FURTHERING PERSPECTIVES

ANTHROPOLOGICAL VIEWS OF THE WORLD

Anthropology Graduate Student Society
2018 | Volume 8

COLORADO STATE UNIVERSITY

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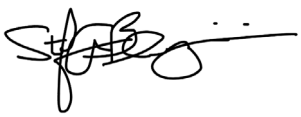
COVER IMAGES:

Top left: A student in Dr. LaBelle's Lithic Technology course making flour using a mano & metate. Photo via www.instagram.com/csuanthro/. *Top right:* A partial Eocene rodent skull found by CSU anthropology student Emma Kilpatrick during the 2017 CSU paleontology fieldschool. Photo via www.instagram.com/csuanthro/. *Bottom left:* Bison painted in the colors of a medicine wheel along a road in the Pine Ridge Indian Reservation. Photo by Stefanie Berganini. *Bottom right:* Nick Simpson teaching future anthropologists during Rice Elementary School's Science Night. Photo via www.instagram.com/csuanthro/.

EDITOR'S NOTE:

Welcome to the eighth issue of *Furthering Perspectives*, the student journal of Colorado State University's Anthropological Graduate Student Society (AGSS). Anthropology is a broad and often interdisciplinary field and this issue's articles reflect that richness and complexity. In these pages you'll find work that ranges from international development to public health to economics to remote sensing and beyond; this diverse collection of research highlights but a small portion of the myriad subjects which can be enriched by an anthropological perspective. Each submission was subject to a blind review process meant to give contributors an experience as close to "real-world" academic publishing as possible. This issue could not have happened without the faculty, instructors, and AGSS officers who volunteered to serve as our review panel - thank you!



Contents

Fair Trade, Women's Empowerment, and International Development

SHADI AZADEGAN

Fair trade constitutes an alternative approach to the production and consumption of goods that includes intersecting aspects of social justice, anti-colonialism, and, at times, faith. The Fair Trade Charter (2009) defines the guiding objective of fair trade as the creation of trade structures and practices based on justice and sustainable development that enable workers to maintain a decent standard of living and develop their full potential. This approach is being promoted by social scientists, international development entities, businesses, and consumers as a way to make trade more socially just, challenging the social, political, and historical inequalities inherent in international trade (Esteva et al. 2013) to create more egalitarian commodity chains that "transform international trade from a vehicle of exploitation to an avenue of empowerment" (Raynolds and Bennett 2015, 3).

The core principles of fair trade include facilitating market access for marginalized producers; fostering sustainable and equitable trading relationships; supporting capacity building and empowerment; raising consumer awareness and advocacy; and promoting fair trade as a partnership between consumers and producers at all levels of the commodity chain (Raynolds & Bennett 2015). Fair trade promotes well-being and sustainable livelihoods by ensuring higher prices and wages, fostering environments that promote better working conditions and stable markets and employment while prioritizing environmental sustainability. It also seeks to build individual and collective capacities by supporting individual and group empowerment, information exchanges, and access to social services. At the same time, this approach promotes equitable trade policies and responsible business models and consumption practices, providing an alternative to socially unjust and environmentally unsustainable goods (Helmore and Singh 2001; Raynolds and Bennett 2015).

The nature and current dynamics of fair trade development have been shaped by conflicts between the movement's principles and the imperatives of the market channels through which the movement operates. While existing market channels facilitate the creation of new socially and ecologically responsible commodity networks, fair trade must concurrently compete against the conventional market forces that create and uphold global inequalities. Fair trade approaches this challenge by promoting a shift from abstract economic principles towards a perspective that views economic markets as embedded within social relationships. By making explicit who was involved in the production of consumer goods and under what conditions, economic transactions between producers and consumers are humanized. This strategy is similar to other 'values-based labeling' efforts employed in organic, heritage, and geographic origin labeled foods, as well as products certified with social seals and eco-labels (Raynolds and Greenfield 2015).

The recent growth of ethical and green consumption has contributed to fair trade's rise in popularity, with consumers in high-income countries voicing their values through their consumer choices. While fair trade provides an avenue for consumer-driven activism to benefit vulnerable producers, it can be argued that its reliance on existing market relationships and conspicuous consumption as a mechanism for activism promotes inequitable global trade relationships and unsustainable environmental resource use, pursuing profit-driven objectives rather than a true transformation of the

underlying capitalist mechanisms of economic exploitation and inequality (Esteva et al. 2013).

Considering fair trade as a critique of neoliberal economic globalization and a social movement advocating for empowerment and political, economic, and environmental justice in developing countries, this approach is aligned with contemporary movements that promote human rights, global democracy, and trade justice (Raynolds & Bennett 2015). In this sense, the fair trade pursuit of equitable and sustainable economic relationships within global production networks echoes alternative development ideals of political ecology, local sovereignty, and civil rights movements (Esteva et al. 2013; Raynolds and Bennett 2015). However, it is worth noting that fair trade institutional arrangements operate outside of the legal system. Thus, while fair trade incorporates ethical and environmental concerns in its regulation of production and trade relations, it remains largely a 'social regulation' system that engages diverse stakeholders in the pursuit of diverse social goals (Raynolds and Bennett 2015; Utting 2015).

The lack of concrete influence that fair trade has had on the global legal frameworks governing international trade can be viewed as a weakness, resulting in the mainstreaming of fair trade as a way for companies to substantiate their values and capitalize on consumer concern for social and environmental issues. While mission-driven organizations pursue alternative business models, offer only fair trade items, and seek to establish partnerships in certified and non-certified sourcing arrangements, market-driven corporations engage fair trade as a way to access niche markets, offering only a small share of fair trade products and using certification to enhance their brands while following conventional business practices. Increasingly, quality-driven firms are occupying a middle ground between these two extremes, providing a significant share of fair trade products, using certification to strengthen their access to high-quality products, and engaging fair trade as a part of their corporate social responsibility strategy. While the increased role of market-driven corporations in fair trade as a result of mainstreaming can be considered a positive impact on conventional business practices, it also creates pressure for fair trade enterprises to conform to and compete with conventional commercial and industrial practices (Dragusanu et al. 2014; Utting 2015).

Fair trade standards have the power to enable the participation of small producers in establishing the terms of their integration in certified trade networks and the distribution of benefits. This includes influencing price negotiations and price guarantees that can protect marginal producers from the shocks of world market fluctuations, but can also work beyond the market to support individual and collective capacity building and community health and education initiatives (Raynolds and Bennett 2015). This multidimensional development approach is in line with the sustainable livelihoods framework, recognizing that community development relies on various forms of capital to support individual and group needs (Helmore and Singh 2001). Such an approach seeks to address the structural injustices of the global free trade system, maintained largely through international trade policies. A response to the negative effects of contemporary globalization, fair trade can serve progressive change and international development objectives (Esteva et al. 2013; Raynolds and Bennett 2015; Utting 2015).

GENDER AND WOMEN'S EMPOWERMENT: A CROSSCUTTING DEVELOPMENT PRIORITY

The growth of fair trade as an effective mechanism for international development is occurring in a context that increasingly prioritizes the importance of explicitly addressing gender and women's empowerment in the pursuit of development objectives. The growing prominence of the gendered dimension of development is due to its cross-cutting nature,

as a factor that affects social, political, and economic well-being. An acknowledgment of the diversity that permeates concepts of gender and development, as well as an understanding of the inherent importance of gender as a basis for achieving broader global development goals, must be infused in an effective free trade approach to development (Smith 2015).

Particularly in a globalized development context, gender challenges must be addressed in a manner that recognizes and respects the complexities of cross-country and cross-cultural collaboration and power differentials. Applying a gender lens to development involves considering components such as education, safety, health and family planning, economic and political empowerment, access to and control of productive resources, and how these factors relate to women's social identities, roles, and expectations (Taylor 2009). The gender lens must also acknowledge the differences between how men and women experience the impacts of economic, political, and social change, being particularly cautious of the potential feminization of poverty as free market-driven policies impact poor women in their traditional roles (Zuckerman 2007).

Gendered development impacts illustrate the intersectionality between women's empowerment and other development goals. This relationship is evidenced in the Sustainable Development Goals (SDGs); while SDG 5 specifically addresses gender equality, women's empowerment is also necessary to achieve goals linked to poverty eradication, food security and nutrition, health and population, promoting full and productive employment, social protection, education, and climate change (Clemencon 2012). The recognition of women as key global development actors requires a mainstreamed approach to gender as a cross-cutting priority issue embedded within every development objective, rather than as an isolated, standalone subject (Taylor 2009). Ultimately, development initiatives must promote the conceptualization of gender equality as a human right. Advocacy related to women's agency needs to inform economic and aid policy. This calls for a transformative process that challenges the social structures in which gender issues are rooted, addressing them at personal, social, cultural, economic, and political levels (Taylor 2009).

TACKLING GENDER INEQUALITY THROUGH FAIR TRADE

Within an environment of increased awareness and action around gender, the fair trade movement can contribute to gender equality and women's empowerment. Gender inequality in global commodity chains hinders development objectives and is in direct conflict with the pursuit of a just and equitable society grounded in respect for human rights (Rice 2010). While improved productivity and participation in the production of consumer goods at various value chain levels are key drivers of poverty reduction, there is a persistent gender gap in access to opportunities. Gender issues in agriculture and the textile and apparel industries provide examples of circumstances where unequal access to resources and decision-making platforms, coupled with low wages and exploitative working conditions, result in work and trade opportunities that offer little in way of empowerment or an escape from poverty (Smith 2015).

The World Fair Trade Organization's (WFTO) 'Principles of Fair Trade' include the commitment to nondiscrimination, gender equity and women's economic empowerment and freedom of association. While addressing an important issue, this focus on non-discrimination fails to address underlying inequalities in production and trade between men and women, as well as the marked differences that exist across countries. For instance, in contexts where gender inequalities are being actively tackled, fair trade has been associated with economic and social benefits for women, improving incomes, assets, skills, confidence, status, and influence. However, the

variability and limitations in the extent to which women can be empowered through fair trade calls for a stance on gender that understands women's empowerment as an individual and collective process that involves social, political, and economic dimensions (Rice 2010; Smith 2015). Fundamentally transforming the status of women in their society requires going beyond addressing women's practical needs at the local level. This involves challenging the structural basis of female subordination, removing institutionalized forms of discrimination, assuring sexual and reproductive rights, and achieving political equality (Rice 2010; Smith 2015).

Fair trade can challenge gender inequalities by acknowledging and rewarding women's productive activities within a fair trade commodity chain; promoting individual empowerment and enabling collective action; and addressing women's practical and strategic needs at both local and national levels (Rice 2010). However, fair trade approaches must emphasize the importance of context for impact, recognizing that strategies can result in different outcomes at both collective and individual levels. The variation of women's participation in fair trade is due to a range of contextual factors such as gender norms and attitudes regarding labor division, employment opportunities in alternative sectors, migration, resource access, and land tenure. Furthermore, the indirect nature of fair trade's contribution to women's empowerment must be highlighted to avoid false development associations (Helmore and Singh 2001; Smith 2015). Fair trade can facilitate access to higher value markets, provide protection from price volatility, and reward collective investments to build the social, political, and economic bases needed to achieve gender development objectives. These elements intersect with historical organizational practices and national government policies, as fair trade does not systematically challenge pre-existing gender relations in producer dynamics, thus resulting in differential outcomes that can either enhance or inhibit individual and collective empowerment (Helmore and Singh 2001; Raynolds and Bennett 2015; Smith 2015).

CASE STUDY: WOMEN AND FAIR TRADE HANDICRAFTS IN ASIA

The complexities of women's empowerment through fair trade are illustrated in Hutchens's (2010) analysis of the fair trade handicraft market in Asia, led by the World Fair Trade Organization (WFTO). WFTO-Asia is the largest supplier to the fair trade craft market, and includes members from Bangladesh, India, China, Sri Lanka, Thailand, Laos, Nepal, Vietnam, Cambodia, Indonesia, East Timor, and the Philippines. 90% of the organization's members – of whom 80% are women – are involved in crafts. Hutchens challenges the claim that the fair trade handicraft market constitutes a direct avenue for women's empowerment, discussing the deleterious effects of fair trade's "charity" approach to the craft sector and the absence of a policy framework that promotes a human-rights based approach to women's empowerment.

Hutchens delves into broader conceptualizations of discrimination to explicitly address gender equity and women's empowerment, beginning with the complex issues surrounding female participation in organizational and decision-making processes. While fair trade participation may improve women's self-esteem and status, it can also exacerbate heavy workloads while reinforcing traditional gender roles. The fair trade craft sector must contend with the challenge of addressing the realities of women's contextual limitations without reinforcing them as stereotypes. This includes the risk of essentializing producers through notions of exoticism and authenticity, based on the idea of women as "keepers of tradition, who are illiterate, unemployed, confined to the private sphere and bear full domestic responsibilities " (Hutchens 2010, 455). While this is a reality for many poor women for whom craftwork may be the only viable option for income generation, the increased likelihood that unskilled jobs

compatible with traditional roles will be assigned to women results in lower economic returns and further social marginalization. Finally, the distribution and management of returns at the household level remain problematic, with women often lacking control over the income they have generated through fair trade craft channels.

The challenges involved in empowering women through fair trade craft production at the local level are aggravated by ineffective fair trade business models at the global level. Due to the higher cost of getting fair trade products to market, fair trade organizations have fallen behind fair-trade labeled competitors who have benefited from the fair trade discourse while following traditional business models. As these competitors have shifted the traditional fair trade message from an ethics-driven to a quality-driven approach, fair trade organizations have resorted to relying on consumer's humanitarian sensibilities. As a result, the craft sector has dropped from 80% to 20% of overall fair trade retail sales.

In considering the systemic problems that contribute to poor competitiveness, market access, and sales, the WFTO has responded by shifting from an organizational to a trading capacity development focus, and from a producer to a market-driven focus. Hutchens emphasizes that the fair trade craft sector must acknowledge the differential distribution of market knowledge and capacities between producers, traders, and consumers in order to strike a balance between providing guidance and respecting cultural tradition and identity. The author also highlights the need for the new market-oriented business model to take women seriously as economic actors, demanding a more robust regulatory framework that requires "proactive female-empowerment initiatives" and considers the myriad positive and negative impacts that the free trade craft sector can have on women's empowerment depending on how these initiatives mesh with existing social and economic practices.

MOVING FORWARD WITH FAIR TRADE

Market access and poverty alleviation remain key components of a fair trade approach to development, but impacts are increasingly reaching beyond economic outcomes to protect human rights by addressing issues of gender and women's empowerment. Fair trade certification systems can set a standard for democratic, transparent, and accountable producer groups that reinforce participatory democracy and mutual aid. At the same time, the relationships established between producer groups and global market stakeholders can promote cooperation and community-led development by establishing necessary organizational spaces for these initiatives to take hold. These mechanisms have the potential to translate the value placed by consumers on socially and environmentally responsible goods into welfare gains for producers and their communities, positively influencing social and political development alongside economic growth for groups struggling with repressive governments, structural and gender inequalities, and cultural discrimination. (Dragusanu et al. 2014; Raynolds and Bennett 2015).

The concept of empowerment in response to unequal power dynamics in conventional trade is central to the ideals that drive fair trade. Mainstreaming has shifted the focus of fair trade from creating alternative trading mechanisms to helping small producers and workers better benefit from existing trade channels and employment opportunities. However, it can be argued that the implicit objective of restructuring power relations within commodity chains remains a guiding principle for the movement. The Charter of Fair Trade Principles (2009) states that providing better organization, resources, and support for marginalized groups is key to secure access to mainstream markets under fair trading conditions. Thus, fair trade pursues this principle by building capacities, improving producers and workers' bargaining power with buyers and employers, and seeking to improve the laws

that regulate conventional trade (Raynolds and Bennett 2015; Smith 2015).

While fair trade has historically had limited focus on explicitly addressing unequal gender dynamics in commodity chains, it has played an important role as an effective channel for economic development. Moreover, its commitment to non-discrimination, broader approach to empowerment, and emphasis on organizational development and access to resources and opportunities have contributed to efforts aimed at tackling gender inequality. Building on these developments requires community inclusion and active participation in the design and implementation of projects, as well as in the decision-making processes that impact them individually and collectively (Dragusanu et al. 2014; Smith 2015). Women must be given the opportunity to maintain forms of fair trade that are suited to their social, political, and economic contexts, alongside formal certification regimes that work to their advantage (Rice 2010). In turn, fair trade retailers, producers, and advocates must ensure that the movement allows disadvantaged and marginalized producers to be represented with dignity, rather than reinforcing harmful stereotypes. Under such circumstances, fair trade can continue to alleviate poverty through a gender-sensitive, culturally appropriate approach to economic development in a globalized context (Raynolds and Bennett 2015; Smith 2015).

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Development Within a Developed Country: How Economic Growth Creates Economic And Social Inequality

KARA LENTZ

To understand development and the consequences of its practice and implementation, the questions of "Development of what?" and "For whom?" must be addressed. Because development benefits many, yet simultaneously burdens, constrains, and even worsens the lives of countless others, development cannot always be perceived to cause good change (Chambers 1997). When a country experiences rapid economic growth, it may appear to be developing and undergoing good change, but more research is necessitated to illuminate the subsequent creation of the underclass. The phenomenon of economic growth producing an impoverished class of people (Rigg 2016), prevails in many middle-income countries, and is prevalent within developed countries as well. As the processes that create poverty are highly contextualized to each locale, it is seen that the positive effects of economic growth are dependent on social, political, cultural, and environmental contexts, and research must consider these variables in development initiatives. Often, increased economic growth is not distributed equally to all citizens, and those that have access to and participate in the market economy benefit, leaving those that do not, or cannot, behind. The result is often an increase in inequality, which has also been seen to concentrate poverty in certain areas, further encumbering the residents of those areas in their ability to participate as equals in economic, social, political and cultural realms. This paper will demonstrate how these domains affect inequalities in middle income countries, with a specific focus on the United States and marginalized populations such as the African Americans inhabiting a low-income area of North Lawndale, Chicago. Further, it will explain the effects of concentrated poverty as a result of increased economic growth, which has been credited as the main cause of many social problems, such as substance abuse, crime, violence, housing abandonment, family instability and low educational achievement (Massey and Denton 1993). While these trends frequently create negative feedback loops, potential solutions exist that can mitigate the negative effects of economic growth; the resulting income inequality. Policy changes and improvements to the education system, especially in areas that suffer from high rates of concentrated poverty, have the potential to provide the underclass with the same resources as the upper echelons of society, which could begin to close the gap between the social classes and endow the poorest groups with new opportunities and abilities to live up to their full potential.

ECONOMIC GROWTH AND INCOME INEQUALITY AT THE GLOBAL SCALE

A dominant ideology structuring many developmental initiatives focuses on economic expansion and increasing income on national and individual levels. Based on antiquated ideas of development that focus on economic development, many proceedings have failed to acknowledge and alleviate the casualties of capitalistic economic growth, specifically the increases in inequality (Rigg 2016). This is most evident in the case of Southeast Asia during the 1980s, as the region experienced, "miracle growth" (Rigg 2016). The economies of Vietnam, Indonesia, Thailand, and Malaysia were growing and becoming highly globalized, living standards were improving and material well-being was increasing in the richest half of the population, and overall rates of poverty were declining.

This trend became so significant that these Southeast Asian countries were promoted by the Tracking Development Project as a successful economic model, which could be employed by less developed countries in Africa to bolster their economies as well (Rigg 2016).

The Produced Poor

The Southeast Asian miracle growth also allowed these countries to enter the ranks of the middle-income countries. However, this created a whole "bottom billion"(Sumner 2010), a new class of produced poor that did not exist before the increase of economic expansion. This neoteric underclass was created because the growth in income was concentrated in the richest half of the population (Rigg 2016), and it did not trickle down to the poorer half. This allowed the upper echelons to take a step forward, while the rest of the populous could not, and thus were left behind, further solidifying and increasing the gap between classes in middle-income countries. This is especially evident in the fact that, in 2005, 69% of Asia's poor lived in low-income countries, and in 2008, this decreased to 19%, meaning that 80% were living in middle- income countries (Rigg 2016). This demonstrates how development has created poverty in the lower echelons, behind the façade of the positive aspects of economic growth.

A holistic examination of the side effects of capitalistic growth would illuminate the sociocultural, political, and economic factors that have caused such discrepancies between incomes, and the systems that reproduce the income inequalities. Much of the rapid economic growth resulted from increased global marketization and neoliberalism, which benefit those who are able to participate in these arenas. Social injustices, however, impede many from participating equally in such areas, and thus exclude them from the market and from receiving the same benefits as the rich. For example, women, ethnic minorities, the uneducated, and those of ill health are often marginalized from many aspects of social and economic life (Rigg 2016), thus disadvantaging them compared to the majority. Political injustices and capitalistic policies affect people's ability to participate in the market economy, which systemically (Lakoff 2014) set whole groups up either for success or destitution. Tania Li, for example, researched the transition away from communal swidden fields in Sulawesi, Indonesia, to the incorporation and privatization of cocoa. Those that had access to the cocoa trees, usually senior men (Rigg 2016), benefited, while women and younger men who lacked access to the sale and distribution of the cocoa lost out and were economically disadvantaged. Unequal accumulation and unequal access to the global market due to the privatization of fields created social differentiation in the community, and thus generated income inequality. This example also demonstrates the various influences of social, political, and economic factors and how they interact under increased global and neoliberal systems (Li 2014).

Socio-Economic Policies

Capitalistic polices also play a large role in the shaping of the social, political, and economic environments of a country by selectively advantaging some more than others. Income inequality has often resulted from policies that were placed to minimize the growth of the poor, in order to facilitate the overall economic growth of the country and the wealthy. For example, the Thai government imposed taxes on consumption rather than income, which enabled the unequal taxation of the poorer classes (Rigg 2016). This demonstrates that much of Thailand's citizenry were experiencing political injustices that enabled the rich to benefit from the poor, which increased the social and economic inequality and hindered the poor's ability to change their situation. Such policies that promote inequality have often been promoted by government officials and the elites who wish to maintain the status quo and want to protect their own

interests at the expense of the poor (Rigg 2016).

Similarly, sectoral protection policies were enacted in Thailand to support industrial activity in Bangkok. As employment opportunities conglomerated in the larger cities, many migrated and much of Thailand's wealth became concentrated in the larger Bangkok region, and income generating activities were diverted away from the rural areas (Rigg 2008). This negatively affected the lives of many of Thailand's rural populations, as the migration has taken many Thais away from their cultural homelands and entered them into a modern and global environment. Because urban employees and factory workers were becoming enmeshed into larger social networks that connected them to a larger global economic system due to the diversifying industrial sector, they were increasingly becoming exposed to global influences on great scales, which often disconnected them from their cultural roots. This often devalued the social perceptions and economic activities of the agricultural sector, and diminished cultural ideas of what it means to be Thai. Further, this phenomenon also demonstrates how the loss of cultural identity and economic and social differentiation resulted from large scale market integration and globalization (Rigg 2008).

Social differentiation often underlies a country's ability to equally distribute wealth and resources, and this can also be seen in the experience of Singapore in the early 2000s. While the country's GNP experienced growth, 75% of the incomes of the working class decreased. This demonstrates how the actual growth was concentrated in Singapore's top 25%, and none of it extended to the lower levels. This can also be due to the "growth at any cost" strategy (Rigg 2016) that enabled policies to decrease the income of the working class to reinforce the country's economy and propel it to becoming one of the world's richest countries. However, the social environment is not conducive to the success of the lower levels, who suffer from the combined effects of increased costs of living and declining salaries.

Singapore has also effectively concealed their poor by statistically assimilating them into the mainstream. As this country lacks an official poverty line (Wong 2013), the most vulnerable groups become hidden and therefore disempowered, as they are systematically excluded from participating in the same social, political, and cultural realms that are available for the elite. Because of the refusal to acknowledge the poorest populations, Singapore has also succeeded in obscuring the growth of inequality. As there is no measurement to define the poor, there is also no way to monitor the experience of the impoverished, and their issues become depoliticized (Rigg 2016). This can minimalize the rights and needs of the poor, for example by hindering social programs in supporting this population, and from devaluing their contribution to various realms. The plight of the underprivileged then becomes normalized as the economic system separates the haves from the have-nots, further widening the gap of inequality.

ECONOMIC GROWTH AND INCOME INEQUALITY IN THE UNITED STATES

The theme of development within a developed country also relates to inner cities within the United States, such as the vast inequalities in social, political, and economic domains that limit the potential for African Americans. Numerous U.S. cities are affected by underlying problems, such as racial exclusion and prejudice, which have laid the foundations to facilitate the unequal and concentrated growth of incomes (Massey and Denton 1993). Racial discrimination in housing policies, as well as widespread racist ideology, discrimination, and violence physically segregated African Americans, and thus excluded them from participating in many sectors. For example, in a study of policies relating to housing conducted in 1950, 80% of realtors refused to sell property to African Americans in

white neighborhoods, and 68% refused to rent to African Americans in white neighborhoods (Massey and Denton 1993). These policies coincided with government programs such as the Home Owner's Loan Corporation (HOLC), which was implemented after the Great Depression to provide families with loans to alleviate mortgage payments. However, in an effort to exclude African American areas, including areas near African Americans, from obtaining loans, the HOLC created a rating system to classify and evaluate neighborhoods. The lowest ranking areas were those with the highest concentrations of African Americans, and subsequently were coded red to prevent these residents from securing a loan (Massey and Denton 1993). This structural racism disadvantaged African Americans from their white counterparts, who were able to acquire federal assistance, purchase titles to land and homes, and to participate fully in the market. Redlining processes also diverted loans away from neighborhoods that might have black people (Massey and Denton 1993) in an effort to mitigate future migration to these neighborhoods, and to drive African American populations away from white communities. Further, resistance and violence were commonly employed by neighborhood associations, real estate firms, mobs, and hostile city governments to scare and drive out the African Americans who did acquire housing in white communities (Biles 2001). These housing policies and the negative communal reactions are the symptoms of the perpetuation of racist ideology, and demonstrate how capitalistic efforts interact with the social environment to systematically benefit one demographic over another.

The Federal Housing Administration (FHA) also impeded the ability of African Americans to purchase a home by denying them access to economic safety nets. The FHA was instituted to measure the value and validity of collateral exchanged to the bank, so that loans could be insured. The FHA was meant to guarantee over 90% of the value of collateral, so families would only cover the remaining 10% in a down payment. Because this policy enabled payments to be paid in small increments and over long periods of time, the interest rates on the loans decreased, allowing more families to purchase homes. However, these applied solely to the HOLC's high ranking neighborhoods and biased the market to favor white home buyers. Not only did the hierarchical rating system created by the HOLC block many African Americans from benefiting from these services, but it also produced a white out-migration from the inner cities to the suburbs. Those receiving financial support and stability could now afford larger homes in the spacious suburban areas, which left the inner cities with systemically disempowered and poor African Americans. This trend in increased suburbanization was further fueled by increased migration of poor African Americans into the inner cities from even poorer areas, which exacerbated the flow of white migration away from the inner city. The practice of investment unequally benefited the white, upper class communities, and this became normalized into mainstream American society.

Segregation

These discriminatory processes led to the early stages of ghettoization with the adoption of urban renewal proceedings, which endeavored to capitalize on the homes and lands of African Americans. The Housing Act of 1954 (Massey and Denton 1993) allocated rights and federal funds to procure homes in black neighborhoods, so the land could be cleared and used for "re-development" projects. However, the Housing Act also incorporated policies aimed at ensuring affordable housing for the displaced African American families, which birthed The Projects. These multi-unit structures sheltered dense conglomerations of poor, black people, and were situated exclusively in black neighborhoods. Because the projects eliminated many opportunities to privately own homes and replaced private property with dilapidated public housing units, the movement of African

Americans was further restricted to these areas (Biles 2001).

A second wave of Project creation occurred in 1955, when more than 65% of the project residents were African American and 73% of the people moving into projects were also of color. This demographic flow was perpetuated and by 1959, 85% of the residents of public housing were African American (Biles 2001). These policies and projects were structures intended to contain the spread of African Americans and to keep them from participating in social and economic life so that whites could capitalize on space once occupied by minorities to pursue future developmental ventures and maintain racial biases and power imbalances. As a result, African Americans lost opportunities for upward mobility and were physically, economically, and socially isolated from the rest of the city, which effectually concentrated poverty in the Projects. This was further aggravated as the non-poor blacks migrated away from inner cities, leaving behind the financially disempowered residents to remain. While this segregation was structurally instituted by local and national governments and perceived to be beneficial for the well-being of the majority, it created a permanent downward spiral for many African American communities throughout the U.S.

Concentration of Poverty

The 1970s was an especially difficult decade for the majority of African Americans inhabiting urban areas, as it was rife with economic recessions, periods of increased inflation, and emerging neoliberal policies that enabled privatization and foreign competition. The early phases of the neoliberal era decreased wages and welfare payments (Massey and Denton 1993), which disproportionately affected the African Americans of the inner cities, who were more likely to receive unequal pay and were relegated the lowest paying jobs. Subsequently, the sharp economic decline of 1973 intensified income gaps, which increased levels of economic and social inequality and further concentrated poverty in project housing and African American neighborhoods. Because many cities had become so segregated, any increase in black poverty disenfranchised specifically the black neighborhoods (Massey and Denton 1993). Poverty has often been credited as the main source of many social problems as well, such as teen pregnancy, crime, violence, housing abandonment, family instability, and low educational achievement. Further, high concentrations of poverty have been correlated with high concentrations of these social dilemmas. Such spatially and racially concentrated poverty demonstrates how residential structuring and the related policies, as well as capitalism, have systematically exploited inner city African Americans, which has led to the deterioration of their neighborhoods for the advancement of other areas.

Unemployment

Unemployment and job disappearance have also emerged and been exacerbated by the declining availability of low skilled jobs, which has translated to a decreased demand for unskilled labor. This trend has more profoundly and negatively impacted African Americans more than whites because, due to the burden of cumulative experiences of racism, a larger proportion of African Americans are unskilled (Wilson 1999). This shows how African Americans are systemically disadvantaged, which explicates why they are disproportionately affected by changes in the job market and thus suffer the consequences of unemployment unequally. Similarly, employment opportunities have been decentralized from the inner cities, consolidating in suburban areas. This pattern compounds negative effects of the political economy by creating a relationship between job acquisition and social stratification. Employers and institutions have disadvantaged urban African Americans not only by shifting jobs away from them, but also by paying lower wages to

inner city blacks than suburban blacks who have similar levels of education (Wilson 1999). This shows how African Americans don't simply experience the ills of racial discrimination in the job market, but also suffer from classist undertones and polices more severely than other groups.

Unemployment also relates to housing foreclosures, as demonstrated by a study done by Kaplan and Sommers (2009). These authors elucidate that a weak or unstable employment situation often increases unemployment by promoting personal and commercial bankruptcies and reduces private and public cash reserves. This may compromise the ability of borrowers to meet their monthly payments, which often results in housing foreclosures. These authors also notice that housing foreclosures do not occur equally across metropolitan areas but are instead systematically clustered in neighborhoods that have already experienced housing foreclosures or have large concentrations of minorities (Kaplan and Sommers 2009), demonstrating the role of spatial disadvantage. Since the 1990s, foreclosures have affected inner cities more than any other area, afflicting these neighborhoods excessively. Once residents are unable to finance their homes, they are often forced to migrate to even poorer areas, which might have cheaper housing options, thus redistributing poverty (Sampson 2012). This phenomenon has hindered many African American families living in inner cities, as they are more likely to also live in poorer neighborhoods, and are more at risk for experiencing racism in relation to housing markets and bank policies and regulations. These compounding effects have resulted in the solidifying concentration of poverty in areas with high concentrations of poor African Americans disenfranchised by their institutional lack of opportunities.

Educational Barriers

Another barrier that many contemporary African Americans experience is access to education or adequate schooling due to the compounding effects of discriminatory housing policies, decreased opportunities, decreased funding, and social and economic marginalization. For example, one of the main theoretical arguments put forth by economist Joseph Stiglitz (2012) is that unequal levels of income lead to inequalities in education. This can be seen as students that come from low income areas usually attend low income schools, which are often of lesser quality compared to schools in middle and high-income areas, situated in dangerous areas, and unequally funded by the government and politicians. These marginalizing factors perpetuate cycles of poverty, as these factors build barriers for students of color and make it harder for them to attend institutions of higher education or college. Eventually this causes the workforce to be less skilled than in communities that benefit from equal access to education (Matthews 2013).

