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Audubon California Spatial Science Report Brief
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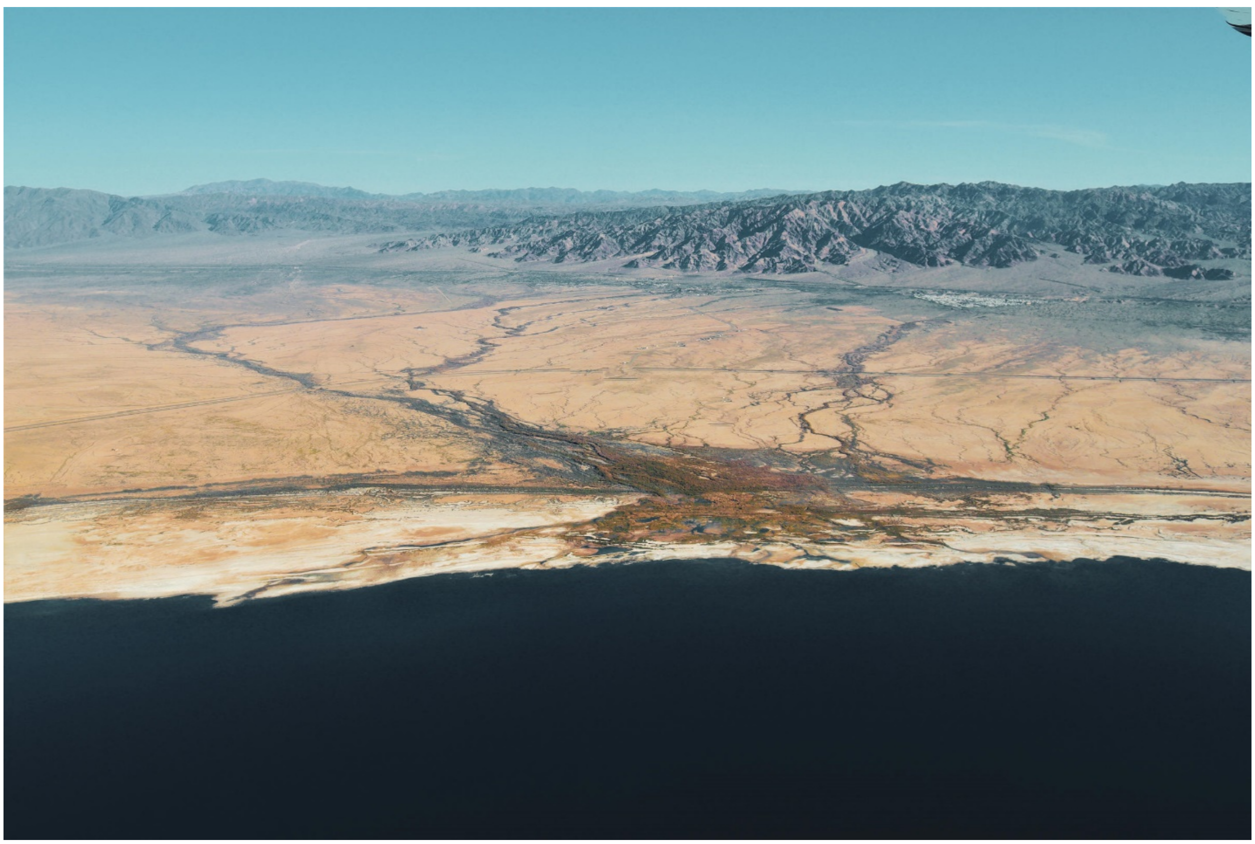
Identifying Existing Areas for Habitat Protection/Enhancement and Dust Suppression Projects on Salton Sea Exposed Playa



Wetlands south of Bombay Beach. Photo: Salton Sea Program Director Frank Ruiz.

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Executive Summary

The receding of the Salton Sea is leading to dynamic changes in bird habitats and food resources and is exposing thousands of acres of exposed seabed (playa) each year. New playa exposure exacerbates the worsening air quality, further impairing the health of local communities. We sought to identify areas that could require less effort to develop habitat and dust suppression projects by identifying newly emerging vegetation on exposed playa. The irrigation drains and other perennial and ephemeral drainage that used to drain directly into the Sea now spread out and slowly flow and pool on the exposed playa where new vegetation and wetlands now form. These emerging vegetated areas can be multi-benefit, by both controlling dust and providing essential habitat for migratory birds and other wildlife.

We used multispectral 10-meter resolution satellite imagery and a Normalized Difference Vegetation Index (NDVI) to identify vegetation and differentiate between algal and plant vegetation. We used Getis-Ord Gi* (pronounced G – i - star) statistic to assess statistically significant clustering of high (hot spot) and low (cold spot) NDVI values for plant vegetated areas on exposed playa. This cluster analysis was used to categorize vegetation into relatively high, medium or low levels of robustness. Here robustness refers to the density and health of vegetation as estimated by NDVI values.

To visually assess the relationship between avian diversity and emerging vegetation we assessed avian data collected in Audubon California's Salton Sea Waterbird Survey. We assessed three years of bimonthly avian diversity at each of 14 sites using the Shannon Wiener Diversity Index and overlaid these with the vegetation analysis.

We found 6,752 acres of emerging vegetation on exposed playa (in January 2020): 5,409 acres of vascular plant vegetation (e.g. Tamarisk, Cattail and others) and 1,343 acres of algal sheet flow vegetation (algae). For plant vegetation, 434 acres were classified as highly robust, 832 acres moderately robust and 4,142 acres were classified as having low levels of robustness relative to the other emergent plant vegetation on Salton Sea exposed playa. High and moderately robust vegetation was primarily located in the northern, southeastern and southwestern portions of the Sea.

Drainage into the Sea is likely the major driver of these pockets of vegetation. Types of drainage vary across the Sea and include irrigation drains, ephemeral washes and streams, and perennial streams and rivers. The dominant drainage in the northern, southeastern and southwestern portions of the Sea is irrigation drainage. These, as well as the agriculture driving them, will likely persist and could provide reliable water to maintain these newly emergent vegetation areas with low effort maintenance. Areas that are relatively less robust (although not necessarily poor vegetation) could potentially be improved with minimal effort by managing current water entering the more robust adjacent areas. These areas likely represent potential opportunities for either habitat or dust suppression projects that could require less investment of time and resources than would constructing such habitats from scratch. Our results, presented here, can inform lower effort and cost habitat restoration and dust suppression project siting where irrigated vegetation and water is already evident and providing habitat values. These "no regrets" projects could complement existing completed, implemented or planned projects by mitigating the immediate impacts to habitats and air quality during the medium and long-term implementation of the Salton Sea Plan.

