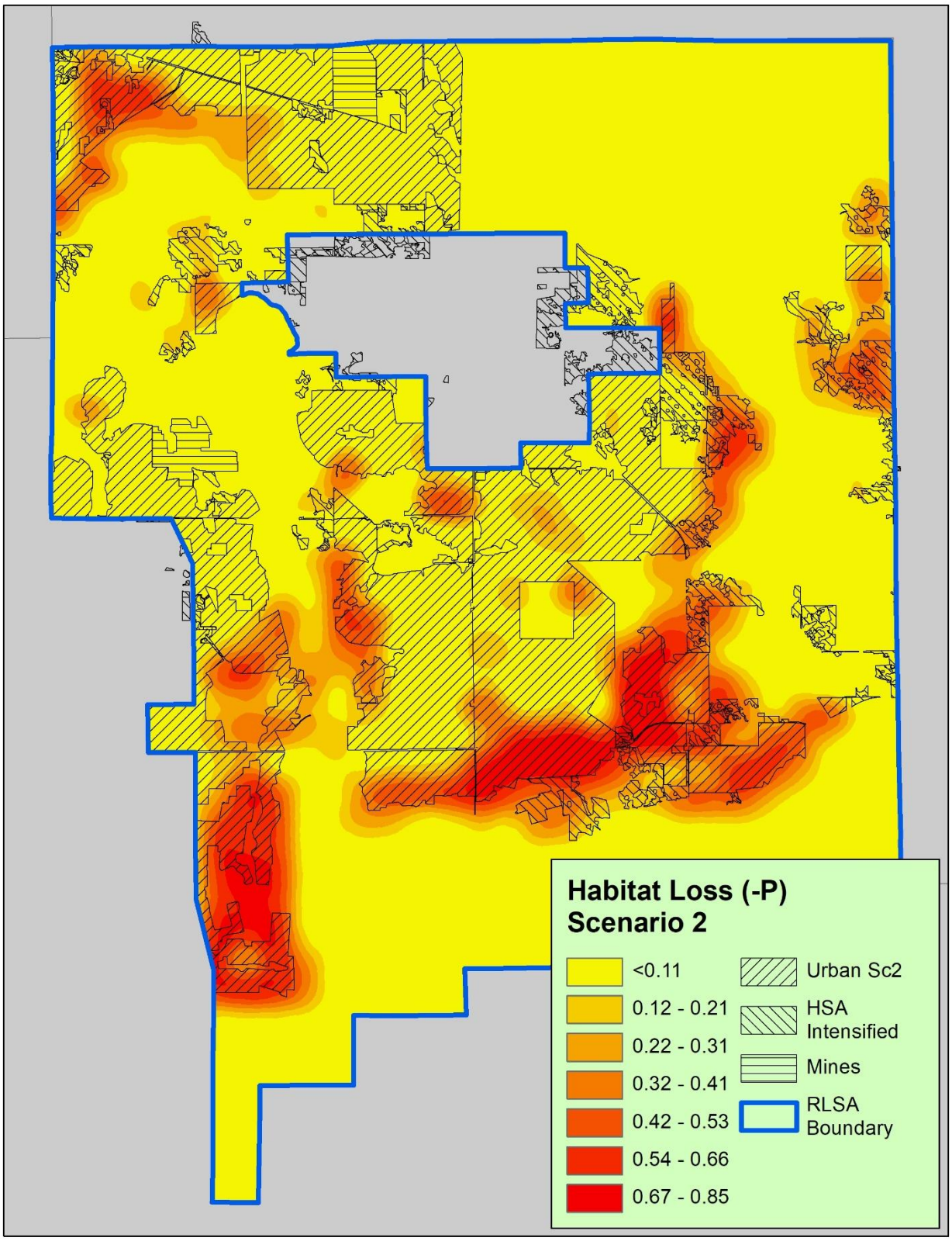

Figure 9. Losses to adult panther habitat quality (decrease in *P*) that are predicted to occur under Scenario 2. Impacts to habitat are shown in relation to the additional urban development, agricultural intensification, and new mines projected under this scenario.

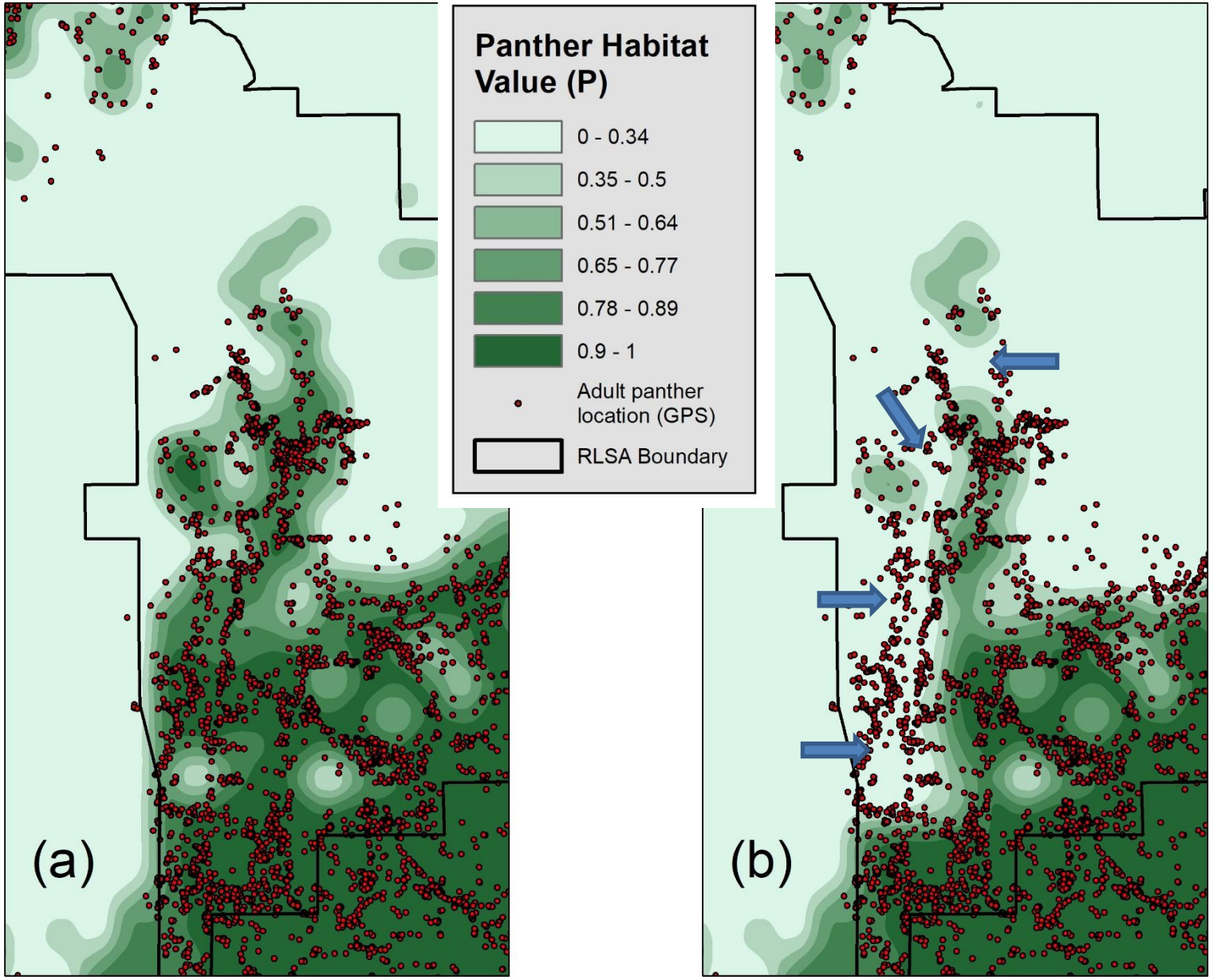

Figure 10. (a) Existing north-south panther habitat connection on the western side of the RLSA, between Florida Panther NWR and Corkscrew Swamp. (b) Model predicted changes after implementation of ECMSHCP (Scenario 1). The pathway that adult panthers use has been broken and substantially narrowed (arrows).

