Permaculture and Public Health: Mitigation of the Lifestyle Risk Factors for Type 2 Diabetes Through the Establishment of Permaculture Edible Forest Gardens

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By Brett Lehner

INTRODUCTION:

As of 2011, “25.8 million children and adults in the United States – 8.3% of the population – have diabetes”(2011 National Diabetes Fact Sheet). In the year between 2010 and 2011, 1.9 million additional cases of diabetes were diagnosed. 79 million Americans are currently in a state of ‘prediabetes’, showing some degree of insulin resistance and are at risk for developing diabetes at some point in their life (2011 National Diabetes Fact Sheet, CDC).It is estimated that the national cost for dealing with diabetes is $174 billion a year, with $116 billion going to direct medical expenditures and $58 billion covering, “disability, work loss and premature mortality” (2011 National Diabetes Fact Sheet).In this paper the prevalence of diabetes and its trends in 20th and 21st century America will be examined, as well as the physiology of type 2 diabetes and the risk factors for this disorder focusing on obesity and activity levels. Type 2 diabetes will be examined as a chronic ‘disease of civilization’. The lifestyles and prevalence of this disorder in pre-agrarian societies will be compared to 21st American society. The establishment of permaculture edible forest gardens will then be discussed as a potential tool to help mitigate the lifestyle risk factors of obesity and activity levels, for type 2 diabetes.

PREVELANCE:

Over the past 30 years, diabetes has shown a rapid increase in the United States. According to the Center for Disease Control and Prevention, “From 1980 through 2010, the number of Americans with diagnosed diabetes has more than tripled (from 5.6 million to 20.9 million)”(CDC, 2011, p1). Of the 25.8 million cases in 2011, 90% are type 2 diabetes (Fowler, 2012).

The distribution of cases in the United States shows a higher prevalence of cases in the South eastern states of the United States; Georgia, Alabama, Mississippi and Louisiana, where the rates of diagnosed diabetes in adults is greater than 10%(2011 National Diabetes Fact Sheet CDC). Across racial groups, American Indians and Alaskan natives show the highest level at a national rate of 16.1%, followed by Puerto Ricans at a rate of 13.8%, and Mexican Americans at a rate of 13.3%. The rate amongst non-Hispanic whites was 7.1% in 2011 (2011 National Diabetes Fact Sheet, CDC).

PHYSIOLOGY OF TYPE 2 DIABETES:

In healthy individuals, blood glucose homeostasis is maintained by glucose absorption through the small intestines, glucose production in the liver, and use by the tissues of the body(Kahn,1992). The oscillation of blood glucose levels are buffered by the hormones insulin and glucagon to keep the levels within physiologically healthy parameters(Smolin, 2010). During the fed state, Insulin is released by the pancreas to, “promote enhanced glucose uptake, metabolism and storage in muscle and adipose tissues,”(Kahn,1992, p1367). During the fasting state, in response to a decrease in blood glucose levels and a decrease in the insulin/glucagon ratio, glucose is released by the liver to maintain blood glucose levels and supply primarily the brain (Smolin, 2010).

The disease of diabetes represents a malfunction in the insulin mediated glucose transport into adipose and muscle tissues. This can occur in two ways. In what is known as type 1 diabetes, insufficient levels of insulin are produced by the pancreas as a result of autoimmune destruction of pancreatic beta cells (Smolin, 2010). This is normally diagnosed in people below the age of 30, and represents between 5% and 10% of all cases of diabetes. In Type 2 diabetes, the other 90-95% of cases, there is decrease in glucose uptake at the level of the cells as a result of decreased insulin sensitivity. The decrease in insulin sensitivity is hypothesized to be linked to the inflammatory effects of elevated fatty acid levels in the bloodstream accompanying certain dietary and lifestyle patterns, as will be discussed in more detail further in the paper.

The defined ‘normal’ range for fasting plasma glucose levels in healthy individuals is between 80 and 99 mg/dL(Smolin, 2010). When people exhibit fasting blood glucose levels above 100mg/dL, in the range between 100 and 125 mg/dL, they are considered pre-diabetic, and above 125 mg/dL fasting glucose, they are considered in the ‘diabetic’ range’(Smolin, 2010). Chronic, elevated blood glucose levels over time lead to, “nervous system damage (neuropathy), renal system damage (nephropathy) and eye damage (retinopathy)”(Deshpande, 2008, p1261). These complications are classified as the ‘microvasular complications’. Microvascular complications in diabetic patients are theorized to arise from a loss of the myogenic response, a homeostatic control mechanism which in healthy individuals protects capillary beds from rapid increases in blood pressure. In diabetic patients, blood pressure is affected by the inability to maintain blood glucose homeostasis. The loss of the myogenic response is hypothesized to lead to the hemorrhaging of capillaries, underpinning microvascular damage. (Malik, 1998) There are also macrovascular complications including, “cardiovascular disease, stroke, and peripheral vascular disease. Peripheral vascular disease may lead to bruises or injuries that do not heal, gangrene, and, ultimately,amputation”(Deshpande, 2008, p1259).

The development of type 2 diabetes in individuals is preceded by metabolic syndrome. Metabolic syndrome is a classification set by health organizations including the International Diabetes Federation and World Health Organization based upon body mass index (BMI), waist circumference, triglyceride levels, cholesterol levels, blood pressure, and fasting plasma glucose. Individuals who fit the criteria for metabolic syndrome are considered at high risk for the development of cardiovascular disease and diabetes. The link between metabolic syndrome and the development of diabetes lies in the induction of chronic low grade inflammation by the factors associated with the syndrome, including the presence of visceral fat, and raised lipid levels in the blood. These factors lead to a pro-inflammatory state within adipocytes and hepatocytes, followed by the release of inflammatory cytokines from immune cells including TNFalpha and IL-6 (Emanuela, 2012). The inflammation associated with metabolic syndrome is implicated in the mechanism for the development of insulin resistance

In a study looking at the relationship between the inflammatory markers of C-reactive protein, fibrinogen and white cell count in Insulin resistance, it was shown that chronic subclinical inflammation was associated with insulin resistance syndrome (IRS).(Festa, 2000) In a study looking at the relationship between obesity, Tumor Necrosis Factor-alpha and insulin resistance in mice, It was found that TNF-αlevels were elevated, 'locally and systematically' in obese mice, and when the TNF-a was neutralized, the mice showed increased response to insulin and glucose uptake(Hotamisligil, 1993). It is hypothesized that TNF-contributes to insulin resistance by "upregulat*ing* the expression of monocyte chemoattractant protein-1 (MCP-1) and adhesion molecules"(Yang, 2009, p 1208). TNF-a and MCP-1 can cause "vascular dysfunction in coronary microcirculation"(Yang, 2009, p 1212). In mice receiving anti-MCP-1 treatment, there was a reduced expression of adhesion molecules (Yang, 2009).

