Appendix F Pollen Analysis Report

The following *Pollen Analysis of Samples from the Honolulu High-Capacity Transit Corridor Project, Honolulu, Hawaii* by Linda Scott Cummings (December 2012) is presented in its entirety. A portion of the report addresses work in the City Center Section.

POLLEN ANALYSIS OF SAMPLES FROM THE
HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT,
HONOLULU, HAWAI'I

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INTRODUCTION

Pollen analyses collected from sediments exposed in trenches for the Kalihi 22 project were conducted in an effort to define the past environment and identify evidence of agriculture. The project is located in the greater Waikiki area on the south shore of Oahu. Samples from trenches in the city center and airport sections have been examined to date.

METHODS

Pollen

A chemical extraction technique based on flotation is the standard preparation technique used in this laboratory for removing pollen grains from the often large volume of sand, silt, and clay with which they are mixed. Since experience of working with sediments from this area has shown that total pollen concentration is usually in the thousands of pollen per cubic centimeter (cc) of sediment, if not the tens of thousands of pollen per cc of sediment, relatively small quantities of sediment (5 to 15 cc) were selected from each sample. The more organic the sediment the smaller the sample volume.

Hydrochloric acid (10%) was used to remove calcium carbonates (shell) present in the sediment, after which the samples were screened through 250-micron mesh. The samples were rinsed until neutral by adding water, letting the samples stand for 2 hours, then pouring off the supernatant. A small quantity of sodium hexametaphosphate was added to each sample once it reached neutrality, then the samples were allowed to settle according to Stoke's Law in settling columns. This process was repeated with ethylenediaminetetraacetic acid (EDTA). These steps remove clay prior to heavy liquid separation. The samples then were freeze dried. Sodium polytungstate (SPT), with a density of 1.8 g/ml, was used for the flotation process. The samples were mixed with SPT and centrifuged at 1,500 rpm for 10 minutes to separate organic from inorganic remains. The supernatant containing pollen and organic remains was decanted. Sodium polytungstate again was added to the inorganic fraction to repeat the separation process. The supernatant was decanted into the same tube as the supernatant from the first separation. This supernatant then was centrifuged at 1,500 rpm for 10 minutes to allow any remaining silica to be separated from the organics. Following this, the supernatant was decanted into a 50-ml conical tube and diluted with distilled water. These samples were centrifuged at 3,000 rpm to concentrate the organic fraction in the bottom of the tube. This pollen-rich organic fraction was rinsed, then all samples received a short (20–30 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles. The samples were acetylated for 3–5 minutes to remove any extraneous organic matter.

A light microscope was used to count pollen at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen and may be interpreted to represent either pollen dispersal

over short distances or the introduction of portions of the plant represented into an archaeological setting. The aggregates were included in the pollen counts as single grains, as is customary. The presence of aggregates is noted by an "A" next to the pollen frequency on the pollen diagram. The pollen diagram was produced using Tilia 2.0 and TGView 2.0.2. Total pollen concentrations were calculated in Tilia using the quantity of sample processed in cubic centimeters (cc), the quantity of exotics (spores) added to the sample, the quantity of exotics counted, and the total pollen counted and expressed as pollen per cc of sediment.

"Indeterminate" pollen includes pollen grains that are folded, mutilated, or otherwise distorted beyond recognition. These grains were included in the total pollen count since they are part of the pollen record. The microscopic charcoal frequency registers the relationship between pollen and charcoal. The total number of microscopic charcoal fragments was divided by the pollen sum, resulting in a charcoal frequency that reflects the quantity of microscopic charcoal fragments observed, normalized per 100 pollen grains.

Pollen extraction retains starch granules, which are reported when observed while counting pollen. An additional search for starches is performed only when starch analysis is part of the suite of analyses performed. Starch granules are a plant's mechanism for storing carbohydrates. Starches are found in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include the following: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, ellipse, circular, eccentric). Some of these starch categories are typical of specific plants, while others are more common and tend to occur in many different types of plants.

ETHNOBOTANIC REVIEW

It is a commonly accepted practice in archaeological studies to reference ethnographically documented plant uses as indicators of possible or even probable plant uses in prehistoric times. The ethnobotanic literature provides evidence for the exploitation of numerous plants in historic times, both by broad categories and by specific example. The presence of numerous sources of evidence for exploitation of a given resource can suggest widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times. Ethnographic sources both inside and outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources document that the historic use of some plants was a carryover from the past. A plant with medicinal qualities is likely to have been discovered in prehistoric times, with its use persisting into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period. The ethnobotanic literature serves only as a guide indicating that the potential for use existed in prehistoric times, not as conclusive evidence that the resources were used. Pollen, phytoliths, starch, and macrofloral remains, when compared with the material culture (artifacts and features) recovered by the archaeologists, can become indicators of use. Plants represented by pollen will be discussed in the following paragraphs to provide an ethnobotanic background for discussing the remains.

Cultigens

Gossypium (*Pulupulu-haole*, Cotton)

Gossypium barbadense (sea-island cotton) has been grown ornamentally in Hawai'i. (Neal 1965:565) notes that cotton has not been grown successfully as a crop due to attacks by the pink bollworm and the tendency for cotton to grow into large perennials. *Gossypium hirsutum* (upland cotton) is a smaller, shrubby plant. *Gossypium arboreum* (tree cotton of India) is attached to legends from the Philippines. *Gossypium tomentosum* (native cotton, *ma'o, huluhulu*) is a native plant on the coasts of Hawai'i (Neal 1965:565).

Oryza (*Laiki*, Rice)

Oryza sativa (*laiki*, rice) is one of six tropical species of rice that grows as either an annual or perennial swamp grass. Most rice fields are terraced to benefit from elaborate irrigation systems. "When the grains begin to ripen and the panicle droops with their weight, the water is drained from the field to hasten the harvest" (Neal 1965:69). Rice seed probably was introduced to Hawai'i from china in 1856. More suitable seed was brought from South Carolina in 1860, and by 1862 rice was the second most important crop in Hawai'i. This economic importance was short-lived, as it yielded to coffee in 1899, largely because of the ancient and rather impractical methods of rice culture, milling, and marketing used in Hawai'i (Neal 1965:71).

