WEATHER-BASED PEST RISK MAPPING PROJECT

RISK ASSESSMENT:

Xanthomonas oryzae pv. *oryzae,* bacterial leaf blight or kresek disease

Cooperative agreement between NCSU and

USDA-APHIS-PPQ-CPHST-PERAL

I. Rationale

We developed this risk assessment to assess the climatic favorability of the United States for bacterial leaf blight (BLB).

Photo: Chin Khoon Min (CABI, 2007)

II. Life History and Biology

Bacterial leaf blight (BLB) or kresek disease, caused by *Xanthomonas oryzae* pv*. oryzae* (Xoo), threatens rice (*Oryza sativa*, *Oryza* spp.) production worldwide. This Gram-negative bacterium can be transmitted in several ways: 1) in seed, 2) from other diseased rice and weedy host plants and infected stubble in irrigation water, 3) through human manipulations such as transplanting and clipping leaves, 4) through naturally made openings in the epidermis (hydrathodes or roots at the bottom of leaf sheaths) or through wounds made by insects or birds, and 5) moved by weather events such as hurricanes or typhoons (Nyvall, 1999; Ou, 1985). Some of the alternate hosts are *Poaceae* spp. (grasses), *Cenchrus ciliaris* (buffelgrass), *Cynodon dactylon* (Bermuda grass), *Cyperaceae* spp. (sedges), *Cyperus difformis* (small-flowered nutsedge), *Cyperus rotundus* (purple nutsedge), *Echinochloa crus-galli* (barnyard grass), *Leersia hexandra* (southern cut grass), *Leersia oryzoides* (rice cutgrass), *Oryza* (rice (generic level)), *Panicum maximum* (Guinea grass), *Paspalum scrobiculatum* (ricegrass paspalum), *Urochloa mutica* (tall panicum), *Zizania aquatica* (annual wildrice), *Zizania palustris* (northern wild rice), and *Zoysia japonica* (zoysiagrass) (CABI, 2007).

On susceptible cultivars in the tropics, such as *O. sativa* ssp. *indica*, Xoo causes kresek and pale-yellow leaf, two seedling diseases with distinct symptoms from typical BLB (Nyvall, 1999). Kresek is a seedling blight that occurs shortly after transplant from nurseries to the field. The common practice of cutting leaf tips before transplanting plays an important role in the development of the syndrome. Additionally, broken roots resulting from pulling seedlings off the seedbed serve as entry points for bacteria present in flood-irrigated fields. Bacteria spread through the vascular system to the growing point of the plant, killing entire plants in 2–3 weeks. Plants that survive kresek are stunted and yellowish-green in color, and the tillers may not develop (Goto, 1992; Nyvall, 1999; Ou, 1985). Pale-yellow leaf is observed in older plants and is sometimes considered a secondary effect of seedling leaf blight and wilt. Whereas older leaves appear green and healthy, younger leaves are uniformly pale yellow or whitish, and tillers do not grow fully (Mew et al., 1993; Ou, 1985).

Foliar symptoms of BLB usually become evident at the tillering stage as small, green water-soaked spots at the tips and margins of fully developed leaves. The spots expand along the veins, merge, and become chlorotic and then necrotic, forming white- to gray-colored lesions that typically extend from the leaf tip down along the leaf veins and margins (Ou, 1985). BLB moves vertically through the leaf through primary veins but also laterally through commissural veins. Bacterial cells and extra-cellular proteins fill the xylem vessels and ooze out from hydrathodes, forming beads or strands of exudate on the leaf surface, which is a characteristic sign of the disease and a source of secondary inoculum (Mew et al., 1993).

BLB is characterized by a high degree of race-cultivar specificity. There are over 30 reported races of isolates from several countries (e.g., Adhikari et al., 1999; Mew, 1987; Noda et al., 2001). A set of races identified in the Philippines using five differential rice cultivars (Mew, 1987) has been used widely for identifying and classifying resistance to BLB in other cultivars (Lee et al., 2003). Breeding resistant cultivars carrying major resistance (R) genes has been the most effective approach to controlling BLB. To date, 29 R genes to BLB have been identified, mostly from *O. sativa* ssp. *indica* cultivars, but also some from japonica varieties and from related wild species including *O. longistaminata*, *O. rufipogon*, *O. minuta,* and *O. officinalis* (Brar and Khush, 1997; Lee, 2003).

III. Prediction Model

Host density

We created a risk map based on percentage host acres per county from National Agricultural Statistics Service data (http://www.nass.usda.gov/). We calculated percent by dividing the total rice acres by the total acres per county (Fig. 3).

