Approaches to Dating Wetland Agricultural Features: An Example from Wailau Valley, Moloka‘i Island, Hawai‘i

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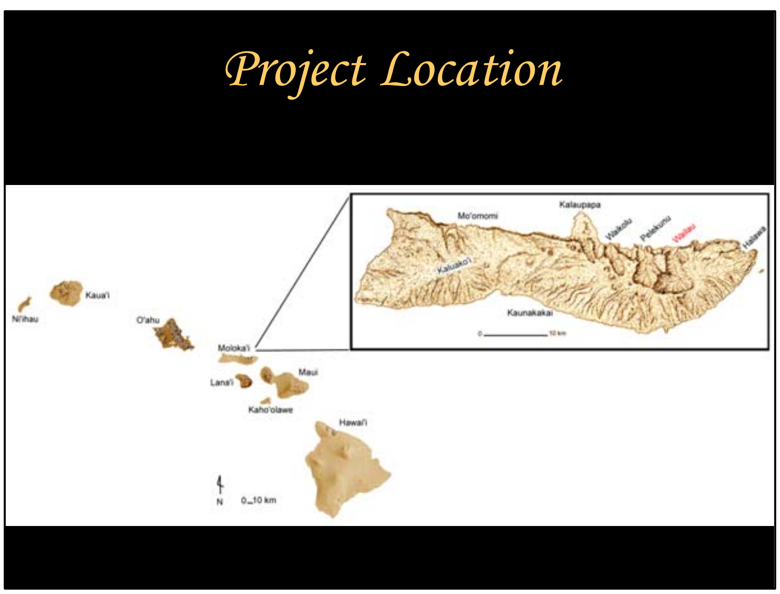
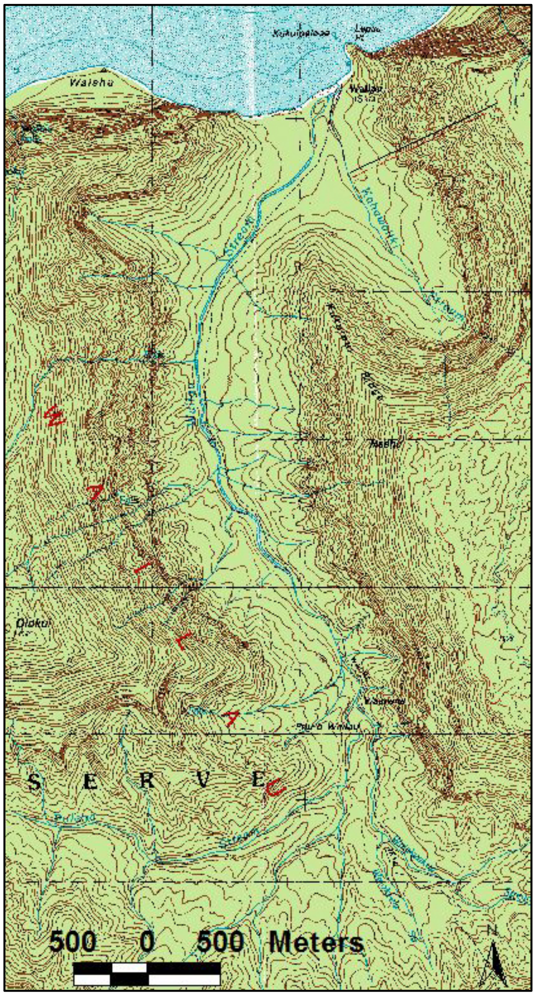
This paper examines the methods used to date 19 wetland agricultural systems in Wailau Valley on the island of Moloka‘i, Hawai‘i. Radiocarbon dates were obtained from short lived charcoal taxa collected from beneath wall foundation stones and several alternative dating approaches were utilized, such as wall superposition and abutment analyses, re-use of wetland terraces for non-agricultural purposes, and the presence of historical material and introduced plant taxa.



