Fremont Legacy in Capitol Reef and the Waterpocket Fold: A Radiocarbon Analysis of the Pectol Collection Coiled Basketry Using Bayesian Modeling

Chelsea Cheney
*Utah State University*

Follow this and additional works at: [https://digitalcommons.usu.edu/etd](https://digitalcommons.usu.edu/etd)

Part of the Anthropology Commons, and the Sociology Commons

**Recommended Citation**
[https://digitalcommons.usu.edu/etd/8829](https://digitalcommons.usu.edu/etd/8829)
FREMONT LEGACY IN CAPITOL REEF AND THE WATERPOCKET FOLD:
A RADIOCARBON ANALYSIS OF THE PECTOL COLLECTION COILED
BASKETRY USING BAYESIAN MODELING

by

Chelsea Cheney

A thesis submitted in partial fulfillment
of the requirements of the degree
of
MASTER OF SCIENCE
in
Archaeology and Cultural Resource Management

Approved:

_________________________  ________________________
Judson Finley, Ph.D.        Erick Robinson, Ph.D.
Major Professor            Committee Member

_________________________  ________________________
Molly Cannon, Ph.D.        Tim Riley, Ph.D.
Committee Member           Committee Member

_________________________
D. Richard Cutler, Ph.D.
Vice Provost of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

2023
ABSTRACT

Fremont Legacy in Capitol Reef and the Waterpocket Fold: A Radiocarbon Analysis of the Pectol Collection Coiled Basketry Using Bayesian Modeling

by

Chelsea Cheney, Master of Science

Utah State University, 2023

Major Professor: Judson Finley
Department: Sociology and Anthropology

Perishable artifacts provide ample opportunity to better understand past human lifeways. Artifacts constructed from shorter-lived plant materials can make a significant contribution to archaeological research through radiocarbon dating. The analysis and dating of basketry from the Pectol Collection aids in the development of a high-precision chronology for the Capitol Reef and Waterpocket Fold (CRWF) area of southeastern Utah. Basketry technology is treated as a signal for Fremont occupational intensity and can provide prior information to build high-precision Bayesian age models. From AD 750–1050, a narrow window of regionally stable environmental conditions could have promoted agricultural intensification, with peak florescence occurring in northern Fremont regions during AD 840–1080. New data will test the hypothesis that peak CRWF occupation occurred concurrently with Cub Creek. However, compared to their northern neighbors, Fremont occupancy in the CRWF peaked later in time, closer to AD 1100. Future research can use new data to examine whether agricultural communities in
the northern Colorado Plateau formed earlier but persisted for a shorter duration than those in the eastern Great Basin.

**Keywords:** Museum Collections, Perishables, Coiled Basketry, Fremont, Radiocarbon, Chronology, Bayesian Modeling, Capitol Reef, Waterpocket Fold, Utah, Great Basin, Colorado Plateau

(290 pages)
Fremont Legacy in Capitol Reef and the Waterpocket Fold: A Radiocarbon Analysis of the Pectol Collection Coiled Basketry Using Bayesian Modeling

Chelsea Cheney

Perishable artifacts provide ample opportunity to better understand past human lives. Artifacts constructed from shorter-lived plant materials can make a significant contribution to archaeological research through radiocarbon dating. Analyzing and radiocarbon dating the basketry construction types from the Pectol Collection aids in the development of a more precise prehistoric timeline for the Capitol Reef and Waterpocket Fold (CRWF) area of southeastern Utah. Basketry technology construction is treated as a signal for growing Fremont occupancy throughout the Colorado Plateau and eastern Great Basin, and can the provide prior information used to better organize Bayesian-based age models. From AD 750–1050, a narrow window of regionally stable environmental conditions could have promoted agricultural intensification, with peak occupancy occurring in northern Fremont regions during AD 840–1080. New data will test the hypothesis that peak CRWF occupation in the south occurred simultaneously with Cub Creek in the north. However, compared to their northern neighbors, Fremont occupancy in the CRWF peaked later in time, closer to AD 1100. Future research can use new data to examine whether agricultural communities in the northern Colorado Plateau formed earlier but persisted for a shorter period of time than those in the eastern Great Basin.
ACKNOWLEDGMENTS

This project would not have been possible without the assistance and support from several people and entities. I deeply appreciate all that has occurred to help me on my way to a Master’s degree and am so grateful for the personal and the professional relationships I have had and have developed on my journey, from times at CWC, UWyo, USU, and everywhere in between—it has been real! Though it has been an arduous one, this adventure has given me a greater understanding of the world around me, the people that came before me, and will hopefully prove useful to those that come after me.

First, I need to thank my incredibly patient and supportive committee at Utah State and the professional connections I made along the course of this project. To my chair, Judson Finley: I cannot express my gratitude for your direction and support. Thank you for bringing me into an incredible project, guiding me through the process, and giving me permission to go for a hike. Thanks for being so rad! To Erick Robinson: your expertise and excitement regarding radiocarbon dating and R were invaluable to me, and I could not have worked with my data without your support. To Molly Cannon: early on in my graduate education, your willingness to provide me access to USU Museum of Anthropology materials was vital in my exposure to basketry and allowed me to hone my skills. To Tim Riley and the staff at the USU Eastern Prehistoric Museum: without your expertise and agreement to allow me access to the Pectol Collection, no part of this project could have occurred. I greatly appreciate your openness and disposition to share Pectol data. To Anne T. Lawlor and the folks at the Natural History Museum of Utah: I am so happy to have spent a day with you and the incredible collections housed at your
facility. Your wealth of perishable knowledge helped me further expand my understanding of the technology. To the USU Mountain West Center for Regional Studies: I am extremely appreciative for your financial assistance to achieve the goals of this project. Your aid enables students, like me, to contribute to our understanding of the beautiful Utah landscape, its people, and its history.

Next, my supportive graduate cohort, past professors and mentors, roommates, friends, and loving family from near and far provided me with so much. Thank you all for being both sympathetic and excited. Though my areas of interest are not always in line with yours, you all were the exact kinds of cheerleaders I needed. Rick Weathermon: you really helped me flourish as an archaeologist and your initial introduction to perishable artifacts truly set me down the path that I chose. Thank you.

Lastly, and most importantly, to my partner and best friend, Eli: your support when apart and your motivational speeches, dinners, and treats when together kept me going through all aspects of graduate school. It was incredibly difficult to live in different states during our respective programs, but our phone chats and visits kept me moving towards the end goal. Your intelligence and ability to talk through ideas with me are greatly appreciated and I could not have done this without you. Through needy animals, late nights, and sleepy mornings, your companionship proves to be one of the most important things in my life. Where would I be without my partner in crime?

Chelsea Cheney
CONTENTS

<table>
<thead>
<tr>
<th>ABSTRACT</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUBLIC ABSTRACT</td>
<td>v</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>vi</td>
</tr>
<tr>
<td>CONTENTS</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>THE FREMONT CULTURE</td>
<td>6</td>
</tr>
<tr>
<td>Fremont Basketry and its Utility for Radiocarbon Analysis</td>
<td>7</td>
</tr>
<tr>
<td>Early Utah Settlers and Archaeological Collections</td>
<td>9</td>
</tr>
<tr>
<td>METHODS</td>
<td>13</td>
</tr>
<tr>
<td>Qualitative Analyses of the Pectol Collection Coiled Basketry</td>
<td>13</td>
</tr>
<tr>
<td>Quantitative Radiocarbon Analyses and Bayesian Chronological Modeling</td>
<td>14</td>
</tr>
<tr>
<td>Legacy and New Data for the Capitol Reef and the Waterpocket Fold</td>
<td>16</td>
</tr>
<tr>
<td>RESULTS</td>
<td>21</td>
</tr>
<tr>
<td>The Pectol Collection’s Coiled Basketry</td>
<td>21</td>
</tr>
<tr>
<td>Modeling the Occupational History of Capitol Reef and the Waterpocket Fold</td>
<td>38</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>52</td>
</tr>
<tr>
<td>Fremont Legacy in Capitol Reef and the Waterpocket Fold</td>
<td>52</td>
</tr>
</tbody>
</table>
CONCLUSION .........................................................................................................................61
REFERENCES CITED ...........................................................................................................63
APPENDIX I – PECTOL BASKETRY RADIOCARBON DATA TABLE ..............................71
APPENDIX II – PECTOL BASKETRY RAW PHOTOS .................................................73
Half Rod, Bundle Stacked, Non-Interlocking Stitches ................................................. 73
Whole Rod, No Bundle, Interlocking Stitches ................................................................. 181
Half Rod, No Bundle, Interlocking Stitches ................................................................. 227
Half Rod, No Bundle, Intricate Stitches ........................................................................ 249
APPENDIX III – CODE ......................................................................................................271
CRWF Legacy Radiocarbon Dataset Code ................................................................. 271
CRWF Pectol Collection Radiocarbon Dataset Code ................................................. 274
CRWF Legacy vs. CRWF Pectol Radiocarbon Datasets Code .................................. 276
CRWF Pectol Basketry Radiocarbon Dataset Code ...................................................... 277
LIST OF TABLES

Table 1. Presence of general construction attributes of the Pectol Collection's coiled basketry .......................................................... 26

Table 2. Presented in years AD, the modeled posterior probability density 95% confidence intervals for each basket phase starts, ends, spans, and median ages.......... 51
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The rugged landscape of the CRWF region</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>Basket wall schematics</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Detail of whole rod and no bundle, interlocked stitches on baskets 86602.244 and 86882.224</td>
<td>28</td>
</tr>
<tr>
<td>4</td>
<td>Pinwheel alignment on baskets 86603.245 and 86580.222</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>Decoration on baskets 86603.245 and 86580.222</td>
<td>29</td>
</tr>
<tr>
<td>6</td>
<td>Additional features on baskets 86603.245, 86582.224, and 86602.244</td>
<td>29</td>
</tr>
<tr>
<td>7</td>
<td>Display damage on whole rod baskets 86579.221 and 86570.212</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>Cordage on basket 86579.221 and display damage on basket 86579.221</td>
<td>31</td>
</tr>
<tr>
<td>9</td>
<td>Half rod and bundle stacked baskets 86484.64b and 86484.64c</td>
<td>33</td>
</tr>
<tr>
<td>10</td>
<td>Non-interlocked stitches and vertical alignment on baskets 86577.219 and 86578.220</td>
<td>33</td>
</tr>
<tr>
<td>11</td>
<td>Decoration on baskets 6577.219, 86576.218, and 86607.249</td>
<td>34</td>
</tr>
<tr>
<td>12</td>
<td>Specimen 86576.218 with a possible modern attempt at repair</td>
<td>34</td>
</tr>
<tr>
<td>13</td>
<td>Cordage on baskets 86576.218, 86607.249, and 86573.215</td>
<td>35</td>
</tr>
<tr>
<td>14</td>
<td>Ochre on intricately stitched basket 86450.30 and damage on basket 86575.217</td>
<td>36</td>
</tr>
<tr>
<td>15</td>
<td>Open coiling on intricately stitched baskets</td>
<td>37</td>
</tr>
</tbody>
</table>
Figure 16. Close coiling rims on intricately stitched baskets .......................................... 37

Figure 17. Repairs and extra Artemisia sp. bark strips wrapped coils on basket 86450.30.................................................................................................................................................. 38

Figure 18. The built environment in the CRWF region...................................................... 41

Figure 19. An SPD of the original 138 legacy ages from the CRWF region ................. 43

Figure 20. An SPD of both the legacy and the new ages from the Pectol Collection out of the CRWF region................................................................................................................................. 44

Figure 21. A permutation test comparing the SPDs of the legacy CRWF radiocarbon dataset and the Pectol Collection radiocarbon dataset................................................................. 46

Figure 22. A multiplot Phase Model of the Pectol Collection coiled basketry............. 50
Introduction

Perishable artifacts provide ample opportunity to better understand past human lifeways, but they are often overlooked due to poor preservation, loss of contextual data from unregulated collection, and overall inaccessibility due to ownership and exhibition. Because of their appeal, perishables are often from donated museum collections and may be devoid of contextual information; however, radiocarbon dating is one area of archaeological research where perishable artifacts such as textiles, basketry, and cordage can make a significant contribution (Adovasio 2020), regardless of contextual background information. Since perishable artifacts are often constructed from short-lived plants or from perennial plants that produce annual growth, the uncertainty between target events and dated events is reduced when compared to dating other organics, especially wood or charcoal. Direct dates on perishable artifacts can improve regional occupational chronologies that inform the timing of human adaptations and transitions, land-use changes, and technological developments (Finley et al. 2020; Kennett et al. 2014; Robinson et al. 2021). Perishable dating is particularly important in Utah’s Fremont archaeological record where high-precision radiocarbon ages enable fine-grained reconstructions of the past, achieving a more precise interpretation of target events, such as the intensification of maize agriculture and the development and abandonment of early agricultural communities (Finley et al. 2020). Assessing the transitional period between mobile hunting and gathering and sedentary aggregated farming communities is better achieved thorough the creation of fine-grained case studies
across the various Fremont regions within the eastern Great Basin and the Colorado Plateau.

