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Searching for Culture in "Cultural Capital": The Case for a Mixed Methods Approach to Production Facility Siting

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Site selection modeling receives much attention in the aviation biofuels literature to ensure sustainability of the aviation biofuel supply chain. These models seek to reflect the multitude of factors and conditions necessary for supply chain success. Social factors impacting that success have received increasingly greater attention but are often excluded due to difficulties in obtaining accurate and standard measures. Some of the most promising work in this arena utilizes a "community capitals approach" to create statistically grounded decision support tools (DSTs) intended to provide rapid assessment of the social characteristics of potential facility locations. Despite the value of the community capitals approach, this methodology is still marked by inconsistent predictivity due to an inability to reliably assess the cultural and historical nuances of local communities that are so vitally important to the long-term viability of these costly projects. This paper more fully examines the Community Assets and Attributes Model (CAAM) that has been developed and applied in the Pacific Northwest to incorporate social assets in site selection modeling. Based on ethnographic fieldwork in Colorado and Wyoming dealing with biomass/bioenergy facility siting, we argue that cultural capital, a key component of the CAAM, is biased to urban locations due to the measurements incorporated. As a result of this bias, current site selection modeling based on the Community Capitals Framework (CCF) does not accurately reflect rural community assets. We assert that the CAAM does not actually measure cultural capital but a product of cultural capital, namely creativity, and innovation Our mixed methods approach that combines quantitative assessment with ethnographic research highlights the limits of the CAAM by revealing that local residents in largely rural counties showed willingness to innovate in some cases but in others referred to history with similar industries that may limit support. The quantitative cultural capital measurements of the CAAM for the four counties we examine, which range in scores from –0.53 to 2, do not capture these dynamics. These scores would generally suggest moderate to high levels of support for

biomass/bioenergy facilities, but the ethnographic research provides nuance for or against support that are not reflected in the quantitative capital scores. This suggests that the quantitative CAAM scores could be misleading without added qualitative context. This work demonstrates that a mixed methods approach, combining ethnographic and historical methodologies with existing quantitative community capital approaches, will produce a more effective predictive methodology for facility siting due to its heightened ability to gather critical data on place-based values, beliefs, and historical legacies relating to natural resource development in general, and the timber industry specifically.

Keywords: aviation biofuels, cultural capital, site selection, mixed methods, sustainability, ethnographic interviews, wood-based biofuels, community assets and attributes model

INTRODUCTION

The ability to select appropriate communities to locate aviation and other similar biofuel supply chain development projects is integral to their long-term sustainability and success. As such, numerous researchers and practitioners have developed methods to optimize site selection to increase the viability of aviation biofuel supply chains. These decision support tools (DSTs) are continuously improving, but most continue to share a glaring omission: the inclusion of social and cultural characteristics that impact the ability, preparedness, and inclination of a given community to support biofuel supply chain development. Rural economic development, while clearly important, does not guarantee that communities will support these projects and inclusion of only economic, natural resources, infrastructure, and other similar resources or criteria, when making decisions renders final conclusion suspect and puts into question the predictions of these models and tools. Unfortunately, this issue is not just prevalent in the site selection literature; it plagues sustainability literature as well, for the simple reason that social sustainability is rarely included in these studies, and social criteria are absent from many certification frameworks.

Fortunately, recent studies and projects have attempted to include social criteria in their frameworks and methods. These include studies that examine relevant, reliable, practical, and important social criteria for sustainability analysis (see Buchholz et al., 2009; Kurka and Blackwood 2013; Kamali et al., 2018) to the addition of social, political, and/or cultural capitals to DSTs for biofuel supply chain development (see Martinkus et al., 2014; Martinkus et al. 2017; Martinkus et al. 2019). These studies attempt to quantify criteria and assets that are often qualitative in nature, relying on quantitative indicators meant to serve as proxies for qualitative concepts. In fact, studies that weight criteria by reliability and practicality lead to the preference for quantitative indicators often collected at the national and potentially at the regional-level, which masks local-level effects and concerns (Anderson et al., Forthcoming 2022). This preference for quantitative indicators and analysis leads not only to incomplete analysis and suspect predictions, but also leads to the relative dearth of qualitative and mixed-methods studies that could provide a more nuanced picture of sustainability and viability of aviation and similar biofuel development.

Nonetheless, recent attempts to include more robust quantitative indicators of the often ignored or limited analysis of social criteria is an important development in both supply chain analysis and broader biofuel sustainability literatures. In particular, the CAAM was developed in the United States to incorporate social criteria more fully in DSTs through the development of county-level capital scores to compare performance in social, capital, political, and human capitals (see Martinkus et al., 2017; Rijkhoff et al., 2017; Mueller et al., 2020; Rijkhoff et al., 2021). This model has been updated and refined over time (adding more capitals and refining indicators) but has only been validated in one study examining biorefineries and similar projects in the Pacific Northwest (see Mueller et al., 2020). CAAM developers have stressed that it should be included in initial support tools, but ground-truthing and mixed-methods analysis is a further step required to ensure accuracy and success due to limits of quantitative measures, especially at a more local-level than a county.

In this study, we take up the call to improve CAAM and other attempts to better measure and include social criteria through mixed-methods research using a case study of woody biomass facilities in the United States Wyoming and Colorado region. Our objective is to compare CAAM model predictions regarding the *social and cultural suitability* of different communities for a new biomass/bioenergy facility with the data obtained though ethnographic interviews with people in those same communities. In doing so, we offer insight on the strengths and limitations of the CAAM approach (in addition to other work based on the CCF) and provide suggestions for improving future industrial siting DSTs. We argue that more comprehensive models, such as the CAAM, should be incorporated in more studies, but mixed methods approaches, especially when assessing cultural capital, are necessary to meet holistic definitions of sustainability, and increase likelihood of aviation biofuels supply chain success.

This paper is organized as follows. First, we discuss DSTs used in biofuels development, followed by the broader literature on capitals which is employed by CAAM. Next, we present an in-depth explanation of the most recent CAAM model and apply this model to make predictions in the Wyoming and Colorado region where woody biomass facilities have been proposed. We

then present the methods section where the ethnographic interview methodology is explained. We conclude with recommendations for not only improving the CAAM but providing recommendations for effective mixed-methods research to better incorporate and examine the social aspects of sustainability which are too often ineffectively incorporated in aviation biofuels research.

LITERATURE REVIEW

Decision support systems (DSS) or DSTs are designed to aid complex decision-making using management information systems (Shim et al., 2002). Gorry et al. (1971) developed an initial framework for assisting managerial decisions within organizations and noted the growth of management information systems but argued that these systems had a limited impact on decision-making within organizations. The development and application of DSTs has grown considerably over the last 30 years, with these tools consisting of three primary components: "a database that can store and manage internal and external information, algorithms necessary for the analysis and an interface for communication with the user" (Perimenis et al., 2011). These tools aid the decision-making process through problem identification and analysis of alternatives which allows decision-makers, through computational modeling, to identify the ideal alternative that optimizes all decision-making criteria to address a problem (Shim et al., 2002).

However, for complex projects and problems, optimizing all decision-making criteria is impossible, and necessitating a compromise solution. Thus, multi-criteria decision analysis (MCDA) which refers to a range of approaches that compare potential solutions through ranking analysis, optimality, or other techniques (Pavan and Todeschini 2009; Wang et al., 2009) is an important component of decision support tools for complex issues (Wang et al., 2009; Perimenis et al., 2011). MCDA-based DSTs involve evaluating alternative solutions to a problem through multiple weighted evaluation criteria with the weighting technique employed impacting results (See Wang et al., 2009). MCDA DSTs have been employed in fields that require balancing areas with conflicting objectives, such as sustainable energy and aviation biofuels, which require balancing across social, economic, and environmental activities (see Afgan and Carvalho, 2002; Jovanovic et al., 2009; Perimenis et al., 2011; Martinkus et al., 2018; Ghose et al., 2019; Xu et al., 2019).

