# CORRECTING THE ERRONEOUS GEOGRAPHIC COORDINATES OF THE SOUTHWIDE PINE SEED SOURCE STUDY SOURCE AREAS

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## ABSTRACT

The Southwide Pine Seed Source Study (SPSSS) provided a tremendous amount of information from its inception in the early 1950s until its conclusion decades later. The silvicultural value of this genetics study, even given some design weaknesses and other limitations, continues to this day and these data will soon be available through the U.S. Department of Agriculture, Forest Service's Research Data Archive. However, while preparing these data, we discovered in the original study plan documentation that most of the geographic coordinates provided for the seed sources were erroneously located. While some of these errors were very minor, others had significantly different latitudes and longitudes. Such departure errors probably had little to no impact on the earlier interpretations of seed source performance; however, they may prove problematic if used in modern geographic analyses that require more precise sample locations. We demonstrate a number of these errors through a series of species-based tables and maps and provide improved coordinates for future researchers.

## INTRODUCTION

As the first large-scale study of southern pine forest genetics, the Southwide Pine Seed Source Study (SPSSS) was developed in the early 1950s to learn about the variation in seed sources and use that knowledge to improve the restoration of the region's forests (Wakeley 1953). Remarkably little was known about the genetics of southern pines to that point, and tree improvement and widespread planting of pines were concepts still in development. Although the SPSSS study design is simple and limited, this research eventually proved highly valuable to forest geneticists and silviculturists, who used this study to refine and improve upon plantation management for decades.

One of the strengths of the SPSSS was its replicated, region-wide study design and statistical analysis of geographic-based variation for the four major southern pine species [longleaf (*Pinus palustris*), shortleaf (*P. echinata*), loblolly (*P. taeda*), and slash (*P. elliottii*)]. The SPSSS was installed across a range of sites designed to follow what were thought to be important regional gradients in temperature, precipitation, and soils for both seed sources and planting locations (Wakeley 1953). This required a monumental amount of coordination with many partners to collect sufficient quantities of pine seed across these gradients to produce meaningful comparisons—not an easy task in the 1950s, especially when faced with limited resources and some major droughts. These challenges led to a number of on-the-fly adjustments to study design and later analyses, which limited some of the interpretation of the results. Another limitation inherent to the SPSSS is that the seeds gathered for this study did not come from controlled collections from known parent trees, but rather were taken from rather large seed production areas that could encompass many thousands of acres. While this undoubtedly facilitated the collection of enough seed to install the planned replicates of outplantings, it also limited the degree of control in determining the actual

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seed source. In other words, instead of having a handful of known trees specifically located on the ground, collections were made from a much broader seed production area.

The SPSSS data collection started in the 1950s and ran into the 1980s, and this extensive and consistently measured study represents a remarkable investment by the U.S. Department of Agriculture, Forest Service. Not surprisingly, the SPSSS has considerable long-term value as a research program. For example, the SPSSS loblolly pine outplantings were studied for decades on a variety of topics, from growth and yield, forest health, mortality, wood quality differences, and pine genetics (Buford 1986, Henry and Hepting 1957, McAlister and Clark 1991, Schmidtling and Froelich 1993, Wells 1983). Given that in recent years, geographic coordinates of genetic source materials have been used to further large-scale analyses (e.g., comparing wood properties with their origins and proximity to geographic features such as oceans or mountains or even latitude) (Jordan and others 2008), the Forest Service has continued to maintain the SPSSS datasets (Nelson and Schmidtling 2022) and has started to make them publicly available on the agency's Research Data Archives (project in progress).

As a part of this data archiving exercise, available metadata—information on the study beyond the data itself—are required to better document the work. This includes good geospatial information on seed source areas. For the SPSSS, locational information in the form of place descriptions (state, county, latitude, longitude, and a physiographic description) for each seed source was provided in a table from a supplement to the original working plan (SGSS 1956: table 1). We decided to use that information to develop a series of digital maps for the included southern pines and add the maps to the materials to be sent to the Forest Service's Research Data Archive. However, to our surprise, some of these plotted source locations taken from the latitude and longitude provided in SGSS (1956) were noticeably incorrect. If a researcher was to try to use seed source locations as a proxy for environmental conditions in some future silvicultural research, these errors may cause significant problems. Hence, this paper is our improvement of the geospatial information for these seed source locations.