Obesity is the largest contributing risk factor for the onset of type two diabetes followed by physical inactivity, age and genetic susceptibility(Mayo Clinic). Over 80 percent of individuals with type two diabetes are either obese or overweight (CDC, 2011). Concurrent with the rise in prevalence of diabetes over the past thirty years in the United States, obesity rates have more than doubled. In the year 2010, the national obesity rate was 35.7%.(CDC, 2011). This can be compared to 1985, in which no state in the US had a recorded rate of obesity over 14%. Adipose tissue releases, "NEFAs(non-esterified fatty acids) and glycerol, hormones — including leptin and adiponectin — and proinflammatory cytokines…(and) in obesity, the production of many of these products is increased"(kahn, 2006, p 840). The presence of elevated levels of these factors in the blood can lead to, "oxidative stress, endoplasmic reticulum stress (ER stress), amyloid deposition in the pancreas, ectopic lipid deposition in the muscle, liver and pancreas, and lipotoxicity and glucotoxicity"(Donath, 2011, p98).

In order for muscle and adipose cells to uptake glucose, they have insulin regulated glucose transporters at the cell membrane. These transporters are known as GLUT-4 transporters. The importance of GLUT-4 in glucose transport and its potential role in the physiology of diabetes was shown through a GLUT-4 gene-knockout experiment in mice done at Harvard medical school. The researchers found that GLUT-4 knockout mice showed, "severe insulin resistance and glucose intolerance from an early age" (Zisman, 2000, p924). The researchers concluded that Glut-4 glucose transporters were the rate limiting step in the trans-membrane transport of glucose in muscle tissue. According to the authors, "any strategy that potentiates the insulin-stimulated recruitment of GLUT-4 would have enormous therapeutic benefit," to addressing insulin resistance in type 2 diabetes. In a study looking at the effects of high plasma fatty acid concentrations on the expression of GLUT-4 in mice; it was found that after a period of 7 weeks, GLUT-4 protein levels decreased by 34% in high fat-fed rats.(Kahn, 1993) High levels of plasma fatty acids, including NEFA's lead to desensitization of the cells to insulin.

With obesity being the main contributing factor to type 2 diabetes, a lifestyle marked by healthy energy balance of caloric intake to output could potentially serve as a treatment for this risk factor. There has been significant research in this area. In a research study looking at the effects of exercise and diet on the gene expression of glut-4 protein in rat skeletal muscles, researchers J.S. Lee and C.R. Bruce took 48 rats and split them into two testing groups, one being fed diets high in fat, and the other being fed diets high in carbohydrates. They then split each group into a control group and an 'exercise' group. After 8 weeks they measured the GLUT-4 protein expression. They found that the GLUT-4 expression did not differ significantly comparing the high fat to high carbohydrate diet groups, however there was significance in the difference in GLUT-4 expression comparing the exercise to non-exercise groups, within the high carbohydrate diet group. "There was a significant diet-training interaction on GLUT-4 mRNA, such that expression was increased in both the soleus (100% 0.05) and EDL (142% < 0.01) in CHO-fed animals"(Lee, 2002, p37).

Another study supporting the effect of exercise on the expression of GLUT-4 looked at the "effects of high-intensity swimming training on GLUT-4 and glucose transport activity in rat skeletal muscle." In this research study, rats were placed into one of three groups; either a control group, a low intensity training group or a high intensity training group. After only 8 days, researchers observed, "GLUT-4 content in the epitrochlearis muscle of the HIT (High intensity training) and LIT (Low Intensity Training) rats were significantly higher than that in the same muscle of control rats" (Terada, 2010). This study did not look at diet, but solely on the effects of exercise. From their findings, the researchers concluded that "exercise training increases GLUT-4 content and improves insulin-stimulated glucose uptake"(Terada, 2010, p2022).

Exercise has been shown to have anti-inflammatory benefits, a possible mechanism for its benefit towards type 2 diabetic patients. In a study looking at type 2 diabetic patients participating in a 6 month aerobic exercise program, the inflammatory markers C-reactive protein and TNF-a were decreased(Kadoglou, 2012).

Another proposed mechanism for the effect of exercise on diabetes is increased expression of GLUT-4 in response to elevated AMP- activated protein kinase activity. "AMPK is a fuel and stress sensing enzyme that can be activated in cultured endothelial cells (ECs) in response to shear stress *(and)* oxidative stress"(Cacicedo, 2011, p 1255). In a study done at the Diabetes and Metabolism Research Unit, AMPK was shown to be activated by acute bouts of exercise, as studied in the aortas of mice. According to the authors, AMPK, "phosphorylates key metabolic enzymes resulting in an increase in processes that generate ATP, such as fatty acid oxidation (FAox)"(Cacicedo, 2011, p 1255). In a study examining the effect of AMPK on GLUT-4 transcription in skeletal muscles, mice were injected with a single dose of 5-aminoimidazole-4-carboxamide-1-β-D-ribofuranoside (AICAR), "a known activator of AMP-activated protein kinase (AMPK)." Researchers Zheng D. and Maclean, P. found that increased levels of AMPK increased GLUT-4 transcription. Zheng and Maclean report, “increasing AMPK activity with a single injection of AICAR leads to the transcriptional activation of the GLUT-4 promoter”(, Zheng, 2001, p1073).