Prediction model

There is limited amount of information to make a predictive model for Xoo. Infection of Xoo is favored by temperatures over 30°C and high relative humidity (Saddler, 2002). More is known about *Xanthomonas axonopodis* pv. *citri* (Xac), the causal agent of citrus canker. Optimal infection requirements for citrus canker were a temperature between 25°C and 35°C, with a minimum of 12°C and a maximum of 40°C, and four hours of leaf wetness (Pria et al., 2006). However, rice has a production system very different from citrus. For example, rice is either aerially planted or transplanted into fields flooded throughout the season until a few weeks before harvest (Wilson et al., 2008). Therefore, leaf wetness requirements for infection and precipitation requirements for splash dispersal may not be relevant.

We created a simple prediction model based on the number of favorable days and defined a favorable day as having a maximum temperature above 30°C and average relative humidity above 80% (Saddler, 2002). Risk maps were created with the NCSU APHIS Pest Forecasting System (NAPPFAST) system (Magarey et al., 2007). The NAPPFAST system uses a web-based graphical user interface to link climatic and geographic databases with templates for biological modeling. The NAPPFAST system includes two daily weather databases with over

30 years of records. The global database is based upon the National Centers for Environmental Prediction (NOAA/NCEP) Global Reanalysis II data set (Kalnay et al., 1996). This data set is a numerical grid created for use as input data for meteorological models. The spatial resolution of the grid is 28 km, which has been resampled from a 1.875 degree (210 km) resolution. Station data from the International Station Hourly (ISH) data (Lott et al., 2001) were used to supplement the NCEP backbone. The North American database includes over 2000 stations for North America (Magarey et al., 2007). The input weather data was interpolated to a 10 km^2 resolution using a 3-D multivariate interpolation (Splitt and Horrel, 1998).

IV. Results and Discussion

Rice can be produced in both tropical and temperate areas (Fig. 1). The distribution of Xoo occurrence indicates that incidence of this pathogen is concurrent with much of the rice production in tropical areas (Fig. 2). However, Xoo does not occur in some temperate areas where rice is grown, for example, irrigated production areas of New South Wales and Victoria in Australia, Egypt, and other areas of North Africa and Argentina. For rice production in the United States, the greatest areas of production are the Mississippi Valley, north central California, and the Gulf Coast of Texas (Fig. 3).

The map based on the NAPPFAST prediction model shows that production areas in the east are at greater risk than those on the west coast (Fig. 4). This prediction was confirmed by international results for the model (Fig. 5). Many of the tropical/sub-tropical areas where rice is produced have more than 10 favorable days, specifically Southeast Asia, India, equatorial Africa, north-eastern Australia, and East Africa. In addition, many of the temperate and irrigated areas (described above) that do not have Xoo have two or fewer days suitable for infection. It may be possible that these areas do not have the disease because the climate is unfavorable. The validation map is not perfect since some areas that have Xoo (such as Ecuador) also have few days favorable for infection. We believe these differences are due to the difficulties with estimating relative humidity in countries with sparse weather observations. Relative humidity is a difficult variable to estimate because it is dependent upon both rainfall and air temperature.