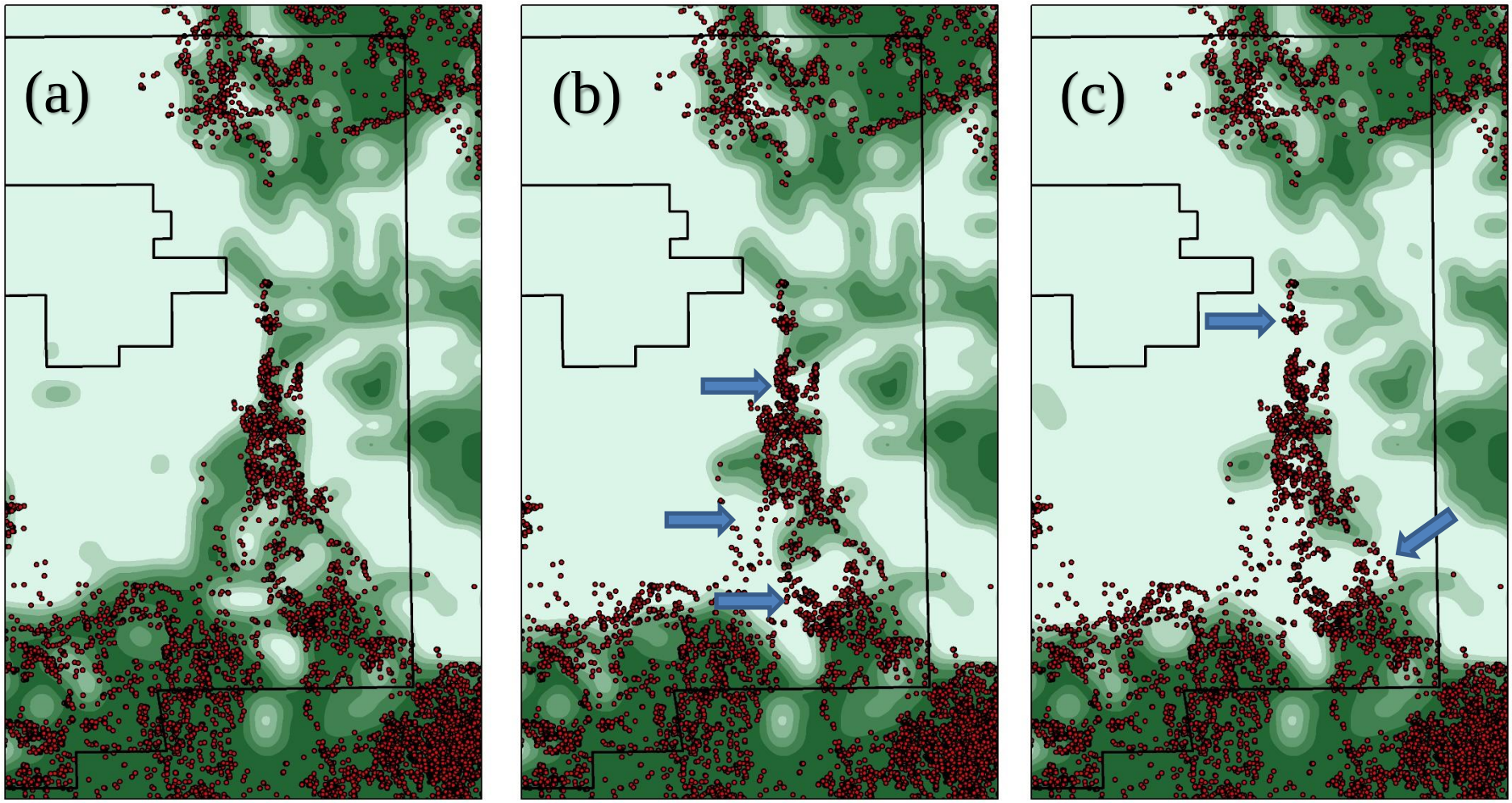

Figure 11. (a) Existing north-south panther habitat connection on the eastern side of the RLSA, between Florida Panther NWR and Okaloacoochee Slough. (b) Model predicted changes after implementation of ECMSHCP as proposed (Scenario 1). (c) Model predicted changes after implementation of ECMSHCP with additional plausible intensification (Scenario 2). The north-south pathway that adult panthers use has been broken in several places and substantially narrowed (arrows). (Legend same as previous figure).

DISCUSSION AND CONCLUSIONS

Section 10 of the Endangered Species Act (ESA) regarding Habitat Conservation Plans states that the Secretary shall issue the permit if he finds that the project "will not appreciably reduce the likelihood of survival and recovery of the species in the wild." Thus, the burden is on the USFWS to demonstrate that issuing the permit *will not* appreciably reduce this likelihood. The meaning of "appreciably" as used in the ESA has been the cause of much debate and confusion among wildlife biologists and managers. Webster's New Collegiate Dictionary defines appreciable as "capable of being perceived or measured; perceptible." Whatever meaning for the term is used, the reduction in habitat extent and quality, fragmentation, and erosion of dispersal corridors predicted in this report most certainly rises to that level.

Few would dispute the fact that the amount of available habitat is the most important factor affecting panther survival. It is also obvious that panther recovery is dependent on the ability of panthers, particularly females, to disperse northward to unoccupied habitats north of the Caloosahatchee River. In this analysis of impacts to panther habitat from the ECMSHCP, the best available quantitative modeling techniques were used to quantify (i.e., measure) losses to panther habitat from the proposed project. It was suggested that these habitat losses could be minimized by moving the impact area of the project outside of the zone of panther breeding habitat. Direct habitat losses that remain after moving the impact area should be compensated for by restoring degraded habitat along the fringes of the breeding zone to replace any habitat function lost.

Free movement of panthers north and south is essential for panther recovery. Highways and roads block panther movements and are a major cause of panther mortality. Highway underpasses and fencing are only partly effective in allowing free movement of panthers from one area to another. An analysis of adult panther home ranges shows that, although some panthers do cross highways, most resident, adult panther home ranges adjacent to major highways are limited to one side or the other and do not cross, even if the highway is equipped with underpasses.[5] Even if habitat losses could be minimized as described above, a development the size of the proposed ECMSHCP would necessitate a large network of multilane highways to provide ingress and egress to this large population center(s). These new roads, especially those running east and west, would impede panther movements and affect the size and shape of home ranges, potentially cutting some existing home ranges in two. Increased road kills will also occur. The ECMSHCP does not offer adequate compensation for these adverse road-related impacts, which will undoubtedly occur as a direct result of this Plan, even if substantial investments are made in crossings and underpasses.

Virtually all peer-reviewed publications and reports on panther conservation (e.g., Florida Panther Subteam 2002, Root 2004, Kautz et al. 2006, Frakes et al. 2015) have recommended complete protection and maintenance of habitat function and extent of the remaining primary zone and breeding habitat in order to achieve a viable panther population in south Florida. The following excerpts from Kautz et al. (2006) are clear:

[5] Frakes, unpublished analysis. Transient panthers and other wildlife do use highway underpasses and underpasses should always be included in highway designs.

> "The maintenance of existing home ranges and habitat function within the Primary Zone is essential to maintaining a viable Florida panther population. Assessments of potential impacts of proposed developments within the Primary Zone should strive to achieve *no net loss* (emphasis added) of landscape function or carrying capacity for panthers within the Primary Zone."

and;

> "Habitat quality, functionality, and availability for panthers must be maintained to ensure that no net loss of function or carrying capacity occurs. When adverse land uses within the Primary Zone are unavoidable, *affected lands should be compensated by the restoration or enhancement of habitat* (emphasis added) that maintains or increases the potential carrying capacity for panthers elsewhere within the Primary Zone."