Introduction

The receding of the Salton Sea is leading to dynamic changes in bird habitats and food resources and is exposing thousands of acres of new playa a year. New playa exposure exacerbates the worsening air quality, further impairing the health of local communities. Habitat and dust suppression projects can be expensive and time consuming to plan, implement and monitor. We sought to identify areas that could require less effort to develop habitat and dust suppression projects by identifying newly emerging vegetation on exposed playa (seabed exposed 2003 to January 1, 2020, -227 ft. to -236 ft. NAVD 88) (USGS, 2020). The irrigation drains that no longer reach the sea as well as other perennial and ephemeral drainage that used to drain directly into the Sea now spread out and slowly flow and pool on the exposed playa where new vegetation and wetlands now form. By identifying these “no regrets” project areas, we hope to inform the management of Salton Sea resources and speed dust suppression and habitat project implementation while potentially minimizing the effort and financial resources needed. These “no regrets” projects could mitigate the immediate impacts to habitats and air quality while the Salton Sea Management Plan (SSMP) is implemented over the medium term.

Methods

To identify new emerging vegetation on exposed playa we used satellite imagery from the European Space Agency’s Sentinel 2 satellite (atmospherically corrected L2A products). We acquired these high resolution (10 meter) multispectral images from January 1, 2020. This date was chosen because we wanted to assess imagery from a period that was a cooler and wetter period of the year and had low cloud cover. Avoiding imagery from hotter periods would likely decrease the chances that we were assessing vegetation drying under heat stress conditions and were more likely assessing a robust period for healthy vegetation on the exposed playa.

We used a Normalized Difference Vegetation Index (NDVI) (Rouse et al., 1974) to identify vegetation in this imagery. NDVI is a commonly used index to identify and assess the density and health or robustness of vegetation in multispectral imagery (Huete and Liu, 1994; Leprieur et al., 2000) and is useful for identifying vegetation in arid environments (Alsharrah et al., 2015; Amiri, 2010; Jafari et al., 2007; Richard and Poccard, 1998). NDVI uses a mathematical equation including visible and near-infrared light wavelengths reflected by photosynthetic organisms to assess vegetation and is measured in values that range from -1 to 1. Here we assessed values above 0.25 as playa vegetation based on peer reviewed literature (Alsharrah et al., 2015) and visual inspection of results. We removed NDVI results that were outside the exposed playa (playa exposed between 2003 and the date of the imagery used) area so that upland vegetation and Salton Sea algal blooms were not included in the results.

Algal sheet flow vegetation on exposed playa (although important avian habitat) do not represent vascular plant vegetation that would most likely be targeted for dust suppression and habitat projects. NDVI analysis detects but does not differentiate these two habitats. The algal sheet flow areas (hereafter algal vegetation) form toward the edge of the water/playa interface where vascular plant vegetation (hereafter plant vegetation) has not yet taken hold but water pools and slowly flows over the playa and into the Sea. We visually identified algal vegetation areas using both the composite satellite imagery and NDVI analysis. We manually digitized these areas to provide a best spatial estimate of the algal vegetation areas to differentiate between algal and plant vegetation.

NDVI analysis is useful to identify emerging vegetation on exposed playa and visual assessment and manual digitization of algal vegetation is useful for narrowing our assessment to plant vegetation. Breaking this broad assessment of plant vegetation into spatial bins (statistical bins grouped by spatial location and numerical value) can help identify potential project areas within broad swaths of plant vegetation. We did this by identifying spatial bins based on clustering of the relative density and health of plant vegetation (identified from NDVI values) which may help identify areas that already have relatively high, medium or lower levels of robust plant vegetation. We used Getis-Ord Gi* (pronounced G – i - star) statistic to assess statistically significant clustering of high (hot spot) and low (cold spot) NDVI values for plant vegetated areas on exposed playa. This approach creates statistical bins of NDVI values at varying confidence intervals (CI) for hot and cold spots. These can be used to categorize vegetation into relatively high (≥ 90% CI hot spot), medium (not statistically significant) or low (≥ 90% CI cold spot) levels of robustness. Here robustness refers to the density and health of plant vegetation as estimated by NDVI values. Categories (high to low robustness) are relative to each other so that the low category does not necessarily indicate poor vegetation health and low density but is low relative to the high values in this dataset.

To visually assess the relationship between avian diversity and emerging vegetation we assessed avian data collected in Audubon California's Salton Sea Waterbird Survey. Audubon California maintains 14 bird monitoring sites across the Salton Sea. We assessed three years of bimonthly avian diversity at each of these sites using the Shannon Wiener Diversity Index. We used these values to symbolize the diversity of each site relative to the others to identify which monitoring sites had higher relative diversity then overlaid this on our vegetation analysis.

Results

Our NDVI analysis identified 6,752 acres of emergent vegetation on exposed playa including 5,409 acres of plant vegetation and 1,343 acres of algal vegetation (Fig. 1). Getis-Ord Gi* analysis (Table 1) of NDVI values found up to 434 acres highly robust plant vegetation, up to 832 acres of moderately robust plant vegetation and 4,142 acres of plant vegetation with low levels of robustness (all relative to each other). The extent of different levels of robustness varied (Fig. 2). High and moderate levels were primarily found in the northern (Fig. 3), southeastern (Fig. 4) and southwestern (Fig. 5) portions of the Salton Sea. These areas were also characterized by relatively higher avian diversity (Fig. 6).

Discussion

Vegetation and Drainage

We found a total of 6,752 acres of vegetation (5,409 acres of plant vegetation and 1,343 acres of algal vegetation) has emerged on playa exposed since 2003. It is important to consider what factors led to this emergent vegetation and may make it persist into the future. Drainage into the Sea is likely the major driver of these pockets of vegetation. Types of drainage vary across the Sea and include ephemeral washes and streams, perennial streams and rivers as well as irrigation drainage. The dominant drainage in the northern, southeastern and southwestern portions of the Sea is irrigation drainage. These areas also hold larger proportions of highly and moderately robust emergent playa plant vegetation relative to other areas of the Salton Sea. Although we did not formally assess the relationship between drains and vegetation hot spots, it is likely that irrigation drainage is the primary diver of the more robust (and majority of) playa vegetation.

One notable exception that is not influenced by irrigation drainage is the area around Bombay Beach (Fig. 4) where drainage to the Sea originates in natural springs used by hot spring and aquaculture operations at higher elevations. These wetlands, as well as wetlands formed by agricultural drains, will likely persist (as analysis of earlier imagery indicates vegetation expansion and increased NDVI values over the previous year) and could provide reliable water to maintain these newly emergent plant and algal vegetation areas with low effort maintenance. Areas that are relatively less robust (although not necessarily poor plant vegetation) could potentially be improved with minimal effort managing current water entering the more robust adjacent areas. It is valuable to note that identical analysis from the same month in 2019 showed slightly less emerging playa vegetation and lower NDVI values (Table 2). This increase in NDVI values appears to not be related to precipitation as local rainfall was greater prior to the 2019 imagery than prior to the 2020 imagery (NOAA, 2020). This may indicate that such areas are likely to persist with reliable water sources. These areas likely represent good opportunities for either habitat or dust suppression projects that would require less investment of time and resources than would constructing such habitats from bare ground.