## METHODS

Our first step was to extract the original latitude and longitude (in degrees, minutes, and seconds) for the seed source (referred to as stock, as in seed or seedling stock) locations from table 1 in SGSS (1956). These coordinates were converted to decimal degrees and entered into a geographic information system (GIS) project using ArcGIS Pro software as X-Y tables; shapefiles were then created from each table. A map showing shortleaf pine seed source locations from the original 1956 coordinates was created, and immediately it became apparent that some kind of problem existed—some seed source locations were produced that made no sense. For instance, the 1956 coordinates situated some seed sources outside of their accepted natural distributions—this was the case for one shortleaf pine seed source area, which was placed in the Mississippi River Alluvial Plain (shortleaf pine is not native to that frequently flooded region). After double-checking the digital data to ensure their fidelity with the original table, maps were also created for longleaf, loblolly, and slash pines, and each of these also provided examples of substantial discrepancies from expectations. These likewise had obvious issues—for example, some coastal seed sources of loblolly and longleaf pine were placed in the Atlantic Ocean or Gulf of Mexico using the 1956 coordinates. While there did not appear to be any clear patterns of systemic displacements, the sheer number of anomalies suggested an underlying problem.

In order to identify and resolve an avoidable source of error—inaccurate seed area coordinates—we looked to the 1950s study documentation to reconstruct their coordinate assignment approaches. Obviously, when the original seed collections were made in the 1950s, precision, satellite-based global position systems (GPS) or comparable technologies were not available to those gathering the seeds in the field. The seed collectors knew their approximate locations and were gathering seeds from a number of trees within a source area. Because accurate and precise locational information was not required under the original intent of the SPSSS, geographic references were only expected to be accurate to a county (or counties, for some source areas). Hence, the original approach was to assign a geographic coordinate (latitude and longitude) for the county seat in which the seed was sourced. There were a number of exceptions to that rule, however. For instance, when the seed was collected from a known smaller location (for example, the Crossett Experimental Forest), that more refined source area was to use those coordinates, rather than the county seat. Another exception is when seeds were gathered from several counties; in that case, a spot (sometimes a county seat, sometimes another location) was chosen as the seed source coordinate. As an example, a point along the boundary between the two counties was chosen for loblolly pine seed stock #309. Under a different application, for longleaf pine seed stock #107 the original coordinates were for the county between the two counties that were the actual source of the seeds. In a final example, longleaf pine seed stock #127's location was recorded as the common latitude and longitude for a point where three counties met.

Using those locational principles, modern coordinates for each county seat were extracted by taking official county seat locations from those published online or an alternative source, if needed. Because the original coordinates were in a nonprojected geographic coordinate system, all generated coordinates using the USA Contiguous Albers Equal Area Conic projection were used to produce a comparable set of coordinates. After creating a "modified" table with these updated locations for each seed source, an ArcGIS Pro process was used to calculate the distance, in miles, between the original coordinates and the county seat coordinates. A geoprocessing tool (Generate Near Table) was used to calculate these distances. After this processing was completed, a departure field was added for distance between the original (1956) coordinate data and the modified locations (in miles).

## RESULTS AND DISCUSSION

Of the 87 SPSSS seed source areas considered, only one had the same latitude and longitude coordinates (within 0.1 mile of each other) between the original and modified values (table 1). Almost 83 percent were at least 10 miles different, and 57 percent were at least 20 miles apart. The highest departures for each species were more than 31 miles, and loblolly pine had one seed source area (#309) that was 36 miles different (table 2). Shortleaf pine had the highest average departure in its seed source coordinates (fig. 1, table 1). As noted earlier, loblolly pine (fig. 2) had the greatest individual departure but had the second lowest average departure. With a couple of notable exceptions, slash pine seed sources were not markedly different from their original placements and had (by more than 5 miles) the lowest average departure of these four southern pines (fig. 3, table 1).