DISCUSSION

The Kalihi 22 project includes an urban area in the vicinity of the Ala Moana shopping center. Several test trenches were used to examine the prehistoric sediments in the area. Four of these trenches (T-080, T-132, T-191, and T-207) were selected for preliminary pollen analysis. Each is represented by three samples collected within Stratum II (Table 1, Figure 1). Additional trenches in the city center section were examined along Dillingham Blvd., Kokea Street, and Ward Avenue. Trenches in the airport section also were examined, specifically along Kamehameha Highway, Nimitz Highway, and Honolulu International Airport. Results of this analysis will be discussed separately, by trench, below.

Airport Section

Trench 006

Trench 006 is located within Kamehameha Highway. The sediments contained cobbles and stones embedded in silty clay loam. Maps indicate this location is very near Wailolowai Stream. A single sample was submitted from a depth of 162-175 cm representing Stratum II. The near absence of pollen from this sample, which yielded very small quantities of *Myrsine* and Cyperaceae pollen (Figure 2, Table 2 and 3), representing growth nearby of *kōlea* and sedges, combined with the presence of cobbles and stones indicates that Wailolowai Stream was sampled. Cobbles and stones are indicative of relatively fast moving water. Water that flows swiftly usually carries pollen with it to down stream locations. Only when water slows do the smaller particles, including pollen, drop to the sediments. In this case it is likely that a sedge

marsh was located along the banks or floodplain of Wailolowai Stream and that the active stream is represented in the Stratum II sample submitted for pollen analysis.

Trench 018

Trench 018 was placed in the sidewalk area of an urban street (Nimitz Highway). A single sample was examined from a depth of approximately 240 cm in Stratum II, representing clay overlying volcanic tuff. Pollen recovered from this sample was dominated by High-spine Asteraceae pollen, representing an abundance of plants in the sunflower family growing locally. This is a signature expected from disturbed sediments. Moderate to small quantities of Cheno-am and Poaceae pollen were noted in this sample, representing *'aheahea*, which grows in relatively dry habitats, and grasses. Small quantities of *Sida*, *Waltheria*, Liguliflorae, *Boerhavia*-type, Cyperaceae, *Euphorbia*, and *Perispermum* pollen indicate that local vegetation also included *'ilima*, *'ulaloa*, members of the chicory tribe of the sunflower family, *alena*, sedges, spurge, and bonamia. Ferns are well represented in this record. A moderately large quantity of charred Asteraceae fragments and a small quantity of charred Poaceae (grass) fragments were noted even though the overall microscopic charcoal frequency was low, suggesting burning weeds, many of which were members of the sunflower family. There is no evidence of agricultural activity in this sample. Total pollen concentration was moderately low at approximately 1260 pollen per cc of sediment.

Trench 022

This trench was located within an airport parking lot at Honolulu International Airport. A silty clay loam exhibiting charcoal or black organic stains was present in Stratum II. Two samples were examined from depths between 150 and 200 cm. No single pollen taxon dominated the record in either of these samples. Moderately small quantities of Cheno-am, *Sida*, High-spine Asteraceae, Liguliflorae, and Poaceae pollen reflect local vegetation that included at least moderate quantities of *'aheahea*, *'ilima*, members of the sunflower family including the chicory tribe, and grasses. A few trees are represented by *Acacia*, *Cocos nucifera*, *Myrsine*, *Pandanus*, and *Pritchardia* pollen indicating local growth of *koa*, coconut, *kōlea*, *hala*, and loulu palm. A pore was visible in one of the *Pandanus* pollen, which is necessary to substantiate a distinction between *Pandanus* and *Colocasia* pollen, since they are of similar size and morphology. Additional shrubby vegetation is represented by small quantities of *Broussaisia*, *Hibiscus*, *Plumbago*-type, *Vitex*-type, and *Waltheria* pollen indicating growth of *kanawao*, *hau*, *'ilie'e*, *kolokolo*, and *'uhaloa*. Alien trees are represented by moderate to small quantities of *Leucaena* and *Prosopis* pollen, indicating *koa haole* and *kiawe* growing in the area. Both of these samples contained *Gossypium*-type pollen, suggesting cultivating cotton in the area, possibly in a field at this location. *Gossypium* pollen is noted to travel for several miles on the wind, so locating the agricultural field using *Gossypium* pollen may mean examining many trenches within a transect, if that is desired. Further, large grass pollen, typical of that produced by *Oryza* (rice) was noted in these two samples. It is interesting to note that the upper sample also contained an abundance of burned or charred Poaceae (grass) fragments, suggesting periodic burning of fields that probably contained rice. Both samples also exhibited smaller quantities of Asteraceae charcoal, indicating that members of the sunflower family probably grew as weeds and were burned when the fields were burned. See Neal for a description of burning, especially related to rice. In light of the recovery of *Oryza*-type pollen it is interesting that a wetland signature was not obtained for either of these samples. *Oryza* pollen is smaller in size than *Heteropogon* pollen, although both show a significant

amount of surface sculpturing. This pollen will be re-checked and the identification clarified prior to the submission of the next set of samples from this project. Moderately large quantities of fern spores were observed in these samples, indicating a substantial fern population growing in the area. Total pollen concentration was very similar in these two samples at slightly more than 1200 and slightly less than 1300 pollen per cc of sediment in the lower and upper samples, respectively.