DSTs have been frequently used for facility siting, with much literature in biofuels applying various models to aid biorefinery site selection (see Stewart and Lambert 2011; Zhang et al., 2011; Perimenis et al., 2011; Martinkus et al., 2017; Martinkus et al., 2018; Ghose et al., 2019). A noted issue in the biofuel site selection literature is how to effectively combine social, economic, and environmental criteria in DSTs as many social criteria are qualitative in nature and thus difficult to adapt to quantitative models (Martinkus et al., 2014; Martinkus et al., 2017; Rijkhoff et al., 2017; Martinkus et al., 2019). Noting several limitations in how social criteria were initially incorporated in past studies, Rijkhoff et al. (2017) used Emery and Flora's Community Capitals Framework (CCF) to identify community assets necessary for successful development and implementation of complex projects and developed the Community Assets and Attributes Model (CAAM). The CAAM quantified three social assets—social, cultural, and human capitals—to include in U.S.-based decision support tools. The authors argued that the CAAM model should be incorporated as criteria in decision support tools for aviation biofuel facility-siting or risk the economic sustainability of their projects but left the weighting of criteria to tool developers (Rijkhoff et al., 2017). The CAAM model was further refined by Mueller et al. (2020) through the addition of political capital and exploratory factor analysis to update the indicators used for each of the capitals and to prevent overlap between capital measurements. While Rijkhoff et al. (2017) and Mueller et al. (2020) improved on social asset modeling compared to earlier studies, which often ignored social assets or used unsuitable proxy measures, several limitations of the CAAM model still impact its incorporation into site selection DSTs. Additionally, assessing the ability of the CAAM to adequately predict levels of these assets is important before full scale adoption in United States biorefinery site selection.

DSTs and similar frameworks have an important role to play in sustainable development through informed siting of a variety of different types of energy facilities. An effective DST can help prevent needless expenditures of time, money, and political capital as they, in theory, and increase the likelihood of locating a proposed facility where it would enjoy long-term economic success and community support. Additionally, holistic methods which can examine environmental, economic, and social sustainability are lacking as social sustainability considerations are often excluded from analysis (see Acquaye et al., 2011; Clarens et al., 2011; Collotta et al., 2019) or includes employment as the only "social indicator" (Collotta et al., 2019; Visentin et al., 2020). This exclusion is often due to lack of easily available social metrics that can be included in initial assessments, but also reflects a key issue in aviation biofuels literature broadly and not just site selection: lip service to the importance of social and cultural assets and social sustainability with limited application across sustainability studies.

While more studies have attempted to incorporate social criteria in sustainability research through a variety of techniques (see Buchholz et al., 2009; Kurka and Blackwood 2013; Kamali et al., 2018; Gnansounou and Alves 2019; Mattioda et al., 2020; Mattioda et al., 2020), the indicators included or suggested for inclusion differ depending on the study and often the evaluation of relevance, reliability, practicality, and other metrics used for final selection of indicators. When combined with economic and environmental indicators, social criteria are often rated lower (Buchholz et al., 2009; Kurka and Blackwood, 2013). Additionally, industrialized and non-industrialized countries rate the relevance and importance of social criteria differently (Buchholz et al., 2009). Kamali et al. (2018) argue that the selection of social criteria for evaluation needs to be case-specific and advocate for using case studies to identify appropriate social criteria for evaluation of social performance of biofuel supply chains. Nonetheless, despite

calls for more focus on social sustainability and social evaluation, these studies are still lacking. Thus, the assessment of the CAAM and recommendations for improved analysis of social criteria, assets, and issues, can significantly move research in site selection and sustainability forward.

Community Capitals Framework

The CAAM is based on the CCF (Emory and Flora, 2006) that models community assets using seven capitals: financial, natural, built, political, cultural, human, and social capitals. Rijkhoff et al. (2017) argue that the CCF approach is especially useful for site selection due to its system approach that combines capitals typically used in site selection modeling (natural, financial, and built capitals) and a theoretical base for building models that can incorporate the capitals not systematically included in current site selection models, especially cultural and social capitals. These authors argue that the inclusion of often neglected capitals, social and cultural capitals, are important for ensuring project sustainability, which is rooted in Emery and Flora (2006) claim that cultural capital is an especially important capital for project success, and social capital is an important structural capital that can lead to increases in all other capitals (known as the "spiral up" effect). Thus, Martinkus et al. (2017); Rijkhoff et al. (2017); Mueller et al. (2020) all model their variations of the CAAM on the CCF framework, with each iteration meant to better reflect the CCF capitals as they apply to site selection for aviation biofuels supply chains.

The broad concern we have with models derived from the CCF or other similar capital-based approaches is the extent to which the various capitals are always "valid" and "reliable" measures. This question becomes more pressing when capitals (for example, social capital or cultural capital) are conflated with "proxies" or "indexes" or "indicators" that 1) may or may not have the social significance that researchers think they do; and 2) may have different meanings at different times in history or even in different cultural and social contexts. Simply put, are preconceived assumptions about the importance of certain social practices (for example, going to church) or social statuses (such as having a college degree) influencing the conclusions that emerge from a capitals-based approach? These are important questions, because without valid and reliable data, the ability of a DST to consistently *predict* what people will think and do is seriously compromised. These issues most prominently appear in the quantification of cultural capital, which is acknowledged by each iteration of the CAAM as difficult to quantify and necessitating further research, but also include aspects of social capital, and such as trust. We focus on concerns operationalizing cultural capital and social capital for the rest of this review.

Social Capital

Social capital refers to connections that exist within and across communities and was popularized by Putnam (1993, 1995, 2000) who focused on the importance of civic engagement and community relationships for democratic development and sustainability. Many studies have examined the impact of social capital in a variety of areas. This capital has been linked to economic growth, increased cooperation and collective action, increased trust, better natural resource management, better health, better COVID19 response, and has been used to predict successful environmental policy and sustainability projects in United States cities (See Coleman, 1988; Flora, 1995; Cramb, 2005; Lovrich et al., 2005; Briceno and Stagl 2006; Budd et al., 2008; Erp et al., 2009; Jones et al., 2009; Portney and Berry, 2010; Ehsan et al., 2019; Pitas and Ehmer, 2020). Based on the impact of social capital found in numerous empirical studies, social capital in site selection has been used to narrow the candidate sites for potential biofuel facilities using a stepwise approach (Martinkus et al., 2017; Rijkhoff et al., 2017), as one aspect of a total social component score included in MCDA (Martinkus et al., 2019), and to help develop strategic engagement recommendations to aid in project development and implementation success (Mueller et al., 2020).

While social capital is incorporated in several studies across numerous scholarly literatures, significant disagreement exists on exactly how the concept should be operationalized, such as whether it should or can be measured at the individual-level (Bourdieu 1986; Coleman 1988; Montgomery 2001), or is more appropriate at the community-level through a focus on density of community associations and other measures of engagement, such as voter turnout (Putnam 1993; Rupasingha et al., 2006). Rijkhoff et al. (2017) adopt Putnam's and Rupasignha et al.'s interpretation of social capital, arguing it is a community-level characteristic that can facilitate collective action and cooperation needed for success in highly technical projects. All iterations of the CAAM use data originally developed by Rupasingha et al. (2006), which includes number of associations in a county, types of organizations, voter turnout, and Census response rates. Mueller et al. (2020) update CAAM measurements by ensuring no overlap exists between the capitals, but the indicators of social capital are still derived from Rupasingha et al. (2006) and thus prioritize Putnam (1993); Putnam (2000) interpretation of social capital. Putnam's studies of social capital, however, have been heavily criticized.

Briefly consider Putnam's classic exploration of late 20th century American civic culture, *Bowling Alone: The Collapse and Revival of American Community* (2000). Putnam famously holds up popular 1950s social practices like bowling, community picnics and involvement with civic organizations as strong indicators of civic and political engagement and, most importantly, community-level democratic processes. Since participation in some of these kinds of activities wanes during the 1960s, he concludes that American democracy may be in peril. As many have pointed out, however, Putnam's "anecdotal" claims (Durlauf 2002) and "arbitrary choice of indicators" (Boggs 2001) leave a lot to be desired in terms of empiricism. Issues of correlation and causation are murky, data seem cherry-picked to fit a preconceived narrative (Samuelson, 1996), and, ironically, social capital itself is not well defined. More broadly, his conclusions about the social character of the United States seem a bit blind to the historical realities of the time. As Carl Boggs writes, "Can he be insisting that Americans *after* 1965 became more disengaged, less aware, less politically active than

they were at the height of the placid fifties, when McCarthyism filled the air, when social movements and third parties were nowhere to be seen, when racism, sexism, and homophobia were part of the taken-for-granted ideological discourse?" (2001, 283–84).

To be fair, Martinkus et al. (2017), Rijkhoff et al. (2017) and Mueller et al. (2020) all acknowledge that some aspects of social capital cannot be operationalized quantitatively in the CAAM due to a lack of consistently measured indicators at the community-level, such as the key component of trust. However, these authors do not critique whether existing CAAM indicators for social capital are good proxies for the qualitative phenomena claimed by Putnam and Rupasingha et al. (2006). Whether these are adequate and accurate proxies and relevant to aviation biofuel supply chains needs more thorough investigation, especially through mixed-method analysis that allows researchers to interrogate these relationships more deeply.