Avian Diversity

When considering habitat restoration from an avian perspective it may be important to consider local species diversity and assemblages. Audubon California maintains 14 bird monitoring sites across the Salton Sea. While not all of these vegetated wetlands have been monitored, we are seeing high species diversity in these emerging wetlands, including shorebirds, wetland and wading birds, and dabbling ducks concentrating at these sites in high numbers. Monitoring has been ongoing for over three years, sampled every two months for the first two years and every month in the third year. Visual inspection of overlaying our avian diversity analysis onto our vegetation analysis supports the idea that areas in the north, southeast and southwest (Fig. 6) of the Salton Sea are likely opportunistic areas for low effort and investment habitat projects. Our observations were corroborated by Oasis Bird Observatory's avian diversity observations from the northern Salton Sea (Bob McKernan personal communication) and information from USFWS around Sonny Bono Refuge (Chris Shoeneman personal communication).

Current Project Planning and SSMP

To use these results in habitat and/or dust suppression project planning it is important to understand where SSMP and other projects are being planned and/or implemented. Our goal here was to provide a guide to highlight areas for potentially lower effort and cost habitat and/or dust suppression projects to be implemented in the short term to complement or add to the more medium and long-term goals in the SSMP. Figures 7-9 show our plant vegetation analysis overlaid with currently implemented and planned habitat and dust suppression project areas.

Dust suppression project areas represent combined datasets from both the California Natural Resources Agency and the Imperial Irrigation District (IID). Both of these entities are developing projects on the ground and IID has implemented and completed a number of these. Habitat project areas represent data from the State of California and include the Torres Martinez project (Fig. 7), the Red Hill Bay project (Fig. 8) and the Species Habitat Conservation project area (Fig. 9). Each of these habitat projects are in various stages of planning or development. The North Lake planning area (Fig. 7) is based on data from Tetra Tech (the firm developing plans for this project). The North Lake plan has had several iterations and has changed dramatically over the years. The currently proposed draft of a deep water plan could be complemented by habitat projects sited in the northern portion of the Salton Sea (Fig. 7). Habitat projects in the south do not necessarily include a public access element. Developing projects in the northern part of the Salton Sea that are closer to local communities could provide these opportunities while complementing the deep water habitat and public access planned at for the North Lake. Our analyses could be used to target areas that would complement these medium to longer-term project areas for more immediate results that could help meet the goals of the SSMP or provide more immediate mitigation for habitat and air quality while the full SSMP is implemented.

Conclusion

Our analyses show that large vegetated areas have emerged on exposed playa and highlight project-siting opportunities. While dust suppression and habitat projects would likely target areas with plant vegetation, the algal vegetation is an important part of these habitats and is an important foraging area for waterbirds. These algal sheet flow areas have not yet become vegetated with plants but it is likely that as the Sea recedes these zones will shift downward and these areas will become vegetated with plants. Current plant vegetated areas that are relatively highly and moderately robust could be used to target areas of emergent plant vegetation on exposed playa as “no regrets” opportunities for habitat and/or dust suppression projects. These analyses should not necessarily exclude other areas of the playa from project development but rather highlight potentially robustly plant vegetated areas that could further minimize effort and resources. These results can inform lower effort and cost habitat restoration and dust suppression project siting where irrigated vegetation is already evident. This could help ease the immediate impacts to habitat and local air quality while the SSMP is implemented over the medium term.

Tables and Figures

Table 1: Acreage by vegetation characteristic. Levels of robustness determined by categorizing Getis-Ord Gi* significant clustering of NDVI values found across all emergent vegetation on exposed playa.

Vegetation Characteristic	Total Acres
Emergent Vegetation on Exposed Playa	6,752
Algal Sheet Flow Vegetation	1,343
Vasular Plant Vegetation	5,409
Relatively High Robustness	434
Relatively Moderate Robustness	832
Relatively Low Robustness	4,142

Table 2: Comparison of emerging vegetation on exposed playa between January 2019 and January 2020. The total number of acres of vegetation on exposed playa are shown as well as the maximum, mean and standard deviation NDVI statistics for each year. The minimum NDVI is not included because is the cut off value of 0.25 used for analysis in both years. Higher NDVI values indicate healthier more robust vegetation.

Statistic	2019	2020
Emergent Vegetation on Exposed Playa (acres)	5,944	6,752
NDVI Maximum Value	0.918	0.995
NDVI Mean	0.424	0.604
NDVI Standard Deviation	0.137	0.205