ECONOMIC GROWTH AND INCOME INEQUALITY IN CHICAGO

Many of these themes are reflected in Chicago, one of the most racially segregated cities in the United States. African American neighborhoods in Chicago have unequally suffered from rises in income inequality, and lag behind other neighborhoods which continue to grow and prosper. Racial segregation has been credited for much of the lack of access to resources within the ghettos, such as employment opportunities, as many residents are isolated from the formal work force. Joblessness in the ghettos of Chicago has been an economic and a social issue for decades, which has disadvantaged the residents of such areas in both these domains. For example, it was noted that in 1990, only a third of the working force, defined as able people aged sixteen years and older, held a job in Chicago's poorest areas (Wilson 1999). This demonstrates that in areas with a poverty rate of 30% or more, most of the population will not be able to acquire a job within the formal economy, which has negative

implications for myriad subsequent issues. For example, in his public discussion on racial issues and their reproduction in American societies, Ibram Kendi states that "unemployment is the cause of social problems" (Kendi 2016). Nothing else, including race or socioeconomic status, is a stronger predictor of violence, illegal activities, family instability, and low educational achievement in an area than high rates of unemployed residents.

Educational Barriers

Inequalities in education are further substantiated by an assessment on teacher quality in U.S. cities. The initial report, conducted by the Ohio, Illinois, and Wisconsin school systems in conjunction with the organization Education Trust, explains that poor students of color often underachieve in schools because they enter behind and because of the educational system's inability to provide them with high quality teachers - the resource they need most if they are to reach their highest potential (Peske and Haycock 2006). This study collected data on teachers and their nation-wide distribution, and found that low-income schools with high levels of low-income and minority students had the highest rates of unqualified or uncertified teachers. Further, students in low income high minority schools are also disproportionately assigned to teachers who are new to the profession, not finished with their teaching licensure, lack a teaching degree, or do not have a strong educational background in the subjects they teach (Peske and Haycock 2006). An in-depth analysis of Chicago Public Schools was also included in this report, and it found that teachers in low income and black areas were more likely to have failed an examination of basic skills, when compared to the national average of teacher evaluations (Peske and Haycock 2006). This study illuminates the fact that contemporary students are marginalized based on their race and geographic location. This not only creates poverty cycles but is also illegal under the 14th amendment of the United States constitution, which states that all students will be given equal educational opportunities no matter their race, ethnic background, religion, or sex, whether they are rich or poor, or whether or not they are a citizen. Although these laws are written in the constitution, these values are not always represented at the local level. Further, these analyses also highlight a portion of the barriers that students must overcome in order to obtain an education, and demonstrate the various systems that have the ability to disadvantage a student's academic success.

Similarly, a study examining resource allocation and investment disparities between inner-city and suburban schools, and how these factors relate to educational success, reflects a dominate trend that is often seen in Chicago. While most suburban and white schools receive a variety of resources and a much higher investment per student, Roscigno (2006) writes that, due to the lack of a combination of realities experienced by inner city families and schools, such as lower family income, underfunded schools, less parental education, large families, and decreased family involvement, student educational achievement and attainment are severely diminished. The author also found, through a model explaining such variation, that students in Chicago's inner city are 28% more likely to drop out of school than their suburban peers. Further, this study aimed to distinguish the impacts of school investment per child in order to determine if this measurement could account for the high rates of drop outs. This determined that, when holding family resource expenditure constant, school investment per student had the strongest impact on scholastic achievement and drop-out rate (Roscigno 2006). Through this study, it is seen that family resources and socioeconomic status influence a student's ability to perform well and to stay in school, but the measure of the school's investment per child also has a significant impact on student's success;. in inner city schools, the amount invested per student is much less than

in suburban schools. This research highlights the external variables that play a role in educational obtainment, and how these factors selectively disadvantage those residing in low income and non-white neighborhoods.

CASE STUDY, NORTH LAWNDALE, CHICAGO

Cultural Background

Moving to a smaller scale, all of these themes are apparent in the case of North Lawndale, Chicago, established in 1857 (Lane et al. 2004). This community, located on Chicago's West side, experienced industrial and residential development beginning in the 1870s with growing boulevards, increased infrastructure, and budding real estate businesses (Rosenthal 1960). Many European immigrants began to move into the area, most from Amsterdam, Ireland, Germany, Russia, and Hungary, and quickly integrated into North Lawndale's middle, working class. After a century of little development, a railroad line was constructed that connected Douglas Park to the neighboring district of Cicero (Rosenthal 1960). This increased connectivity made North Lawndale an ideal location for large industries, as it provided a means of transportation for the working class, and soon after, seven new businesses operations were established in the area. Among them were Western Electric (Rosenthal 1960), McCormick Reaper Works, Joseph T. Ryerson and Son Steele Plant, the Sears Headquarters, and Roebuck and Co, which opened in 1906. North Lawndale was renowned for its booming industrial businesses, as they provided the town with well-paying jobs in the manufacturing sector, social services, health clinics, libraries, sports arenas, gardens, music venues, and a burgeoning economy (Lane et al. 2004). During this time, the housing market also grew rapidly.

Beginning in 1915, construction was devoted to building multi-family dwellings and cultural amenities. With such an increase in housing facilities, including large apartment buildings that had upwards of 20 units, the population grew 20%, and the majority (75,000 out of 112,000) of these new residents were Jewish (Rosenthal 1960). With the drastic population growth and increased concentration of the Jewish community, many neighborhoods began to experience land crowding and the prevalence of Jewish facilities and services dominated North Lawndale. For example, Kosher butcher shops, Hungarian delicatessens, and Jewish book stores were rapidly erected to support the increased immigration. Analogously, over 40 new synagogues were constructed by 1929, including the Congregation Anshe Kneseth Israel, which, with 3,500 seats, was the largest in the entire city of Chicago (Rosenthal 1960). Soon after its establishment, the congregation supplemented its service with a Hebrew school. Herzl Junior College, a tuition-free institution, was then founded in 1935 on Ridgeway Avenue, in the center of North Lawndale, to honor Jewish political activist and Zionist Theodor Herzl. This school educated 1,000 local students at its inception (Rosenthal 1960). Another large educational facility, the Jewish People's Institute, was built to encourage adult education and provided resources for lectures, forums, discussion groups and formal classes for adult learners, extended support to the public-school program, and additional educational opportunities such as after-school activities, a music school, an art program, library facilities, and clubs, (Rosenthal 1960). As a result of such successful programs and services, the standard of living and life expectancy increased.

Socio-economic restructuring

This era of social and economic prosperity ceased when, in the 1950s, a majority of Jewish, white Americans left North Lawndale for newly constructed suburbs in the city's northern regions (Lane et al. 2004). Due to the overcrowding, which led to housing deterioration, many of North Lawndale's properties declined in value and prompted wealthier, white residents to move

to nicer neighborhoods (Rosenthal 1960). This white flight caused a decrease in town status, which also influenced younger generations to venture elsewhere for new opportunities, thus leaving behind an aging population and those who could not move. For example, many Jewish immigrants left their initial residence in North Lawndale to live in more prosperous areas such as Albany Park, Rogers Park, and the luxury tower apartments off Sheridan Road in the prosperous Lakeview neighborhood (Rosenthal 1960). This is also apparent in the population decrease from 87,000 white residents to 11,000 inhabitants during the decade between 1950 and 1960 (Lane et al. 2004, Lawndale Christian Health Center, North Lawndale History). This population decline caused a vacancy in housing units in North Lawndale, allowing lower income families to move in and changing the socio-demographic makeup of the area in a process reminiscent of the ghettoization of the 1950s and 60s.

With the large migration of Jewish people out of North Lawndale, many of the cultural facilities were dismantled, as they were the product of volunteers and were not governmental undertakings. Because so many of the social services were created by the Jewish groups, there were often many debates as to whether these institutions should stay in North Lawndale, move with the Jewish community, or disassemble completely. For example, the 1953 Chicago Board of Education terminated the Herzl Junior college and eventually turned it into a predominately African American elementary school, Herzl School of Excellence (Rosenthal 1960). Many other social service buildings, such as labor groups, religious centers, the Jewish People's Institute, and the Hebrew Theological college were also turned into public schools, many of which were eventually abandoned, or African American churches of many Christian denominations.

North Lawndale experienced further change as jobs within the manufacturing sector began to disappear due to a shift in the global market that favored service jobs. Deindustrialization affected many social-economic factors in the period between the 1970s and 1980s, a time marked by an 80% decrease of manufacturing jobs. One of the most devastating events during this time was the shut-down of the Sears headquarters, which employed a large portion of North Lawndale's residents and sustained the town's industry. Once this industry had closed, the majority of the town became unemployed, and an underclass was produced.

Educational Barriers

The theme of decreased access to education is especially prevalent in parts of Chicago where many schools with high proportions of students of color are negatively affected by policies that enable discriminatory funding. For example, students of the Chicago Public Schools system are put at a disadvantage due to the policies enacted by the Governor of Illinois, Bruce Rauner. His rulings allocate only 15% of the state's funding to the 20% of students that reside and attend schools in Chicago, and the 5% difference amounts to $500 million dollars a year that could be used to increase educational opportunities in inner-city schools, but that are instead funneled into other schools (Chicago Public Schools, n.d.).

Further, this trend is worsening. This can be seen statistically, as state funding to CPS decreased by 8% between 2009-2017, while funding to all other school districts between the same years increased by 45%; $9,571,937,253 was spent on schools outside of Chicago, while the state only spent $1,604,828,661 on Chicago public schools. This amounts to stark contrasts in educational opportunities for both teachers and students, especially teacher pensions and funds spent per student. For example, in 2017, Illinois spent $2,437 per student on teacher pensions outside of Chicago, but only spent $32 per student for teachers within the city limits. This also means that for every dollar

spent per student in the state of Illinois, only 78 cents is allocated to students in Chicago (Chicago Public Schools, n.d.). This demonstrates that students in Chicago public schools are receiving separate, but not equal, educations due to structural inequalities within the political and educational systems.

These policies disproportionately affect students of color, as CPS schools have student populations that are 90% of color compared to other schools in the state of Illinois that are 90% white. For example, in public schools in the state of Illinois, an African American child is 11 times more likely to attend CPS and a Hispanic student is 9 times more likely than a white student to attend CPS (Chicago Public Schools, n.d.). One such school, Herzl School of Excellence, is a CPS school located in North Lawndale on Chicago's West side. It is 97.8 % black and 99.3% low income, and is ranked 291 out of 358 schools in Chicago. It's Chicago Public Schools status declares that it receives intensive support from Title 1 and AUSL (Chicago Public Schools, n.d.) as government funding alone does not sustain it. Many members of this community have expressed their concern that the school does not receive adequate funding, does not provide equal opportunities for students compared to the greater Illinois area, is located in a dangerous part of town, and, due to lack of funding, does not have a bus route to transport students to school safely. Interviews from school officials, parents, and teachers highlight the discriminatory processes perpetuating unequal access to educational resources. This unequal access increases income inequality, as students of this neighborhood are systemically disadvantaged compared to their white and wealthier peers (personal interviews).

While many argue that these schools are up to par with other Illinois schools, more research is needed to further highlight the ways that political, economic, and educational systems disadvantage students, so solutions to break down barriers can commence. Much work has shown that discriminatory funding will negatively affect a student's ability to obtain an education as they will systemically be left behind their white counterparts for the year, which will also disadvantage them in subsequent grades or in college. Further, lack of funding can send covert messages to students - who are aware that their education is at risk of being cut short due to injustices in state and federal policies - that they are worth less than other students because of where they come from. Racism and income inequality are compounded to create and reproduce social inequalities that will follow residents of such areas throughout their entire education careers, unless policies are enacted and monitoring methods are used to make sure that policies that declare equal opportunities actually provide equal opportunities for all students.

Conclusions

Economic growth in a developed country does not mean development, or good change, for all. This can be seen at the global level, by the various economic booms throughout Asia that brought prosperity to a portion of the population, increased the gap in income inequality, and produced a class of people who were now poor relative to those who had access to the capitalistic market and benefited from economic growth. In Thailand, jobs often shifted away from impoverished rural areas to accommodate economic growth in urban centers, and in Singapore, wealth did not trickle down to the lowest levels of poor people, thus intensifying income inequality. This trend is also evident at the national level in the case of the United States. While this developed country did experience drastic increases in economic growth during the 1950s and 1960s in reaction to WWII, this wealth was not distributed equally, and marginalized locations, such as urban areas with high concentrations of poor African Americans, experienced negative cultural transformations, economic downturns, and job disappearance.

Further, when the 1970 recession transpired, those at the bottom - those who experienced the compounding effects of being a part of an ethnic group and the lower class - felt the impact of job disappearance and decreased salaries more strongly than any other group. North Lawndale, Chicago, and more specifically, the community surrounding Herzl School of Excellence, are prime examples of the produced poor, as this area became poor and marginalized because of changes in the global economy and increased growth within the U.S. in conjunction with racist and prejudiced foundations. Numerous economic, political, and cultural transformations occurred as reactions to economic growth and decreased North Lawndale's access to jobs, the capitalist market, education and social services, which in turn increased social ills and widened the gap between the rich and the poor. Economic growth, while often synonymous with development, does not always mean good change, but instead can also create undesirable change. Therefore, the term "development", and the ideology of development, must continue to be contested, so that initiatives to bring good change can work to do so in a holistic, just, and sustainable manner.

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Ethical Consumption: Moral Sentiment And The Capitalist Market

STEFANIE BERGANINI

Recent decades have seen the rise of what has become known as "ethical consumption": various types of spending – from fair-trade to organic to sweatshop-free products – which embrace a consumer's personal sense of morality. In recontextualizing the moral status given to wastefulness as a sign of affluence, ethical consumption re-situates Thorstein Veblen's notion of conspicuous consumption.

Traditional notions of affluence took for granted the natural subsistence wage provided by the economy; early economists including Adam Smith, Richard Cantillon, and David Ricardo all discussed the obvious assumption that the reproduction of the economy was tied to the ability of workers to meet their basic needs through their labor. As modern economies – and modern capitalism – have evolved, wages have stagnated, income inequality has increased, and many members of society are no longer able to provide for their basic needs without assistance. In analyzing the presence – or lack – of subsistence wages through the framework of Adam Smith's *Theory of Moral Sentiments*, ethical consumption can be seen as the natural outcome of a shifting understanding of the nature of poverty.

THE ECONOMY: NATURAL PROVIDER OF SUBSISTENCE

Throughout the history of classical economics, many prominent theorists have observed the need for a natural wage tied to the ability of workers to provide for their subsistence needs. Adam Smith is likely the most salient historical figure advocating for subsistence wages, noting that there is a minimum rate above which "even the lowest species of labor" (2009 [1776], Ch. 8) must be paid. For Smith, it was taken for granted that "a man must always live by his work, and his wages must at least be sufficient to maintain him" (2009 [1776], Ch. 8). It is important to understand that the idea of subsistence did not apply solely to the worker himself, but to his entire family, as without a new generation of workers the economy could neither survive nor grow. Subsistence, then, included whatever was needed to maintain a wife and raise children. In *The Wealth of Nations* Smith reflects on Cantillon's assertion – from 1775's *Essay on the Nature of Trade in General* – that a subsistence wage should equal twice the requirements to sustain a single worker, but concludes only that subsistence should, at the very least, be a dynamic amount "consistent with common humanity" (2009 [1776], Ch. 8).

Several decades later, in discussing the difference between market and natural wages, David Ricardo confirmed the need for subsistence wages, noting that a worker must "support himself, and the family which may be necessary to keep up the number of labourers" (2010 [1817], Ch. 5). Again we see the call for a wage which supports not only individual laborers, but also their wives and children. Ricardo also notes that this wage is not a fixed dollar amount, but whatever rate is necessary for a worker to purchase "food, necessaries, and conveniences become essential to him from habit" (2010 [1817], Ch. 5) at their current market rates. The market wage fluctuates around this natural wage, with workers "flourishing and happy" when the market rate is above the natural rate and suffering in "most wretched" poverty when the market rate is below it (2010 [1817], Ch. 5).

Even Karl Marx recognized the hypothetical power of the capitalist market to provide for the subsistence needs of workers. In *Das Kapital*, he notes:

> The fact that half a day's labour is necessary to keep the labourer alive during twenty-four hours does not in any way prevent him from working a whole day. ... The owner of the money has paid the value of a day's labour-power; his, therefore, is the use of it for a day; a day's labour belongs to him. The circumstance that, on the one hand, the daily sustenance of labour-power costs only half a day's labour, while, on the other hand, the very same labour-power can work during a whole day, that consequently the value which its use during one day creates, is double what he pays for that use, this circumstance is, without doubt, a piece of good luck for the buyer, but by no means an injury to the seller (1867, 394).

This relationship is key to Marx's labor theory of value: workers are entitled to the portion of their productivity needed to meet their subsistence needs, and capitalists are entitled to any surplus productivity above and beyond the subsistence level. This creation of excess productivity is the mechanism by which surplus value is created and the economy is able to grow. This passage highlights two important facts: first, it assumes the necessity of a subsistence wage, and second, it positions this scenario as amenable to both worker and capitalist.

For economists such as Smith, Ricardo, and even Marx, subsistence wages were an obvious and necessary element of a functional society: if workers could not survive and reproduce, the economy could not survive and reproduce either.

THE ECONOMY: SITE OF EXPLOITATION

While the existence of a subsistence wage is taken for granted in much of classical economics, many theorists also recognize the potential of markets to minimize wages as much as possible. Adam Smith, for example, takes care to explain the ongoing tension between "masters" (2009 [1776], Ch. 8), who want the lowest possible wage, and workers, who want the highest. This situation rarely works to benefit workers, as the control of resources wielded by masters means that "it is not, however, difficult to foresee which of the two parties must, upon all ordinary occasions, have the advantage in the dispute, and force the other into a compliance with their terms" (2009 [1776], Ch. 8).

Marx understood this power dynamic very well; it is the same conceptual basis upon which he builds the theory of exploitation. For Marx, exploitation is exacerbated by the industrial reserve army, that pool of surplus population left unemployed by the diminishing proportion of labor needed as capital accumulates. The presence of the industrial reserve army positions employed laborers in competition with those unemployed, incentivizing employed workers to "submit to over-work and to subjugation under the dictates of capital" (1867, 401). Marx is clear about the harsh reality posed by these inherent relations of production, concluding that "accumulation of wealth at one pole is, therefore, at the same time accumulation of misery, agony of toil, slavery, ignorance, brutality, mental degradation, at the opposite pole" (1867, 404). Thus, although – as mentioned previously – working conditions hypothetically provide a mutually beneficial environment for both workers and capitalists, in practice workers are often forced to offer their labor at below-subsistence rates or risk falling into the ranks of unemployment.

John Kenneth Galbraith, providing another explanation for downward pressure on wages, describes the rise of "convenient social virtue" (1973, 30). This label is given to many professions – from social worker to janitor to nurse – which provide some benefit to more powerful members of society but for which workers receive inadequate financial remuneration. By assigning merit to these positions, "the moral commendation of the community for convenient

and therefore virtuous behavior then serves as a substitute for pecuniary compensation" (1973, 30). Workers in these professions receive praise for providing a public good, but this praise comes at the expense of acceptable wages. Failure to adhere to this recontextualizing – to demand, for example, a fairer rate of pay – becomes "deviant" or "despicable" behavior subject to the "righteous disapproval" of the community (1973, 30).

These issues still plague the contemporary United States economy. A 2014 report by the Economic Policy Institute (Bivens et. al) found that financial deregulation, changes in overtime pay, shifts in protective labor standards, and other deliberate policy actions have engendered a modern economic system in which "the last 35 years have been mostly (excepting the late 1990s) a period when hourly wages of the vast majority lagged far behind economy-wide productivity". These changes have serious consequences: the report also concludes that, from 1979 to 2012, wage inequality contributed more to the incidence of poverty – several times more, in fact – than did other more commonly cited factors such as education level, family structure, or race/ethnicity. In discussing the most recent data compiled by MIT's Living Wage Calculator, Glasmeier and Nadeau note that in a typical American family comprised of two adults and two children, each adult would need to work nearly 80 hours a week at minimum wage in order to meet their family's basic needs. Modern American society has clearly deviated from the assumption that subsistence wages are a hallmark of a successful economy.

THE RISE OF ETHICAL CONSUMPTION

The modern increase in income inequality parallels the rise of a type of consumerism known as ethical consumption. Rooted in Thorstein Veblen's theory of conspicuous consumption, ethical consumption allows for the simultaneous expression of capitalism and personal morals.

Veblen's premise is based on the observation that the institution of private property, wherever it is found throughout history, brings with it "a struggle between men for the possession of goods" (2008 [1899], Ch. 2). This struggle, once it meets modern industrialization and productivity, becomes divorced from the need to accumulate wealth for the purposes of subsistence. For those no longer struggling to meet their everyday needs, "it [property] therefore becomes the conventional basis of esteem. Its possession in some amount becomes necessary in order to any reputable standing in the community. It becomes indispensable to accumulate, to acquire property, in order to retain one's good name" (2008 [1899], Ch. 2). The accumulation and display of wealth becomes an honorable and meritorious act, with grandiose displays of consumerism marking the position of the most affluent members of society. Key to Veblen's model is the element of waste: elevated status involves the waste of either time – termed "conspicuous leisure" (2008 [1899], Ch. 3) - or goods.

Ethical consumption represents a new version of Veblen's framework. In choosing fair-trade, organic, or otherwise ethically or sustainably produced goods, consumers signal their strong moral commitments to those around them. Instead of focusing on waste as a marker of status, ethical consumers choose products incorporating environmental sustainability, corporate transparency, and/or fairness toward workers. This type of consumption is "motivated not only by the desire to do the right thing, but also by the promise that sustainable goods will help them to construct a moral identity consistent with their values and beliefs" (Isenhour 2012, 241).

While there is no official definition of "ethical" consumption, a wide variety of data points to a growing trend with real effects in the marketplace. The number of fair-trade organizations – those dedicated to fair and sustainable conditions

for producers in developing countries – has more than doubled over the past decade. In 2007, there were 553 officially certified fair trade organizations across 54 countries (FLO 2007); last year there were 1,240 organizations across 75 countries, and 2015 revenue from fair trade products topped €1 billion (Fairtrade International 2016). The United Nations recognizes "sustainable consumption and production" as the twelfth of its sustainable development goals, with associated metrics to monitor sustainable business practices and shifts in material consumption (United Nations Economic and Social Council 2017). The last decade has seen the continuing rise of B Corporations, for-profit companies committed to "rigorous standards of social and environmental performance, accountability, and transparency" (B Corporation, n.d.); in 2009 there were 205 B-Corps in the United States and Canada, today there are nearly 2,500 spread across over 50 countries (B Corporation, n.d.). These trends are significant enough that a 2009 cover of Time magazine heralded "The Rise of the Ethical Consumer" (Stengel, see Fig. 1).

Industry research illustrates the growing importance of these issues to consumers: over half of American consumers will stop purchasing products by brands they think are unethical; over a third will do so even if there is no substitute available; and nearly two-thirds feel that "ethical issues are becoming more important" (Mintel 2015). And in 2015, the United Kingdom marked its fifteenth consecutive year of growth in the "ethical purchases" sector of the economy (Triodos Bank and Ethical Consumer 2016, see Fig. 2).

Figure 1: Time *magazine cover, September 21, 2009.*

To be clear, ethical consumption is still a form of conspicuous consumption: a privilege reserved for those with enough wealth to shop according to their morals. For those who reach a certain level of affluence, ethical consumption "signal[s] membership in an emerging group of upper middle-class people who can afford ethical goods targeted toward those willing to pay more for a greener lifestyle" (Isenhour 2012, 241). Thus, while ethical consumption is still firmly entrenched within the existing capitalist ethos, it also reflects shifting sentiments on the part of capitalist consumers.

CHANGING MORAL SENTIMENTS

I believe that this shifting sentiment can be traced back to the presence – or lack – of subsistence wages in the economy, and the related effects on the perception of poverty in society. Much of this transformation can be illustrated by returning to Adam Smith, and undertaking an analysis of selections from *The Theory of Moral Sentiments.*

While discussing "the effects of prosperity and adversity upon the judgment of mankind" (Part I, Section III), Smith notes that:

> It is because mankind are disposed to sympathize more entirely with our joy than with our sorrow, that we make parade of our riches, and conceal our poverty... For to what purpose is all the toil and bustle of this world? What is the end of avarice and ambition, of the pursuit of wealth, of power, and preheminence? Is it to supply the necessities of nature? The wages of the

> meanest labourer can supply them. We see that they afford him food and clothing, the comfort of a house, and of a family (2002 [1759], 60-61).

Here we see the classical assumption of a living wage: that amount necessary not just to sustain a laborer, but a laborer and his family. For Smith, the culturally appropriate response to poverty was rooted in the presence of wages which supplied basic needs. In this historical context, every laborer willing to exert effort could achieve, if not affluence, at least an increase in living standards significantly above subsistence level: "In the middling and inferior stations of life, the road to virtue and that to fortune, to such fortune, at least, as men in such stations can reasonably expect to acquire, are happily in most cases, very nearly the same. In all the middling and inferior professions, real and solid professional abilities, joined to prudent, just, firm, and temperate conduct, can very seldom fail of success" (Smith 2002 [1759], 74). At a time when "poverty may easily be avoided, and the contempt of it therefor almost ceases to be a virtue" (Smith 2002 [1759], 240) it became uncouth to acknowledge the mere existence of poverty, let alone take action to understand its causes and solutions. In contrast to successful men, the impoverished man of Adam Smith's day "goes out and comes in unheeded, and when in the midst of a crowd is in the same obscurity as if shut up in his own hovel" (Smith 2002 [1759], 62).

This moral distance is not related to any sort of cruelty, but rather the limits of empathy. Smith holds that the only way we can understand the plight of our fellows is through our imagination, by "conceiving what we ourselves should feel like in the like situation" (2002 [1759], 11). If, as Smith believes, poverty is easily avoided, it is easy to understand that poverty in this context would be seen not as a condition deserving sympathy, but one indicative of some kind of "fraud, falsehood, brutality [or] violence" and deserving of "scorn and abhorrence" (2002 [1759], 195).

I posit, however, that as the economy moved away from subsistence wages into modern conditions of wage stagnation and extreme income inequality, the moral position of poverty also became decoupled from its classical roots. Smith's conception of human nature is neither unfeeling nor exclusively self-interested; he holds that in the end we are moral creatures who care about the plight of our fellows:

> There can be no proper motive for hurting our neighbor, there can be no incitement to do evil to another, which mankind will go along with, except just indignation for evil which that other has done to us. To disturb his happiness

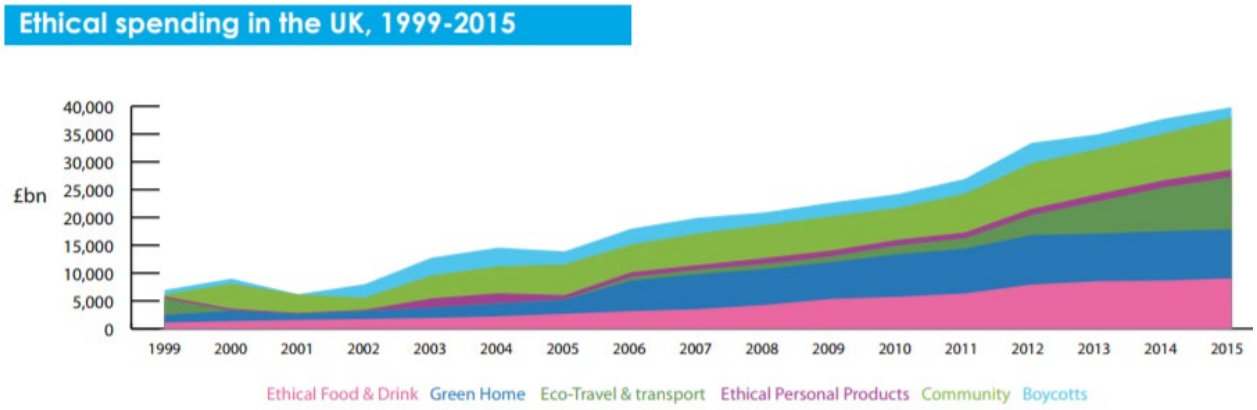

Figure 2: Ethical spending in the United Kingdom by market sector (from Triodos Bank and Ethical Consumer 2016).

> merely because it stands in the way of our own, to take from him what is of real use to him merely because it may be of equal or of more use to us, or to indulge, in this manner, at the expense of other people, the natural preference which every man has for his own happiness above that of other people, is what no impartial spectator can go along with (2002 [1759], 96).

Our inherent sense of justice, when triggered, becomes a driving force in shaping our moral response to poverty. For Smith, the presence of objective instances of injustice – for example, the realization that our economic system exploits some for the gain of others – does not just arouse sympathy, it requires action. In an increasingly globalized world it can be hard to conceptualize the vast interconnected webs that comprise international supply chains and distribution networks, but an increasingly globalized world also provides the technology through which determined individuals can inform themselves about their purchasing decisions. A recent report by the World Bank Group, for example, notes that despite the slow success of poverty-alleviation programs, "we continue to live in a world characterized by intolerable inequality of opportunity, gender disparities, and deprivations, particularly in health, education, safe water and sanitation, nutrition, and consumption" (2016). According to the group's most recent data, nearly 11% of the global population lives below the extreme poverty line, an amount equivalent to an income of $1.90 per day (World Bank Group 2016). The United States Census Bureau calculates a "supplemental poverty measure", or SPM, which defines poverty based on expenditures needed for food, clothing, shelter, and utilities – what could arguably be defined as the necessities required for subsistence. The most recent report found that 14% of Americans live below this threshold, unable to meet their basic needs without assistance (Fox 2017, see fig. 3).

This plight awakens the better angels of our nature, invoking a shared sense of struggle and an increased feeling of empathy for those marginalized, exploited, or otherwise relegated to poverty. As we realize the suffering manifest in our economic systems, we feel moved to act, as we are able, to alleviate what suffering we can. As the previously presented data shows, I believe increasing awareness of the poverty created by modern global capitalism has triggered real, measurable changes in ethical consumption patterns.

CONCLUSION

Ethical consumption does not overturn conspicuous consumption, it merely re-situates it within a different moral framework. When natural wages are enough to meet subsistence needs, conspicuous consumption bears no moral penalty; it is merely an expression of Smith's conclusion that "to deserve, to acquire, and to enjoy the respect and admiration of mankind, are the great objects of ambition and emulation" (2002 [1759], 73). Naturally then, the outcome of such a society is the existence of those engaging in Veblen's wasteful conspicuous consumption. This also explains the lack of moral condemnation of such spending in these contexts, as a subsistence

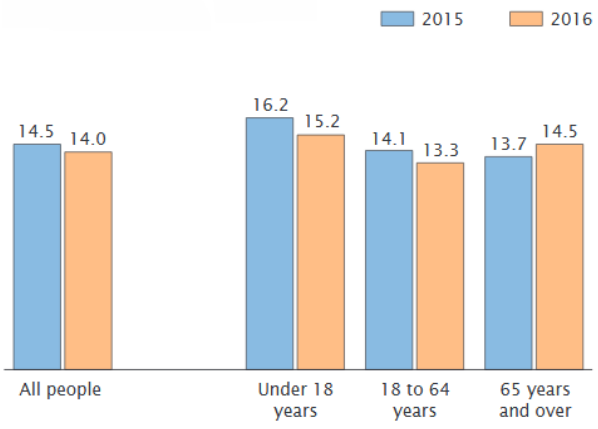

Figure 3: SPM Poverty Rates for Total Population and by Age Group, 2015 and 2016 (in percent, from Fox 2017).

wage leads to an environment in which "the vices and follies of the powerful [are] much less despised than the poverty and weakness of the innocent" (2002 [1759], 73).

Yet, as the nature of wages changes, so to does the moral framework within which we situate poverty. If members of society are unable to meet their needs despite their application of Smith's "real and solid professional abilities, joined to prudent, just, firm, and temperate conduct" (2002 [1759], 74), we are obligated by the "principles of [our] nature" (2002 [1759], 11) to recognize this as a valid predicament deserving not only empathy and sympathy, but changing consumption habits. Veblen's wasteful conspicuous consumption becomes, in this setting, illustrative of the gain of some at the expense of others; what was a marker of elite status and reputation now becomes "wicked and worthless" (Smith 2002 [1759], 255). While still existing within the bounds of capitalism, ethical consumption provides an alternative moral path, one through which consumers can signal "[their] social status, [their] membership in a group and [their] understanding of shared norms and values" (Isenhour 2012, 234).

