Teeth Tell Tales:
Subsistence strategies and dental wear patterns at Anse à la Gourde (Guadeloupe) and Tutu (U.S. Virgin Islands)

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Abstract: The study of the patterns of wear and pathology on human teeth from prehistoric populations is part of a larger subject of research which sees the study of teeth as a key to the biology and behaviour of past and living populations. This area of research was established in the early sixties, though important work on the subject was done much earlier. Now commonly known as dental anthropology, this multi-disciplined field of research has proved itself valuable to researchers in human biology, anatomy, biological anthropology, forensic odontology, osteology, (palaeo)pathology, evolutional biology, and of course (bio)archaeology. Increasingly, dental anthropology is being used by (bio)archaeologists as another line of evidence in an evermore multi-disciplined research field. The latter is not surprising, as this discipline has a lot to offer for archaeology. In this article, I will explore a fraction of what dental anthropology has to offer for Caribbean archaeology, through the dental anthropological study of two skeletal assemblages from sites in the Caribbean. These sites are Anse à la Gourde, Guadeloupe, and Tutu, St. Thomas, U.S. Virgin Islands.

Résumé: L'étude des modèles d'usure et de la pathologie sur les dents humaines des populations préhistoriques fait partie d'un plus grand sujet de recherche qui voit l'étude de dents comme une clef à la biologie et le comportement de populations passées et vivantes. Ce secteur de recherche a été établi dans les années soixante, bien que travail important sur le sujet a été fait beaucoup plus tôt. Maintenant ordinairement connue comme l'anthropologie dentaire, ce champ multidisciplinaire de recherche est prouvé valable aux chercheurs dans la biologie humaine, l'anatomie, l'anthropologie biologique, l'odontologie légale, l'ostéologie, la (paléo)pathologie, la biologie d'évolution, et bien sûr l'archéologie. De plus en plus, l'anthropologie dentaire est utilisée par les archéologues comme une autre ligne de preuve dans un champ de recherche plus en plus multidisciplinaire. Le dernier n'étonne pas, pourquoi cette discipline a beaucoup à offrir pour l'archéologie. Dans cet article, j'explorerai une fraction de quelle anthropologie dentaire peut offrir pour l'archéologie des Antilles, par l'étude anthropologique dentaire de deux collections squelettiques des sites dans les Antilles. Ces sites sont Anse à la Gourde, Guadeloupe, et Tutu, St. Thomas, les Iles Vierges Américaines.

Resumen: El estudio del desgaste de uso y patología en dientes humanos de poblaciones prehistóricas forma parte de un enfoque más amplio de investigación en que el estudio de dientes es visto como un clave a la biología y el comportamiento de poblaciones prehistóricas y poblaciones actuales. Este área de investigación fue establecido en los primeros años de sesenta, aunque otros trabajos importante fueron hecho más antes. Actualmente común conocido como antropología dental, este campo de investigación multi-disciplinario se ha mostrado de valor para investigadores de biología humana, anatomía, antropología biológica, odontología forense, osteología, (paleo)patología, biología evolutiva, y por supuesto para arqueólogos. Cada vez más, la antropología dental es utilizada por arqueólogos como otra línea de evidencia en un campo de investigación más y más multi-disciplinario. El último no sorprende, porque la antropología dental puede ofrecer mucho para la arqueología. En este artículo, exploraré algunas dimensiones de qué antropología dental puede ofrecer para la arqueología del Caribe, por medio del estudio antropológico dental de dos colecciones esqueléticas de sitios en el Caribe. Estos sitios son la de Anse à la Gourde, en la isla de Guadalupe, y el de Tutu, en la isla de St. Thomas, Islas Virgenes de Estados Unidos.
Diet, Health, and Cultural Practices

In its most simple sense, human dental wear is the wear and loss of the occlusal (or chewing) surfaces of the tooth crowns. Tooth wear is a normal process, resulting from a number of factors, which affects an individual progressively during his/her lifetime.