Trench 33

A commercial parking lot on Waiwai Loop was trenched to reveal silty clay loam with charcoal flecking. One sample from Stratum II, at a depth of 128-139 cm, was examined from Trench 33. The pollen signature for this sample was dominated by Cheno-am pollen, probably reflecting primarily *Chenopodium oahuense* (*'aheahea*). These shrubs prefer drier habitats. Small quantities of *Acacia*, Anacardiaceae, *Cocos nucifera*, Myrtaceae, *Pittosporum*, and *Pritchardia* pollen were noted, representing trees including *koa*, a member of the sumac family, coconut, a member of the myrtle family, *ho 'awa*, and lolou palm, suggesting the presence of trees typically associated with a coastal location. Pollen indicating shrubby vegetation includes *Broussaisia* and *Waltheria* in addition to Cheno-am representing *kanawao* and *'uhaloa*. Small quantities of Low-spine Asteraceae, High-spine Asteraceae, Cyperaceae, and *Euphorbia* pollen indicate that members of the sunflower family, sedges, and spurge also grew locally. Small to moderate quantities of *Leucaena* and *Prosopis* pollen represent *koa haole* and *kiawe* growing in this area. Once again *Gossypium* pollen was present, but in a smaller quantity than was observed in Trench 022, suggesting that cotton grew farther from this location. This sample also yielded a moderate quantity of *Oryza*-type pollen in spite of the fact that there is no indication in the pollen record of a substantial wetland in this area. Ferns are represented by a few spores. Charred sunflower family fragments were recovered, but charred Poaceae (grass) fragments were not. Total pollen concentration was moderately high at approximately 8500 pollen per cc of sediment, which is more typical of a wetland than a dry deposit.

City Center Section

Trench 041

Trench 041 was located within Dillingham Blvd. Alluvial silty clay loam contained charcoal flecking. Historic maps of this area indicate taro fields as well as a rice plantation in this area. A single sample was collected and analyzed from a depth of 46-64 cm from Stratum II. This sample was dominated by Cheno-am pollen, suggesting a sizeable population of *Chenopodium oahuense* (*'aheahea*) growing in the area. This suggests a relatively dry habitat was sampled. In addition, small quantities of *Pelea*, *Broussaisia*, *Sida*, High-spine Asteraceae, Liguliflorae, Cyperaceae, *Euphorbia*, Poaceae, and *Vigna* pollen represent *kukaemoa*, *kanawao*, *'ilima*, various members of the sunflower family, sedges, spurge, grasses, and *mohihihi* or beach pea grew in the area. This sample also contained both *Oryza* and *Colocasia* pollen, indicating that the rice and taro agriculture noted on the historic maps can be verified for this area. It is interesting that there is such a minor signature for other plants that usually populate wet areas, such as sedges. This suggests the possibility that specific fields were located in this area that were tended and weeded. *'Aheahea* would have grown in drier sediments outside the ponds. Pollen from these shrubby plants is produced in abundance and travels readily on the wind. Recovery of *Leucaena* and *Prosopis* pollen from this sample

indicates that this deposit is part of the historic record. Fern spores were present, but in small quantities. Microscopic charcoal also was present, but not abundant. Charred Poaceae (grass) leaf fragments were observed, but also were note abundant, suggesting the possibility that local fields were burned. Total pollen concentration was relatively low at just under 2000 pollen per cubic centimeter (cc) of sediment.

Trench 67

Trench 67 was located within the community college lawn on Kokea Street, very close to Kapalama Stream. The sediments from Stratum II were silty clay typical of wetlands in a stream floodplain. This area might have been used for taro and/or rice fields. The pollen record is very different from that noted in Trench 41. In this location Cyperaceae pollen was dominant, indicating a well established wetland that supported a large sedge population. Most of the rest of the pollen taxa recovered in the three samples examined from Stratum II were noted in very small quantities. Small quantities of *Vigna* pollen were noted in the upper two samples in this trench. Neal (1965:468) notes that *Vigna sinensis* (cow pea) was introduced, probably from southeastern Asia. This vining legume produces green pods that measure between 8 and 12 inches long. These beans are used in Chinese cooking and have been termed yard-long beans. Recovery of *Vigna* pollen from this location suggests use of this area for growing these beans.

Moderately large quantities of *Oryza*-type pollen were recovered from all three of these samples, suggesting rice fields were located in the wetlands along Kapalama Stream. Recovery of *Typha angustifolia*-type pollen in the two upper samples indicates that non-agricultural wetland vegetation including cattails also grew in the area. A single *Saccharum* pollen grain was observed in the lowest sample examined from Stratum II. This indicates the presence of a sugar cane field within close proximity to the stream, as well. It could have been located several tens of meters from this area along the stream. Ferns are documented to have been moderately abundant in this area, as expected. Only a few Foraminifera fragments were observed in the lower two samples from this location. It is possible that they traveled inland with storm surge and were deposited in this area. None of the foraminifera observed consisted of more than a few units along the spiral. Charred Poaceae (grass) fragments were moderately abundant in the sediments from this location, suggesting burning the rice fields or perhaps nearby sugarcane fields. Other microscopic charcoal fragments were not as abundant. Total pollen concentration was much higher in this location, varying from nearly 14000 to almost 42000 pollen per cc of sediment. This is more consistent with quantities expected in wetlands, whether they represent a marsh or agricultural fields.

Trench 080

This trench was located within Dillingham Blvd. The stratigraphic provenience is described as including silty clay sediment that contained freshwater snails, wood, and grass in Stratum II) that might represent rice field deposits overlying previous Hawaiian wetland cultivation or perhaps natural wetlands.

Pollen analysis of these samples provides supporting evidence for the presence of wetlands. Cyperaceae pollen (Figures 1 and 2, Table 3) was dominant in samples from the city center section, followed by moderate quantities of Poaceae and Cheno-am pollen. Grasses probably would have included a variety of wetland grasses that grew mixed with the sedges.