In this thesis, I conduct a chronological analysis of the coiled basketry from the Pectol Collection, a well-known but understudied assemblage of perishables from the Fremont River area of Capitol Reef National Park in southeastern Utah’s Waterpocket Fold (Baker 2002; Janetski 2005; Kreutzer 1994). Although this region is fundamental to the Fremont cultural area, the chronology of local occupations remains poorly developed. Recent analysis of Fremont radiocarbon chronologies in Cub Creek suggests that agricultural village occupations in the north were relatively brief, peaking within the period AD 840–1080 (Finley et al. 2020). Although there is debate concerning the comparative longevity of Fremont villages in the eastern Great Basin and northern Colorado Plateau (Allison 2010, 2019; Madsen and Simms 1998; Talbot 2019), analysis of the legacy radiocarbon database indicates that existing dates lack the precision necessary for comparison, and the few high-precision ages suggest there is no difference in the timing and longevity of agricultural groups across the two regions (Robinson et al. 2021). In this study, I treat perishables—specifically coiled basketry—as a signal for occupational intensity in the Fremont River drainage and test the hypothesis that peak occupation occurred during the narrow window of AD 750–1050, a time of regionally stable environmental conditions that promoted agricultural intensification (Finley et al. 2020). In this study, I analyze the attributes of the Pectol Collection’s coiled basketry to develop a set of informative priors to couple with new, high-precision radiocarbon ages in the construction of a Bayesian chronological model for the Capitol Reef and Waterpocket Fold area of southeastern Utah. These priors are informative beliefs based
on archaeological evidence and allow the introduction of specific parameters in the Bayesian age models (Bayliss 2009; Bayliss et al. 2007; Bronk Ramsey 2009, 2017; Finley et al. 2020). *Informative priors* constrain the calibration of radiocarbon ages into calendar dates, and enhance the precision of the sample with the target event (Bayliss 2009; Bayliss et al. 2007; Bronk Ramsey 2009, 2017; Finley et al. 2020). Compared to and supplemented with legacy radiocarbon data from Capitol Reef National Park and the Waterpocket Fold region, these new data and resulting models provide an additional case study that examines the timing of growing agricultural occupations on the Colorado Plateau. The development of multiple Fremont case studies, especially those using high-precision radiocarbon data, can better examine whether regional agricultural communities formed earlier but persisted for a shorter duration than those elsewhere in the eastern Great Basin.

In the following study, I first introduce the Fremont people as we understand them archaeologically, describe their basketry and its utility in radiocarbon dating, and touch upon early Euro-American settlers of Utah and the origins of the Pectol Collection. Next, I discuss the initial methods used to better understand the legacy radiocarbon chronology of Capital Reef National Park and the Waterpocket Fold (CRWF) region. The legacy radiocarbon data are organized and modeled in several ways, providing a coarse-grained chronology for the study area and a base to move forward with the Pectol research. Here, both qualitative and quantitative analyses are compulsory. Qualitative analyses on the Pectol Collection coiled basketry establish the construction methods that support cultural affiliations (i.e., Fremont or Ancestral Puebloan), and provide prior information for constructing the updated, high-precision age models and regional chronologies. I
examined and described the Pectol Collection coiled baskets and sampled them accordingly for quantitative radiocarbon analysis. Radiocarbon data are necessary to understand the ages of the coiled basketry, and can help assess the accuracy of their presumed cultural affiliations, in addition to the construction type categories. Following the initial legacy modeling and the qualitative basket analyses, the new radiocarbon ages are added to the legacy chronology and are re-modeled to provide fine-grained insights into trends in the coarse-grained models. The new age-models result in a higher-precision chronology for the study area. The final task in this project uses the new CRWF chronology as a case study to compare with archaeological findings from across the Fremont cultural region. Future comparisons from other regional datasets are possible with an updated CRWF age model and can begin to address the timing and duration of differing Fremont agricultural communities across the western landscape.

In sum, this project uses the prior information from the Pectol coiled basketry analyses, models the legacy radiocarbon ages, models the new basketry radiocarbon ages, and then compares new and legacy data to understand the local Fremont occupational chronology within a larger regional context. A new, high-precision CRWF chronology helps us better understand the temporal intricacies of Fremont occupations throughout the eastern Great Basin and Colorado Plateau. Fine-grained data and comparable case studies can address florescence of Fremont agricultural communities in the CRWF area and neighboring regions by viewing the record in higher resolution, generational timescales. With more detailed information, we can better understand how agricultural village intensification may be similar or dissimilar compared to other Fremont communities across the eastern Great Basin and northern Colorado Plateau, testing the timing and
duration of those communities. This project also shows the utility of donated museum collections (St. Amand et al. 2020), the importance of legacy radiocarbon datasets, and provides groundwork for future research in Fremont archaeology and beyond.

In this study, four types of coiled basketry from the Pectol Collection appear at during the Fremont period during specific periods of time, showing a tight age range spanning a few hundred years. I argue that dated materials with similar radiocarbon ages coming from the same general region provide a signal for intensification and investment in specific places on the natural and cultural landscape. Using the Pectol basketry as a signal for occupational intensity in the Fremont River drainage and the surrounding Waterpocket Fold, the resulting radiocarbon ages fall just before, into, and shortly after the narrow window of AD 750–1050, a time of regionally stable environmental conditions that promoted agricultural intensification elsewhere in the greater region (Finley et al. 2020). Compared to the legacy radiocarbon data, the combined legacy Pectol data and the new Pectol basketry radiocarbon data indicate periods of reorganization and intensification that are otherwise invisible without the addition of the dated, annually-grown materials—like those used in basketry construction. Moreover, specific construction methods appear at opportune times within the occupational history of the CRWF, and paints a more informative picture of the Fremont people.
The Fremont Culture

The term *Fremont* describes an eastern Great Basin and Colorado Plateau archaeological cultural complex consisting of diverse ethnic and linguistic groups that shared material culture traits, technologies, and subsistence strategies (Madsen and Simms 1998; Marwitt 1986; Morss 1931; Ortman and McNeil 2018; Simms 2008). Noel Morss first identified the Fremont during a 1928–1929 Harvard Peabody Museum expedition in the Fremont River drainage of southeast Utah, guided by local enthusiast, E. P. Pectol (Baker 2002; Morss 1931). Previous research and the ‘Standard Fremont Model’ suggest the Fremont inhabited the area north of the Colorado River from roughly AD 0–1300, likely originating from foraging roots centered in the Archaic eastern Great Basin and influenced by the influx of Southwestern agriculturalists (Madsen and Simms 1998; Marwitt 1986; Simms 2008). Arguably, over a short time span, various Fremont groups quickly incorporated agricultural traits from their contemporaneous southern Colorado Plateau and Southwest neighbors (Allison 2019; Janetski 1990; Lekson 2014; Madsen and Simms 1998). The resulting material culture is distinct from neighboring regions, and the identified trait list consists of a mix of pithouse architecture, typically undecorated pottery, clay figurines, corner-notched projectile points, anthropomorphic rock art, hock moccasins, stone balls and gaming pieces, trough metates, mixed subsistence strategies of foraging and farming, and typically undecorated one-rod and bundle coiled basketry (Adovasio 1980, 1986; Adovasio et al. 2002; Lekson 2014; Madsen and Simms 1998; Marwitt 1986; Morss 1931; Ortman and McNeil 2018; Simms
Regional Fremont variants in the eastern Great Basin and Colorado Plateau (Ambler 1966; Marwitt 1970) were highly adaptive and practiced residential cycling, operating on seasonal rounds with fluidity between their modes of food production and associated strategies (Finley et al. 2020; Lekson 2014; Madsen and Simms 1998; Marwitt 1986; Simms 2008, 1986). The Fremont are not considered a singular culture across the wider landscape but were likely made up of several variant groups that shared some traits and ideals across the region. The constellation of shared traits and relationships provide unique opportunities in interpreting Fremont archaeological assemblages and addresses variability in hunter-gatherer adoption of agriculture, village intensification, and the timing and duration of occupational histories in the eastern Great Basin and Colorado Plateau.

Fremont Basketry and its Utility for Radiocarbon Analysis

Basketry is a unique material culture category that identifies a major fundamental difference between the Fremont and other cultural complexes (Adovasio 1980, 1986; Adovasio et al. 2002; Lekson 2014; Ortman and McNeil 2018; Simms 2008; Sinkey 2002; Webster and Hays-Gilpin 1994). Through the twentieth century, countless textile objects have been recovered and looted from Fremont contexts, and basketry in particular enables researchers to address several avenues of inquiry. Through the analysis of basketry from differing contexts and time, examples of potential research include, but are
not limited to: construction techniques, style and decoration, material choices, the transmission of ideas and learning, precision dating, cultural affiliation and ethnicity, aesthetic variability, utility and functionality, cultural interactions, or immigration and movement. In this project, basketry construction types and the radiocarbon ages from the objects allude to age, affiliation, and regional occupancy. Evidence of older coiled basketry traditions in the eastern Great Basin suggest an affinity for one-rod variants beginning in the Middle Archaic period, with an increasing variety of one-rod types favored through the Fremont period (Adovasio 1980, 1986). Arguing in support of Fremont ancestry in the Archaic Great Basin, Simms (2008:203) suggests,

“...basketry is by itself a compelling demonstration of this legacy. The bases of Fremont basketry technology are the one-rod and bundle and the half rod and bundle foundations... Not only is Fremont basketry fundamentally different from that of the Anasazi [Ancestral Puebloan], it shows a clear continu...”

Regarding the eastern Great Basin and popularity of coiling in the archaeological record, Adovasio states (1986: 201), “...single-rod foundations and variants thereof are by far the most numerous at all times before about AD 1200.” The idea that the Fremont grew out of an Archaic base, with similar basketry types compared to the people that previously inhabited the region, allows this class of artifacts to better inform change through time, providing informative prior data for precision chronological models (Bayliss 2009). If different types of construction methods are practiced at variable times, this can advance our knowledge of cultural transmission and the transition from hunting and gathering to agriculture in the region. Because the objects are constructed from the annual growth of perennial plants, coiled basketry foundation construction techniques are
a logical basis for informative prior information in chronological age modeling (Bayliss 2009; Bayliss et al. 2007; Bronk Ramsey 2009, 2017).

**Early Utah Settlers and Archaeological Collections**

At the turn of the twentieth century, both professional and amateur explorers were “drawn by the sense of mystery and intrigue about the past,” resulting in the discovery and collection of many unique material culture assemblages from the American Southwest and beyond (Baker 2002: 21). Despite the authorization of the Antiquities Act in 1906—which aimed to limit mass collection of artifacts by prohibiting antiquities excavations on public lands without permission from the Secretary of the Interior—relic hunting, or looting, remained popular among western settlers (Baker 2002; King 2013). With permitting, professional archaeologists and explorers often employed local amateur collectors on scientific expeditions due to their knowledge of the areas they lived and worked. Near Torrey, Utah, well-known artifact collectors included E. P. Pectol and Charles William Lee, both early settlers of southern Utah and members of the LDS church (Baker 2002; Janetski 2005; Kreutzer 1994). As a guide, Pectol assisted Noel Morss during his 1928–1929 expedition in the Fremont River drainage, which resulted in the discovery and definition of the Fremont cultural complex (Baker 2002; Janetski 2005; Morss 1931).
Throughout the early decades of the 20th century, Pectol and Lee illegally collected in the Waterpocket Fold geographical area of what would eventually become Capitol Reef National Park. They were primarily interested in promoting tourism through their collections and exhibitions (Baker 2002). Personal letters suggest the men attempted to monetize their efforts, hoping to sell the recovered objects to museums and antique collectors across the country during the 1920s and 1930s (Baker 2002). Famously, three large hide shields were excavated by Pectol and his family by the light of a bonfire, but hundreds of other perishable and non-perishable artifacts had been recovered by Pectol, Lee, and their families during their time in the area (Baker 2002). As amateur collectors, Pectol and Lee were not permitted by the Secretary of the Interior to work on public lands; consequently, the men did not produce in-depth documentation of their work, and much of the original provenience of the materials is unknown (Baker 2002).

Later in the 1930s, federal government officials were notified of the mass collecting on both private and public lands, the latter violating the Antiquities Act of 1906, resulting in an investigation and subsequent “confiscation” of a portion of Pectol and Lee’s collection (Baker 2002; King 2013; Kreutzer 1994). Despite seizure of some artifacts as government property, Pectol and Lee were permitted to continue housing and exhibiting those “confiscated” materials (Baker 2002; Kreutzer 1994). Though Pectol and Lee collected hundreds of objects without permission, Pectol was an advocate for protecting and promoting the Waterpocket Fold region for tourism and advocated for the establishment of Capitol Reef National Park to better protect the resources moving forward (Baker 2002).
The Pectol Collection Today. Pectol and Lee’s assemblages traded hands throughout the twentieth century. Some items, like the infamous shields, were repatriated while others entered private collections (Baker 2002; Kreutzer 1994). Over the last few decades, the E. P. and Dorothy Hickman Pectol Family Organization provided around 220 artifacts from the collection for exhibition and study (Baker 2002: 24). Today, much of the collection is curated at the Utah State University Eastern Prehistoric Museum in Price, Utah and provides an educational exhibit on Fremont-era habitations in the Capitol Reef and Waterpocket Fold.