Traditionally, dental anthropology categorizes dental wear according to the agent causing the wear. Attrition and abrasion are identified as the two main components of dental wear. The former is caused by tooth-on-tooth contact, whereas the latter is the result of contact with foreign materials (e.g. food, abrasives in food, other objects held in the mouth). More recently, dental anthropology has come to consider a third agent in dental wear due to influences from the discipline of modern dentistry: erosion. Erosion is the result of chemical dissolution of hard tissues due to the introduction of acidic chemicals into the mouth.

Once a human tooth has become worn, it does not remodel or repair itself. Dental wear, therefore, is the cumulative result of all abrasive factors on the teeth during an individual’s lifetime. In this way, it is possible that certain forms of dental wear become erased by later wear. On the other hand, it can be possible to distinguish multiple types of wear on individual teeth, often resulting from wear at different stages during life.

Through extensive research in the past, dental anthropologists have been able to link certain types of dental wear and pathology to certain diets/subsistence patterns and cultural practices. Furthermore, certain ‘special’ patterns of wear have been linked to cultural practices involving the use of the teeth as a tool or ‘third hand’. The key to this approach is the use of a large enough sample for the presence of certain dental wear patterns to be statistically significant.

Dental Wear Patterns and Pathology

For the purpose of this paper, I will focus on a number of the most important dental wear patterns and pathologies which can be linked to certain subsistence strategies. These will be discussed below, together with the subsistence strategies they are indicative of. To demonstrate the value of this type of information for Caribbean archaeology, the presence of these patterns and pathologies will be evaluated for the site of Anse à la Gourde, Guadeloupe, and the site of Tutu, St. Thomas, U.S. Virgin Islands.

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1 For a far more detailed discussion of these results and the method(s) of analysis - including results pertaining to dental wear patterns caused by the use of the teeth as tools - the reader is referred to the author’s published MA thesis “Teeth Tell Tales. Dental wear as evidence for cultural practices at Anse à la Gourde and Tutu” (Mickleburgh 2007).
The sample used in this study consisted of 66 dentitions from Troumassoid burials from the site of Anse à la Gourde, Guadeloupe, and 26 dentitions from Cedrosan Saladoid and Chican Ostionoid burials from the site of Tutu, U.S. Virgin Islands (Table 1). In total 1320 teeth were studied. The Tutu assemblage can be divided into an early and a late component as is shown in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Child</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anse à la Gourde</td>
<td>19</td>
<td>31</td>
<td>8</td>
<td>8</td>
<td>66</td>
</tr>
<tr>
<td>Tutu</td>
<td>6</td>
<td>14</td>
<td>5</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>45</td>
<td>13</td>
<td>9</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 1: The number of individuals per sex and site

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Child</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedrosan Saladoid</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Chican Ostionoid</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>14</td>
<td>5</td>
<td>1</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 2: The number of individuals per sex and period at Tutu

Degree of Wear

The degree of dental wear can sometimes be an indicator of the type of diet or type of food processing employed by a particular group (Benfer & Edwards 1991; Deter 2009; Littleton & Frohlich 1993; Molnar 1971; Pastor 1992; Powell 1985; Walker & Hewlett 1990; Watson 2008). It is important to keep in mind, however, that the average degree of wear is not

Figure 1: Anse à la Gourde, located on the island of Guadeloupe, courtesy of Dr. M.L.P. Hoogland

Figure 2: Tutu, located on the island of St. Thomas, U.S. Virgin Islands
necessarily directly correlated to the diet, but can also be the result of the use of the teeth as tools. Furthermore, comparing average degree of wear for different groups brings the added problem that different age profiles can not be compared reliably, as degree of wear is related to age (although not in a simple linear or predictable fashion). The same problem applies to assemblages that are in such poor condition that estimates of skeletal age can not be made; this was the case for the Anse à la Gourde material.2

The early and late-component skeletons at Tutu, however, were in a sufficiently good condition to age the individuals. As the age profile for both of these groups and the mean number of teeth per individual were very similar, comparison of the mean degree of wear for each group is deemed possible. Table 3 presents these data for comparison.