Cheno-am pollen probably represents *Chenopodium oahuense* (*'aheahea*), a shrub that would have grown in drier setting outside the wetland. Large size Poaceae pollen was observed in the upper two samples suggesting the possibility that either sugar cane was grown in the area or that *pili* grass grew locally. Small quantities of *Typha* pollen were observed in all three samples, with the largest quantity noted in the lowest sample. Cattails are expected to be part of the population of local wetland plants. *Cocos nucifera* pollen was observed in the middle sample from this trench, indicating the presence of coconut trees growing in this general area. *Sicyos* pollen was observed in the lowest sample. These endemic vines may grow from the coast well into the mountains and occupy a variety of habitats (Wagner et al. 1990:573-581). *Commelina* pollen was observed only in sample T-080-4. *Honohono* has been naturalized in Hawai'i. This plant, which is native to tropical Asia and Africa, grows in both dry and wet habitats. *Honohono* usually grows in disturbed areas. The earliest collection of *Commelina diffusa* was made in 1837 (Wagner et al. 1990:1379). It is this recovery of *Commelina* pollen that provides a possible date of mid to late nineteenth century (or later) for the middle sample from this trench. The presence of *Commelina* pollen lends interpretive value supporting a date during the historic era to the small quantities of *Prosopis* pollen observed in samples from this trench, since *kiawe* pollen was noted only in the upper two samples.

Samples examined from the airport section tended to be dominated by Cheno-am pollen or not to have any single dominant pollen taxon. Poaceae pollen also was abundant in many of the samples from the airport section. High-spine Asteraceae pollen, while present, was dominant in only one sample.

Most other pollen types noted were observed in very small quantities. The only pollen noted that represents agricultural activity was *Colocasia*, representing taro cultivation. It was observed in the upper sample from this trench. It is possible that the *Commelina* pollen recovered from the lower sample relates to use of this area as an agricultural field, as *honohono* often grows in disturbed areas such as agricultural fields. No grass pollen that could be positively ascribed to rice was observed. Distinction between rice and other grass pollen is made on a combination of size and surface characteristics. Grass pollen sizes tend to overlap, so do not provide as robust an identification criterion as do phytoliths. Rice produces both a distinctive buliform phytolith and also an arrangement of the bilobates in the leaves when the cells have not been broken apart by post-depositional processes. Phytoliths provide a much more robust interpretation of the presence or absence of rice agriculture. Additional phytolith analysis of samples from this location is recommended to answer this question more fully. Phytolith analysis is also recommended for any other locations where identifying rice agriculture is important.

Evidence for pollen representing alien plants is limited to a very few *Prosopis* pollen observed in the upper two samples. Either these pollen indicate that these depths represent historic deposits or they are present through downward intrusion into the sediments.

Spores were present in small quantities in each of these samples, indicating that local vegetation also included a variety of ferns. Quantities of microscopic charcoal increased through time, as the largest quantity was observed in the upper sample. A few charred grass cells were noted in the upper and lower samples. Total pollen concentration was very high at more than 60,000 pollen per cubic centimeter (cc) of sediment in each of these samples.

Trench 132

Trench 132 was located in the Halekauwila Street parking lot. Stratum II at this location is described as sandy silty clay sediment containing organics and is thought to represent a possible natural coastal wetland. The three samples examined from this location were dominated by Poaceae pollen, with much smaller quantities of Cyperaceae pollen, indicating a local habitat dominated by grasses and also including sedges. The quantity of Cheno-am pollen noted in each of these samples was reduced compared to the quantities noted in most of the other samples examined from this project to date. Only a small quantity of *Typha* pollen was noted in the uppermost sample from this location. Most of the other pollen observed was noted in very small quantities. *Acacia* pollen was observed in small quantities in the upper and lower sample from this trench, documenting local growth of *koa*. Recovery of a small quantity of *Cocos nucifera* pollen in the upper sample represents local growth of coconut trees in the area at the time these sediments accumulated. No evidence of agriculture was noted in any of these samples.

Interestingly, all three of these samples contained *Prosopis* pollen, representing the alien *kiawe*. In addition, a small quantity of *Leucaena* pollen were noted, representing *koa haole*. The *Tribulus* pollen observed in this sample might represent either the alien or the indigenous plant. Due to the sandy nature of these samples it is possible there was downward intrusion of pollen from more recent vegetation above.

Spores were present in small quantities, which is consistent with a local population of ferns. Total pollen concentrations were widely variable in these samples with the lower deposits hovering around 9,000 to 10,000 pollen per cc of sediment and the upper sample weighing in at nearly 26,000 pollen per cc of sediment. Lower total pollen concentrations are consistent with sandy sediments.

Larger quantities of microscopic charcoal were observed in these three samples, with the lowest sample exhibiting the largest quantity. Small quantities of foraminifera and a scolecodont (polychaete worm jaw fragment from an annelid worm) were noted in this sample, which are consistent with inundation of these sediments with marine water.

Trench 161

Trench 161 was located within the parking lot of Ross-Dress-for-Less at Ward Avenue. This area is described as typical of wetland sediments. Organic matting that might have had an agricultural function was observed at its upper boundary. The lowest sample represents the Stratum IIa/IIb interface and the upper two samples represent Stratum IIa. The pollen record is dominated by Cyperaceae pollen in all three of the samples examined. The lowest sample also contained moderate quantities of Fabaceae and Poaceae pollen, suggesting growth of a legume and grasses along the margins of the wetland. Very small quantities of Poaceae pollen that exhibited the characteristics typical of *Oryza* (rice) were observed in each of these three samples. It is possible that rice was grown in this area, but that use of these wetlands for rice fields did not persist over time. Quantities of charred Poaceae (grass) fragments were very small in these sediments, also suggesting limited use of this area for wetland agriculture. A single Spirogyra algal spore also was noted in the lowest sample from this trench. The middle sample yielded the largest quantity of Cyperaceae pollen, which suggests the presence of a sedge marsh in this area. The uppermost sample yielded a diminished quantity of Cyperaceae

pollen, offset by a large increase in *Myrsine* pollen, reflecting *kōlea* trees growing in or at the edges of the wetlands. This pattern is probably associated with a change in the marsh, such as more open water and a smaller sedge population. This also might reflect clearing some of the sedges and use of the wetland for another purpose, such as a taro field. Unfortunately, no *Colocasia* pollen was observed in this sample to substantiate such a use. Spores were present in increasing quantities from the base to the top of this record, suggesting an increase in the local fern population through time. Microscopic charcoal and charred Poaceae (grass) fragments were present, but not abundant in samples from this trench.