Cultural Capital

According to Emery and Flora (2006), "cultural capital reflects the way people 'know the world' and how they act within it, as well as their language and traditions" (21). It influences which voices are heard and prioritized, as well as "how creativity, innovation, and influence emerge and are nurtured" (Emery and Flora 2006). As the elements of cultural capital are difficult to measure quantitively, it seems its inclusion in quantitative frameworks focuses on innovation and creativity, or at least proxies that are meant to reflect creativity and innovation. Thus, as currently conceptualized, these frameworks focus on an effect of cultural capital rather than the concept itself. Relying on the work of Florida (2002), Martinkus et al. (2014), Martinkus et al. (2017) and Rijkhoff et al. (2017) use either elements of the creative vitality index (CVI) or the entire index to measure cultural capital. This index measures the presence of the "creative class" (jobs that require creativity), innovation (patents per capita), high-tech industry and diversity (using the Gay Index created by Florida) as a proxy for community openness and acceptance.

If Putnam's work serves as a cautionary tale about overloading "arbitrary indicators" with broad social significance and not bringing a historical perspective into capitals research, Richard Florida's influential work on the "creative class" also warrants scrutiny for its own reliance on empirically dubious indexes, such as the "Bohemian index" and the "Gay index" to assess the potential economic vitality of urban centers. Importantly, Florida played a vital role in the way that the idea of culture is understood in later "capitals" work. Culture, rather than referring to shared values, beliefs, practices, and traditions in the vein of Emery and Flora (2006), became a shorthand for "creativity" that, in turn, is used as a "proxy" for a community's openness to change and innovation. Academics and cultural critics have pointed out that Florida's notion of the "creative class" is an elitist notion at its core (O'Callaghan, 2010; Bures, 2017; Wainwright, 2017). As cultural geographer, Cian O'Callaghan, put it, "The creative class concept is primarily tailored towards a core audience of urban elites and young high-earning professionals. Thus, the version of "creativity" that is extolled fits neatly with the lifestyles and work practices of this group..." (2010, 1,610). Florida's rather bourgeois understanding of creativity was injected into capitals work largely through the adoption of the CVI (which was created by a non-profit arts preservation organization in Denver called the Western Arts Foundation) to measure "cultural capital" (Florida 2002). In addition, Florida initiated the tendency in capitals work to define "creativity" very narrowly, as having to do with elite cultural practices, such as attending the ballet or the opera.

The work of Martinkus et al. (2014), Martinkus et al. (2017), which should be lauded for striving to bring social dimensions into industrial siting, is a good example of utilizing the idea of culture as, more or less, a synonym for creativity which, in turn, is measured by an index that is then used to indicate a community's openness to change. A community's willingness to try new things, of course, would indicate a community that might be a good candidate for something innovative like a bioenergy facility. As sensible as this chain of logic might seem at first glance (leaving aside the numerous levels of separation from actual communities), when one digs into the details of what counts as "culture," this approach, like Putnam's and Florida's, seems to be weighed down with empirically dubious assumptions about what certain social activities and "indexes" mean. For studies that use the CVI or elements of CVI (Martinkus et al., 2014; Martinkus et al., 2017; Rijkhoff et al., 2017), it is unclear how indicators such as the number of arts related organizations, occupational employment in the arts, and revenues of arts related goods and services might impact which communities would be more open to building bioenergy facilities or which communities would be more creative and adaptable about how and why these facilities should be built.

While Mueller et al. (2020) improve on past efforts by forgoing the use of the CVI, their measure of cultural capital still includes the "creative class" (measured as the proportion of the working population 16 and over employed in management, business, science, and the arts) and education. In fairness, both Mueller et al. (2020); Rijkhoff et al. (2017) argue that lower cultural capital scores may mean that expertise must be imported from other areas to support development and implementation. They also encourage further ground-truthing before final selection of communities. However, whether these measures are valid indicators of cultural capital or even creativity is inadequately addressed. Part of this difficulty is that the very definition of cultural capital is qualitative in nature and points to conditions, culture, and language, which are difficult to quantify and not regularly collected at any level of analysis. Another difficulty is the resources necessary to conduct mixed-methods research and evaluative case studies to more deeply explore these relationships and collect data on the very foundation of cultural capital, history, which has been shown to impact biofuel-related projects (Mueller et al., 2020). *Put simply, there is a need to put culture back into cultural capital and acknowledge at the very least that most frameworks are attempting to measure creativity and not cultural capital.* There is further need to acknowledge that understanding cultural capital and its impact in aviation biofuels requires additional assessment and move the

field towards more integrative mixed-methods research, combining qualitative and quantitative approaches, to better address local-level concerns which are currently lacking.

To achieve these goals, we conduct a mixed-methods study that combines quantitative assessment with ethnographic interviews in southeastern Wyoming and northeastern Colorado. This region has been the focus of woody biomass supply chain development for the past 8 years, with numerous studies conducting supply chain assessment in the region. As such, it provides an ideal opportunity to assess and improve the CAAM and other models that seek to include social measures. Based on the combination of quantitative and qualitative methods, we not only offer suggestions to improve the CAAM for future research, but also provide recommendations to help scholars and practitioners conduct these mixed-methods assessments in the future.

METHODS

This mixed methods analysis combines quantitative analysis of social assets using the most recent version of CAAM (Mueller et al., 2020) and ethnographic interviews conducted in southeastern Wyoming and northeastern Colorado. First, we provide more information on the latest CAAM, including indicators, scores, and interpretation of scores. Next, we provide more information on the thematic analysis and focus of the ethnographic interviews.

Mixed Methods: CAAM

The CAAM dataset provides county-level scores for cultural, social, human, and political capitals. The CAAM itself was created by performing an exploratory factor analysis (EFA) on several different quantitative indicators traditionally associated in the literature with cultural, social, human, and political capitals. After a few iterations of EFA to identify multicollinearity among variables and further simplify the model, a final EFA yielded a four-factor solution, grouping related indicators into each of the four factors, which matched with the four capitals listed above. The final result produces the CAAM in its current version, which measures four capitals using 11 quantitative, county-level indicators. These include income inequality, child poverty, low birth rates, unemployment level, and violent crime rates for human capital, education level and proportion of the population in creative class occupations (see Florida 2019) for cultural capital, turnout levels in the 2012 and 2014 elections for political capital, and data from Rupasingha et al. (2006) for social capital, which includes the number of non-profit organizations per capita, and the aggregated, per capita number of religious, civic, business, political, professional, labor, bowling, recreational, golf, and sports organizations in any given county.

The capital scores in the CAAM are calculated by taking the normalized values for each indicator, multiplying this by each indicator's factor loading as produced by the final EFA, effectively weighting each indicator within each capital, and adding these values together to produce a single score for each capital. Because these scores are not by themselves particularly intuitive, aside from a basic understanding that higher scores reflect higher capital, these scores are further normalized based on the Census Region, Division, or other geographical boundary related to a given study area. This process normalizes the raw scores to the average of a given geography, turning the scores into z-scores that show how many standard deviations a county lies above or below some geographic average. Because the study area of this paper is in Wyoming and Colorado, we use CAAM scores normalized to the Census Mountain Division, which includes the states of Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico. In other words, all CAAM scores indicate how many standard deviations a county sits above or below the Mountain Division average for each respective capital.

Mixed Methods: Ethnographic Interviews

The second source of data includes 31 ethnographic interviews that were conducted with residents of southeastern Wyoming and northeastern Colorado from the summer of 2015 to the summer of 2019.[1] These 31 interviews represent just a portion of a greater ethnographic data set that was produced by various University of Wyoming faculty and students (both graduate and undergraduate) working on the multi-institution United States Department of Agriculture (USDA) Bioenergy Alliance Network of the Rockies project. Our research participants were loggers, entrepreneurs, small business owners, state and federal foresters, politicians, and other local residents with an interest in forestry and knowledge of land management. Initial interviews were conducted with people with obvious connections to the bioenergy industry. Subsequently we built our sample by using a "snowball" method wherein research participants would recommend other people to interview (Bernard 2018), or we would reach out to people who seemed necessary to contact due to a connection to forestry or forest products. The interviews were coded for relevant themes and analyzed using Atlas ti, versions 8 and 9. Ultimately, the research team delineated 41 different codes.