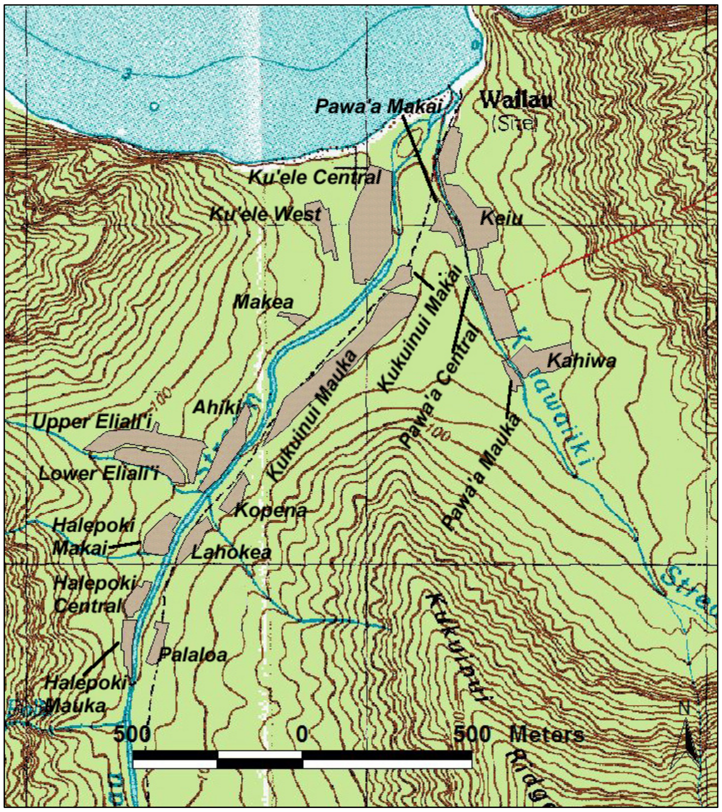
The Study Area

Wailau is the largest of four valleys on the remote windward coast of Moloka‘i, which stretches from Hālawa Valley on the east to Kalaupapa Peninsula on the west.

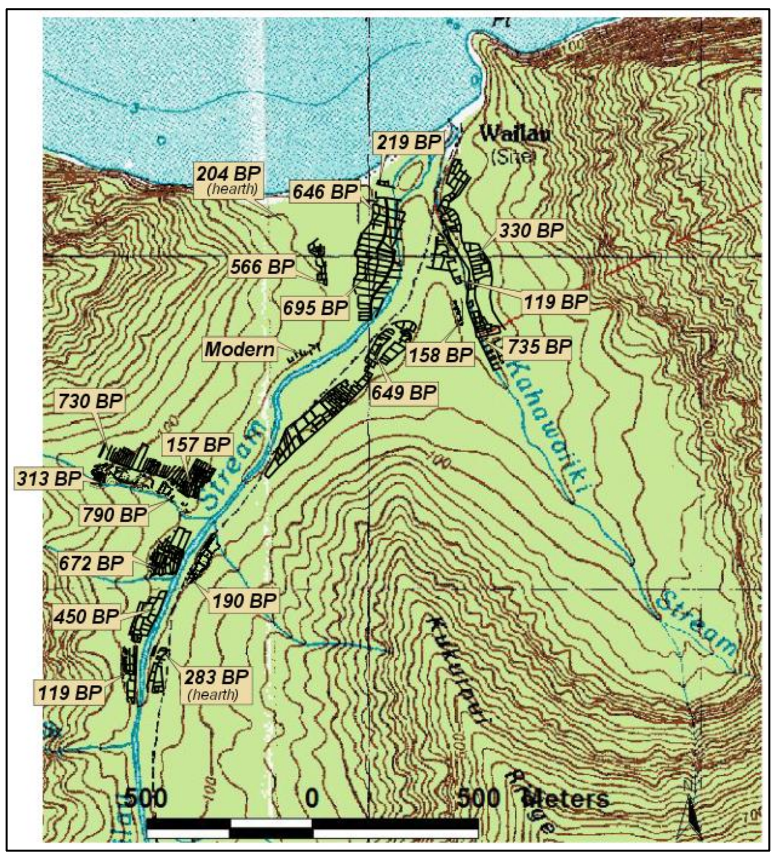


Heavy rainfall feeds two perennial watercourses, Wailau Stream and Kahawaiʻiki Stream, that cut through Wailau Valley and join at the coast. A series of intact irrigated terraces, or *loʻi*, forms an agricultural system that encompasses nearly the entire surface area of the 936-ha valley. Terraces such as these were used traditionally for pondfield agriculture of the staple crop, taro. Taro continued to be cultivated in Wailau until the 1930s when the valley was abandoned, due to a combination of factors, including flooding and unfavorable economic conditions.

Hawaiian *loʻi* systems, or complexes, are typically a set of adjoining terraces that are often reinforced with dry-laid stone walls and soil berms. Wetland taro thrives on flooded conditions, and cool, circulating water is optimal for taro growth, thus a system may include one or more irrigation ditches, or *ʻauwai*, to divert water into and out of the planting area. Terraces are generally cut into a slope to facilitate water movement from the upper to lower fields.