Smith makes clear that, given the continued presence of evidence, this change in moral sentiment eventually affects all members of society: "How selfish soever man may be supposed, there are evidently some principles of his nature which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it except the pleasure of seeing it... the greatest ruffian, the most hardened violator of the laws of society, is not altogether without it." Indeed, if Adam Smith were alive today, I suspect he would be not just an ethical consumer, but an ardent proponent of raising the minimum wage to a living wage which provides all members of society with the necessities of modern subsistence.

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The Decline of Swidden in Southeast Asia under Changing Property Regimes: Assessing Political-Economic Drivers of Land-use/Land-cover Change and Associated Human-Environment Impacts

KIRK SAYLOR

This paper provides a brief geographical and historical background on swidden[1] (shifting cultivation) as a mode of "common property" production enduring over centuries or perhaps millennia (Fox et al. 2009; Leisz 2017). It was discovered and documented in Southeast Asia (SEA) by various observers in the colonial to post-colonial periods, before collectivization under communism, which marginalized but did not succeed in eliminating the practice altogether. The rise of market-oriented agricultural production and timber extraction in the post-Cold War, along with various neoliberally oriented policy measures, pose a new challenge to the continuance of swidden as a viable *modus vivendi* and by extension the socio-cultural cohesion of its increasingly marginalized practitioners (i.e. upland ethnic minorities). Outcomes for both humans and the environment might ultimately benefit from initiatives to accommodate swidden practice rather than continued efforts to eliminate it altogether.

During the modern era of economic development and accelerating rates of deforestation, subsistence farmers have been assigned a lion's share of blame for deforestation and degradation of forest lands by both governments and outsiders, despite other actors and factors having contributed significantly more to changing LULC in the region over the last several decades. While the vast majority of the populations of Lao PDR and Vietnam do in fact reside in rural areas, with UN/World Bank estimates still ranging from 75-80% for both countries as of the early 2000s (Rigg 2005), it would be unfair to assign blame on the rural poor and in a sense wrong to do so, i.e. a "blaming the victim" sort of fallacy, for reasons this paper will seek to enumerate. A central issue for this forest transition pertains to the question of property regimes, in particular the shift from a "common property" framework for managing a "common pool" resource to a private property regime that requires clear binary classifications of land as privately held by individuals or publicly held by the government. This binary system admits no possibility for an intermediate "common property" regime that does not neatly fall into either a distinctly agricultural or forested category. To the extent that a public/private dichotomy commoditizes extractable resources, it can also discount ecosystem services and externalize negative outcomes. This subject relates to many themes of international development, including social science concerns about equity and fairness with respect to the dominant political-economy, as well as conservation/degradation of natural resources, ecosystems viability, and environmental sustainability, which this paper seeks to explore.

DEFINING "COMMON PROPERTY" AND HISTORICAL OBSERVATIONS OF SHIFTING CULTIVATION PRACTICE IN SEA

To place the discussion in its proper theoretical framework, this paper defines the concept of "common property" (alternately referred to by some as "plural property") and some related terms. For the purposes of this paper, "common

property" will be defined as *shared private property* for a given resource that is essential to survival or well-being of a community. Such resources are regarded as "common-pool" category resources and historically were managed by "common property regimes", where users enjoy *rights to use*, rather than explicit legal *ownership of*, a particular stock, and where rights to resource flows can be parceled. Such rights would be limited to a *specific group of users* and therefore conducive to "responsible stewardship" of resources over "long time horizons" (McKean 2000, 28-37). McKean characterizes this mode of resource use as appropriate to *indivisible* resources such as forests.[2] McKean differentiates a true commons from an *unmanaged* open-access regime that inevitably leads to what Hardin mistakenly (by his own admission) called the "tragedy of the commons" rather than the "tragedy of the unmanaged commons" (Hardin 1968).

Next, to place the discussion in its proper historical context, this paper will briefly consider the practice of shifting cultivation during the *status quo ante* period where a "common property" approach seems to have more or less applied, but the practitioners of this mode were arguably caught in a poverty trap. This section draws on the contributions of two important chroniclers of who studied this topic at different periods over fifty years ago: Karl Pelzer and Gerald Hickey.

To start with a perspective focused on local populations in their "original state", Pelzer worked during the World War II period to document the practice of shifting cultivation across the tropical climate zone of SEA with support from Johns Hopkins University (see Figure 1). On both the mainland and offshore island nations of this region, shifting cultivation practices could be found in the hinterland regions where population density was typically quite low, estimated in the range of less than ten persons per square kilometer (see Figure 2). His work establishes a formal definition of these shifting cultivation practices and depicts their prevalence across the region.

Figure 1: Historical political map of region (from Pelzer 1945, 10).

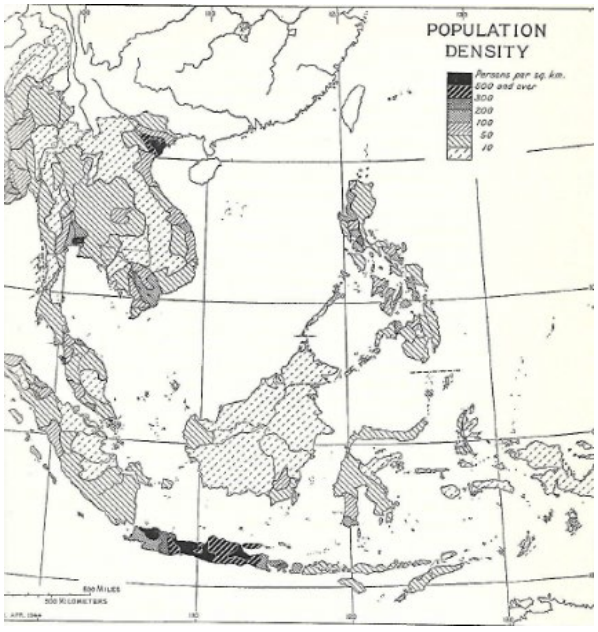

Figure 2: Historical demographic map of region (from Pelzer 1945, 11).

Despite qualms that modern readers would likely have with the characterization of swidden as a"primitive" practice, one evolutionary step up from hunter-gatherer modes of subsistence, Pelzer did make an important contribution to documenting a way of life that now appears to be decidedly threatened. His work helped to establish a baseline against which later swidden cultivation practice can be measured, as shifting cultivators have been increasingly marginalized by processes of modernization. With regard to the sustainability of agroforestry, Pelzer made the following observations, which are important with respect to baselining, in this case from an ecosystems sustainability perspective:

> Shifting cultivation is characterized by lack of tillage; the soil is hardly disturbed, and no plow turns it. There is less labor involved than in other methods of cultivation, and the work is more evenly spread over the year – an advantage where labor is relatively scarce. The tasks involved are cutting, burning, and planting; sometimes simple fencing of the field against animals, guarding – especially before the harvest and usually by women and children – and finally, harvesting. In additional, there may be some weeding in the first year and certainly the during the second. Shifting cultivation, the most primitive type of agriculture, may be briefly defined as an economy of which the main characteristics are rotation of fields rather than of crops; clearing by means of fire; absence of draft animals and of manuring; use of human labor only; employment of the dibble stick or hoe; short periods of soil occupancy alternating with long fallow periods (1945).

Furthermore, Pelzer notes the inherent issue of "diminishing returns" as motivating the rotational and shifting character of this mode of production: "as forest land is generally free from weeds or grasses and the soil is usually rich in humus and well-supplied with ash of burned plant matter after clearing, it produces a very good, or even excellent, first harvest; the second harvest begins to show a *decline in yield*, and *thereafter the returns diminish rapidly*" (Pelzer 1945). This decline in fertility and yield has been established quantitatively, as noted by Jepsen et al. (2006), for which a table has been generated based on their formula (see Figure 3). Pelzer also noted that conflicting views were held among different scholars, including Carl Sauer (a preeminent geographer of that era), who considered swidden to be an "excellent device for maintaining permanent productivity" provided it was practiced properly (Pelzer 1945).

Pelzer notes that persistent clearing and cultivation will eventually exhaust the soil and render the area unsuitable for agriculture, thereby forcing a downgrading of the land use to grazing and/or hunting. The perceived demographic threshold for sustainability appeared to Pelzer to be 50 persons per square kilometer, where a population below that density could practice swidden sustainably, while a population above that density would degrade and destroy the land. He also observes that "location matters" insofar as the terrain is concerned, e.g. clearing of steep slopes leads to accelerated soil loss due to erosion. In proposing the relocation of populations and planting of permanent trees on steep slopes, he was anticipating some measures that would later be taken by government programs although not necessarily motivated purely by conservation goals (Pelzer 1945, 23-31).

This paper also wishes to acknowledge (if only very briefly in passing) another scholar of yesteryear, Gerald Hickey, who lived among and studied the upland populations during the turbulent Cold War era. Through immersion in French Indochina over the period 1956-1973, he provides a unique perspective on the socio-economic organization of Vietnamese society not otherwise available to the outside world. Hickey

perceived a significant deterioration in relations between lowland and upland populations starting in 1965, which culminated in military campaigns led by the Vietnamese governments (north and south) against upland villages starting in 1972 (later compounded by the extensive aerial spraying of herbicides, e.g. Agent Orange) which led to the death of approximately 200,000 people and the eradication of possibly as many as 85% of settlements (Hickey 2002). To characterize such acts of violence as less than appalling would be a colossal distortion of reality, and this tragic chapter forms a necessary backdrop to the remainder of this paper focused on more recent decades.

DEFORESTATION: LONG-TERM GLOBAL TRENDS AND RECENT REGIONAL DEVELOPMENTS IN SOUTHEAST ASIA

Having highlighted some of the more recent historical context surrounding swidden cultivation and its practitioners, this section seeks to establish (again, as briefly as possible) some longer term historical context within which this regional study is set. Trends in LULC change over the last few centuries show a general pattern of associated with the conversion of forested areas to cleared areas (Ellis et al. 2013; see Figure 4). Rudel squarely assigns blame for the intensification of this trend in the late 20th century on corporations, noting that "the overall demand for natural resources from the tropical biome grew substantially during the last decades [of the 20th century]... Large landowners, the proximate agents of deforestation, moved quickly to meet the demand." As a result, large tracts were cleared of trees and converted to plantations. The role of the small-holder in this

FALLOW LENGTH	YIELD (KG PER HECTARE)	PERCENT INCREASE (T2->T1)	PERCENT DECREASE (T1->T2)
1	321.8472821		-50.49870212
2	484.3759824	33.55424426	-42.90310877
3	692.188337	30.02251605	-34.24040422
4	929.1964216	25.50677974	-25.55971993
5	1166.696425	20.35662388	-17.91865837
6	1375.752771	15.1957787	-11.9231892
7	1539.786377	10.6530106	-7.629396961
8	1657.262792	7.088580979	-4.751346413
9	1736.005088	4.535833262	-2.906886006
10	1786.468777	2.824773073	-1.758595571
11	1817.885538	1.728203461	-1.056567843
12	1837.092732	1.045521202	

Figure 3: Shifting cultivation yields of rain-fed upland rice (i.e. not irrigated) for given fallow-lengths (tabled produced by author, per formula given by Jepsen et al. 2006, 1071).

scenario was simply to try to find a niche to make money by growing some cash crops the fringes of these clearings (Rudel 2015).

With respect to SEA, this trend had accelerated markedly in the last decades of the 20th century. Deforestation rates over the period 1980-2000 may well have exceeded those of the Amazon basin, possibly reaching levels as high as 2.4 million hectares per year, per the United Nation's (UN) Food and Agriculture Organization (FAO), with degradation of extensive areas as well (Lambin and Geist 2006; Rudel 2005). Estimates for Vietnam specifically suggest a significant decline in the amount of forest-covered area from 45% in 1943 to 28% in 1991 (Castella et al. 2006).

As will be discussed in the next section, these trends are correlated with a shift away from a "common-property regime" toward one based on the increasing privatization of land rights by parceling a stock (forest land) to discrete individuals (heads of households) rather than being held by the community as a collective entity. McKean notes that "common-property regimes…were once widespread" in use for managing natural resources (e.g. forests) for "long- term benefit" (i.e. sustainably). Such regimes have in numerous cases been "legislated out of existence" with an expectation that private property ownership would result in both greater efficiencies *and* protection of the resource (McKean 2000). The next section of this paper will examine the extent to which a generally opposite scenario has been prevalent in the study area for the time period considered.

AGRARIAN/FOREST TRANSITION: DECLINE OF SWIDDEN, THE RISE OF A NEW POLITICAL-ECONOMIC ORDER, AND ASSOCIATED HUMAN-ENVIRONMENT IMPACTS OVER THE LAST 30 YEARS

Having established some of the relevant terminology, concepts, and historical background, attention will now turn to developments over the period of the last 30 years (i.e. from the late 1980s to present) in an attempt to characterize the scope of swidden cultivation in this region,

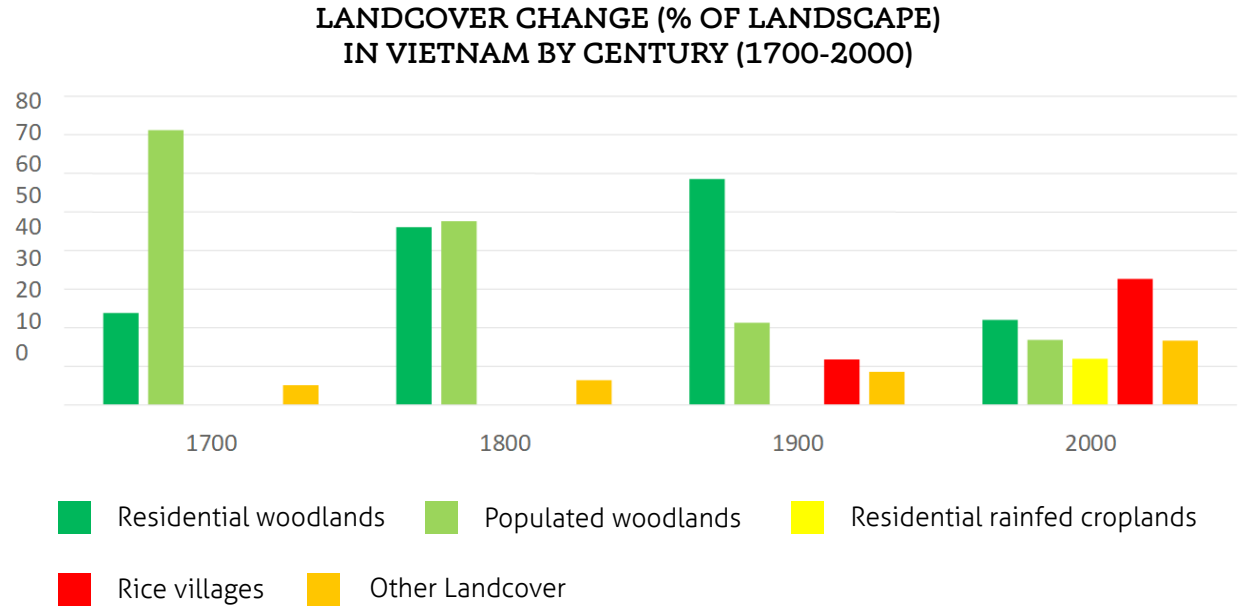

Figure 4: LULC change, 1700-2000 (produced by author, based on data published by Ellis et al. 2013).

identify why it has entered into a period of major decline, and what environmental consequences have resulted. Discussion will then turn to considering how swidden cultivators have adapted to these changing circumstances, and what prospects may exist to reconcile conservation and development objectives under a sustainability-oriented framework.

The more recent historical period of the last 30 years has witnessed the abandonment of a centralized approach to land management characteristic of Communist governance, with the passage of land reform laws in 1986-1987 ("Doi Moi" restructuring). Forestland allocation (FLA) laws have effectively undermined swidden cultivation by effectively fixing villagers in place and preventing them from shifting cultivation of their plots (Knudsen and Mertz 2015). The 1993 Land Law further reinforced these changes by allocating land tenure certificates for forested lands to individual households and concurrently imposing of a number of restrictions on other activities, such as bans on the growing of opium and felling of timber, and the implementation of massive reforestation programs on all sloping areas deemed unsuitable for agriculture[4] (Turner and Pham 2015).

According to Castella et al. (2006), the FLA led to each village defining clear boundaries for agricultural and forestry activities, and it prevented individuals from using land to which they did not have formal rights. This led in turn to some villagers who had access to suitable land engaging in paddy rice cultivation, while others who did not were displaced upslope to marginal areas. Bans on burning and clearing land presented a hardship for the latter group, who lacked adequate alternative means to provide food for their families (Castella et al. 2006).

Such policies could be seen as the expression of a well-intentioned "farmer-first" view that the solution to poverty endemic in the rural world requires the "reinvigoration of agriculture" through reallocation of land as the critical resource to boost production (Rigg 2005). This new order fits well with the prevailing conventional wisdom of mainstream Western economics, which holds that secure land tenure will lead to investment and capital accumulation, and even aid sustainable development over the longer term, i.e. a "rising tide" to "lift all boats" as espoused by the late President John F. Kennedy. While lowland urban areas may have thrived under the new economic order, the reality was rather different for upland rural populations. As noted elsewhere in this paper,any such rising tide has not been uniformly uplifting.

This effort to modernize the peasant farmer into a "modern" agriculturalist can also be seen from a cultural standpoint as the culmination of a government strategy aimed at putting an end to the "destructive and primitive practice" of swidden cultivation (Li and Feng 2014). However, it is debatable whether assigning chief responsibility to swiddeners for the preponderance of recent LULC change is justified. This is partly a function of national-level data deficiencies and technical challenges, such that it has been difficult to approximate the extent of this practice geographically using available observations, e.g. Landsat (Li and Feng 2014; Padoch et al. 2007).

What is the significance of FLA policies, and how much of the country did it actually affect? To meaningfully answer these questions, it would help to have an accurate measurement of the actual extent of the areas under swidden cultivation across the entire time series. As noted by Schmidt-Vogt, Leisz, et al., "there has been no official attempt to categorize or map" this for Vietnam by the government, as of 2009. Whether that lack of effort reflects benign neglect, a lack of funds, or some other factor(s), it reinforces the marginal status of upland populations by ignoring them in a sense, while other policies seem aimed at making their mode of production obsolete and thereby nullifying swidden cultivation as a viable way of life.

Technically-oriented outside experts have noted that there are practical difficulties in remotely estimating this extent because, for example, the relatively small size of swidden clearings (often about 0.5 hectares) and their dispersion over fairly large areas creates difficulties in identification from imagery taken at a moderate level of resolution with somewhat sparse temporal frequency (30 meters and 16-days, respectively, for Landsat). This has led to the characterization of such areas as a "residual" or "degraded" category of land use (Mertz et al. 2009; Padoch et al. 2007; Schmidt-Vogt et al. 2009). Some progress applying a "land cover mosaic" approach to Lao PDR, developed by Messerli et al. could be extended to neighboring states (Schmidt-Vogt 2009). Additionally, data with higher spatial and temporal resolution for this study area over the entire timeframe would be tremendously beneficial for more accurate estimation (e.g. European platforms such as SPOT and Sentinel with regular repeat/revisit and commercial systems).

Setting such technical challenges and issues aside, there remains a need to seek answers to the more immediate question: "How are local populations adapting and responding to this changing legal order and political-economy?" To the extent that these largely marginalized populations can be, and are, sought out and engaged by outside experts can help to gauge the intensity of trends whereby populations are "rapidly abandoning traditional land use practices" at the local level (Padoch et al. 2007). Such work can help connect people back to changing LULC dynamics, including the restoration of forests and the diverse range of associated ecosystem services.

As a result of the legal shift to a private property regime and the entry of timber companies (para-state entities in many cases) and large agribusinesses as major drivers of deforestation in tropical regions such as SEA, local populations have lost access to prime agricultural lands to commercial/market-oriented actors. This could be seen as one of the key factors contributing to the diminished viability of shifting cultivation, by pushing cultivators onto more marginal land areas with less productivity and profitability, where fallow lengths have often been reduced (Schmidt-Vogt et al. 2009). Such land areas would be prone to slower recovery and more vulnerable to degradation, with soil erosion and loss reducing yields to low levels and perhaps rendering the area a permanent grassland (i.e. not capable of ever reverting to forest). In this sense, swidden cultivators can be seen as victims of circumstance, who have also been put into a position where clearing any additional land for subsistence might be seen as a threat to conservation objectives.

Meanwhile, in an ironic turn of events, prime agricultural lands are being intensively cultivated,with negative impacts on streamflow, water quality, and erosion of soils, as well as elevated landslide risk (see Ziegler et al. 2009). Furthermore, tracts of forests are being submerged by reservoirs, as can be seen in freely accessible public domain data, for example through Google Earth Engine Explorer's cloud-served datasets for the time period under consideration.

As noted by numerous scholars, this period has witnessed the emergence of an increasingly bifurcated land-management system oriented toward intensive agriculture and forested areas. Fallowed areas do not fit into the binary classification system on which property law and government policies are built – and are inherently problematic as such. To the extent that the dominant political-economic agenda requires conformity with a binary system (in terms ofcategorizing ownership and resources), such intermediate systems need to be eliminated (at least conceptually by administrators, for the purposes of governance, if not in reality).

How and why is this drastic change in LULC happening (i.e. what is driving these changes)?

According to Fox et al., "six factors that have contributed to the demise or transformation of swidden systems", which they enumerate as follows:

1. classifying swiddeners as ethnic minorities within nation-states
2. dividing the landscape into forest and permanent agriculture
3. expansion of forest departments and the rise of conservation
4. resettlement
5. privatization and commoditization of land and land-based production
6. expansion of market infrastructure and the promotion of industrial agriculture

Fox et al. further note that "externally driven changes are *often not sensitive* to local demands for development and favor macroeconomic development over environmental protection and local welfare." This seems like a rather polite way of characterizing what appears to be a concerted, deliberate, and multi-pronged policy by the government of Vietnam aimed at controlling and dominating minorities by fundamentally changing their relationship to owner/operators who are fixed in location and taxable (and can be co-opted and bought out through joint ventures). One could conceivably even go so far as to argue that these policies are in fact tantamount to a strategy of "accumulation by dispossession" (Glassman 2006).

Whether or not one agrees with Glassman's Marxist-oriented perspective – i.e. that the state is re-engineering the social structure by seizing lands to promote "large commercial farms" and thereby "free the agricultural population" to serve as a labor supply for manufacturing – it seems apparent that this combination of factors has effectively undermined the viability of swidden cultivation and its associated village-based culture (Fox et al. 2009). It might seem fair, at the very least, to characterize the state as acting somewhat hegemonically toward those populations that, by remaining "backward", are seen as obstacles to progress, and using available tools of persuasion and coercion short of blatant or brute-force approaches.[5]

Setting aside debates about the intent of outside actors who are driving these changes and whether the decline of swidden cultivation might be a positive or negative development, it appears that villagers who formerly relied on this mode of subsistence are adapting by changing to a cash crop orientation, including the cultivation of cash crops (bananas, cassava, cinnamon, coffee, wet rice, etc.) and alternative approaches to agroforestry, which are perceived as less demanding in terms of physical labor and less vulnerable to climate perturbations (Knudsen and Mertz 2015).

This shift to a market orientation represents a departure from prevailing practices over many past generations. As Le and Rambo observed, "villagers tend to make similar land-use decisions" under their traditional modes of production, historically, but "as conditions change and greater economic and political differentiation occurs among villagers, presumably land-use decisions will vary among households as cash crops replace subsistence cultivation, and it will become increasingly important to establish a one-to-one relationship between a household and its land parcels" (Le and Rambo 2001).

ENVIRONMENTAL IMPACTS OF CHANGING LULC TRENDS; CONSIDERING REDD+ AND "SOCIAL FORESTRY"

From an environmental standpoint, forest cover has been a key indicator by which the success or failure of LULC change policy can be gauged, given the importance of forests as carbon sinks in regulating the climate and the loss of forests as a contributing factor to global climate change (in addition to concerns about direct effects at a local level on soil and water). Although there were strong trends of net loss in tropical forest cover

across this region for much of the latter half of the 20th century, driven by population pressures that were amplified by state resettlement practices,[6] efforts to answer the question "are forest density *and quality* diminishing?" prove more complicated in the current context.

Complex landscape mosaics, which are generally regarded as "degraded lands" but can in fact be rapidly regrowing, and therefore taking up more CO2 than mature forests (while also potentially supporting more biodiversity), present a challenge in this regard (Mertz et al. 2012). On the other hand, commercial timber extraction followed by mono-cropping (i.e. intensive agriculture or oil palm/rubber tree plantations), as well as infrastructure projects (e.g. road- and dam-building projects) continue to affect large areas of the uplands. Driven by demands from nearby and more distant markets, these land uses constitute either semi-permanent or permanent conversion of affected areas. Whether it makes sense to include tree plantations under REDD+ seems rather dubious, but that angle is being pursued by some industrial agricultural interests (Fox et al. 2014).

With a marked decline in the extent of clearings for swidden cultivation, one would expect a net gain in closed canopy forest cover, but that depends to a large extent on how areas that are no longer under cultivation are being used. Assessing LULC change during this agrarian/forest transition will require the concerted ongoing efforts of anthropologists working at the local level in the field and technical experts working with remotely-sensed data to connect "people to pixels" and vice versa. Engaging key stakeholders at the local level and perhaps government officials, who may not be regarded positively by locals, might also help in this endeavor.

RECONCILING ENVIRONMENTAL CONSERVATION IMPERATIVES AND HUMAN NEEDS THROUGH CAPITALISM: SUSTAINABILITY THROUGH PAYMENTS FOR ECOSYSTEM SERVICES (PES)?

This section considers how local populations can be engaged and motivated to maintain a place-based livelihood through sustainable practices. Having established that market-oriented economics has spurred an agrarian/forest transition, with mixed consequences for humans and the environment, the challenge appears to be how to respond. Environmental considerations must also account for human reliance on the forest lands – and other lands not "improved" by human intervention – for basic necessities. Angelsen et al. (2014) make a clear economic case for "quantifying the relative and absolute contribution of environmental income to total income" to better understand a range of factors necessary to "design effective development and conservation strategies," which they identify as follows:

1. the livelihoods of rural peoplethe extent and determinants of poverty and inequality
2. the welfare implications of the degradation of natural resources (see Figure 5).

To that end, "contextually appropriate policies" should be "easier to implement" and help aid in the stabilization of land cover essential to this agrarian/forest transition (Angelsen and Rudel 2013). Bottom-up approaches have used surveys of local populations and social network analysis to identify key stakeholders and actors with influence (Moeliono et al. 2016).

One promising example of such an effort in Vietnam and Lao PDR might be the "ASEAN-Swiss Partnership on Social Forestry and Climate Change" (ASFCC). Through this partnership, the Center for International Forestry Research (CIFOR) is researching swidden to better projects that reflect "local knowledge, practices and social networks."[7] This approach recognizes that practitioners of traditional swidden cultivation methods have a working knowledge of their surroundings that would be integral to any

environmental management plan, whether focused on biodiversity, carbon sequestration, or other objectives.

There are also top-down PES efforts being implemented, and others under consideration, that take a much different approach. Operating at vastly larger scale, McElwee et al. (2014) note that an ambitious project is being undertaken to restore 4 million hectares to forest cover through a mandatory fee on water and electricity use. Since the relatively low cost per capita is multiplied across a large population base, this approach certainly has the potential to raise substantial revenues. If those funds can be properly channeled in a targeted way to benefit communities, it could help to complement micro-level projects. If, on the other hand, funds are siphoned off by corrupt officials or managed in a way that reinforces inequality and heightens alienation between groups, then it might be detrimental and possibly counterproductive. There appear to be many other concerns regarding implementation to date (McElwee et al. 2014).

Additional PES possibilities authorized by the government of Vietnam, per "Decision 99 ND-CP", include payments for the protection of land (against soil erosion), protection of watersheds, carbon sequestration, tourism-oriented landscape and biodiversity protection, and aquaculture-oriented protection of spawning grounds. Should the hydropower-funded PES projects in northwestern and south-central Vietnam prove successful, this may constitute a precedent for application elsewhere in-country and perhaps neighboring states in the region. The fact that hydropower is the principal funding mechanism, of course, strikes this author as somewhat ironic insofar as this industry is a major contributor to the displacement of local populations from their homes and dislocation from traditional livelihoods.

To the extent that the needs of local populations can be met through NFTP, PES, or other offsetting measures, it would be worthwhile to incentivize ecosystems recovery for the benefit of local populations. The compliance of local populations would be critical, of course, where McElwee et al. (2014) note that about 25% of households receiving PES did not modify their behavior, so a clear linkage would need to be established. The exclusion of outside actors, particularly timber interests, would also be critical to the success of such an endeavor (i.e. local compliance is necessary but not sufficient). The clear-cutting

LANDCOVER TYPE	1700	1800	1900	2000	CHANGE (1700-1800)	CHANGE (1800-1900)	CHANGE (1900-2000)	CHANGE (1700-2000)
Residential woodlands	24%	46%	59%	22%	94%	27%	-62%	-7%
Populated woodlands	71%	48%	21%	17%	-33%	-55%	-21%	-76%
Rainfed croplands	0%	0%	0%	12%	N/A	N/A	N/A	N/A
Rice villages	0%	0%	12%	33%	N/A	N/A	179%	N/A
Other Landcover	0%	6%	9%	17%	27%	34%	94%	231%

Figure 5: Percentage of landscape coverage by landcover type, including change over time (from Angelsen et al. 2014, pg. S17).

of such areas, or even the selective removal of endangered or threatened trees, whether by locals or outside actors, would of course undermine any enlightened PES-oriented effort.

CONCLUSION

To recap the key points, the world is witnessing a marked decline in swidden cultivation concurrent with the rise of state-led and market-driven developments that have effectively replaced a "common property" regime with a privatized commodification-oriented system. This is markedly so for SEA over recent decades. Having reviewed much scholarly literature on this subject, this author has come to recognize that mainland montane SEA is undergoing a dramatic transformation in terms of its human and environmental landscape, as manifested in an agrarian/forest transition. Local actors are being forced to adapt or move (or some combination thereof) as a matter of survival. While the physical displacement of some local populations is *fait accompli* in many cases, those who remain and have suffered dislocations could be incentivized through partnerships and payments to act as stewards of resources that they know better than outsiders from firsthand experience. To that end, they could benefit from PES while helping to advance REDD+ objectives. Per Rigg, among others, we ought to at least lament the loss of the village-based livelihood system, while confronting the challenges that have emerged for marginalized local populations to promote more equitable opportunities and outcomes that promote a sustainable future for the ecosystems on which the future of life depends.

While the demise of "common-property regimes" conducive to "sharing rights" seems to have been overtaken by events and eclipsed by state-led interference and market-driven imperatives, one can hope that local partnerships with outside organizations could enable local resource users to more effectively monitor each other and achieve cohesion at the group level, which can help to exclude outside intruders (McKean 2000).

Postscript on PES (included here to acknowledge the need for considering climate change as a relevant factor for this issue in looking to the future)

Circling back to the grassroots, bottom-up approach, this author would submit that it might also behoove local populations to ally with conservation organizations in seeking PES funding for climate-change adaptation funding. Given near-to-medium term concerns about the implications of changing temperature and precipitation patterns, forests may fare badly due to forces beyond human control. In addition to climate oscillations (ENSO) and longer-term trends associated with climate change, intermittent extreme weather events, such as cold spells and hailstorms, could also have deleterious direct effects as well (Koubi et al. 2016). Funding designated "core areas" as nature reserves could help threatened and endangered species of trees integral to the forest ecosystem, which have shown some capacity to recover if given adequate protection (Dao and Hölscher 2015). Local communities in such areas would need to be engaged as stakeholders with a long-term interest in the maintenance of ecosystem, while also being allowed to pursue livelihoods in a compatible manner (i.e. viewed as conservation partners rather than seen as impediments or opponents that need to be overcome or managed) – and as such properly compensated for managing the ecosystem. Given a lack of nuanced understanding of the inner workings at the level of the national government, this author would not put forward specific policy prescriptions at that level but would at least identify a need to reconcile governance objectives to promote investment in local communities and agriculture over and above prevailing priorities geared toward conventional development objectives through investment in infrastructure geared toward support of agro-forestry and industrial concerns.