The interviews focused on gaining an "emic" or an "insider" perspective, which anthropologists have argued should be incorporated in energy studies (Strauss, Rupp, & Love 2013; Chatti et al. 2017). These understandings are gained through cultural data, which refers to information gathered through conversations, interviews, observations, or participation in mundane activities that shed light on the ways that people carry out everyday tasks (whether it be tracking an animal or managing a small business), how they conceptualize their worlds (often referred to as "worldviews" or "ontologies") and the meanings that they attach to social and personal activities. As opposed to "individual attribute data" (age, education, and income, etc.), which can expose illuminating sociological profiles of cohorts of people (say, cross-country skiers or Pennsylvania Republicans), cultural data is extremely effective for providing a more nuanced understanding of what cross-country skiing means to people or why people identify as Republicans. Both sorts of data (cultural and individual

[1]To see a map of this region, please visit https://ngmdb.usgs.gov/topoview/viewer/#9/41.0555/-106.0771.

attribute) and the research methods they require are critical to holistic social science inquiries (Bernard 2018). Ethnographic research is part of larger inductive research project that starts "on the ground" and attempts to find consistent patterns in data that will eventually help researchers understand how people in specific circumstances (a place, a particular social movement, an occupational group, and so forth) conceptualize their worlds, how they think they should act in the world, and what they expect of others. We note that this research took place while the Rocky Mountain region was reeling from a massive mountain pine bark beetle epidemic that left millions of dead trees in the forest. Beyond the obvious waste of a valuable natural resource, people in forest communities were extremely concerned about the possibility of catastrophic forest fires. Also of relevance, during the period of this research, petroleum prices went from extremely high to extremely low, which also colored the ways in which people viewed the value of developing biomass sources for biofuels over time.

While more research would be necessary for us to offer any definitive overarching conclusions on the "worldviews", "ontologies", or "cultural logics" of the communities we visited, we are very confident that our empirical field research provides a more informative data set for understanding the specific perspectives and concerns of our research participants than quantitative county level data. The ethnographic interviews covered a wide range of topics, from pine bark beetles to forest management policies to woody biomass bioenergy facilities. We refer to our interviews as "ethnographic" for the following reasons: First, we asked open-ended questions and invited people to go wherever they wanted to go with their answers. Second, we wanted people to answer questions in their own terms. For example, we never asked what impact global warming was having on the local forest. Instead, we asked people to talk about the various "natural" and "human-caused" impacts on the forest. Third, we were interested in detailed answers, rather than the more general answers that less open-ended interviews elicit. Four, we were interested in the things that people would tell us that we could not have predicted and, therefore, could not have asked about. Any ethnographer would likely admit that it is not uncommon to realize, after conducting months of interviews, that they were not asking "the right questions." There are always aspects of local life that cannot be understood from the comfort of our university offices. There is no proxy for "being there."

The last aspect of our research that is "ethnographic" is the attempt our fieldworkers made to build rapport with community members. The multi-sited (Marcus 1995; Strauss 2004) BANR project engaged with places impacted by pine bark beetle destruction in the Rockies and involved multiple researchers returning to the various communities under study over the course of 6 years. Through this process, BANR researchers gained valuable comparative perspectives shared with the team in succession, as people moved into and out of the project. For example, researchers kept up with local newspapers, and often spent multiple days in towns while conducting research. We attempted to meet in comfortable settings, such as a participant's home or a local restaurant or diner and made it very clear that we valued our participants' unique opinions on these complicated topics. Additionally, because we utilized snowball sampling, we found ourselves more enmeshed in social networks as time passed and through return trips to particular communities. As a result, our meetings with community members often felt more like structured conversations than formal interviews.

The goal of these interviews was to arrive at a better understanding of local perspectives on the feasibility of woody biomass bioenergy facilities. The specific data presented in this paper focus on themes that directly speak to the idea of "cultural capital" as it is used in CCF research. In other words, to what extent are people in Southeastern Wyoming and Northeastern Colorado open to the idea of locating bioenergy facilities in their communities, and to what extent are interview participants willing to innovate or express past instances of innovation? As explained earlier, this paper compares the conclusions reached through our ethnographic analysis with the CAAM predictions (Mueller et al., 2020) for the counties where the ethnographic interviews were conducted. In this way, we can "ground truth" the CAAM predictions and make suggestions for improving DSTs.

Cultural capital is a particularly important aspect of capitals research to interrogate because it seems to be the most difficult capital to define and measure and it is relied upon as an indicator of a community's willingness to change and innovate. As we see in research that attempts to incorporate a mixed-methods approach (Roemer, 2017; Mueller et al., 2020), there seems to be a disconnect between the quantitative cultural capital scores that are based on statistical analysis of county or regional data and the qualitative data that were gathered through interviews with local residents. The reason for this, as alluded to above, is that the statistical indexes and proxies that represent cultural capital are meant to measure the "creativity" (as popularized by Richard Florida) of the local population by analyzing individual attribute data related to topics such as educational attainment and numbers of high-tech employees, but the qualitative interviews, on the other hand, are oriented toward learning about shared values and historical legacies by allowing people to explain their experiences, and share their personal perspectives. In short, the quantitative cultural capital scores and qualitative findings do not always agree, and the fact that they are not even measuring the same things makes the idea of cultural capital difficult to utilize with confidence (Roemer, 2017; Mueller et al., 2020).

RESULTS

The CAAM Predictions

As previously discussed, CCF work relies heavily on cultural capital scores to understand the extent to which communities are willing to adapt, change, and innovate. In the case of industrial siting, the higher the cultural capital z-score the more confidence one would have in a particular community being a good place to locate a facility, since it is more likely such a community would have higher levels of innovation and would not require as much outside expertise to successfully set up a biofuel supply chain. All our Wyoming interviews were conducted in Carbon County. The cultural capital score for

Carbon County (0.56) lands below the regional average. This score would suggest that Carbon County may be a more challenging candidate for a woody biomass energy facility because the community appears to lack the capability for change and innovation that such an endeavor would require. In contrast, the cultural capital scores from the Colorado counties were generally higher than Carbon County, WY: Grand (0.75), Jackson (−0.53), Larimer (2.00), and Routt (1.52). To reiterate, these numbers, which are z-scores, indicate how many standard deviations above or below the Mountain Division average these counties sit. These scores, according to the CAAM, suggest that creativity and innovation may be higher in these counties and thus increase the likelihood of project success. It is important to note that Mueller et al. (2020) would not necessarily rule out Carbon County for biofuel facilities, but "strategically recommend" that outside expertise may be needed in project development and implementation phases.

Ethnographic Interviews

Regardless of state or county, our interviews were noteworthy for their nearly unanimous support of bioenergy as a potential local industry. People across the region were enthusiastic about local jobs that would keep their communities alive; the ability to maintain a natural resource economic tradition; and the long-term economic and environmental sustainability of their communities. This is not to say, however, that all the research participants thought that a bioenergy facility would be economically viable. Indeed, most participants expressed concerns about one or more of the following issues: markets, start-up costs, transportation costs, government policies, and confidence in the sustainability of feedstock supplies. These concerns reflect what researchers have found in other locations (Roos et al., 1999; Upreti and van der Horst 2004; White et al., 2013).

The following quotes are representative responses to interview questions about bioenergy and the potential impacts of a new bioenergy facility on these rural communities. These lengthy ethnographic quotes are not intended to merely provide evidence that people are agreeing (or disagreeing) with each other on a particular topic, but rather to show the wide variety of issues that are taken into consideration by people as they make decisions that will have important consequences for their families, friends, communities, and surrounding landscapes (Strauss and Reeser, 2016; Jensen-Ryan et al., 2019). The complexity of local discourses on bioenergy presented in these quotes illuminates what is missed when "cultural capital," a very general and poorly defined term that has been shown to be an unreliable predictor of behavior (Roemer 2017; Mueller et al., 2020), is relied upon to provide critical insights into the perspectives of people in specific communities at particular moments in history. These statements, then, should disabuse readers of the assumption that residents in small, rural communities are somehow unlikely to embrace change and innovation. On the contrary, they demonstrate that these people are quite capable, in the words of Richard Florida (2019), of being "creative"—regardless of their CVI scores.

Elected Official in Wyoming

"Oh, absolutely it would benefit the community. You know especially if we had some kind of, of a facility. You know other with a value-added thing, fuel would be a really good way, if we had some way of developing a fuel product that could be used in vehicles for example, that value-added would be enough to where the transportation would be a big issue, I don't think. So, yeah, it certainly would benefit the entire community. You know, people here are very proud of their school. It's a very great school. It's named number 19 of the best 50 schools in the United States here just in the last month or so. They want to be able to have enough population here to sustain that school, you have another competing school up the road another 20 miles from ya, it would be real easy to close the high school here and take the high school kids down there. And that would be disastrous to the community. The area where I was raised, they closed the school there and now the town doesn't barely exist, ya know? When you do that it's the center of activity for the whole community, it's a source of pride. So, any kind of any industry that would really help stabilize the population and diversify the income potential, you know, so that you didn't have to just become a bedroom community and commute outta here would certainly be beneficial to us. That's why you know, trying to restart this little sawmill up here would be very beneficial to us. We've got some possibilities of getting that reopened, and it wasn't a good thing for us when it did close, because we did employ people there and it did help the economy. Hopefully we can get it back up and running again. But any kind of a thing, that would do that—and bioenergy sure has a lot of potential for some expansion on that, I just need to find out more about what's going on in the research departments and figure out what we, a program that we can get behind from a state standpoint that we can incentivize, and this would be a perfect place to do it for a pilot program. If it'll work here, it'll work here in more populated areas."