The Pectol Collection includes numerous archaeological materials that arguably aided in the definition of the Fremont cultural complex in the 1930s during Morss’ expedition. There are a wide range of perishable and non-perishable artifact types, such as raw materials prepared for crafting new objects, ecofacts, food remains, fishhooks, projectile points and arrow shafts, pottery and figurines, basketry and textiles, worked animal bone, antler, and horn, and items of adornment and leisure like jewelry, musical instruments, and toys (Allen 2002; Kreutzer 1994).

In the early 2000s, a handful of the collections’ artifacts were analyzed for the Relics Revisited (2002) research publication, including a small, twined cradle board (Allen and Munsey 2002), a deer headdress (Allen and Munsey 2002), and some of the more unique basketry (Sinkey 2002). Sinkey specifically examined a select group of baskets that she thought appeared to be Fremont but did not adhere to typical construction types. Sinkey’s goal was to “attest the Fremont basketry repertoire had more variety than previously thought” (Sinkey 2002:146). In general, Fremont basketry is considered a continuation of Archaic eastern Great Basin coiled basket traditions with minimal
decoration, but many of the coiled baskets from Pectol’s original collection suggest otherwise. During these previous analyses of the Pectol artifacts, minimal radiocarbon dating was completed, and according to Sinkey (2002:161), “radiocarbon dating would be helpful” in teasing out the intricacies of the Pectol basketry as either Ancestral Puebloan, Fremont, or Numic especially regarding the thirteen baskets that appear to use a mix of construction and decoration techniques.

Presently, around thirty radiocarbon ages have been produced for the objects in the Pectol Collection (Tim Riley, 2021 personal communication), including the three repatriated shields, the Relics Revisited (2002) research objects—the twined cradle board and the deer headdress—and scraps from leather, plant materials, and other perishable artifacts. Only four of the twenty coiled basketry specimens have been previously dated and include a large bulrush bundle jar, a small, decorated seed basket, and two large parching trays. With new AMS radiocarbon ages from the Pectol Collection’s coiled basketry materials—specifically baskets with varying degrees of rod construction configurations, shape, and decoration—a more robust chronology for the habitation of the Capitol Reef and Waterpocket Fold region is possible. Due to the lack of contextual information, ages derived from dating the Pectol coiled basketry provide a random sample of the CRWF region’s basketry repertoire, which is presumed to be Fremont. An updated regional radiocarbon chronology provides additional research potential, and can specifically address questions surrounding the timing and duration of Fremont occupations throughout the eastern Great Basin and Colorado Plateau regions.
Methods

Qualitative Analyses of the Pectol Collection Coiled Basketry

Qualitative analyses of perishable basketry construction and design aid in understanding cultural preferences and affiliations, utility, and functionality, and can serve as the basis for informative prior knowledge in Bayesian age models. Analytical methods for the Pectol Collection coiled basketry follow Adovasio (2010) and include several parameters: the technique employed (i.e., coiled), spacing and configuration of the technique (i.e., close half rod and bundle stacked), the overall shape (i.e., tray or shallow bowl), general measurements (i.e., height, mouth or base widths, diameter or length), how and when warps and wefts are engaged and what types of stitches are used (i.e., interlocked versus non-interlocked stitches, intricate stitches, or functional versus decorative stitches), how structural or non-structural decorations and designs are created (i.e., through dyed stitches, paint, or stitch manipulation), treatments for specific uses or damage from use (i.e., pitched, burned, repaired, or containing food residues), presumed material choices, and any additional construction characteristics encountered during analysis, such as the presence of attached cordage bundles or modern additions after the specimens’ collection and exhibition in the 1920s. With the information derived from the qualitative analyses on baskets, Bayesian ‘phase models’ (Bronk Ramsey 2009, 2017)
can be constructed in OxCal that address fine-grained patterns and produce higher-precision chronologies.

Quantitative Radiocarbon Analyses and Bayesian Chronological Modeling

Radiocarbon dating the annual plant growth typically used in basketry construction is ideal for building a more precise chronology due to the reduced uncertainty between target and dated events (Finley et al. 2020; Kennett et al. 2014). AMS radiocarbon ages are derived from coiled basketry samples weighing 0.5 grams or less and were sent to the University of California Irvine Keck AMS facility for analysis. Organic samples plus ¹⁴C-free wood process blanks and known-age secondary standards were treated with acid-base-acid (1N HCL, 1N NaOH at 75°C, with the base washes repeated until the solutions remained clear). The samples, blanks, and known-age secondary standards were then washed with ultrapure Milli-Q water and dried, prior to combustion with CuO and silver wire getter at 900°C in quartz tubes sealed under vacuum. The samples were graphitized by hydrogen reduction at 525°C with an iron catalyst (Santos et al. 2007) and measured by AMS at the Keck AMS laboratory at University of California Irvine (Southon et al. 2004). The ¹⁴C data were normalized to results from six aliquots of the NIST OX-1 standard (SRM 4990B) run with each batch and corrected for isotopic fractionation using stable isotope measurements (δ¹³C) made online with the AMS spectrometer. Samples were measured multiple times over a 24-
hour period and the quoted age errors consider the scatter in repeated runs and uncertainties in the normalizing standards and background subtractions, as well as counting statistics.

Quantitative analyses involve assembling and modeling the new ages with and against the existing, legacy radiocarbon ages from the CRWF region, including the Pectol Collection. The original dataset and the updated dataset of CRWF radiocarbon ages result in coarse-grained, summed probability distributions (SPDs). The coarse-grained models track broad patterns of past regional occupation at multi-centennial scales. The Pectol coiled basketry attributes argued to be derived from the Archaic eastern Great Basin and continued by the Fremont in later time periods provide prior information for fine-grained, high-precision chronologies at centennial and decadal scales. Using Bayesian methods, the informative prior beliefs and the allocated parameters in the model result in posterior probability density ages (Bayliss 2009; Bayliss et al. 2007; Bronk Ramsey 2009, 2017; Finley et al. 2020). When parameters are assigned 68% and 95% posterior probability density ages, the results are fine-grained age estimates approaching the scales of human generations (Bayliss 2009; Bayliss et al. 2007; Finley et al. 2020; Kennett et al. 2014). Archaeological time periods and Pecos Classifications (i.e., Archaic, Basketmaker II, Fremont, post-Fremont, Late Prehistoric) are used in both the legacy chronology and the updated chronology. Radiocarbon ages are presented in calibrated radiocarbon years BC/AD.
Legacy and New Data for the Capitol Reef and Waterpocket Fold

Legacy radiocarbon ages for the CRWF region are from a previously unpublished database of Utah radiocarbon ages (Kelly et al. 2022). The locational data of the Utah statewide radiocarbon dataset was imported into ArcGIS Pro using the WGS 1984 projection. I created a ten-mile buffer around the current park boundary and selected the radiocarbon ages that fell within that buffer. It is presumed that the Pectol and Lee families were not venturing far from their hometown of Torrey to collect archaeological materials, and all artifacts from the collection are presumed to be from somewhere in the rugged Capitol Reef and Waterpocket Fold region. The previously unpublished database includes sample ages from donated museum collections, like the Pectol Collection, that do not have proper site location context or provenience; therefore, the town of Torrey was chosen as the arbitrary location for the Pectol artifact ages, based on the aforementioned assumption. The data were organized in ArcGIS Pro according to primary watershed to better understand how the dated materials are situated in a dry landscape (Figure 1). Several ages were omitted from the dataset, including 26 samples from sites in the forested uplands near Salina, Utah and three ages on the southern edge of the study area that are known Ancestral Puebloan sites located near the mouth of Glen Canyon.
Figure 1. The rugged landscape of the Capitol Reef and Waterpocket Fold region, including the associated primary watersheds with their secondary boundaries, larger rivers, towns, and the site locations that have produced legacy radiocarbon ages.
OxCal version 4.4 using IntCal20 (Bronk Ramsey 2009, 2017; Reimer et al. 2020) enables calibration and aids in modeling the legacy CRWF radiocarbon dataset. OxCal was instrumental in producing the initial SPD models (Bronk Ramsey 2009, 2017; Reimer et al. 2020). The ‘rcarbon’ package in RStudio further enabled the construction of the SPDs for a permutation test, to compare the chronological models and produce more informative figures (Crema and Bevan 2021; Crema et al. 2017; R Core Team 2022). The legacy CRWF dataset is treated in several ways to provide information about the existing regional chronology. It is primarily built from sampled miscellaneous wood, charcoal, or charred sediments, plant food products or short-lived plants (i.e., wild plants, maize, cotton from a figurine, or cordage), animal-based materials (i.e., leather, hide, or bone), or the annually grown shoots of perennial plants in either their raw form or from miscellaneous perishable objects (i.e., willow wood or basket stitches). The sampled materials are derived from several sites in the Capital Reef and Waterpocket Fold, as well as those from private collections, such as the Pectol Collection, and include a total of 138 ages. The initial two sets of pilot models included coarse-grained summed probability distribution (SPD) models, kernel density estimate (KDE) models, and fine-grained phase models. The first set of three models were organized by watershed and the second set by the material types sampled to get an idea of the spatial and temporal span of the regional prehistoric occupation.

Following this initial tactic, modeling methods were simplified and the CRWF dataset was assessed on a coarse-grained scale, with and without the inclusion of the new AMS data and prior information derived from the basket analyses. This third set of models included coarse-grained SPDs produced with radiocarbon ages organized
sequentially. One model consisted of the 138 legacy radiocarbon ages for the CRWF region, which also includes previous ages derived from Pectol Collection materials. The second SPD model examined items in the Pectol Collection as a whole, modeling the collective 53 legacy and newly derived AMS ages on basketry together. These two coarse-grained SPD models were then compared using a permutation test (Crema et al. 2017) in RStudio (R Core Team 2022) with the ‘rcarbon’ package (Crema and Bevan 2021). The permutation test highlights significant time periods in which the different sub-sampled datasets differ from a permuted null model derived from the complete CRWF radiocarbon dataset. Using iterations in a Monte Carlo (MC) simulation, the permutation test creates a 95% confidence interval from the entire dataset, against which statistically significant periods in the sub-sampled dataset can be identified. The permutation test method is robust for dealing with different types of sampling biases, either geographical or material type specific, biases introduced by the calibration process, and biases introduced by small sample sizes.

The fourth and final set of models specifically addressed the 23 new ages derived from the Pectol Collection’s coiled basketry. The first of these models is a coarse-grained SPD organized sequentially by the age of the coiled baskets. The second model differs from the previous models in that it disaggregates the data into a series of Bayesian phase and sequence models (Bronk Ramsey 2009, 2017). Organizing the data into phases and sequences highlights the fine-grained patterns in construction and design techniques and uses those attributes as informative model priors (Bayliss 2009). This high-precision age model treats different basketry foundation construction types as phases, which means that there is no prior belief of chronological order constraining the model. Radiocarbon ages
are then organized chronologically into rod-type *sequences* with *boundaries* representing the start and the end of the use of that basket construction type. *Sequence* models imply a prior belief that chronological order exists. *Spans* provide information on the duration of each basket phase across the Capitol Reef and WaterPocket Fold region. As people transition to denser villages and invest time into place, more materials, like basketry, are deposited in those singular locations. Bayesian phase models produce a more informed, fine-grained output that targets specific events, like agricultural intensification. In contrast, the SPD models produced for this project are not placed into identified *phases* with event *sequences*, *boundaries*, and *spans*; however, the ages are organized sequentially, producing a coarser-grained, aggregated output looking at the overall use and inhabitation of the landscape through time (See Appendix III – Code).

In sum, chronological age models were constructed in varying degrees of complexity. SPDs are typically lower resolution and coarse-grained, resulting in a more generalized view of the region’s occupational history, while the more complex, high-resolution phase model informs on the timing and duration of specific events. With basketry construction types used as a chronological proxy for maize agriculture intensification, the random sample provides insight to high-resolution, generational trends surrounding the changes in Fremont lifeways. Specifically, it is posited that the timing and duration of the construction of specific coiled basketry types and their increased production are signals for an investment in place and the flourishment of agricultural practices. Coarse grained SPD models do not necessarily provide the resolution to address the signals of Fremont agricultural intensification in the CRWF. The coarse-grained SPD models allude to broader, general periods of occupation and land-
use, and result in single plots outputs. The fine-grained phase model results in multi-plot outputs informing the starts and ends of specific artifact types and assumed associated behaviors.

**Results**

*The Pectol Collection’s Coiled Basketry*

There are twenty coiled baskets in the Pectol Collection housed at the Prehistoric Museum in Price, Utah. Two of these twenty baskets are constructed with an open-coiled arrangement using wide stitches with wide gaps and large bulrush bundles for the walls. The bulrush baskets were not included in the analysis; however, one of the bulrush baskets had been previously dated and is included in the legacy models and the Pectol models. The collection also has examples of ‘basket ringlets’ that contain only a few rounds of coil—likely materials saved or are the beginnings of a future vessel. The ringlets were also omitted from this project. Eighteen coiled baskets of varying wall construction configuration and design were analyzed and sampled for radiocarbon dating in this project (See Appendix II – Pectol Basketry Raw Photos).