In regards to dietary intervention for the treatment of obesity and type 2 diabetes, studies have been done to look at the effect of the ‘Mediterranean Diet’. The Mediterranean diet is marked by “mostly foods of vegetable origin…fruits, vegetables, legumes, nuts, cereals and olive oil”(Schroder, 2007 p149). In an epidemiological study looking at rates of obesity in Spanish men consuming a Mediterranean diet, they found an inverse correlation between diet and BMI. In an intervention study, where one group of healthy young males was fed a Mediterranean diet, one a diet high in carbohydrates and one a diet high in saturated fats, it was found that glucose absorption was most affected in the individuals consuming a diet high in saturated fats. The researchers concluded that ,“Isocaloric substitution of carbohydrates and monounsaturated fatty acids for saturated fatty acids improved insulin sensitivity in vivo and in vitro, with an increase in glucose disposal”(Perez-jiminez, 2001, p2038).

In another dietary intervention study looking at the effects of the paleolithic diet on type 2 diabetes compared to a control diet, it was shown that HbA1c , glycosylated hemoglobin, a marker for type 2 diabetes, was decreased in individuals put on a paleolithic diet for three months. The Paleolithic diet is marked by, “lean meat, fish, fruits, vegetables, root vegetables, eggs and nuts.”(Jonsson, 2009, p 1).

In a study comparing the effects of the Mediterranean diet to the Paleolithic diet on glucose intolerance in people with ischemic heart disease, 29 patients were studied over a period of twelve weeks, given one of the two diets. Both groups showed weight loss and a decrease in blood glucose levels. The Paleolithic Diet group lowered their blood glucose by 22% as compared to an 8% decrease by the Mediterranean Diet group(Lindeberg, 2012). The differences between the two diets included the glycemic load, which was 43% lower in the Paleolithic Diet than the Mediteranean Diet, the presence/absence of dairy, which was absent in the Paleolithic diet, and the intake of fruit and nuts, which was greater in the Paleolithic Diet (Lindeberg, 2012).

One critique of the Paleolithic diet is that although many people may like to eat this way, as is argued, it can be cost prohibitive for a large percentage of the population to do so. In a paper titled, 'The feasibility of the Paleolithic diet for low income consumers' looking at the availability per cost of the Paleolithic diet for consumers in the US, researchers write that, "The shift to a modern Paleolithic diet showed a shift toward more expensive foods on a cost per energy basis. The higher protein content of the Paleolithic diet is a factor because protein is generally more expensive per energy than other macronutrients"(Metzgar, 2011, p 448). However, the author argues it is not cost that is the main barrier to a dietary change but the change in behavioral habits of food choice. "Such a diet is a radical departure from the observed food choices of the average consumer. Roughly half of all the 58 food categories are eliminated under a simulated Paleolithic diet. Food choices end up heavily weighted into a few categories such as lean poultry and potatoes"(Metzgar, 2011, p449). The author argues that it is feasible to get most of the daily requirements for nutrients for low income individuals from a Paleolithic diet, however, the diet falls short in the requirements for some micronutrients and calcium. The author concludes that for low-income individuals living in the United States, "a 9.3% increase in income is needed to consume a Paleolithic diet that meets all daily recommended intakes except for calcium"(Metzgar, 2011, p451).

DIABETES TYPE 2 AS A 'DISEASE OF CIVILIZATION':

Inflammatory mechanisms that accompany obesity and sedentary lifestyles have been shown to contribute to insulin resistance characteristic of type 2 diabetes and the behavioral modifications of proper exercise and a healthy diet have been shown to improve symptoms of type 2 diabetes. In a paper titled, 'Diabetes and Culture,' Steve Ferzacca, an anthropologist at the University of Lethbridge writes that unlike many other diseases, diabetes type 2 is not spread primarily by an infectious agent such as virus or a microbe. Rather, the rise in prevalence of the disease across the world coincides with the "adoption of Western, modern, affluent, civilized lifestyles." Microbes may play a role in obesity and diabetes in that the intestinal flora of obese patients have been shown to differ from healthy individuals with consequences for the immune system and metabolism. But, diet has a large effect on the composition of the gut microbiota, so it is largely the behavioral aspect of food choice that precedes the change in gut microbiota (Tilg, 2011). I"Even though human biology plays some role, the onset and spread of type 2 diabetes are the result of social and cultural processes related to change in quality and quantity of energy consumed (diet) and energy expended (physical activity)"(Ferzacca, 2012, p412).

An example of the effects of westernization on type 2 diabetes is that of the Pima Indians. In a study looking at the difference between Pima Indians living in the US and Mexico, groups which share common a ancestry, researchers from the Biomedical Research center in Louisiana found that levels of type 2 diabetes in the Pima living in the US are more than 5 times greater than levels of type 2 diabetes in the Pima living in Mexico. The Pima Indians living in the US have higher rates of obesity and lower levels of physical activity than their Mexican counterparts, contributing to the prevalence of the disease(Schulz, 2006).

Another example of culture as a vector for type 2 diabetes is on the island of Naura in the Pacific Ocean. The first case of Type 2 diabetes among native Naurans was diagnosed in 1925. At present, one third of the population over the age of thirty, two thirds of the population over the age of 55 and 70% of people over age 70 are diabetics. Accompanying the change in prevalence of type 2 diabetes over the course of the last century, there has been a cultural shift. In 1922, a mining company was established on the island, and many of the inhabitants of the island gave up agriculture and fishing to work in the mines. With the money they earned they could import goods. In 1927, the average sugar consumption of Naurans was a pound a day(Diamond, 2003). The change in diet and lifestyle of the Naurans is implicated in their increase in diabetes over the past century.

The effect of culture on diabetes prevalence is multifaceted and systemic. The physical structures of human living environments and the relationships between aspects of the living environments can affect the behaviors of individuals. In a paper titled, ‘Built environment and diabetes,’ the role of city planning and zoning is discussed in relation to diabetes. According to the authors, “factors such as cul-de-sacs, lack of parks, high speed traffic and automobile-focused transport could discourage activity and ultimately increase the risk of obesity”(Pasala, 2010 p63). Other factors including urban grids and single-use zoning are implicated as well in the decrease of activity levels over the past half century .