Obviously, mere protection of existing agricultural uses, as proposed in the ECMSHCP, does not compensate, in the sense advised by Kautz et al., for the loss of habitat function and extent predicted in this study. In fact, the ECMSHCP as written would allow for intensification of uses within the Preserve/Plan-Wide Activities area (e.g., conversion from pasture to row crops), resulting in even more uncompensated loss of panther habitat value. In addition, most of the existing Preserve/Plan-Wide areas would already be protected from most forms of development by the RLSA policies contained in the Collier County Comprehensive Plan and Land Development Code. It is clear that the compensation proposed in the Plan amounts to little or no compensation at all. Meaningful compensation can only be achieved through acquisition and restoration of degraded lands to a natural landscape that provides a level of habitat function and extent equivalent to that lost to development. To approve the ECMSHCP without meaningful compensation (replacement of lost habitat function and extent) would be to ignore the recommendations of the leading experts in panther conservation (i.e., best available science).

In conclusion, approval of the ECMSHCP by the USFWS would appreciably reduce the likelihood of survival and recovery of the Florida panther, due to significant habitat loss and fragmentation. It would result in the direct loss of 68-87 km^2 (16,800-21,500 acres) of adult panther breeding habitat. In addition to the loss of areal extent of habitat, it would reduce the overall habitat quality within the RLSA by approximately 18-23 percent, and it would damage or break existing north-south dispersal corridors. Given the infrastructure required to support such a large human population, other indirect and cumulative impacts, though difficult to predict, will undoubtedly occur. The ECMSHCP provides little or no meaningful compensation for these adverse impacts and does not demonstrate minimization and mitigation to the maximum extent practicable.

Acknowledgments

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Literature Cited

Florida Fish and Wildlife Conservation Commission (FWC). 2014. Annual report on the research and management of Florida panthers: 2013–2014. Naples: Fish and Wildlife Research Institute & Division of Habitat and Species Conservation.

Florida Panther Subteam of the Multi-species/Ecosystem Recovery Implementation Team. 2002. Landscape Conservation Strategy for the Florida Panther in South Florida. Vero Beach, Florida.

Frakes RA, Belden RC, Wood BE, James FE. 2015. Landscape Analysis of Adult Florida Panther Habitat. PLoS ONE 10(7): e0133044.doi:10.1371/journal.pone.0133044

Kautz R, Kawula R, Hoctor T, Comiskey J, Jansen D, Jennings D, et al. 2006. How much is enough? Landscape-scale conservation for the Florida panther. Biological Conservation 130: 118–133.

Root, K. 2004. Florida panther (*Puma concolor coryi*): Using models to guide recovery efforts. Pages 491-504 *in* HR Akcakaya, M Burgman, O Kindvall, CC Wood, P Sjogren-Gulve, J Hatfield, and M McCarthy (eds). Species Conservation and Management, Case Studies. Oxford University Press, New York, NY.

Stantec. 2015. Eastern Collier Multiple Species Habitat Conservation Plan (ECMSHCP). First Draft. Prepared for Eastern Collier Property Owners and submitted to the U.S. Fish and Wildlife Service by Stantec Consulting Services, April 22, 2015.

U.S. Census Bureau. 2011. TIGER/Line shapefiles of Florida roads. Washington, D.C.: U.S. Census Bureau. http://www.census.gov.

U.S. Fish and Wildlife Service (USFWS). 2012. Panther Habitat Assessment Methodology. South Florida Ecological Services Office home page. https://www.fws.gov/verobeach/ListedSpeciesMammals.html#fp

APPENDIX

Raw Model Outputs for 895 Grid Cells

In the Study Area

cell	P_before	P_Sc1	P_Sc2
9555	0.802	0.802	0.802
9556	0.848	0.848	0.848
9557	0.836	0.836	0.836
9683	0.826	0.826	0.826
9684	0.852	0.852	0.852
9685	0.892	0.892	0.892
9810	0.832	0.832	0.832
9811	0.84	0.84	0.84
9812	0.972	0.972	0.972
9937	0.804	0.804	0.804
9938	0.918	0.918	0.918
9939	0.906	0.906	0.906
10064	0.738	0.738	0.738
10065	0.93	0.93	0.93
10066	0.962	0.962	0.962
10067	0.974	0.974	0.974
10068	0.944	0.944	0.944
10069	0.984	0.984	0.984
10190	0.746	0.746	0.746
10191	0.984	0.984	0.984
10192	0.908	0.908	0.918
10193	0.976	0.976	0.976
10194	0.922	0.922	0.922
10195	0.922	0.922	0.922
10318	0.796	0.796	0.796
10319	0.976	0.976	0.976
10320	0.956	0.956	0.94
10321	0.974	0.974	0.974
10322	0.856	0.856	0.856
10323	0.958	0.958	0.958
10324	0.98	0.98	0.98
10325	0.996	0.996	0.996
10326	0.996	0.996	0.996
10327	0.988	0.988	0.988
10446	0.8	0.254	0.13
10447	0.902	0.202	0.09
10448	0.952	0.372	0.256
10449	0.966	0.548	0.53
10450	0.964	0.964	0.964
10451	0.952	0.952	0.952
10452	0.96	0.96	0.96
10453	0.944	0.944	0.944
10454	0.994	0.994	0.994
10455	0.978	0.978	0.978
10574	0.816	0.148	0.098
10575	0.102	0.216	0.072
10576	0.786	0.208	0.082
10577	0.964	0.61	0.572
10578	0.89	0.89	0.89
10579	0.024	0.024	0.024
10580	0.738	0.738	0.738
10581	0.86	0.86	0.86
10582	0.97	0.97	0.97
10583	0.988	0.988	0.988
10584	0.984	0.984	0.984
10585	0.972	0.972	0.972
10586	0.952	0.952	0.952
10587	0.982	0.982	0.982
10699	0.088	0.104	0.104
10700	0.854	0.152	0.08
10701	0.94	0.362	0.278
10702	0.848	0.254	0.058
10703	0.856	0.856	0.856
10704	0.962	0.962	0.962
10705	0.928	0.928	0.928
10706	0.968	0.968	0.968
10707	0.966	0.966	0.966
10708	0.974	0.974	0.974
10709	0.986	0.986	0.986
10710	0.962	0.962	0.962
10711	0.97	0.97	0.97
10712	0.982	0.982	0.982
10713	0.994	0.994	0.994
10823	0.06	0.074	0.074
10824	0.916	0.344	0.344
10825	0.952	0.276	0.276
10826	0.97	0.408	0.338
10827	0.962	0.962	0.962
10828	0.948	0.948	0.948
10829	0.962	0.962	0.962
10830	0.972	0.972	0.972
10831	0.43	0.43	0.43
10832	0.98	0.98	0.98
10833	0.868	0.868	0.868
10834	0.928	0.928	0.928
10835	0.944	0.944	0.944
10836	0.968	0.968	0.968
10947	0.08	0.054	0.05
10948	0.978	0.374	0.374
10949	0.96	0.106	0.106
10950	0.954	0.278	0.278
10951	0.994	0.994	0.994
10952	0.99	0.99	0.99
10953	0.434	0.434	0.434
10954	0.974	0.974	0.974
10955	0.972	0.972	0.972
10956	0.982	0.982	0.982
10957	0.338	0.338	0.338
10958	0.952	0.952	0.952
10959	0.97	0.97	0.97
10960	0.938	0.938	0.938
10961	0.978	0.978	0.978
10962	0.988	0.988	0.988
10963	0.98	0.98	0.98
10964	0.972	0.972	0.972
10965	0.968	0.968	0.968
10966	0.94	0.94	0.94
10967	0.978	0.978	0.978
10968	0.892	0.892	0.892
10969	0.806	0.806	0.806
10970	0.716	0.716	0.716
10971	0.832	0.832	0.832
10972	0.964	0.964	0.964
11070	0.036	0.046	0.048
11071	0.89	0.166	0.166
11072	0.878	0.316	0.316
11073	0.762	0.17	0.186
11074	0.892	0.892	0.914
11075	0.878	0.878	0.9
11076	0.896	0.896	0.902
11077	0.932	0.932	0.942
11078	0.89	0.89	0.89
11079	0.338	0.338	0.338
11080	0.79	0.79	0.834
11081	0.994	0.994	0.994
11082	0.986	0.986	0.986
11083	0.9	0.9	0.9
11084	0.98	0.98	0.98
11085	0.974	0.974	0.974
11086	0.992	0.992	0.992
11087	0.996	0.996	0.996
11088	0.986	0.986	0.986
11089	0.076	0.076	0.076
11090	0.914	0.914	0.914
11091	0.886	0.886	0.886
11092	0.942	0.942	0.942
11093	0.248	0.248	0.248
11094	0.886	0.886	0.886
11095	0.868	0.868	0.868
11191	0.11	0.088	0.044
11192	0.786	0.248	0.248
11193	0.85	0.258	0.23
11194	0.772	0.204	0.18
11195	0.702	0.702	0.77
11196	0.4	0.4	0.286
11197	0.846	0.532	0.532
11198	0.878	0.652	0.648
11199	0.95	0.95	0.96
11200	0.92	0.92	0.92
11201	0.896	0.678	0.678
11202	0.968	0.968	0.968
11203	0.674	0.674	0.244
11204	0.766	0.766	0.452
11205	0.958	0.958	0.898
11206	0.966	0.966	0.964
11207	0.914	0.914	0.914
11208	0.918	0.918	0.918
11209	0.124	0.124	0.124
11210	0.146	0.146	0.146
11211	0.96	0.96	0.96
11212	0.982	0.982	0.982
11213	0.984	0.984	0.984
11214	0.908	0.908	0.908
11215	0.83	0.83	0.83
11312	0.062	0.036	0.024
11313	0.246	0.082	0.082
11314	0.892	0.076	0.068
11315	0.89	0.428	0.428
11316	0.856	0.856	0.856
11317	0.302	0.302	0.302
11318	0.76	0.348	0.348
11319	0.756	0.274	0.122
11320	0.666	0.222	0.094
11321	0.948	0.304	0.226
11322	0.892	0.11	0.11
11323	0.964	0.366	0.362
11324	0.8	0.8	0.558
11325	0.824	0.824	0.346
11326	0.976	0.976	0.754