<table>
<thead>
<tr>
<th></th>
<th>Mean no. teeth present per individual</th>
<th>Mean age</th>
<th>Mean degree of wear (tooth count method)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedrosan Saladoid</td>
<td>14.11</td>
<td>41.55</td>
<td>3.86</td>
</tr>
<tr>
<td>Chican Ostionoid</td>
<td>16.25</td>
<td>43.46</td>
<td>4.70</td>
</tr>
</tbody>
</table>

Table 3: Comparison of the mean degree of tooth wear for both periods at Tutu

As the table clearly shows, there is a marked increase in the mean degree of wear between the Cedrosan Saladoid component and the Chican Ostionoid component at Tutu. This increase is statistically significant at P<0.05.

The reasons for this increase in mean degree of wear can be related to a change in diet between these two periods, as reported by Farnum and Sandford (2002). The results of their trace element analysis suggest a shift from a lesser to a greater reliance on marine foods in the later period. It has been demonstrated that a (heavy) reliance on marine foods is related to a higher degree of tooth wear, especially when dried fish are regularly consumed. The sand and grit adhering to marine foods, possibly coupled with the fact that the bones weren’t always removed before consumption, has been suggested as the main cause of severe dental wear (Littleton & Frohlich 1993). Although stable isotope analysis of the Tutu skeletal material gave no indication of a difference in diet between the early and late periods (Norr 2002), the evidence from trace element analysis combined with this significant increase in the degree of wear appears to indicate a heavier reliance on marine foods in the Chican Ostionoid period.

Molar Wear

A study on patterns of dental wear by B.H. Smith proved that there are systematic differences in patterns of molar wear related to major differences in subsistence and food preparation (Smith 1984). She presents evidence for flatter molar wear in hunter-gatherers, due to the mastication of tough and fibrous foods, and oblique molar wear in agriculturalists, due to the higher proportion of ground and prepared food in the diet. Smith also briefly discusses the topic of the occlusal surface shape of molars. It has been proven that agriculturalists often develop a cupped occlusal surface shape whereas hunter-gatherers do not

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2 It is sometimes possible to solve this issue using intra-individual rates of wear, as opposed to group averages of degrees of wear. In this case, the rate of wear is measured using the difference in degree of wear between the permanent molars: M1, M2, and M3. This is possible due to the fact that these teeth erupt at approximately 6-year intervals in all humans, which means inter-individual and inter-group comparisons can be made. These comparisons are thus based on mean rate of wear as opposed to mean degree of wear (Scott & Turner 1988; Smith 1972). This method relies on statistical calculations, however, which were not possible in this case due to the size of the samples in question.
develop cupping in such a way (Costa & Greaves 1981). The most likely cause of this
difference in wear patterns is the presence of fine particles of grit in the processed foods eaten
by agriculturalists. It is known that food that has been ground in preparation for consumption
often contains tiny particles of stone which come loose from the grindstone during processing
(Costa & Greaves 1981; Larsen et al. 2002; Smith 1984).

The molar tooth wear was assessed for both the direction of wear and the occlusal
surface shape at both sites. The categories used to distinguish the different types of molar
wear broadly followed Stephen Molnar’s dental wear evaluation method (Molnar 1971). For
the purposes of this summarizing article, however, the four categories indicating oblique
wear, and the two categories indicating rounded wear, have been grouped.3 The results of this
assessment are presented in Tables 4 and 5.