One large driving force in the structure and culture of the United States is the economic system within which the United States operates, capitalism. Founded upon the notion of individual property rights and the ideal that the market most efficiently allocates goods and services to individuals, capitalism affects the structure of the built environments of modern America as well as the information displayed through advertising, the availability of products which can be chosen for diets and activity patterns, and aspects of the relationships that people have with one another. Of concern to the public health of modern Americans is that the goals of capitalism do not align with the goals of public health. What is most profitable for the food industry is not what is healthiest for Americans. In the words of Kelly Brownell, from the Yale Rudd center for Food Policy and Obesity, “There is a fundamental and irreconcilable conflict between the interests of the food and beverage industry’s interests and public health policy interests on obesity”(Brownell). Brownell spoke these words in a formal debate with Derek Yach, a former senior executive at PepsiCo and former WHO employee. Yach replied saying that the market for healthy food couldn't be more than a niche market because of its lower demands and higher costs.

In the debate, Brownell compared the modern marketing of junk food to the marketing of cigarettes by the tobacco industry in the 1950's and 1960's (Charles, 2012). In 1970, The 'Public Health Cigarrette Smoking Act' was passed which banned tobacco advertisements from television and radio. Since the early seventies, smoking rates have declined from 40% to 20% among adults in the United States (CDC, 2010). If measures similar to that were to be taken for energy-dense foods , the rates of obesity could potentially also decrease.

Legislation has the potential to influence peoples' diets and activity levels through industry regulation and city and town planning. In this paper, an alternative, more organic method for altering behavior and diet patterns will be discussed through the establishment of permaculture edible forest gardens. Both methods may complement each other in the addressing of the diabetes epidemic. While legislation works through the regulation of the market, the establishment of edible forest gardens can potentially exist largely outside of a market economy, which may be a long term strength but may hamper growth in the short term, or explain the lack of prevalence of forest gardens currently in America.

To look at the potential effect that an economic system can have on the culture and health outcomes of a nation, diabetes rates in the US can be compared to diabetes rates in Cuba, a communist country. Cuba is the only communist country in the Americas and also has the lowest death rate from diabetes, approximately 8 times lower than that of the USA. As opposed to the United States, the mortality rates associated with Diabetes have declined from 2010 to 2012 (Pan-American Health Organization, 2012). However, the prevalence, as in the United States, is still on the rise. One factor that may play role in the health outcomes in Cuba may be structure of their agricultural system. Controlled by the government and not by private corporations, the goals and motivations of food production in Cuba may differ from that of the United States, influencing the products grown and the marketing of products.

The agricultural system of Cuba has largely been shaped by the isolation from foreign trade in the latter part of the 20th century, resulting from the fall of the Soviet Union and trade embargos enforced by countries including the United States, such as the 'Cuba Democracy Act' of 1992. The resulting reorganization of the agricultural system localized the production of food, establishing many small organic and semi-organic farms to fit the food needs of the nation. Food production in Cuba is now split into Popular Gardens – privately operated gardens for residents living in cities, Intensive Gardens- state run cultivation of food in raised beds , Autocomsumos – gardens which supply food for workplace cafeterias, and empresas estatales –state run agricultural enterprises which facilitate profit sharing among workers(Warwick, 1999). The health outcomes of Cuba may speak to the effect that communism has on health outcomes for diabetes . It may also speak to the effect of localized organic farms and gardens can have on health outcomes, which aren't diametrically opposed to capitalism, in theory. With the proper legislative regulation in the US, the agricultural markets could be structured to favor the growth of small organic and semi-organic farms.

CHANGE IN DIET:

If we compare the diets and activity levels in modern America to that of our hunter-gatherer ancestors, there are clear differences between the groups, and an associative decrease in the prevalence of type 2 diabetes. The diets of our hunter-gatherer ancestors, "consisted of wild game, seafood, fruits, roots, leafy greens, legumes, nuts, and honey. The food was consumed within hours of collection, often uncooked. Essentially no grains or dairy foods were consumed"(McCully, 2001, p 53). They ate with the seasonal variation of food supply, and migrated as food sources changed in availability(Cronon, 2003). In areas where there was a significant change in seasonal temperatures, these humans ate more vegetable foods in the summer, as when available, more meat in winter(McCully, 2001).

The nutrient intake of Paleolithic humans differed greatly from modern humans. “Paleolithic humans are thought to have consumed two to three times the amounts of fiber, minerals, vitamins and phytochemical antioxidants as those eaten by modern man” (Eaton et al. 1997). The fiber intake of Paleolithic humans is estimated to have been 104 g per day, as compared with a current U.S. intake of 10 to 20 g per day (McCully, 2001). The mineral composition of the diet was different in that “Calcium intake was 1,956 versus 750 mg per day; zinc 43 versus 10 to 15 mg per day; iron 87 versus 11 mg per day; and potassium 10,500 versus 2,500 mg per day”(McCully, 2001, p54). The only mineral which modern humans consume more of in their daily diets is sodium. “Sodium intake, on the other hand, was much lower in the Paleolithic era, perhaps 768 mg compared with the contemporary intake of 4,000 mg per day”(McCully 2001, p 54).

The composition of vitamins in the diet also differed in that:

> Folate intake of Paleolithic man is estimated to be 357 mcg per day, as compared with the current U.S. intake of 149 to 205 mcg; vitamin [B.6] intake is estimated to be 3 to 3.5 mg per day, compared with the U.S. intake of 1.5 mg; vitamin [B.12] intake is estimated to be 15 to 18 mcg per day, compared with the U.S. intake of 9 mcg; and ascorbate intake is estimated to be 604 mg per day, compared with a current intake of 77 to 109 mg per day (McCully 2001 p55).

Approximately 11,000 years ago, the agricultural revolution began in the Fertile Crescent. Homo-sapiens who adopted the change from hunter-gatherer lifestyles to agricultural ones experienced a significant change in the structure of their lives, including a change in diet and activity level. The time since then, marks only 0.5% of the history of the Homo genus, 366 human generations. The time since the beginning of the industrial revolution is merely between four and seven generations(Carrera, 2011). This period of time is too short to allow for a genetic adaptation/evolution explanation for the increase of diabetes type 2 disease rate, or for evolutionary selection of mechanisms which confer protection to aspects of the modern living environment such as ubiquitous availability of energy-dense foods, according to the hypothesis of 'civilization diseases'.