The above quote covers an impressive amount of ground. From concerns about community development to town pride about their school to reminiscing about a long-ago school closing that doomed his hometown to the hope of bolstering the community by getting the local sawmill up and running to an affirmative answer to the only actual question that the interviewer asked: Do you think bioenergy could benefit your community? This is a great example of the "value-added" of an in-depth, open-ended interview and an equally instructive example of the cost of relying on quantitative methods to gather insight into very specific, personal issues. It also shows local resources that could aid the development and implementation of biofuel supply chains that are not necessarily reflected in the quantitative metrics, including willingness to incentivize for development.

Below is the response of a Wyoming resident with family history in the local timber industry when asked about the pros and cons of developing the local bioenergy industry:

"Opportunities is employment, a GOOD employment, not just. . .ya know, manual type, whatever or anything. If you

could get a good industry in here and start keeping some of our youth here. Our youth would like to stay here. They're really, they have to drive a lot of em. Their families live here, and they commute back and forth to the oil fields, the gas fields, wherever they get. And then they come home on weekends or every other week or whanot, ya know. And uh, the community needs a viable economic base. They need an industry. All we have now is tourism, really. That's it. And our ranches."

Interviewer: "Yeah. So, thinking about using the forest for bioenergy. . .um, what are the positives and negatives of that?"

Participant: "I think its. . .um. . .the positives are, you would be using the resources, it wouldn't just be sitting there rotting, dying, going away, burning, whatever. You would use the resource. And we should, we really need to use our resources. Um, so you would be using the resource. There's always a tradeoff. Um, because if you do that, particularly for us locals that view this as our private little playground and whatnot, then there's more people, there's more accessibility, there's more roads, there's more activity in OUR forests. So, it has to be done, I think, in a responsible way."

The response above, like the one before it, provides a textured, and multidimensional snapshot of the thought process of a local resident on the pros and cons of bioenergy. Like the first quote, it expresses concerns about the long-term prospects of the community and the hope that a bioenergy industry could keep some young people at home. The second part of this response delves into concerns about too much industrial use of the forest and points to the affection that people in this community have for their local federal land. Interestingly, this person resides in Carbon County, WY, with its lower (−0.56) CVI score. This quote points to a history with the industry and lands that could lead to more support in this community for biofuel projects and shows a nuanced understanding of the industry and its impact on the community. This suggests that the lower cultural capital score may not reflect the true value of cultural capital in this community as this person, like others we interviewed, is clearly willing to adapt and innovate in the face of changing circumstances.

Wyoming rancher when asked if a biomass facility would benefit local communities:

"Oh, I think so because you know, you've created some jobs. Um, the problem with the tourism industry is there's about 4 months where that's really good. And the rest of the year those people are sitting, local people are going, "well. . .all right I like to go huntin' in ya know October, so I take that month off anyway" but they're unemployed a lot of the year. So yes, if you could provide year-round employment for people, I think it would benefit the community...I think people would be receptive to that, again, as long as it's managed properly and you know, we don't just wipe out a hillside turn it into pellets and ship 'em outta here. And then not care for what you've left behind and not, um ensure that what you've left behind is something sustainable. Or something that will be sustainable."

Again, as with the Wyoming residents in general, we see an interest in bioenergy as a driver of community development, a concern for a sustainable process, and evidence of local residents valuing their local federal land for recreational purposes. It also highlights that bringing employment opportunities is not enough. The impact of this development and what is "left behind" is a concern that will have to be addressed if bioenergy development occurs in this community.

The following two quotes appeared in interviews with two different Colorado foresters. They were commenting on the pros and cons of a local bioenergy facility. These foresters focused their answers more on forestry and less on community development than the previous interview examples. This may have been due to their professions and/or their locations. Their concerns about the viability of bioenergy, however, were commonly held across our research area.

Colorado forester expressing enthusiasm for bioenergy and concerns about supply:

"Well, I really think it's a pro. It would be that it could help us treat some additional forest that's in poor condition and we could do some beneficial treatments there. I would love to see expanded possibilities for some of the value that the biomass can contribute to that processing go back to help offset some of the cost to doing the treatments. Would love to see that."

"I believe our volume per acre is a liability on that because even if there was a high volume per acre right now and we did that treatment and got it down, the productivity is such that we couldn't do that again soon. We would have supply problems unless we had a really big land base which, we've got a pretty big land base but it's in such diverse ownership that it'd be difficult to count on it to be able to access that."

Colorado forester expressing enthusiasm for bioenergy and concerns about cost:

"I think it's a positive thing, probably 100% positive in the situation that we're in strictly because there is so much material that needs to be put to use. There's a way to do it. It takes money to be able to convert your TV in your home to burning wood. By the time you do it, it's far cheaper to do it. You know what I mean? You're not having to pay the gas bills. You're not having to pay the electric bills or whatever that you would to heat your home by simply just burning wood. There's a lot of people out there that do that. I think that's a good thing."

"I think that being able to heat or whatever you can with wood pellets is something that's a good thing. It's just being able to get the wood from the forests to get it processed and then get it into your living room that makes it a viable option. Like I said before, the Forest Service is not cutting up enough forests to let those entities through. If they make it so difficult that you can't get it, then it becomes so expensive that you can't ... If you go through that process, it just makes it more difficult. If that process wasn't so difficult, wasn't so expensive, I think it would be a good thing."

These participants express concerns about feedstock supply and costs that temper their enthusiasm for bioenergy This suggests, if this community were to be selected as a possible location for future development, that these concerns will need to be addressed to help ensure community support despite the relatively high cultural capital scores.

The following is a comparatively "negative" perspective on bioenergy from a land manager in a Colorado tourist community:

Manager: "I think that as a destination community, any type of industrial development, there would be opposition to from

certain camps. When I look at what they had in Walden, that'd be really tough to do here. It's a big industrial plant, you've got big trucks, they've got large amounts of material stored outside, it's not particularly aesthetically attractive and since that's where our bread and butter comes from...we don't have that much land...it would be near someone's home and people aren't going to want to live by that. Depending on the technology, emissions, and odors could be an issue."

Interviewer: "I think you talked a little bit about the pros, but any kind of positive impacts that you can think of for your community specifically?"

Manager: "I think people here are early adopters in some of the environmental things, some people would see it as, just from an ethical point, a better way to go, they'd like to look at alternatives. We've got a lot of people adopting solar and seeing it as an alternative to fossil fuels, so that would be good. I think visitors like to see that kind of thing when they come to an environment like this, to say, 'Hey, we are doing something. We're green. We're using our waste in a positive manner.' I think it's something that could be marketed as well, as part of the culture and lifestyle of living in a place like this."

Interviewer: "So the economics are the major constraint?"

Manager: "I think so. You don't see sawmills ... I've seen sawmills come and go for years in Larimer County because they just can't make it. And you can't be competitive with the mass-marketing and stuff that's coming out of the northwest and Canada. Our trees are just too small and you can't get the product out of them. It has to be more of a specialty market."

This quote is noteworthy because it provides the perspective of a land manager from a community that, unlike the great majority of communities in this study, is not dealing with "rural development" issues and does not have a meaningful connection to a natural resource export economy. The manager's words provide a clear example of a community that does not seem to fall in line with CAAM predictions. Even though Larimer County, Colorado scores well above the regional mean for cultural capital (2.00, as opposed to −0.56 for Carbon County, WY), this land manager suggests that their local community would not necessarily welcome a bioenergy facility with open arms because it would not be "aesthetically attractive." Similarly, the manager speculates that one appealing dimension of bioenergy in this community would be its alignment with "green" lifestyles.

The following comments were made by a forester in Colorado and reflect a common concern about the economic feasibility of bioenergy in a region that currently faces challenges associated with feedstock supplies and transportation costs. An important theme that this forester touches on is the ability of a biomass facility "to stand on its own two legs." Concerns about bioenergy being "propped up" by government subsidies were common in our interviews. Ironically, research participants often held up the fossil fuel industry as an example of an industry that does not need government subsidies. While there were a few participants who offered unsolicited support for government investment in bioenergy, only one person (an employee of a local conservation district) pointed out that fossil fuel receives considerable financial support from the government. This (potential) general misunderstanding of energy economics would seem to be an interesting topic for future investigation.