Coiled basketry construction methods involve stitching together repetitive coils by using active wefts and passive warp materials. Rods and bundles, the warps, make up
the interior of the wall foundation, and are wrapped by stitches, the wefts. Coiled basket wall construction always contains at least one rod or a continuous bundle, but often uses a combination of the two (Figure 2a). Foundation bundles are often made of strips and tufts of plant fiber bundled together or are made from lengths of cordage. The bundles help fill up space and can create tighter fitting coils and solid walls. Rod(s) and/or bundle(s) can be bunched or stacked, producing varying widths and heights of individual coils. Basket stitches may be spaced infrequently or spaced tightly, resulting in open or close-appearing coil structures. When coiling a basket, the stitches engage with the coil rows above and below by either piercing or encircling the rod and/or bundle. Stitches may interlock with the previous coil’s stitching, resulting in an angled, pinwheel alignment, whereas non-interlocked stitches appear vertically aligned (Figure 2b-c). Materials are soaked prior to starting the basket-making process to improve flexibility and rods are sometimes purposely split. Materials may also be dyed for decoration prior to beginning construction. Numerous combinations of coiling basketry foundation types exist and result in an abundance of vessel shapes, designs, and utility. Foundation types noted in this project include single rod variants with or without stacked vegetal bundles.
Figure 2. (A) Basket wall schematics showing whole rod and no bundle, half rod and no bundle (with flat side of the rod face down), and half rod and bundle stacked configurations; (B) Non-interlocking stitches encircling the rod, vertical alignment; (C) Interlocking stitches encircling the rod, pinwheel alignment. Adapted from Adovasio 2010.
The qualitative analyses of the eighteen coiled baskets from the Pectol Collection resulted in several noticeable patterns. Baskets and basket fragments of the single rod design fall into two general rod foundation types: whole rod and half rod variants. Four general technical construction categories exist in the Pectol coiled basketry: 1) whole rod without bundles and with functional, interlocking stitches; 2) half rod without bundles and with functional, interlocking stitches; 3) half rod with bundles stacked and with functional, non-interlocking stitches; and 4) half rod without bundles and with intricately wrapped stitches (Table 1). All eighteen Pectol baskets are close coiled in their stitching method except the baskets with the intricate stitches. The result of an open coil, rather than a tight, close coil, is a basket tray with holes and air space not permeable or structurally sound for small-item storage purposes. Some of the baskets exhibit holes from early collection display or have modern repair attempts to prevent their desiccation and destruction. Insect activity, rodent nesting activity, and subsequent damage has occurred on some of the basket walls through time. Additional prehistoric features include possible ochre smudges, cordage stubs or remnant handles, food residues, possible pitching, and stains or char marks. A portion of the baskets have formal decorations created through the alternation of different colored stitch materials. Overall, the Pectol Collection’s coiled basketry appear to be split equally between small bowls or bowl fragments and larger trays and tray fragments, regardless of construction methods. Three wall fragments were likely originally tray-shaped vessels, due to their flatter profile and the fragment sizes, but it is possible they were originally larger bowls or even urns.
In sum, four baskets in the collection exhibit close-coiled, whole rod foundation construction with interlocked stitches and no bundles. In contrast, the collection contains ten close coiled, half rod and bundle stacked baskets with non-interlocking stitches. Additionally, two baskets are constructed using half rods with interlocked stitches and are lacking bundle materials. Two of the other half rod and no bundle baskets were open-coiled and constructed with intricately wrapped stitches, rather than the more common close-coiled arrangement. In addition to general construction attributes recorded on the analyzed Pectol baskets, there is a varying degree of design and decoration on eight of the specimens. Five baskets exhibit cordage stubs or additional pieces of fiber and/or plant bundles attached to their walls, but these additional features are not part of the coil foundation. Six baskets are shallow trays, seven baskets are bowls, and the remaining five fragments vary from an unidentified center fragment, a bowl center fragment, and probable tray wall fragments.
Table 1. Presence of general construction attributes of the Pectol Collection's coiled basketry. An 'X' indicates a present attribute.

<table>
<thead>
<tr>
<th>Basket ID</th>
<th>Object Shape</th>
<th>Whole Rod</th>
<th>Half Rod</th>
<th>Bundle (Stacked)</th>
<th>Non-Interlock</th>
<th>Interlock</th>
<th>Open Intricate</th>
<th>Designs</th>
<th>Cordage</th>
</tr>
</thead>
<tbody>
<tr>
<td>86433.10</td>
<td>Bowl Center</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86484.64a</td>
<td>Fragment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86484.64b</td>
<td>Fragment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86484.64c</td>
<td>Fragment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86754.213</td>
<td>Tray Frags.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86573.215</td>
<td>Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>86576.218</td>
<td>Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>86577.219</td>
<td>Bowl</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86578.220</td>
<td>Bowl</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86607.249</td>
<td>Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86580.222</td>
<td>Bowl</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86582.224</td>
<td>Bowl</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86602.244</td>
<td>Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86603.245</td>
<td>Bowl</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86570.212</td>
<td>Center Frag.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86579.221</td>
<td>Shallow Bowl / Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86450.30</td>
<td>Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86575.217</td>
<td>Tray</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Whole Rod, No Bundle, Interlocking Stitches. In the Pectol Collection, specimens 86580.222, 86582.224, 86602.244, and 86603.245 are close-coiled and built using whole, decorticated rods, no bundles, and interlocking stitches (Figure 3). The interlocking stitches secure the coil and produce a stitch alignment resembling a pinwheel pattern when viewing the baskets in plan-view (Figure 4). Bowls 86580.222 and 86603.245 feature structural decoration through dyed stitch materials in contrast with naturally colored stitches, resulting in geometric zig-zags or simple stripes in darker shades of either brown or tan, respectively (Figure 5). All four whole rod and no bundle baskets are presumed to have been constructed with either Salix sp. or Chrysothamnus sp. rods and Salix sp. stitches. In addition, baskets 86582.224 and 86603.245 each have small fragments of cordage attached near their rims. The longer cordage stubs on both specimens are likely S-twist and Z-spun, while the shorter stubs are too small to discern the method of twist and spin (Figure 6a-b). The cordage stubs on both baskets are presumed to belong to either Asclepias sp. or Apocynum sp. Of the whole rod and no bundle baskets, three are bowl-shaped, while specimen 86602.244 is a large tray that does not have a center, possibly as an intentional feature (Figure 6c).
Figure 3. Detail of whole rod and no bundle, interlocked stitches on (A) basket specimen 86602.244 and (B) basket 86882.224, with some insect damage. Photos by C. Cheney.

Figure 4. (A) Basket 86603.245 in plan-view with interlocked stitches that produce an angled, pinwheel stitch alignment. (B) A pinwheel alignment on basket specimen 86580.222. Photos by C. Cheney.
Figure 5. (A) Basket 86603.245 with a small stripe made with darker-colored stitches near the rim. (B) Dyed stitches contrasted with naturally colored stitches resulting in a geometric step pattern on specimen 86580.222. Photos by C. Cheney.

Figure 6. Additional Z-spun cordage features on (A) specimen 86603.245 and (B) basket 86582.224. (C) A closeup and photo insert of 86602.244 showing an absent center, possibly a purposeful construction attribute. Photos by C. Cheney.

_Half Rod, No Bundle, Interlocking Stitches._ Specimens 86570.212, a center fragment, possibly from a flat tray or flat-bottom bowl, and 86579.221, a shallow bowl or smaller tray, are constructed without bundles and contain decorticated rods split in half with the flat side placed face down in the coil (Figure 7). The stitches secure the rods by
interlocking, resulting in an angled, pinwheel stitch alignment. Both the half rod and no bundle baskets are presumed to have been constructed using Salix sp. rods and stitches. There is no discernable structural decoration on either specimen. Basket 86570.212, the center fragment, appears to have charring along the damaged coil edge (Figure 7b-c). A very small, fragmented cordage stub is present on the rim of basket 86579.221, but spin and twist are difficult to discern with the size of the fragment (Figure 8a). The cordage is presumed to be Asclepias sp. or Apocynum sp. More recently, basket 86579.221 may have been hung up, as suggested by the hole punched through the center of the specimen (Figure 8b). Basket 86579.221, the shallow bowl or larger tray specimen, appears to have food and/or sediment residue accretions.
Figure 7. (A) Basket 86579.221 with a probable nail hole from modern display. (B) Specimen 86570.212, a center fragment. (C) A closeup of the half rod and no bundle wall construction type. Photos by C. Cheney.

Figure 8. (A) The small stub of cordage on the wall of basket 86579.221. Unable to discern spin and twist, due to the small size of the remaining cordage. (B) A hole punched through the center of specimen 86579.221. Photo by C. Cheney.
Half Rod, Bundle Stacked, Non-Interlocking Stitches. Ten close-coiled baskets in the collection were constructed using the half rod and bundle stacked foundation method. The rods are decorticated and split, with the flat side placed face down in the coil. In this type of coil construction, bundles are stacked on top of the halved rods and are secured with non-interlocking stitches (Figure 9). Non-interlocking stitches display a vertical alignment pattern in plan-view (Figure 10). Five of the half rod and bundle stacked baskets use dyed stitches against naturally colored stitches to create structural designs varying from geometric steps, stripes, and concentric rings (Figure 11a-d). Dye colors range from brown to dark brown, dark purple, and a deep red. The rods and stitches are likely *Salix sp.*, but some of the specimen may be constructed from either *Rhus sp.* or *Chrysthamnus sp.* The stacked bundles are presumed to be *Yucca sp.*, *Asclepias sp.*, or *Apocynum sp.* fibers. Some baskets in the Pectol Collection also exhibit features from repair attempts or display damages; for example, on basket specimen 86576.218, a strip of material is attached to deteriorating coils (Figure 12). Additionally, cordage is present on some of the Pectol trays. Specimen 86576.218 differs from the other half rod and bundle stacked baskets, in that it has what appears to be an S-twist and Z-spun cordage bundle, likely made from *Asclepias sp.* fibers (Figure 13a). Specimens 86573.215 and 86570.212 each have small fragments of cordage attached near their rims (Figure 13b-c). Both sets of cordage stubs are likely Z-twist and S-spun and are presumed to be constructed from *Apocynum sp.*
Figure 9. Examples of foundation construction using the half rod and bundle stacked configuration: (A) Basket fragment 86484.64.c with broken coils and (B) Fragment 86484.64b exhibiting the frayed edge of a broken wall. Photos by C. Cheney.

Figure 10. (A) Non-interlocked stitches producing a vertical stitch alignment pattern when viewed in plan-view on specimen 86577.219. (B) A close-up of 86578.220 with a vertical alignment. Note the faint decorative patterning on the former and the presumed food residue on the latter. Photos by C. Cheney.
Figure 11. (A) Specimen 86577.219 with faded, black geometric steps and stripes. (B) A close-up of 86576.218’s black stripe and (C) a plan-view depicting the basket’s purple-red stitch coloring, its black stripe that parallels the rim in one direction only, and the two thicker, perpendicular black stripes that bisect portions of the tray wall. (D) Basket 86607.249 with three black concentric circle rings and both purple-red rings and brown-red rings that separate the black rings. Photos by C. Cheney.

Figure 12. Specimen 86576.218 with a possible modern attempt at repairing damaged coils. The added material type is unknown. The strip of material is thin and folded, and was secured when wet or with a clear adhesive. Photo by C. Cheney.
Figure 13. (A) 86576.218, the only Pectol basket tray with what appears to be a Z-spun cordage bundle. (B) Basket 86607.249 with S-spun cordage near the rim. (C) A close-up of one of the S-spun cordage stubs found on the interior wall of 86573.215. Photos by C. Cheney.

**Half Rod, No Bundle, Intricate Stitches.** Two of the eighteen coiled Pectol baskets were created using the half rod and no bundle foundation configuration. However, instead of regular, functional stitches, either interlocked or non-interlocked, the stitches on specimens 86450.30 and 86575.217 are intricately wrapped, resulting in an open-coiled, rather than close-coiled arrangement (Figure 14). Each intricate wrapping stitch appears to engage with the stitches above and below it in the coil’s progression, thus keeping the semi-rigid coiled frame intact. The specimens appear to be tray-shaped, and specimen 86575.217 was either constructed purposefully without its center and now exhibits some
damage, or the remaining coils are damaged from the loss of a center that once existed (Figure 15a-b). The rims on both baskets are constructed using close, functional, interlocking stitches that continue for two to three rows (Figure 16a-b). All rods are decorticated and split, with the flat sides face down in the coils. Rods and stitches are also presumed to be *Salix sp.* Furthermore, specimen 86450.30 has sections of *Artemisia sp.* fibers wrapped in half-hitch knots, keeping the inner coils attached to the outer coils. A large bundle of *Artemisia sp.* is also attached near the half-hitch knots with what appears to be a stub of Z-twist and S-spun *Yucca sp.* cordage (Figure 17).

Figure 14. (A) Basket specimen 86450.30 with intricate stitches and ochre staining. (B) Basket 86575.217 with damaged intricate stitches. Photos by C. Cheney.
Figure 15. Open coiling as the result of intricate stitches on (A) specimen 86575.217 with an absent center, and (B) basket tray 86450.30. Photos by C. Cheney.