Part of the hypothesis of 'diseases of civilization' is the 'thrifty gene hypothesis.' According to this hypothesis, mammals, including humans have evolved genetic mechanism to afford protection from starvation; a more prevalent problem in the history of humanity than over-nutrition. Within modern American society, these genes are not beneficial; instead they actually contribute to an increase in obesity and diabetes type 2. "The changing dietary patterns of Western civilization had compromised a complex homeostatic mechanism" (Neel, 1998, p2). It is difficult to target a specific gene or gene locus as being the 'thrifty genes' because of the 'multifactorial and oligogenic,' nature of type 2 diabetes. Also, "there may well be epigenetic interactions between the components of the genetic contribution to NIDDM(Non-insulin dependent diabetes mellitus)"(Neel, 1998, p2). However, there is strong reason to believe that the interaction between the genetics of our ancestors and the living environment of modern America underpins the risk factors for the development of type 2 diabetes. According to Researcher Carerra, "It is increasingly recognized that certain fundamental changes in diet and lifestyle that occurred after the Neolithic revolution, and especially after the Industrial Revolution and the Modern Age are too recent on an evolutionary time scale for the human genome to have completely adapted. This mismatch between our ancient physiology and the western diet and lifestyle underlies many so-called diseases of civilization"(Carrera, 2011, p15).

Looking specifically at the changes in behavior and diet over the past three decades, as correspond with the rapid increase in obesity levels over that time period, factors which are implicated include the increase in 'mean passive activity time' of children and the increase in the consumption of energy dense foods. Over the past half century, accompanying many of the technological advancements of modern society, there has been a shift from active physical activity among children to passive activity time including but not limited to an increase in time spent watching television and playing videogames. (Scerri) Also accompanying technological advancements of the television and internet has been an increase in exposure to advertisements, of which energy-dense food and beverage advertisements carry a significant share of the market. [This really doesn't make sense since the sharp increase in obesity/TTD has been over the past one or two generations; not over the past two hundred years . . .]

Looking back to theagricultural revolution, humans began cultivating wheat and other cereal grains in the Fertile Crescent. In the western hemisphere, starchy root vegetables such as the potato, as well as quinoa began to be cultivated. A few thousand years later, the cereal grain corn was domesticated and cultivated in the western hemisphere (McCully,2001). One effect that it had, along with allowing humans to remain more sedentary, was that it changed the ratio of carbohydrates to protein, fats, vitamins, minerals and fiber in the diet. In modern American society, humans consume a larger percentage of carbohydrates and foods of a higher GI (glycemic index) than our hunter-gatherer ancestors. Glycemic Index is a measure of how quickly carbohydrates can be absorbed into the bloodstream (Bell,2003). In a paper titled, Low-Glycemic-Load Diets: Impact on Obesity and Chronic Diseases, researchers write, "It has become clear that in order to understand the effect of diet on obesity and chronic disease that both the total intake of carbohydrate and the glycemic index of those carbohydrates (i.e., the glycemic load) must be considered together"(Bell, 2003, p358). In discussing the effects of refined carbohydrates on chronic disease, Bell writes, "Higher blood glucose triggers the release of increased amounts of insulin to bring down these levels. This elevated secretion of insulin favors anabolism, and the storage of all in-coming fuel substrates, in particular fat and glucose. As blood glucose levels drop due to the enhanced insulin action, hunger develops. The constant exposure to high-

GL meals promotes the development of insulin resistance and results in continual hyper-insulinemia"(Bell, 2003, p363). In summary, Bell writes "The root of the problem very likely is the increased consumption of high-GI carbohydrates…These carbohydrates produce profound hunger after ingestion and create a hormonal milieu that fosters the development of chronic disease"(Bell, 2003, p372).

In a paper, 'Glycemic index and obesity' researcher Brand-Miller discusses the role that glycemic index plays in the acquisition of adipose tissue. "Many high-carbohydrate foods common to Western diets produce a high glycemic response [high-glycemic-index (GI) foods], promoting postprandial carbohydrate oxidation at the expense of fat oxidation, thus altering fuel partitioning in a way that may be conducive to body fat gain"(Brand-Miller, 2002, p281).

Not only can high GI foods play a role in the physiological components of fat acquisition, but they may also play a role in the behavior components of calorie consumption. A study was done looking at the effects of glycemic index on eating behavior in humans. In this study, of twelve obese teenage boys, it was seen that the amount of calories consumed, the 'voluntary energy intake', was greater for high GI meals than for low GI meals. The voluntary energy intake was on average 5.8 megajoules for high-GI meals, 3.8 mJ for medium-GI meals, and 3.2mJ for low-GI meals(Ludwig, 1999). According to Ludwig, "Consumption of high-GI meals induces a sequence of hormonal and metabolic changes that promote excessive food intake in obese subjects"(Ludwig, 1999, p261).

In a dietary intervention study looking at the effects of lower GI foods on weight management, showed that diets with a low glycemic index were associated with weight loss. Studying 99 participants over a period of 22 weeks, the GI of the diets corresponded to the weight loss of the participants in that for every one point decrease in GI, there was an associative .44lb decrease in weight (Turner McGrievy, 2011).

CHANGE IN ACTIVITY LEVELS:

The activity levels of our ancestors differed greatly from modern Americans. In hunter-gatherer societies, normal physical activities include, “Walking while gathering, during hunting trips and on visits to neighboring campsites; running after wounded prey; carrying children, carrying game meat, gathering plant foods or firewood; erecting shelters; flint knapping and making composite tools; digging for roots or tubers; butchering and cleaning game animal carcasses; shelling nuts; breaking open crania and long bones for brains and marrow; dancing for simple recreation or as part of religious ceremonies; vigorous play and so forth”(Eaton, 2003, p154). According to Eaton, 2003, most of the physical activity in hunter-gatherer societies would be similar to ‘cross-training’ of athletes today, a mix of non-specific aerobic and strength training activities. Men hunted between 2 and 4 days a week, during which there was a more vigorous expenditure of energy and women gathered every 2 to 3 days. “The best available estimates of energy expenditure as physical activity for humans (males and females averaged) living in the late Paleolithic era, say 25 000 years ago, center approximately 5.4 MJ (1240 kcal)/d or near 91.3 kJ (21.8 kcal)/kg for a 57-kg composite individual[2]”(Eaton, 2003, p154). The energy expenditure of contemporary Americans is estimated at, “2.3 MJ (555 kcal)/d or 36.4 kJ (8.7 kcal)/kg for a hypothetical 64-kg male/female”(Eaton, 2003, p154). That reflects more than an estimated 50% decrease in energy expenditure.