**Table 1**—Description and distribution of departures between original and modified coordinates by species for the Southwide Pine Seed Source Study source locations

| | | | | | | Displacement category (miles) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Seed sources** | **Average** | **SD** | **Min** | **Max** | **0** | **>0–5** | **>5–10** | **>10–20** | **>20** |
| | *number* | *~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ miles ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~* | | | | *~ ~ ~ ~ ~ ~ ~ ~ ~ ~ number of source areas ~ ~ ~ ~ ~ ~ ~ ~ ~* | | | | |
| **Longleaf** | 32 | 20.7 | 8.2 | 0.0 | 31.5 | 1 | 2 | 1 | 9 | 19 |
| **Shortleaf** | 30 | 21.3 | 8.7 | 3.8 | 32.8 | 0 | 3 | 1 | 8 | 18 |
| **Loblolly** | 16 | 20.5 | 7.2 | 3.8 | 35.9 | 0 | 1 | 1 | 4 | 10 |
| **Slash** | 9 | 15.3 | 13.0 | 1.8 | 32.8 | 0 | 3 | 2 | 1 | 3 |
| **Totals** | 87 | | | | | 1 | 9 | 5 | 22 | 50 |

SD = standard deviation; min = minimum; max = maximum.

**Table 2**—Departures between original SGSS (1956) and current (this study) seed source location assignments using county seats (in miles)

| | | Original | | Modified (this study) | | |
|---|---|---|---|---|---|---|
| Species | Stock number | Latitude | Longitude | Latitude | Longitude | Difference |
| | | ~~~~~~ *degrees* ~~~~~~ | | ~~~~~~ *degrees* ~~~~~~ | | *miles* |
| **Longleaf** | 102 | 36.43 | -76.35 | 36.70 | -76.63 | 24.6 |
| **Longleaf** | 103 | 34.37 | -78.36 | 34.63 | -78.61 | 22.8 |
| **Longleaf** | 104 | 34.37 | -78.36 | 34.63 | -78.61 | 22.8 |
| **Longleaf** | 105 | 34.56 | -79.46 | 34.94 | -79.76 | 31.5 |
| **Longleaf** | 107 | 34.11 | -79.45 | 34.11 | -79.45 | 0.0 |
| **Longleaf** | 108 | 34.11 | -79.45 | 34.19 | -79.78 | 19.3 |
| **Longleaf** | 109 | 34.44 | -80.05 | 34.74 | -80.09 | 20.7 |
| **Longleaf** | 111 | 32.22 | -82.35 | 32.38 | -82.59 | 17.8 |
| **Longleaf** | 112 | 32.22 | -82.35 | 32.38 | -82.59 | 17.8 |
| **Longleaf** | 114 | 27.57 | -82.27 | 27.95 | -82.46 | 28.4 |
| **Longleaf** | 115 | 30.45 | -86.34 | 30.76 | -86.57 | 25.5 |
| **Longleaf** | 117 | 30.53 | -87.46 | 30.88 | -87.77 | 30.7 |
| **Longleaf** | 119 | 33.39 | -85.35 | 33.65 | -85.59 | 22.5 |
| **Longleaf** | 122 | 30.36 | -89.03 | 30.37 | -89.09 | 3.8 |
| **Longleaf** | 123 | 30.50 | -90.09 | 30.85 | -90.15 | 24.3 |
| **Longleaf** | 125 | 31.18 | -92.26 | 31.30 | -92.46 | 14.6 |
| **Longleaf** | 126 | 31.18 | -92.26 | 31.30 | -92.46 | 14.6 |
| **Longleaf** | 127 | 30.42 | -94.56 | 30.53 | -94.55 | 7.4 |
| **Longleaf** | 151 | 36.43 | -76.35 | 36.70 | -76.63 | 24.6 |
| **Longleaf** | 153 | 34.37 | -78.36 | 34.63 | -78.61 | 22.8 |
| **Longleaf** | 155 | 34.56 | -79.46 | 34.94 | -79.76 | 31.5 |
| **Longleaf** | 157 | 34.11 | -79.45 | 34.19 | -79.78 | 19.3 |
| **Longleaf** | 161 | 34.44 | -80.05 | 34.74 | -80.09 | 20.7 |
| **Longleaf** | 163 | 32.22 | -82.35 | 32.38 | -82.59 | 17.8 |
| **Longleaf** | 167 | 27.57 | -82.27 | 27.95 | -82.46 | 28.4 |
| **Longleaf** | 169 | 30.45 | -86.34 | 30.76 | -86.57 | 25.5 |
| **Longleaf** | 171 | 30.53 | -87.46 | 30.88 | -87.77 | 30.7 |
| **Longleaf** | 175 | 32.38 | -87.19 | 32.63 | -87.32 | 19.0 |
| **Longleaf** | 177 | 30.36 | -89.03 | 30.37 | -89.09 | 3.8 |
| **Longleaf** | 179 | 30.50 | -90.09 | 30.85 | -90.15 | 24.3 |
| **Longleaf** | 181 | 31.18 | -92.26 | 31.30 | -92.46 | 14.6 |
| **Longleaf** | 183 | 30.42 | -94.56 | 30.71 | -94.94 | 29.8 |
| **Shortleaf** | 401 | 39.56 | -77.39 | 39.93 | -77.65 | 29.1 |
| **Shortleaf** | 403 | 39.59 | -74.47 | 40.00 | -74.79 | 32.8 |
| **Shortleaf** | 409 | 34.16 | -81.37 | 34.38 | -81.62 | 20.9 |