Trench 191

Trench 191 was located along Kona Street west of the Ala Moana Center Station. Deposits in this area were sandy clay in Stratum IIa and clay in Stratum IIb. Stratum IIb likely represents a former marsh or wetland and sits just above the modern water table. The pollen record from this trench was heavily dominated by Cyperaceae pollen, representing a local population of sedges growing in a marsh. It is interesting that there is little difference in the pollen content of the samples from the IIb and IIa sediments. Poaceae pollen was noted in much smaller quantities, suggesting that there were few grasses mixed with the sedges in this marsh. Cheno-am pollen indicates that *'aheahea* likely grew in drier sediments somewhat removed from the marsh. *Acacia* pollen was observed in the uppermost sample, indicating that *koa* grew in the area. Recovery of very small quantities of a variety of other pollen taxa from these sediments is typical of the pattern observed in other samples and represents general pollen rain probably derived from wind transport. It is interesting that very small quantities of *Prosopis* pollen were observed in each of these samples. It is likely that these represent intrusion of relatively modern pollen, either through rare downward movement through the sediments or perhaps introduced at the time of sample collection. The pattern observed in these samples does not suggest severe contamination of the pollen record by modern or recent pollen. No evidence of agricultural activity was noted in samples from this trench.

Spores representing ferns were observed, but not particularly abundant. Microscopic charcoal was not abundant in these samples, with the exception of the uppermost sample. Foraminifera were much more common in these samples than in samples from Trenches 080 or 132, suggesting more regular inundation of these sediments. Total pollen concentration was moderately high, which is typical of marshes. It varied between nearly 20,000 and more than 23,000 pollen per cc of sediment.

Trench 207

This trench was also located on Kona Street, this time at the Ala Moana Mall. Samples were collected entirely from Stratum IIa, which is described as sandy clay sediment that contained organics and freshwater snails. It is likely that this area also was a former marsh or wetland. The pollen record again was dominated by Cyperaceae pollen, as was the record at T-191. Increasing quantities of Poaceae and Cheno-am pollen, accompany by declining quantities of Cyperaceae pollen indicate that these sediments dried out through time, but still were sufficiently wet to support a sedge marsh for the entire time period represented. Ferns were more abundant in the upper two samples, as the sediments dried, suggesting that they grew best when the marsh began to dry out. *Acacia* pollen was observed in the upper two samples from this trench, indicating local growth of *koa*.

Total pollen concentration also supports this interpretation, as it was high at approximately 83,000 pollen per cc in the lower sample and the reduced greatly to only approximately 6500 pollen per cc in the middle sample. This was accompanied by evidence of fire in the middle sample, which displayed the largest quantity of microscopic charcoal observed in samples from this trench.

Once again very small quantities of *Prosopis* pollen were noted in each of these samples, but the quantity does not appear to be sufficient to indicate a problem with the record as a whole.

SUMMARY AND CONCLUSIONS

This portion will be completed when the last batch of samples has been analyzed.

Notes: *Colocasia* pollen was observed in the uppermost sample from T-080, indicating taro agriculture in this location. Recovery of *Commelina* pollen in sample T-080-4, below the one containing taro, indicates that taro agriculture was part of the historic use of this area.

Matt: If additional clarification of this use of the field is desired, please consider analysis of the intervening samples (5, 3, and 2) from this trench. Also, please consider analysis of these samples for phytoliths to gain more information on the potential for rice agriculture. Taro does not produce opal phytoliths, so information about taro needs to come from the pollen record. This is why both pollen and phytolith analyses are recommended (pollen for taro and commelina and phytolith for rice).

The significance of the presence of very small quantities of *Prosopis* pollen will be reviewed when all of the samples have been examined. At present, very small quantities are considered to be insignificant. The only trench that appears to have recent deposits is T-132. The large quantity of *Prosopis* pollen observed in the uppermost sample from that trench might have contributed *Prosopis* pollen to lower sandy samples as portions of the pollen record percolated downward. The recovery of larger quantities of Poaceae pollen in these lower samples dictates additional thought into the significance of portions of the record in this trench.

Two types of *Acacia* pollen were observed in these samples. Pollen ascribable to *Acacia koa* was noted in samples T-191-1, T-207-2, and T-207-6. Trenches 191 and 207 were located to the West of the Ala Moana shopping center and in a parking lot of the Ala Moana shopping center. Proximity of these trenches is consistent with *Acacia koa* growing in this portion of the project area. The other *Acacia* pollen could not be identified to species. *Acacia koa* pollen was noted in samples from the Airport Section (Trenches 022 and 033).

Trenches in areas identified as probable marshes (T-080, T-191, and T-207) exhibited Cyperaceae as the dominant pollen type, indicating that these areas were sedge marshes. The area represented by T-080 appears to have been used as a taro field. Sedges also dominated the record in Trenches 067 and 161, which were noted to represent a wetland along Kapalama Stream and wetlands that might have had an agricultural function.

Trench 006 contained cobbles and stones in the single Stratum II sample submitted, which have been interpreted, along with the near absence of pollen, to represent a fast moving stream in this location. It appears the Wailolowai streambed was sampled.

Taro pollen was noted in a sample from Trench 041 along with rice pollen, indicating sampling an agricultural field that had been used to grow taro and rice, not necessarily simultaneously.