Figure 16. (A) Specimen 86450.30 with three rows of close coiling on the rim. (B) Basket 86575.217 exhibiting the change to close coiling on its rim. Photos by C. Cheney.
Figure 17. Repairs to damaged coils on Basket specimen 86450.30 including sections of Artemisia sp. bark strips wrapped around damaged coil. Note the loop of S-spun cordage holding a spare bark bundle to the damaged coils. Photos by C. Cheney.

*Modeling the Occupational History of Capitol Reef and the Waterpocket Fold*

Utah’s statewide radiocarbon database consists of thousands of individual radiocarbon ages derived from a variety of archaeological materials (Kelly et al. 2022). To build a new, regional case study using dated basketry to help understand the timing and duration of Fremont maize agriculture intensification in the periphery of the eastern Great Basin and Colorado Plateau, I chose to reduce the statewide dataset to include 138 individual ages from within a 10-mile vicinity of the modern park boundary, located in the Waterpocket Fold geological feature in southeastern Utah. These CRWF legacy ages are derived from both site excavation samples and private collection materials, including the Pectol Collection. The legacy radiocarbon ages chosen for the CRWF dataset required
a spatial analysis, radiocarbon calibration, and various levels of modeling to better understand the chronology of the region’s occupational history.

**A Spatial Summary of the Legacy Capitol Reef and Waterpocket Fold Dataset.**

Most archaeological sites with radiocarbon ages within the legacy CRWF dataset are found near natural landscape phenomena and the present built environment. Many site locations are near major rivers across four primary watersheds, including the Muddy, Fremont, Escalante, and Upper Lake Powell watersheds (Figure 1). Focusing on the Fremont River watershed in the Capital Reef region, radiocarbon ages are concentrated in a few choice locations: around Fruita, Utah on the Fremont River, south of the Fremont River on Pleasant Creek, and further south in the Waterpocket Fold on Oak Creek (Figure 1). In the southern end of the park and the Waterpocket Fold, the topography narrows, restricting the water flow in drainages that trend southward towards Bullfrog and Hall’s Crossing, emptying into the Glen Canyon National Recreation Area and Lake Powell. Many of the heavily dated sites are located near the built aspects of the environment, including the modern roads and scenic highways through Capitol Reef National Park and the surrounding sandstone desert (Figure 18). Outside of Torrey, Utah, Scenic Route 12 parallels the modern park boundary, running southward and through Boulder, Utah. US Highway 24 connects Hanksville to Torrey, paralleling the Fremont River and bisecting the northern end of the park from east to west. Vehicular travel in this area is relatively restricted, due to the rugged topography and environment. Much of this region is remote, despite the proximity to towns, National Parks, State Parks, and other designated recreation areas and monuments. The small towns found throughout the region are rural
and scarcely populated. In addition to the main highways and small roads nearest to the towns in the area, the CRWF terrain is primarily accessed through designated recreation trails on foot or in off-road, 4x4 vehicles.
Figure 18. The built environment in the Capitol Reef and Waterpocket Fold region, including the towns, designated study and wilderness areas, the National Park boundary, trails and pathways, main roads and scenic highways, and the locations that have produced legacy radiocarbon ages. Note the concentrations of radiocarbon samples near towns and popular roads and trails.
Coarse-Grained, Summed Probability Modeling. The 138 legacy radiocarbon ages were modeled in a simple SPD. The result of the initial legacy CRWF model is a coarse-grained window into the regional occupational history and includes the previous Pectol ages, but none of the new basket ages (Figure 19). The radiocarbon ages span several time periods and are the result of dating many materials. A small subset of the older ages date to the Middle and Late Archaic, while most of the legacy ages are from the Late Prehistoric. Of the older materials, one legacy sample dates to a median age of 5346 BC, and the remaining set of older ages date to between the median ages of 3307 to 1805 BC. All ages prior to AD 100 were derived solely from charcoal or longer-lived wood samples. Many of the later ages are derived from a mixture of perishable artifacts, agricultural food waste, short-lived plants, or annual plant growth in their raw form or from prepared materials that were never constructed into objects. The majority of the later CRWF ages occur after 1000 BC and fall within the Early to Late Basketmaker II periods (from roughly 1500 BC to AD 500) (Kidder 1927; Simms 2008). The first major set of dated materials appear during the Early Basketmaker II period. During the Late Basketmaker II period (AD 50–500), a valley between the sets of ages appears. An abrupt increase in dated materials appear after roughly AD 200, nearing the end of the Late Basketmaker II (Kidder 1927; Simms 2008). The presence of materials increases and persists through the Fremont period. An abrupt decline in dated material is apparent after the Fremont period ends, roughly AD 1300. The ages that date to the post-Contact period, starting around AD 1500, were sampled from a combination of agricultural food waste and leather from the Pectol Shields. The latest ages in the chronology are considered ethnographic or historic.
Figure 19. An SPD of the original 138 legacy ages from the CRWF region. The previously dated Pectol Collection materials are included in this dataset. Median ages are identified with + symbols.

The CRWF Pectol Collection radiocarbon dataset includes both the previously sampled legacy Pectol ages as well as the 23 new AMS ages derived from the coiled basketry for this project. In total, 53 radiocarbon ages have been produced from Pectol materials. The legacy Pectol ages and the new Pectol basketry ages were modeled together as a coarse-grained SPD (Figure 20). The result of the Pectol SPD age model shows that all materials from the collection date to the Late Basketmaker II and the Fremont periods. A series of several positive peak signals and negative valleys occur during a relatively brief period, between roughly AD 400 and AD 1400, with a few ages occurring up until the present. The majority of the Pectol materials date to roughly AD 1000–1300. The series of peaks and valleys falls within the Fremont period and the ages are primarily from the newly dated coiled basketry.
Figure 20. An SPD of both the legacy and the new ages from the Pectol Collection out of the CRWF region. All dated materials are from perishable items and short-lived materials. Median ages are identified with + symbols.

A permutation test of the coarse-grained SPDs for the legacy portion of the CRWF dataset and the Pectol portion of the CRWF dataset allow for statistical comparisons between the two different sub-sampled SPDs of radiocarbon age distributions. In this permutation test comparison, the legacy dataset does not include any ages from the Pectol Collection. The test identifies the significant positive and negative deviations from the permuted null model, which posits that all samples come from the same distribution (Crema et al. 2017). The permutation test focuses on the last 2500 years of occupation in the CRWF region, as most of the ages are from the Late Archaic to Late Prehistoric time periods. Figure 21a-b depicts the permutation test, with the legacy CRWF data arrayed without the Pectol materials presented in Figure 21a and all Pectol
Collection ages depicted in Figure 21b. The colored vertical bands indicate periods of significant deviation from the null model, with blue representing significant negative deviations and red representing significant positive deviations.

An increase in dated perishable artifacts within the late Basketmaker II period (AD 50–500) and the Fremont period (AD 300–1300) is apparent in the coarse-grained SPD models compared in the permutation test (Kidder 1927; Simms 2008). The increase in dated perishable artifacts is due to the tight age range of the Pectol materials and the occurrence of agricultural food products in the dataset. The legacy dataset viewed against the Pectol dataset indicates several significant deviations during the same time periods. In the Basketmaker II period, a longer duration from 450 BC–AD 100 appears, following by a brief deviation from the model in AD 150–200. An additional deviation occurs at AD 300–450, and again momentarily around AD 800, spanning the Basketmaker II and transitional Fremont period. Another longer duration during the late Fremont period occurs from AD 1000–1250 (Figure 21a-b). The permutation test highlights how the perishable and shorter-lived materials specifically from the Pectol Collection result in a change to significant positive deviation during the Fremont period (Figure 21b). Without the addition of the tightly dated Pectol materials, the dataset suggests the samples are not from the same distribution, and does not indicate a positive deviation from the null model. The legacy data alone, which does include some perishable materials, suggests peak Fremont occupation occurred around AD 1100 with a steady rise in occupancy through the end of the late Basketmaker II period. With the addition of the perishable-only Pectol data, a possible reorganization period occurs at AD 900, then there is a sharp, peak signal at AD 1100. The Pectol perishable ages show higher periodicity in the
occupancy of the region, compared to the legacy data alone, and confirms the effects of old wood in Fremont chronologies in the northern Colorado Plateau (Finley et al. 2020; Robinson, personal communication 2023).

Figure 21. A permutation test comparing the SPDs of (A) the legacy CRWF radiocarbon dataset, n=138; and (B) the Pectol Collection radiocarbon dataset, n=53. All Pectol basketry date to the Fremont period, primarily between AD 1000 and AD 1250. Red bands indicate significant positive deviation from the null model, and blue bands indicate significant negative deviation from the null model. The 95% confidence interval is shown as a horizontal grey band.
High-Precision Basketry Phase Modeling. The 23 new basketry ages produce a fine-grained, phase model that informs chronological relationships of major construction methods (i.e., half rod, bundle stacked, non-interlocking stitches). The construction methods and attributes analyzed for this project result in the ‘prior information’ that are built into the Bayesian ‘phase model’ as major parameters. Parameters include whether a basket is constructed with half a rod or a whole rod, if the coil foundation has a bundle stacked, bunched, or no bundle at all, and if the stitches are interlocking, non-interlocking, or intricately stitched. The resulting model depicts four types of basketry construction methods used during the history of CRWF occupation. Three coiling types appear in one temporal phase in the chronological model, whereas the half rod, bundle stacked, non-interlocking stitch basketry type appears in two separate phases of time. Each phase has a start and end boundary signifying the range in which a type of basket was created. Median radiocarbon ages for each phase date the Pectol coiled basketry to the very end of the Late Basketmaker II period and covering the entirety of the Fremont period. The earliest sequence boundaries begin in approximately AD 90, in the Late Basketmaker II period, and the latest sequence boundaries end around AD 1810, post-Fremont, with median ages specifically between AD 550 and 1270, and the latest sequence boundaries end around AD 1810, post-Fremont, with median ages specifically between AD 550 and 1270 (Figure 22, Table 2, Appendix I – Radiocarbon Data Table).

Detailed patterns become apparent in the Pectol basketry phase model regarding the four types of coiling methods used in construction (Figure 22, Table 2, Appendix I – Radiocarbon Data Table). Half rod, bundle stacked, non-interlocking (HRBSNI) stitched baskets appear during two phases in time, between the median start and end ages of AD
550 and 900, and appearing again between AD 1070 and 1190. Whole rod, no bundle, interlocking (WRNBI) stitch baskets appear during the construction hiatus of the HRBSNI baskets, between AD 1010 and 1110. The median ages suggest the whole rod type briefly replaces the HRBSNI basket type, following the reorganization period seen in the permutation test around AD 900 (high-lighted in green in Figure 22).

Two remaining basketry construction types, the half rod, no bundle interlocking (HRNBI) stitch type and the half rod, no bundle, intricately (HRNBINT) stitched baskets are represented by only two baskets each. The small sample sizes resulted in only one phase for each coiling method, despite some of the wider range in ages between the objects. The two HRNBI stitched baskets are relatively far apart in age. The older HRNBI basket provided the early sequence age for the Pectol coiled baskets (Table 2, Appendix I – Radiocarbon Data Table), with ages between AD 90 and 950. The younger HRNBI basket also provided the oldest sequence age, dating between AD 1045 and 1810. The median ages suggest the two baskets were actually constructed in AD 710 and in AD 1250. These two baskets appear to both predate and postdate the valley or reorganization period identified in Figure 21 and in Figure 22. The remaining two baskets are constructed differently from the previous three basket types. The HRNBINT stitched baskets produced median ages between AD 1010 and 1270, first appearing briefly after the highlighted valley and again prior to the end of the Fremont period. To compare, the older HRNBINT basket sequence dated between AD 680 and 1150, and the younger basket sequence dated between AD 1160 and 1580 (Table 2, Appendix I – Radiocarbon Data Table).
In sum, half rod, bundle stacked, non-interlocking stitched basketry appear in two phases, with the whole rod, no bundle, interlocking stitched type briefly replacing the former during the reorganization period identified in the permutation test. With a smaller sample number, the half rod, no bundle, interlocking stitched baskets and the half rod, no bundle, intricately stitched basket types provide less information; however, one of each type seem to appear much later in time, near the end of Fremont occupation in the CRWF.
Figure 22. A multiplot Phase Model of the Pectol Collection coiled basketry. Four types of coiled basketry appear during the Fremont period. The valley, or possible reorganization period, from AD 850–1000, is high-lighted in green. Median ages are displayed as small crosses.

The half rod, bundle stacked, non-interlocking stitch baskets appear earliest, with a brief hiatus filled by the whole rod, no bundle, interlocking stitch baskets. HRBSNI baskets reappear for a second phase, but are then replaced by the half rod, no bundle, interlocking stitch baskets. Later, half rod, no bundle, intricately stitched baskets appear briefly, and no other baskets appear in the record after AD 1200. (See Appendix I – Pectol Basketry Radiocarbon Data Table).
Table 2. Presented in years AD, the modeled posterior probability density 95% confidence intervals for each basket phase starts, ends, spans, and median ages (rounded to nearest ten). Median ages place the Pectol basketry within the Fremont period, AD 300–1300. (See Appendix I – Pectol Basketry Radiocarbon Data Table).