V. Authors

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VI. References Cited

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VII. Figures

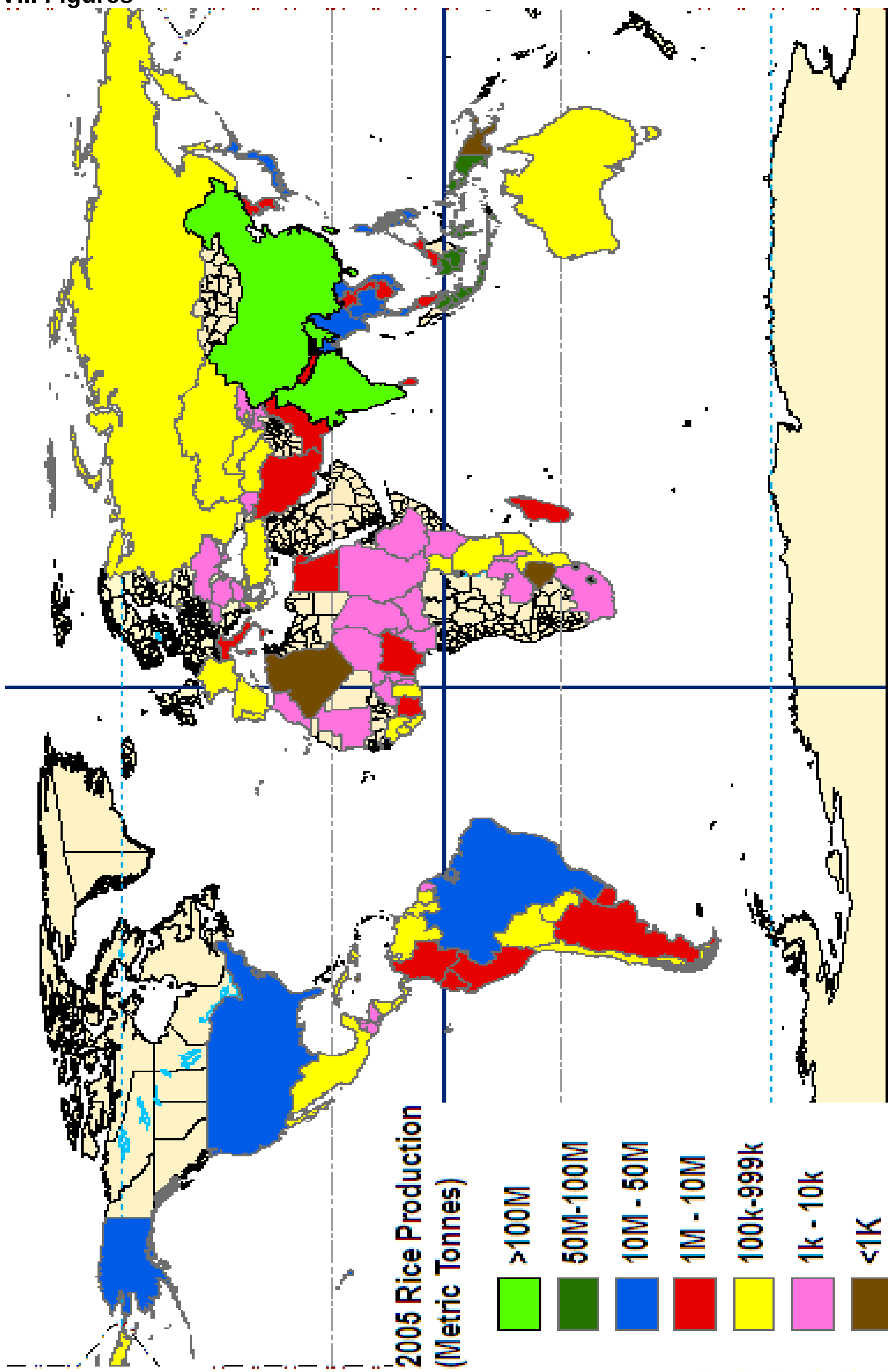

Figure 1. 2005 estimates of rice production across the world. Information was obtained from http://www.gramene.org/.