| Species | Stock number | Original Latitude | Original Longitude | Modified (this study) Latitude | Modified (this study) Longitude | Difference |
|---|---|---|---|---|---|---|
| | | ~~~~~~ *degrees* ~~~~~~ | | ~~~~~~ *degrees* ~~~~~~ | | *miles* |
| **Shortleaf** | 413 | 33.14 | -84.16 | 33.25 | -84.26 | 9.5 |
| **Shortleaf** | 415 | 32.50 | -85.45 | 32.83 | -85.76 | 29.3 |
| **Shortleaf** | 417 | 33.07 | -89.03 | 33.12 | -89.06 | 4.0 |
| **Shortleaf** | 419 | 34.22 | -89.31 | 34.37 | -89.52 | 15.6 |
| **Shortleaf** | 421 | 30.50 | -90.40 | 30.83 | -90.67 | 27.9 |
| **Shortleaf** | 423 | 31.20 | -94.43 | 31.33 | -94.72 | 19.7 |
| **Shortleaf** | 425 | 34.14 | -95.37 | 34.24 | -95.62 | 15.7 |
| **Shortleaf** | 427 | 34.07 | -93.03 | 34.12 | -93.05 | 3.8 |
| **Shortleaf** | 429 | 33.13 | -91.48 | 33.03 | -91.94 | 27.3 |
| **Shortleaf** | 431 | 35.52 | -92.07 | 35.87 | -92.12 | 24.4 |
| **Shortleaf** | 433 | 37.38 | -91.32 | 37.65 | -91.54 | 21.9 |
| **Shortleaf** | 435 | 36.06 | -84.36 | 36.10 | -84.60 | 13.6 |
| **Shortleaf** | 451 | 39.56 | -77.39 | 39.93 | -77.65 | 29.1 |
| **Shortleaf** | 453 | 39.59 | -74.47 | 40.00 | -74.79 | 32.8 |
| **Shortleaf** | 455 | 36.43 | -77.04 | 36.72 | -77.07 | 19.9 |
| **Shortleaf** | 457 | 34.43 | -81.37 | 34.72 | -81.63 | 24.9 |
| **Shortleaf** | 461 | 33.57 | -83.22 | 33.96 | -83.38 | 28.6 |
| **Shortleaf** | 463 | 33.19 | -83.23 | 33.33 | -83.39 | 13.2 |
| **Shortleaf** | 465 | 32.04 | -84.32 | 32.07 | -84.54 | 12.8 |
| **Shortleaf** | 467 | 32.50 | -85.45 | 32.83 | -85.76 | 29.3 |
| **Shortleaf** | 473 | 30.50 | -90.40 | 30.83 | -90.67 | 27.9 |
| **Shortleaf** | 475 | 31.47 | -95.09 | 31.80 | -95.15 | 22.8 |
| **Shortleaf** | 477 | 34.14 | -95.37 | 34.24 | -95.62 | 15.7 |
| **Shortleaf** | 478 | 33.53 | -94.49 | 33.89 | -94.83 | 31.8 |
| **Shortleaf** | 481 | 33.13 | -91.48 | 33.03 | -91.94 | 27.3 |
| **Shortleaf** | 485 | 37.38 | -91.32 | 37.65 | -91.54 | 21.9 |
| **Shortleaf** | 487 | 36.06 | -84.08 | 36.11 | -84.13 | 4.7 |
| **Loblolly** | 301 | 38.12 | -75.41 | 38.20 | -75.69 | 16.3 |
| **Loblolly** | 303 | 34.45 | -77.26 | 34.75 | -77.42 | 22.7 |
| **Loblolly** | 305 | 35.08 | -76.46 | 35.14 | -76.77 | 17.9 |
| **Loblolly** | 306 | 35.08 | -76.46 | 35.14 | -76.77 | 17.9 |
| **Loblolly** | 307 | 34.16 | -81.37 | 34.38 | -81.62 | 20.9 |
| **Loblolly** | 309 | 31.59 | -83.18 | 31.96 | -83.61 | 35.9 |
| **Loblolly** | 311 | 33.57 | -83.22 | 33.96 | -83.38 | 28.6 |
| **Loblolly** | 315 | 34.10 | -86.50 | 34.17 | -86.84 | 20.2 |
| **Loblolly** | 317 | 33.16 | -85.50 | 33.27 | -85.84 | 20.9 |
| **Loblolly** | 319 | 33.31 | -86.48 | 33.52 | -86.80 | 23.6 |