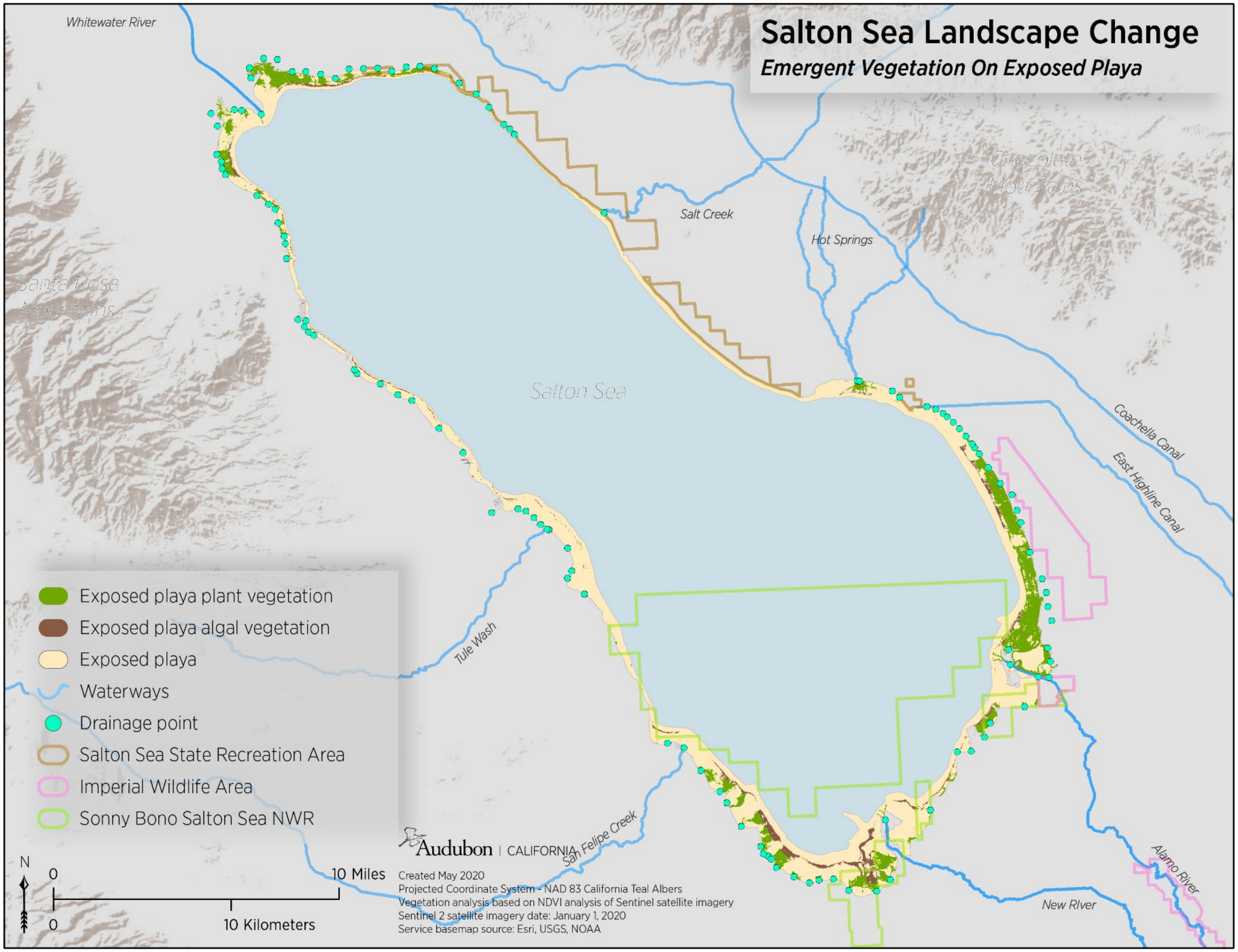

Figure 1: Emergent vegetation on newly exposed playa. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Drainage points and waterways are indicated in the figure for reference.

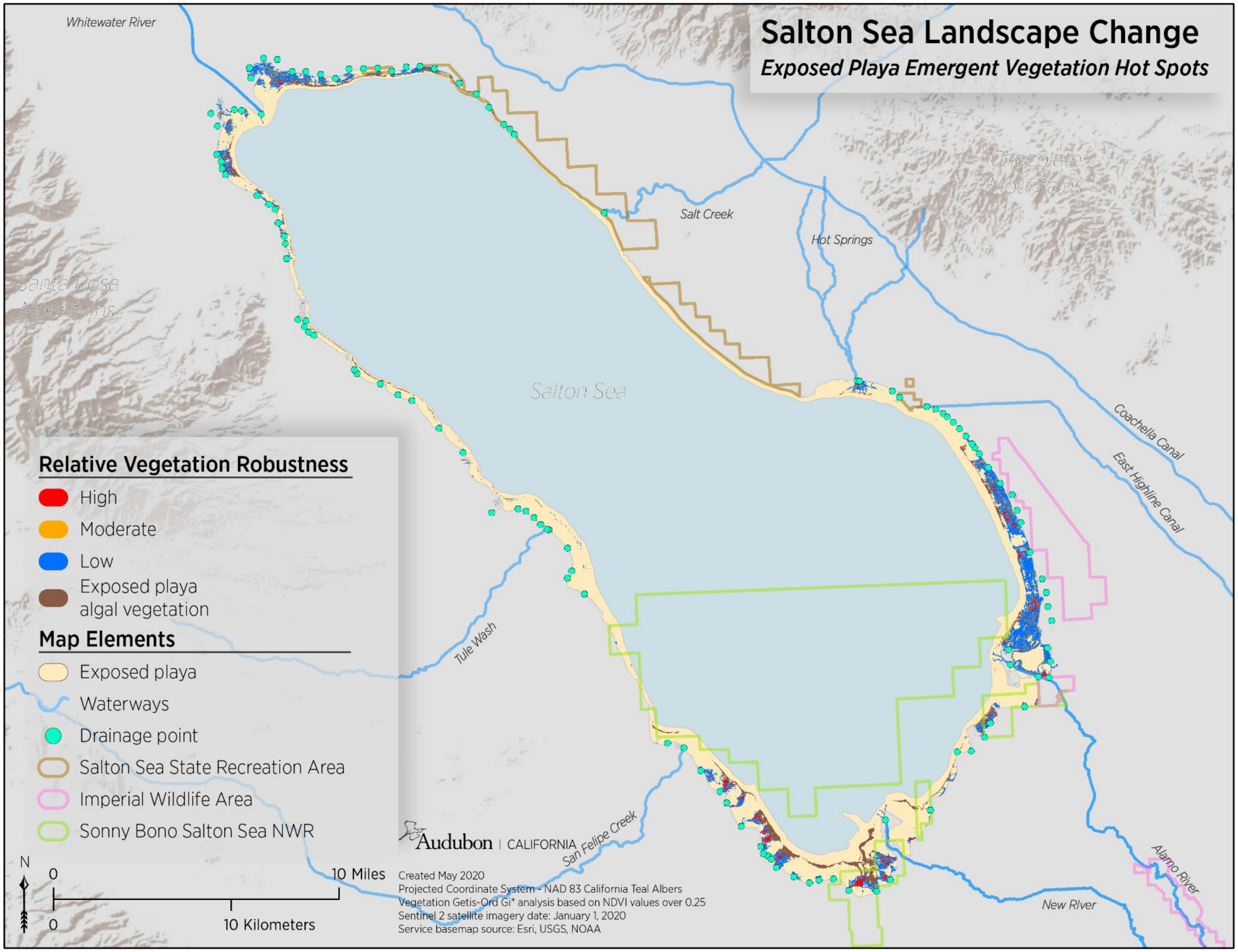

Figure 2: Vegetation hot spots of emergent vegetation on newly exposed playa. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Drainage points and waterways are indicated in the figure for reference.