Colorado Forester

"Whatever biomass I've seen used successfully has had to be done with a higher value product in conjunction. Sawmills using wood waste to drive a kiln, heat a kiln for example. That's an example of a fairly efficient system or produce energy, but when it has to stand on its own two legs I think it's been oversold to the public. To a public that doesn't understand the nuances and the economics. They still think there's a lot of smoke and mirrors going on with biomass. If you take away subsidies, I don't see it as economically viable at this time. It's not that I'm against it. It's just that it doesn't seem sustainable on its own right now. We should not lose sight, any resource would go to highest and best use..."

"I'm sorry to say, but it just doesn't seem like it's being successful right now. Now you're shipping wood all the way to Saratoga. You could cut a tree outside the plant, and we do. A few miles away trees are being harvested, sent to Saratoga, Wyoming and then a byproduct of those trees is then shipped down to the mill. I don't even know if they're making any pellets right now, but in any case, I don't see that as sustainability, good economics. The people who were there were laid off, were told that they may or may not reopen. They bring some people in from time to time. It's not a boom to the local economy and in no way, that I can see, does it help my forest management program at all. I suppose when it was grinding logs and making pellets, when it did take a lot of that lower value wood and allowed us to clean that up rather than burning it in a big pile."

"I think the one lesson is co-locating. When you're shipping wood, you've got to consider co-locating. Creating bio-mass facilities in conjunction with higher use facilities. To ship this wood all over the country makes no sense. The shipping is one of your biggest costs. The economics just don't add up. One set of economics is this: it cost 25 dollars a ton to harvest right now in this economy, it depends, it's variable on the size of the job lots of other things go into this, but as a rule of thumb, 25 dollars a ton to cut a log and stack it onto a log truck. Someone's invested 25 dollars a ton just to put it on a truck, now they need to bring it somewhere. That's going to cost you 4 or 5 dollars round trip mile, loaded mile. Now you've got it to the plant. Well, now what have you got into that? Maybe 28, 30 dollars a ton. Nobody's paying 30 dollars a ton for biomass right now. It doesn't compete with natural gas, so someone has to make up that difference.

This quote again shows considerable concern for viability of the industry. Not only does it reveal concerns that it is not economically viable, but it also speaks to the history of the industry in the area and specifically past failures in the industry. Perhaps even more importantly, it points to concerns that development has not benefited the local community and future bioenergy development in the area will fail to serve the local community. It also points to a willingness to innovate to make future endeavors successful, such as co-

locating, which could reflect the higher cultural capital score found by the CAAM. However, the CAAM cannot capture the perspectives of the industry based on historical experience, or the concern that projects would not benefit the local community.

Again, while all our interviews did touch on the same topics because of the common interview guide, the open-ended structure of the ethnographic interviews allowed for more expansive answers than we could have gathered with a quantitative method or a more streamlined qualitative method. All at once, this approach provided us with basic objective information, such as the number of people who "supported" bioenergy; detailed information about why, for example, people have doubts about the viability of another pellet facility in northern Colorado; and with more subjective reflections that speak to the kinds of activities that people would find ethically or environmentally "acceptable" on their local federal lands. When we assessed the broad sweep of our 31 interviews from this region, it became clear that the CAAM predictions about places with low "cultural capital" did not represent the people we interacted with in various rural communities in Wyoming and Colorado. These individuals showed not only nuanced understandings of the industry and its potential pitfalls and benefits but also reflected a willingness to innovate to meet changing circumstances, something CAAM measures suggest would be difficult for these communities. Part of the limitation of the CAAM may be that the measures are only available at the county level and set to a regional standard (United States Census Region West) for comparison. Thus, these scores are not reflective of more local communities.

Lastly, these interviews highlight an important aspect of cultural capital that the current CAAM score cannot measure quantitatively: history. Many of the interview participants touched on local history and how it impacted perceptions of bioenergy and these perspectives were largely negative. Roemer (2017); Mueller et al. (2020) show that history impacts support for projects and that is something CAAM and similar quantitative models cannot adequately address yet is vital to understanding the culture of a region and local opinions of bioenergy industries.

CONCLUSION AND RECOMMENDATIONS

Clearly, as Roemer (2017); Mueller et al. (2020) suggest, these interviews present a far more nuanced understanding of decision-making processes in these rural Wyoming and Colorado communities than quantitative cultural capital scores can capture. Again, the concerns expressed by our research participants were varied, but these people were certainly not opposed to innovative technological solutions that would allow them to adapt to challenging environmental and economic circumstances. In fact, as we mentioned, participants in the communities with the lower cultural capital z-scores, for a variety of economic and cultural reasons, may be more supportive of a bioenergy facility than communities with higher cultural capital scores.

While there are several potential reasons for this discrepancy between CAAM expectations and the ethnographic data, one in particular stands out. As we have previously discussed, CAAM's cultural capital scores are largely derived from Florida (2019) creative class concept, which already tends to favor larger cities—where the "creative class" tends to be concentrated. If this remains the core of how cultural capital is measured in the CAAM, more rural counties will usually see lower cultural capital scores. Work on the ground, however, clearly shows that these communities do demonstrate a willingness to adapt to change and to support technological innovation. While CAAM is rooted in the CCF, the focus on the "creative class" means that researchers are not assessing cultural capital, but a product of cultural capital in the original conceptualization and should perhaps return to the "creative capital" concept that was used in earlier iterations (Martinkus et al., 2014; Martinkus et al., 2017). Nonetheless, cultural capital is an inherently qualitative concept and the disconnect between quantitative proxies that attempt to measure creativity such as CAAM and the ethnographic interviews reinforces the need, emphasized by Mueller et al. (2020); Boglioli et al. (2019), for qualitative on-the-ground research in communities under consideration for biorefinery projects to understand community contexts that the CAAM alone cannot capture. Mueller et al. (2020) recommend a more strategic application of the CAAM, where capital scores are not used to eliminate potential communities when determining suitability for biofuel projects. They note that CAAM scores should support an initial community assessment that can yield strategies for how to successfully engage with selected communities and potential interventions to help increase support for the projects. However, they emphasize that some critical metrics, like community support for a biofuel project or historic relationships with the industry, can only be ascertained through qualitative research. This paper demonstrates the merits of that recommendation, revealing that the use of the CAAM by itself might have resulted in a community in, for example, Carbon County, WY, getting passed over, and despite potential support for such projects—or at least a willingness to innovate that were only discovered through interviews with community members. Future research is needed to gain a better understanding of this potential trend and develop strategies for using the CAAM as an initial assessment tool supplemented by qualitative research.

Based on our research in Wyoming and Colorado, we suggest developing a mixed-methods DST that would combine the more reliably measured capitals with semi-structured ethnographic interviews and increased attention to local historical legacies. By merging these methodologies, researchers would be capable of producing a DST that is effective at both the general (quantitative) and specific (qualitative) level. Presumably, this would produce a more accurate and less costly technique because it would eliminate the confusions that currently emerge around cultural capital. In this scenario, cultural capital scores, as we presently understand them, would no longer be necessary because cultural issues would be assessed with ethnographic, and historical methods. Instead, future

research could focus on "creative capital" and whether the presence of higher levels of the "creative class" leads to higher levels of innovation on biofuels projects, and additionally, whether the recommendation that additional expertise may be needed for project development and implementation are supported with more case studies. As Mueller et al. (2020) found support that lower "creative class" scores required additional expertise, testing this premise with more cases is especially important.

In a hypothetical search for suitable communities in which to build biorefineries, a set of communities could be chosen based first on whether they meet the biogeophysical requirements for biofuel production. CAAM scores could then uncover a general, quantitative overview of social conditions within these communities, which would provide recommendations about how to engage within them and identify potential challenges to project development. At this point, we would recommend commencing with qualitative ethnographic research in these communities to gain a detailed understanding of local perspectives on bioenergy and what kinds of historical relationships these communities might have with biofuel production or other major industrial projects. This approach would help ascertain whether the community has the innovative capacities to sustain a biofuel supply chain based on local historical considerations that neither biogeophysical nor CAAM data alone can reveal. As these results suggest, a mixed methods approach—incorporating biogeophysical, CAAM, and ethnographic data—provides a more nuanced and comprehensive approach to assessing cultural capital for biofuel site selection and development. By starting with quantitative data and narrowing down community suitability with more qualitative research, we believe projects setting up bioenergy production chains would enjoy higher rates of success and longevity. The key to this approach is the combination of CAAM or similar quantitative approaches with ethnographic approaches to assess cultural capital.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Materials, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

SS, TAB, and RB contributed to the original conception and ethnographic research design to obtain interview data for the USDA Bioenergy Alliance Network of the Rockies project. RB, TAB, MB, and SS conducted interviews analyzed for this manuscript. DM and SH contributed to the original conception and design of the CAAM model. SH, DM, MB, and SS contributed to the conception and design of mixed method study used in this research. MB and SS analyzed interviews. DM conducted quantitative analysis. MB, SS, SH, and DM wrote sections of the manuscript. MB, SS, SH, and DM contributed to manuscript revision. TAB and RB contributed to manuscript editing and revision.