11327	0.974	0.974	0.794	11575	0.836	0.33	0.33	11918	0.91	0.91	0.9
11328	0.906	0.906	0.704	11576	0.256	0.256	0.256	11919	0.822	0.34	0.34
11329	0.832	0.232	0.256	11577	0.744	0.744	0.744	11920	0.786	0.314	0.316
11330	0.81	0.31	0.308	11578	0.766	0.766	0.766	11921	0.064	0.188	0.188
11331	0.938	0.436	0.452	11672	0.052	0.052	0.088	11922	0.03	0	0
11332	0.982	0.83	0.83	11673	0.042	0.042	0.09	11923	0.03	0.04	0.04
11333	0.984	0.984	0.984	11674	0.06	0.07	0.054	11924	0.346	0.012	0.014
11334	0.96	0.96	0.96	11675	0.95	0.758	0.758	11925	0.104	0.244	0.036
11335	0.778	0.778	0.778	11676	0.98	0.72	0.72	11926	0.242	0.382	0.202
11336	0.62	0.62	0.62	11677	0.256	0.222	0.222	11927	0.09	0.248	0.054
11432	0.03	0.03	0.04	11678	0.808	0.524	0.53	11928	0.122	0.122	0.006
11433	0.044	0.044	0.092	11679	0.794	0.794	0.84	11929	0.898	0.278	0.248
11434	0.05	0.04	0.028	11680	0.686	0.288	0.302	11930	0.746	0.228	0.046
11435	0.122	0	0	11681	0.004	0.006	0.002	11931	0.748	0.158	0.062
11436	0.28	0.112	0.104	11682	0.012	0.024	0.002	11932	0.112	0.112	0.1
11437	0.206	0.334	0.334	11683	0.106	0.058	0.058	11933	0.84	0.84	0.84
11438	0.978	0.978	0.978	11684	0.738	0.056	0.068	11934	0.742	0.742	0.742
11439	0.94	0.784	0.784	11685	0.046	0.018	0.018	11935	0.216	0.216	0.37
11440	0.166	0.196	0.196	11686	0.092	0.214	0.078	11936	0.172	0.172	0.28
11441	0.046	0.038	0.026	11687	0.166	0.298	0.008	11937	0.14	0.14	0.176
11442	0.078	0.024	0.02	11688	0.162	0.162	0.39	11938	0.068	0.068	0.098
11443	0.156	0.06	0.062	11689	0.946	0.106	0.076	12035	0.038	0.014	0.008
11444	0.834	0.062	0.062	11690	0.918	0.226	0.046	12036	0.062	0.062	0.016
11445	0.882	0.15	0.148	11691	0.172	0.03	0.018	12037	0.05	0.066	0.012
11446	0.924	0.068	0.048	11692	0.834	0.834	0.182	12038	0.76	0.34	0.22
11447	0.934	0.104	0.122	11693	0.79	0.666	0.308	12039	0.258	0.258	0.258
11448	0.95	0.158	0.158	11694	0.066	0.114	0.082	12040	0.896	0.322	0.322
11449	0.958	0.65	0.55	11695	0.804	0.332	0.342	12041	0.716	0.142	0.142
11450	0.214	0.152	0.14	11696	0.746	0.746	0.104	12042	0.006	0	0
11451	0.058	0.02	0	11697	0.028	0.028	0.028	12043	0.004	0.004	0.004
11452	0.26	0.042	0.028	11698	0.1	0.1	0.114	12044	0.018	0.008	0.008
11453	0.906	0.074	0.074	11794	0.1	0.068	0.046	12045	0.02	0.026	0
11454	0.778	0.214	0.214	11795	0.942	0.26	0.26	12046	0.086	0.112	0.066
11455	0.954	0.696	0.696	11796	0.864	0.196	0.196	12047	0.222	0.222	0.222
11456	0.874	0.874	0.874	11797	0.23	0.128	0.128	12048	0.128	0.128	0.196
11457	0.706	0.706	0.706	11798	0.93	0.472	0.472	12049	0.112	0.112	0.002
11458	0.152	0.152	0.152	11799	0.84	0.74	0.742	12050	0.316	0.404	0.404
11552	0.092	0.092	0.162	11800	0.704	0.272	0.276	12051	0.89	0.362	0.35
11553	0.02	0.02	0.034	11801	0.074	0.076	0.042	12052	0.764	0.764	0.294
11554	0.092	0.028	0.012	11802	0.016	0	0	12053	0.67	0.67	0.264
11555	0.362	0.074	0.07	11803	0.02	0.046	0.046	12054	0.754	0.754	0.704
11556	0.916	0.468	0.468	11804	0.028	0.012	0.006	12055	0.22	0.22	0.348
11557	0.792	0.262	0.252	11805	0.022	0.014	0.01	12056	0.768	0.768	0.5
11558	0.88	0.682	0.682	11806	0.014	0.05	0.05	12057	0.114	0.114	0.322
11559	0.77	0.552	0.56	11807	0.136	0.232	0.01	12058	0.122	0.122	0.122
11560	0.048	0.07	0.07	11808	0.188	0.188	0.11	12059	0.112	0.112	0.164
11561	0.052	0.034	0.034	11809	0.844	0.228	0.066	12155	0.03	0.038	0.056
11562	0.006	0.032	0	11810	0.762	0.034	0.03	12156	0.08	0.118	0.006
11563	0.072	0.068	0.066	11811	0.118	0.078	0.002	12157	0.04	0.12	0.046
11564	0.106	0.088	0.044	11812	0.75	0.75	0.046	12158	0.188	0.188	0.188
11565	0.714	0.022	0	11813	0.754	0.754	0.554	12159	0.192	0.192	0.192
11566	0.712	0.144	0.012	11814	0.664	0.664	0.664	12160	0.86	0.228	0.228
11567	0.834	0.11	0.004	11815	0.79	0.79	0.77	12161	0.102	0.208	0.208
11568	0.798	0.252	0.094	11816	0.122	0.122	0.236	12162	0.006	0.002	0.002
11569	0.786	0.076	0.07	11817	0.084	0.084	0.108	12163	0.002	0	0
11570	0.854	0.08	0.006	11818	0.034	0.034	0.036	12164	0.012	0.008	0.008
11571	0.814	0.116	0.052	11914	0.028	0.022	0.024	12165	0.002	0.006	0.002
11572	0.768	0.256	0.208	11915	0.058	0.006	0.008	12166	0.346	0.154	0.022
11573	0.102	0.032	0.038	11916	0.346	0.032	0.002	12167	0.074	0.08	0.118
11574	0.7	0.042	0.042	11917	0.66	0.34	0.204	12168	0.638	0.494	0.014