Evidence for rice was noted in Trenches 022, 033, 041, and 067. The very small quantities of *Oryza*-type pollen recovered in samples from Trench 161 might represent rice agriculture in the area, but not this specific location, or might represent short-term use of the wetland for rice agriculture before switching to another crop or perhaps abandoning the wetland as an agricultural field. *Oryza*-type pollen from Trench 022 will be re-checked.

TABLE 1
PROVENIENCE DATA FOR SAMPLES FROM
HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT, CITY CENTER SECTION

Trench	Column Sample No.	Depth (cmbs)	Stratum	Description/ Provenience	Analysis
T-080	1	140-143	II	Silty clay sediment containing freshwater snails, wood and grass (Stratum II)– possibly representative of rice field deposits overlying previous Hawaiian wetland cultivation and/or natural wetlands.	Pollen
	4	163-167			Pollen
	6	185-188			Pollen
T-132	1	137-139	II	Sandy silty clay sediment containing organics (Stratum II)– possible natural coastal wetland sediment.	Pollen
	2	142-144			Pollen
	3	147-149			Pollen
T-191	1	85-90	IIa	Sandy clay (Stratum IIa) and clay (Stratum IIb) sediment– likely former marsh/wetland.	Pollen
	5	105-110			Pollen
	8	120-125	IIb		Pollen
T-207	2	91-95	IIa	Sandy clay sediment containing organics and freshwater snails (Stratum IIa) – likely former marsh/wetland.	Pollen
	6	107-111			Pollen
	11	127-131			Pollen
Submission 2:					
T-041	1	46-64	II	Alluvial silty clay loam (Ewa series: EmA) with charcoal flecking. Historically near taro fields and a rice plantation.	Pollen
T-067	1	152-154	II	Silty clay wetland sediments in stream floodplain– possibly taro and/or rice fields.	Pollen
	2	157-160	II		Pollen
	3	167-169	II		Pollen

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TABLE 1 (Continued)

Trench	Column Sample No.	Depth (cmbs)	Stratum	Description/ Provenience	Analysis
T-161	1	130-165	IIa	Silty clay wetland sediments with organic matting at upper boundary– possible agricultural function.	Pollen
	2	165-140	IIa		Pollen
	3	140-145	IIa/IIb interface		Pollen

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TABLE 2
PROVENIENCE DATA FOR SAMPLES FROM
HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT, AIRPORT SECTION

Trench	Column Sample No.	Depth (cmbs)	Stratum	Description/ Provenience	Analysis
T-006	1	162-175	II	Cobbly/stony silty clay loam. Historically near Waiolowai Stream.	Pollen
T-018	1	240	II	Clay overlying volcanic tuff– possibly Makalapa clay series.	Pollen
T-022	1	150-170	II	Silty clay loam– possibly Mamala soil series. Charcoal or black organic stains visible.	Pollen
	2	~200	II	Silty clay loam– possibly Mamala soil series.	Pollen
T-033	1	128-139	II	Silty clay loam with charcoal flecking.	Pollen

TABLE 3
POLLEN TYPES OBSERVED IN SAMPLES FROM
THE HONOLULU HIGH-CAPACITY TRANSIT CORRIDOR PROJECT

Scientific Name	Common Name	Nat	Pol	End	Ind
TREES:					
Acacia	*Koa, kolu, koai'a*	x		x	
Alectryon	*Mahoe, 'ala'alahua*			x	
Anacardiaceae	Mango family	x		x	
Antidesma	*Hame, ha'a, ha'amaile, hamehame, mehame, mehamehame, bignay*			x	
Artocarpus	Breadfruit		x		
Cheirodendron	*'Olapa, lapalapa*			x	
Cocos nucifera	Coconut, *Niu, alolani*		x		
Morinda trimera	*Noni kauhiwi*			x	
Myrsine	*Kōlea, 'Ōiiko, Kōlea lau nui, Kōlea lau li'i*			x	
Myrtaceae	Myrtle family	x	x	x	x
Nothocestrum	*'Aiea, halena*			x	
Pandanus tectorius	*Hala, pū hala*				x
Pelea clusiifolia	*Kukaemoa, kolokolo mokihana*			x	
Pisonia	*Pāpala kēpau, pāpala*			x	x
Pittosporum	*Ho'awa, ha'awa*	x		x	
Pritchardia	Loulu palm, *Loulu hiwa*			x	
Rhamnaceae	Buckthorn family	x		x	x
Straussia	*Kopiko kea*				x
Zanthoxylum	*A'e, manele, hea'e, kawa'u, kawa'u kua kuku kapa*, prickly ash			x	
SHRUBS:					
Broussaisia arguta	*Kanawao, pū 'ahanui*			x	
Chenopodium	Goosefoot, pigweed, lamb's quarters, Mexican tea, worm seed, *'aheahea, 'ahea, 'ahewahewa, alaweo, alaweo huna, 'aweoweo, kaha'iha'i*	x		x	

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TABLE 3 (Continued)