This study is based on data collected for 19 *lo'i* systems located from the coast of Wailau to approximately 2.5 km inland. Together, these 19 systems include 667 individual terraces and 19 irrigation ditches. Additional *lo'i* systems occur farther inland along Wailau Stream that were not examined.



Dating of Wetland Agricultural Features

Radiocarbon Dating: Termini Post Quem, and Dating Re-Use of Terraces

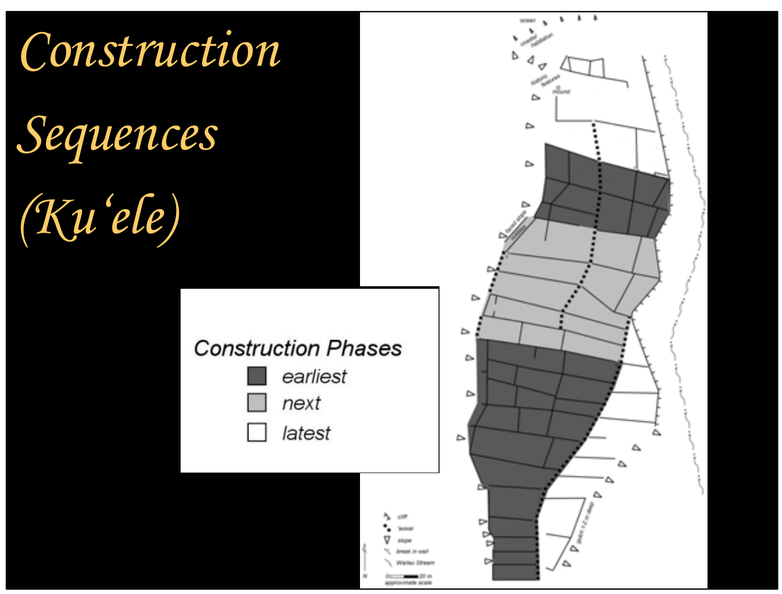
The dynamic environment of wetland agricultural systems presents unique challenges for dating. As water and sediment move through the system, charred plant material is transported as well, thus scattered charcoal collected from pondfield deposits may have originated from anywhere upslope. Wailau is a wet valley, where natural fires are highly unlikely, and the occurrence of any charcoal almost certainly dates human presence. Collecting charcoal samples from contexts that are stratigraphically inferior to terrace wall foundations secures a date that is unquestionably associated with wall construction, providing *termini post quem*, or dates before which the walls were not constructed. Before agricultural terraces were built, vegetation was likely cleared by burning, thus the resulting charcoal found beneath terrace foundation stones does not pre-date terrace construction by a considerable amount of time.

A total of 20 AMS radiocarbon dates have been obtained for Wailau Valley, and 16 are from wetland agricultural contexts. All samples were taxonomically identified prior to dating and only short-lived taxa were selected.

Construction Sequences: Wall Superposition and Abutment

Recent work in Hawaiian dryland field complexes has developed and applied methods of relative dating utilizing wall abutment data. This work has demonstrated that the temporal relationships of wall segments and trails can be discerned from surface examination alone, and relative chronologies have been tested through excavation. Construction sequences offer a more precise means of dating agricultural complexes than radiocarbon dates alone can provide. One radiocarbon date might pinpoint the age of a single wall or terrace within a complex, leaving the age of other parts of the complex unknown.

Construction sequences were devised by looking at the size, shape, and orientation of the terraces and the way that the terrace walls abut each other. Terraces that are relatively uniform in size and shape and that are similarly oriented were likely built at the same time and are grouped together in a cluster. Terraces that were added on later can be identified by walls that are offset to those of another terrace. *‘Auwai* are particularly useful in this analysis, because if a ditch cuts through an existing set of terraces, walls on either side will line up, whereas walls that are offset on either side of an *‘auwai* indicate that the ditch was built first, or before the walls on at least one side.