| Species | Stock number | Original Latitude | Original Longitude | Modified (this study) Latitude | Modified (this study) Longitude | Difference |
|---|---|---|---|---|---|---|
| | | ~~~~~~ degrees ~~~~~~ | | ~~~~~~ degrees ~~~~~~ | | miles |
| Loblolly | 321 | 34.39 | -88.34 | 34.66 | -88.57 | 22.6 |
| Loblolly | 323 | 30.30 | -90.45 | 30.50 | -90.75 | 22.8 |
| Loblolly | 325 | 31.20 | -94.43 | 31.33 | -94.72 | 19.7 |
| Loblolly | 327 | 34.07 | -93.03 | 34.12 | -93.05 | 3.8 |
| Loblolly | 329 | 35.15 | -88.59 | 35.26 | -89.00 | 24.1 |
| Loblolly | 331 | 33.14 | -84.16 | 33.25 | -84.26 | 9.5 |
| Slash | 201 | 32.54 | -80.40 | 32.90 | -80.67 | 29.2 |
| Slash | 203 | 30.17 | -82.07 | 30.28 | -82.12 | 8.3 |
| Slash | 204 | 30.17 | -82.07 | 30.28 | -82.12 | 8.3 |
| Slash | 205 | 27.53 | -81.50 | 27.90 | -81.84 | 32.8 |
| Slash | 206 | 27.53 | -81.50 | 27.90 | -81.84 | 32.8 |
| Slash | 207 | 31.31 | -87.19 | 31.53 | -87.32 | 17.0 |
| Slash | 209 | 30.36 | -89.03 | 30.37 | -89.09 | 3.8 |
| Slash | 210 | 30.36 | -89.03 | 30.37 | -89.09 | 3.8 |
| Slash | 211 | 30.28 | -90.06 | 30.48 | -90.11 | 1.8 |