NOTES

1. Coined by Karl Gustav Izikowitz of Sweden and defined as follows by a panel of experts in this field of research: "a land use system that employs a natural or improve fallow phase, which is longer than the cultivation phase of annual crops, sufficiently long to be dominated by wood vegetation, and cleared by means of fire" (Mertz et al. 2009). The practice as a traditional form of rotating fields rather than crops (i.e. dispersed rather than fixed locations) has been proven appropriate for sustainable long-term cultivation practice in settings with marginal soil conditions prevalent in the humid subtropics and tropical regions. This system was practiced across much of pre-modern Europe where it was practiced for centuries, e.g. as observed by Linnaeus in Scandinavia (Dove 2015).

2. Indivisibility is based on the dependence of forests on animals hosts ability to roam in order disperse seeds, consequently "forests need to be managed in large units at least the size of watershed basins" for reasons of maintaining biodiversity that is essential to the health of the ecosystem per McKean, pg. 38.

3. A perspective not unique to Western observers and which was also held by communist leaders of a Marxist- Stalinist orientation (Fox et al. 2009).

4. Defined as areas with slope measuring over 25 degrees. In reality, swiddeners could and did cultivate plots on slopes up to – but generally not above – 35 degrees, per Jepsen, Leisz, et al. (2006).

5. Rudel appears to take a more apolitical or value-neutral perspective that does not see an ulterior motive on the part of the government: "The rugged topography that covers much of Southeast Asia provides a more hopeful note for conservationists, because a greener trajectory of landscape change may be emerging in the region's marginal lands, usually in upland settings. The limited agricultural productivity of inaccessible steeper-sloped land reduced the marginal utility of farming on these lands. Smallholders seem likely to reassess the viability of upland agriculture if the rapid economic growth and urbanization of the past two decades continues in Southeast Asia. Under the circumstance, upland farmers may choose to work in intensified lowland agricultural enterprises or expanding urban labor markets. If they opt for either of these choices, they will labor less on upland farms, most likely by reducing lands devoted to more labor-intensive agricultural uses and increasing lands devoted to less labor-intensive forests and agroforests" (Rudel 2005, 134-135).

6. Including in-migration and out-migration, often times with inadequate or no compensation, as well as in some cases non-state directed "spontaneous migration", as summarized by Fox et al. (2009).

7. See http://www.cifor.org/asfcc/

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Climate Change and Food Security: Nutrition and Health Impacts on Women and Children in Sub-Saharan Africa

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Anthropogenic climate change is expected to impact the quality and quantity of global food production and its equitable distribution across the world (Myers et al. 2017). Agriculture is an important driver of economic growth and crucial to feed a growing population (FAO 2016). Projected shifts in regional climate variables are likely to render areas unsuitable for food production (Rippke et al. 2016). In sub-Saharan Africa, where approximately 50% of subsistence farmers are women, these changes are expected to disproportionately impact women and children (FAO 2016). This research paper will explore two main pathways through which reduced crop yields will impact the nutrition and health of women and children in sub-Saharan Africa. The first is malnutrition, considering costs to society in terms of child and female morbidity and mortality, population development, and economic productivity. The second is socioeconomic stress, in terms of the broader impacts of hunger and poverty on social determinants of health. Identifying the direct and indirect pathways through which climate change impacts human nutrition and health is necessary to develop mitigation and adaptation strategies that minimize negative impacts on vulnerable populations. This paper will conclude with an overview of proposed mitigation and adaptation strategies, including agricultural resilience and guidelines for policy frameworks and future research.

CLIMATE CHANGE, AGRICULTURE, AND FEEDING A GROWING POPULATION

The current geologic epoch is being referred to as the Anthropocene in recognition of the unprecedented scale of global interconnectedness and economic intensity – and the consequent environmental and social changes – of contemporary human activity. These shifts are influencing patterns of human health at national and international scales, reflecting the interrelated pressures and tensions arising from a growing world population; pervasive and increasingly systemic environmental impacts of economic activities; urbanization; the spread of consumerism; and the widening gap between the rich and the poor, both within and between countries (Kawachi & Wamala 2007; McMichael 2013). These human-induced forces have distorted Earth's natural systems beyond limits considered to be safe for human social and biological health and well-being.

Concern over an exponentially growing population outgrowing the life-support capacity of its resource base dates back centuries (Malthus 1798). The establishment of a global economic model based on unsustainable resource exploitation has created a context of accelerated resource depletion that is exacerbated by climate change. Global climate change is part of the larger Anthropocene syndrome of human-induced global environmental changes, including land degradation and disruption of soil fertility, fresh-water resources, biodiversity stocks, ecosystem functioning, and global nitrogen and phosphorous cycles (Myers et al. 2017). Most of the health risks from climate change will arise from climatic influences on environmental systems and social conditions that affect factors such as food yields and water supplies (FAO 2016). Without substantial and prompt international action to abate these emissions, average global temperatures are likely to rise by three to four degrees Celsius by 2100, returning Earth's temperature to levels

not experienced for 10 million to 20 million years (McMichael 2013). Rainfall patterns will also change, with projected increases in regional aridity and in the geographic range and severity of droughts. The frequency and intensity of extreme weather events is also expected to increase in most regions. As a result, anthropogenic climate change is acting alongside environmental, demographic, and social stressors that influence regional food yields, nutrition, and health (Phalkey et al. 2015).

Populations living in diverse social, economic, and physical conditions will be affected differently by climate change. Low-income and remote populations are more vulnerable to undernutrition, infectious diseases, and the health consequences of displacement as access to traditional food sources becomes more difficult. Decreased food crop yields coupled with often ineffective economic policies will exacerbate hunger, particularly for marginalized groups. A negative feedback loop exists between population growth and climate change mitigation, whereby excessive population pressures on regional environments results in soil exhaustion, water depletion, and the loss of various wild animal and plant food species. This exacerbates global environmental and ecologic challenges while entrenching conditions of poverty and disadvantage (McMichael 2013).

Anthropogenic climate change will present challenges to the four essential dimensions of food security: food availability, stability, access, and utilization (Phalkey et al. 2015). Stakeholders at local, national, and international levels will need to consider these dimensions when devising strategies to mitigate the costs of malnutrition to society, projected impacts of climate change on global food supplies and food security for vulnerable populations, and addressing impacts on the social determinants of health.

HEALTH, NUTRITION, AND ECONOMIC DEVELOPMENT IN SUB-SAHARAN AFRICA

The World Health Organization (WHO) and the Intergovernmental Panel for Climate Change (IPCC) present malnutrition as a major challenge to the health and productivity of populations, particularly in low- and middle-income countries, where it is viewed as one of the largest adverse health impacts of climate change. Malnutrition refers to both undernutrition (underweight, wasting, and stunting) and overnutrition (overweight and obesity) as well as to micronutrient deficiencies that may occur in both groups. The largest burden of current undernutrition is attributed to calorie insufficiency caused by lack of food intake (Phalkey et al. 2015). Undernutrition adversely affects the productivity of nations while creating economic and social challenges among vulnerable groups. Poor nutrition is associated with suboptimal brain development, which negatively affects cognitive development and educational performance, and can have irreversible consequences on child growth, increased risk for morbidity and mortality, and reduced economic productivity in adulthood (Akombi et al. 2017).

Women of child-bearing age (especially pregnant and lactating women), infants and young children are in the most nutritionally vulnerable stages of the life cycle (Lartey 2008). Maternal malnutrition is a major factor for female morbidity and mortality in Africa. Causes include inadequate food intake, poor nutritional quality of diets, frequent infections and short inter-pregnancy intervals. Up to 20% of African women have a low body mass index (BMI) due to chronic hunger, with prevalence of micronutrient deficiencies across the continent ranging from 21-80%. High rates of HIV infection further compromise maternal nutritional status. Poor maternal nutrition results in low pregnancy weight gain and high infant and maternal morbidity and mortality. At the same time, sub-optimal infant feeding practices, poor quality of complementary foods, frequent infections and micronutrient deficiencies contribute to high infant and child

morbidity and mortality in the region (Lartey 2008). Although the proportion of malnourished children has decreased globally, progress has been slow in sub-Saharan Africa, with evidence suggesting that climate change will hinder this secular decrease. Furthermore, an additional 25.2 million children are expected to become malnourished as a result of climate change, with projected relative increases in severe stunting of 31-55% in sub-Saharan Africa, making it an impending epidemic and therefore a critical research priority (Phalkey et al. 2015).

Stunting is a serious risk factor for subsequent disease and death, associated with 53% of the infectious disease-related deaths in developing countries. Childhood stunting is also linked to poor overall health, delayed milestone achievements, late school enrollment, poor cognitive and psychomotor functioning, decreased fine motor skills, and poor social skills. Thus, stunting affects productivity and may reduce lifetime earnings by more than 7%. Furthermore, children born to malnourished mothers are at risk for fetal growth retardation, small-for-age births, prematurity, childhood stunting, delivery complications, and increased

	MATERNAL MALNUTRITION	CHILD MALNUTRITION
CAUSES	• Calorie insufficiency due to inadequate food intake • Micronutrient deficiency due to poor nutritional quality of diets • Frequent infections • Short inter-pregnancy intervals • High rates of HIV infection further compromise nutritional status	• Calorie insufficiency due to inadequate food intake • Micronutrient deficiency due to poor nutritional quality of diets • Suboptimal infant feeding practices • Poor quality of complementary foods • Frequent infections
IMPACTS	• Low pregnancy weight gain • Increased risk for fetal growth retardation • Increased risk for premature childbirth • Increased risk for childbirth complications • Increased risk for morbidity and mortality • Reduced economic productivity and earnings	• Poor nutrition associated with suboptimal brain development • Reduced cognitive development and educational performance • Stunting ◦ Poor overall health ◦ Delayed milestone achievement ◦ Late school enrollment ◦ Poor cognitive and psychomotor functioning ◦ Decreased fine motor skills ◦ Poor social skills • Increased neonatal and postnatal mortality • Increased risk for morbidity and mortality • Reduced economic productivity and earnings in adulthood • Increased risk of obesity and chronic disease in adulthood

Figure 1: Causes and impacts of maternal and child malnutrition.

neonatal and postnatal mortality. Malnourished children are also at a higher risk of adult obesity and chronic diseases (Phalkey et al. 2015). The causes and impacts of maternal and child malnutrition are summarized in Figure 1.

Agricultural, socioeconomic, and demographic factors at the household and individual levels play substantial roles in mediating the nutritional impacts of a changing climate (FAO 2016). Environmental and socioeconomic conditions constitute an extra burden on the nutritional status of women and children in sub-Saharan Africa. Pervasive poverty affects diet quality, with women's heavy workloads increasing their nutritional requirements and frequent, short reproductive cycles preventing them from adequately replenishing body nutrient stores. Infants and young children suffer frequent infections and have poor-quality diets. These factors result in an environment where malnutrition becomes a vicious cycle that is difficult to escape (Lartey 2008). Interventions to improve female and child nutrition, particularly in relation to the improvement of micronutrient intakes, address a key dimension of the problem. However, issues are also raised around necessary redistributive measures through policies aimed at alleviating the socioeconomic determinants of malnutrition in the region (Strauss & Thomas 1998). This is of particular importance in the context of developing countries, where the labor market consequences of poor health are likely to be more serious for poor women, who are at higher risk of suffering from severe health problems and to work in jobs for which physical strength (and therefore good health) has a payoff (Strauss & Thomas 1998).

Global food production is likely to be altered by various climate-change related pathways affecting the quantity and quality of food produced, with the prospect of disrupted capacities to maintain an adequate supply of nutritious foods. Nutrition and food security are determined not only by aggregate food supply, but also by the political and economic forces that dictate the ability of people to access, afford, and use food. As global climate change unfolds, there is a high risk that the purchasing power of wealthier populations will leave the poor with an insufficient food supply as resources flow towards the wealthy (Myers et al. 2017). Climate change may exacerbate social exclusion by increasing competition for scarce natural resources, resulting in volatile food prices and forcing mass migration, factors that played important roles over the past few decades in severely restricting food access during civil conflicts in sub-Saharan Africa. Projected increases in global temperatures are associated with higher levels of intergroup violence and a resulting impingement on rights critical to ensuring food security. The hardest-hit regions will be precisely those at greatest risk of undernutrition, including sub-Saharan Africa (Myers et al. 2017). The socioeconomic and environmental factors that mediate the impact of climate change on food security and nutritional status are summarized in Figure 2.

CLIMATE CHANGE, AGRICULTURE, AND GENDER IN SUB-SAHARAN AFRICA

Undernutrition results from a combination of closely linked, interdependent, complex agricultural, environmental, socioeconomic, demographic, and health factors at the community, household, and individual levels. A large proportion of the mediating factors are climate- and weather-sensitive. Household and environmental variables play equally significant roles in determining maternal and child undernutrition (Phalkey et al. 2015). Changes in weather averages, climate variability, and extreme weather events – particularly floods and droughts – determine the quantity, quality, and stability of crop yields. Climate change is likely to reduce agricultural production and affect more than 30% of the farmers in developing countries that are already food insecure. These impacts will be borne disproportionately by smallholder subsistence farming households (Phalkey et al.

2015), 50% of which are led by women (FAO 2016). Beyond quantity of food crops, climate change is also expected to affect the quality of food crops. Recent evidence confirms that elevated atmospheric carbon levels significantly decrease micronutrient concentrations in the main staple crops of African countries, including wheat, barley, and rice (Myers et al. 2017; Phalkey et al. 2015). These changes in the quality of food crops will accelerate the epidemic of micronutrient deficiency, increasing the risk of acquiring infectious diseases and worsening undernutrition (Phalkey et al. 2015). The complexity of climate-change induced food insecurity can be illustrated through a more detailed analysis of projected impacts of climate change on food security in sub-Saharan Africa.

According to the 2015 Millennium Development Goal (MDG) report, sub-Saharan Africa accounts for one-third of all undernourished children globally, highlighting that malnutrition remains a major health concern for children under five years in the sub-region (Akombi et al. 2017). It is important to note that exploring undernutrition on a regional basis can mask differences in the burden of malnutrition within sub-regions, as well as obscure potential solutions. Akombi et al. (2017) conducted a critical analysis of the sub-regional prevalence of malnutrition within the WHO-designated geographical regions of sub-Saharan Africa: West Africa, East Africa, Central Africa, and Southern Africa. East Africa was found to have the highest rates of stunting in the region, while wasting and underweight were highest within countries in West Africa. Such insight into the sub-regional distribution of undernutrition can assist decision-makers across sectors in identifying the most pressing issues that need to be targeted in the most vulnerable sub-regions where nutrition-related interventions are needed.

The study also found that East Africa has the potential and capacity to produce enough food for its local consumption and a surplus for export to the world market. However, the region suffers food shortages, unfavorable climatic conditions, and limited access to land for agricultural purposes. The demographic, socioeconomic, and agroecological characteristics of the sub-region have adversely influenced the nutritional status of children as rapid population growth, rising cost of living, and desertification have affected food access, availability, and production. These

PERVASIVE POVERTY	INEFFECTIVE POLICY ENVIRONMENT
• Reduction of quantity, quality, and stability of agricultural production • Inadequate food intake and reduced diet quality • Frequent, short reproductive cycles prevent the adequate replenishing of body nutrient stores • Lack of treatment for frequent infections • Heavy, physically demanding workloads that require physical strength and good health • Vicious cycle of chronic malnutrition and reduced economic productivity	• Failure to implement redistributive measures to alleviate socioeconomic determinants of malnutrition • Financial constraints and inadequate food distribution due to poor infrastructure • Political and economic forces that determine the food security (food availability, stability, access, and utilization) of vulnerable populations • Exacerbated social conflict and exclusion

Figure 2: Socioeconomic and environmental factors that mediate the impact of climate change on food security and nutritional status.

factors undermine progress toward improving agricultural productivity, food security, and child nutrition in the region (Akombi et al. 2017).

The adverse effects of food insecurity on maternal and child health in the region are exacerbated by financial constraints and inadequate food exchange between locations of abundant harvests and those with deficits due to poor infrastructure. Evidence across agriculture-nutrition pathways reveals a positive relationship between effective food systems and maternal and child nutrition. Thus, an assessment of the convergence between climate change, agriculture, food security, and maternal and child health across the sub-regions of sub-Saharan Africa emphasizes the need to effectively address the various dimensions of food security and nutrition in the face of climate change (Akombi et al. 2017; Phalkey et al. 2015).

Addressing food insecurity and malnutrition in the age of climate change also requires a consideration of differential vulnerabilities, particularly regarding gender. Vulnerability is determined by geographic, social, economic, ecological, and political factors, which determine an individual household's resources to achieve food security in the face of climate shocks and trends (Campbell et al. 2016). Gender affects individual and household exposure to risk, as well as access to and control of resources, finance, land, technology, and services. In the context of climate-driven agrarian stress, men's out-migration is a primary factor in climate change vulnerability. Reduced household resources put women at increased risk to shocks such as droughts, and reduce their capacity to invest in off-farm activities. Women's lack of access to information and extension services, weaker participation in some social institutions, and increased workloads under climatic stress all affect adaptation. Thus, work in this area must understand social differentiation to enable more inclusive approaches to adaptation, being cautious of avoiding the implementation of actions that fail to address – or further entrench – inequality (Campbell et al. 2016). The aspects of gender-differentiated vulnerability to the impacts of climate change on food security and health are summarized in Figure 3.

GENDER-DIFFERENTIATED VULNERABILITIES

- Disproportionate burden on female-led smallholder farming households
- Increased prevalence of malnutrition
- Increased prevalence of micronutrient deficiencies
- Increased rates of morbidity and mortality
- Increased workloads and vulnerability to climate shocks
- Increased exposure to risk
- Limited access to and control of resources and services
- Migration
- Limited inclusion and participation in social institutions

Figure 3: Gender-differentiated vulnerabilities to the impacts of climate change on food security and health.

Poverty remains a main cause of malnutrition in sub-Saharan Africa, with 48.55% of the population living on less than $1.25 per day. The majority of the world's poor reside in rural areas and lack access to basic health services. The causes of poverty are related to harmful economic systems, conflict, environmental factors such as drought and climate change, and population growth. Therefore, addressing poverty with the objective of improving food security and child nutrition is critical in strengthening livelihoods among vulnerable populations in the face of climate change (Akombi et al. 2017).

POVERTY, HUNGER, AND SOCIAL DETERMINANTS OF HEALTH

Additional looming determinants of health in the age of climate change include increasing disparities in wealth, education, autonomy,

and social inclusion (Kawachi & Wamala 2007; McMichael 2013). Patterns of malnutrition and food insecurity cluster with aspects of social disadvantage, whereby social, economic, political, legal, and material factors affect health and determine vulnerability. It is therefore crucial to consider the underlying causal relationships between social determinants and health outcomes, as well as their link to health and nutritional inequities (Kelly & Doohan 2012). The WHO's Commission on the Social Determinants of Health (CSDH) highlights early child development and women and gender equity as key hubs for the promotion of broader social determinants of population health. Furthermore, the CSDH argues that social justice, economic systems, and political arrangements are the principal macro determinants of patterns of health and disease within and between societies (Kelly & Doohan 2012). Differences in mortality and morbidity are, in principle, preventable, resulting from human activities rather than random biological variations. The patterns of vulnerability as a result of social factors, including levels of malnutrition that are projected to increase as a result of climate change, are unfair and their prevention is a matter of social justice. Thus, the impact of these factors on the lives of people can be ameliorated by preventive activities operationalized at local, national, and international levels (Kelly & Doohan 2012).

CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

Certain aspects of globalization are beneficial to human health, such as the enhanced flow of information and a greater capacity for long-distance responses to crises. The current level of global connectedness and interdependence has the potential to offset the vulnerabilities detailed in this paper via more effective global alerts and more rapid distribution of food aid. Leveraging these advantages to remediate or adapt to global climate changes requires an understanding of dynamic systems – and their complexity and associated uncertainties – alongside coordinated policy responses across relevant sectors (Kawachi & Wamala 2007; McMichael 2013). The consequences of maternal and child malnutrition have both short- and long-term implications for women and their offspring. Countries that seek to tap the full potential of their human resources cannot afford to neglect the nutrition of their citizens, especially that of women and children (Lartey 2008). A multi-sectoral approach is vital in tackling undernutrition in sub-Saharan Africa. This approach calls for holistic efforts across agencies to achieve food security, proper nutrition, and poverty reduction in the long-term, and to improve agricultural capacity to meet food demands in a context of population growth and climatic variability. Conservation agriculture approaches that reduce women's labor and increase diversity can address issues of crop yields while increasing household nutrition levels (Campbell et al. 2016). Policies that support cost-effective interventions around family planning, nutrition, and health education that considers the sociocultural and environmental particularities of each sub-region are urgently needed to reduce malnutrition in sub-Saharan Africa (Akombi et al. 2017).

The Sustainable Development Goals (SDGs) reflect the principle that concern for humans must be at the center of sustainable development, emphasizing the need to address the link between environmental and sociocultural conditions and basic human biological and psychological needs. The mitigation of climate change is a crucial first-order task for the world. While governments tackle this unprecedented, complex political and ethical task, the more immediate challenge for the health sector is to identify the main regional health threats posed by climate change to ensure the development of effective adaptations (FAO 2016; McMichael 2013). Human-caused climate change is due to the globally aggregated excess of greenhouse emissions. Therefore, its risks to population

health cannot be countered effectively at the local level alone. Primary prevention of health and nutrition problems requires coordinated international policy, supplemented by more local policy-making and action. Future global health goals must prioritize integration with the fundamental impacts of poverty, inequity, illiteracy, climate change, land-use patterns, and food insecurity on population health (FAO 2016; McMichael 2013).

The impacts of climate change on farmer and consumer food security will depend on how transformational change in staple crops is managed. Governments will need to prepare for potentially large losses in national production potentials - and production areas - of up to 15% by 2050 and over 30% by 2100 (Rippke et al. 2016). Effective adaptive strategies will require collaboration among diverse government sectors, research disciplines, and communities (McMichael 2013) to determine the kinds of public policy actions that enable transformational shifts of cropping systems while addressing all dimensions of food security and gender-differentiated social determinants of health, nutrition, and well-being. These necessary shifts will demand transformations among farming communities, value chains, and consumers alike, as well as a flexible, enabling policy environment for self-directed change among vulnerable populations in response to climatic changes, situated within the wider context of rapid demographic and economic changes (Rippke et al. 2016).

Adaptation capacities are particularly urgent where rates of preexisting disease, including malnutrition, are already high, and would thus increase due to the multiplier effects of climate change. Weather variables are significant determinants of crop yields, especially in the rain-fed farming systems on which poor smallholder women farmers in sub-Saharan Africa rely. Additionally, the region's agricultural productivity is struggling to keep up with population growth, resulting in high levels of food insecurity and poor nutritional outcomes for women and children under five years of age. These challenges highlight the need to secure agricultural productivity through reliable early warning systems for crop failure that can help subsistence farmers offset these impacts. The planning of acute weather event relief programs, such as floods and droughts, must include considerations for mitigation of undernutrition. The effectiveness of such systems relies on the incorporation of factors such as rainfall, temperature, extreme weather events, and accounting for all nutritional parameters, including micronutrient deficiencies (Phalkey et al. 2015). Furthermore, educational programs geared towards family planning to regulate population growth should also be prioritized. While this approach can lead to an effective reduction in population growth and family size, thus contributing towards improved nutritional standards by increasing the available per capita food supply (Akombi et al. 2017), it is important to note that this approach is incomplete without addressing equitable food distribution and access. Future research can support these mitigation and adaptation strategies by building a long-term and wide-ranging evidence base to inform policy and to develop targeted adaptation strategies at a household level in areas in which climate changes are likely to negatively impact agricultural production (Phalkey et al. 2015).

CONCLUSION

Rapid globalization has brought new, large-scale influences to light regarding patterns of human health. Macro scale economic, social, demographic, and environmental changes are linked to changes in regional food yields and resulting health and nutrition disparities. Preventive efforts to tackle health risks from these global influences requires conceptual insights beyond the conventional understanding of causation and prevention, as well as political will, trust, and resources (McMichael 2013). The complexities of policies to mitigate anthropogenic climate change are clear, with additional resources and strategies needed to

reshape how human societies plan, produce, consume, and share food resources (FAO 2016; McMichael 2013).

The political will to drive these changes is often lacking. Nevertheless, a growing evidence base provides a framework for action and a range of dimensions for understanding the causal relationships between global forces, social determinants of health, and nutrition outcomes in vulnerable women and children (Kelly & Doohan 2012). The relationship between nutrition and economic development must be prioritized as both a logical development strategy and as a matter of human rights. Pregnancy and the first few years of life are critical stages of human development that present opportunities for significant improvement in human capital through direct health and nutrition interventions. Energy and micronutrient deficiencies, exacerbated by climate change, reduce human capital and economic growth. Therefore, governments are urged to adopt policies that mitigate the impacts that climate change will have on the livelihoods of the most vulnerable (especially women and children) and to prioritize a multifaceted approach to nutrition, health, and education which combines short- and long-term development strategies (Martorell 1996).

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"Indians Don't Get Transplants": Barriers in Accessing Kidney Transplantation on the Pine Ridge Indian Reservation

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American Indian and Alaska Native populations in the United States have, in recent years, been plagued by metabolic disorders, particularly diabetes which, when uncontrolled, leads to the development of end-stage renal disease (ESRD). The Pine Ridge Indian Reservation, located in the southwest corner of South Dakota, is no exception. Discrimination, extreme poverty, rampant unemployment and limited access to healthy foods, among other factors, have led the Oglala Lakota people of Pine Ridge to have one of the highest rates of ESRD and the lowest life expectancies in the United States (Narva 2008; Re-Member 2007). Previous research has shown that kidney transplantation as a treatment for ESRD in lieu of long-term dialysis provides both increased life expectancy and improved quality of life (Esposito et al. 2017; Laupacis et al. 1996; Port et al. 1993; Wolfe et al. 1999). Despite these advantages, however, the percentage of American Indian individuals receiving a kidney transplant is lower than that of every other ethnic group in the United States despite having the highest prevalence of ESRD (Narva 2002; Narva 2003; Yeates and Tonelli 2006).

With limited organ availability and the necessity to match organs based on blood type and the presence of protein antibodies, the waiting list for a donor kidney through the United Network for Organ Sharing (UNOS) grows longer each day (UNOS 2017). UNOS, the nationwide institution which distributes all organs for transplantation, including kidneys, claims equal opportunity for all patients to receive a transplant. However, studies have shown significant disparities in organ distribution among minority populations as well as within rural or remote communities (Alexander and Sehgal 1998; Cao et al. 2016; Davison and Jhangri 2014; Epstein et al. 2000; McPherson et al. 2017; Mucsi et al. 2017; Kucirka et al. 2011; Rubin and Weir 2015; Wu et al. 2017; Yeates et al. 2009). The Oglala Lakota, being both a minority as well as a rural, marginalized group, have significantly reduced opportunities to obtain kidney transplantation leading many with ESRD to suffer the negative health consequences associated with long-term dialysis treatment.

KIDNEY TRANSPLANTATION VS. DIALYSIS

End-stage renal disease, also known as end-stage kidney disease is a chronic disease resulting from the gradual loss of kidney function. The kidneys, which remove waste from the blood stream, function as a filter removing toxic substances from the body and excreting them as urine. When the kidneys become damaged, they are no longer able to filter out waste material, allowing these toxins to become more concentrated within the bloodstream. Without treatment, ESRD is fatal. The leading causes of ESRD are Type 1 and Type 2 diabetes, high blood pressure, inflammation of the kidney's filtration units and tubules, and frequent or prolonged obstruction of the urinary tract. ESRD can be devastating, often presenting with nausea, vomiting, loss of appetite, fatigue and weakness, sleeping problems, alterations in normal urination patterns, decreased mental acuity, swelling of the feet and ankles, and a buildup of fluid in the lining around the heart (Mayo Clinic 2017, CDC 2001).

Treatment for ESRD requires either mechanical filtration of the blood through hemodialysis or peritoneal dialysis, or the implementation of a 'used' filtration system by means of kidney

transplantation. Comparisons in patient outcomes between these two treatment methods have shown that kidney transplantation is associated with lower long-term health risks than dialysis treatments (Port et al. 1993; Wolfe et al. 1999). Kidney transplantation can occur in one of two forms: living donor kidney transplant or cadaveric kidney transplant. Living donor renal transplantation confers improved outcomes over the transplantation of cadaver kidneys; however risks to donor health, need for organ compatibility between donor and recipient, and financial burden of recovery make live donor kidney transplantation a less available option (Wolfe et al. 1999). With compounding health conditions common on the Pine Ridge Indian Reservation and limited financial resources, live organ donation is unlikely as a treatment. Therefore, the following discussion will be focused on cadaveric renal transplantation: transplantation from a deceased or brain-dead organ donor.

When measuring and comparing health outcomes, frequently cited are mortality and relative risk as well as overall quality of life as health indicators. Early studies examining the comparative mortality of dialysis and transplantation used population samples of those who received kidney transplants and those being treated with dialysis. These studies, conducted in the 1980s, have since been disregarded as being biased because of the selective advantage of those eligible to list for and receive a kidney transplant (Hutchinson et al. 1984; Port et al. 1983; Weller et al. 1982). Patients whose health conditions have significantly deteriorated would not be considered for transplantation as were most patients above the age of 65, therefore those who were healthier and younger were selected for transplant (Port et al. 1993; Wolfe et al. 1999). In a series of landmark studies, Friedrich Port, Robert Wolfe, and colleagues addressed these former biases and compared mortality rates among those eligible for transplantation. All study participants were wait listed for kidney transplantation and outcomes were compared between those who had received a transplant and those who remained on the waiting list (Port et al. 1993; Wolfe et al. 1999).

Results from these studies show that even after eliminating selection biases, kidney transplantation decreases long-term health risks in patients with ESRD. These results have been replicated in a number of countries including the United Kingdom, Germany, and Canada (Oniscu et al. 2005; Rabbat et al. 2000; Schnuelle et al. 1998). Following renal transplantation, mortality risk is higher than that seen in dialysis patients due to risks associated with having undergone a major surgical procedure, high doses of immunosuppressant drugs to prevent organ rejection, and the chance of a non-functioning renal allograft (Port et al. 1993; Wolfe et al. 1999). The risk of death due to the aforementioned factors decreases with time from transplantation and becomes equal to that of dialysis patients at approximately 110 days post-surgery (Port et al. 1993; Wolfe et al. 1999). Patients surviving past this point in time had a 68% lower risk of death than wait-listed dialysis patients (Port et al. 1993; Schnuelle et al. 1998; Wolfe et al. 1999). The long-term health benefits associated with kidney transplantation were shown to double life expectancy - from 5-10 years for those on dialysis waiting for transplantation to 15-20 years for those who had received a kidney transplant (Oniscu et al. 2005; Wolfe et al. 1999). For young patients, those aged 20-39 years, the projected life expectancy was up to 17 years longer than those who remained on the transplant waiting list (Wolfe et al. 1999).

Across all patients undergoing transplantation, there was a lower long-term risk of death regardless of age group or original condition leading to the development of ESRD (Oniscu et al. 2005; Rabbat et al. 2000). These survival benefits were even seen among high risk patients (Oniscu et al. 2005). Particularly significant were the long-term survival benefits for individuals for whom diabetes was the root cause of their ESRD (Port et al. 1993; Rabbat et al. 2000; Wolfe et al. 1999). Patients with diabetes were

projected to gain approximately 11 years of life after transplantation compared with the 8 years of life gained by those whose ESRD was caused by other health conditions (Wolfe et al. 1999). Using mortality as a health indicator, it is strongly supported that cadaveric renal transplantation increases life expectancy and decreases risk of death, despite the short-term increased risk of death in the months following transplantation (Port et al. 1993; Rabbat et al. 2000; Schnuelle et al. 1998; Wolfe et al. 1999).

In addition to long-term survival, it is important to account for the quality of the extended life years associated with kidney transplantation (Port et al. 1993). Health related quality of life, defined as "a person's sense of well-being and ability to function productively in daily life", is an important measure in gauging the physical, social, and mental well-being of an individual or population (Avramovic and Stefanovic 2012, 581). As with mortality, the period directly following surgery is associated with major limitations in one's physical, social, and emotional life (Esposito et al. 2017). Hospitalization and restrictions such as wearing a face mask, limited contact with animals, and frequent hand washing, were shown to decrease quality of life (Esposito et al. 2017). However, after this initial period of decreased quality of life, significant improvements have been demonstrated in cognitive, physical, and sexual function as well as in mental and emotional well-being (Esposito et al. 2017; Kostro et al. 2016).