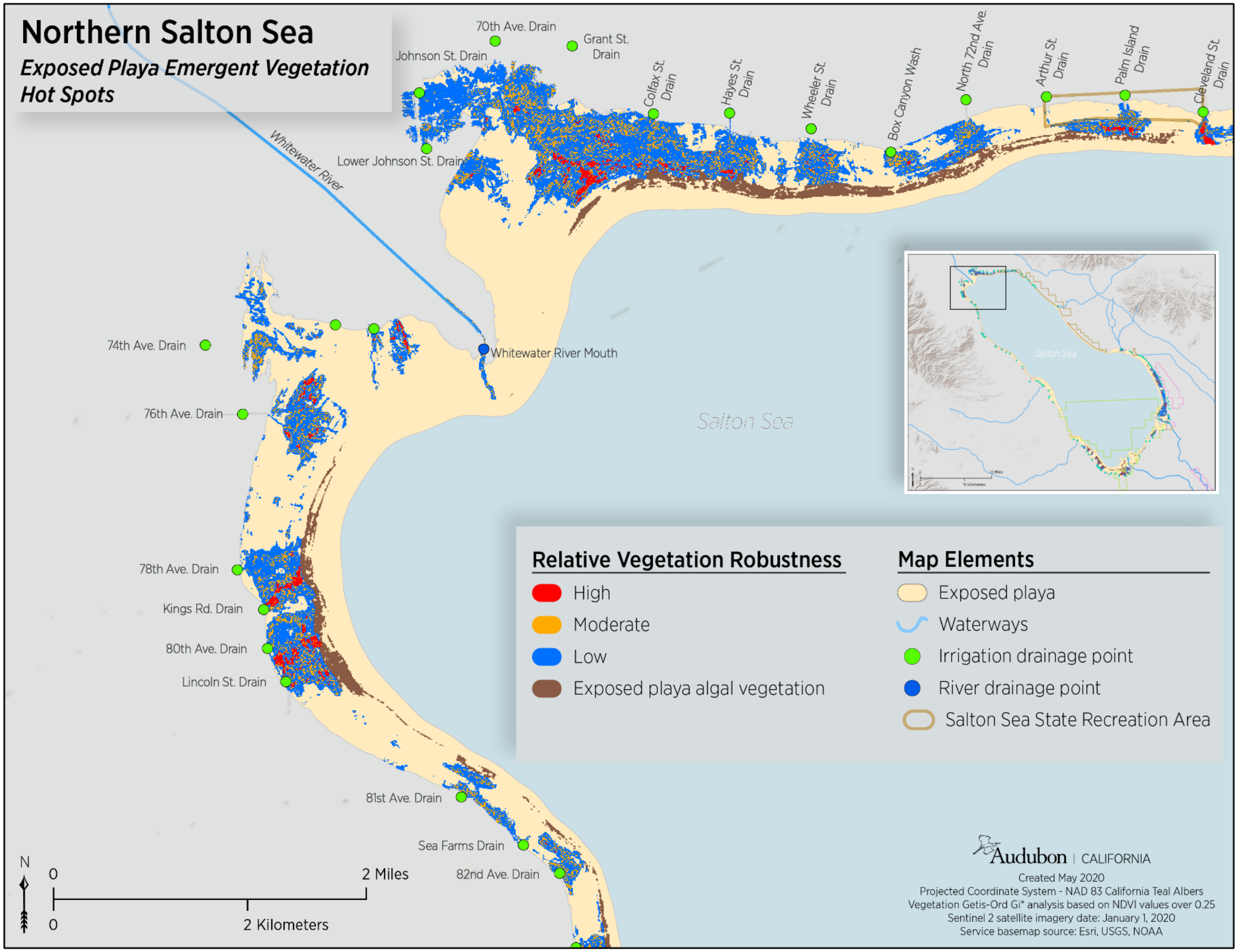

Figure 3: Vegetation hot spots of emergent vegetation on newly exposed playa. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Drainage points, type and waterways are indicated in the figure for reference.

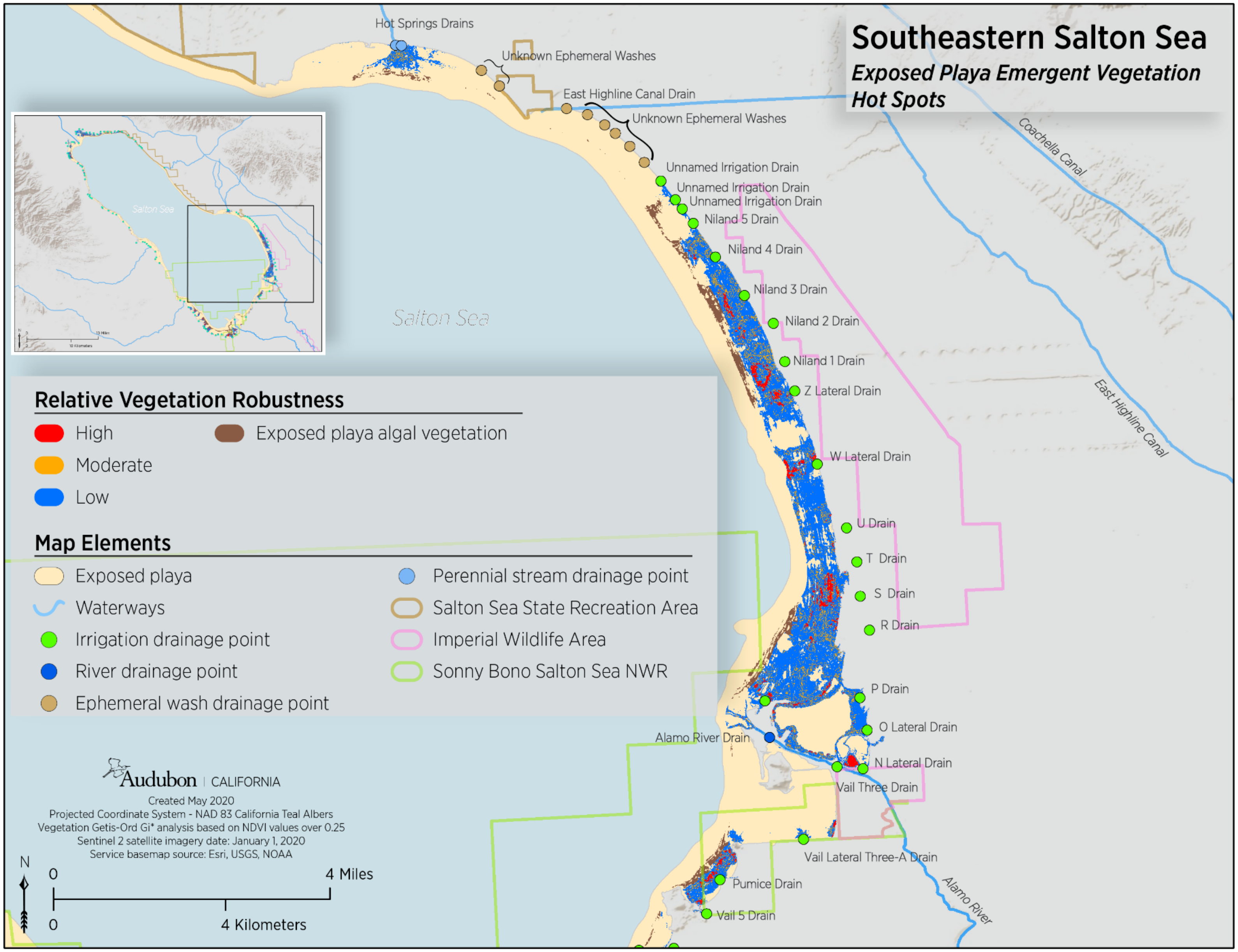

Figure 4: Vegetation hot spots of emergent vegetation on newly exposed playa. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Drainage points, type and waterways are indicated in the figure for reference.