Modern lifestyles of individuals in industrial technological societies are remarkably more sedentary than the lives of hunter-gatherers. With the electrification of society, the acquisition of food became less directly connected to physical expenditure of energy. “Through nearly all of human evolution, physical exercise and food procurement were inextricably linked”(Booth, 2002, p 402). But, in technological industrial societies with refrigeration and an industrialized food system, “Physical activity is no longer a requirement for daily living; the relationship between eating and physical work has been abrogated" (Eaton, 2003, p154). The effect that refrigeration of food can have on obesity is that, "refrigerators greatly increase the availability of rich and/or refined foods, and especially of meat and milk derivatives, whose high-fat variants are now known to cause all forms of civilization diseases"(Gracia, 2010. p615). In summary, with the invention of the electric motor, there was "a dramatic shift from muscular work to skill-based tasks such as the use or maintenance of electric appliances"(Gracia, 2010, p615).

The effect of decreased physical activity in technological industrial societies on chronic disease is the role that exercise plays in gene expression. "In a sense, physical inactivity is analogous to a loss of function resulting from a silencing of a gene, except that the missing element is not the gene but the environmental interaction of physical activity with the gene"(Booth, 2002, p 399). In a paper discussing the, 'physiological regulation of the human genome through physical activity', researchers discuss the effects of exercise on the muscular-skeletal, cardiovascular and endocrine system. "Although trained athletes retain the relative muscle mass of early humans (at least until competitions are over), modern humans are characterized by a 'striking sarcopenia'"(Booth, 2002, p400). Sarcopenia is a decrease in muscle mass commonly associated with aging in modern society.

In a paper titled, physiological and health implications of a sedentary lifestyle, researchers write, "One of the demonstrated effects of sedentary behavior is metabolic dysfunction, characterized by increased plasma triglyceride levels, decreased levels of high-density lipoprotein (HDL) cholesterol, and decreased insulin sensitivity"(Tremblay, 2010, p430). There is also a decreased bone mineral density for individuals who lead more sedentary lives(Tremblay, 2010). By living lives associated with greater comfort and ease of access to the necessities of life, there is less physical stress put on the body, and without this stress, certain genes can't be activated to increase the strength of muscles and bones, the cardiovascular and the endocrine system. This theme, that certain environmental and lifestyle stressors are necessary for proper development, is characteristic of many of the diseases of civilization.

ON EDIBLE FOREST GARDENING:

Modern American culture is responsible for the rise of type 2 diabetes., But, there are cultural shifts that could potentially decrease the risk factors for type 2 diabetes. The field of edible forest gardening may hold answers to the lifestyle-mediated risk factors for type 2 diabetes, addressing obesity and activity levels through potential dietary and exercise changes, fostering a modern living environment more suitable to our genetic ancestry.

In the 1940's, Robert Hart, a horticulturist in England, began experimenting with forest gardens of perennial food crops for temperate climates. He created a .12 acre edible forest garden comprised of apple trees, pear trees, currants, gooseberries, perennial vegetables and herbs, mimicking the relationships between niches of plants in transitionary woodland ecosystems (Jacke, 2005). From his initial work and publications, he inspired a modern movement in edible forest gardening as a means of sustainable agriculture, and is considered the father of temperate climate forest gardening. In the words of Robert Hart, "The forest is a vast and infinitely varied resource that should be developed for the sake of humanity, not in an exploitative but sustainable way." Forest gardens, according to Hart, "make it possible to grow not only an abundance of nourishing foods and beverages, but also medicines, fuels, fibers, timbers oils resins…"(Hart, 1997, p11).

Robert Hart may or may have not been aware that the idea of mimicking ecosystem structures in the design of a food producing garden was not original. The Maya, destroyed by genocide and disease, cultivated edible forest gardens for thousands of years before they were conquered. "When the Spanish arrived in Mesoamerica in the 16th century, they encountered the Maya living in villages filled with trees. The account of the Spanish priest Diego da Landa (1566) describes the Maya homes surrounded by diversity of tree species used for daily household needs: forest gardens"(Ross, 2011, p 75). The gardens contained food plants, medicinal plants and plants for spiritual use, for which the Maya practiced species selection for a period of over 3000 years. (Ross, 2011) "The diversity of life forms among the forest garden tree species indicates that the gardens mimicked the structure of the natural forest, utilizing all levels of the canopy"(Ross, 2011, p 75). Since that time, the Maya civilization has been destroyed, but the forests of Meso-America have been permanently altered, to a degree, by their practices.

There is also evidence of other forest gardens throughout the world. In Morocco, there is a forest garden, which is still in use today, claimed to be over 2000 years old, in an oasis below the Grissafane Mountian range (Lawton, 2008). This forest garden is approximately 3 km in length and contains a diversity of banana trees, date palms, olives, figs, pomegranates, carob trees and citrus trees, organized in a manner mimicking a natural forest ecosystem. According to Lawton, there are remnants of forest gardens in desert oases from northern Africa to central Asia, many which are threatened by modernization and industrialization occurring in these countries. The four main products of an edible forest garden are fruits, nuts, tubers and leafy green vegetables(Whitefield, 1997). Compared to the agriculture of industrial technological societies which produces a large percentage of grains to other food sources, the output of a forest garden is more similar in nature to the diet of pre-agricultural hunter and gatherers. The difference between the food supply of hunter-gatherers to that of forest gardeners is less the composition of the diet than the availability of the foods. Forest gardeners have control over the characteristics and location of the plants. Some plant characteristics that can be selected for can include productivity, flavor, hardiness and disease resistance.

Factors that limit the consumption of fresh fruits and vegetables in modern day America include cost, and "the propensity to purchase and consume food away from the home"(Richards, 2003,p2). , as seen through a public health survey of five states. (Richards) According to Richards, "Quality appears to have had no effect on the demand for either fruits or vegetables in the U.S."(Richards, 2003, p20). With forest gardens, for the home gardener, the factor of cost of fresh produce can be addressed. Once fruit trees and perennial vegetables are planted, they can continue to produce fresh food for many years, paying themselves back and more.