Dialysis patients (both peritoneal dialysis and hemodialysis) tend to experience severe disability and myriad symptoms such as muscle and joint aches, dry and itchy skin, gastrointestinal pain and discomfort, difficulty concentrating, shortness of breath, cramps, dizziness, and decreased sexual function (Laupacis et al. 1996). These symptoms often lead to high rates of unemployment, depression, pain, poor sleep quality, malnutrition, inflammation and anemia (Esposito et al. 2017). Each of these symptoms and their related outcomes has been shown to improve after renal transplantation (Kostro et al. 2016; Laupacis et al. 1996). Employment rates increased from 30% employed before transplantation to 45% post renal transplantation. For individuals with functioning transplanted organs after two years - eliminating those with complications in the first two years after surgery - employment rates increased to 51% (Laupacis et al. 1996). As with mortality rates, the health related quality of life benefits experienced by diabetic patients was particularly significant (Esposito et al. 2017; Laupacis et al. 1996). While transplantation does not restore a patient's health to that of the general population, compared to long-term dialysis, kidney transplantation offers patients increased life expectancy as well as improved quality of life (Avramovic and Stefanovic 2012; Esposito et al. 2017; Griva et al. 2013; Kostro et al. 2016).

KIDNEY TRANSPLANTATION DISPARITIES

Cadaver renal transplantation is controlled and distributed in the United States through the United Network for Organ Sharing (UNOS), meaning patients must join the kidney waitlist and remain on dialysis until a matched organ becomes available. Cadaver organs are matched using blood type, height, weight and the human leukocyte antigen (HLA- a factor in transplantation graft survival) to the next patient on the waiting list within the given region who has these same biomarkers (UNOS Wu et al. 2017). Although frequently described as a wait list, UNOS describes their system for organ matching as a "pool of candidates who are waiting for organ transplants" (UNOS 2017). This computer matching system then "generates a ranked list of transplant candidates who are suitable to receive each organ" based on wait time, donor/recipient immune system compatibility, prior living donor, distance from donor hospital, survival benefit, and pediatric status in addition to the previously mentioned biological factors (UNOS 2017). Significant improvements in "immunosuppressive therapy, organ preservation, and recipient selection by

HLA matching have resulted in increased graft survival" and corresponding positive health outcomes among transplant patients (Schnuelle et al. 1998, 2135).

With sharp increases in the number of individuals in the developed world suffering from ESRD and kidney transplantation providing the best treatment option, the world faces a serious shortage in available organs as the rates of organ donors has not significantly changed in recent decades (Alexander and Sehgal 1998; Jha et al. 2017; Wu et al. 2017). Recent estimates show that the number of patients currently listed for renal cadaver transplants in the United States have doubled in the last decade reaching a current high of around 100,000 patients. With an average wait time of about four and half years on the kidney transplant list, almost 5,000 patients die each year while waiting for a kidney to become available (Wu et al. 2017).

In addition to the risk of death while waiting for an organ match due to complications with ESRD, wait time while on dialysis is strongly correlated with post-transplant health outcomes (Meier-Kriesche et al. 2000). In a linear relationship, the longer duration of time spent on dialysis leads to a correspondingly increased risk of morbidity and mortality via graft deterioration (Meier-Kriesche et al. 2000; Wu et al. 2017). The poor nutrition, chronic inflammation, and altered immunologic function experienced by those on dialysis may predispose patients to decreased tolerance of immunosuppressive therapies and anti-rejection medications after transplantation (Meier-Kriesche et al. 2000). Age is also considered a risk factor for successful transplantation with older individuals tending to have worse health outcomes after transplantation (although still improved from conditions on dialysis) than their younger counterparts. Therefore, extensive delay in waiting for transplantation creates added risk based on age demographics alone (Esposito et al. 2017; Wu et al. 2017).

In the United States, UNOS claims their organ matching and allocation system is based "only [on] medical and logistical factors... Personal or social characteristics such as celebrity status, income, or insurance coverage play no role in transplant priority" (UNOS 2017). Although this 'blind' system appears to provide equal opportunity to waiting transplant recipients, significant disparities exist in the allocation of organs based on ethnicity (Alexander and Sehgal 1998; Cao et al. 2016; Davison and Jhangri 2014; Epstein et al. 2000; Kucirka et al. 2011; McPherson et al. 2017; Mucsi et al. 2017; Rubin and Weir 2015; Wu et al. 2017; Yeates et al. 2009). The biomarkers and blood types necessary for appropriate renal allograft survival create a biological disadvantage among minority populations because deceased donor kidneys are primarily harvested from donors within the white majority population (Yeates et al. 2009). Although disparities still exist, changes to the UNOS allocation system in 2014 reduced biological disparities by placing an increased priority on "highly sensitized patients and patients with rare HLA types" commonly found among minority patients (Cao et al. 2016; Wu et al. 2017). More significant and difficult to address are the ethnic disparities caused by discrimination, likelihood of referral, and remote geographical location (McPherson et al. 2017; Rubin and Weir 2015).

Discrimination, institutional biases, or racism in areas of the United States puts minority groups at a disadvantage in relation to their ability to access kidney transplantation (Yeates et al. 2009). Compared to their white counterparts, minority populations such as Blacks, Hispanics, and American Indians all have been shown to have a higher prevalence of ESRD, yet despite having higher rates of ESRD, minority populations have a lower prevalence of kidney transplantation (Alexander and Sehgal 1998; Avanian et al. 1999; Cao et al. 2016; Epstein et al. 2000; Kucirka et al. 2011; Mucsi et al. 2017; Wu et al. 2017; Yeates et al. 2009). A significant factor in one's ability

to obtain a successful kidney transplant is the timely referral to the UNOS transplant waiting list. It has been shown that minority populations have lower rates of transplant referral and longer duration of dialysis treatments than their white counterparts (Kucirka et al. 2011; Yeates et al. 2009). As previously mentioned, the more time spent on dialysis, possibly due to delayed referral, the worse health outcomes individuals tend to experience;individuals with delayed referral may no longer be eligible for transplantation due to deteriorated health conditions (Alexander and Sehgal 1998; Wu et al. 2017).

In addition, social determinants persist beyond the realm of the renal transplantation health system (Yeates et al. 2009). Poverty and low levels of educational attainment reduce the likelihood of kidney transplantation due to a limited ability to consume health care information and reduced engagement in one's own health situation (Yeates et al. 2009). Additionally, socioeconomic status- closely linked to one's insurance status, patient preferences, lack of knowledge regarding transplantation, and past experiences with discrimination in the health care system all act as contributing factors in creating health disparities in access to kidney transplantation (Cao et al. 2016; Mucsi et al. 2017).

Geographical remoteness has also been linked to decreased accessibility to access kidney transplantation treatment (Anderson et al. 2009; Yeates et al. 2009). UNOS operates 58 donor service areas which are grouped into 11 regions. Due to the limited lifespan of a preserved organ (kidneys can be preserved for 24-36 hours), recipients for kidney transplantation within a given region are only able to be matched with a donor from the same region (UNOS 2017). This system leads to a number of geographical inequalities because organ accessibility is directly linked to regional populations (high numbers of wait listed recipients in a given region) and donor rates within a given region (Cao et al. 2016; Wu et al. 2017). Issues regarding remote locations involve additional barriers related to distance, financial stability, and access to appropriate health care. Increased distances to health care facilities or transplant centers require ownership or access to a car and a corresponding financial ability to pay for gas and an overnight stay (Anderson et al. 2009; Bello et al. 2012). Populations in remote areas were "less likely to receive appropriate specialist care" and "distance was viewed as a deterrent to initiating renal transplantation" (Bello et al. 2012,2852).

BARRIERS IN ACCESSING KIDNEY TRANSPLANTATION AMONG NATIVE POPULATIONS

Of particular importance, yet understudied, are disparities in access to kidney transplantation among indigenous populations of the developed world, and American Indian populations in the United States specifically (Davison and Jhangri 2014; Mucsi et al. 2017; Yeates et al. 2009). Rates of diabetes, heart disease, hypertension, and obesity, previously rare among American Indian populations, have skyrocketed in recent decades (Wiedman 2012). Poverty, unemployment, and the adoption of modern diets and lifestyles have led to the development of these diseases of modernity. Those living on reservations in the United States are geographically marginalized, often times leading to a lack of opportunity and limited access to adequate health care facilities (Wiedman 2012).

The epidemic of metabolic diseases which plague American Indian populations was, at one time, thought to be due to genetic differences: the result of fewer generations to genetically adapt to modern environments (Thrifty Genotype Hypothesis: James Neel). This paradigm has since largely been abandoned and instead now focuses on the cultural "embodiment of the chronicities of modernity" (Wiedman 2010; Wiedman 2012). This theory focuses on the social and cultural factors which influence daily life leading to the three main risk factors which

result in the development of metabolic disorders: decreased physical activity, overnutrition, and chronic stress (Wiedman 2012). The United States reservation system, which allotted areas of land for tribal groups across the country, confined native populations physically, psychologically, politically, and economically. The institutions and legacies of past colonial relationships create "structural violence" through land appropriation, powerlessness, and economic isolation (Wiedman 2012). The introduction of a western diet and lifestyle, an obesogenic environment, has led many to develop metabolic disorders, especially diabetes. Diabetes, difficult to control due to the persisting structural violence suffocating native populations, has led to particularly high rates of ESRD on reservations nationwide. While many look to individual behaviors, choices, and biology as the root causes of the current poor health of native populations, chronicities of modernity theory instead shifts the focus away from "blaming the victim to blaming the society and culture of modernity" (Wiedman 2012, 606).

In the United States, American Indian populations experience rates of ESRD which are up to four times the rates of white populations (Blagg et al. 1992; Yeates 2003). This trend can be seen in other developed nations such as Australia, Canada, and New Zealand where local indigenous or aboriginal populations suffer significantly higher rates of ESRD (Davison and Jhangri 2014; Yeates et al. 2009). In addition to high rates of ESRD, American Indian populations have the lowest prevalence of kidney transplantation among minority groups in the United States (Anderson et al. 2009; Narva 2002; Narva 2003; Yeates and Tonelli 2006). These low rates of transplantation have been attributed to a number of social factors such as language barriers, home sanitation, remote living locations, perceived lack of motivation, patient preferences, health practitioners' attitudes, and a lack of culturally appropriate patient education programs (Anderson et al. 2009; Yeates et al. 2009). In addition, lack of education and unfamiliarity with the long-term benefits of kidney transplantation leads patients to feel conflicted towards or wary of renal replacement surgery because of its associated short-term risks (Davison and Jhangri 2014; McPherson et al. 2017).

Remote locations of reservations in the United States have created difficulties in accessing healthcare facilities and transplant centers (Cao et al. 2016; Condiff 2009). The Pine Ridge Indian Reservation, located in the southwestern corner of South Dakota, is situated in a particularly remote area of the country. Despite having a clustered population of high rates of ESRD on and around the Pine Ridge reservation - including Rapid City, a 'hot-spot' for high ESRD - there is a lack of health care facilities and a complete absence of transplantation centers. Despite these high rates of ESRD, the nearest transplant centers are located in Sioux Falls, SD, Denver, CO, and Omaha, NE (5.5 hours, 6 hours, and 7 hours away, respectively)(Cao et al. 2016). Small population and comparatively low numbers of donors make the availability of organs that much more limited within this region (Cao et al. 2016).

While information regarding cultural norms surrounding kidney transplantation on the Pine Ridge Indian Reservation has not yet been studied, previous research has been conducted among other native populations in the United States, Canada, and Mexico which indicates that cultural beliefs, opinions, and spirituality may deter individuals from seeking transplantation as a treatment option for ESRD (Anderson et al. 2009; Blagg et al. 1992; Condiff 2009; Crowley 1999; Davison and Jhangri 2014). In 1999, Megan Crowley examined the cultural views on organ transplantation in Mexico. She found that popular beliefs in Mexico focused on the sacred integrity of the body (Crowley 1999). These cultural views and meaning of the body contrasted starkly with the "mechanistic view of the body in which organs are simply interchangeable parts to be replaced as needed" (Crowley 1999, 130).

Another study conducted by Davison and Jhangri, examined traditional beliefs regarding organ donation and transplantation among Canadian First Nation members. It was commonly stated that "the dead must be left in peace" and that it is important for one to "enter the spirit world with an intact body" (Davison and Jhangri 2014, 782). While these beliefs were commonly held and may have been a deterrent for some individuals, only 18.7% of participants reported that these views influenced their opinions about organ donation or transplantation (Davison and Jhangri 2014). Among Northwest Native American tribes in the United States, similar views were held regarding the importance of one's body remaining whole, contributing to low rates of organ donation and a general lack of awareness or interest in organ transplantation (Blagg et al. 1992).

SOLUTIONS

Being both geographically marginalized and of an ethnic minority, American Indian individuals face myriad barriers in accessing kidney transplantation. If desired, transplantation as treatment for end-stage renal disease could be the difference between life and death. Therefore, it is vital that work is done to minimize the impacts of the many barriers previously addressed to provide the best possible health outcomes for those suffering from end-stage renal disease. By opening more clinic locations in rural or remote areas and improving the public transportation to and from these facilities, individuals living in marginalized areas will have improved access to adequate health care services and transplant centers. As an alternative to the construction of additional health facilities, telehealth technology (health care received via telephone) may be useful in providing additional access to care without the lengthy and costly trips to existing medical centers (Bello et al. 2012). Lastly, increased awareness and an emphasis on the life-saving benefits of kidney transplantation nation-wide may stimulate and encourage the public to become organ donors, thereby increasing available organs and providing improved treatment for patients suffering from end-stage renal disease (Oniscu 2005).

On the Pine Ridge Indian reservation, highlighting which barriers are most inhibitive for patients will help to focus initiatives and target interventions to provide increased opportunities in accessing kidney transplantation treatment (Alexander and Sehgal 1998). Working with existing non-governmental organizations on the reservation and emphasizing the restrictiveness of specific barriers to Indian Health Services and the tribal government, it is possible to address the disparities and poor health outcomes associated with the highly prevalent ESRD among the Oglala Lakota people.

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Mismatch and the Effects of Hormonal Contraceptives on Breast Cancer Risk

ASHLEY SNYDER

Often, when people refer to breast cancer, images of chemotherapy and races for the cure come to mind. Breast cancer is the most common cancer for women in the United States today, regardless of race or ethnicity (Centers for Disease Control and Prevention 2017). Yet many women do not know that breast cancer is a result of evolutionary mismatch. Breast cancer in modern industrialized societies is often the result of lifestyle choices that were uncommon throughout much of human history. Indeed, some of the best evidence we have to support this are studies that document breast cancer rates, or the lack thereof, among women who choose the lifestyle that was common for much of human history.

What is this lifestyle? In short, it is the lack of menstruation. This is often accomplished by consistent pregnancy and lactation throughout the reproductive years of a woman's life (Strassmann 1999). We see mismatch in our modern industrialized environment when women choose not to have as many children as possible. This is further impaired by use of hormonal contraceptives as the reproductive hormones added to a woman's body exacerbate the hormonal effects already created by the lack of pregnancy and lactation. Decreased prevalence of pregnancy and lactation are one side to this mismatch. In this article, I will address how hormonal contraceptives affect breast cancer risk in women and how this presents another side to the discussion of breast cancer as a mismatch disease in modern industrialized societies.

It is thought that the hormonal fluctuations that occur during the menstrual cycle are a result of natural selection as these fluctuations may have helped prime women's bodies for reproduction and, thus, offered a selective advantage. This strategy appears to have been very effective. Until relatively recently, the norm for women was to have several children within their lifetimes, rather than just one or two – if any – as is often the case in modern industrialized societies. In fact, early work on the correlation between reproductive cancers and parity found that women, such as nuns, who had no children were more likely to experience cancers in reproductive organs than women who had several children. If a woman intends to have many children, these hormonal fluctuations may prove to be a benefit; however, for women who choose not to have children, these fluctuations cause disease risk to increase (Lieberman 2013).

Many studies within the last few decades have shown support for this correlation. In a study that looked at breast cancer risk among Greenland Inuit women, it was found that longer duration of breastfeeding was associated with decreased risk for breast cancer and having three or more full-term pregnancies may also confer some protection against breast cancer (Wielsøe, Gudmundsdottir, and Bonefeld-Jørgensen 2016). A study assessing breast cancer in Norwegian women found that breast cancer risk not only decreased with higher parity (unless higher parity occurred in the 20-29 age bracket) but also decreased greatly the younger the mother was, particularly if age at first birth was under twenty; however, the effects of higher parity were offset if age at first or last birth was higher (Albrektsen et al. 1994). Several studies have found that women who were religious and aligned with the Church of Jesus Christ of Latter-day Saints (LDS) were less likely to develop breast cancer perhaps due to greater

parity, which is associated with LDS culture (Daniels et al. 2004; Merrill and Folsom 2005; Merrill and Lyon 2005). One of these studies found that LDS women also were less likely to use oral contraceptives, which the authors explain could have some association with the risk for breast cancer (Daniels et al. 2004).

Hormonal contraceptives have provided a new sense of freedom for many women over the last century. Because of access to hormonal contraceptives, women can better plan for pregnancy as well as get rid of painful, unwanted effects of menstruation, among other benefits. However, though there are a variety of benefits to hormonal contraceptives, there can also be negative effects from exposing women's bodies to the exogenous hormones that contraceptives introduce; given how new the use of hormonal contraception is, there has not been much time, from an evolutionary perspective, for women to adapt to the effects these added hormones create.

Several studies have indicated that current use of oral contraceptives increases breast cancer risk. A Nurses' Health Study (NHS) found that premenopausal women who were currently using oral contraceptives had a 50% greater risk for breast cancer regardless of past use (Bhupathiraju et al. 2016). The authors of one study looked at this correlation in women between the ages of 29-39 because in recent years the authors' clinic had seen an increase in cases of breast cancer in women under the age of 40 (Arleo et al. 2015). The authors from this clinic found that most women who were diagnosed with breast cancer in the 29-39 age category did not have a known family history of breast cancer nor did most of those who did have a family history of breast cancer have a first degree relative who had had breast cancer (which is significant because genetics has long been a focus of cancer research); however, a little over half of the participants had used oral contraceptives, though the exact amount of time between when oral contraceptives were used and when breast cancer was diagnosed was not revealed in their article (Arleo et al. 2015). In a study looking at oral and injectable contraceptive use in black South African women, it was found that women who had used either of these contraceptives had significantly increased rates of breast cancer compared to women who had never used these contraceptives, though there was no difference based on whether the contraceptive used was oral or injectable (Urban et al. 2012). However, this risk diminished if women had previously used these contraceptives but had not used them in the last ten years (Urban et al. 2012). In addition, risk decline was not affected by the duration of contraceptive use (Urban et al. 2012). These studies indicate that use of hormonal oral or injectable contraceptives increase risk for breast cancer, but as was previously discussed, parity appears to be greatly associated with risk for breast cancer. Since contraceptives can play a large part in preventing pregnancy, an important question would be whether the increased risk for breast cancer associated with hormonal contraceptives is really due to lack of pregnancy or lactation rather than use of contraceptives.

As was previously assessed, parity is one of the most important factors in determining breast cancer risk, regardless of country or ethnicity, and the use of contraceptives has certainly played a role in decreasing the number of children women have and at what ages they have them. A large analysis using information from 54 studies found that there was a small overall increase in breast cancer risk among women who had used oral contraceptives in the last ten years, and risk was higher for those who were current users and who started using oral contraceptives under the age of 20 compared to women who were current users and started using oral contraceptives at a later age. The outcomes did not appear to be affected by factors like ethnicity, family history of breast cancer, or parity. In fact, there was similar risk regardless of whether a woman was nulliparous or parous,

how many children a woman had, and when a woman starting using contraceptives relative to the birth of her children. Thus, the elevated risk for breast cancer associated with hormonal contraceptives appears to be independent of how many children a woman has in her lifetime (Collaborative Group on Hormonal Factors in Breast Cancer 1996).

In the same study just mentioned, there did not appear to be a difference in breast cancer risk related to specific type of hormone used, such as estrogen or progesterone, but women who took high doses of hormones were apparently at a greater risk for breast cancer (Collaborative Group on Hormonal Factors in Breast Cancer 1996). Several studies have indicated that the dosage has a significant impact on what forms of hormonal contraceptives affect risk. One study found that women who used combined oral contraceptives (containing both estrogen and progestin) or who had used both combined oral contraceptives and progestin-only oral contraceptives had a higher risk for breast cancer mortality than women who had never taken these (Samson et al. 2017). However, the authors also found that use of oral contraceptives that contained only progestin created a decreased risk for breast cancer mortality (Samson et al. 2017). The authors admit, though, that the number of participants in some categories, such as that for progestin-only oral contraceptives, was small and thus not as likely to be a good representation of the greater population (Samson et al. 2017). In the Nurses' Health Study, when comparing oral contraceptive formulas in the 1990s with more recent formulas, they found that triphasic preparations of levonorgestrel had an association with the higher risk for breast cancer (Bhupathiraju et al. 2016). In contrast, levonorgestrel-releasing intrauterine devices have been prescribed as contraceptives for women with high breast cancer risk as these devices are very effective as contraceptives yet give a lower systemic exposure to exogenous hormones (Dinger, Bardenheuer, and Minh 2011). A study conducted among German and Finnish women found that levonorgestrel-releasing intrauterine devices appeared to have no significant effect on breast cancer risk, and its effects were about the same as when women used copper intrauterine devices, which do not expose users to exogenous hormones (Dinger, Bardenheuer, and Minh 2011).

The association between use of exogenous hormones, like those found in hormonal contraceptives, and breast cancer risk is further supported by evidence surrounding hormone replacement therapy. Hormone replacement therapy has now been shown to increase breast cancer risk, particularly when a treatment involving both estrogen and progesterone are used (Chen 2008). The Nurses' Health Study found that hormone therapy, such as those that used estrogen and/or progestin, increased breast cancer risk among postmenopausal women, and this risk increased the longer the duration of hormone therapy (Bhupathiraju et al. 2016). Another assessment of the NHS found that current use of hormone therapy was associated with breast cancer risk among postmenopausal women (Rice et al. 2016), similar to the finding that oral contraceptive use may confer risk only if currently being used (Bhupathiraju et al. 2016).

A study looking at cases of breast cancer in relation to oral contraceptives and hormone replacement therapy in Icelandic women found that women who used both oral contraceptives and hormone replacement therapy in their lifetimes were even more likely to develop breast cancer than women who had ever only used one of these treatments. However, the type of hormone replacement therapy regimen had an effect as women whose regimen used both estrogen and progesterone showed significant increased risk, while those who used a regimen that included only estrogen did not have this risk. Interestingly, they also found that women who used estrogen-only hormone replacement therapy and did not use oral contraceptives

were at a decreased risk for breast cancer. There were a few limitations to this study though; for example, though the authors did use a hazard ratio to control for other factors like parity and age at menarche that might affect breast cancer risk, the authors acknowledge that age at menopause was an important factor but was not tracked due to data limitations. The authors did find a clear association between breast cancer and use of therapy that includes both estrogen and progesterone, but the question remains about whether other factors could have affected breast cancer risk. A question to consider further on this subject is whether the reasons for undergoing a specific type of hormone replacement therapy (i.e. estrogen only versus both estrogen and progesterone) in the first place might be a factor in breast cancer development (Thorbjarnardottir et al. 2014).

It should be noted that there are not always clear associations between hormonal contraceptives and risk for breast cancer. A study using MammaPrint® testing to assess risk factors did not find an overall association between contraceptive use and breast cancer risk (Makama et al. 2017). There are some studies that find family history and parity have greater effect on breast cancer risk than exogenous hormones (Kawai et al. 2010). There are also certain lifestyle factors that have to be accounted for; for example, one study found that those who used hormonal contraceptives were less likely to have smoked or consumed alcohol than those who had never used hormonal contraceptives (Urban et al. 2012). Another cause for concern is endogenous hormones already circulating in women's bodies (Chen 2008). One of the assessments of the Nurses' Health Study found that the endogenous hormone prolactin was positively associated with breast cancer risk, a factor that is not necessarily influenced by exogenous hormone usage (Rice et al. 2016).

Much evidence indicates there is a relationship between parity and breast cancer risk. Perhaps needless to say, the increased use of hormonal birth control has contributed to this by decreasing the number of births that occur, but hormonal birth control may also be a factor in breast cancer risk in other ways besides affecting parity. The hormonal fluctuations that naturally occur from the menstrual cycle and that create the risk associated with lower parity are going to be affected by using hormonal contraceptives. There is mixed evidence on how hormonal contraceptives do this, mainly because there are several types and degrees of hormones introduced depending on what hormonal contraceptive method, specifically, is used. However, there is enough evidence to indicate that certain hormonal contraceptives, particularly those that expose women to higher amounts of exogenous hormones, can increase risk for breast cancer.

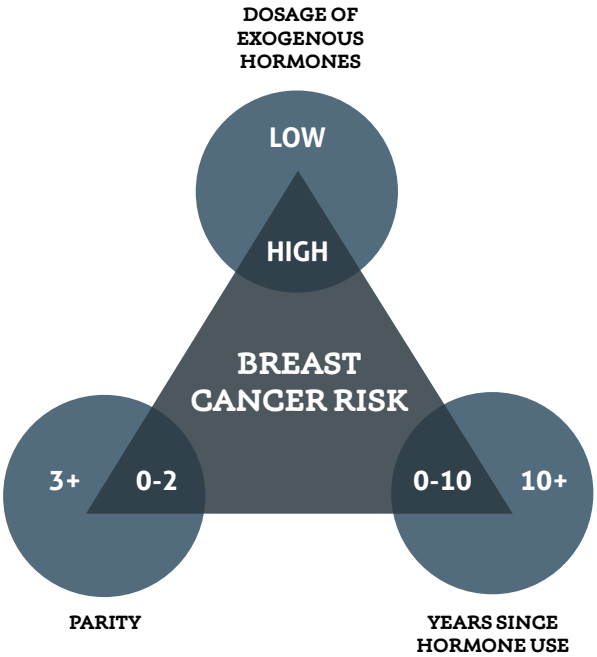

Figure 1. A simplified depiction of the conditions under which amount of hormonal contraceptives, parity, and years since hormone use affect breast cancer risk where the values presented are the relative dosages, number of children, and number of years, respectively, when breast cancer risk either does (inside of triangle) or does not (outside of triangle) appear to be of great concern. Exact amounts may vary by study, and degree of risk for breast cancer will vary by individual.

Given that women did not have access to hormonal contraceptives for much of human history, use of these treatments could play a role in an evolutionary mismatch. The hormonal fluctuations that evolved to help us conceive as many children as possible are presently cause for concern in diseases like breast cancer. Indeed, the evidence that hormonal contraceptives only impact breast cancer risk within ten years of last use further indicates that hormonal contraceptives are an environmental mismatch that can be reversed.

Many lifestyle factors need to be weighed when looking at what could affect risk for breast cancer. For example, greater amounts of physical activity is a lifestyle factor that can decrease risk for breast cancer (Rice et al. 2016). In addition, any costs from the use of hormonal contraceptives must be weighed against the benefits hormonal contraceptives can provide; long-term use of hormonal contraceptives, for example, may help decrease risk for ovarian cancer (Bhupathiraju et al. 2016). Use of hormonal contraceptives is only one risk factor for breast cancer, but understanding this association may provide a deeper understanding of some of the root causes of the disease.

Research on hormonal contraceptives can help shed light on new treatments as the impact of exogenous hormones could indicate which hormones are more likely to be linked to breast cancer. If the problem becomes not the type of hormone but how much hormone is present overall, then methods to avoid excess reproductive hormone exposure may be necessary to prevent breast cancer in patients. This could be in the form of using lower hormone doses in contraceptives, or perhaps it could extend to measures where physicians attempt to decrease the amount of hormones present in women who do not use hormonal contraceptives, who have few or no children, or who choose to have children at a later age. Viewing hormonal contraceptive use as part of an evolutionary mismatch may help us understand not only the development of breast cancer and its associated risks but also how this disease can be treated in the future.

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Just Scraping By: An Analysis of Unifacial Tool Reduction from Pack Rat Shelter (5LR170)

NICK SIMPSON

Lithic analyses can tell us a great deal about the lifeways of mobile foragers and hunting and gathering societies based on the artifacts that make up the assemblages they leave behind. One of the most common lithic artifacts found on archaeological sites are flakes. They are most often either the result of reduction processes involved in making other stone tools, or the flakes were produced for use as tools themselves. Unifacial flake tools lend themselves well to analyses focused on patterns of curation and lithic reduction. Tools can be either used expediently, resulting in little to no reworking, or they can be heavily rejuvenated which suggests the intent of long-term use and reuse. Multiple studies have been conducted relating the frequency of raw materials found and a site and the intensity with which they are reworked to the distance from raw material sources. These studies indicate a "decay-like" pattern, where increasing distance from raw material sources decreases the frequency of tools made of non-local material, while the amount of retouch performed on them increases (Brantingham 2003, 489). Raw materials are described as being "local" at a distance of less than 5 km away, and "non-local" at distances that exceed 20-30 km (Feblot-Augustins 1993; Gamble 1999). Generally speaking, the closest raw materials should dominate the assemblage of a site, with frequencies dropping off as distance increases. However, it's important to note that other factors such as material quality may bias the distribution of raw materials at a site.

For this study, a collection of flake tools from Pack Rat Shelter (5LR170) was analyzed for lithic reduction intensity in relation to material type. Pack Rat Shelter is located north of Fort Collins, Colorado and is described as two shelters overlooking Spring Gulch (Figure 1). The site contains evidence of Early through Late Archaic occupations, however the cultural material suggests a predominantly Middle Archaic occupation, yielding 19 McKean cluster points. The McKean cluster technology has been recorded across the northwestern Great Plains since the 1950s, and spans from Northern Colorado to Montana and North Dakota (Davis and Keyser 1999). Due to the presence of non-local materials, it seems obvious to claim that the occupants of Pack Rat Shelter were mobile foragers, however evidence from other sites in the region suggest that adaptive strategies to exploit the areas around the Rocky Mountains in Northern Colorado year-round were in place possible as early as 10,000 yBP (Black 1991). It is possible that with ample access to water, migrating game, a raw material source, and edible vegetation located near the foothills of the Colorado Rockies, the inhabitants of Pack Rat Shelter used the site extensively and for long periods, however this question is outside

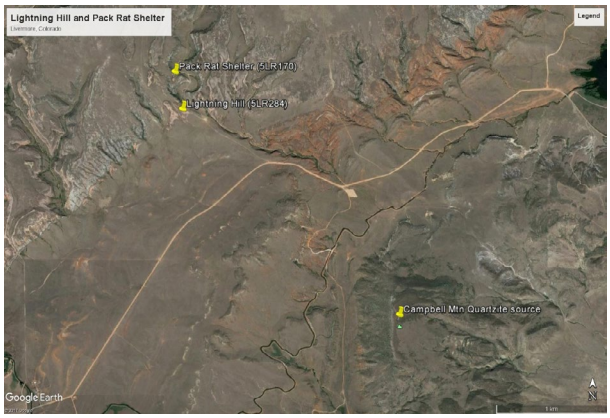


Figure 1: Google Maps Image depicting the location of Pack Rat Shelter and the associated quartzite source.

of the scope of this paper and would require multiple other lines of evidence.

The flaked lithic assemblage of Pack Rat Shelter is dominated over 90 percent by quartzite, likely quarried from a nearby source located about 3 km southeast of the shelter. The flake tools from this site were recovered from both the surface as well as controlled excavation units. They were analyzed without regard to recovery provenience, investigating 5LR170 as a locality independent of changes through time. The goal of this analysis was to determine if there are differences in the amount of lithic reduction and rejuvenation performed on unifacial tools based on local versus non-local materials. The assumption here is that the lithic material was procured opportunistically, rather than selectively, which implies that the procurement of raw materials was embedded within other activities involved in mobile forager lifeways (Binford 1979). Holding all else equal, the makeup of materials in the assemblage meets expectations for lithic patterning of raw materials, with quartzite tools dominating the assemblage, chert, and chalcedony making up the remainder of materials present. The chert artifacts are visually reminiscent of materials produced by the Hartville Uplift located in eastern central Wyoming, however this is not verified by any means. The hypothesis for this analysis is that tools made of non-local materials (cherts) should be more intensively reworked than tools made from local materials (quartzite and chalcedony). This expectation is based on the premise that it would be beneficial for the occupants of Pack Rat Shelter to extend the use-life of materials that are not readily available to access more than on materials that are close by and readily available.