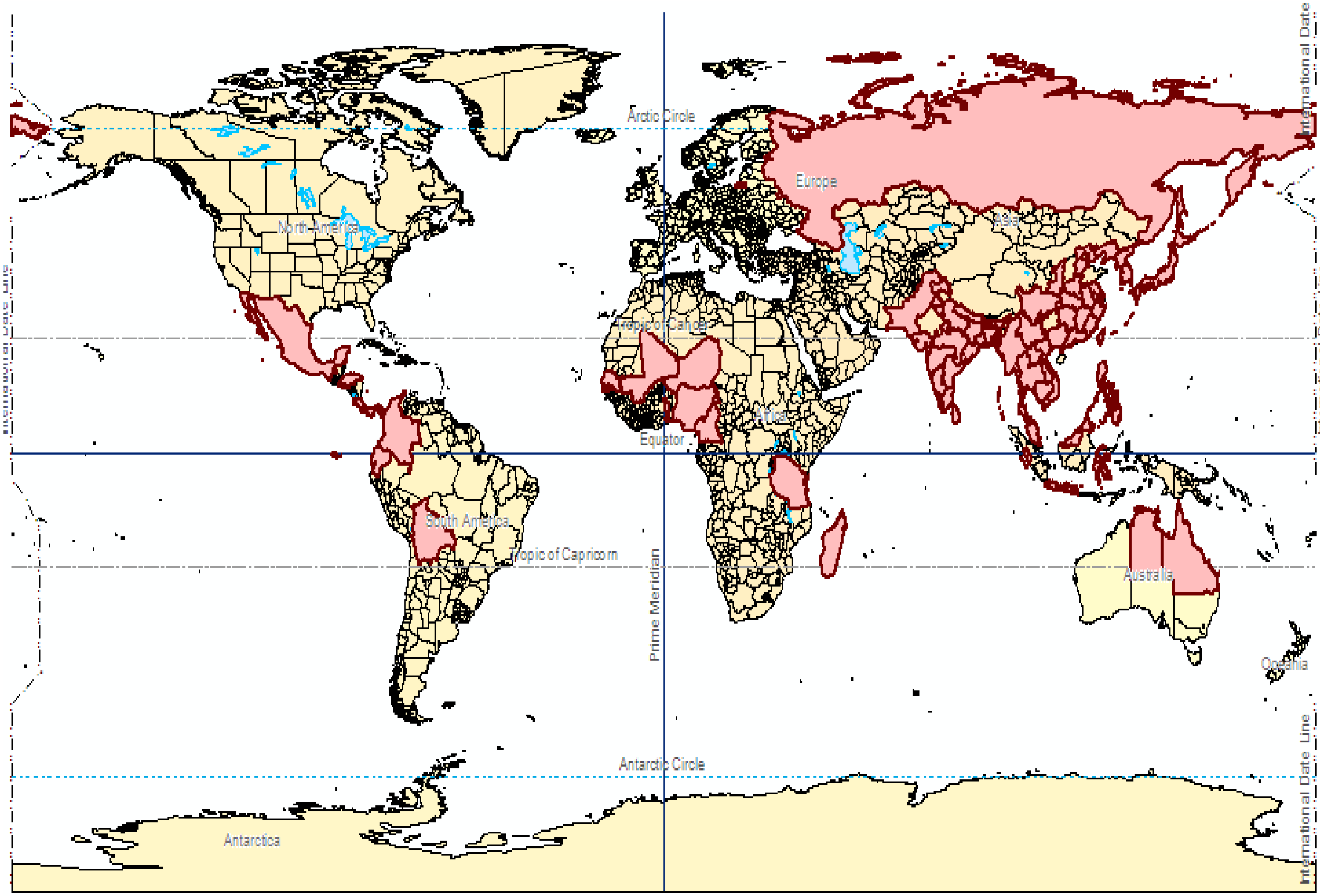

Figure 2. Current geographical distribution of *Xanthomonas oryzae* pv *oryzae*, cause of bacterial leaf blight of rice. Information was obtained from CABI 2007.