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REFERENCES

Acquaye, A. A., Wiedmann, T., Feng, K., Crawford, R. H., Barrett, J., Duffy, K. J., et al. (2011). Identification of 'Carbon Hot-Spots' and Quantification of GHG Intensities in the Biodiesel Supply Chain Using Hybrid LCA and Structural Path Analysis. *Environ. Sci. Technol.* 45 (6), 2471–2478. doi:10.1021/es103410q

Afgan, N. H., and Carvalho, M. G. (2002). Multi-Criteria Assessment of New and Renewable Energy Power Plants. *Energy* 27 (8), 739–755. doi:10.1016/S0360-5442(02)00019-1

Anderson, B. J., Mueller, D. W., Hoard, S. A., Sanders, C. M., and Rijkhoff, S. A. M. (Forthcoming 2022). Social Science Applications in Sustainable Aviation Biofuels Research: Opportunities, Challenges, and Advancements. *Front. Energy Res.*.

Bernard, H. R. (2018). *Research Methods in Anthropology: Qualitative and Quantitative Approaches*. Sixth Edition. Lanham: Rowman & Littlefield.

Boggs, C. (2001). Social Capital and Political Fantasy: Robert Putnam's 'Bowling Alone. *Theor. Soc.* 30 (2), 281–297. doi:10.1023/a:1010875611192

Boglioli, M. A., Strauss, S., Hoard, S., Mueller, D., Budowle, R., Beeton, T. A., et al. (2019). "Searching for Culture in 'Cultural Capital': The Case for a Mixed Methods Approach to Production Facility Siting," in *Presented at the Biochar & Bioenergy Conference* (Fort Collins, CO: Colorado State University)

Bourdieu, P. (1986). "The Forms of Capital," in *In Handbook of Theory and Research for the Sociology of Education* (Westport, CT: Greenwood), 241–258.

Briceno, T., and Stagl, S. (2006). The Role of Social Processes for Sustainable Consumption. *J. Clean. Prod.* 14 (17), 1541–1551. doi:10.1016/j.jclepro.2006.01.027

Buchholz, T., Luzadis, V. A., and Volk, T. A. (2009). Sustainability Criteria for Bioenergy Systems: Results from an Expert Survey. *J. Clean. Prod.* 17 (November), S86–S98. doi:10.1016/j.jclepro.2009.04.015

Budd, W., Lovrich, N., Jr., Pierce, J. C., and Chamberlain., B. (2008). Cultural Sources of Variations in US Urban Sustainability Attributes. *Cities* 25, 257–267. doi:10.1016/j.cities.2008.05.001

Bures, F. (2017). Richard Florida Can't Let Go Of His Creative Class Theory. His Reputation Depends On It. *Belt Magazine*Available at https://beltmag.com/richard-florida-cant-let-go/.

Chatti, D., Archer, M., Lennon, M., and Dove, M. R. (2017). Exploring the Mundane: Towards an Ethnographic Approach to Bioenergy. *Energ. Res. Soc. Sci.* 30 (August), 28–34. doi:10.1016/j.erss.2017.06.024

Clarens, A. F., NassauWhite, H., Resurreccion, E. P., White, M. A., and Colosi, L. M. (2011). Environmental Impacts of Algae-Derived Biodiesel and Bioelectricity for Transportation. *Environ. Sci. Technol.* 45 (17), 7554–7560. doi:10.1021/es200760n

Coleman, J. S. (1988). Social Capital in the Creation of Human Capital. *Am. J. Sociol.* 94, S95–S120. doi:10.1086/228943

Collotta, M., Champagne, P., Tomasoni, G., Alberti, M., Busi, L., and Mabee, W. (2019). Critical Indicators of Sustainability for Biofuels: An Analysis through a Life Cycle Sustainabilty Assessment Perspective. *Renew. Sustain. Energ. Rev.* 115 (November), 109358. doi:10.1016/j.rser.2019.109358

Cramb, R. A. (2005). Social Capital and Soil Conservation: Evidence from the Philippines. *Aust. J. Agric. Res. Econ.* 49 (2), 211–226. doi:10.1111/j.1467-8489.2005.00286.x

Durbin, T. J., Bendixsen, C. G., Jensen-Ryan, D., Molzer, A., and Strauss, S. (2019). The Dangerous Middle: Situational Awareness and Worker Perception of Beetle Kill. *J. Agromedicine* 24 (2), 157–166. doi:10.1080/1059924X.2019.1567424

Durlauf, S. N. (2002). On the Empirics of Social Capital. *Econ. J.* 112 (483), F459–F479. doi:10.1111/1468-0297.00079

Ehsan, A., Klaas, H. S., Bastianen, A., and Spini, D. (2019). Social Capital and Health: A Systematic Review of Systematic Reviews. *SSM - Popul. Health* 8 (August), 100425. doi:10.1016/j.ssmph.2019.100425

Emery, M., and Flora, C. (2006). Spiraling-Up: Mapping Community Transformation with Community Capitals Framework. *Community Develop.* 37 (1), 19–35. doi:10.1080/15575330609490152

Erp, M., Gaffney, M., Goldman, J., Gray, K., and Lovrich, N., Jr. (2009). *WRICOPS – A Decade of Service, 1997-2007: A Brief History, Major Accomplishments, Principal Activities and Prospects for the Future*. Pullman, WA: Division of Governmental Studies and Services, Washington State University.

Flora, C. (1995). Social Capital and Sustainability: Agriculture and Communities in the Great Plains and Corn Belt. *Res. Rural Sociol. Develop.* 6, 227–246.

Florida, R. L. (2002). *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday Life*. New York, NY: Basic Books.

Florida, R. (2019). *The Rise of the Creative Class*. Updated edition. New York, NY: Basic Books.

Ghose, D., Naskar, S., and Uddin, S. (2019). "Q-GIS-MCDA Based Approach to Identify Suitable Biomass Facility Location in Sikkim (India)," in In 2019 Second International Conference on Advanced Computational and Communication Paradigms (ICACCP) (Gangtok, India: IEEE), 1–6. doi:10.1109/ICACCP.2019.8882978

Gnansounou, E., and Alves, C. M. (2019). "Social Assessment of Biofuels," in *Biofuels: Alternative Feedstocks and Conversion Processes for the Production of Liquid and Gaseous Biofuels* (London Wall, London: Academic Press), 123–139. doi:10.1016/b978-0-12-816856-1.00005-1

Gorry, G. A., Michael, S., and Scott, M. (1971). *A Framework for Management Information Systems*. Cambridge, MA: Massachusetts Institute of Technology:

Jensen-Ryan, D., Budowle, R., Strauss, S., Durbin, T. J., Beeton, T. A., and Galvin, K. A. (2019). A Cultural Consensus of Fire and Futility: Harvesting Beetle-Kill for Wood-Based Bioenergy in Wyoming and Colorado. *Energ. Res. Soc. Sci.* 58 (December), 101272. doi:10.1016/j.erss.2019.101272

Jones, N., Sophoulis, C. M., Iosifides, T., Botetzagias, I., and Evangelinos, K. (2009). The Influence of Social Capital on Environmental Policy Instruments. *Environ. Polit.* 18 (4), 595–611. doi:10.1080/09644010903007443

Jovanović, M., Afgan, N., Radovanović, P., and Stevanović, V. (2009). Sustainable Development of the Belgrade Energy System. *Energy* 34 (May), 532–539. doi:10.1016/j.energy.2008.01.013

Kurka, T., and Blackwood, D. (2013). Participatory Selection of Sustainability Criteria and Indicators for Bioenergy Developments. *Renew. Sustain. Energ. Rev.* 24 (August), 92–102. doi:10.1016/j.rser.2013.03.062

Lovrich, N. P., Gaffney, M. J., Weber, E. P., Bireley, R. M., Matthews, D. R., and Bjork, B. (2005). Inter-Agency Collaborative Approaches to Endangered Species Act Compliance and Salmon Recovery in the Pacific Northwest. *Int. J. Organ. Theor. Behav.* 8 (2), 237–273. doi:10.1108/IJOTB-08-02-2005-B005

Marcus, G. E. (1995). Ethnography In/of the World System: The Emergence of Multi-Sited Ethnography. *Annu. Rev. Anthropol.* 24, 95–117. doi:10.1146/annurev.an.24.100195.000523

Martinkus, N., Latta, G., Brandt, K., and Wolcott, M. (2018). A Multi-Criteria Decision Analysis Approach to Facility Siting in a Wood-Based Depot-And-Biorefinery Supply Chain Model. *Front. Energ. Res.* 6 (November). doi:10.3389/fenrg.2018.00124