Direction of Wear

Clearly, at Anse à la Gourde the category natural form is far greater than the other
categories. It is important to keep in mind, however, that this category only exists when dental
wear is still at a minimum. In order to get a picture of the directions of occlusal surface wear
present in the sample, we must look at the more severely worn teeth. Therefore, the category
natural form was excluded (after careful assessment of any minor wear facets which may have
been present). When we leave out this category, the number of obliquely worn molars is
significantly greater than the remaining category of horizontal (P<0.01).

At Tutu the category oblique is the largest. However, comparison between the
category oblique and horizontal shows that this difference is not significant (P<0.05). There
is a significant difference between the number of obliquely worn molars from Tutu and
Anse à la Gourde; Tutu has a significantly larger percentage of obliquely worn molars
(P<0.05).

Comparison between the early and late components at Tutu did not reveal any
significant differences.

<table>
<thead>
<tr>
<th></th>
<th>Natural form</th>
<th>Oblique</th>
<th>Horizontal</th>
<th>Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anse à la Gourde</td>
<td>182</td>
<td>39</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Tutu Cedrosan Saladoid</td>
<td>12</td>
<td>10</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Tutu Chican Ostionoid</td>
<td>12</td>
<td>22</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>Tutu total</td>
<td>24</td>
<td>32</td>
<td>21</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4: Number of molar teeth per direction of wear

Occlusal Surface Shape

At Anse à la Gourde the category natural form again by far outnumbers the other
categories of occlusal surface shape. Disregarding this category, it appears that the number of
cupped molars is significantly greater than the number of molars in the remaining categories
flat and other (P<0.05). At Tutu (both periods taken together), the cupped molars also
significantly outnumber the other categories (P<0.05).

Comparison of the percentages of cupped molars from both sites revealed that there is
no statistically significant difference between the two samples. Comparison between the early
and late periods at Tutu, however, did indicate a statistically significant increase in the

3 The categories of oblique wear direction distinguished by Molnar are: buccal-lingual, lingual-buccal, mesial-
distal, and distal-mesial. The categories of rounded wear distinguished by Molnar are: rounded buccal-lingual,
and rounded mesial-distal (Molnar 1971).
number of flatly worn molars in the later period (P<0.05). As flatly worn molars are mostly associated with a hunter-gatherer food economy, the increase in flat molar wear at Tutu may again reflect the shift toward a larger marine food component in the diet (Smith 1984).

<table>
<thead>
<tr>
<th>Natural Form</th>
<th>Flat</th>
<th>Cupped</th>
<th>Round</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anse à la Gourde</td>
<td>179</td>
<td>14</td>
<td>36</td>
<td>-</td>
</tr>
<tr>
<td>Tutu Cedrosan Saladoid</td>
<td>10</td>
<td>4</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Tutu Chican Ostionoid</td>
<td>11</td>
<td>14</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>Tutu</td>
<td>21</td>
<td>18</td>
<td>40</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5: Number of molar teeth per occlusal surface shape

Caries

The presence of dental caries in the human dentition informs us about oral health and hygiene, and the amount of carbohydrates (particularly sugars) in the diet. In the latter case, the percentage of carious teeth in a population sample is indicative of different subsistence strategies. An agricultural existence is paired with a large proportion of carbohydrates in the diet, and subsequently a high percentage of dental caries. The hunter-gatherer subsistence usually involves a much smaller carbohydrate consumption, which is reflected in the much lower percentage of carious teeth in hunter-gatherer populations (Hillson 1996, 2008; Koca et al. 2006; Larsen 1983; Larsen et al. 1991; Lukacs 1992; Powell 1985; Scott & Turner 1988; Temple & Larsen 2007; Walker & Erlandson 1986; Walker & Hewlett 1990). Worldwide reviews of caries frequencies in hunter-gatherers, mixed economies, and agricultural economies have found that hunter-gatherers generally have a less than 2% caries rate, mixed economies about 5%, and agricultural economies 10% or more (Turner 1979).