BACKGROUND

The study of lithic technology organization deals with strategies revolving around the procurement, production, maintenance, and discard of stone tools (Andrefsky 2009). The way that we understand the use, curation, and discard of stone tools can tell us a great deal about prehistoric lifeways, land use, and mobility practices. A single flake blank may go through multiple changes throughout its life history, which alter both its form and function. The distribution and variability of lithic raw materials are greatly influential to the ways that humans manufacture, use, and rework stone tools (Andrefsky 2009). A study conducted from a Middle Paleolithic site in southwest Asia shows that stone toolmakers conserved raw material in the face of lithic resource constraints by changing technological strategies (Braun 2005). We also cannot discount that different lithic materials possess different properties in terms of their fracture patterns, and these differences may make some materials more desirable for certain tasks than others. Another study conducted by Brantingham (2006) suggests that greater mean and maximum stone transport distances reflect increased planning depth and greater optimization of tool utility. If this study holds true for Pack Rat Shelter, we should see greater amounts of curation on tools made of non-local materials.

In terms of lithic analyses of unifacial tools, the measurement of reduction intensity is one of the most common. Clarkson (2002) proposed an index of invasiveness for measuring retouch intensity on unifacial and bifacial tools. This is a relatively simple method in which the artifact is separated into 16 analytical segments, with 8 on the dorsal side and 8 on the ventral side. A line is drawn, somewhat arbitrarily, to divide the segments into two "zones of invasiveness", and a value of 0.5 or 1 is applied depending upon how far flakes intrude into the segment. This method is a good indicator of the degree and extent of retouch invasiveness, however it does not help to indicate the original size of the flake, and does not account for variation in size, thus is only useful as an absolute measure and not well suited for determining retouch intensity across many artifacts within an assemblage. Likewise,

Kuhn (1990) proposed a geometric index of reduction for unifacial stone tools based on the modeling of flake cross-sections. He argued that estimating the extent of artifact reduction should be relatively free of assumptions about reduction sequence and independent of artifact size. Kuhn's method for indexing reduction assumes a typical flake morphology should approximately reflect a triangular cross-section. He noted that as reduction occurs, the terminations of the retouch scars approach the centerline of the flake and achieve the same value as the maximum thickness once the terminations reach midline. His index is measured through two different methods, both of which assess the relative thickness of the retouched termination to the maximum midline thickness. The first method is executed by measuring "t", or the thickness of the tool at its termination of retouch scars, and dividing it by "T", which represents the maximal medial thickness of the specimen simply using calipers (Kuhn 1990). The second method involves trigonometric calculations where the retouch scar length is multiplied by the sine of the retouch angle (Kuhn 1990). This method has been critiqued for several reasons by Hiscock and Clarkson (2005). They note that the index can only be measured on unifacial tools, which have not experienced reduction on the ventral surface, since ventral modification creates an inaccurate representation of the retouched angle. Secondly, they address what is known as the "flat-flake problem", proposed by Dibble (1995) as a criticism of Kuhn's index. The flat-flake problem occurs when a flake's dorsal surface parallels the ventral face. He argued that in these instances, the Kuhn's index approaches the maximum thickness much more quickly than it will on more convex flakes (Dibble 1995). Additionally, Kuhn's index gives an absolute value measurement for reduction, but does not take variability of size into account, and is best used as a continuous but uncalibrated measure of reduction (Kuhn 1990).

The method selected for the measurement for reduction of unifacial flake tools from Pack Rat Shelter is described by Eren et al. (2005) and it is used to calculate the volume of material that has been removed during the reduction process from the original flake. This method operates under several assumptions about flake morphology and reduction, however is a good measure for comparing reduction intensity among flake tools of varying sizes. After performing the calculations necessary for estimating the volume of removed material, values can be converted into percentages by measuring the volume of the tool, and adding it to the calculated volume of removed material to come up with a calculated estimate of the original unretouched flake. These calculations are performed under the assumption that when a flake is removed from a core, its cross section is generally triangular in shape, and that the angle created between the ventral and dorsal sides of the flake is continuous and ends in a feathered termination. While it is unlikely that all flakes represented in the assemblage conform to this ideal, experiments performed by Eren et al. (2005) indicate that this method is a highly accurate measure for the intensity of lithic reduction of unifacial tools.

MATERIALS AND METHODS

The entire assemblage for the Pack Rat Shelter excavations contains a diverse range of chipped stone artifacts dating from the Early to Late Archaic. The chipped stone materials are made up of projectile points (n=33), knives (n=4), likely projectile points (n=19), flake tools (n=53), and lithic debitage. The flake tools were selected for analysis because of the number of tools available, and the representation of both local and non-local materials. Of the 53 flake tools in the assemblage, only the unifacial tools (n=37) were selected for lithic reduction analysis. Unifacial tools recognized by archaeologists typically encompass a series of artifacts that include "sidescrapers", "endscrapers" "retouched flakes", "gravers", and several others such as "spokshaves" (Andrews et al. 2015). Of the 37 unifacial tools selected, 34 were classified as

unifacial scrapers, with no distinction between "end" or "side" scrapers because specifying the location of the utilized edge is not relevant to the analysis of reduction intensity, though it would be interesting to see how the reduction intensity is affected (if at all) by the locations of the worked edges. The raw material classes are dominated by local quartzite (n=25), with chert (n=9), and chalcedony (n=3) making up the remainder of the material.

All of the unifacial tools were recorded for standard measurements including material type, provenience, maximum length, width, and thickness, as well as mass (g). Figure 2 illustrates the relationship between mass and thickness of the tools, showing that as mass of the tools increase, so too does their maximum thickness. This indicates that the tools with the greatest remaining mass likely began as larger flakes than did those with a smaller mass, following the notion of flakes as idealized triangles in cross-section. Figure 2 also shows that only four flake tools exceeded 20g in weight, all of which are quartzite, with the majority of tools clustering between 1-15g in mass and 3-12mm in thickness.

The method employed in this study is derived from Eren et al. (2005) analysis for defining and measuring reduction in unifacial stone tools. This method determines reduction as a function of volume, thus representing three-dimensional material loss, as opposed to two-dimensional measurement indices (Clarkson 2002; Kuhn 1990). It operates on a premise similar to Kuhn (1990) in that it assumes an idealized triangular cross-sectional flake morphology. This method calculates the area of the triangle created by measuring the angle of the initial flake, and the angle and length of the reworked edge. By approximating a triangle from the angle of the original flake and knowing the angles

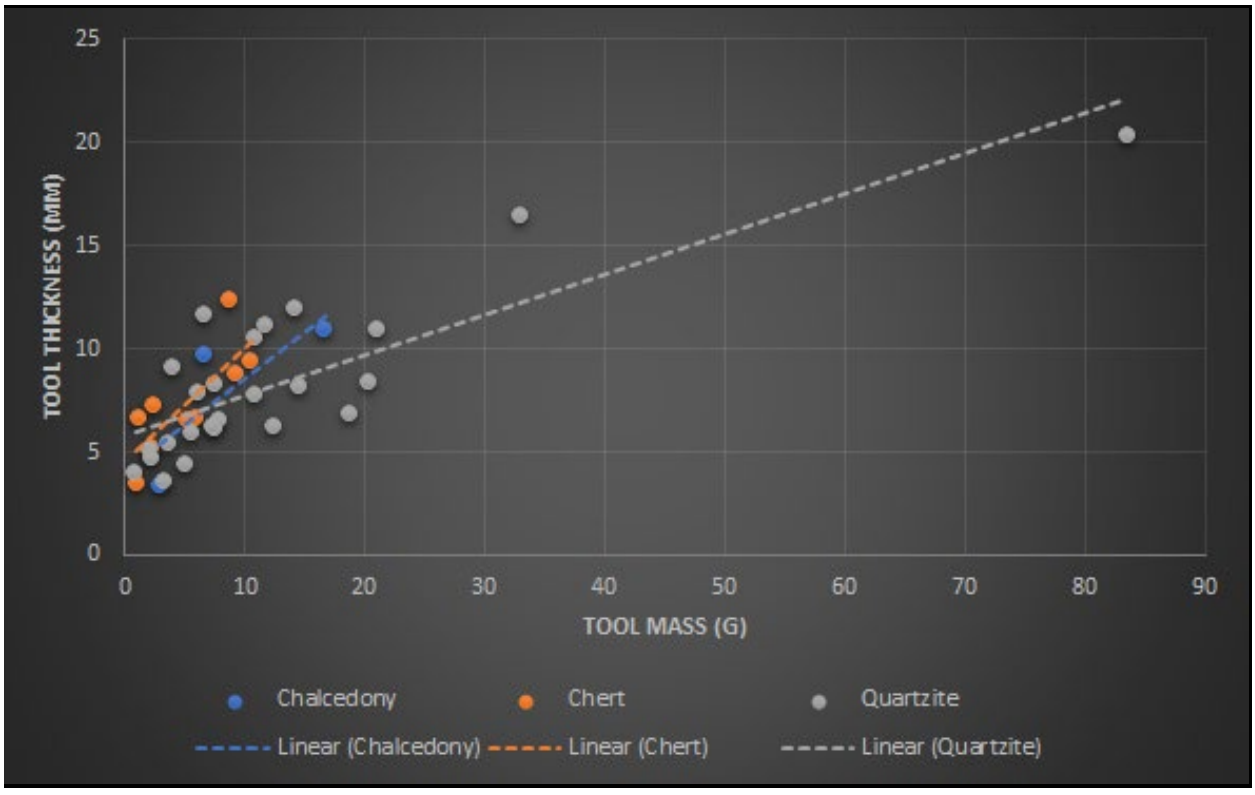


Figure 2: Bivariate plot showing relationship between mass and maximum thickness of tools.

and length of the reworked edge, the missing portion, representing the material removed during reduction, can be calculated with a simple formula. The angles of the initial flake and length and angles of retouched edges were measured using the DinoLite in conjunction with DinoCapture 2.0 software. The measurements were taken by calibrating the DinoLite to the appropriate magnification and drawing lines to calculate lengths and angles. Figure 3 depicts the results of measurements with the DinoLite on a scraper specimen from the assemblage. In this image, TA1 = the angle of the initial flake relative to the ventral surface, TA2 and TA3 = two angles of the triangle representing the reduced material, and DL1 = the length of the retouched edge.

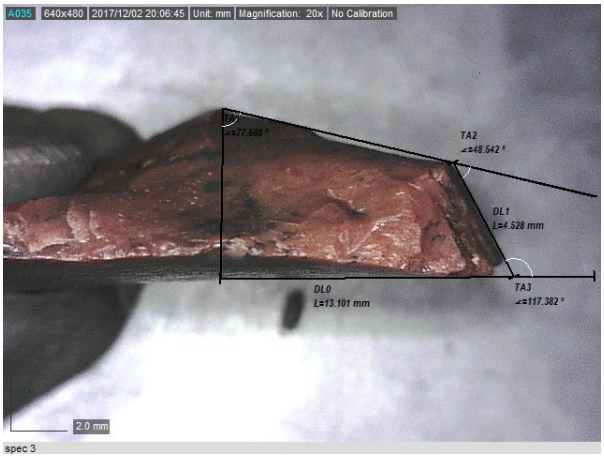


Figure 3 (top): Dinolite image of angles measured on Specimen 3 (Chert scraper). Figure 4 (bottom): Dinolite image of measured length of worked edge on Specimen 3 (Chert scraper).

The area of retouched material is calculated by using a formula for which two angles and the length between them is known, but the remaining sides and angle is unknown. The remaining angle can be easily calculated by subtracting the sum of the two known angles from 180°. In the case of Figure 3, we calculate 180° = 117.4° + 48.5° + TA4 (unknown angle). Solving for TA4 gives us a missing angle of 14.1°. The length of the sides opposite of angles TA2 and TA3 (we will call them DL2 and DL3) is calculated using the Law of Sines, which can be expressed: DL1/sinTA4 = DL2/sinTA2. In the case of Figure 3, we would calculate 4.5/sin(14.1) = DL2/sin(48.5), so that DL2 = 4.5/sin(14.1) x sin(48.5). For this example, DL2 = 13.8 mm. The final side can be calculated using the same formula, but substituting in the appropriate angles and side lengths. It is then possible to calculate the area of the triangle using the formula area = ½ base x height. In order to eliminate any user error in calculations, the lengths of sides and area of the triangles representing the area of retouch were calculated using a tool found online. The website used is triangle-calculator.com, and it allows the user to input lengths of available sides and measurements of available angles to determine the lengths of sides and angles which are missing. The input options allow for triangles with three sides present, two sides and one angle, or two angles and one side. In the case of the unifacial tools from Pack Rat Shelter, two angles and one side were entered to calculate the length of the sides and area of removed material. For tools which exhibit differing degrees of retouch with varying angles of retouch, multiple measurements were taken and averaged together to determine the average area of reduced materials.

Volume was then calculated for the reduced portion of the original flake by measuring the length of the worked edge using the DinoLite, which can measure distance along a curve rather than relying on linear distance (Figure 4). The formula V = Length x Area was used to

calculate the volume of the reduced portion of the flake. The volume of the tool was then calculated using graduated cylinders filled to 100mL. The flake tools were placed in the water and the amount of displaced water was recorded as the volume in terms of mm^3. Unfortunately, volumes could only be calculated to the nearest mL, which is equivalent to 1000 mm^3. Eren et al. (2005) approached this problem by calculating volume by measuring the radius of the beaker and the height of the water displaced by the tool with calipers, then used the equation for the volume of a cylinder $V=\pi r^2h$, which accurately calculates the volume in mm^3. I did not use this calculation for the sake of time, although the results of using this formula would likely more accurately reflect the volume of the tools. The measured volumes of the tools were added to the calculated volume of the reduced material to determine a calculated volume of the original flake blank. The calculated volume of retouched material was then divided by the total volume of the original flake blank to express the amount of material removed in terms of percentages. Eren et al. (2005) continued by calculating the density of the tools and retouched material using the formula density = volume/mass, however material density was not calculated for this study, therefore the mass of the removed debitage could not be calculated for inclusion into this project.

RESULTS

After calculating volumes for retouch debitage and measuring the volume of all tools, the percentage of retouch was able to be calculated, and conforms to previously stated expectations. A box plot depicting the results of the percentage calculations shows that chert artifacts are retouched to a higher degree on average than were either chalcedony or quartzite (Figure 5). The plot shows that the chert artifact were mostly retouched between 14-55%, while quartzite ranged mostly between 4-33%. The chalcedony artifacts showed a very low percentage of retouch, ranging between 5-7%. There were two outliers in the quartzite data, one expressing retouch at 83%, and the other at 65%. However, based on the general shape and thickness of these tools, it seems unlikely that these flakes terminated in a feathered edge, or approximated an idealized triangle in cross-section. These results meet the expectations of the hypothesis and suggest that the occupants of Pack Rat Shelter preferentially retouched chert artifacts to a higher degree than quartzite artifacts before they were discarded. The chalcedony artifacts exhibited the lowest rates of retouch, however this may be a result of the much lower number of chalcedony artifacts (n=3), only representing 8% of the assemblage, than either chert or quartzite. It may also be the result of the types of tools and the flake morphologies associated with these tools, which were characterized as a utilized flake (spec 3), and two thick scrapers (spec 2 and 30) which both had cortex and relatively small worked edge areas (Figure 6). The chalcedony was described as a local material, and so might not show the extensive retouch expected for chert, but the resulting percentages were unexpectedly low for any material, thus was worth noting.

DISCUSSION AND CONCLUSIONS

There are likely several inferences that can be made both by the material distribution present

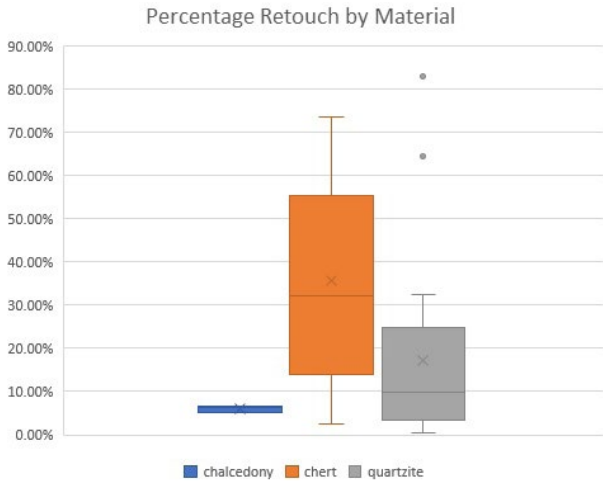
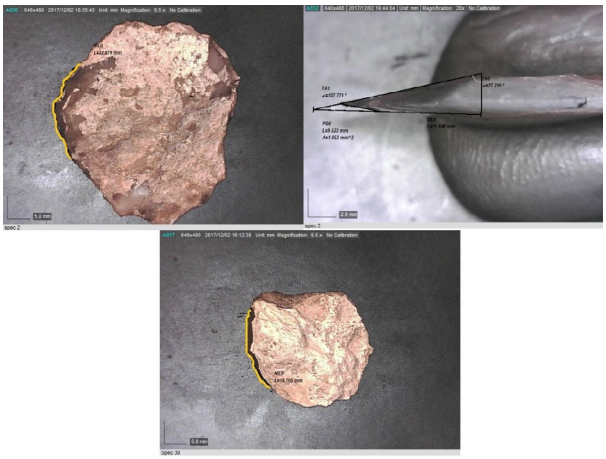


Figure 5: Calculated percentages of retouch.

at Pack Rat Shelter and the levels of retouch intensity based upon material type. It must be noted that because the assemblage was analyzed as components of a locality, rather than being separated through time, that there may be temporal patterns and variations that are not visible in this data. The dominance of quartzite at the site, and the high degree of variation with which it was reworked before it was discarded suggest that quartzite tools may have been used for both formalized as well as expedient tools.

The unifacial flake tool artifacts recovered from Pack Rat Shelter are comparable to several other assemblages from the region, such as the Spring Canyon Site (5LR205), a large multicomponent campsite located in Larimer County Colorado. The Spring Canyon Site was reported in the early 1950s as an archaeological site, and work has continued on it intermittently through 2011 (Pelton et al. 2016). A total of 363 edge modified flakes have been recovered from the site. A chart depicting chipped stone tools selected from CSU's multiple visits to the site show an assemblage containing 81 unifacial tools, which are represented by quartz (n=4), quartzite (n=31), chert (n=22), chalcedony (n=13), petrified wood (n=10), and other (n=1) (Pelton et al. 2016). These distributions of materials compare well with the assemblage of unifacial tools from Pack Rat Shelter, which exhibits quartzite (n=25), chert (n=9), and chalcedony (n=3). Although the assemblage for Pack Rat Shelter is smaller, the material frequencies are somewhat comparable (Figure 7). It is obvious that quartzite primarily dominates at both sites followed in frequency by chert, with chalcedony being the least represented.



The Spring Canyon site also has a component represented by the McKean Complex, which is also represented at Pack Rat Shelter, suggesting that these sites were both occupied during the Early to Middle Archaic. The edge modified flakes at Spring Canyon show a maximum length which ranges from 3.9 to 55.0 mm, with a mean length of 23.6 +/- 9.1 mm. The maximum length of unifacial flake tools from Pack Rat Shelter range from 15.4 to 72.2 mm, with a mean length of 38.0 mm, displaying a slightly broader range of variation in length and a higher mean length.

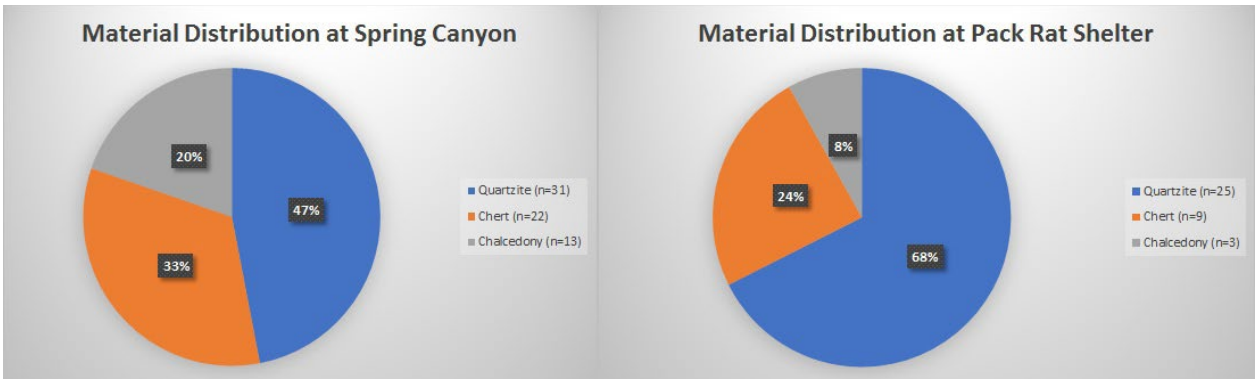


Figure 6 (top): Chalcedony tools with worked edges highlighted. Figure 7 (bottom): Percentages of artifacts of similar material from Spring Canyon and Pack Rat Shelter.

This may be a result of the proximity of Pack Rat Shelter to a local quartzite source, which means larger blanks and cores may have been brought to the site due to the short distance.

Although it may be obvious, the presence of such a large number of flake tools indicates that this was a campsite rather than a trap or kill site. Unifacial tools, particularly scrapers, are commonly associated with hide working, game processing, and maintenance of other tools such as arrow or spear shafts. This contrasts with other Colorado sites, such as the high-altitude game drives at the Olson site (5BL147). Compared to lowland sites, the Olson site contains a narrow range of tool forms, and represent a relatively minor component of the assemblage (21.7%) (LaBelle and Pelton 2013). This suggests that at this site, processing was not a major activity. This contrasts with Pack Rat Shelter, which produced a large number of flake tools (n=53), making up 48.6% of the excavated and collected assemblage. With this kind of representation it's obvious that processing of game, hides, and maintenance of other tools was a major activity at Pack Rat Shelter.

Pack Rat Shelter represents a multicomponent occupation that spans the entire Archaic Period and is characterized by a large quantity of locally procured quartzite. The large number of flake tools at this site represented an opportunity to look at the rates of reduction in terms of differences between raw material types. The method employed in this study, as outlined by Eren et al., 2005 was selected due to its relatively simple procedures, and seemingly accurate results. However, unlike Eren et al. (2005) I used a DinLlite to acquire measurements as accurately as possible along dorsal, ventral, and worked planes of the unifacial flake tools. Some of the challenges presented by employing this method included finding the best angles underneath the DinoLite from which accurate measures could be taken that would be representative of the tool being measured. Additionally, the degree of accuracy with which the volume of the tools was measured could be refined so that volume measurements were taken at a greater degree of accuracy than at the mL level. By following the procedure for calculating the volume of a cylinder, rather than reading from the lines of the graduated cylinder, much higher levels of accuracy in volume measurements will be possible.

The results of the study still seem reflective of the artifacts when looking at the overall shape and intensity of reworking performed on them. This study would suggest that chert materials were more extensively retouched before they were discarded, whereas quartzite artifacts, which are abundant and readily available for procurement, exhibited highly diverse levels of curation before they were ultimately discarded. The chalcedony artifacts were the only group that did not necessarily conform to expectations, however the source has been described as semi-local, and so they may not necessarily follow the trend we would expect from materials brought from greater distances away. It may also be a result of the small number of chalcedony artifacts represented at the site. A greater sample of materials from the site may increase the amount of chalcedony present, which would likely alter the results to show a different trend for this class of artifacts. The results would lend credence to the notion that in the face of material scarceness, stone workers are likely to increase tool efficiency and longevity by working them until they reach their maximum potential usability before they are discarded. Also, the large number of scrapers at this site may indicate that the activities taking place at this locality heavily emphasized hide and game processing. Only further research at Pack Rat Shelter will shed more light on the use and maintenance of the unifacial stone tools which are prolific at the site.

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Lasers Through the Leaves: An Overview of LIDAR Applications in Archaeology for Forested Regions

ALEX FRIEDL

The value of aerial reconnaissance techniques has long been acknowledged in archaeology, however until relatively recently these techniques were limited to vertical and oblique aerial photography. Despite the success of such methods for documenting and discovering archaeological features, traditional aerial photography often requires particular weather conditions and is not always successful in expressing subtler changes across a landscape (Devereux et al. 2005). Due to rapid advances in technology and improvements in data processing software, archaeologists now have access to many different aerial remote sensing techniques, including airborne laser scanning. This paper will attempt to review the current state of airborne laser scanning technology and explain how and why it is used in archaeological applications around the world, using specific site examples.

Airborne laser scanning (ALS) systems, also known as light detection and ranging (LiDAR), emit light pulses in the infrared or near infrared range that are reflected and the return rates of these pulses are recorded. To ensure spatial accuracy, scanners are linked to global navigation satellite system (GNSS) reference stations and an inertial measurement unit (IMU) on the aircraft helps account for inconsistencies in the flight path. Although early scanners could emit only several thousand pulses per second, currently available commercial scanners can send out hundreds of thousands of pulses per second and some record multiple returns per pulse, as well as the intensity of those returns (Fernandez-Diaz et al. 2014). In the initial data output, every detected return results in a point with coordinates (x,y,z) that come together to form a larger point cloud representing the entire scanned area. These raw point clouds are then processed using a variety of algorithms to distinguish between the bare surface, vegetation, and other features. There is no singular algorithm that works best for processing data in every situation (Fernandez-Diaz 2014) and the selected approach is often dependent on terrain and research objectives. The most widely used of these algorithms is described by Sithole and Vosselman (2004) will be discussed later in more detail. Following proper classification of points, the visualization stage of data processing also presents some choice for archaeologists. In many cases, LiDAR data is used to produce some variation of a digital elevation model (DEM) that represents the ground surface after other features, such as vegetation and buildings, have been removed. There are various interpolation and visualization techniques available to create models of the survey area and each is good at illuminating different types of archaeological features. Some of these visualization techniques will be discussed later on, but it should be noted that a combination of approaches yields the most comprehensive understanding of the data (Fernandez-Diaz et al. 2014).

The earliest LiDAR remote sensing systems were used by NASA in the 1970s for mapping ice-covered areas (Krabill et al. 1984). The technology was not utilized in other fields until the 1990s when georeferencing technology as well as general software and data storage capabilities improved (Opitz and Cowley 2012, 15). General cost and accessibility to equipment have become less prohibitive over time, giving rise to the application of LiDAR in many fields. The significance of LiDAR systems has been acknowledged in forestry (see Dubayah and Drake 2000) and a wide variety of other environmental and biological applications (e.g Moore et al. 1991). LiDAR is particularly

attractive to archaeologists because large areas of land can be surveyed quickly and the data can be used to create spatially accurate 3D models of the ground surface, often revealing new features and placing known sites within a larger context. The ability of algorithms within the processing stages to effectively remove vegetation and expose detailed topography hidden beneath the canopy may be the most important aspect of LiDAR systems for archaeology. The ability of ALS units to 'cut' through vegetation and collect high quality ground surface data for archaeological purposes has been well demonstrated (Devereux et al. 2005; Doneus et al. 2008; Doneus et al. 2010; Gallagher and Josephs 2008). In many cases, topographic features identified on LiDAR-derived models can be ground-truthed using traditional pedestrian survey to establish the validity of potential new discoveries, although in some areas dense vegetation inhibits such ground-based efforts. For example, in the Mosquitia region of Honduras a massive 3000 km2 area was overflown by a LiDAR system, which would be impossible to fully survey on foot. Fisher et al. (2016, 4) acknowledge that LiDAR data collection alone does not replace "boots on the ground" survey, but the research team was only able to feasibly field-verify around 40% of features at the 3 km2 main site of the City of the Jaguar. Dense tropical forest vegetation in the Mosquitia limited surface collection of artifacts and complicated feature verification efforts. In cases such as this, researchers can utilize LiDAR data to execute targeted ground-based surveys or excavations creating an adequate sample of features for the assessment of cultural validity (Fisher et al. 2016). ALS has proven to be a valuable tool in archaeology for documenting large-scale cultural landscapes, especially those obscured by vegetation, which has aided archaeologists with both discovery and preservation of archaeological sites.

PREFERRED METHODS IN ARCHAEOLOGICAL APPLICATIONS

Prior to the actual collection of LiDAR data, there are specifications related to the technology and survey design that must be considered by archaeologists. Laser scanners can be broadly divided into two categories: discrete echo (conventional) or full-waveform (FW) devices. Conventional scanners generally record only the first and last returns from each pulse. These scanners were initially the only technology available and discrete echo units were used in many early applications of LiDAR in archaeology (see Sittler 2004 and Bewley et al. 2005). Even early studies touted the abilities of ALS to cut through vegetation, though conventional scanners are not so successful in regions with a dense understory and can result in confusion between ground returns and low vegetation. As technology has advanced, FW scanners have become more popular because they have the ability to record the full range of detectable returns, often resulting in 3-4 returns per pulse. The effectiveness of FW scanners in wooded areas has been broadly established (Doneus et al. 2008) and Doneus et al. (2010) even compared ALS data to terrestrial laser scanning (TLS) information collected in a forested area surrounding a monastery complex south of Vienna, Austria. After georeferencing both the ALS and TLS point clouds in the same coordinate system, the archaeologists found no major visual discrepancies between the two data sets and concluded that the top of the canopy and dense upper branches were well represented in the ALS point cloud, while small branches under the very dense canopy layer were less obvious. Doneus et al. (2010) did not complete a quantitative study of the accuracy of the data in this particular study, but their preliminary comparisons affirmed the abilities of FW scanners to better distinguish the understory in densely vegetated areas. FW scanners record more returns per pulse than conventional scanners and therefore make it easier to separate ground surface points from low vegetation. Even within the last decade, the pulse rate frequency (PRF) of commercially manufactured laser scanners has increased exponentially (see Table 1) and the increased

pulse rate frequency (PRF), in conjunction with faster scanning rates, have allowed for more ground point data to be collected, resulting in more accurate surface representations.

ALS Unit and Flight Specifications

In addition to the general type of unit, there are other specifications archaeologists must consider to maximize data collection using ALS technology. The scanning pattern, PRF, scanning frequency, flight elevation, and flight path must all be taken into account prior to beginning LiDAR survey. Scanners typically come in three types, which have different scanning patterns: oscillating mirror, rotating polygon, and Palmer scanners (Fernandez-Diaz et al. 2014). The oscillating mirror scanner uses a mirror that is rotated back and forth, creating a diagonal path for the laser pulses.

The oscillating mirror accelerates and decelerates, creating a non-uniform distribution of laser points. Rotating polygon scanners have a constant rotational speed and a parallel scan pattern, which allows for more uniform data collection. The Palmer scanner moves in a loop pattern, causing uneven distribution of points centered off-nadir, or off-center, where the signal has the potential to be the strongest (Fernandez-Diaz et al. 2014, 9958). The oscillating mirror and rotational polygon scanners are most popular for archaeological applications. A detailed technical overview of each of these scanner types can be seen in Wehr and Lohr (1999). The primary parameters that can be set on each ALS unit include the PRF, scan angle, and laser divergence. The aircraft to which the scanner is attached can control altitude above ground, air speed, and flight line orientation. Each of these settings has the potential to affect

AUTHOR	PROJECT	SURVEY YEAR	SCANNER TYPE	FLIGHT ALT. (M)	AREA (KM2)	LASER SHOT DENSITY/M^2	PRF (Hz)
Sittler (2004)	Rastatt, Germany	2000	Discrete echo	1000	35,000	-	25,000
Bewley et al. (2005)	Stonehenge, England	2001	Discrete echo	1000	-	-	33,000
Devereux et al. (2005)	Welshbury Hill, England	2004	Discrete echo	-	-	4 pts.	-
Gallagher & Josephs (2008)	Isle Royale, Michigan	2004	Discrete echo	1200	2,314	-	50,000
Doneus et al. (2008)	Purbach, Austria	2006	FW	600	9	8 pts.	66,000
Doneus et al. (2010)	St. Anna in der Wüste, Austria	2009	FW	500	2.25	20 last echo pts.	-
Evans et al. (2013)	Angkor Wat, Cambodia	2012	FW	800	370	4-5 pts. in single pass	200 MHz

Table 1: Comparison of LiDAR surveys in forested areas outside of Mesoamerica. Dash (-) represents absence of data in project reporting.

the overall shot density and the portion of the ground surface made visible (Fernandez-Diaz et al. 2014, 9968). Current scanners can have pulse rate frequencies of several hundred megahertz, resulting in incredibly dense point clouds. In many archaeological applications, a lower PRF is desirable for cutting through multistory vegetation. A lower PRF has shorter pulse width, which increases ALS range resolution and allows for stronger pulses with more recorded returns (Fernandez-Diaz et al. 2014). The scan angle primarily affects swath width and can decrease shot density as width increases because pulses must cover a broader area. The majority of LiDAR systems allow for a scan angle up to 60 degrees, though a lower scan angle (40 degrees or less) is recommended (Opitz 2012) in order to avoid exterior swath pulses from hitting flat ground at an angle and decreasing accuracy. Vertical and horizontal accuracy can also be compromised by the width of pulse footprints resulting from the divergence of laser beams. These slight divergences create cone-shaped pulses, with the widest part of the cone encountering the surface and near surface objects. As the diameter of the laser footprint increases, the level of accuracy decreases because more noise and objects are encountered by a single pulse (Opitz 2012). Many ALS devices allow pulse divergence to be limited for smaller laser footprints and increased accuracy of point cloud data. Flight elevation can also make a difference in the data collection process and must be considered in relation to the survey topography and project objectives. Higher flight altitudes with wide scan angles allow for greater swath width and faster coverage of large areas. This larger swath width typically reduces laser shot density and decreases horizontal accuracy and the likelihood of detecting weaker ground returns (Fernandez-Diaz et al. 2014).