12169	0.106	0.094	0.022	12413	0.95	0.95	0.856	12653	0.826	0.332	0.284
12170	0.91	0.91	0.91	12414	0.834	0.834	0.834	12654	0.116	0.116	0.116
12171	0.906	0.906	0.906	12415	0.154	0.154	0.154	12655	0.228	0.228	0.228
12172	0.764	0.764	0.396	12416	0.148	0.148	0.148	12656	0.806	0.806	0.806
12173	0.686	0.686	0.166	12417	0.184	0.184	0.184	12657	0.92	0.92	0.822
12174	0.78	0.78	0.588	12418	0.186	0.186	0.186	12658	0.926	0.926	0.758
12175	0.13	0.13	0.256	12419	0.87	0.87	0.87	12659	0.308	0.308	0.396
12176	0.11	0.11	0.296	12510	0.014	0.014	0	12748	0.212	0.212	0.212
12177	0.046	0.046	0.03	12511	0.152	0.218	0.054	12749	0.268	0.346	0.322
12178	0.126	0.126	0.126	12512	0.25	0.236	0.208	12750	0.234	0.338	0.26
12179	0.062	0.062	0.1	12513	0.058	0.028	0.004	12751	0.096	0.068	0.066
12274	0.056	0.056	0.034	12514	0.012	0.028	0	12752	0.076	0.076	0.198
12275	0.03	0.062	0.016	12515	0.336	0.262	0.258	12753	0.212	0.212	0.246
12276	0.008	0.046	0.004	12516	0.126	0.2	0.266	12754	0.33	0.33	0.574
12277	0.122	0.244	0.122	12517	0.114	0.366	0.366	12755	0.212	0.212	0.212
12278	0.188	0.188	0.248	12518	0.284	0.284	0.284	12756	0.21	0.248	0.248
12279	0.908	0.908	0.678	12519	0.878	0.878	0.578	12757	0.15	0.25	0.246
12280	0.834	0.254	0.276	12520	0.218	0.266	0.124	12758	0.036	0.054	0.018
12281	0.222	0.16	0.202	12521	0.262	0.262	0.522	12759	0.024	0.042	0.002
12282	0.162	0.242	0.262	12522	0.228	0.402	0.402	12760	0.008	0.036	0
12283	0.192	0.196	0.2	12523	0.732	0.058	0.038	12761	0.636	0.23	0.21
12284	0.042	0.064	0.036	12524	0.688	0.04	0.038	12764	0.01	0.008	0.006
12285	0.022	0.034	0.018	12525	0.026	0.008	0.01	12765	0.006	0.046	0.028
12286	0.006	0.012	0.01	12526	0.204	0	0.002	12766	0.108	0.142	0.124
12287	0.002	0.002	0.036	12527	0.268	0.048	0.006	12767	0.234	0.138	0.15
12288	0.112	0.02	0.022	12528	0.01	0.016	0.01	12768	0.104	0.028	0.03
12289	0.024	0.044	0.044	12529	0.026	0.008	0	12769	0.014	0.018	0.024
12290	0.124	0.188	0.188	12530	0.02	0.002	0	12770	0.082	0.082	0.09
12291	0.912	0.532	0.492	12531	0.03	0.002	0	12771	0.814	0.814	0.124
12292	0.822	0.822	0.668	12532	0.094	0.03	0.046	12772	0.85	0.85	0.334
12293	0.168	0.168	0.314	12533	0.874	0.318	0.298	12773	0.228	0.228	0.228
12294	0.758	0.758	0.676	12534	0.11	0.11	0.11	12774	0.2	0.2	0.2
12295	0.244	0.244	0.244	12535	0.206	0.206	0.206	12775	0.36	0.36	0.36
12296	0.162	0.162	0.166	12536	0.252	0.252	0.252	12776	0.92	0.92	0.92
12297	0.814	0.814	0.814	12537	0.94	0.94	0.94	12777	0.34	0.34	0.502
12298	0.73	0.73	0.73	12538	0.866	0.866	0.766	12866	0.172	0.172	0.172
12299	0.78	0.78	0.76	12539	0.212	0.212	0.21	12867	0.768	0.332	0.276
12390	0.048	0.046	0.048	12630	0.092	0.202	0.138	12868	0.19	0.264	0.122
12391	0.098	0.054	0.052	12631	0.264	0.334	0.088	12869	0.188	0.288	0.288
12392	0.02	0.062	0.076	12632	0.24	0.308	0.274	12870	0.264	0.264	0.318
12393	0.01	0.014	0.02	12633	0.006	0.04	0.01	12871	0.346	0.346	0.33
12394	0.034	0.022	0.018	12634	0.058	0.046	0.002	12872	0.204	0.204	0.204
12395	0.058	0.118	0.036	12635	0.148	0.234	0.25	12873	0.2	0.2	0.2
12396	0.046	0.096	0.03	12636	0.2	0.2	0.398	12874	0.168	0.252	0.252
12397	0.176	0.206	0.206	12637	0.31	0.31	0.31	12875	0.134	0.162	0.122
12398	0.834	0.834	0.62	12638	0.28	0.28	0.28	12876	0.018	0.002	0.006
12399	0.17	0.17	0.328	12639	0.21	0.328	0.306	12877	0.016	0.042	0.002
12400	0.074	0.056	0.062	12640	0.834	0.082	0.074	12878	0.016	0.028	0.008
12401	0.168	0.238	0.242	12641	0.17	0.226	0.134	12879	0.07	0.096	0.122
12402	0.298	0.298	0.548	12642	0.22	0.22	0.172	12884	0.044	0.074	0.108
12403	0.128	0.26	0.26	12643	0.126	0.08	0.06	12885	0.212	0.132	0.04
12404	0.014	0.034	0.02	12644	0.1	0.032	0.016	12886	0.064	0.016	0.006
12405	0.008	0.076	0.014	12645	0.008	0.034	0.02	12887	0.096	0.074	0.082
12406	0.02	0.032	0.02	12646	0.016	0.048	0.052	12888	0.058	0.058	0.098
12407	0.274	0.274	0.016	12647	0.026	0.048	0.004	12889	0.684	0.684	0.138
12408	0.22	0.038	0.038	12648	0.054	0.116	0.03	12890	0.86	0.86	0.27
12409	0.052	0.008	0	12649	0.044	0.074	0.074	12891	0.932	0.932	0.932
12410	0.04	0.04	0.032	12650	0.082	0.006	0.008	12892	0.326	0.326	0.326
12411	0.092	0.058	0.026	12651	0.068	0.03	0.03	12893	0.344	0.344	0.344
12412	0.802	0.13	0.128	12652	0.106	0.028	0.03	12894	0.292	0.292	0.408