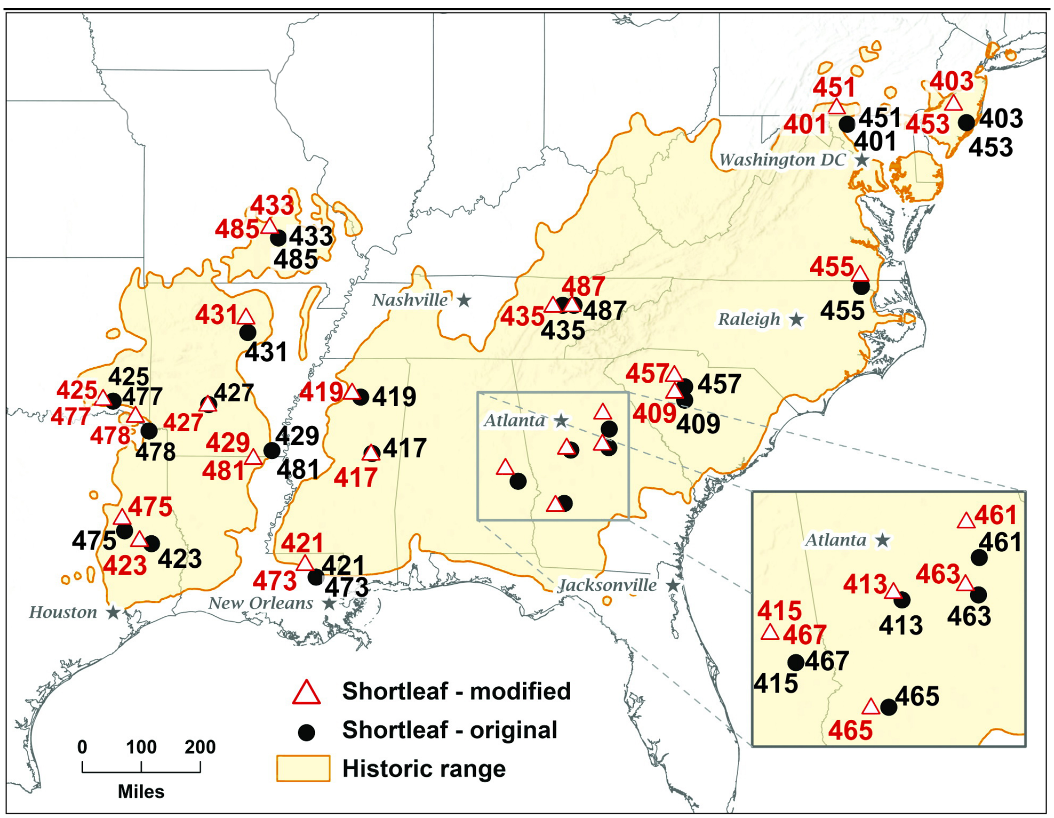


Figure 1—Map of the original Southwide Pine Seed Source Study shortleaf pine seed source locations using coordinates provided in SGSS (1956) and those using digitized latitude and longitude from the county seat locations as determined by a geographic information system. Inset map near Atlanta, GA, helps to clarify this dense cluster of seed sources.

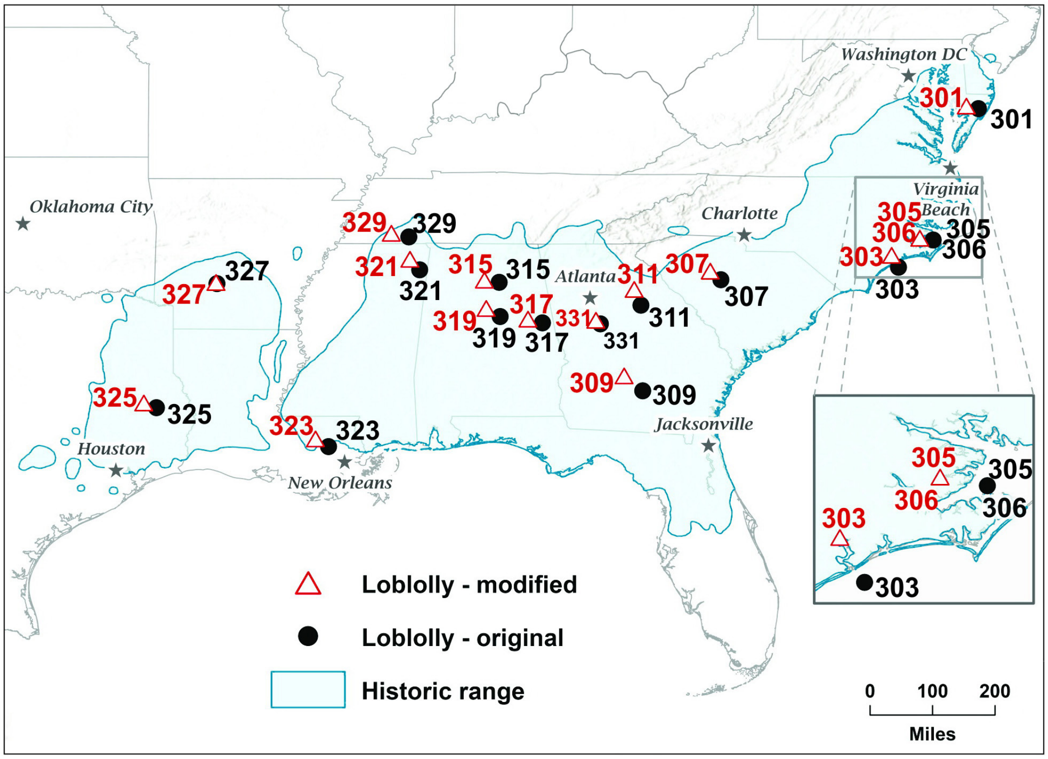


Figure 2—Map of the original Southwide Pine Seed Source Study loblolly pine seed source locations using coordinates provided in SGSS (1956) and those using digitized latitude and longitude from the county seat locations as determined by a geographic information system. The inset map of the North Carolina coast shows why the original, uncorrected latitude and longitudes are potentially quite problematic—three of the loblolly seed sources (#303, #305, and #306) were mapped using coordinates in the Atlantic Ocean.