Scientific Name	Common Name	Nat	Pol	End	Ind
Cheno-am	*Achyranthes*, *Chenopodium oahuense*, *Amaranthus*, *Charpentiera*, etc.	x		x	
Cressa	Cressa				x
Euphorbia (shrub or herb)	*Kaliko*, spurge, Mexican fireplant (wild poinsettia)	x		x	
Fabaceae	Legume or pea family	x	x	x	x
Senna gaudichaudii	*Kolomona*, *heuhiuhi*, *kalamona*, *uhiuhi*	x			x
Sesbania	*'Ohai*, Egyptian rattlepod	x		x	
Hibiscus	*Aloalo*, *hau*, *koki'o ke 'oke'o*, (*hau hele*, *koki'o kea*, *pamakani*), *ma'o hau hele*, *kaiohala*, (*akiahala*, *hau hele wai*), *koki'o* (*mākū*), large-leaved hau, cotton or confederate rose (*aloalo waikāhuli*, *waikāhuli*)	x		x	x
Kadua	*Au*, *pilo*, *'Awiwi*, *kio'ele*, etc.	x		x	
Labordia	*Kamakahala*			x	
Malva	Mallow	x			
Plumbago	*Ilie'e*, *hilie'e*				x
Scaevola	*Naupaka*			x	x
Sida	*'Ilima*, Prickly sida	x			x
Solanaceae	Nightshade family	x	x?	x	x
Vitex	*Kolokolo kahakai*, *hinahina kolo*, *mānawanawa*, *māwanawana*, *pōhinahina*, *pōlinalina*, beach vitex				x
Waltheria	*'Uhaloa* (*'ala'ala pū loa*)				x?
HERBS:					
Low-spine Asteraceae	Sunflower family; Includes ragweed and others	x		x	x
High-Spine Asteraceae	Sunflower family; Includes *Bidens*	x		x	x
Liguliflorae	Sunflower family, chicory tribe	x			
Boerhavia	*Alena*, *anena*, *nena*	x			x

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TABLE 3 (Continued)

Scientific Name	Common Name	Nat	Pol	End	Ind
Bonamia menziesii (Perispermum)	None (Vine in dry to mesic forest)			x	
Brassicaceae	Mustard family				
Lepidium	*'Anaunau, 'anounou, kunana*	x		x	x
Cleome	Spider plant, spider flower, spider wisp, *honohina, 'ili'ohu, honohino*	x			x?
Commelina	*Honohono*	x			
Cressa truxillensis	Cressa				x
Plantago	*Laukahi kauhiwi*, plantain	x		x	
Polygonum sp.	Knotweed/smartweed	x			
Polygonum glabrum	*Kāmole*	x?			
Sicyos	*'Anunu*			x	
Stenogyne	*Pua'ainaka, Ma'ohi'ohi, Mohini*			x	
Tribulus	*Nohu, nohunohu*, goat head	x			x
GRASSES, etc.:					
Cyperaceae	Sedge family	x		x	x
Poaceae	Grass family	x		x	x
Typha	Cattail	x			
CULTIGENS:					
Colocasia	Taro, *kalo*		x		
Gossypium tomentosum	*Ma'o, huluhulu*, native cotton			x	
Oryza	Rice	x			
Saccharum	Sugar cane	x			
Vigna	*Mohihihi, nanea*, beach pea			x	x
ALIENS:					
Leucaena	*Kao-haole ('ekoa, lilikoa)*	x			
Prosopis	*Kiawe*, mesquite	x			
Indeterminate	Too badly deteriorated to identify				
SPORES:					
Dicksoniaceae	Tree fern family			x	x

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TABLE 3 (Continued)

Scientific Name	Common Name	Nat	Pol	End	Ind
Lycopodium cernuum	Club moss (*Wawae'iole*)			x	
Monolete	Fern				
Trilete	Fern				
OTHER:					
Tetraploa					
Starch angular	Grass seed-type starch				
Foraminifera	Forams				
Spirogyra	Algae				
Scolecodont	Polychaet worm jaw				
Microscopic charcoal	Microscopic charcoal				
Charred Asteraceae fragments	Charred pieces of a member of the sunflower family				
Charred Poaceae fragments	Charred pieces of grass				

Plant names and information derived from (Wagner, et al. 1990)
Fern (spore) names derived from (Selling 1946)

Nat = Naturalized
Pol = Polynesian introduction
End = Endemic
Ind = Indigenous

Pollen identifications to species were made based on the fact that only 1 species is reported by (Wagner, et al. 1990). Species identification was not made based on morphologic characteristics observed under the microscope.

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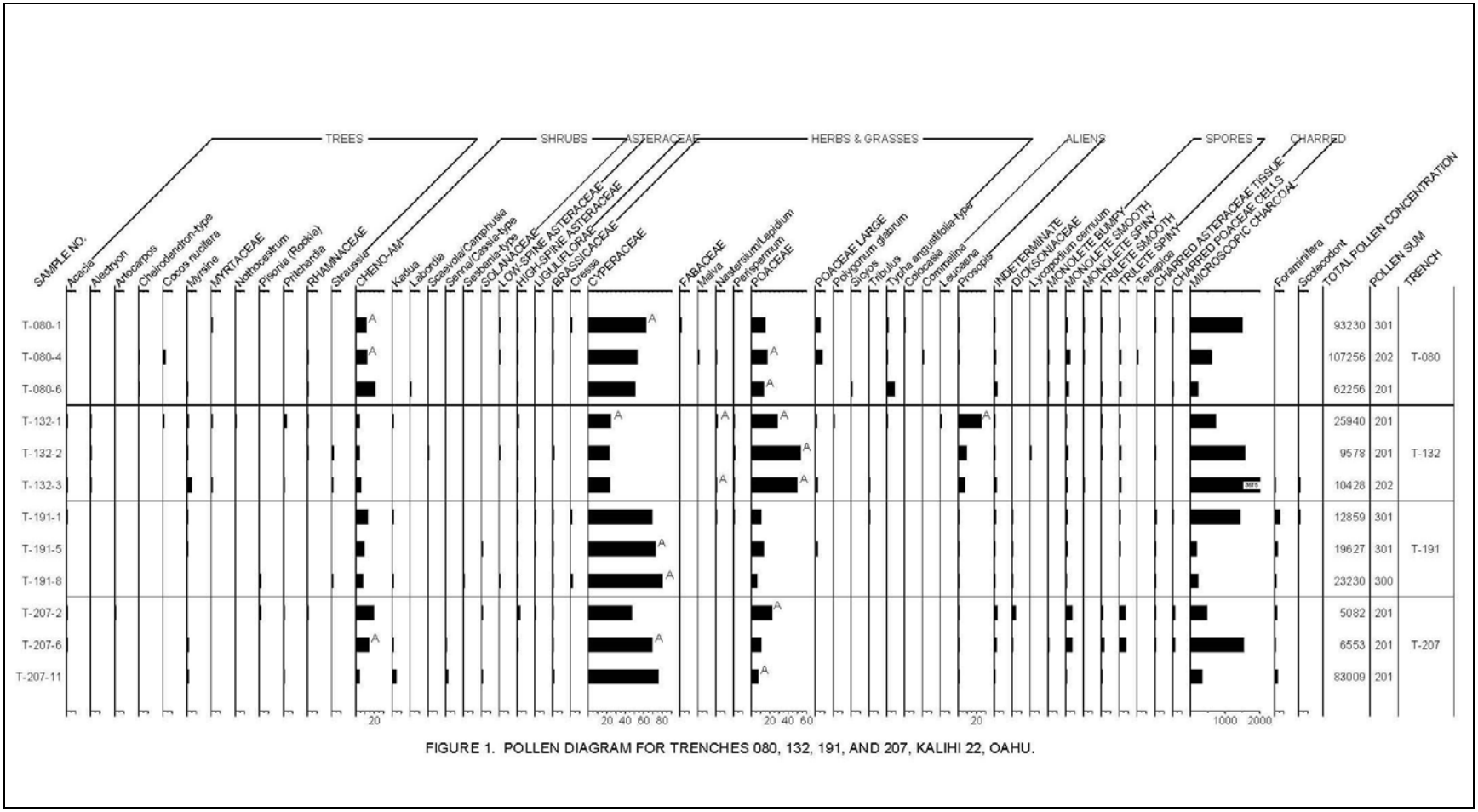