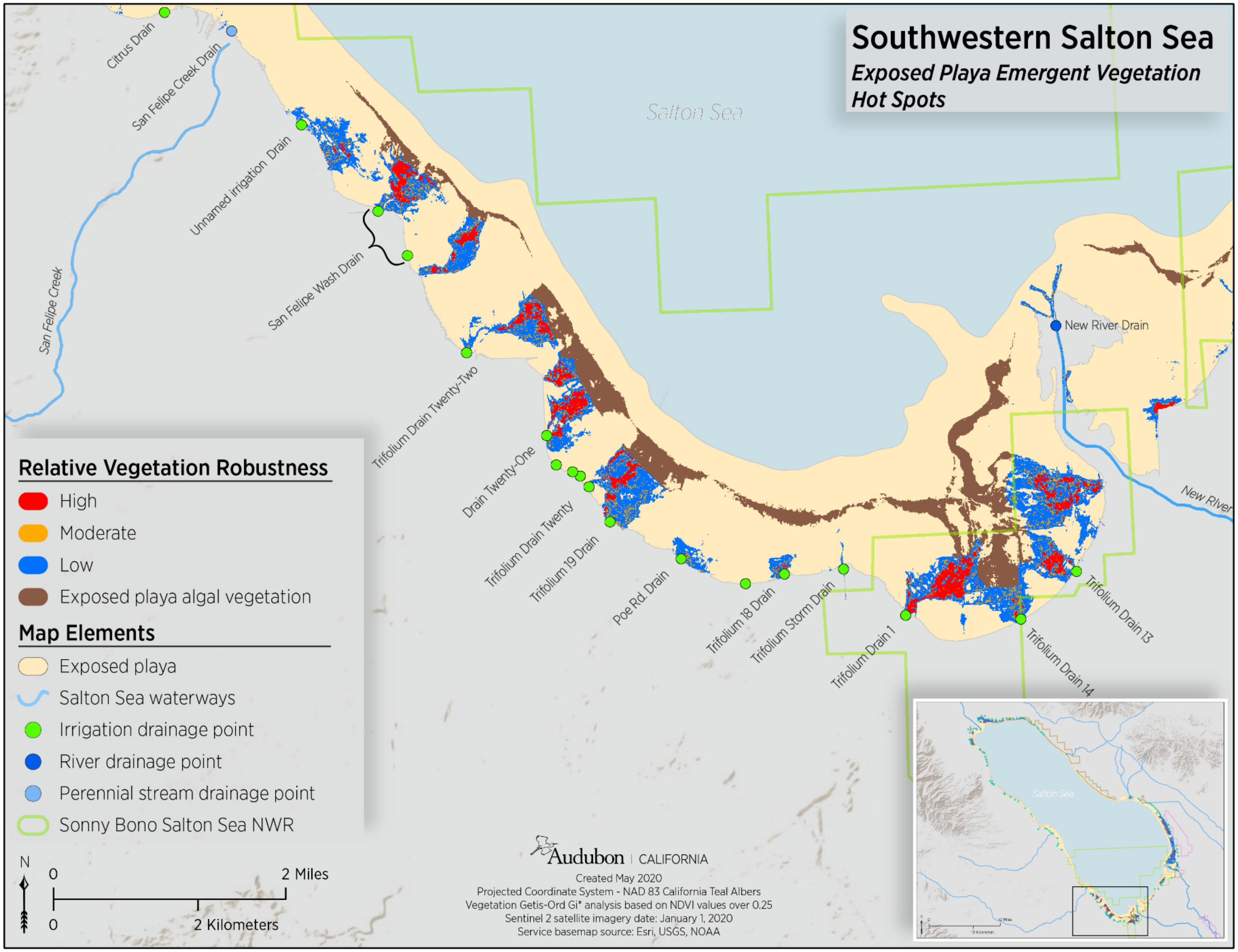

Figure 5: Vegetation hot spots of emergent vegetation on newly exposed playa. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Drainage points, type and waterways are indicated in the figure for reference.

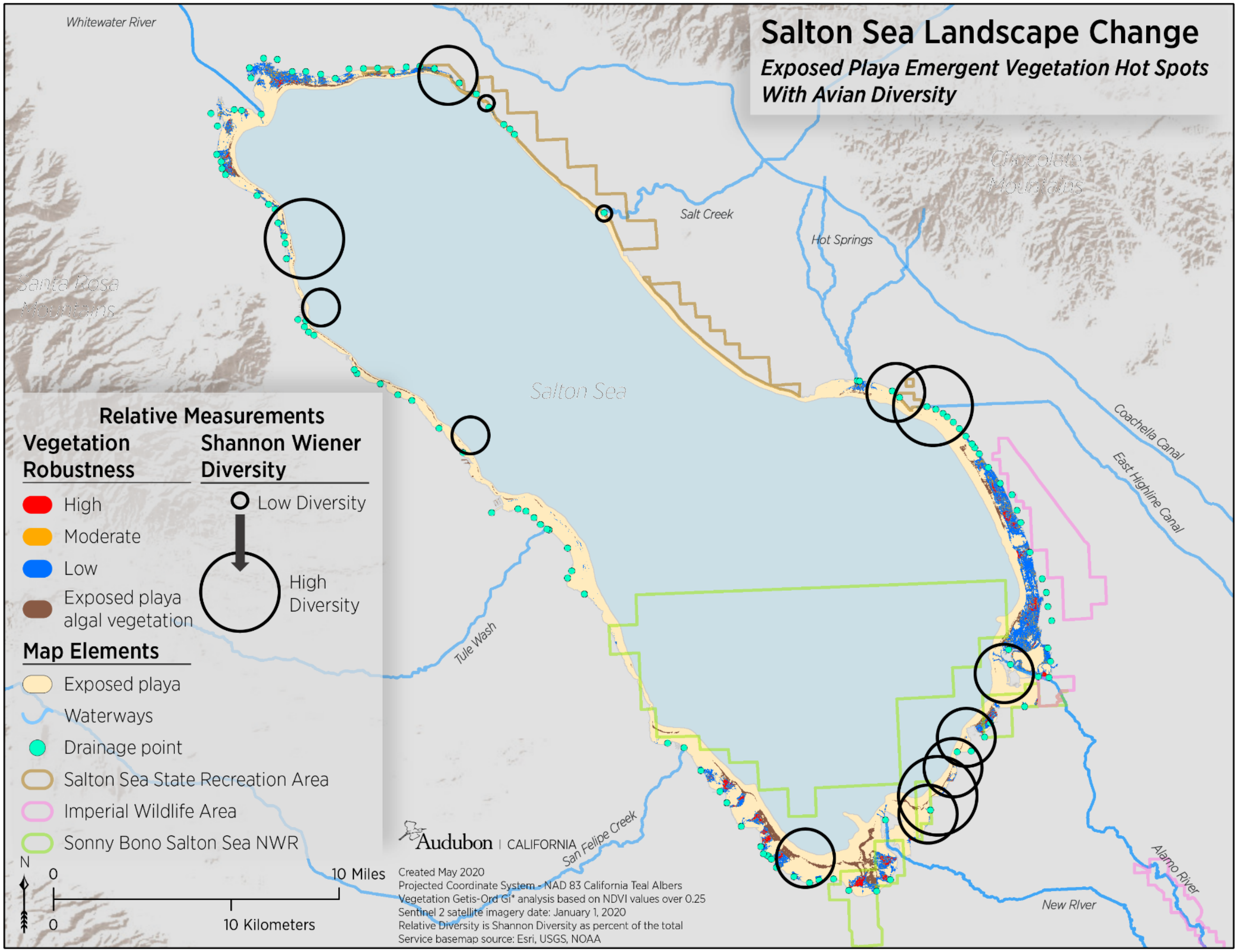

Figure 6: Vegetation hot spots of emergent vegetation on newly exposed playa. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Relative avian diversity (Shannon-Wiener Index) at Audubon California's waterbird survey sites are from three years of bi-monthly survey data. Drainage points and waterways are indicated in the figure for reference.