Differences in caries frequency between males and females have been shown to indicate differences in preparation and consumption of food between the sexes (Kelley et al. 1991; Larsen 1983; Larsen et al. 1991; Lukacs 1992; Temple & Larsen 2007; Walker & Hewlett 1990). Although some research suggests that these differences are purely biological - e.g. hormonal differences or differences in general health and immunity due to menstruation and pregnancy – (Lukacs & Largaespada 2006; Lukacs 1996; Lukacs 2008), varying caries frequencies between males and females are still thought to be an important indicator of division of labour and other daily activities between the sexes.

The percentages of caries per sex for both sites can be found in Table 6.\(^4\) At Anse à la Gourde the percentages seem to fall generally between a mixed economy and an agricultural economy, as described by Turner (1979). These data would seem to corroborate earlier indications that the Anse à la Gourde inhabitants used the prime location of the site for heavy marine resource exploitation, while at the same time consuming more refined carbohydrate-rich foods (Delpuech et al. 1999; Stokes 1998). There are no statistically significant differences between males, females, and individuals of unknown sex, although females and individuals of unknown sex appear to be slightly more frequently affected than males. However, there are significant differences between all three aforementioned groups and the children (P<0.05). The percentage of caries in the Anse à la Gourde children is extremely high. For the greater part this is due to the exceptionally high number of carious teeth in individual F377. This child, estimated at 3 to 5 years of age, counted 15 carious teeth in a total

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\(^4\) Caries percentages were calculated using the ‘tooth count method’ as described by Lukacs and Thompson (2008).
of 17. As this seems to be a unique case of rampant caries, it is deemed fair to exclude this individual from the calculations in order to get a more balanced picture of juvenile caries rate. Once individual F377 is excluded, the percentage of caries in the Anse à la Gourde children drops from 42.6% to 15.6%. This percentage of caries is not significantly different from any of the other groups at Anse à la Gourde, although it does appear very high in comparison with the adults.

At Tutu, the percentages are clearly very high, and fall well within the range of an agricultural economy, suggesting there was a large amount of sticky refined carbohydrates in the Tutu diet. It was not deemed possible to make a reliable comparison between the different sexes of the early and late period at Tutu, as the number of individuals in the different sample groups is too small. However, Larsen et al. studied the entire Tutu skeletal assemblage (a larger sample than was used in this study) and concluded that although not statistically significant, there was a larger percentage of caries in females than in males, based on both the tooth count method and the individual count method (Larsen et al. 2002). The fact that the latter is not reflected in this study, appears to be the result of the smaller sample size which includes one male individual with an exceptionally large number of caries.

Comparison between caries percentages of the total number of adults for the early and late period at Tutu indicates a decrease in the percentage of caries, although this decrease is not statistically significant. The latter was already observed by Larsen et al. (2002) in their analysis of the dental pathology of the complete Tutu skeletal assemblage.

In comparison, the percentages of carious teeth for the entire adult populations of Anse à la Gourde and Tutu show a significant difference (P<0.05). It is clear from the data that the Tutu adults were more severely affected by caries than the Anse à la Gourde adults. Differences between the sexes from both sites were not statistically significant.

When we compare the juvenile population for both sites - excluding individual F377 - there is no significant difference. Still, it seems that Anse à la Gourde children were more frequently affected by dental caries than Tutu children. The reason for this difference remains unclear, although it is possible that the Anse à la Gourde children were fed a more carbohydrate-rich diet than the adults and the Tutu children. Another possible explanation is a difference in the age at which the children were weaned, as extended periods of breastfeeding are often linked to high caries prevalence in children (Department of Health 1994).