Asparagus for example, is a perennial vegetable with good potential for forest gardening. Crowns can be planted at an initial upfront cost of 12 dollars for a pack of 10 crowns (starkbros.com), and each crown can produce a plant which lives for upwards of twenty years, producing between 2 and 3 pounds of asparagus per year. That totals between 20 and 30 pounds a year, and over a twenty year period, between 400 and 900 pounds of asparagus.(asparagus-lover.com) Asparagus costs approximately 3 dollars a pound at the grocery store, so for an initial upfront cost of twelve dollars, one can save a potential $1,192-$2,692, if they were to eat the same amount of asparagus from the grocery store over that time period. The asparagus picked from home will also be fresher and sweeter because asparagus has a high natural sugar content, which within hours after picking is converted into starch(Moyer, 2012).

Another cost/benefit ratio can be assessed with a pear tree. A 3 to 4 foot Bartlett pear tree can be purchased from an online supplier for $13, shipping and handling included,(willisorchards.com).Bartlett pears have few pest problems, so they require little to no expenditure on pesticides or insecticides over the course of their lives. After five to six years of initial growth the estimated productive life of a Bartlett pear tree is 30 years, and at maturity under optimal conditions they can produce upwards of 100 lbs of fruit per year. (2010 Washington state university extension fact sheet). Assuming half of optimal production, 50 lbs of fruit a year for 30 years, the total production is 1,500 pounds of pears, for a twelve dollar initial cost. $2,988 can be saved over the thirty year time period if the same amount of pears were to be purchased from the store at $2 per pound.

These cost/benefit analyses presented above are primarily applicable to landowning individuals who have arable land which they are not currently using for food production. Across America, there is suburban lawn space that could potentially be supplemented with the establishment of edible forest gardens. Not everyone has access to their own arable land, however, and in particular, not everyone who is affected by type 2 diabetes. In a study looking at the association between socioeconomic status and type 2 diabetes prevalence, it was found that among African American women and White women, the poverty income ratio, PIR was associated with type 2 diabetes such that individuals with lower socioeconomic status have higher a prevalence of type 2 diabetes (Robbins, 2001). Individuals with lower socioeconomic status are less likely to have access to arable land.

In addition to private land, there are also public spaces such as community gardens and public parks where forest gardens may be applicable. An example of this is a seven acre public park in Seattle Washington, where an 'edible food forest' is being established, as started in 2012 . When the plants mature and produce food, the edibles will be available to all who walk through the park when they are ripe. A public edible forest garden may seem like an affront to a capitalist economy, marked to fail by 'the tragedy of the commons,' but picking all the fruits from a tree does not deplete a trees health in the way that overgrazing a piece of land with livestock decreases a piece of lands health, as the argument for the privatization of land in defense of individual property rights has been made in the past (Lloyd, 1832). As long as individuals are not actively destructive towards the plants in a forest garden, the health of the forest garden is unlikely to decrease over time.

Instead of trying to fit forest gardening into the current economic system as a market alongside organic agriculture and conventional farming, edible forest gardens may have their own niche as a personal and community endeavor. However, even with public parks, unanswered questions remain about the availability of the fresh foods to individuals in densely populated urban areas. It does raise the question of whether access to healthy food should be a human right, or at least something that we actively work towards as communities? Potentially, public forest gardens could serve as plant libraries for towns, from which home gardeners could propagate plants if they have land and the desire to do so. As plants provide the means for their own propagation, the spread of forest gardens hypothetically does not need to enter into a market economy. According to the Land Institute, “Nearly all of nature's land-based ecosystems feature perennial plants grown in diverse mixtures. Natural ecosystems, in general, use and manage water and nutrients most efficiently and build and maintain soils”(landinstitute.org). The plants of a forest garden can be classified into 7 niches of an ecosystem. These niches include a canopy layer of fruit and nut trees, a dwarf fruit tree layer, a shrub layer for fruits and berries, an herbaceous layer of perennial vegetables, a rhizosphere layer of root vegetables, a soil surface level of groundcovers and prostrate herbs and a vertical layer of climbing vines, growing up the trunks of the canopy and dwarf tree layer(Burnett, 2006). Forest gardens are comprised largely of perennial plants, which aren’t reseeded annually. According to David Jacke, author of Edible Forest Gardening, edible forest gardens work towards the “practical goals of a high, diverse yield of food and other products,” but they also contribute to, “a self-renewing, self-fertilizing, self-maintaining garden; and healthy ecosystem function”(Jacke, 2005). They “combine conservation of the environment with methods to produce the basic necessities of life”(Hart, 1997, p12).

From a public health perspective, forest gardens may have a lot to offer. The potential effect on the diet of this food production model could be that more fruits, nuts, tubers and leafy greens are eaten, and a lower percentage of refined grains. Forest gardens are not the only answer to an increase in fresh produce consumption however. There are also legislative solutions related to an increase in produce grown for fresh fruit and vegetable consumption. In 2011, the top three crops produced in the

US were corn at 12.4 billion bushels, soybeans at 3.06 billion bushels and wheat at 2 billion bushels.(USDA Crop Production Summary 2011). While a significant portion of this went to animal feed, the old addage, 'you are what you eat' should maybe be followed by, 'and you eat what you grow'. Corn alone was planted on 91,921,000 acres. Comparatively, the total acreage of fresh vegetable production in the US in 2011 was 1,795,350 acres. Of the vegetables produced, the three main ones were onions at 3.3 billion metric tons, head lettuce at 2.2 billion metric tons and watermelons at 1.7 billion metric tons.(USDA Vegetable Summary 2011) An increase in conventional fruit and vegetable production and consumption could curb the increasing rates of type 2 diabetes.

Another movement which has potential to help diabetes rates and public health is the 'locavore' movement, gaining traction over the past 10 years in the United States. Locavorism is a movement emphasizing eating foods grown within an approximately 100 mile radius of their homes, consciously recognizing the carbon footprint associated with the production and transport of food. The potential benefit of locavorism in addressing type 2 diabetes could be the quality associated with foods locally grown, which can be grown with flavor in mind as opposed to transport resilience (NOFA NY). The higher quality of the produce could potentially influence people to consume greater amounts, budget dependently. The average distance of foods from farm to plate in US supermarkets is currently 1,500 miles.