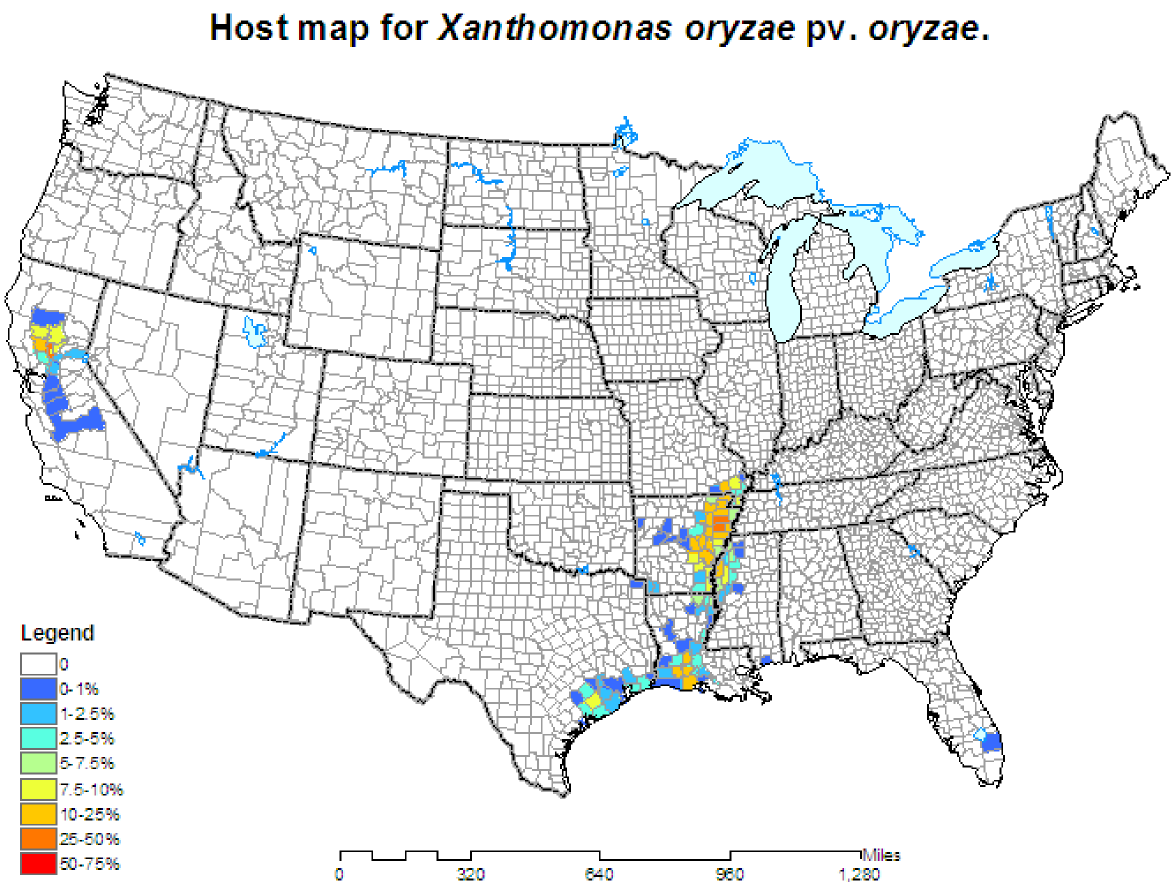

Figure 3. Percentage of county acres in *Oryza sativa* (rice) commercial production in the United States.

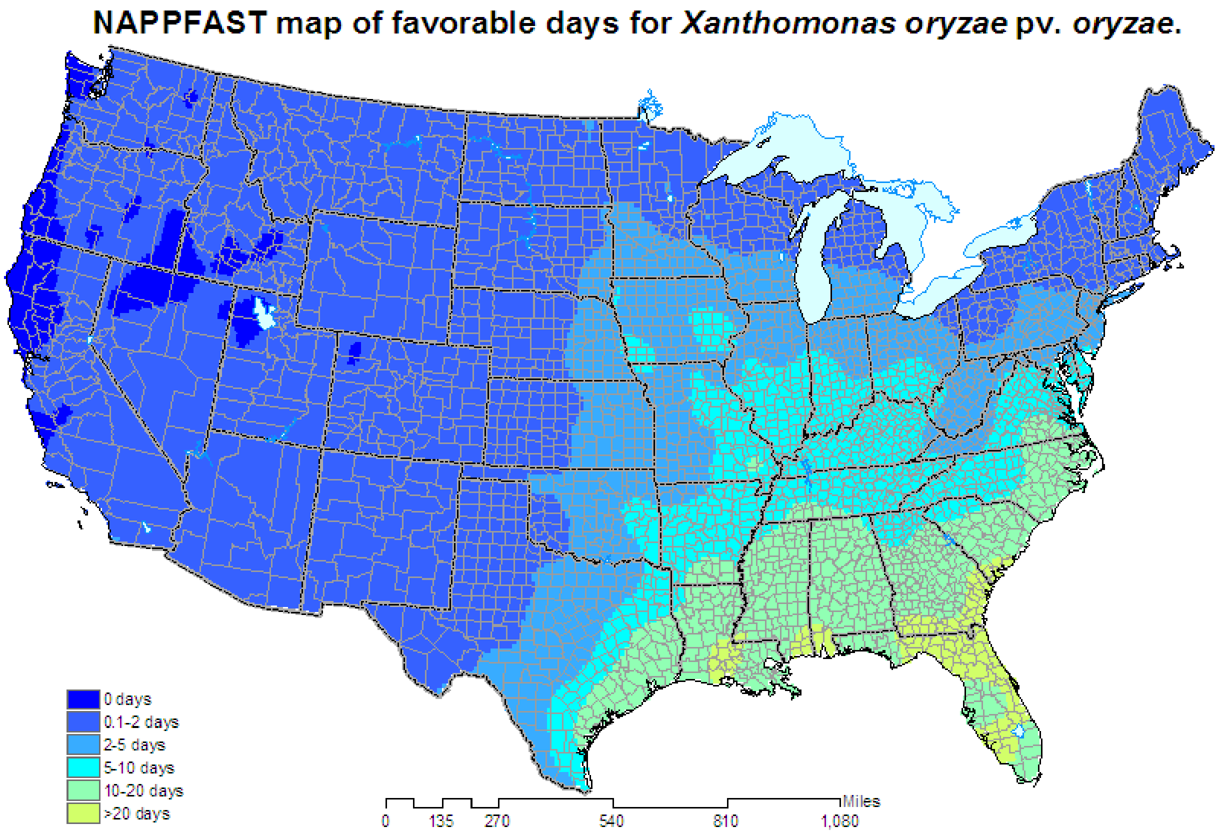

Figure 4. NAPPFAST prediction model map for favorable days for *Xanthomonas oryzae* pv. *oryzae* infection.