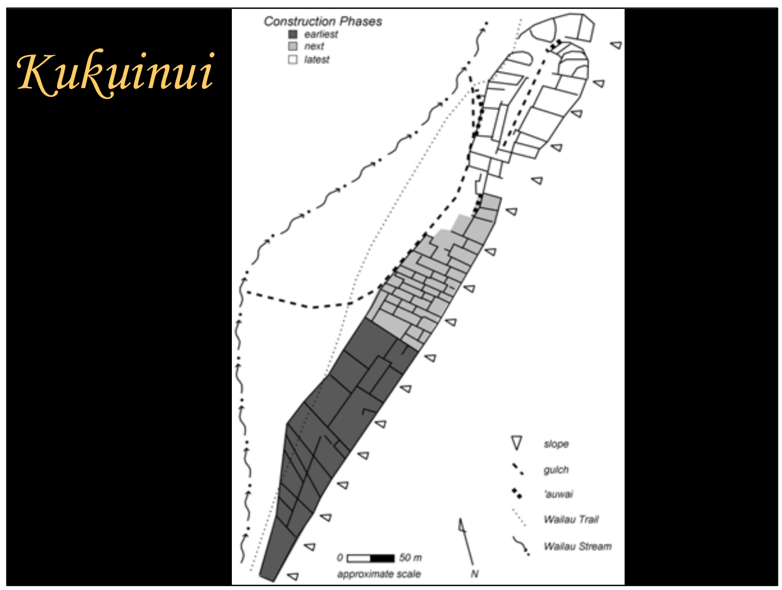
This approach is admittedly intuitive to some degree, but can be easily tested and refined by radiocarbon dating terraces from each of the proposed construction sequences in a given system.

Example:

This example is from the Ku‘ele *lo‘i* system. It’s made up of 63 terraces and three

ʻauwai. Three possible construction sequences could be generated, with the earliest fields likely at either end of the complex. The terraces at the far south end and those toward the north both stand alone as discrete blocks. The portion between these sets was probably next to be filled in. The two *ʻauwai* that feed the earliest terrace blocks were probably constructed along with those blocks and later extended as the system was expanded. The *ʻauwai* that skirts the western part of the complex was likely added during the second construction phase to provide additional water to the expanded system. The latest terraces were probably on the southeast side of the complex and at the far north side, although I think that the northernmost terraces are habitation areas and not *loʻi*. The southeast set was assigned to the latest construction phase because walls are offset from those of the earliest phase on the opposite side of the *ʻauwai*. This suggests that the southeastern block was added on to an already established system.

Although I only showed you one example here, the larger sample of Wailau construction sequence data clearly indicate two trajectories of development. The first is where a series of terrace sets are initially built within a circumscribed area and then the locations between them are filled in. The Kuʻele complex is an example of this first trajectory. The second is where construction begins at one end of a system and then spreads out from it. In this second case, the earliest construction always occurred farthest up-slope or up-stream. I don't have time to explain this figure, but the Kukuinui system is an example of that trajectory.

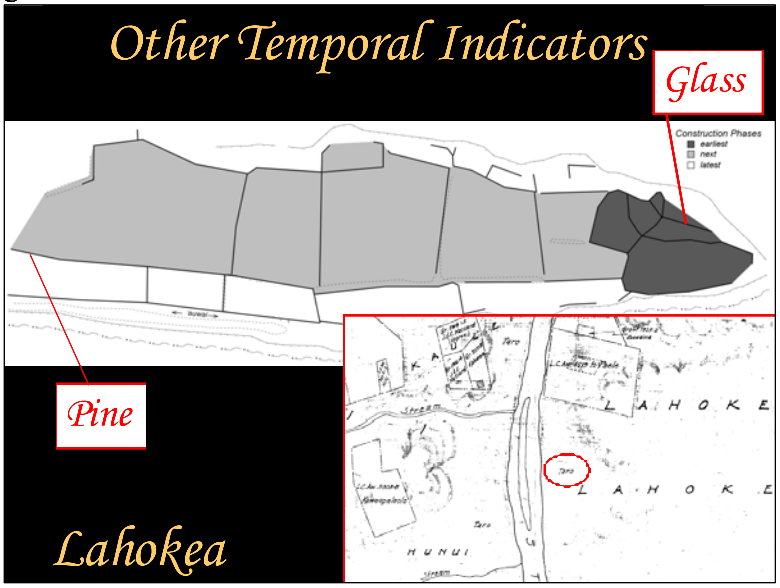


Other Temporal Indicators: Historic Material, Introduced Plant Taxa, and Historic Documents

Temporal indicators other than wall abutments and radiocarbon dates include the presence of historic artifacts and charcoal from recently-introduced taxa, and historic maps and photos. Associated materials on the surface or in cultivated zones indicate use of terraces, while artifacts beneath walls and abutment relations indicate when parts of each complex were constructed. Historic artifacts and historically-introduced charcoal taxa found in excavation at a lower depth than a wall foundation provide *termini post quem*, while historic material found at a depth above a wall foundation or on the surface provide *termini ante quem*. Historic maps and photos that depict the *loʻi* complexes also provide *termini ante quem*, because the *loʻi* were already constructed at the time the map was drawn or the photo was taken. I'll just give you one example of how this can be done.

