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Project Purpose:

Over the past decade, numerous private land owners and public land managers have become concerned with widespread decline and in stand health in Bishop pine (*Pinus muricata*) forest in the immediate coastal environments of Sonoma and Mendocino counties.

WRA, Inc. (WRA) as the lead consultant to the Sea Ranch Association (TSRA) is collaborating with other consultants, public land managers, and academics to develop a forest management plan aimed at minimizing the spread of pathogens and impacts to Environmentally Sensitive Habitat Areas, and restoring impacted areas with appropriate and viable vegetation.

The initial step in developing a comprehensive forest management plan was to obtain a property-wide baseline map of declining trees over the approximately 3,850-acre property, in a timely and cost-effective manner, using remote sensing and GIS technology supplemented by field verification.



Photo depicting declining stand of Bishop pine forest with approximately 50 percent mortality.



Photo depicting Bishop pine tree showing likely infection response to pitch canker.

Methods:

WRA acquired color and infrared imagery with additional NDVI (Normalized Difference Vegetation Index - a measurement of the amount of live vegetation (chlorophyll) in an area) and thermal imagery from a manned flight in Summer 2018.

WRA acquired vegetation height from the Sonoma County Vegetation Mapping and Lidar Project. Using the vegetation height layer, all vegetation over 8 feet was extracted to create a 3D tree layer (Figure 1).

Using NDVI analysis, vegetation health was classified into two categories: good health, dead/poor health/unvegetated (non-tree). Extracting the dead/poor health/unvegetated layer, the 3D tree layer was clipped to it to create a dead/poor health tree layer (Figure 3). This layer was further refined by clipping out erroneous false positive areas readily visible on aerial imagery (Figure 4). Field verification site visits were conducted to further refine the map as described in detail below.

Using the preliminary declining trees map, WRA's ISA-Certified Arborist and GIS Analyst conducted field verification site visits to remove potential false-positives (i.e. stands showing up as declining trees that appear healthy, or are simply deciduous species which seasonally lack leaves), and to refine the threshold for what constitutes a dead/dying stand versus a healthy stand.

Areas shown as red on the preliminary results figure (Figure 4) were visited in the field to assess the efficacy of the declining trees mapping, with special focus on areas with a high concentration and broad distribution of supposed declining trees. Several false-positive areas were removed from the preliminary results map. Types of false-positives identified in the field included deciduous riparian trees (e.g. *Alnus rubra* and *Salix* spp.) along drainages, and Monterey cypress hedgerows which have been previously topped, thus exhibiting a high percentage of non-photosynthetic tissue (i.e. exposed trunks and branches).

A baseline declining trees map was obtained by removing false-positives as a result of the field verification. Further field assessment was conducted to identify high priority stands for near-term management. Areas that are shown in red on the Preliminary High-Priority Areas figure (shown at right) were determined to be the highest priority stands as they show numerous symptoms of decline, including thinning or dying crowns, indicators of one or more fungal pathogens or pests, and a relatively high (40-60 percent) dead trees.