FIGURE 1. POLLEN DIAGRAM FOR TRENCHES 080, 132, 191, AND 207, KALIHI 22, OAHU.

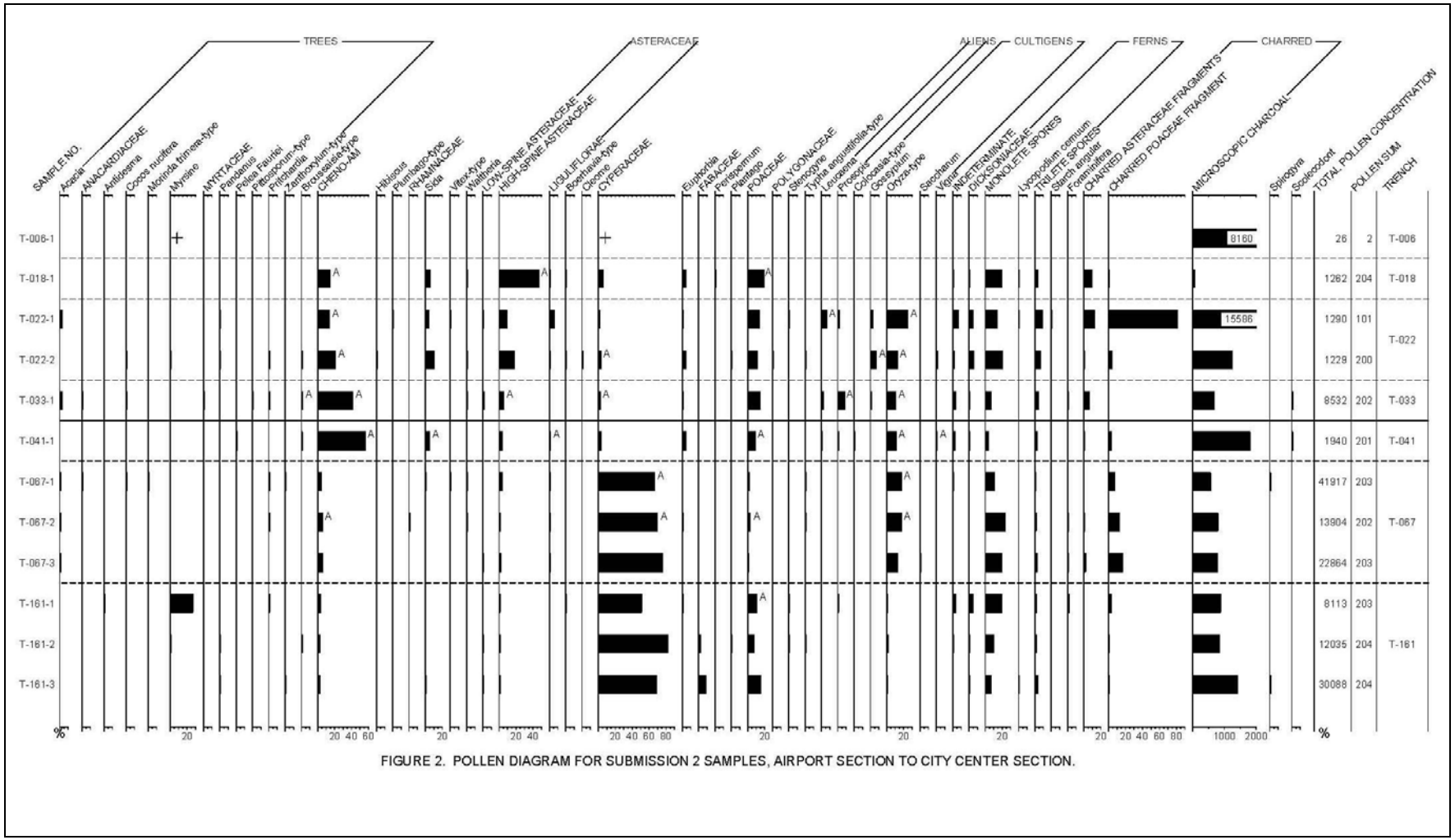

FIGURE 2. POLLEN DIAGRAM FOR SUBMISSION 2 SAMPLES, AIRPORT SECTION TO CITY CENTER SECTION.

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