<table>
<thead>
<tr>
<th></th>
<th>From</th>
<th>To</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Rod Bundle Stacked Non-Interlocking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Phase 1</td>
<td>350</td>
<td>630</td>
<td>550</td>
</tr>
<tr>
<td>End Phase 1</td>
<td>800</td>
<td>1100</td>
<td>900</td>
</tr>
<tr>
<td>Span 1 HRBSNI</td>
<td>210</td>
<td>670</td>
<td>360</td>
</tr>
<tr>
<td><strong>Whole Rod No Bundle Interlocking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Phase 1</td>
<td>850</td>
<td>1120</td>
<td>1010</td>
</tr>
<tr>
<td>End Phase 1</td>
<td>1030</td>
<td>1290</td>
<td>1110</td>
</tr>
<tr>
<td>Span 1 WRNBI</td>
<td>0</td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td><strong>Half Rod Bundle Stacked Non-Interlocking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Phase 2</td>
<td>1010</td>
<td>1160</td>
<td>1080</td>
</tr>
<tr>
<td>End Phase 2</td>
<td>1060</td>
<td>1270</td>
<td>1190</td>
</tr>
<tr>
<td>Span 2 HRBSNI</td>
<td>0</td>
<td>220</td>
<td>110</td>
</tr>
<tr>
<td><strong>Half Rod No Bundle Intricate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Phase 1</td>
<td>90</td>
<td>940</td>
<td>710</td>
</tr>
<tr>
<td>End Phase 1</td>
<td>1050</td>
<td>1810</td>
<td>1250</td>
</tr>
<tr>
<td>Span 1 HRNBINT</td>
<td>120</td>
<td>1570</td>
<td>580</td>
</tr>
<tr>
<td><strong>Half Rod No Bundle Intricate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Phase 1</td>
<td>680</td>
<td>1150</td>
<td>1010</td>
</tr>
<tr>
<td>End Phase 1</td>
<td>1160</td>
<td>1580</td>
<td>1270</td>
</tr>
<tr>
<td>Span 1 HRNBINT</td>
<td>30</td>
<td>900</td>
<td>280</td>
</tr>
</tbody>
</table>
Discussion

Fremont Legacy in Capitol Reef and the Waterpocket Fold

Spatial Context and Distribution. Understanding the contexts and locations in which the CRWF ages were derived is important in interpreting the regional chronology. Archaeological sites are often discovered and tested because they are found during development projects or because of their scientific value. Some suggest that the current radiocarbon dataset could be biased towards sites that have been disproportionately sampled or to sites that were only found due to heavy development following initial Euro-American settlement and during undertakings subject to the National Historic Preservation Act (Crema et al. 2017; King 2013; Rhode et al. 2014; Robinson et al. 2019; Timpson et al. 2014). Because the region is in a primarily dry and poorly vegetated desert environment, many of the identified and sampled archaeological sites are near water and other resources used by people today. Fremont farmers may have relied on the same resources, but also may have accessed the more remote areas by caching resources along travel routes. Both scientific investment in sampling and the differential discovery of camps, villages, agricultural areas, granaries, caches, and other types of sites may introduce a sampling bias. Whether or not the current radiocarbon dataset is biased towards specific types of sites or specific areas, the dataset still provides valuable
information regarding Indigenous occupations in the Capitol Reef and Waterpocket Fold region.

Assuming all the materials dated from the Pectol Collection were recovered by Pectol and Lee within a reasonable distance from Torrey, Utah and Capitol Reef, and have not come from far away distances, this collection represents a random sample of regional perishable materials and their production. Thus, the Pectol Collection basketry, as well as associated perishable items, could indicate intensification of agricultural practices and the aggregation of smaller bands into larger communities. If larger groups of people aggregated and invested energy into a few choice locations over time, they would have deposited an abundance of materials in those areas. Conversely, if people were more mobile and spent time in smaller groups, they may be likely to deposit materials over a wider range of locations over time. To put it simply, mobile groups deposit more materials over larger areas and in many locations, while sedentary groups deposit more materials in singular areas and do not need to cover as much ground (Crombé and Robinson 2014). People that spend time moving across a wider landscape are unlikely to accumulate a high abundance of materials in only a few choice locations. I argue that dated materials with similar radiocarbon ages coming from the same general region is a signal for intensification and investment into place. In the case of the Fremont, people transitioned to a more sedentary, agricultural village lifestyle for a brief period of time, and as a result, they would have created items and discarded items in fewer locations than when they hunted and gathered across a wider landscape. The increase in
basketry production and other perishable objects could indicate agricultural intensification and aggregation into village locations.

**Temporal Distribution.** The legacy CRWF dataset and the new basketry ages suggest several periods of regional occupation, with periods of organization, reorganization, and intensification. Very few ages date to the Paleoindian or Early Archaic periods, with only a small sample of CRWF ages dating prior to 2000 BC. There could be several reasons as to why older time periods are poorly represented by the CRWF dataset. The smaller number of older radiocarbon ages may not be an accurate representation of occupation during that time due to taphonomic loss or bias in the archaeological record (Surovell et al. 2009). It is also unclear if the older dates are potentially suffering from the old wood problem (Schiffer 1983), as the oldest Paleoindian ages in the dataset are derived from wood charcoal and charcoal stained sediments. The Pectol dataset (that does not contain charcoal-derived ages) confirms the Finley et al. (2020) proposal that there is an old wood offset in the chronology behind the ‘Standard Fremont Model’ (Robinson, personal communication 2023).

Both the legacy and the Pectol SPD models indicate an increase in Late Archaic and Late Prehistoric population and land-use, with the first large peak signal in radiocarbon ages appearing around 2000 BC. Prior to this, the region appeared to maintain low population levels during the Paleoindian and Early Archaic, due to such a small number of ages derived from the periods. Later, beginning around 1200 BC, the CRWF region experiences a steady growth in human occupation compared to the previous time periods. More materials date to the Late Archaic, suggesting that the region
became more favorable for human occupation. Around 500 BC, the large number of radiocarbon ages indicate a peak signal in occupancy, corresponding with more favorable climate for the spread of maize agriculture throughout neighboring regions. During the height of CRWF occupation between roughly AD 500–1200, mobile hunter-gatherers began to diversify their foodways, learned agricultural practices, and arguably began aggregating into more sedentary communities. From AD 750–1050, Finley et al. (2020) proposed a window in which predictable precipitation favored agricultural intensification. The sharp decline that the legacy SPD models indicate after approximately AD 1200 could suggest a shift in peak conditions and a waning in CRWF occupancy or a possible deaggregation of the larger communities. The abundance of radiocarbon ages plummets during the end of Fremont period and remains low until European settlers arrive in the following centuries. The latest ages on CRWF archaeological materials begin to date to the ethnographic or historic period post-Contact.

In contrast to the SPD models, the permutation test comparing the legacy dataset to the complete Pectol dataset suggests more periodicity in the regional occupation after AD 500. Additional peaks and valleys in the record become more apparent by dating the perishable artifacts from the Pectol Collection. The legacy dataset alone depicts a slow and steady rise with minimal valleys, reaching the peak of CRWF occupancy after AD 1000. In contrast, the ages from the variety of Pectol materials allude to more periods of growth and reorganization, with a final period of expansion beginning just after AD 900 and persisting briefly before decline. This reorganization phase occurs near the end of the AD 750–1050 period of prime climatic conditions for maize intensification. A sharp rise to the peak occupation in the region occurs after the end of the period of ideal climatic
conditions and village formation in the northern Uinta Basin. Presumed intensification seems to be brief, and a reorganization or abandonment is signaled by a steady drop in the abundance of radiocarbon ages after AD 1150. Though the legacy dataset suggests a slight lull in activity and a somewhat steady decline, the Pectol materials indicate a sharper decline. Following a decrease in the presence of radiocarbon ages from the region, very few dated materials are from post-AD 1300. Intensification during and lagging after the prime climatic conditions and the following decline in regional occupancy are both signaled by changes in the creation of specific types of Pectol coiled basketry. As climate became more ideal for the production of maize, reorganization occurred and basketry types changed. A general increase in basketry production suggests a need for more food storage and processing tools, whereas the changes in techniques used can allude to the transmission of methods, people, or ideas regarding structural functionality or personal identity.

**Pectol Basketry and the Fremont.** Most of the baskets found by Pectol and Lee appear to fit the idea of typical Fremont basketry with the use of single rod construction, and many of the baskets fall into the common half rod and bundle stacked, non-interlocking stitch type. The interlocked baskets with pinwheel alignments are less abundant in this collection. Despite past suggestions that decoration is atypical in the Fremont basket repertoire (Adovasio 1980, 1986; Adovasio et al. 2002; Lekson 2014; Simms 2008; Sinkey 2002), the Pectol Collection shows that several colors and patterns may have been present in Fremont basketry, at least later in time after the introduction of agricultural practices. Five baskets are structurally decorated using dyed or painted stitch
materials, ranging from black, to red-brown, to dark brown, to red-purple. Geometric structural patterns are visible on two of the interlocked stitch baskets. These baskets are from the second phase of HRBSNI basketry. Two other baskets with dyed stitching are of the WRNBI variety, thus appearing in the CRWF record earlier than the other decorated HRBSNI baskets. Prior to the AD 900 reorganization, basketry was HRBSNI and undecorated. During prime climate conditions and the reorganization period, WRNBI types briefly appear, and some are decorated. Quickly, HRBSNI baskets reappear, replacing the whole rod types, but now they include decoration. As Sinkey (2002) suggested, radiocarbon dating the unique basketry within the collection would determine their age as likely Fremont, despite their unique features. The ages derived from coiled basketry in this collection do indicate what archaeologists define as a Fremont-era occupancy and the materials are presumed to be from the Torrey, Utah and Fremont River Drainage, due to the history of Pectol and his family’s activity in the area. The appearance of decorated basketry in the supposed Fremont assemblage could be from migrant influence as maize agriculture spread throughout the eastern Great Basin and Colorado Plateau.

Small bowls and larger trays are the primary types of coiled baskets in the Pectol Collection. Some of the objects could have been impermeable, due to tight stitching and bundles, and some of the smaller fragments appear to have possibly been pitched (or are simply coated in pack-rat residues); however, none of the basket shapes indicate they would have been ideal for transporting water. Cordage is present on the edges of a few baskets, possibly remnants of handles. It is presumed that most of the trays were likely used in food preparation, serving, or possibly in ritual purposes, rather than storage, while
conversely, the bowls could have been used for preparation or for the storage of seeds and other food products. Additional studies on residues and charring could address the utility and functionality of the Pectol coiled basketry.

*Radiocarbon and Basketry Implications in the CRWF.* The basketry construction types and their subsequent radiocarbon ages show clear temporal patterns in the area. Generally, the half rod, bundle stacked, non-interlocking stitch basketry appear to be the primary type of basket constructed through two phases of time. During a brief hiatus between the two phases of HRBSNI basket production, the whole rod, no bundle, interlocking stitch baskets appear. The half rod, no bundle, interlocking stitch baskets and half rod, no bundle, intricate stitch baskets appear during the later centuries of the Fremont period in the region, but the sample sizes are small and insignificant (n=2, each).

If the increase in production of perishable artifacts and tools, like basketry, are proxies for maize intensification and investment in to place, then the Pectol Collection ages suggest a later occupancy and intensification in the CRWF region compared to other studies in the Uinta Basin in the northern Colorado Platuea (Finley et al. 2020; Hora-Cook 2018; Schiele 2021). If the Cub Creek village phases began around AD 840 and waned around AD 1080, the changes between HRBSNI and WRNBI baskets in the CRWF occur before the peak occupancy in northern Utah. In the CRWF in southeastern Utah, a potential reorganization period around AD 900 occurs during the HRBSNI basket phase hiatus, and the WRNBI baskets briefly appear during this proposed reorganization (Figure 21, Figure 22, Table 2). As climatic conditions become noticably ideal for intensifying maize agriculture in the wider Fremont region between AD 750 and 1050,
the methods used in basketry construction reverts back to the HRBSNI type, but the vessels are larger trays with decoration. By AD 1070, within a decade of the end of village occupation in the northern Uinta Basin, HRBSNI baskets were again the primary basketry type in the CRWF. The apparent change back to HRBSNI basketry and the identified peak of maize intensification in the CRWF occurs after the Cub Creek village phases—later in time around AD 1100. Peak occupation at other Fremont site locales throughout the eastern Great Basin and Colorado Plateau are argued as contemporaneous with the intensification signal produced by the Pectol basketry (Finley and Robinson, personal communication 2023).