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Unknown</th>
<th>All adults</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anse à la Gourde</td>
<td>7.3</td>
<td>8.6</td>
<td>12.5</td>
<td>8.1</td>
<td>42.6/15.6&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tutu Cedrosan Saladoid</td>
<td>37.5&lt;sup&gt;6&lt;/sup&gt;</td>
<td>11.2</td>
<td>25&lt;sup&gt;7&lt;/sup&gt;</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Tutu Chican Ostionoid</td>
<td>8.7</td>
<td>13</td>
<td>-</td>
<td>10.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Tutu total</td>
<td>12.8</td>
<td>11.6</td>
<td>33.3&lt;sup&gt;8&lt;/sup&gt;</td>
<td>12.6</td>
<td>5.3</td>
</tr>
</tbody>
</table>

Table 6: Percentages of carious teeth per site and sex

Discussion

For both sites, the direction of molar wear and occlusal surface shape point to a substantial amount of refined foods in the diet. This indicates a large agricultural (or horticultural) component in the diet. The direction of molar wear, however, also indicates that

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<sup>5</sup> Including and excluding individual F377 respectively.

<sup>6</sup> Based only on one individual.

<sup>7</sup> Based only on one individual.

<sup>8</sup> The category of Unknown sex at Tutu comprises only one individual, with just three teeth present of which one is carious.
Tutu inhabitants most likely consumed a larger amount of refined foods than Anse à la Gourde inhabitants. This is also demonstrated by the difference in caries prevalence at both sites: Anse à la Gourde falls generally between a mixed economy and an agricultural economy, whereas Tutu clearly falls in the range for a typically agricultural diet.

The degree of wear, occlusal surface shape, and caries prevalence at Tutu indicate that there was a shift away from an agriculturally (or horticulturally) dominated diet in the Chican Ostionoid period. These data concur with the evidence from trace element analysis, which has indicated a larger marine food component in the diet (Farnum & Sandford 2002).

Some research suggests that differences in caries prevalence between the sexes are caused by increased levels of female hormones during puberty, menstruation, and pregnancy (Lukacs & Largaespada 2006). However, the fact that many prehistoric skeletal assemblages show no evidence for differences in caries prevalence between the sexes seems to imply that any variation is the reflection of cultural practices (Douglas 2006; Larsen 1983; Temple & Larsen 2007; Walker et al. 1998). The larger number of females affected by dental caries at Anse à la Gourde, although not statistically significant, may therefore reflect the fact that females often consume a larger amount of refined, cariogenic foods in comparison with males, due to gender-based differences in preparation and consumption of food. Although not reflected in the data presented here, Larsen et al.’s observation that females seemed to be more frequently affected by caries at Tutu may also be the result of such gender-based differences (Larsen et al. 2002).

**Conclusions**

The value of dental anthropological research as a source of information on diet and subsistence strategies in Caribbean archaeology has been argued for here, using a limited number of dentitions from just two sites. As was mentioned in the introduction to this paper, the key to the successful application of this type of research lies in the statistical analysis of a large number of dentitions. Even so, the comparison of the Anse à la Gourde and Tutu dentitions has yielded some interesting results. Most significantly, the analysis of dental wear patterns and pathology has served to corroborate earlier indications of diet and subsistence strategies by trace element analysis (Tutu: Farnum and Sandford 2002) and stable isotope analysis (Anse à la Gourde: Stokes 1998). In the case of Tutu, this is particularly significant, as earlier research - trace element analysis and stable isotope analysis - produced slightly different results.

The use of dental anthropological research for the pre-Columbian Caribbean will prove to be particularly effective for identifying shifts in diet and subsistence strategies over time. The latter has been demonstrated by the evidence for a dietary shift at Tutu. However, when applied to numerous sites and over different periods in time, a picture can be formed of larger, regional trends in diet and subsistence changes. Moreover, the study of dental wear patterns and pathology can be equally informative of cultural practices involving the teeth (‘teeth as tools’), and gender-based differences in such practices. With a range of applications, dental anthropology can be used to study human behaviour at both the individual level and at the site or regional level.

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Lukacs, J.R.

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Norr, L.

Pastor, R.

Powell, M.L.

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Stokes, A.V.

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Turner, C.G.

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Watson, J.T.