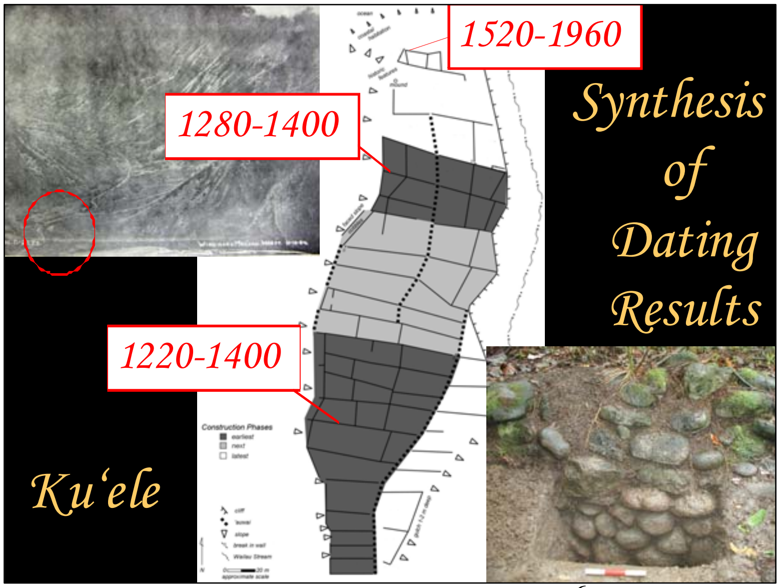
Example:

At Lahokea, two 19th-20th Century glass shards were found at a depth lower than the wall foundation, clearly indicating that the wall was constructed in the historic era. Wall abutment analysis placed these terraces in the earliest construction phase of the complex, demonstrating that the entire complex was constructed late in time. In addition, historically-introduced pine charcoal was found beneath one of the walls. A 1903 map indicates that taro was being grown in Lahokea at that time, thus the system was constructed between ca. 1800 and 1903.



Synthesis of Dating Results

Radiocarbon dates, construction sequences, and other temporal indicators are three discrete lines of evidence that were utilized to estimate the timing of *lo'i* construction in Wailau. I'll use the Ku'ele *lo'i* system to show how the radiocarbon dates can be tied in to the other dating analyses.



Example:

The system was already in place when a 1924 aerial photo was taken. Radiocarbon dates suggest that the complex was built at an early time, AD 1280–1400 for the northern portion of the system and AD 1220–1400 for the southern portion. These very similar dates at opposite ends of the complex support the hypothesized construction sequence in which the north and south sides of the system were built first. The central part of the system was filled in later, and finally the southeast portion was expanded along Wailau Stream. The terraces on the far north side were probably habitation areas and these dated to AD 1520–1960, thus they were constructed after the *lo'i* system was established and probably after the system was at least partially expanded.

Conclusion

In conclusion, this work outlines methods used to determine the dates of construction, use, and abandonment for irrigated agricultural systems in Wailau. A refined radiocarbon dating scheme was applied, utilizing wood taxa identification to select short-lived species and collecting samples from beneath wall foundations as *termini post quem*. Taking these simple steps in the radiocarbon dating process protects against the old wood problem, so that the event being dated (burning of the charcoal) is reasonably close in time to the target event (wall construction) and that the event being dated is truly associated with the target event.

Supplementary dating methods introduced here include generating construction sequences from wall abutment relationships and looking at other temporal indicators such as historic maps and photos and the occurrence of historic material and plant taxa. These methods complement and extend the utility of the radiocarbon chronology by providing additional context for the radiocarbon dates. Whereas one radiocarbon date might pinpoint the age of a single wall or terrace within a complex, applying supplementary dating methods might identify relationships between different parts of the system relative to that one date. No specialized training is needed to apply the supplementary dating techniques, making them particularly cost and time effective, compared to radiocarbon dating, where samples must be sent to a laboratory. And the examination of surface wall abutments and historic maps and photos requires no excavation, providing a completely non-destructive addition to the dating suite.

Radiocarbon dating is also a vital tool for testing the results of the other methods. For example, in Ku'ele, three construction sequences were hypothesized from wall abutment relations, with the north and south ends of the complex thought to be the earliest and the central portion filled in later. Radiocarbon dates from either end of the system turned out to be very similar to each other and very early in time, as would be expected from the proposed construction sequence. A third, later, date from the central portion of the complex would clearly confirm the sequence.

Wetland agricultural systems are often difficult to date because of their dynamic environment, large size, and complexity of features. Rigorous methods must be applied to date them accurately. This paper proposes ways in which this can be done in a cost-effective, minimally-destructive manner.