12895	0.2	0.2	0.238	13236	0.194	0.194	0.258	13578	0.84	0.84	0.596
12984	0.702	0.702	0.702	13237	0.03	0.03	0.088	13579	0.832	0.832	0.648
12985	0.18	0.368	0.352	13238	0.112	0.182	0.214	13580	0.28	0.28	0.498
12986	0.194	0.282	0.26	13239	0.822	0.822	0.066	13581	0.196	0.264	0.412
12987	0.234	0.234	0.234	13240	0.788	0.788	0.764	13582	0.008	0.008	0.248
12988	0.186	0.186	0.186	13241	0.244	0.244	0.244	13583	0.006	0.012	0.006
12989	0.2	0.2	0.2	13242	0.206	0.206	0.206	13584	0.002	0	0.018
12990	0.002	0.002	0.002	13243	0.162	0.162	0.162	13585	0.01	0.004	0.004
12991	0.062	0.062	0.062	13244	0.746	0.746	0.456	13586	0.014	0.012	0.054
12992	0.164	0.164	0.25	13245	0.094	0.094	0.042	13587	0.008	0.004	0.004
12993	0.374	0.374	0.414	13246	0.69	0.69	0.284	13588	0.004	0.006	0.006
12994	0.09	0.104	0.04	13247	0.716	0.716	0.332	13589	0.004	0.004	0.004
12995	0.142	0.142	0.118	13336	0.846	0.846	0.736	13590	0	0.002	0.002
12996	0.316	0.316	0.404	13337	0.838	0.838	0.838	13591	0.01	0.01	0.01
12997	0.108	0.108	0.192	13338	0.018	0.018	0.018	13592	0.024	0.044	0.026
13002	0.08	0.098	0.132	13339	0.858	0.858	0.55	13593	0.036	0.036	0.082
13003	0.094	0.03	0	13340	0.318	0.318	0.538	13594	0.03	0.03	0.03
13004	0.04	0.02	0.004	13341	0.802	0.802	0.158	13595	0.144	0.144	0.144
13005	0.042	0.056	0.056	13342	0.174	0.174	0.056	13596	0.844	0.844	0.844
13006	0.068	0.068	0.196	13343	0.174	0.174	0.3	13597	0.778	0.778	0.778
13007	0.634	0.634	0.178	13344	0.084	0.084	0.198	13598	0.292	0.292	0.292
13008	0.1	0.1	0.156	13353	0	0	0.01	13599	0.918	0.918	0.918
13009	0.156	0.156	0.156	13354	0.026	0.026	0.078	13600	0.13	0.13	0.13
13010	0.912	0.912	0.766	13355	0.028	0.07	0.082	13601	0.08	0.08	0.032
13011	0.908	0.908	0.722	13356	0.044	0.046	0.086	13602	0.032	0.032	0.028
13012	0.822	0.822	0.372	13357	0.752	0.752	0.036	13603	0.006	0.006	0.008
13013	0.682	0.682	0.18	13358	0.264	0.264	0.264	13697	0.822	0.822	0.13
13100	0.168	0.168	0.168	13359	0.126	0.126	0.126	13698	0.07	0.07	0.092
13101	0.194	0.194	0.194	13360	0.052	0.052	0.052	13699	0.002	0.002	0.002
13102	0.192	0.358	0.358	13361	0.182	0.182	0.246	13700	0.032	0.032	0.032
13103	0.256	0.256	0.31	13362	0.764	0.764	0.476	13701	0.044	0.044	0.044
13104	0.864	0.864	0.664	13363	0.182	0.182	0.226	13702	0.824	0.824	0.712
13105	0.218	0.218	0.334	13364	0.764	0.764	0.49	13703	0.782	0.782	0.646
13106	0.002	0.002	0.002	13365	0.092	0.092	0.122	13704	0.06	0.064	0.058
13107	0	0	0	13453	0.152	0.152	0.252	13705	0.236	0.236	0.236
13108	0.108	0.108	0.15	13454	0.804	0.804	0.736	13706	0.236	0.226	0.016
13109	0.28	0.396	0.48	13455	0.782	0.782	0.782	13707	0	0	0.024
13110	0.23	0.252	0.514	13456	0.092	0.092	0.106	13708	0.028	0.038	0.036
13118	0.06	0.064	0.114	13457	0.204	0.204	0.478	13709	0.024	0.024	0.07
13119	0.112	0.04	0.062	13458	0.73	0.73	0.442	13710	0.012	0.01	0.01
13120	0.086	0.01	0.012	13459	0.14	0.14	0.312	13711	0	0.016	0.012
13121	0.062	0.068	0.032	13460	0.138	0.138	0.262	13712	0	0	0
13122	0.742	0.742	0.262	13461	0.14	0.14	0.23	13713	0.046	0.082	0.082
13123	0.718	0.718	0.676	13470	0.006	0.006	0.012	13714	0.052	0.036	0.036
13124	0.774	0.774	0.774	13471	0.004	0.004	0.008	13715	0.01	0.008	0.008
13125	0.764	0.764	0.764	13472	0.02	0.042	0.03	13716	0.042	0.042	0.042
13126	0.89	0.89	0.692	13473	0.108	0.108	0.178	13717	0.09	0.09	0.09
13127	0.702	0.702	0.208	13474	0.176	0.176	0.142	13718	0.17	0.17	0.17
13128	0.83	0.83	0.188	13475	0.304	0.304	0.304	13719	0.848	0.848	0.848
13129	0.066	0.066	0.03	13476	0.702	0.702	0.702	13720	0.86	0.86	0.86
13218	0.782	0.782	0.738	13477	0.214	0.214	0.214	13721	0.92	0.92	0.92
13219	0.78	0.78	0.78	13478	0.288	0.288	0.38	13722	0.954	0.954	0.954
13220	0.124	0.124	0.124	13479	0.804	0.804	0.804	13723	0.762	0.762	0.762
13221	0.248	0.248	0.248	13480	0.076	0.076	0.066	13724	0.742	0.742	0.624
13222	0.844	0.844	0.668	13481	0.762	0.762	0.098	13725	0.768	0.768	0.344
13223	0.198	0.198	0.086	13482	0.016	0.016	0.028	13726	0.018	0.018	0.03
13224	0	0	0	13574	0.806	0.806	0.682	13820	0.058	0.054	0.04
13225	0	0	0	13575	0.896	0.896	0.844	13821	0.836	0.836	0.124
13226	0.042	0.042	0.1	13576	0.862	0.862	0.862	13822	0.838	0.838	0.64
13235	0.032	0.032	0.11	13577	0.04	0.04	0.04	13823	0.002	0.002	0.002

13824	0.004	0.004	0.004	14065	0.888	0.42	0.414
13825	0.044	0.044	0.044	14066	0.874	0.536	0.534
13826	0.252	0.286	0.286	14067	0.572	0.314	0.3
13827	0.336	0.022	0.008	14068	0.356	0.034	0.004
13828	0	0.024	0	14069	0.004	0.03	0
13829	0.002	0.008	0	14070	0.004	0.012	0.006
13830	0	0	0.014	14071	0	0	0
13831	0.016	0.018	0	14072	0.002	0.006	0.008
13832	0.004	0.004	0	14073	0.004	0.01	0.004
13833	0.006	0.008	0	14074	0.022	0.03	0.028
13834	0.012	0.038	0.042	14075	0.026	0.032	0.032
13835	0.018	0.018	0.018	14076	0	0.01	0.01
13836	0.01	0.01	0.01	14077	0.024	0.028	0.028
13837	0.006	0.006	0.006	14078	0.034	0.034	0.034
13838	0.028	0.042	0.042	14079	0.012	0.012	0.012
13839	0.076	0.076	0.076	14080	0.664	0.664	0.664
13840	0.8	0.8	0.8	14081	0.804	0.804	0.804
13841	0.914	0.914	0.914	14082	0.142	0.142	0.142
13842	0.876	0.876	0.876	14083	0.19	0.19	0.19
13843	0.244	0.244	0.244	14084	0.632	0.632	0.632
13844	0.93	0.93	0.93	14085	0.946	0.946	0.946
13845	0.878	0.878	0.878	14086	0.368	0.368	0.368
13846	0.76	0.76	0.76	14087	0.916	0.916	0.916
13847	0.044	0.044	0.068	14088	0.932	0.932	0.932
13848	0.732	0.732	0.356	14089	0.96	0.96	0.96
13849	0.718	0.718	0.64	14090	0.894	0.894	0.894
13942	0.168	0.238	0.248	14180	0.064	0.112	0.114
13943	0.818	0.438	0.36	14181	0.678	0.074	0.016
13944	0.856	0.844	0.844	14182	0.758	0.194	0.046
13945	0.77	0.77	0.77	14183	0.8	0.126	0.056
13946	0.002	0.002	0.002	14184	0.086	0.108	0.08
13947	0.208	0.208	0.208	14185	0.106	0.16	0.084
13948	0.842	0.458	0.45	14186	0.002	0.036	0.006
13949	0.012	0.034	0	14187	0.004	0.018	0
13950	0	0.022	0	14188	0.004	0.01	0
13951	0.006	0.004	0.012	14189	0.006	0.014	0.01
13952	0.004	0.004	0.02	14190	0.008	0.008	0.008
13953	0	0.002	0	14191	0.016	0.024	0.03
13954	0.006	0.012	0.002	14192	0.012	0.018	0.01
13955	0.004	0.034	0.014	14193	0.02	0.048	0.048
13956	0.012	0.022	0.02	14194	0.002	0.012	0.012
13957	0.058	0.058	0.058	14195	0	0	0
13958	0.006	0.014	0.014	14196	0.086	0.086	0.086
13959	0.004	0.012	0.012	14197	0.032	0.032	0.032
13960	0.096	0.112	0.112	14198	0.044	0.044	0.044
13961	0.824	0.824	0.824	14199	0.712	0.712	0.712
13962	0.244	0.244	0.244	14200	0.788	0.788	0.788
13963	0.884	0.884	0.884	14201	0.154	0.154	0.154
13964	0.942	0.942	0.942	14202	0.918	0.918	0.918
13965	0.148	0.148	0.148	14203	0.88	0.88	0.88
13966	0.892	0.892	0.892	14204	0.824	0.824	0.824
13967	0.92	0.92	0.92	14205	0.836	0.836	0.836
13968	0.88	0.88	0.88	14206	0.916	0.916	0.916
13969	0.83	0.83	0.83	14207	0.93	0.93	0.93
13970	0.836	0.836	0.836	14208	0.982	0.982	0.982
13971	0.732	0.732	0.732	14209	0.89	0.89	0.89
14061	0.062	0.088	0.026	14291	0.156	0.164	0.164
14062	0.66	0.178	0.11	14292	0.626	0.146	0.132
14063	0.81	0.35	0.314	14293	0.144	0.118	0.11
14064	0.844	0.498	0.492	14294	0.08	0.092	0.064