Figure 1. Aerial Survey Results – Color



Figure 2. Aerial Survey Results – Declining Trees NDVI

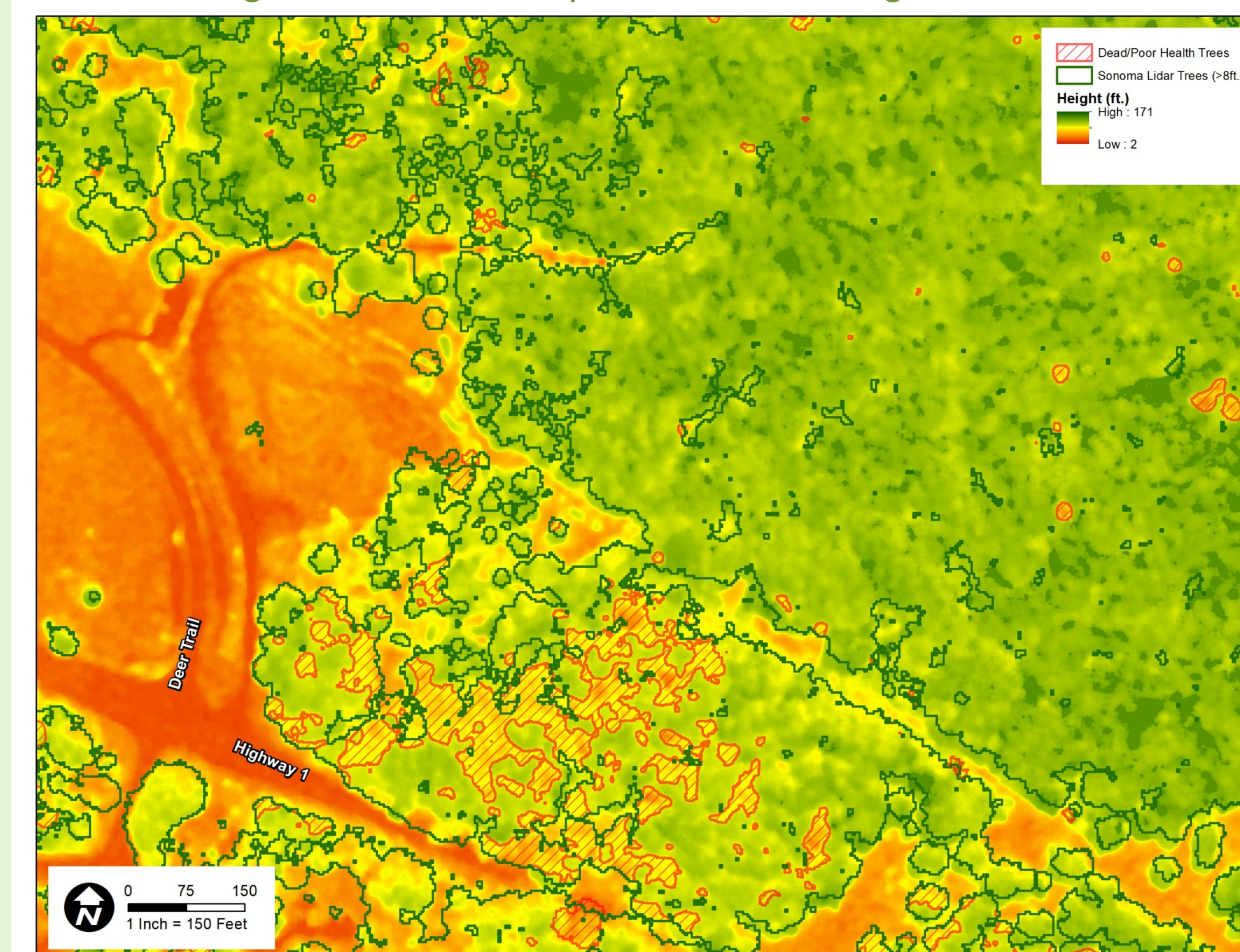
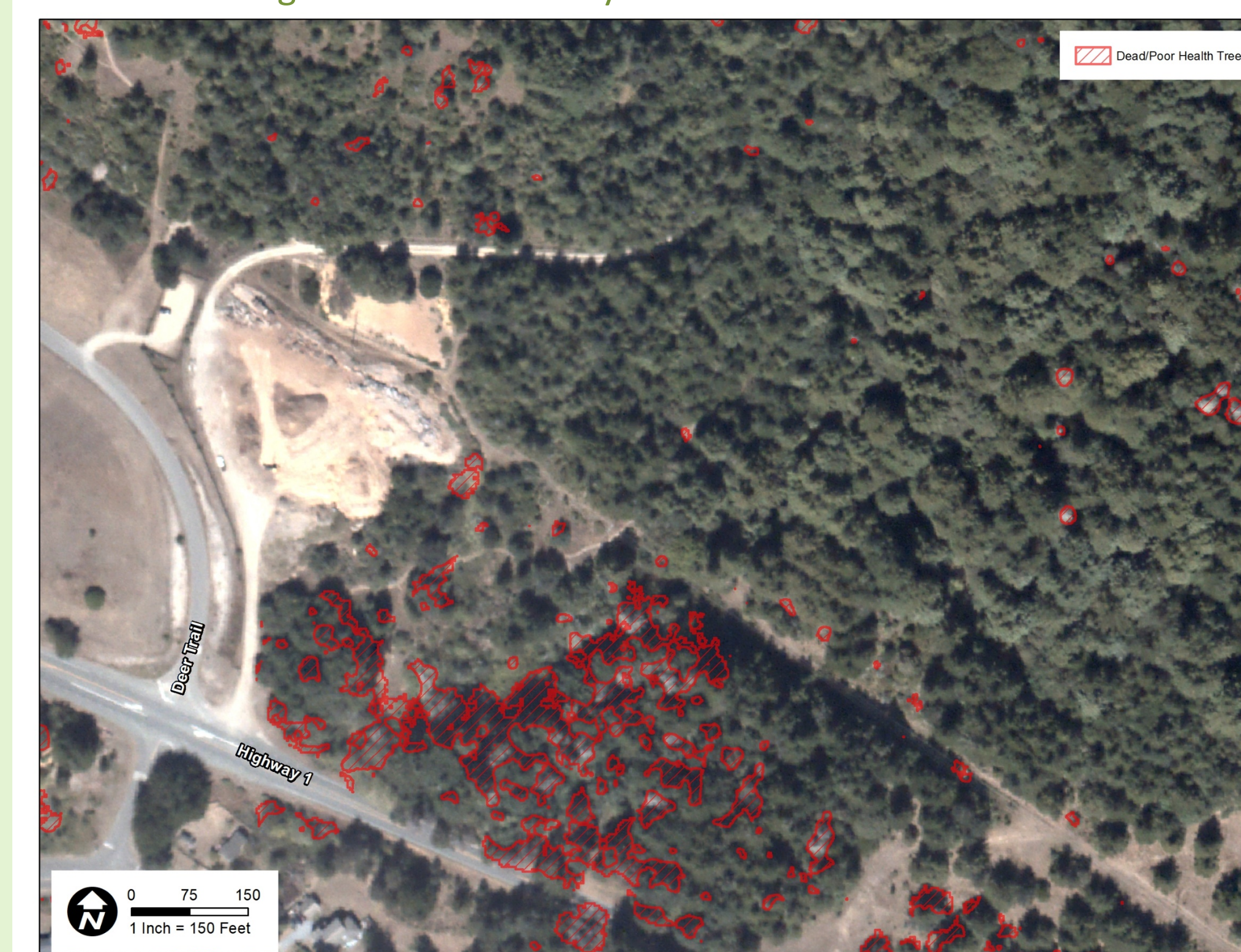