Looking at Table 1, we can see that the flight elevations used within studies can vary between 500 and 1200m above ground and some of the studies seen in Table 2 extend up to nearly

AUTHOR	PROJECT	SURVEY YEAR	SCANNER TYPE	FLIGHT ALT. (M)	AREA (KM2)	LASER SHOT DENSITY/M^2	PRF (Hz)
Chase et al. (2011)	Caracol, Belize	2009	FW	800	200	20	-
Rosenswig et al. (2013)	Chiapas, Mexico	2011	FW	1220-1488	43.1	3.2	-
Prufer et al. (2015)	Uxbenka, Belize	2011	FW	500	132	13.8	-
Fisher et al. (2016)	Mosquitia, Honduras	2012-2013	FW	600-1000	3000	6	125,000
Chase et al. (2014)	West-Central Belize	2013	FW	-	1057	15	125,000
Hare et al. (2014)	Mayapan, Mexico	2013	FW	-	40	40	-

Table 2: Comparison of LiDAR studies done in Mesoamerica. Dash (-) indicates absence of information in project reporting.

1500m above the ground. If a high altitude is necessary for topographic or other reasons, some of the loss in shot density can be mitigated by increased PRF and adjustments to other settings. Fernandez-Diaz et al. (2014) provide an overview of ALS canopy penetration experiments completed in Mesoamerica utilizing varied PRF and beam divergence values. Based on this study, the combination of a low PRF and wide beam divergence were found to be most effective in cutting through the canopy to produce ground returns (Fernandez-Diaz et al. 2014, 9973).

Although general suggestions for parameters can be made according to terrain type, flight plans differ significantly between archaeological LiDAR survey projects and specifications must be decided with regard to each individual project.

Classification and Filtering

Following data collection, the raw point cloud output must be processed through classification of points. Classification schemes can be based on many different attributes, although the most commonly used schemes in archaeology focus on separating ground from non-ground return points. Fernandez-Diaz et al. (2014) assert that no singular ground/no-ground classification algorithm can be used in all situations and there are many different algorithms that approach this separation with varying levels of success. Sithole and Vosselman (2004) suggest that the majority of filtering methods fit within four different categories, seen in Table 3, and only the most popular approach will be briefly discussed here.

Between the filtering groups, surface-based filtering methods were found by Sithole and Vosselman (2004) to produce the best results when discerning ground points from other non-ground points. A list of surface-based algorithms can be seen in Masini et al. (2011), which includes Peter Axelsson's (2000) algorithm based on progressive Triangular Irregular Network (TIN) densification. Beginning with a coarse interpolated surface, points are added in successive waves, essentially using the lowest pulse return in every defined grid cell

ALGORITHM TYPE	DETAILS
Slope-based algorithms	Measure the difference in slope or elevation between two points and assumes the highest point does not represent the ground if the slope is above a given threshold value.
Block minimum algorithms	Assume as discriminant function a horizontal plane with a buffer zone above it, which creates a defined 3D space where ground points are expected to be.
Surface-based filtering methods	Assume as discriminant function a parametric surface with a buffer zone above it, which creates a defined 3D space where ground points are expected to be.
Clustering/ segmentation filtering	Assumes that any clustered points belong to a non-ground object if the cluster is above surrounding points not within the cluster.

Table 3: Primary filtering algorithm categories defined by Sithole and Vosselman (2004). Chart adapted from Masini et al. (2011, 267).

to create the basis for further triangulation. This particular filtering algorithm was utilized in the processing of data from the Mosquitia region of Honduras where only 87 million (or 1.9%) out of 4.5 billion returns were classified as ground returns (Fisher et al. 2016) to be utilized in the creation of data products. Opitz (2012) draws attention to the importance of selecting appropriate classification algorithms and filtering parameters in order to maximize the appearance of archaeological features. While overly aggressive algorithms can result in the removal of small variations in elevation that may represent archaeological remains, filtering algorithms that include too many low vegetation points can create false features that only look archaeological (Doneus et al. 2008; Opitz 2012). Gallagher and Josephs (2008) note five distinct negative aspects associated with LiDAR image interpretation that are widely acknowledged in the literature:

1. Filtering has a smoothing effect on the landscape, which makes ground-truthing some features difficult
2. Elevational differences are not always accurately portrayed, especially in areas with steep slope
3. Distinguishing the differences between natural and cultural features is not always easy and becomes more difficult in smaller feature classes
4. Clustered features can sometimes be displayed as a single feature
5. Some linear features easily seen on the ground are not visible in LiDAR derived models

The degree to which Gallagher and Joseph's (2008) study was affected by these negative aspects may be greater than in other situations because their data was provided at no cost by the National Park Service and was of admittedly low quality for fine-scale archaeological prospection. The solution for reducing the effects of these factors lies in the intentional selection of data filtering algorithms and visualization techniques that are best suited to the data set and project area.

Data Interpolation & Visualization

The final step in the processing of LiDAR data is the production of 3D models from classified and filtered returns. Common products include the digital elevation model (DEM), the digital terrain model (DTM) and the digital surface model (DSM). Each of these models utilizes slightly different parts of the dataset to express various aspects of the ground surface and near surface objects (Masini et al. 2011). A DEM typically represents the ground surface stripped of all vegetation and other features in an effort to represent the natural topography. The DTM is probably the most popular model used by archaeologists because it represents the ground surface and near-surface features stripped of vegetation. DSMs show the initial surface encountered by the laser beams, which often represents the top of the canopy in forested areas. In order to create these LiDAR-derived products, interpolation between points is necessary to create a dense point mesh that can be translated into an accurate and continuous surface model. Masini et al. (2011) outline the three most common data structures for surface interpolation as follows:

1. Grid-Based Structure: each individual cell in the grid is assigned an elevation value
2. Triangulated Irregular Network (TIN): network of planar triangular facets is created that join the three closest points in such a way that the area of each triangle is minimized (see also Fernandez-Diaz et al. 2014)
3. Contour Method: based on the concept that landscapes can be divided into irregular polygons based on elevation contours (for more detail see Moore et al. 1991)

The grid-based structure was the most popular in the past because of its simplicity, however, the singular height value per cell can have the

tendency to smooth out small topographic variations and cluster together separate features (Masini et al. 2011). TIN models allow for the density of the triangulation to be easily varied, resulting in better representation of discontinuities and abrupt changes in elevation. The majority of LiDAR derived models in archaeology are now based on either TIN or Kriging interpolation methods. Kriging has the strongest basis in theoretical principles and assumes that "a variable's value can be estimated through the data's spatial characteristics" (Masini et al. 2011, 269). A much more detailed overview of these interpolation methods can be found in Pfiefer (2005).

ARCHAEOLOGICAL PROSPECTION USING LIDAR IN FORESTED AREAS

LiDAR technology can be used to document many different kinds of landscapes, and the ability of the laser pulses to cut through vegetation makes the technology particularly useful in forested areas. ALS devices have proven successful in creating an accurate representation of the surface below canopy and low vegetation. This section reviews multiple archaeological studies that helped establish the usefulness of ALS scanners in forested regions and discusses more recent, large-scale applications in Mesoamerica and several other regions.

Early Applications

Sittler's (2004) application of LiDAR in Rastatt, Germany represents one of the earliest applications of LiDAR in a forested area. Using a discrete echo scanner, Sittler was able to reveal medieval ridge-and-furrow agricultural fields, which had long since been hidden by tree cover from aerial photographs. These features were then manually delineated using GIS to get dimensional measurements of singular furlongs. Sittler (2004) concludes that ALS technology accurately records the ground below the canopy, but ground survey was not performed to corroborate the identification of new features. Devereux et al. (2005) build on Sittler's research by using LiDAR to examine a prehistoric hillfort in a forested area in Gloucestershire, United Kingdom and verifying the results through ground survey. Unfortunately, many of the parameters used for the Welshbury Hill survey are not reported, but this study also utilized a conventional scanner. Using the last return data, Devereux et al. (2005) produced a DEM that clearly showed the multiple-ring hill fort, and pedestrian survey confirmed many of the new features discovered from the surface model. Gallagher and Josephs (2008) also utilized ground survey in conjunction with ALS data to look at archaeological features on Isle Royale located in Michigan, United States. In this case, the researchers specifically use LiDAR derived products to identify new features, inform pedestrian survey strategy, and help create safer, more efficient research design. The Isle Royale LiDAR survey covers the entire island (2314 km2), from which three study locations were selected for traditional pedestrian survey using parallel transect lines with 15m spacing across areas of varying size. Based on these targeted traditional ground surveys, Gallagher and Josephs (2008, 201) conclude that "LiDAR-derived imagery could be used to effectively locate archaeological sites and respective features in a heavily forested environment." This study also points out the economic advantages of LiDAR by comparing the cost of ALS survey with ground survey.

Very few studies directly address the cost of LiDAR data collection, with the majority referring to the benefit of a more generalized, unquantified savings of time and money. Sittler (2004) says that LiDAR surveys in Germany range from less than 7,000 Euro (7,630 USD) to upwards of 20,000 Euro (21,800 USD) depending on the data provider and the size of the project area; smaller project areas in the tens of acres will result in much higher costs because of scanner mobilization costs. For the vast survey area of Baden Württemberg (35,000 km2), Sittler's team

had access to data for 15 Euro/km2 (16.35 USD/km2) if completely unfiltered and 60 Euro/km2 (65.38 USD/km2) if the data was ready to be used for surface model production (Sittler 2004). Gallgher and Josephs (2008) quote the average cost for collecting and processing LiDAR data between 100-500 USD/mi2 or 39-195 USD/km2, which they conclude is significantly more cost effective than traditional ground survey.

This study, and the others mentioned in this section, represent earlier applications of LiDAR in archaeology that were focused in part on establishing the legitimacy of the methodology as a reliable and efficient means for collecting ground surface data under varying degrees of vegetation. The uptake of ALS technologies for archaeological applications was faster in Europe, though the Americas have quickly caught up in recent years. This difference in speed of methodology adoption could be explained by the fact that European government agencies appear to have paid for the surveys (see Bewley 2005; Sittler 2004). In many cases states paid for LiDAR survey for the monitoring of other environmental features, but archaeologists were given access to the data (Masini et al. 2011). Around the mid-2000s, scanner technology became more refined producing the FW scanner, which was widely adopted (see trend in Table 1) for its multiple return detection capabilities in forested areas. Whereas studies utilizing discrete echo scanners often had to use higher flight altitudes and lower pulse frequencies, the newer FW scanners allowed for greater flexibility in data collection specifications and increased accuracy.

More Recent Applications

In more recent applications of ALS survey in forested areas, the use of full wavelength scanners has become standard. Opitz and Cowley (2012) do note however, that in some areas of the world the cost and lack of availability of LiDAR technology can be prohibitive. As an example, they cite the 2012 survey over Angkor Wat in Cambodia, which required over 20 years and many bureaucratic struggles to achieve (Opitz and Cowley 2012). The cost of the technology in Cambodia is still significant in comparison to Europe or the Americas and Evans et al. (2013) hope to set a precedent for LiDAR in the region that creates momentum for further missions. One of the first archaeological studies assessing the potential for FW scanners in forested areas took place in eastern Austria over the Iron Age hillfort of Purbach. Doneus et al. (2008) demonstrate the ability of FW scanners to better represent surface vegetation of varying types (trees, bushes, brush, etc), which permits for better filtering and more accurate surface models. At Purbach, the LiDAR point cloud consisted of over ten million points, while previous terrestrial survey maps were based on less than 2,500 topographic points. The high point density allows for the removal of significantly more vegetation points during data processing than conventional scanners and in this case revealed microtopograhical features such as low earthworks that were missed during traditional ground surveys. Doneus et al. (2008) advocate the use of full waveform ALS devices in forested areas as a more objective alternative to ground survey and a more accurate alternative to discrete echo technologies. Based on the success of LiDAR in forested regions of Europe and North America, use of the methodology has expanded to some of the densest jungles in the world, most notably in Mesoamerica and parts of Asia. The use of ALS survey in Mesoamerica has been extensive and will be discussed in greater detail later on, however, the unprecedented level of discovery at the prehistoric urban center of Caracol, Belize established the potential for LiDAR survey to uncover entirely modified anthropogenic landscapes hidden under dense canopy (Chase et al. 2011, 2014). Analyses at Caracol and other large-scale sites moved beyond explaining the legitimacy of ALS techniques and began to address more culturally relevant questions related to settlement patterns, urban planning, and land use change through time.

The studies following ALS survey of the Angkor Wat temple complex and surrounding area clearly display the range of questions that archaeologists can now ask using LiDAR-derived models. The data gave new insights on the primary Khmer temple enclosure, but more importantly exposed a previously undocumented, formally planned urban landscape. Evans et al. (2013) use anthropogenic landscape modifications revealed by the LiDAR to link the downfall of the Khmer civilization to structural complexity, unsustainable agricultural practices and climate variation. In an attempt to understand spatial organization within the 12th century Khmer temple enclosure, Evans and Fletcher (2015) focused on the newly exposed residential blocks, identifying a pattern of occupation mounds and ponds. Measurements of ponds from the DTM provided archaeologists the opportunity to calculate water volume in the features and make preliminary population projections. Stark et al. (2015) also focus on settlement structure at Angkor Wat, looking at the potential of LiDAR data for illuminating shifts in settlement grouping through time. The combination of DTM analysis and concentrated excavation showed that occupational mound and pond patterns emerged as early as the 6th century. Stark et al. (2015) were able to assess both continuity and change within Khmer residential patterning and gain a more comprehensive understanding of land-use through time.

In a general sense, ALS survey has opened up a new world of archaeological inquiry, placing known sites into the context of much broader regional landscapes and uncovering the true scope of prehistoric influence on the environment. In a relatively short period of time, improvements in scanner technology and filtering algorithms have prompted the survey of larger surface areas using higher PRF values to maximize ground point collection. Despite the immense potential of LiDAR for the detection of new archaeological features, nearly all the studies discussed here recognize the importance of ground-truthing to prevent the possibility of misinterpretation. Although data processing and feature detection are now largely automated, Opitz and Cowley (2012) highlight the lack of basic landscape knowledge as a leading cause for misinterpreting laser scanner data. This and other limitations of ALS systems will be reviewed in more detail following discussion of LiDAR applications in Mesoamerica.

LIDAR IN MESOAMERICA

Perhaps the most extensive and fruitful applications of LiDAR survey in archaeology have taken place across the densely forested regions of Central America. Chase et al. (2012,12916) refers to the use of LiDAR as a "paradigm shift" in Mesoamerican archaeology, transferring attention from obvious sites with monumental architecture to largely unstudied surrounding areas. LiDAR surveys have been particularly effective in revealing unexpected aspects of early urban complexes related to the Maya and contemporaneous civilizations. The first major ALS survey completed in Mesoamerica covered just under 200 km2 and focused on the Preclassic through Postclassic period (A.D. 350 – 950) urban center of Caracol, Belize. LiDAR-derived models clearly displayed monumental architecture, connective causeways, and vast landscape modification (including reservoirs, agricultural terracing, earthworks, and more). The survey at Caracol is one of the first in Mesoamerica to reveal the potential for LiDAR to discover lost landscapes. Researchers were able to expand their understanding of the size of urban sprawl radiating out from the main site and produce more accurate population estimates (Chase et al. 2011). Many of these insights were confirmed by an extension project in West-Central Belize just four years later, which was aimed at placing Caracol in an even larger spatial context (Chase et al. 2014a). In southern Belize, the Classic Maya Uxbenka polity was also surveyed using LiDAR to look at the potential for detecting a range of settlement types. Prufer et al. (2015) compared settlement structures

detected in the LiDAR to previously mapped structures and found that very few, only 3 out of 135 structures, were visible on the bare-earth hillshade model. More structures were evident as slight rises in ALS point profiles, but features under 0.5m in height were not visible and the authors conclude that LiDAR hillshade raster files are not reliable for detecting small settlements in disturbed tropical environments with dense understory vegetation. Rosenswig et al. (2013) reach a similar outcome through analysis of ALS data from the Izapa polity in the Soconusco region of southern Mexico. The goal of the Izapa Regional Settlement Project (IRSP) is to document regional scale settlement patterns and discern changes in population levels through time as they relate to the environment and political organization. The LiDAR-derived DEM helped identify nearly 700 mounds within the 43.1km2 survey area and previous terrestrial survey data was overlaid for comparison. Some of the previously mapped mounds were not obvious on the hillshade raster and ground-truthing confirmed that the undetected features were all below 0.5m in height (Rosenswig et al. 2013). Overall, survey at Izapa provided evidence for a change in occupational distribution related to disruptive environmental events. Another example of ALS application in Mexico centers on the Mayapan polity located in the Yucatan Peninsula. Hare et al. (2014) set out to document the settlement system and the environment in which that system developed with high-density (40 pts/m2) LiDAR data. Based on the bare-surface model, the research team located and ground-truthed 38 different settlement clusters outside of the Mayapan city wall, establishing a pattern of residential clusters surrounded by lower density occupations radiating outward in a highly modified landscape. The ability of LiDAR survey to cover large land areas has led to the recognition of massive human-engineered environments throughout Central America. The range and scale of anthropogenic modifications often identified in LiDAR data can be exhibited by Fisher et al.'s (2016) study of the Mosquitia region in Honduras. Covering 3000 km2 over dense rainforest, this survey uncovered an entire "lost city" including complex organizations of earthen mounds, agricultural terraces, plazas, and water control features. Although dense vegetation prevented comprehensive ground survey, Fisher et al. (2016) were able to verify nearly 40% of the main Jaguar city and gain a representative understanding of how features appear on the digital models. Ground-truthing, even in limited areas, greatly reduces the chance of misinterpretation of the data and increases the likelihood for proper pattern recognition.

In Mesoamerica, LiDAR reveals new magnitudes for the size and modification of urban environments (see all examples in Table 2), resulting in increased population estimates and better understandings of landscape modification and residential settlements. ALS data has allowed the expansion of research questions beyond just obvious sites with monumental architecture. These often-known sites are now placed within much broader spatial contexts that form a more complete picture of how Mayan and other Mesoamerican polity networks function. All of these examples (Chase et al. 2011, 2014a, 2014b; Fisher et al. 2016; Hare et al. 2014; Prufer et al. 2015; Rosenswig et al. 2013;;) include some level of ground verification, however part of the advantage of LiDAR is that it can reach areas with limited ground accessibility. The ability to cut through dense tropical forests using ALS scanners and increasingly accurate filtering algorithms is well established in Central America (Fernandez-Diaz et al. 2014). Aside from the clear advantages of ALS data for studying regional settlement patterns, Maya and other complex polity relationships can also be seen and defined on a new scale and finer level of detail (Chase et al. 2014b). LiDAR-derived surface models have become integral in the study of prehistoric urban organization and human-environment interaction legacies as expressed on the landscape.

LIMITATIONS OF LIDAR SURVEY IN ARCHAEOLOGY

Despite the great potential for application of LiDAR survey in archaeology around the world, there are some limitations and drawbacks to the technology worth mentioning. First and foremost, there is no industry standard when it comes to the usage of LiDAR. Parameters, such as those discussed earlier, can be set to fit particular places, however, this variation coupled with the lack of reporting standards makes comparative analysis of LiDAR studies somewhat difficult. Major sources of error, as identified by Opitz (2012), can be divided into three categories: random error (navigational system noise), systematic error (internal to laser scanner), or terrain-dependent error (resulting from interaction of laser beam with surface features/vegetation). These sources of error can include:

1. Platform navigational errors
2. GPS/IMU errors
3. Laser scanning calibration errors (range measurement and scan angle)
4. Timing resolution
5. Boresight misalignment
6. Terrain and near terrain object characteristics

Error can be introduced at any point during the LiDAR data workflow (data collection, classification/filtering, interpretation) and it is the archaeologist's responsibility to minimize this error through careful attention to scanner specifications, reliability of filtering methods, and ground-truthing efforts. Additionally, ALS scanners are limited in their detection of microtopographic features under 0.5m tall (see Prufer et al. 2015 and Rosenswig et al. 2013) and the nature of smaller features is often hard to determine. Obtaining similar returns from multiple flight angles can help with proper representation (Fernandez-Diaz et al. 2014), but inevitably some smaller features will not be detected. Feature detection in forested areas is especially affected by dense understory vegetation (Prufer et al. 2015), which again highlights the necessity of traditional pedestrian survey for verifying results. Occasionally, LiDAR can also produce false positives for features related to misclassifications of ground surface points in the filtering process and the only way to identify these errors is through ground-truthing efforts. Although much of the data collection and filtering processes for raw data are now automated, Opitz and Cowley (2012) argue that engaging with digital 3D data still requires particular localized knowledge and considerable skill in reading the topography. Archaeologists working with ALS data must also be ready to deal with very large, complex datasets over an extensive scale. Part of the challenge is fairly addressing the range of visible features in the LiDAR-derived models without actually being able to get boots on the ground across the entire area. Rosenswig et al. (2013) point out the difficulty in gaining permission to access all survey areas, citing uncooperative private land owners as a potential inhibitor to ground survey. Advances in filtering algorithms and algorithms for the automatic extraction of features in the LiDAR derived models are helping alleviate some of the problems related to big data analysis. Another consideration linked to the size of LiDAR data sets is the storage and management of that data once it has been collected. Data sets covering hundreds of square kilometers can contain billions of points that can easily take up multiple gigabytes of hard drive space. High resolution surface models produced from the dense point clouds also pose their own challenges for data management and typically need large amounts of RAM and updated graphics cards for their creation and manipulation. A more detailed overview of data management and dissemination issues for ALS data sets can be seen in Opitz (2012). On a basic level, the key to avoiding major problems with LiDAR survey and data sets, as with any archaeological undertaking, is to carefully plan every step of the workflow process before data is collected, then adjust the plan if contingencies arise.

CONCLUSION

Based on this broad overview of ALS technology application in archaeology, and more specifically in forested areas, the potential for airborne laser reconnaissance in making new discoveries, as well as contextualizing known sites, has been established. The use of LiDAR scanners has become particularly attractive for researchers because it allows for accurate coverage of large tracts of land and has the potential to survey areas inaccessible on foot, often saving time and money. Aerial reconnaissance techniques have revolutionized survey potential, allowing archaeologists to expand their research questions and view sites within a significantly larger spatial context. In Mesoamerica and other heavily forested regions, the ability of LiDAR to effectively cut through vegetation has led to entirely new conceptualizations of prehistoric urban environments and better understandings of the scope of human impact on the environment. The spatial accuracy of LiDAR-derived models permits archaeologists to target excavation efforts and traditional pedestrian survey to maximize the production of knowledge about their region of study. Looking forward, the accuracy and availability of ALS technology will only continue to grow. Improvements in the algorithms for classification and filtering of data, coupled with rapidly advancing visualization techniques, continue to push LiDAR methodology forward and hold great potential for new and compelling archaeological inquiry.

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Identification of Kaplan-Hoover Projectile Point Assemblage: A Geometric Morphometric Analysis

EDWIN HARRIS

Point typologies are a staple in archaeology and necessary to understand local culture sequences, as projectile points can often be the only means of differentiating one possible culture from another, e.g. Yonkee (Ferguson 1993). How projectile points are typed is usually done through visual analysis which can easily involve researcher biases and result in a different point type for each site across a region based on what criteria is used to separate A from B from C. The assumption that a projectile point can serve to identify specific cultures is weak and to assume one culture made one point is also tenuous (Ferguson 11).

This weakness is highlighted by the Kaplan-Hoover bison bonebed; within this single event, two supposedly different point types – Yonkee and Pelican Lake - are associated with the bison remains. The relationship between Yonkee and Pelican Lake has been intertwined since the beginning with some early on arguing Yonkee could be a regional variation of Pelican Lake (see Reeves 1970). Today the growing adoption of Geometric Morphometrics (GMM), a means of multivariate analysis to study changes in shapes, by archaeologists can possibly provide insight into the issue of typing projectile points, and in the case of Kaplan-Hoover help understand and define the relationship between Yonkee and Pelican Lake projectile points. Using GMM and a combined dataset of n=70 projectile points – consisting of the Kaplan-Hoover projectile points and additional Yonkee and Pelican Lake points – this paper hopes to demonstration how GMM can be applied to point typologies in quantifying shape variation.

KAPLAN HOOVER

The Kaplan-Hoover bison bonebed is a late archaic site located in Larimer county, Colorado, approximately 800m south of the modern-day channel of the Cache la Poudre river. Excavation of the site began in 1997 and at the time of publication (Todd et al. 2001) the site was still undergoing excavations with a few more years planned. The bonebed was once an arroyo before being used as a bison trap approximately 2724+-35 rcybp which subsequently was filled in by natural processes until its discovery. Over 4,000 bison bone and bone fragments were excavated from the site, including 44 crania providing the estimate for minimum number of individuals at the site. This estimate is, by the author's account, extremely low as just as many crania were continuing to be exposed beyond the 44 excavated (Todd et al. 135), the estimate of total individuals approaches 200. Estimated time of year the bison were killed is believed to be early fall based upon analysis of calf mandibles.

Only a handful of lithic artifacts were recovered from the area of the site which was excavated. Nine projectile points were recovered from the site, with eight being complete or near complete. One end scraper and two biface fragments round out the number of tools collected, with an additional 126 flakes, the majority of them being small retouch flakes (n=102). Of the nine projectile points/fragments three can be sources such as Flattop chalcedony, three as possible Hartville uplift chert, and the last three as a fine-grained quartzite which is unable to be sourced (Todd et al. 2001).

The eight complete or near complete projectile points have been initially classified as Yonkee points (n=4) and possibly Pelican Lake points

(n=4) (see appendix A for point classification). This is an interesting observation; while the Yonkee and Pelican Lake points fall within the same overarching corner-notched style, they are assumed to be two separate point types. If they are two separate types this would make Kaplan-Hoover a very interesting site due to its high-resolution temporal aspect (a single kill event) consisting of two different point types. This can be inferred as one of two possibilities: either Kaplan-Hoover is a cooperative hunt between two different Plains cultures or the Yonkee and Pelican Lake point types are simply variations of the same point.

POWERS-YONKEE

The Yonkee point complex (full name Powers–Yonkee) is named after the Powers-Yonkee site in Wyoming which was first excavated in 1961 by members of the local Wyoming Archaeological Society. Geographically, the Yonkee complex is typically confined to the Powder River Basin of northeastern Wyoming stretching into southern Montana (Figure 1). The area is home to a handful of major tributaries which flow into the Yellowstone river; today it is a semi-arid badlands to the north with a pine parkland environment to the south (Ferguson 1993).

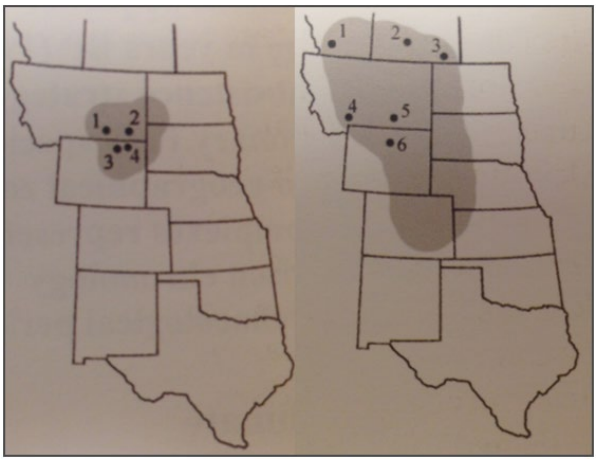


Figure 1. Geographic range of Powers-Yonkee(a) and Pelican Lake(b) points. a) 1. Kolbold, 2. Powers-Yonkee, 3. Mavrakis-Bentzen-Roberts, 4. Powder River. b) 1. Head-Smashed-in, 2. Mortlach, 3. Long Creek, 4. Schmitt, 5. Kobold, 6. Medicine Lodge Creek. (from Taylor 2006)

The morphology and identification of the point centers around a single defining characteristic, the basal notch. Ferguson (1993) provides the definition of a Yonkee point by multiple studies and all refer to the basal notching: either full notching resulting from flake removal or simply thinning of the base to produce a concave appearance. Compared to other point complexes of the northeastern plains the Yonkee complex spans between 3089+-207 uncalibrated B.P. to 2290+-50 uncalibrated B.P (Ferguson 1993), an unusually short period of time compared to the earlier McKean complex (5000-3000 rcybp) (Rennie 1994) and the contemporaneous to later Pelican Lake complex (3300-1850 cal BP) (Kevinsen 2013). Defining the Yonkee as a unique point is questionable, as its geographic location and temporal range fall within both the Pelican Lake geographic and temporal ranges.

PELICAN LAKE

Pelican Lake (3300-1850 cal BP) points were first identified in south-central Saskatchewan at the Mortlach Site and published by Wettlaufer (1955). Similar to the Powers-Yonkee point, Pelican Lake points are corner-notched, but the primary difference is the lack of basal-notching. The Pelican Lake complex is similar in some aspects to the earlier McKean complex; it covered a fairly large geographic area and includes a number of possible intra-complex variations. Kehoe (1974) describes barbed and eared varieties, and stemmed varieties. Later, Dyck (1983) would alter the complexes variety to two primary subgroups based upon basal morphology: an earlier straight-based form and a later-occurring convex base which is sometime referred to as the Bracken phase (Peck 2011).

Geographically, the range of Pelican Lake extends from southern Colorado northward to southern Saskatchewan and Alberta, incorporating the Powder River Basin which demarks the Powers-

Yonkee complex (Figure 1). At this time in the plains the corner-notched style projectile point was quite prevalent from the Pelican Lake complex in the northwestern plains to contemporaries stretching to the great basin (Kevinsen 2013).

KAPLAN-HOOVER ANALYSIS

Todd et al. (2001) did not venture to type the Kaplan-Hoover assemblage based on the small number of completed points (n=7 in the initial publication of the site). As stated before, the points appear to be Yonkee and Pelican Lake (appendix A). The points identified as Pelican Lake do not raise any questions since the date for the bison kill and its location in Larimer County, CO fall within the known Pelican Lake range. The Yonkee points however do raise questions, primarily because the site of Kaplan-Hoover is over 250km straight-line distance from the southern extent of the Powder River Basin.

Additionally, as briefly mentioned before the difference between Yonkee and Pelican Lake complexes is not unambiguous. From a strictly visual comparison between Kaplan-Hoover and various Yonkee and Pelican Lake assemblages (Table 1) the only difference between the two types is the basal-notching. Pelican Lake basal feature is either straight or convex (except Schmitt #4) while Yonkee points basal-notching displays a range of notching depth/concavity to include Mavrakis-Bentzen-Roberts site #4 which is nearly straight. The reliance upon points to distinguish cultural complexes has been noted as being weak; the only means to distinguish Yonkee sites from other complexes, for example is due entirely to its projectile point and no

TYPE	SITE & ABBREVIATION	COUNT	SOURCE
Mixed	Kaplan-Hoover (KH)	8	On-hand
Pelican Lake	Crane (PL_CR)	9	Kevinsen (2013)
Pelican Lake	Walter Felt (PL_WF)	3	Kevinsen (2013)
Pelican Lake	Walter Felt(b) (PL_WFb)	4	Kevinsen (2013)
Pelican Lake	Long Creek (PL_LC)	5	Taylor (2006)
Pelican Lake	Kobold (PL_KO)	4	Taylor (2006)
Pelican Lake	Schmitt (PL_SC)	8	Taylor (2006)
Powers-Yonkee	Kobold (YK_KO)	4	Taylor (2006)
Powers-Yonkee	Cooley (YK_CO)	5	Ferguson (1993)
Powers-Yonkee	Powers-Yonkee (YK_PY)	11	Ferguson (1993)
Powers-Yonkee	Powers-Yonkee(b) (YK_PYb)	5	Taylor (2006)
Powers-Yonkee	Mavrakis-Bentzen-Roberts (YK_MA)	4	Taylor (2006)
TOTAL		**70**	

Table 1. Sub dataset breakdown.

other tool type (Ferguson 1993). Determining the usefulness of using only projectile points to distinguish cultural complexes is not in the scope of this paper. Due to this paper relying only upon projectile points for the analysis, this needed to be noted.