14295	0.1	0.058	0.028
14296	0.192	0.15	0.074
14297	0.03	0.074	0.062
14298	0.012	0.034	0
14299	0.002	0.022	0.002
14300	0.006	0.02	0.004
14301	0.004	0.004	0.01
14302	0.014	0.024	0
14303	0.018	0.004	0
14304	0.014	0.032	0.034
14305	0	0.012	0.014
14306	0.012	0.012	0.012
14307	0.008	0.008	0.008
14308	0.006	0.006	0.006
14309	0.626	0.626	0.626
14310	0.646	0.646	0.646
14311	0.73	0.73	0.73
14312	0.844	0.844	0.844
14313	0.896	0.896	0.896
14314	0.818	0.818	0.818
14315	0.878	0.878	0.878
14316	0.838	0.838	0.838
14317	0.934	0.934	0.934
14318	0.916	0.916	0.916
14319	0.83	0.83	0.83
14320	0.908	0.908	0.908
14396	0.052	0.052	0.076
14397	0.032	0.016	0.014
14398	0.038	0.044	0.024
14399	0.016	0.016	0.02
14400	0.05	0.058	0.04
14401	0.068	0.046	0.034
14402	0.008	0.018	0.018
14403	0.006	0.016	0.016
14404	0.014	0.004	0.008
14405	0.006	0.006	0.004
14406	0.002	0.002	0.024
14407	0	0.014	0
14408	0.038	0.036	0.016
14409	0	0.014	0.004
14410	0	0	0
14411	0.01	0.01	0.01
14412	0.004	0.004	0.004
14413	0.004	0.004	0.004
14414	0.004	0.004	0.004
14415	0.032	0.032	0.032
14416	0.692	0.692	0.692
14417	0.908	0.908	0.908
14418	0.298	0.298	0.298
14419	0.202	0.202	0.202
14420	0.832	0.832	0.832
14421	0.822	0.822	0.822
14422	0.858	0.858	0.858
14423	0.934	0.934	0.934
14424	0.942	0.942	0.942
14425	0.966	0.966	0.966
TOTALS	397.576	339.538	313.032

CURRICULUM VITAE

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EDUCATION:

Ph.D. in Environmental Toxicology
Center for Environmental Toxicology and Department of Veterinary Sciences, Utah State University, Logan, UT, 1985

M.S. in Zoology (Animal Ecology)
Department of Zoology, Washington State University, Pullman, WA, 1978

B.S. in Biology
Department of Biology, University of Cincinnati, Cincinnati, OH, 1973

Graduate Training Fellowship
National Institute of Environmental Health Sciences Predoctoral Trainee in Toxicology
Utah State University, Logan, UT (1981-1985)

EXPERIENCE:

Supervisory Ecologist (2000-2014)
U.S. Fish and Wildlife Service, South Florida Ecological Services Office, Vero Beach, FL.
Developed food chain and habitat models for endangered species such as the Everglade snail kite and Florida panther.

Refuge Manager (1998-2000)
U.S. Fish and Wildlife Service, Florida Keys National Wildlife Refuges, Big Pine Key, FL.
Worked on conservation and management of nine endangered species in the Florida Keys, including the Key deer, American crocodile, and Lower Keys marsh rabbit.

Supervisory Fish and Wildlife Biologist (1993-1998)
U.S. Fish and Wildlife Service, New Jersey Field Office, Pleasantville, NJ.
Conducted and supervised environmental contaminant studies to assess risks to the bald eagle, peregrine falcon, and other species.

State Toxicologist (1986-1993)
Maine Department of Human Services, Augusta, ME.
Primary authority in Maine state government on toxicology and chemical risk assessment for humans, fish, and wildlife.

PEER-REVIEWED PUBLICATIONS:

Frakes, R.A., R.C. Belden, B.E. Wood and F.E. James. 2015. Landscape analysis of adult Florida panther habitat. *PLoS ONE* 10(7): e0133044.doi:10.1371/journal.pone.0133044.

Hoang, T.C., R.L. Pryor, G.M. Rand, and R.A. Frakes. 2011. Use of butterflies as nontarget insect test species and the acute toxicity and hazard of mosquito control insecticides. *Environmental Toxicology and Chemistry* 30(4): 997-1005.

Hoang, T.C., R.L. Pryor, G.M. Rand, and R.A. Frakes. 2011. Bioaccumulation and toxicity of copper in outdoor freshwater microcosms. *Ecotoxicology and Environmental Safety*: 74(4): 1011-1020.

Hoang, T.C., L.J. Schuler, E.C. Rogevich, P.M. Bachman, G.M. Rand, and R.A. Frakes. 2009. Copper release, speciation, and toxicity following multiple floodings of copper enriched agricultural soils: Implications in Everglades restoration. Water Air Soil Pollut. 199:79-93.

Frakes, R.A., T.A. Bargar and E.A. Bauer. 2008. Sediment copper bioavailability to freshwater snails in south Florida: risk implications for the Everglade snail kite (*Rostrhamus sociabilis plumbeus*). *Ecotoxicology* 17:598-604.

Hoang, T.C., E.C. Rogevich, G.M. Rand, and R.A. Frakes. 2008. Copper uptake and depuration by Florida apple snails (*Pomacea paludosa*): Bioconcentration and bioaccumulation factors. *Ecotoxicology, Vol. 17, pp 605-615.*

Hoang, T.C., E.C. Rogevich, G.M. Rand, P.R. Gardinali, R.A. Frakes and T.A. Bargar. 2008. Copper desorption in flooded agricultural soils and toxicity to the Florida apple snail (*Pomacea paludosa*): Implications in Everglades restoration. *Environmental Pollution, Vol. 154, pp 338-347.*

Frakes, R.A. and L.R. Hicks. 1993. Fungicides, in: *Handbook of Hazardous Materials*, M. Corn, ed. Academic Press, Inc., San Diego, CA.

Frakes, R.A., C.Q.T. Zeeman and B. Mower. 1993. Bioaccumulation of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) by fish downstream of pulp and paper mills in Maine. *Ecotoxicology and Environmental Safety* 25:244-252.

Frakes, R.A. 1988. Drinking water guideline for ethylenethiourea, a metabolite of ethylene bisdithiocarbamate fungicides. *Regul. Toxicol. Pharmacol*. 8:207-218.