Summary. Both the legacy CRWF and the updated CRWF radiocarbon datasets inform our current understanding of past regional occupations. Overall, radiocarbon ages suggest a short, occupational time span, primarily during the Late Basketmaker II through Fremont time periods, and then again later into stages of contact and the Historic period. Outlier ages occur occasionally during the Paleoindian and the Archaic, but the number of dated materials is small. The older ages are also derived from charcoal and wood materials. A small number of the baskets produced more than one radiocarbon age for the 23 new ages; however, different types of plant materials were sampled for dating, and it is argued that the materials provide a random sample of regional artifact production. Testing different materials from the same basket provided insight into the precision and accuracy of AMS-dating methods and can help us narrow target events versus dated events.
With coarse-grained chronologies, such as the one created by pooling all legacy dates from charcoal, charred sediment, animal materials, and short-lived plants, we are left with a limited view of regional occupation sequences, where high-precision radiocarbon chronologies enable finer-grained reconstructions of the past. Depending on the materials dated and their contexts, some models may over-estimate the length and intensity of regional occupations. The legacy CRWF radiocarbon dataset supplemented with new ages on perishable materials allows us to achieve a more precise interpretation of target events—such as the intensification of maize agriculture and the development and abandonment of early agricultural practices and communities. Through dating perishable basketry, early peaks of intensification are identified, where charcoal-based SPD models alone miss those nuanced signals. Following signals of intensification, dating basketry materials also shows sudden valleys or reorganization periods otherwise missed by SPDs. A waning in CRWF occupancy and the end of the Fremont period are more clearly identified through dating shorter-lived plants used in basketry construction. Periodicity of Fremont groups in the CRWF region become more apparent when building better informed phase models. By sampling and radiocarbon dating the perishable artifacts derived from shorter-lived materials, rather than relying on charcoal-based ages (Finley et al. 2020), we can achieve the resolution necessary to identify briefer or more abrupt periods of intensification and reorganization. With this project, it is not to say that dating charcoal is not valuable. When a site only contains charcoal and charred sediments, they are still viable options for radiocarbon analysis. Modeling both the legacy CRWF ages and ages derived from technologically specific perishables like basketry, we
begin to understand the utility of perishable dating and the importance of legacy data and museum collections (St. Amand et al. 2020).

**Conclusion**

Prehistoric basketry and other perishable textiles previously recovered from Capitol Reef National Park and the Waterpocket Fold region provide ample research opportunity. First, this project demonstrates that we can derive important new data from older museum collections, including those with limited contextual data like the Pectol Collection (St. Amand et al. 2020). Radiocarbon dating is not the only possibility for developing new data from legacy collections. For example, future analyses of the residues found on perishable objects could allude to a better understanding of object utility, treatments, or food preferences and preparation. Another example of useful research includes the identification of specific materials used in the creation of perishable objects and how they are processed or decorated. Second, the development of a case study like the CRWF chronology provides testable data to address the timing and duration of agricultural community formation. Fremont occupation and a proposed agricultural intensification appears to have fluoresced quickly, over a handful of generations (Finley et al. 2020). The CRWF and Pectol basketry suggest the Fremont in the southern areas may have peaked later than their neighbors in the north. To compare
the timing and duration of Fremont agricultural communities across the eastern Great Basin and Colorado Plateau, we need finer-grained age models from additional materials and perishable collections. High-precision chronologies that achieve generational scale provide the resolution to address Fremont agricultural intensification and the formation of Fremont communities. Dating items like food remains, short-lived plants, and perishables made from the young, annual growth of perennial plants—like coiled basketry—and coupling the data with Bayesian statistical methods for developing phase-based age models, we can achieve the result of a high-precision chronology. Third, because other studies, like the Cub Creek study (Finley et al. 2020), suggest a change in precipitation variability at certain time periods, comparing high-precision chronologies to precipitation models can help us understand the factors that may have resulted in the Fremont’s growth through time. And finally, the Fremont have been described as enigmatic in their Archaic relationships to the eastern Great Basin, their fluidity between hunting and gathering and the transition to agriculture, and their proposed disappearance or reorganization by the end of the twelfth century AD. The Fremont have a basketry repertoire that could provide refined information regarding cultural transmission, social organization, and changes in technology. Nuances in Fremont history and land-use across the eastern Great Basin and Colorado Plateau are better identified through holistic studies that incorporate multiple lines of evidence, through identifying patterns, and are better supported by informed, high-precision phase models.
Adovasio, James M.

Adovasio, James. M.

Adovasio, James M., David R. Pedler, and Jeff S. Illingworth

Adovasio, James M.

Adovasio, James M.

Allen, Marti L.
Allen, Marti L. and Michelle R. Munsey


Allen, Marti L. and Michelle R. Munsey


Allison, James


Allison, James


Ambler, John Richard


Baker, Shane A.

Barlow, Renee K.

Bayliss, Alex

Bayliss, Alex, Christopher Bronk Ramsey, Johannes van der Plicht, and Alasdair Whittle

Bronk Ramsey, Christopher

Bronk Ramsey, Christopher

Crema, Enrico R., Andrew Bevan, and S. Shennan

Crema, Enrico R. and Andrew Bevan

Crombé, Philippe and Erick Robinson
Finley, Judson B., Erick Robinson, R.J. DeRose, Elizabeth Hora

Hora-Cook, Elizabeth A.
2018 Resource Competition Among the Uinta Fremont. *All Graduate Theses and Dissertations* 7338.

Janetski, Joel C.

Janetski, Joel C., Lee Kreutzer, Richard K. Talbot, Lane D. Richens, and Shane A. Baker

Kelly, Robert L., Madeline E. Mackie, Erick Robinson, Jack Meyer, Michael Berry, Matthew Boulanger, Brian F. Codding, Jacob Freeman, Carey James Garland, Joseph Gingerich, Robert Hard, James Haug, Andrew Martindale, Scott Meeks, Myles Miller, Shane Miller, Timothy Perttula, Jim A. Railey, Ken Reid, Ian Scharlotta, Jerry Spangler, David Hurst Thomas, Victor Thompson, and Andrew White

Kennett, Douglas J., Brendan J. Culleton, Jaime Dexter, Scott A. Mensing, and David Hurst Thomas

Kidder, Alfred V.
King, Thomas F.

2013 *Cultural Resource Laws and Practice*. AltaMira Press, Maryland.

Kreutzer, Lee Ann


Lekson, Stephen H.


Madsen, David B.


Madsen, David B. and Steven R. Simms


Marwitt, J.P.


Marwitt, J.P.

Morss, Noel


Ortman, Scott G. and Lynda D. McNeil


Rhode, D., P.J. Brantingham, C. Perreault, D.B. Madsen


Robinson, Erick, R. Kyle Bocinksy, Darcy Bird, Jacob Freeman, and Robert L. Kelly


Robinson, Erick, R. H. Jabran Zahid, Brian F. Codding, Randall Haas, and Robert L. Kelly

R Core Team


Santos, G.M., R.B. Moore, J.R. Southon, S. Griffin, E. Hinger, and D. Zhang


Schiele, Trista N.

2021    Space-Time Dynamics of the Uinta Fremont Agricultural Transition in Eastern Utah and Northwestern Colorado. *All Graduate Theses and Dissertations* 8069.

Simms, Steven R.


Simms, Steven R.


Sinkey, Leslie-Lynne


Talbot, Richard K.


Timpson, A., S. Colledge, E. Crema, K. Edinborough, T. Kerig, K. Manning, M.G. Thomas, S. Shennan


Webster, Laurie D. and Kelley A. Hays-Gilpin

Appendices
### Appendix A – Pectol Basketry Radiocarbon Data Table, 95% Confidence Interval

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Rod Bundle Stacked Non-Interlocking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Start Phase 1</strong></td>
<td>355</td>
<td>634</td>
</tr>
<tr>
<td>R_Date UCIAMS-259662 (86433.10)</td>
<td>551</td>
<td>635</td>
</tr>
<tr>
<td>R_Date UCIAMS-259665 (86484.64a)</td>
<td>676</td>
<td>869</td>
</tr>
<tr>
<td>R_Date UCIAMS-259664 (86484.64a)</td>
<td>688</td>
<td>875</td>
</tr>
<tr>
<td>R_Date UCIAMS-259666 (86484.64a)</td>
<td>773</td>
<td>878</td>
</tr>
<tr>
<td>R_Date UCIAMS-259667 (86484.64b)</td>
<td>773</td>
<td>879</td>
</tr>
<tr>
<td>R_Date UCIAMS-259668 (86484.64c)</td>
<td>772</td>
<td>894</td>
</tr>
<tr>
<td><strong>End Phase 1</strong></td>
<td>798</td>
<td>1096</td>
</tr>
<tr>
<td><strong>Span 1 HRBSNI</strong></td>
<td>208</td>
<td>670</td>
</tr>
<tr>
<td><strong>Whole Rod No Bundle Interlocking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Start Phase 1</strong></td>
<td>850</td>
<td>1118</td>
</tr>
<tr>
<td>R_Date UCIAMS-259680 (86582.224)</td>
<td>992</td>
<td>1125</td>
</tr>
<tr>
<td>R_Date UCIAMS-259679 (86580.222)</td>
<td>994</td>
<td>1125</td>
</tr>
<tr>
<td>R_Date UCIAMS-259682 (86603.245)</td>
<td>1021</td>
<td>1152</td>
</tr>
<tr>
<td>R_Date UCIAMS-259681 (86602.244)</td>
<td>1032</td>
<td>1169</td>
</tr>
<tr>
<td><strong>End Phase 1</strong></td>
<td>1031</td>
<td>1294</td>
</tr>
<tr>
<td><strong>Span 1 WRNBI</strong></td>
<td>0</td>
<td>395</td>
</tr>
<tr>
<td><strong>Half Rod Bundle Stacked Non-Interlocking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Start Phase 2</strong></td>
<td>1007</td>
<td>1158</td>
</tr>
<tr>
<td>R_Date UCIAMS-259676 (86577.219)</td>
<td>1033</td>
<td>1160</td>
</tr>
<tr>
<td>R_Date UCIAMS-259683 (86607.249)</td>
<td>1035</td>
<td>1160</td>
</tr>
<tr>
<td>R_Date UCIAMS-259677 (86578.220)</td>
<td>1036</td>
<td>1159</td>
</tr>
<tr>
<td>R_Date UCIAMS-259684 (86607.249)</td>
<td>1045</td>
<td>1164</td>
</tr>
<tr>
<td>R_Date UCIAMS-259670 (86571.213)</td>
<td>1049</td>
<td>1173</td>
</tr>
<tr>
<td>R_Date UCIAMS-259671 (86571.213)</td>
<td>1049</td>
<td>1204</td>
</tr>
<tr>
<td>R_Date UCIAMS-259675 (86576.218)</td>
<td>1051</td>
<td>1215</td>
</tr>
<tr>
<td>R_Date UCIAMS-259672 (86573.215)</td>
<td>1055</td>
<td>1211</td>
</tr>
<tr>
<td>R_Date UCIAMS-259673 (86573.215)</td>
<td>1055</td>
<td>1212</td>
</tr>
<tr>
<td><strong>End Phase 2</strong></td>
<td>1061</td>
<td>1268</td>
</tr>
<tr>
<td><strong>Span 2 HRBSNI</strong></td>
<td>1061</td>
<td>1268</td>
</tr>
<tr>
<td><strong>Half Rod No Bundle Interlocking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Start Phase 1</strong></td>
<td>93</td>
<td>944</td>
</tr>
<tr>
<td>R_Date UCIAMS-259678 (86579.221)</td>
<td>773</td>
<td>972</td>
</tr>
<tr>
<td>R_Date UCIAMS-259669 (86570.212)</td>
<td>1035</td>
<td>1159</td>
</tr>
<tr>
<td><strong>End Phase 1</strong></td>
<td>1046</td>
<td>1808</td>
</tr>
<tr>
<td><strong>Span 1 HRNBI</strong></td>
<td>121</td>
<td>1569</td>
</tr>
<tr>
<td><strong>Half Rod No Bundle Intricate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Start Phase 1</strong></td>
<td>678</td>
<td>1149</td>
</tr>
<tr>
<td>R_Date UCIAMS-259674 (86575.217)</td>
<td>1030</td>
<td>1156</td>
</tr>
<tr>
<td>R_Date UCIAMS-259663 (86450.30)</td>
<td>1156</td>
<td>1220</td>
</tr>
<tr>
<td><strong>End Phase 1</strong></td>
<td>1164</td>
<td>1583</td>
</tr>
<tr>
<td><strong>Span 1 HRNBI</strong></td>
<td>26</td>
<td>900</td>
</tr>
</tbody>
</table>
Appendix B – Pectol Basketry Raw Photos

*Half Rod, Bundle Stacked, Non-Interlocking Stitches.* Basket 86433.10 – Median Radiocarbon Age AD 584
Basket 86484.64a – Median Radiocarbon Ages AD 730, 795, 819
Basket 86484.64b – Median Radiocarbon Age AD 819
Basket 86484.64c – Median Radiocarbon Age AD 838
Basket 86571.213 – Median Radiocarbon Ages AD 1135, 1153
Basket 86573.215 – Median Radiocarbon Ages AD 1170, 1170
Basket 86576.218 – Median Radiocarbon Age AD 1166
Basket 86577.219 – Median Radiocarbon Age AD 1121
Basket 86578.220 – Median Radiocarbon Age AD 1121
Basket 86607.249 – Median Radiocarbon Ages AD 1122, 1129
Whole Rod, No Bundle, Interlocking Stitches. Basket 86580.222 – Median Radiocarbon Age AD 1031
Basket 86602.244 – Median Radiocarbon Age AD 1065
Basket 86603.245 – Median Radiocarbon Age AD 1045
Basket 86882.224 – Median Radiocarbon Age AD 1030
Half Rod, No Bundle, Interlocking Stitches. Basket 86570.212 – Median Radiocarbon Age AD 1088
Basket 86579.221 – Median Radiocarbon Age AD 876
Half Rod, No Bundle, Intricate Stitches. Basket 86450.30 – Median Radiocarbon Age AD 1185
Basket 86575.217 – Median Radiocarbon Age AD 1113
Appendix C – Code