Martinkus, N., Latta, G., Rijkhoff, S. A. M., Mueller, D., Hoard, S., Sasatani, D., et al. (2019). Season Hoard, Daisuke Sasatani, Francesca Pierobon, and Michael WolcottA Multi-Criteria Decision Support Tool for Biorefinery Siting: Using Economic, Environmental, and Social Metrics for a Refined Siting Analysis. *Biomass and Bioenergy* 128 (September), 105330. doi:10.1016/j.biombioe.2019.105330

Martinkus, N., Rijkhoff, S. A. M., Hoard, S. A., Shi, W., Smith, P., Gaffney, M., et al. (2017). Biorefinery Site Selection Using a Stepwise Biogeophysical and Social Analysis Approach. *Biomass and Bioenergy* 97 (February), 139–148. doi:10.1016/j.biombioe.2016.12.022

Martinkus, N., Shi, W., Lovrich, N., Pierce, J., Smith, P., and Wolcott, M. (2014). Integrating Biogeophysical and Social Assets into Biomass-To-Biofuel Supply Chain Siting Decisions. *Biomass and Bioenergy* 66 (July), 410–418. doi:10.1016/j.biombioe.2014.04.014

Mattioda, R. A., Tavares, D. R., Casela, J. L., and Junior, O. C. (2020). "Social Life Cycle Assessment of Biofuel Production," in *Biofuels for a More Sustainable Future* (Amsterdam, Netherlands: Elsevier), 255–271. doi:10.1016/B978-0-12-815581-3.00009-9

Montgomery, J. D. (2001). "Social Capital as a Policy Resource," in *Social Capital as a Policy Resource*. Editors J D. Montgomery and A Inkeles (Boston, MA: Springer US), 1–17. doi:10.1007/978-1-4757-6531-1_1

Mueller, D., Hoard, S., Roemer, K., Sanders, C., and Rijkhoff, S. A. M. (2020). Quantifying the Community Capitals Framework: Strategic Application of the Community Assets and Attributes Model. *Community Develop.* 51 (5), 535–555. doi:10.1080/15575330.2020.1801785

O'Callaghan, C. (2010). Let's Audit Bohemia: A Review of Richard Florida's 'Creative Class' Thesis and its Impact on Urban Policy. *Geogr. Compass* 4 (11), 1606–1617. doi:10.1111/j.1749-8198.2010.00397.x

Pashaei Kamali, F., Borges, J. A. R., Osseweijer, P., and Posada, J. A. (2018). Towards Social Sustainability: Screening Potential Social and Governance Issues for Biojet Fuel Supply Chains in Brazil. *Renew. Sustain. Energ. Rev.* 92 (September), 50–61. doi:10.1016/j.rser.2018.04.078

Pavan, M., and Todeschini, R (2009). "Multicriteria Decision-Making Methods," in *Comprehensive Chemometrics*. Editors S. D. Brown, R. Tauler, and B. Walczak (Elsevier), 591–629. https://www.sciencedirect.com/science/article/pii/B9780444527011000387.

Perimenis, A., Walimwipi, H., Zinoviev, S., Müller-Langer, F., and Miertus, S. (2011). Development of a Decision Support Tool for the Assessment of Biofuels. *Energy Policy* 39 (3), 1782–1793. doi:10.1016/j.enpol.2011.01.011

Pitas, N., and Ehmer, C. (2020). Social Capital in the Response to COVID-19. *Am. J. Health Promot.* 34 (8), 942–944. doi:10.1177/0890117120924531

Portney, K. E., and Berry, J. M. (2010). Participation and the Pursuit of Sustainability in U.S. Cities. *Urban Aff. Rev.* 46 (1), 119–139. doi:10.1177/1078087410366122

Putnam, R. D. (1993). *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton, NJ: Princeton University Press.

Putnam, R. D. (1995). Bowling Alone: America's Declining Social Capital. *J. Democracy* 6 (1), 65–78. doi:10.1353/jod.1995.0002

Putnam, R. D. (2000). *Bowling Alone: The Collapse and Revival of American Community*. New York, NY, USA: Simon & Schuster [u.a.

Rijkhoff, S. A. M., HoardHoard, S. A., Gaffney, M. J., and Smith, P. M. (2017). Communities Ready for Takeoff. *Polit. Life Sci.* 36 (1), 14–26. doi:10.1017/pls.2017.6

Rijkhoff, S. A. M., Roemer, K., Martinkus, N., Laninga, T. J., and Hoard, S. (2021). "A Capitals Approach to Biorefinery Siting Using an Integrative Model," in *Energy Impacts: A Multidisciplinary Exploration of North American Energy Development*. Editors J B. Jacquet, J H. Haggerty, and G L. Theodori (Boulder, CO: University Press of Colorado), 176–212. http://www.jstor.org/stable/j.ctv19t41pj.10.

Roemer, K. F. (2017). *Exploring the Role of Social Assets in Refinery Implementation: Using Case Study Research to Ground-Truth CAAM. "* Moscow, ID: University of Idaho.

Roos, A., Graham, R. L., Hektor, B., and Rakos, C. (1999). Critical Factors to Bioenergy Implementation. *Biomass and Bioenergy* 17, 113–126. doi:10.1016/s0961-9534(99)00028-8

Samuelson, R. J. (1996). Bowling Alone' is Bunk. *Washington Post*.

Rupasingha, A., Goetz, S. J., and Freshwater, D. (2006). The Production of Social Capital in US Counties. *The J. Socio-Economics* 35 (1), 83–101. doi:10.1016/j.socec.2005.11.001

S. Strauss, S. Rupp, and T. F. Love (Editors) (2013). *Cultures of Energy: Power, Practices, Technologies* (Walnut Creek, CA: Left Coast Press).

Shim, J., Warkentin, M., James, C., Daniel, J. P., Ramesh, S., and Carlsson, C. (2002). Past, Present, and Future of Decision Support Technology. *Decis. Support Syst.* 33 (June), 111–126. doi:10.1016/S0167-9236(01)00139-7

Stewart, L., and Lambert, D. M. (2011). Spatial Heterogeneity of Factors Determining Ethanol Production Site Selection in the U.S., 2000-2007. *Biomass and Bioenergy* 35 (3), 1273–1285. doi:10.1016/j.biombioe.2010.12.020

Strauss, S. (2004). *Positioning Yoga*. Oxford: Berg Publishers, Ltd.

Strauss, S., and Reeser, D. (2016). "Siting, Scale, and Social Capital: Wind Energy Development in Wyoming," in *Cultures of Energy: Power, Practices, Technologies* (Walnut Creek, CA: Left Coast Press), 110–125.

Upreti, B. R., and van der Horst, D. (2004). National Renewable Energy Policy and Local Opposition in the UK: The Failed Development of a Biomass Electricity Plant. *Biomass and Bioenergy* 26 (1), 61–69. doi:10.1016/S0961-9534(03)00099-0

Visentin, C., da Silva Trentin, A. W., Braun, A. B., and Thomé, A. (2020). Life Cycle Sustainability Assessment: A Systematic Literature Review through the Application Perspective, Indicators, and Methodologies. *J. Clean. Prod.* 270, 122509. doi:10.1016/j.jclepro.2020.122509

Wainwright, O. (2017). 'Everything is Gentrification Now': But Richard Florida isn't Sorry. *The Guardian* Available at https://www.theguardian.com/cities/2017/oct/26/gentrification-richard-florida-interview-creative-class-new-urban-crisis.

Wang, J.-J., Jing, Y.-Y., Zhang, C.-F., and Zhao, J.-H. (2009). Review on Multi-Criteria Decision Analysis Aid in Sustainable Energy Decision-Making. *Renew. Sustain. Energ. Rev.* 13 (9), 2263–2278. doi:10.1016/j.rser.2009.06.021

White, W., Lunnan, A., Nybakk, E., and Kulisic, B. (2013). The Role of Governments in Renewable Energy: The Importance of Policy Consistency. *Biomass and Bioenergy* 57 (October), 97–105. doi:10.1016/j.biombioe.2012.12.035

Xu, B., Kolosz, B. W., Andresen, J. M., Ouenniche, J., Greening, P., Chang, T.-S., et al. (2019). Performance Evaluation of Alternative Jet Fuels Using a Hybrid MCDA Method. *Energ. Proced.* 158 (February), 1110–1115. doi:10.1016/j.egypro.2019.01.275

Zhang, F., Johnson, D. M., and Sutherland, J. W. (2011). A GIS-Based Method for Identifying the Optimal Location for a Facility to Convert forest Biomass to Biofuel. *Biomass and Bioenergy* 35 (9), 3951–3961. doi:10.1016/j.biombioe.2011.06.006

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