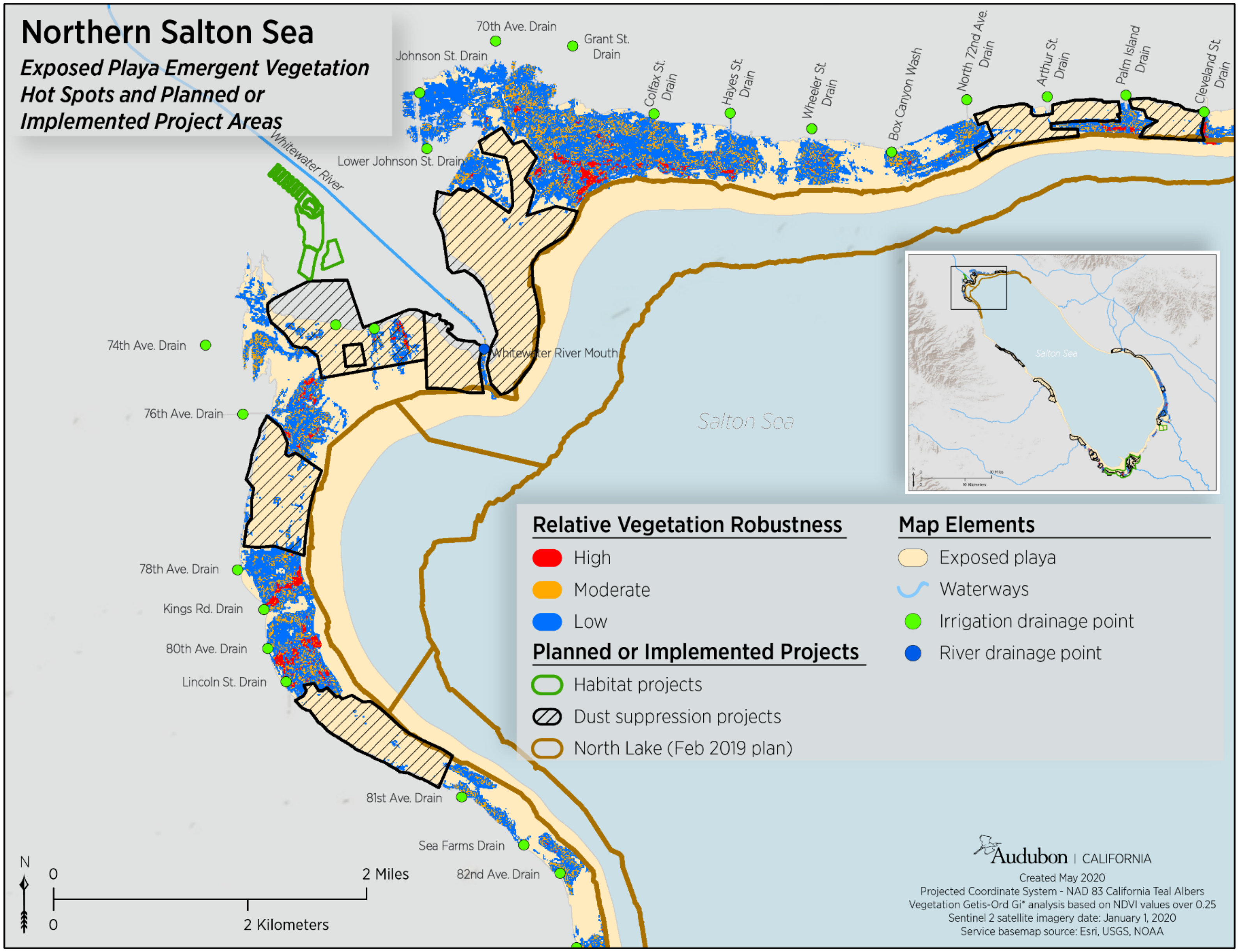

Figure 7: Vegetation hot spots of emergent vegetation on newly exposed playa and medium to long-term project planning areas. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Dust suppression project area data are combined data from the California Natural Resources Agency and Imperial Irrigation District. Habitat project area data are from the State of California and the February 2019 North Lake planning area based on data from Tetra Tech.