While visual identification is often used to type projectile points, this isn't a quantifiable way to identify points and clearly determine what type a point may belong to. The aim of this project is to use the Kaplan-Hoover assemblage as a starting point and, through a morphometric analysis, compare Yonkee and Pelican Lake points to identify how the shape of each type compares when multiple assembles are combined. While currently the two points are considered distinct, their appearance together at a single event site does call this into question. It is hopeful the morphometric analysis can statistically determine whether Yonkee and Pelican Lake are distinct or simply variations of the same complex.

GEOMETRIC MORPHOMETRICS

Morphometrics is a field of mathematics dedicated to understanding shapes and how they change. Geometric Morphometrics (GM) is a means of measuring shapes using discrete landmarks on the shape which correspond to a coordinate system and allows comparisons between individual and collections of shapes (Kevinsen 2013). The benefit of a GM approach compared to a basic morphometric approach is that the coordinate landmarks on the shapes encode all the information needed to measure and analyze, whereas previous methods were based on distances, ratios, and angles (Slice 2007). The use of morphometrics and GM is not new to anthropology; as morphometrics is often associated with biological applications it is no surprise it has been used previously by physical anthropologists studying human evolution (Slice 2007). In the past few years the application of GM has extended into archaeology, within lithic studies and in other sub fields as well (Buchanan et al. 2007, Buchanan et al. 2014, Nelson et al. 2017).

The benefit of GM compared to other means of understanding variation between individual shapes or assemblages is its focus on the shape as a whole. The drawback to this application is that the shape is determined by the landmarks which are decided upon by the researcher. General guidelines advise to choose landmarks which are related to the morphometric question being asked. This can lead to human-induced error if the landmarks are not thoughtfully chosen.

DATA

When perform a GM analysis, a larger dataset means increased chances that the resulting data can answer the question being asked. For the comparison between Yonkee and Pelican Lake points, the eight Kaplan-Hoover points were included with the addition of other datasets being built from available literature. The other datasets provided either a) a to-scale image of projectile points, or b) images with a clear scale included. Due to the Kaplan-Hoover points being physically available for study, the points were individually photographed using a DinoLite, with a ruler (metric side) included in the image. The total dataset equals eight Kaplan-Hoover points, thirty-three Pelican Lake points, and twenty-nine Yonkee points (Table 1) for a total of seventy points used in the GM study.

METHODOLOGY

Today the ability to perform a GM analysis is open to anyone with the right dataset and willingness to learn a handful of programs. All programs used in this study are open source and have a multitude of online resources available to troubleshoot issues. The three programs used were tpsUtil, tpsDig, and MorphoJ (Klingenberg 2011). Basic information about these programs and other available opensource programs for GM can be found at http://life.bio.sunysb.edu/morph/.

MorphoJ is the primary program used to conduct the GM analysis, though the preparation of the data needs to be completed first in tpsUtil and tpsDig. Once the images of the points were collected, the datasets needed to be converted into a .TPS file; this is completed first in tpsUtil. The datasets were placed in individual .TPS files based on the site, so Kaplan-Hoover in one, Kobold in one, etc. The Powers-Yonkee type site was split into two different files due to the points being pulled from two separate sources.

The second step is the most time consuming and the most important to produce an accurate analysis: the application of landmarks onto the individual points in tpsDig. Kevinsen (2013) provides a solid overview about the basics of landmarks and how to identify them. For this study a total of six landmarks were placed on the projectile points only on one side of the point (Figure 2). The reasoning for only utilizing one side of the projectile points was based upon the question being asked, and for convenience as some points did not fully complete basal portions. The key difference between Yonkee and Pelican Lake is the basal morphology, so landmarks (LM) 1-3 were placed on the basal end with LM4 in the notch, LM5 on barb, and LM6 approximately a centimeter up the edge. Additionally, this step requires proper scaling of the images for late analysis, hence the need for a scale in the images. tpsDig has a built-in scaling tool requiring a line to be drawn (measured) between two known points. This is also the reason the points were separated by their site and the Powers-Yonkee type point by the source the images were collected from. Each .TPS file has a different scale because of the dimensions of the images collected, combining all images into one .TPS would have skewed the analysis in morphoJ since the scale would not have remained accurate for the all datasets.

Figure 2. Location of Landmarks on KH_1.

RESULTS AND DISCUSSION

Once the .TPS files were imported into morphoJ a series of statistical analyses were applied to a data set consisting of all points, and a second iteration with the Kaplan-Hoover data set split into separate Yonkee and Pelican Lake sub datasets. The analyses produced were a Procrustes distance fit (Figure 3), principle component analysis (PCA) (Figure 4), canonical variate analysis (CVA)(Figure 5, Figure 6), and a discriminate function analysis (DFA). Due to the

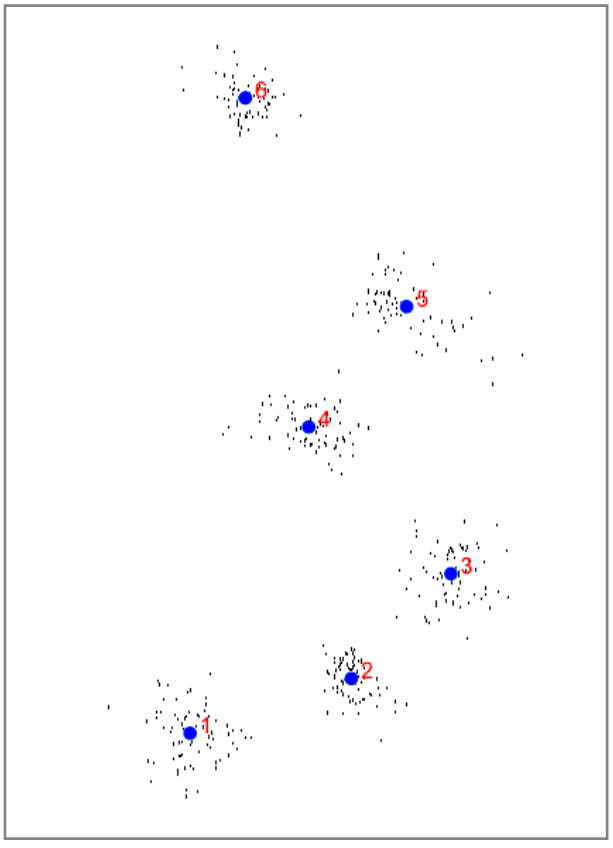


Figure 3. Procrustes fit visualization. Average of each Landmark and the position of each Landmark from the points in the dataset.

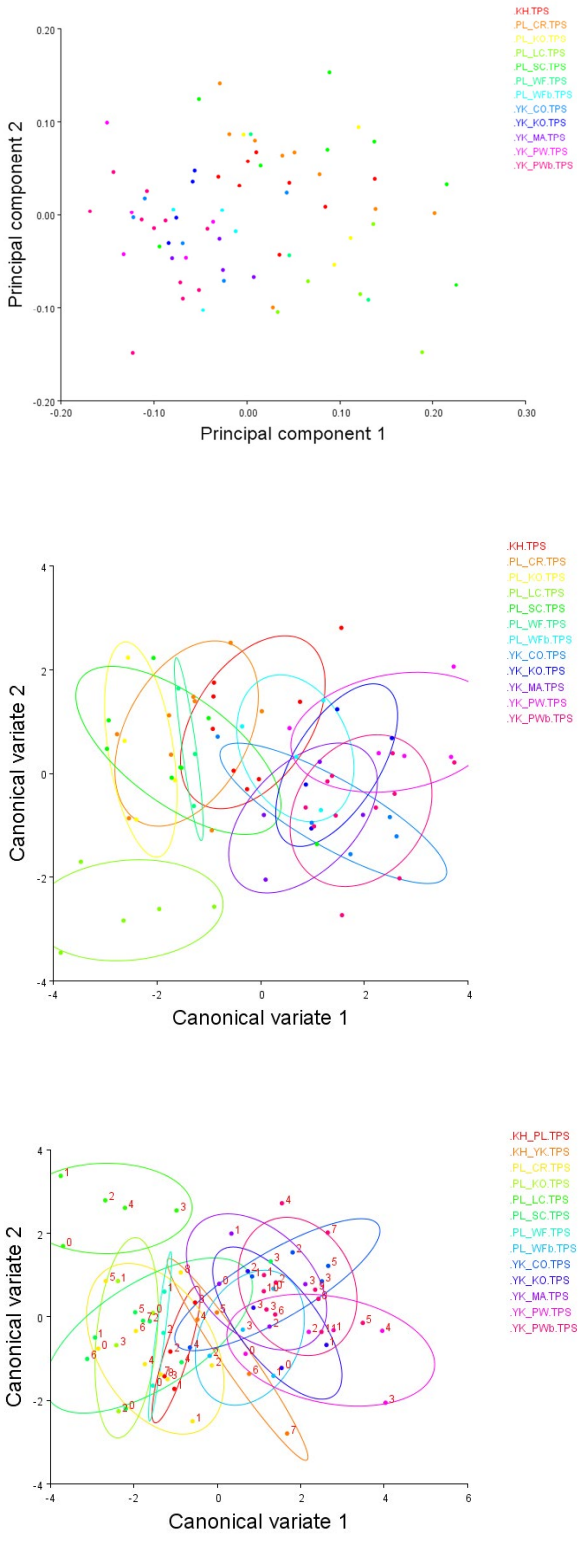


Figure 4 (top). Principle Component Analysis visualization of PCA 1 to PCA 2. Figure 5 (middle). Canonical Variate Analysis, CVA 1 to CVA 2, with confidence ellipses (.8). Figure 6 (bottom). Canonical Variate Analysis, CVA 1 to CVA 2. KH sub dataset is splt into KH_PL and KH_YK.

number of points (n=70), and sub data sets (12 for the first iteration and 13 for the second iteration) it is beyond the scope of this paper to delve into the full analysis between all the datasets. The results presented here are narrowed to focus on the primary goal of understanding the relation of Yonkee/Pelican Lake assemblages to the Kaplan-Hoover assemblage.

The first analysis necessary is a Procrustes fit (Figure 3), which aligns all the landmarks on a single coordinate plane and thus allows other analysis to be conducted. Next, a PCA was applied, which is a multivariate analysis that can be summarized as a means to identify key attributes which account for the majority of the variation within the dataset. From iteration 1 the PCA (Figure 4) is displayed by PC1's relation to PC2, with PC1 & PC2 accounting for 61% of the total variation (Figure 7). Initial analysis of the PCA appears to show a spectrum of variation with Yonkee sub datasets to the left, Pelican Lake sub datasets on the right, and Kaplan-Hoover's eight points in the middle as expected. Further analysis was able to highlight any form difference between Yonkee and Pelican Lake as well as how Kaplan-Hoover fits into the two types.

The next analysis conducted was a CVA. The CVA is similar to the PCA as it is a multivariate approach to determine variation, however this "is a method used to find the shape features that best distinguish among multiple groups of specimens" (Klingenberg 2011). The CAV takes shape into account while the PCA is simply looking for the most variation. The CVA was applied to both iteration 1 (Figure 5) and 2 (Figure 6) with 1000 permutations, primarily to produce the statistical results related to the Procrustes distance data (Table 2) and to visualize the relationship between the two types better than the PCA. This analysis provides a clearer understanding of the relationship

between Kaplan-Hoover (both full assemblage and split YK/PL) which will be explained more in the discussion section.

Lastly, a DFA analysis was applied. This analysis was used to produce specific visualizations which can better clarify the numerical results. Through this analysis in MorphoJ a wireframe comparison can be produced (Figure 8). Unlike a CVA, a DFA analyzes the sub datasets in pairs and not as a complete dataset, e.g. comparing Kaplan-Hoover Pelican Lake to the Pelican Lake Long Creek sub dataset (Klingenber 2011). The DFA was processed for each pair of subdata sets available (n=66), though only a few of the pairs related to the Kaplan-Hoover assemblage will discussed.

Analysis of results from the Kaplan-Hoover sub datasets - both the full assemblage and the split Yonkee/Pelican Lake sub datasets - are interesting once the statistical relationships are properly understood. The Procrustes distance data is the clearest analysis to understand the similarity and differences between the different assemblage sub datasets (Table 2). The goal of the project to quantitatively determine the relationship between the Kaplan-Hoover assemblage and the Yonkee and Pelican Lake point types cannot be definitely addressed however there are tentative lines of evidence which can shed some light on why two different point types were found at a single event site.

The CVA (Figure 5, Figure 6) unquestionably shows how closely related the two point types are. There is no defining demarcation between the two types, and while one sub dataset may be an outlier (Pelican Lake_Long Creek), the rest show

Principal Component Analysis: PCA: CovMatrix, All, Procrustes coordinates

	Eigenvalues	% Variance	Cumulative %
1.	0.00910902	41.107	41.107
2.	0.00442248	19.958	61.065
3.	0.00308287	13.912	74.977
4.	0.00163010	7.356	82.334
5.	0.00140321	6.332	88.666
6.	0.00113761	5.134	93.800
7.	0.00078794	3.556	97.356
8.	0.00058594	2.644	100.000

Total variance: 0.02215916

Variance of the eigenvalues: 0.0000071928238
Eigenvalue variance scaled by total variance: 0.01465
Eigenvalue variance scaled by total variance and number of variables: 0.13393
Note: throughout all calculations of eigenvalue variances, the dimensionality used was 8.
Please double-check because this dimensionality may not be appropriate for all situations.

Iteration 1

Procrustes Distance

	KH	PL_CR	PL_KO	PL_LC	PL_SC	PL_WF	PL_WFb	YK_CO	YK_KO	YK_MA	YK_PW
PL_CR	0.0607										
PL_KO	0.1279	0.0790									
PL_LC	0.1777	0.1596	0.1537								
PL_SC	0.0698	0.0488	0.0987	0.1552							
PL_WF	0.0845	0.0679	0.0868	0.1311	0.0970						
PL_WFb	0.1102	0.1343	0.1690	0.1996	0.1589	0.1123					
YK_CO	0.1248	0.1370	0.1656	0.1962	0.1536	0.1434	0.1002				
YK_KO	0.1196	0.1368	0.1850	0.2225	0.1593	0.1512	0.1028	0.0675			
YK_MA	0.1294	0.1361	0.1481	0.1692	0.1559	0.1204	0.0906	0.0590	0.0970		
YK_PW	0.1523	0.1812	0.2273	0.2615	0.2000	0.1861	0.1092	0.1019	0.0641	0.1258	
YK_PWb	0.1524	0.1750	0.2095	0.2284	0.1966	0.1695	0.0843	0.0681	0.0817	0.0872	0.0939

Procrustes P value

	KH	PL_CR	PL_KO	PL_LC	PL_SC	PL_WF	PL_WFb	YK_CO	YK_KO	YK_MA	YK_PW
PL_CR	0.3706										
PL_KO	0.0163	0.3042									
PL_LC	0.0001	0.0030	0.0028								
PL_SC	0.4352	0.7424	0.3912	0.0360							
PL_WF	0.3650	0.5645	0.4470	0.0912	0.4764						
PL_WFb	0.0361	0.0091	0.0298	0.0037	0.0556	0.1771					
YK_CO	0.0184	0.0059	0.0263	0.0046	0.0512	0.1140	0.1820				
YK_KO	0.0195	0.0089	0.0220	0.0075	0.0544	0.0322	0.0265	0.6745			
YK_MA	0.0144	0.0067	0.0056	0.0093	0.0596	0.0849	0.1671	0.7499	0.0518		
YK_PW	0.0006	0.0004	0.0067	0.0083	0.0047	0.0152	0.0253	0.0835	0.5088	0.0291	
YK_PWb	<0001	<0001	0.0003	0.0002	0.0003	0.0028	0.0933	0.3330	0.1033	0.1112	0.0246

Iteration 2

Procrustes Distance			Procrustes P-value		
	KH_PL	KH_YK		KH_PL	KH_YK
KH_YK	0.0981		KH_YK	0.2164	
PL_CR	0.0795	0.0765	PL_CR	0.3135	0.3391
PL_KO	0.1479	0.1251	PL_KO	0.0241	0.0786
PL_LC	0.1776	0.1909	PL_LC	0.0070	0.0059
PL_SC	0.0717	0.0969	PL_SC	0.6860	0.3959
PL_WF	0.1042	0.0907	PL_WF	0.2775	0.4169
PL_WFb	0.1495	0.0823	PL_WFb	0.0297	0.3135
YK_CO	0.1661	0.0914	YK_CO	0.0130	0.3364
YK_KO	0.1584	0.0914	YK_KO	0.0274	0.2494
YK_MA	0.1704	0.0963	YK_MA	0.0269	0.2167
YK_PW	0.1920	0.1197	YK_PW	0.0014	0.0191
YK_PWb	0.1915	0.1207	YK_PWb	0.0008	0.0013

Figure 7 (top). Principle Component Analysis component data. Table 2 (bottom). Procrustes Distance data and associate P-values for Iteration 1 and Iteration 2.

clustering based on their type; with a confidence ellipse of .8 applied the overlay cannot be ignored. Ferguson (1993) considers Yonkee to be a region adaptation due to its limited geographic range, and with this analysis the likelihood of Yonkee being a regional variation of Pelican Lake appears to be more likely than a separate point type by itself. The relevant and most interesting result from the CVA graph is where Kaplan-Hoover falls in comparison. The Kaplan-Hoover Yonkee and Pelican Lake points are centrally located between the two minor clusters. This may be a random statistical anomaly (equal split of Yonkee and Pelican Lake points in the assemblage), as the placement of those eight points seems to convenient. Delving into the Procrustes distance data helps explain these relationships.

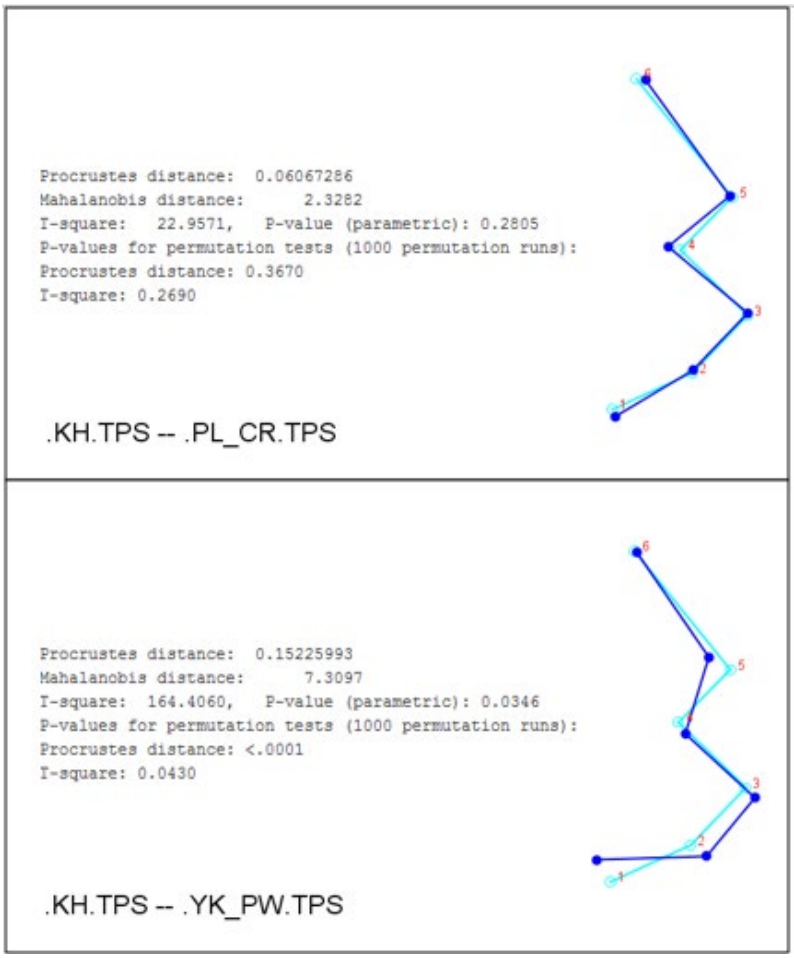


Figure 8. Discriminate Function Analysis wireframes. Light-blue wireframe is the Kaplan-Hoover assemblage average.

The closer to zero the Procrustes distance is, the closer the overall relationship between the two sub datasets. Based on the closeness between the Kaplan-Hoover assemblage and the other sub dataset assemblages,all eight points combined are more closely related to Pelican Lake overall than to Yonkee (Table 2). Kaplan-Hoover/Pelican Lake has three pairs with a closeness of <.09, (Crane .0607, Schmitt .0698, Walter Felt .0845), with a total Kaplan-Hoover/Pelican Lake average of .1051. This is less than the nearest Yonkee sub dataset, Kobold, at .1196. The relationship these numbers represent are easier represented visually (Figure 8) thanks to the DFA.

Overall, visually the CVA shows that the Kaplan-Hoover assemblage appears to be a bridge between the Pelican Lake and Yonkee point types. It appears the assemblage can be placed generally in the Pelican Lake type. While not the primary focus of this analysis, this may provide more evidence for classifying the Yonkee point as a regional sub-type of Pelican Lake. This tentative conclusion aligns well with the known geographic ranges of the two point types (Figure 1). However, this cannot answer how the two point types came to be located together at the Kaplan-Hoover bison bone bed. The reasons can range from a communal hunt (would have to account for why no other Yonkee points are found outside of the general Powder River Basin to date), to trade and exchange of projectile points between groups. Determining

this will probably not be possible based only upon the projectile point assemblage, and the lithic assemblage in general.

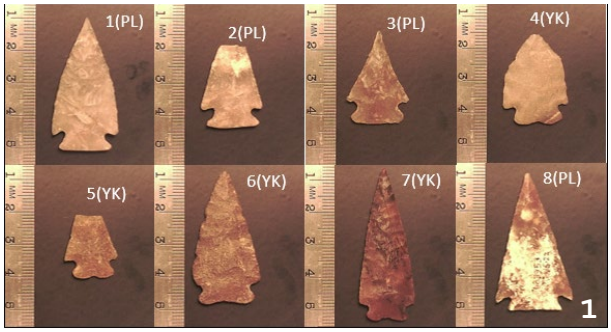
CONCLUSION

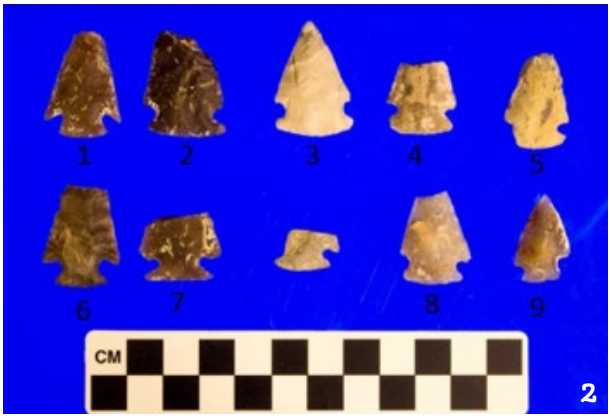
Geometric Morphometrics is a means of analysis which can measure variation based upon the shape of a point and not simple a collection of measured attributes. The process of applying this methodology is fairly easy to learn with the primary limiting factor being an in-depth understanding of multivariate statistical analysis. Using this methodology on the Kaplan-Hoover bison bonebed to better understand the relationship between the two projectile point types associated with this single event site is one application. The results from this study point to its ability to better quantify the differences between point types and can even serve as a means to reanalyze previous point typology and remove the visual and human bias which can influence point typing.

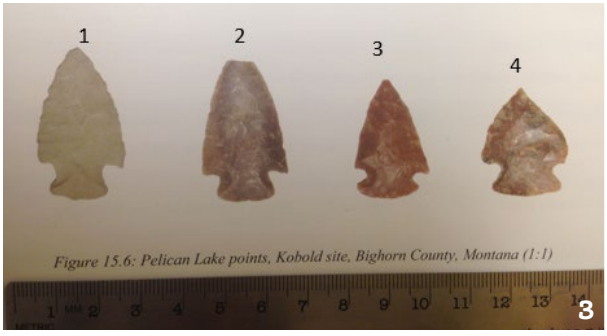
The analysis conducted on the 12/13 different sub datasets was not as exhaustive as is possible using the MorphoJ software (see Kenvinsen 2013). The depth of analysis is only limited to the questions being asked and the time willing to be devoted. For example, a more thorough analysis could have processed each of the projectile points (n=70) as individual datasets not as assemblage datasets. It would be safe to say Geometric Morphometrics does have a promising future in lithic analysis due to required data (e.g. photographs with a scale) that's easy to produce and minimal computational power needs for statistical applications. It cannot be overstated that the ability to measure shape variation in its entirely will benefit not just projectile point analysis but other aspects of archaeology, it simply needs to be tested.

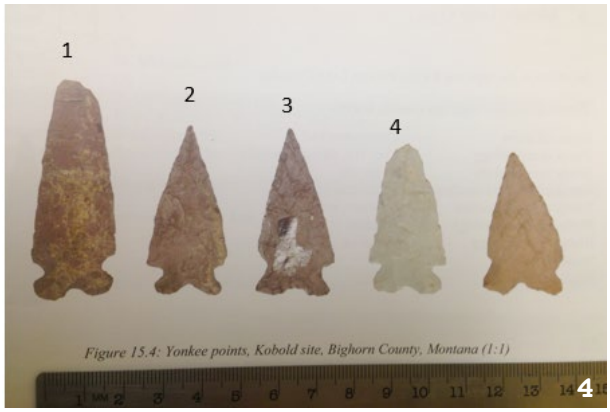
APPENDIX: PROJECTILE POINT IMAGE DATASETS

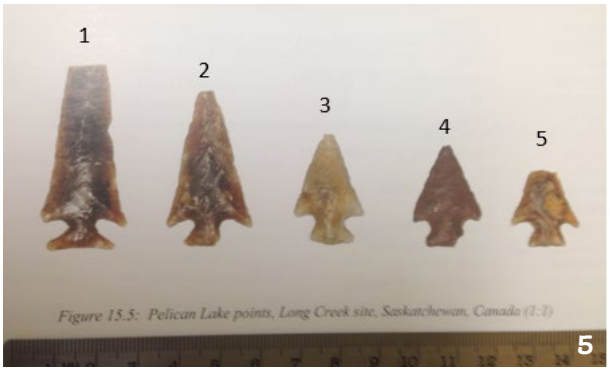
1: Kaplan-Hoover. 2: Crane. 3: Kobold (PL). 4: Kobold (YK). 5: Long Creek. 6: Mavrakis-Bentzen-Roberts. 7: Powers-Yonkee and Cooley. 8: Powers-Yonkee(b). 9: Schmitt. 10: Walter Felt. 11 Walter Felt(b).

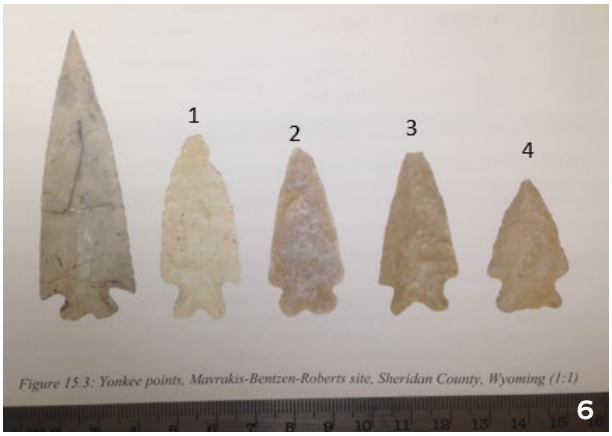


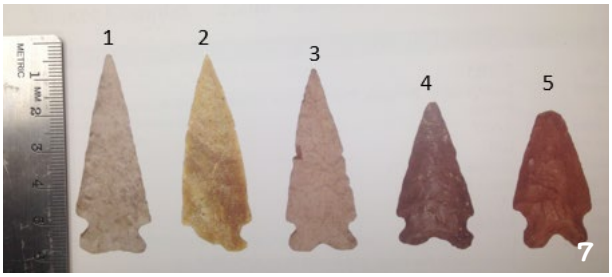


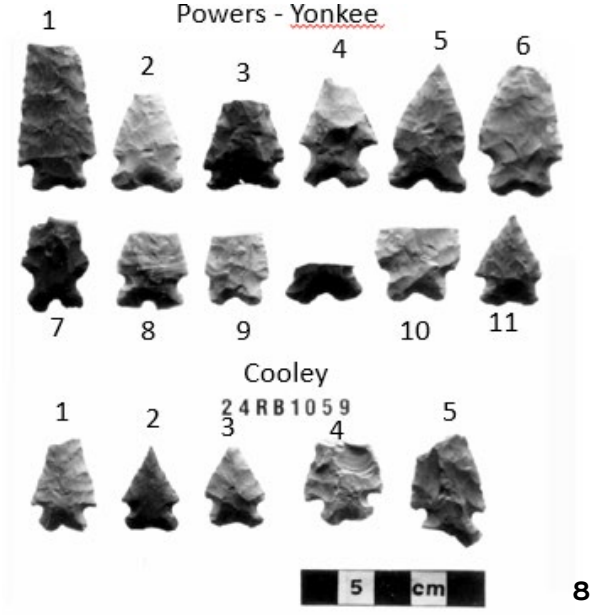


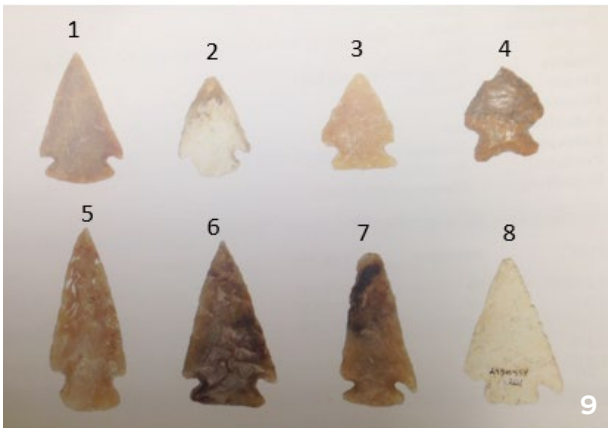


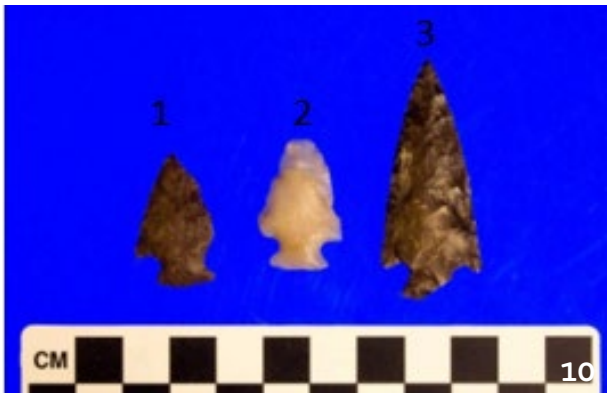


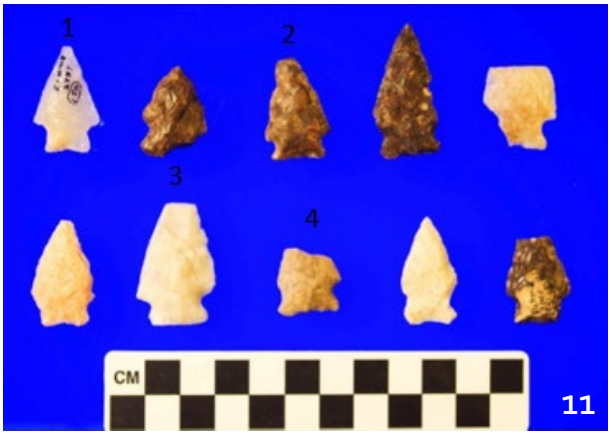












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