CRWF Legacy Radiocarbon Dataset – Summed Probability Distribution Code, OxCal

Plot(CRWF Legacy Radiocarbon Dataset)
{
  Sum("CRWF All Legacy Ages")
  {
    R_Date("B-124186", 6370, 70);
    R_Date("RL-463", 4590, 140);
    R_Date("RL-488", 4290, 140);
    R_Date("B-161587", 4050, 60);
    R_Date("B-108500", 3520, 60);
    R_Date("B-91329", 3480, 40);
    R_Date("B-35319", 2760, 100);
    R_Date("RL-486", 2600, 120);
    R_Date("B-161595", 2480, 40);
    R_Date("B-133977", 2360, 100);
    R_Date("B-144289", 2320, 70);
    R_Date("B-39256", 2320, 60);
    R_Date("B-91330", 2310, 70);
    R_Date("B-166842", 2300, 70);
    R_Date("B-124191", 2290, 60);
    R_Date("B-144291", 2260, 70);
    R_Date("B-161591", 2230, 100);
    R_Date("B-161590", 2230, 70);
    R_Date("B-142657", 2220, 50);
    R_Date("B-101267", 2180, 80);
    R_Date("B-91331", 2160, 100);
    R_Date("B-142656", 2150, 60);
    R_Date("B-101268", 2120, 60);
    R_Date("B-128679", 2110, 70);
    R_Date("B-144290", 2080, 40);
    R_Date("RL-487", 2050, 110);
    R_Date("B-128674", 2040, 50);
    R_Date("B-161574", 2030, 120);
    R_Date("B-161593", 2020, 70);
    R_Date("B-160651", 1820, 80);
    R_Date("B-108501", 1770, 80);
    R_Date("B-161592", 1770, 50);
    R_Date("B-161599", 1760, 60);
    R_Date("B-108499", 1760, 50);
    R_Date("B-154657", 1750, 70);
    R_Date("B-7705", 1700, 60);
    R_Date("B-124182", 1700, 50);
    R_Date("B-144290", 1590, 50);
    R_Date("86642", 1589, 23);
    R_Date("B-128680", 1580, 80);
    R_Date("B-128675", 1570, 70);
    R_Date("B-124185", 1500, 60);
  }
}
R_Date("B-160652", 1500, 60);  R_Date("B-161586", 1160, 50);  
R_Date("B-154658", 1500, 40);  R_Date("B-161584", 1150, 40);  
R_Date("B-124190", 1470, 60);  R_Date("B-128676", 1140, 60);  
R_Date("B-101269", 1470, 60);  R_Date("B-161579", 1110, 40);  
R_Date("B-124189", 1460, 60);  R_Date("B-161598", 1100, 50);  
R_Date("B-124188", 1390, 50);  R_Date("B-161582", 1100, 40);  
R_Date("B-35318", 1380, 70);  R_Date("B-160656", 1080, 60);  
R_Date("B-107656", 1360, 70);  R_Date("86594", 1063, 22);  
R_Date("B-160654", 1360, 70);  R_Date("B-108491", 1060, 50);  
R_Date("B-101263", 1350, 70);  R_Date("B-128671", 1040, 60);  
R_Date("B-108498", 1350, 60);  R_Date("B-124183", 1040, 50);  
R_Date("B-128672", 1340, 60);  R_Date("B-154227", 1040, 40);  
R_Date("B-154655", 1320, 60);  R_Date("86580", 1038, 30);  
R_Date("86551", 1320, 34);  R_Date("B-272314", 1020, 40);  
R_Date("B-160650", 1300, 60);  R_Date("B-152520", 1010, 40);  
R_Date("B-108492", 1300, 60);  R_Date("B-161589", 1000, 60);  
R_Date("B-128681", 1290, 90);  R_Date("B-181512", 990, 40);  
R_Date("B-181510", 1290, 80);  R_Date("86599", 982, 34);  
R_Date("B-108495", 1280, 60);  R_Date("86550", 978, 22);  
R_Date("B-124187", 1270, 60);  R_Date("B-124181", 970, 70);  
R_Date("B-161578", 1220, 90);  R_Date("B-108490", 970, 60);  
R_Date("B-108493", 1220, 60);  R_Date("B-275711", 970, 40);  
R_Date("B-161577", 1200, 80);  R_Date("B-161600", 960, 60);  
R_Date("B-117938", 1200, 80);  R_Date("B-117939", 960, 60);  
R_Date("B-181511", 1190, 70);  R_Date("B-190227", 960, 40);  
R_Date("B-160655", 1180, 60);  R_Date("UGAMS-6487", 950, 25);  
R_Date("B-161585", 1180, 40);  R_Date("UGAMS-6486", 950, 25);  
R_Date("B-161581", 1170, 70);  R_Date("B-154655", 950, 50);  
R_Date("B-161583", 1170, 50);  R_Date("86549", 950, 27);  
R_Date("B-128673", 1160, 50);  R_Date("86436", 941, 29);
R_Date("B-128677", 940, 30);  
R_Date("86549", 936, 32);  
R_Date("B-161576", 930, 60);  
R_Date("B-161596", 930, 40);  
R_Date("B-108496", 920, 70);  
R_Date("B-152521", 920, 40);  
R_Date("86576", 920, 20);  
R_Date("86575", 913, 23);  
R_Date("86619", 910, 23);  
R_Date("86533", 903, 27);  
R_Date("86437", 898, 29);  
R_Date("B-108494", 890, 70);  
R_Date("B-128678", 890, 60);  
R_Date("86640", 890, 27);  
R_Date("B-124184", 880, 40);  
R_Date("86588", 871, 23);  
R_Date("86550", 861, 23);  
R_Date("B-154654", 860, 60);  
R_Date("B-161597", 850, 80);  
R_Date("B-161588", 840, 50);  
R_Date("B-124192", 840, 50);  
R_Date("86609", 788, 22);  
R_Date("B-20673", 770, 60);  
R_Date("B-161580", 770, 50);  
R_Date("86608", 748, 22);  
R_Date("NZA-2280", 459, 89);  
R_Date("B-108497", 400, 60);  
R_Date("NZA-2280b", 397, 83);  
R_Date("NZA-1980", 364, 91);  
R_Date("86585", 351, 21);  
R_Date("B-152519", 310, 40);  
R_Date("B-101266", 300, 70);  
R_Date("86498", 270, 23);  
R_Date("B-152522", 200, 40);  
R_Date("86621", 137, 24);  
};  
};
Plot(CRWF Legacy Radiocarbon Dataset)

{ Sum("CRWF Pectol Ages")
  R_Date("86642",1589,23);
  R_Date("UCIAMS-259662",1500,15);
  R_Date("86551",1320,34);
  R_Date("UCIAMS-259665",1250,20);
  R_Date("UCIAMS-259664",1235,20);
  R_Date("UCIAMS-259666",1210,15);
  R_Date("UCIAMS-259667",1210,15);
  R_Date("UCIAMS-259668",1175,20);
  R_Date("UCIAMS-259678",1170,20);
  R_Date("86594",1063,22);
  R_Date("B-154227",1040,40);
  R_Date("86580",1038,30);
  R_Date("B-152520",1010,40);
  R_Date("UCIAMS-259680",1005,20);
  R_Date("UCIAMS-259679",1000,20);
  R_Date("86599",982,34);
  R_Date("86550",978,22);
  R_Date("UCIAMS-259676",975,20);
  R_Date("UCIAMS-259682",975,20);
  R_Date("UCIAMS-259683",970,20);
  R_Date("UCIAMS-259674",965,15);
  R_Date("UCIAMS-259677",965,15);
  R_Date("86549",950,27);
  R_Date("86436",941,29);
  R_Date("UCIAMS-259684",940,20);
  R_Date("86549",936,32);
  R_Date("UCIAMS-259669",935,20);
  R_Date("UCIAMS-259670",925,20);
  R_Date("86576",920,20);
  R_Date("B-152521",920,40);
  R_Date("86575",913,23);
  R_Date("86619",910,23);
  R_Date("UCIAMS-259671",910,20);
  R_Date("UCIAMS-259681",910,20);
  R_Date("86533",903,27);
  R_Date("86437",898,29);
  R_Date("86640",890,27);
  R_Date("UCIAMS-259675",890,20);
  R_Date("UCIAMS-259672",885,15);
  R_Date("UCIAMS-259673",885,15);
  R_Date("UCIAMS-259663",875,15);
  R_Date("86588",871,23);
  R_Date("86550",861,23);
  R_Date("86609",788,22);
  R_Date("86608",748,22);
  R_Date("NZA-2280",459,89);
  R_Date("NZA-2280b",397,83);
R_Date("NZA-1980",364,91);  
R_Date("86585",351,21);  
R_Date("B-152519",310,40);  
R_Date("86498",270,23);  
R_Date("B-152522",200,40);  
R_Date("86621",137,24);  
};
CRWF Legacy vs. CRWF Pectol Radiocarbon Datasets – Permutation Test Code, Rstudio

#Load RCarbon Package
require(rcarbon)

#Install Package for Minor Ticks Argument
install.packages("Hmisc")
library("Hmisc")

#Import CRWF Full Dataset
crwf <- read.csv("CRWFall.csv", header = T, sep = ',')

#Calibrate Ages
cal <- calibrate(x = crwf$cra, errors = crwf$se, normalised = F, timeRange = c(9000,0))

#Permutation Test
perm <- permTest(cal, marks = as.character(crwf$collection), nsim = 1000, runm = 200, timeRange = c(9000,0))

#Plot All Legacy Ages - Last 2500 Years
plot(perm, focalm = "Legacy", main = "Legacy CRWF Ages", calendar = 'BCAD', lwd = 1.5, xlim = c(-2500,2000))
##Add Minor Ticks
axis(1, at = c(-1500,-1000,-500,1,500,1000,1500), lwd.ticks=1)

#Plot All Pectol Ages - Last 2500 Years
plot(perm, focalm = "Pectol", main = "Pectol Collection Ages", calendar = 'BCAD', lwd = 1.5, xlim = c(-2500,2000))
##Add Minor Ticks
axis(1, at = c(-1500,-1000,-500,1,500,1000,1500), lwd.ticks=1)
Plot(CRWF Pectol Collection)
{
  Phase(Pectol Coiled Baskets)
  {
    Sequence(HRBSNI1)
    {
      Boundary("Start 1 HRBSNI");
      Phase("1 HRBSNI")
      {
        R_Date("UCIAMS-259662", 1500, 15);
        R_Date("UCIAMS-259665", 1250, 20);
        R_Date("UCIAMS-259664", 1235, 20);
        R_Date("UCIAMS-259666", 1210, 15);
        R_Date("UCIAMS-259667", 1210, 15);
        R_Date("UCIAMS-259668", 1175, 20);
      }
      Boundary("End 1 HRBSNI");
      Span("1 HRBSNI");
    }
    Sequence(HRBSNI2)
    {
      Boundary("Start 2 HRBSNI");
      Phase("2 HRBSNI")
      {
        R_Date("UCIAMS-259676", 975, 20);
        R_Date("UCIAMS-259683", 970, 20);
        R_Date("UCIAMS-259677", 965, 15);
        R_Date("UCIAMS-259684", 940, 20);
        R_Date("UCIAMS-259670", 925, 20);
        R_Date("UCIAMS-259671", 910, 20);
        R_Date("UCIAMS-259675", 890, 20);
        R_Date("UCIAMS-259672", 885, 15);
        R_Date("UCIAMS-259673", 885, 15);
      }
      Boundary("End 2 HRBSNI");
      Span("2 HRBSNI");
    }
    Sequence(WRNBI)
    {
      Boundary("Start WRNBI");
      Phase("1 WRNBI")
      {
        R_Date("UCIAMS-259680", 1005, 20);
        R_Date("UCIAMS-259679", 1000, 20);
        R_Date("UCIAMS-259682", 975, 20);
        R_Date("UCIAMS-259681", 910, 20);
      }
      Boundary("End WRNBI");
      Span("1 WRNBI");
    }
  }
}
{ Boundary("Start HRNBI");
  Phase("1 HRNBI")
  {
    R_Date("UCIAMS-259678", 1170, 20);
    R_Date("UCIAMS-259669", 935, 20);
  }
  Boundary("End HRNBI");
  Span("1 HRNBI");
  };
Sequence(HRNBINT)
  {
    Boundary("Start HRNBINT");
    Phase("1 HRNBINT")
    {
      R_Date("UCIAMS-259674", 965, 15);
      R_Date("UCIAMS-259663", 875, 15);
    }
    Boundary("End HRNBINT");
    Span("1 HRNBINT");
    };
}