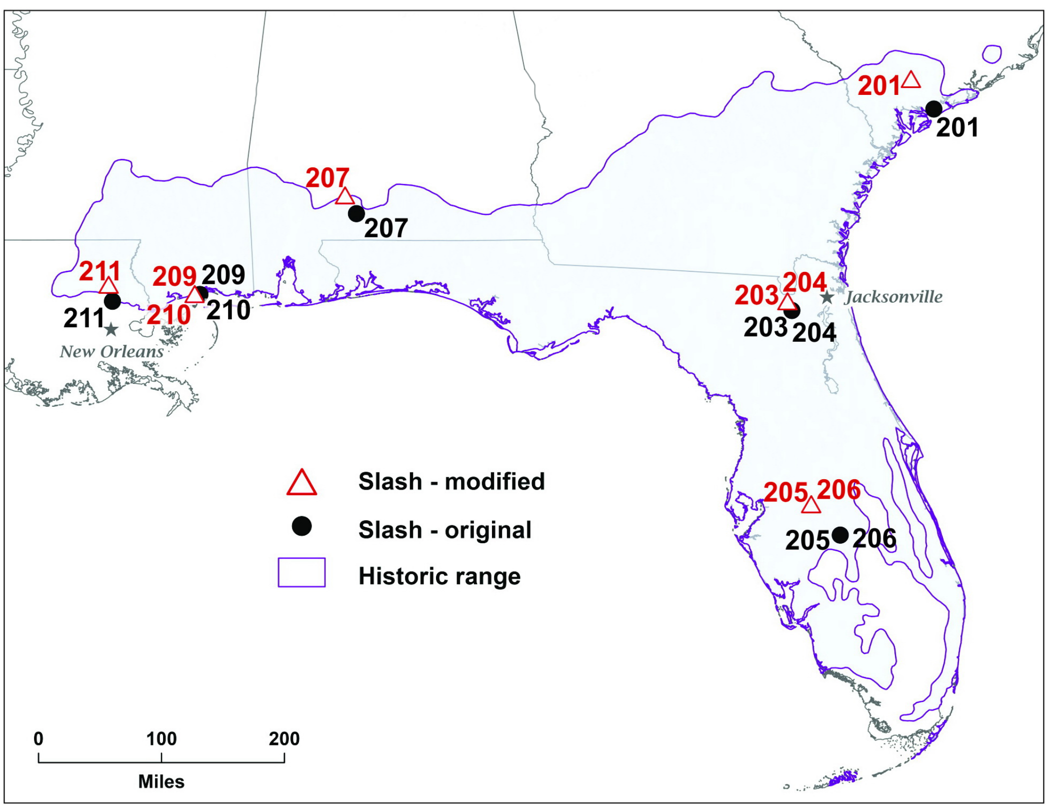


Figure 3—Map of the original Southwide Pine Seed Source Study slash pine seed source locations using coordinates provided in SGSS (1956) and those using digitized latitude and longitude from the county seat locations as determined by a geographic information system.

Given these were seed source areas rather than specific sites or locations, they were never intended to be very precise. However, such disparities between the intended locations and those coordinates provided in 1956 can be problematic. For instance, when longleaf pine was mapped (fig. 4), a high proportion of seed source areas were collected near the margins of the accepted botanical distribution of this species, and this could influence later interpretations of the performance of those sources.

A more critical issue than the distance between original and modified locations occurred in numerous locations when the assigned 1956 coordinates were actually in the ocean or other major waterbodies, or moved from one ecoregion (e.g., Upper West Gulf Coastal Plain) to another (Mississippi River Alluvial Plain). Each species had its own examples of these problematic displacements; rather than describing all of them, we selected a couple of examples to show why these displacements are problematic. For some reason, shortleaf pine seeds sourced from the Crossett Experimental Forest (#429 and #481) were not given coordinates of either the experimental forest or the county seat for which this experimental forest is found. Both the Crossett Experimental Forest and the Ashley County seat (Hamburg) are well situated on the Upper West Gulf Coastal Plain, which is good habitat for shortleaf pine. Rather, the #429 and #481 coordinates are for eastern Ashley County in the Mississippi River Alluvial Plain. The heavier textured, frequently flooded soils of the Mississippi River floodplain are highly unfavorable for shortleaf pine germination and growth, meaning that virtually no shortleaf pine of natural origin are found in this ecosystem. Any post-hoc geospatial analysis considering factors such as soil type and site hydrology would have gotten incorrect information for shortleaf pine.