Frakes, R.A., R.P. Sharma, C.C. Willhite and G. Gomez. 1986. Effect of cyanogenic glycosides and protein content in cassava diets on hamster prenatal development. *Fundam. Appl. Toxicol*. 7:191-198.

Frakes, R.A., R.P. Sharma and C.C. Willhite. 1986. Comparative metabolism of linamarin and amygdalin in hamsters. *Food and Chemical Toxicology* 24:417-420.

Frakes, R.A., C.C. Willhite and R.P. Sharma. 1985. Developmental toxicity of the cyanogenic glycoside linamarin in the golden hamster. *Teratology* 31:241-246.

Willhite, C.C., N.L. Rossi, R.A. Frakes and R.P. Sharma. 1985. Cranioschisis aperta with encephaloschisis in cephalothoracopagus hamster twins. *Can. J. Comp. Med*. 49:195-201.

Taylor, M.J., R.A. Frakes, R.P. Sharma and C.C. Willhite. 1984. Comparative pharmacokinetics of trypan blue in female Sprague-Dawley and Long-Evans rats. *Food and Chemical Toxicology* 22(11):875-878.

Frakes, R.A. and R.E. Johnson. 1982. Niche convergence in *Empidonax* flycatchers. *Condor* 84:286-291.

TECHNICAL REPORTS:

Frakes, R.A. 2018. Impacts to panther habitat from the proposed Eastern Collier Multiple Species Habitat Conservation Plan: a quantitative analysis. Report prepared for the Conservancy of Southwest Florida, October 2018.

Frakes, R.A., T.A. Bargar, B. Arrington, J.F. Boggs, J. Tutton, and A. Sowers. 2010. Pesticide and nutrient contamination in the Cypress Swamp of the A.R.M. Loxahatchee National Wildlife Refuge. U.S. Fish and Wildlife Service, Vero Beach, FL. July 2010.

Frakes, R.A., T.A. Bargar, B. Arrington, J.F. Boggs, J. Tutton, and A. Sowers. 2010. Pesticide and nutrient contamination in the Strazulla Marsh of the A.R.M. Loxahatchee National Wildlife Refuge. U.S. Fish and Wildlife Service, Vero Beach, FL. July 2010.

Frakes, R.A., E.A. Boughner, J.F. Boggs, J. Tutton, and T.A. Bargar. 2007. Delineation of the nature and extent of contamination at the former NAS Key West Skeet Club on Great White Heron National Wildlife Refuge. U.S. Fish and Wildlife Service, Vero Beach, FL. October 2007.

Bargar, T.A., R.A. Frakes, J.F. Boggs, and E.A. Boughner. 2005. Uptake of copper by apple snails from contaminated sediments in south Florida. Interim report. U.S. Fish and Wildlife Service, Vero Beach, FL. January 2005.

Frakes, R.A. 2004. Ecological risk assessment guidance for wetland restoration on agricultural lands in south Florida. U.S. Fish and Wildlife Service, Vero Beach, FL. August 2004.

Frakes, R.A. 2000. McMurrain Farms ecological risk assessment, summary and recommendations. U.S. Fish and Wildlife Service, Vero Beach, FL. November 2000.

Frakes, R.A. 2000. Derivation of "No-Application Periods" for interim use pesticides. U.S. Fish and Wildlife Service, Vero Beach, FL. April 2000.

USFWS. 1999. Evaluation of contaminant residues in Delaware Bay bald eagle nestlings, 1996-98. U.S. Fish and Wildlife Service, Pleasantville, NJ. January 1999.

Frakes, R.A. 1998. Preliminary contaminants survey, Naval Air Station Key West Skeet Club. U.S. Fish and Wildlife Service, Big Pine Key, FL. October 1998.

USFWS. 1998. Metals in New Jersey's Pinelands National Reserve sediments, surface water and biota: an emphasis on mercury. U.S. Fish and Wildlife Service, Pleasantville, NJ. April 1998.

USFWS and NJDEP. 1998. Reproductive success and egg contaminant concentrations of southern New Jersey peregrine falcons. U.S. Fish and Wildlife Service, Pleasantville, NJ. March 1998.

USFWS. 1996. Biological opinion on the effects of the U.S. Environmental Protection Agency's approval of the State of New Jersey's Surface Water Quality Standards on the bald eagle, peregrine falcon, and dwarf wedgemussel. U.S. Fish and Wildlife Service, Pleasantville, NJ. June, 1996.

USFWS. 1996. Environmental contaminants impact analysis and ecological risk assessment for the Federal Aviation Administration Technical Center CERCLA sites in Atlantic County, New Jersey. U.S. Fish and Wildlife Service, Pleasantville, NJ. April 1996. (study director).

USFWS and NJDEP. 1995. Evaluation of contaminant residues in Delaware Bay bald eagle nestlings. U.S. Fish and Wildlife Service, Pleasantville, NJ. October 1995. (study director).

USFWS. 1994. Evaluation of contaminants in sediments and forage organisms, Cape May National Wildlife Refuge. Technical assistance report. U.S. Fish and Wildlife Service, Pleasantville, NJ. August 1994. (study director).

Frakes, R.A. 1990. Health-based water quality criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Maine Department of Human Services, Augusta, ME. November 1990.

Frakes, R.A. 1989. Risk assessment of uncontrolled ash releases from the Maine Energy Recovery Company (MERC) in Biddeford, Maine. Maine Department of Human Services, Augusta, ME. January 1989.

Frakes, R.A. 1987. Maximum Exposure Guideline for ethylenethiourea in drinking water. Maine Department of Human Services, Augusta, ME.

Frakes, R.A. 1987. Risk assessment for dioxin-contaminated fish. Maine Department of Human Services, Augusta, ME. February 1987.

Frakes, R.A. 1986. Health risks associated with land-spreading of dioxin-contaminated sludge. Maine Department of Human Services, Augusta, ME. June 1986.

SELECTED TRAINING

Spatial Distribution, Animal Movement and Home Range Analysis. National Conservation Training Center, US Fish and Wildlife Service, Shepherdstown, WV (2012).

Data Analysis IIIB: Species Distribution Modeling Using R. National Conservation Training Center, US Fish and Wildlife Service, Panama City, FL (December 2009).

Data Analysis IIIA: Species Distribution Modeling Using R. National Conservation Training Center, US Fish and Wildlife Service, Panama City, FL (August 2009).

Data Analysis II. Ecological Modeling Using R. National Conservation Training Center, US Fish and Wildlife Service, Panama City, FL (July 2009).

GIS Introduction for Conservation Professionals. National Conservation Training Center, US Fish and Wildlife Service, Vero Beach, FL (2008).

Geostatistical Analysis of Environmental Data. University of Florida, Gainesville, FL (2006).

Migratory Bird Conservation – A Trust Responsibility. National Conservation Training Center, US Fish and Wildlife Service. Taught at Vero Beach, FL, February 5-8, 2007.

Hazardous Waste Operations and Emergency Response (40-hour). Center for Safety and Environmental Management, Slippery Rock University. Taught at Vero Beach, FL, May 1-4, 2006.

Endangered Species Act - Section 7 Training: Level 1. U.S. Fish and Wildlife Service, Vero Beach, FL (2003).

National Environmental Contaminants Training Conference. Division of Environmental Quality, U.S. Fish and Wildlife Service, Tucson, AR (2003).

National Environmental Contaminants Training Conference. Division of Environmental Quality, US Fish and Wildlife Service, Fish Camp, CA (2001).

National Environmental Contaminants Training Conference. Division of Environmental Contaminants, US Fish and Wildlife Service, Branson, MO (1999).

Cold Weather Oil Spill Response. US Coast Guard, Portland, ME (1996).

Oiled Wildlife Recovery, Reception, and Response. Tri-State Bird Rescue and Research, Sudbury, MA (1996).

Natural Resource Damage Assessment. National Conservation Training Center, US Fish and Wildlife Service, Tacoma, WA (1995).

Mid-America Toxicology Course. Kansas City, MO (1992).