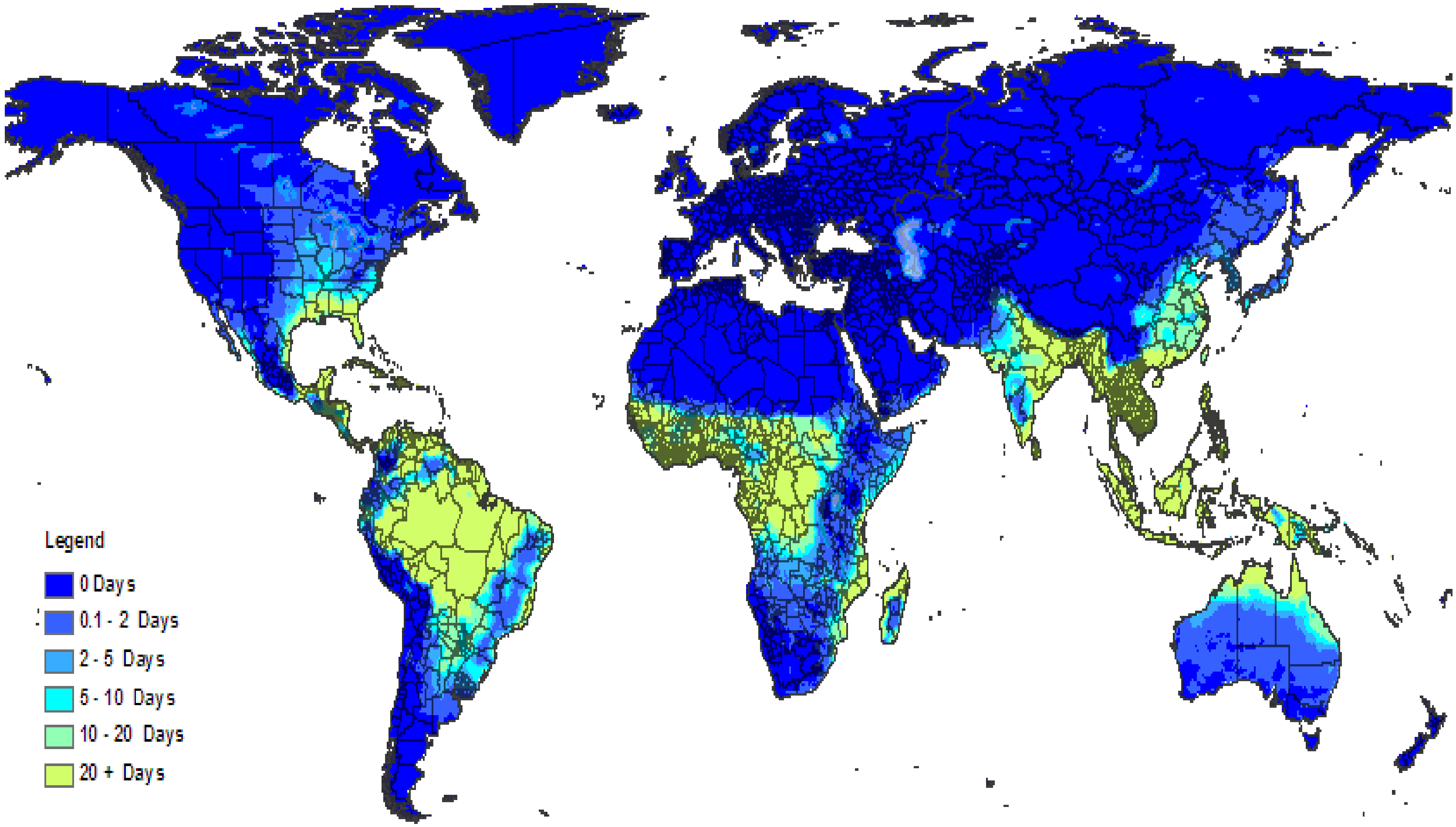

Figure 5. NAPPFAST prediction model map for favorable days for *Xanthomonas oryzae* pv. *oryzae* infection.