All the other species had similar problems. For example, given the limited number of slash pine seed source areas in the SPSSS, placement near the coast (as for #201) versus a more appropriate location could markedly skew analyses. Several loblolly pine seed sources (for example, #303, #305, and #306) were originally placed in the

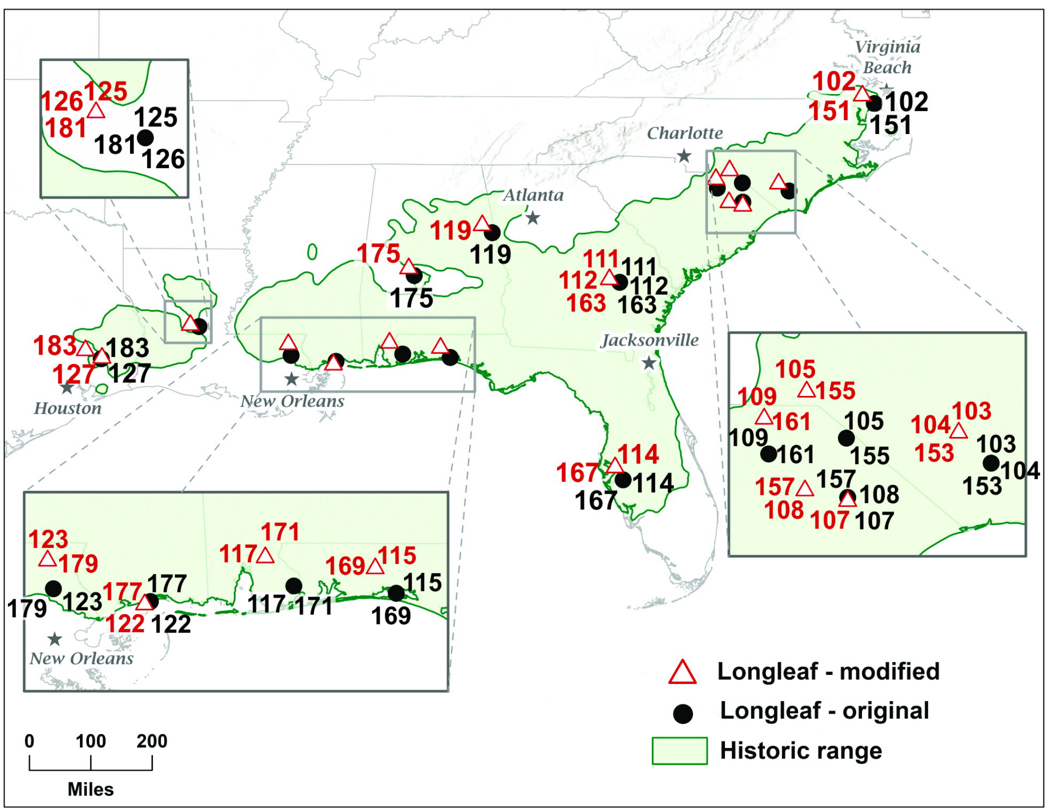


Figure 4—Map of the original Southwide Pine Seed Source Study longleaf pine seed source locations using coordinates provided in SGSS (1956) and those using digitized latitude and longitude from the county seat locations as determined by a geographic information system. The three inset maps are intended to make dense clusters of seed sources more visible and highlight how location errors could move collection points from the land to a body of water.

Atlantic Ocean off of the North Carolina coast when they should have been placed some miles inland (see inset in fig. 2). Such erroneous placements can produce significant errors in post-hoc geospatial or ecological analysis.

## CONCLUSIONS

Unfortunately, there is no way of knowing why any of these errors arose. It seems likely that at least some were the result of incorrect readings or recordings of latitude and longitude. Others may have resulted from differing interpretations of precisely which county (or counties) to assign the original field samples to; these were seed source *areas*, after all, and precise sampling coordinates using satellite-based technology was still decades away. Regardless of the reasons, the updated coordinates provided in table 2 are more consistent with the stated intentions of the original SPSSS.

The SPSSS offers a wealth of data on the major southern pines and this "old" information could still provide even more insights into a dynamic, highly managed region of the country. With silvicultural research work increasingly dominated by meta-analyses of existing data sets, elimination of known errors is critical for improving these analyses. Hence, our correction of these seed source locations should help current and future silvicultural research.

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