Figure 3. Aerial Survey Results – Dead Trees Color



Conclusion:

The preliminary results indicated approximately 142 acres of potentially declining tree stands across the 3,850-acre property based on the NDVI index.

This baseline map will be used for long-term monitoring and management of declining trees at the Sea Ranch. These maps identify individual dead trees and significant tree mortality centers on TSRA property, and will be central to developing a property-wide adaptable management plan to address declining Bishop pine forest health. WRA is developing this plan in collaboration with other consultants, public land managers, and academics which provides recommended treatments for declining stands, while minimizing the spread of pathogens and impacts to Environmentally Sensitive Habitat Areas, and ultimately restoring tree removal areas with appropriate and viable vegetation.

Figure 4. Aerial Survey – Preliminary Results

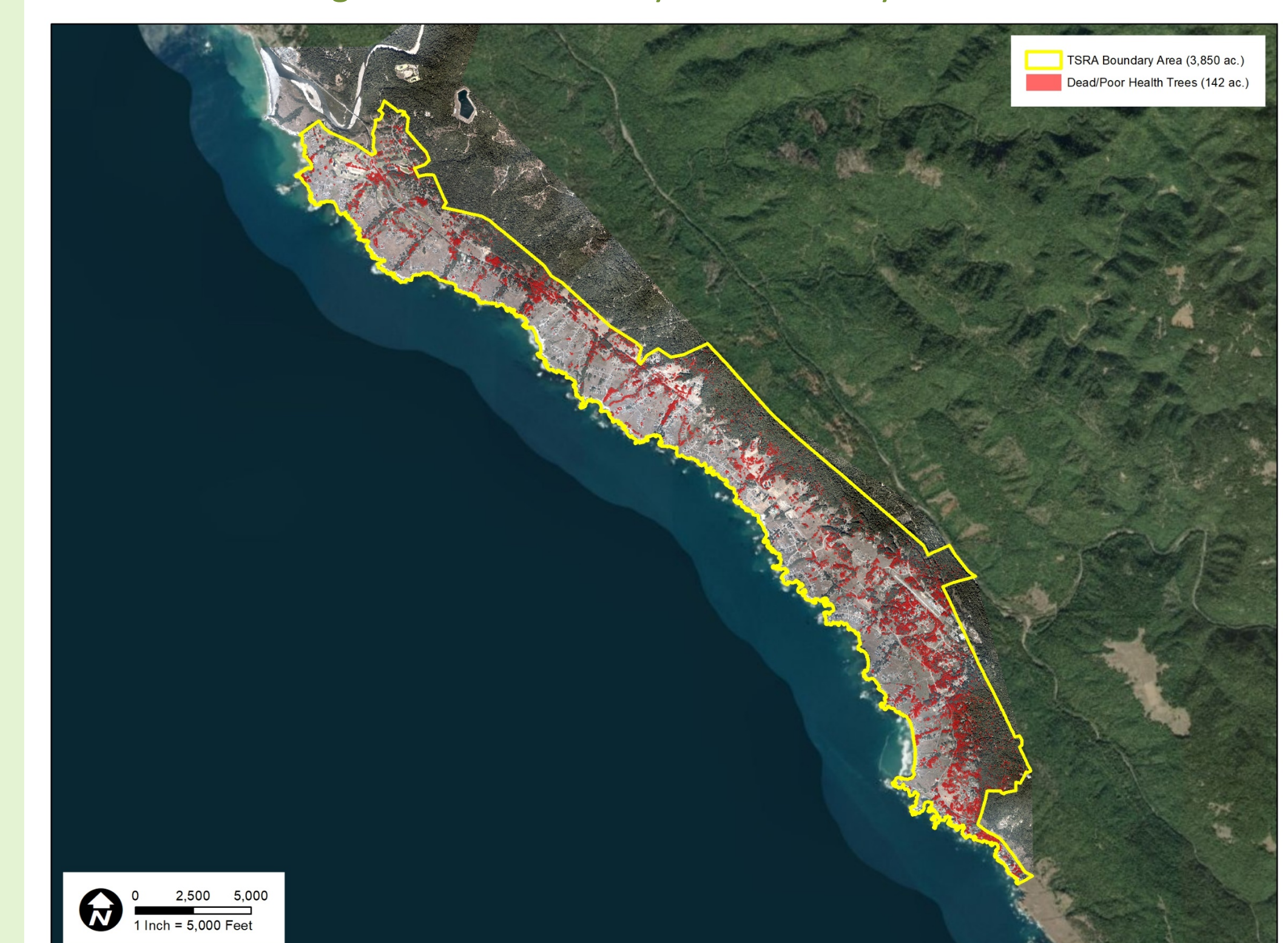


Figure 5. Near-Term Priority Management Areas