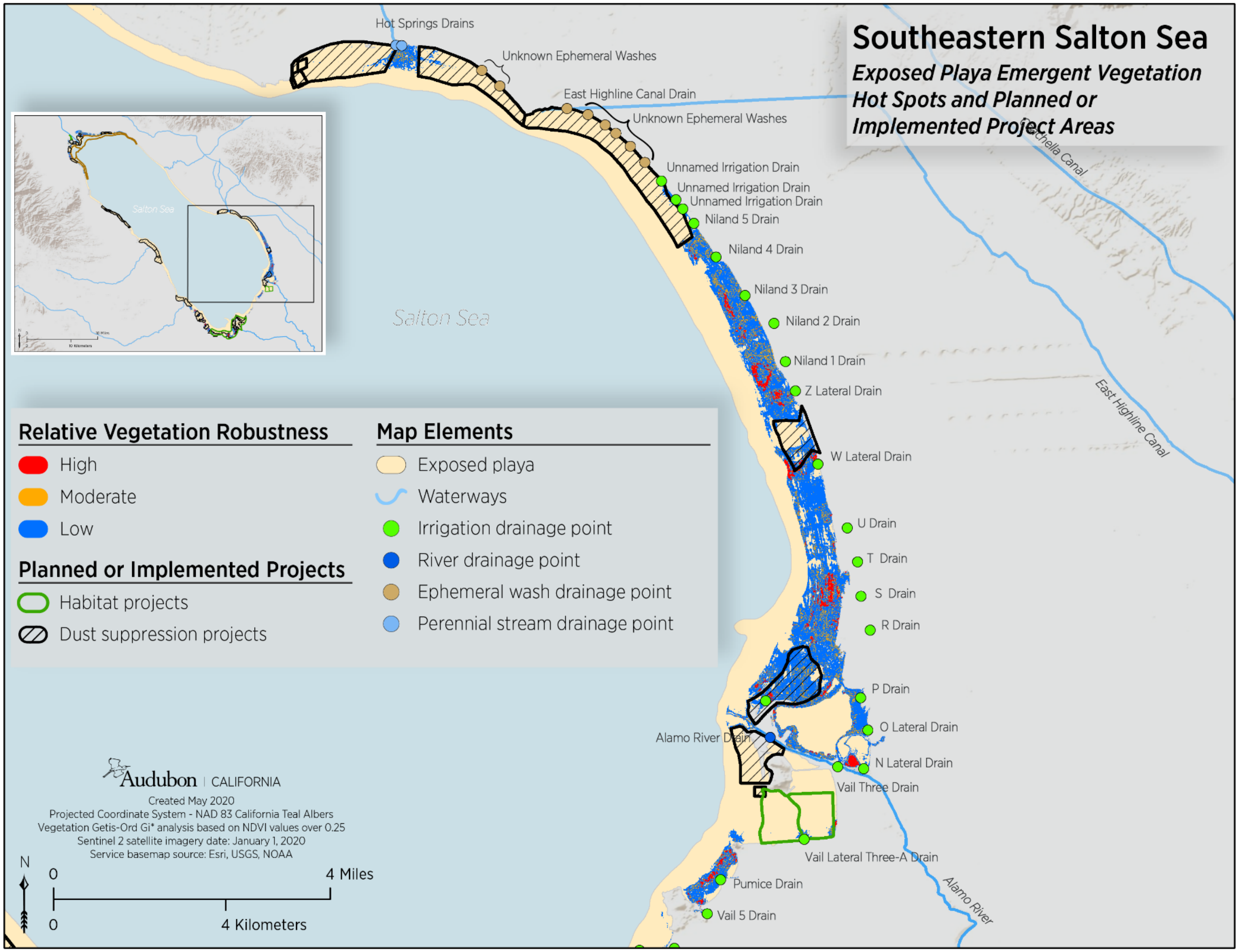

Figure 8: Vegetation hot spots of emergent vegetation on newly exposed playa and medium to long-term project planning areas. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Dust suppression project area data are combined data from the California Natural Resources Agency and Imperial Irrigation District. Habitat project area data are from the State of California. Drainage points, type and waterways are indicated in the figure for reference.

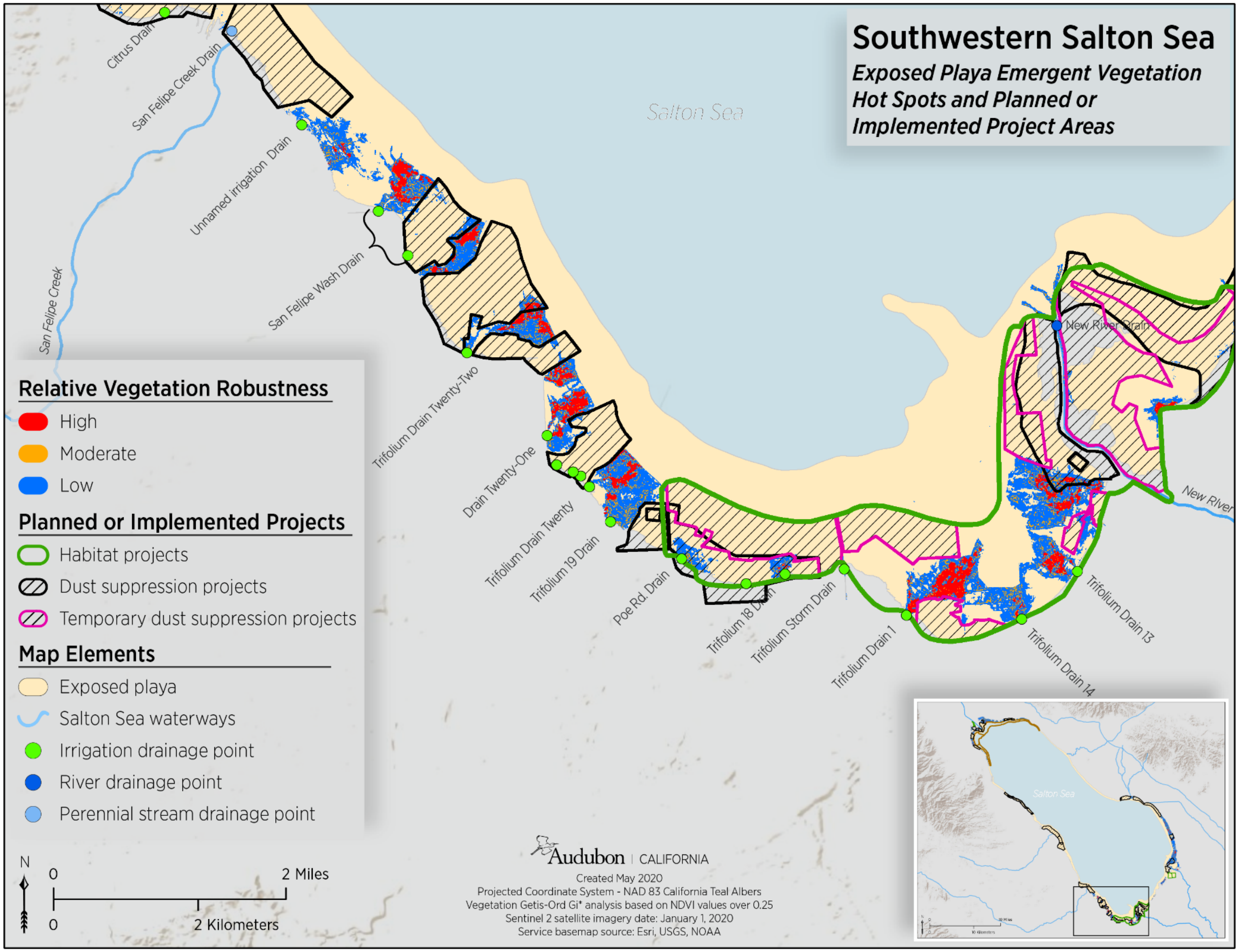

Figure 9: Vegetation hot spots of emergent vegetation on newly exposed playa and medium to long-term project planning areas. Hot spots indicate areas with more robust vegetation relative to other emerging vegetation on exposed playa. Relative vegetation robustness categories based on Getis-Ord Gi* analysis statistical binning of NDVI values. Exposed playa shown is the 2020 projected exposed playa (SALSA2 Hydrologic Model) and differs from the playa extent used to assess vegetation on exposed playa, which matched the imagery date. Dust suppression project area data are combined data from the California Natural Resources Agency and Imperial Irrigation District. Habitat project area data are from the State of California. Drainage points, type and waterways are indicated in the figure for reference.

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