The great expanses of green grass across suburban America could be atransformed into personal home edible forest gardens and from these gardens, the quality of the fruits and vegetables may even be better than what is currently available in grocery stores. While grocery stores may select fruits and vegetables to sell based on appearance or storage ability, the home gardener can focus on flavor, nutrition or a decreased use of pesticides in species selection. Need to talk about social class here and what would urban folks or rural poor folks do with no access to land? Would there be public food forests? If so who would get the food? Agreed. An urban garden substitute for instance – using less land in a more intensive fashion.

There are many edible fruits and vegetables that have escaped marketing in grocery stores which have potential for the home forest gardener, including perennial plants such as groundnut (Apios Americana,not to be confused with the peanut) and Jerusalem artichoke which cannot be easily mechanically harvested, and fruit trees such as American persimmons and paw paws which do not ship well without bruising. Looking at the public health potential of the vegetable groundnut, a study was done assessing the effects of a dietary intervention with groundnut on hypertension and plasma lipid levels in hypertensive rats. Groundnut is a member of the legume family, commonly eaten by Native Americans in pre-colonial and colonial times, a root vegetable which can be cooked similar to a potato. Compared to a potato, the groundnut has 14.7% crude protein content (Iwai, 2007). Potatoes have between 7.5%-8.4% protein content (Bartova, 2009). In the dietary study assessing the effects of groundnut on hypertensive rats, after a three week intervention, there was a decrease in blood pressure and plasma total cholesterol. The researchers hypothesized the effects of the groundnut were due to proline-rich peptides within the plant (Iwai, 2007). According to the organization, Plants For a Future, the groundnut is among the top twenty edible plants to be reintroduced into modern food consumption.

Another vegetable which can potentially provide health benefits to type 2 diabetics from a forest garden model is that of the Jerusalem artichoke. The Jerusalem artichoke is a tuberous vegetable related to the sunflower, which can grow vigorously under many conditions. Jerusalem artichokes are noted for having a high inulin content (Panchev, 2007). Inulin is a dietary fiber known as a fructan, a fructose polysacharride, as compared to starch, a glucose polysaccharide. The dietary benefits of inulin include pre-biotic activity, providing nourishment for pro-biotic bacteria through fermentation in the gut, promoting the growth of beneficial bifidobacteria and lactic acid bacteria(Roberfroid, 2007), increasing in absorption of minerals through the gut, namely calcium, and decreasing the synthesis of triglycerides and fatty acids by the liver(Kaur, 2002). As directly related to type 2 diabetes, "These fructans modulate the hormonal level of insulin and glucagon, thereby regulating carbohydrate and lipid metabolism by lowering the blood glucose levels"(Kaur, 2002). This was shown through an intervention study in rats, where fructans were made 10% of the diet for thirty days. The result was a 26% decrease in insulinemia in diabetic rats (Oku, 1984). Jerusalem artichoke is another plant that was commonly eaten by Native Americans which has decreased in availability in present times. This decrease is not necessarily due to a lack of quality of a plant as a food source. Jerusalem artichokes sell for 7 dollars a pound at specialty food stores (Willimantic Co-op). Rather, plants like Jerusalem artichokes and groundnuts lack compatibility with our industrialized food system in its present state. Both require selective harvesting, and cannot be annually, uniformly, mechanically harvested if they are to produce the following year. However in a home garden, where manual labor is the major source of work input, tubers can be selectively harvested by hand.

Forest garden based societies can differ from traditional agricultural based societies in the difference of the relationship between humans and their food sources and the difference in relationship between the food sources and the natural ecosystem. In a forest garden, people become "designers and managers more than hard laborers" (Jacke, 2005). The system maintains the resilience of a natural ecosystem while adopting the anthropocentricity of agriculture. The forest garden integrates the necessities for human life into the ecosystem in a sustainable, co-evolutionary way(Jacke, 2005).

The effect that a forest garden based society could potentially have on activity levels of people corresponds with the activity levels that are required to maintain them. In order for a forest garden society to operate efficiently, as opposed to modern agriculture, the separation between farmland and land for houses and dwellings would be less defined, and the separation between food producers and other professionals less defined as well. Trees planted in a suburban setting could be food producing trees and the owners of the property could care for them and reap their benefits. Similar to the mixed, cross-training exercise discussed for the hunter-gatherer lifestyle, activities involved in care of a forest garden would include a mix of activities of varying strenuousness. Some initial activities would include removing and moving brush and invasive species, digging holes with shovels, altering the landscape with stones and other objects, moving dirt and compost in wheelbarrows, raking, and climbing trees, as desired. Further activities would include harvesting, pruning and managing the growth of species to ones liking. In a study looking at the effects of the presence of gardens on the activity levels of individuals, researchers found that, in California, the presence of school gardens increased physical activity levels (Pasala, 2010).

The establishment of forest gardens could help re-establish the 'outdoors' as a living space and food-producing space, which has largely been lost with the electrification of society making the refrigerator the main source of food.

Following the work of Robert Hart, Bill Mollison, born in 1928 in Australia, a researcher, teacher and naturalist developed a framework and language for discussing the ecological design of human agricultural and societal models mimicking the themes and patterns of natural ecosystems, as is present in edible forest gardens. The name he gave for his and David Holmgren's design theory was 'Permaculture'. The design theory of permaculture encompasses principles found in nature and provides the groundwork and justification for the efficacy of forest gardening as a design solution and model for sustainable agriculture. Some of the principles of permaculture include the promotion of closed loop systems which buffer themselves through negative feedback, the value of diversity for the resilience of a system and the utilization of outputs from one part of a system as inputs for another, where the system as a whole creates no waste.(Mollison, 1995). The design theory of Permaculture is founded on three ethics, 'care for people', 'care for the earth' and 'fair share'.

The lack of prevalence of forest gardens in our present age makes it difficult to research the comparative outputs of forest garden models compared to modern industrial agriculture. It is difficult to answer the question of, how many calories can be produced in a year using the two different methods of agriculture, on the same size plot of land? It is possible that in a one year period the caloric output of a conventional agriculture model exceeds that of a forest garden of comparable size. However when both the inputs and outputs of both systems are summed and compared in that one year period, and more-so, over a one-hundred or one-thousand year time period, the net productivity of a forest garden is likely to exceed that of its industrial agricultural counterpart in the long term, in the face of pending decreasing fossil fuel supplies and soil degradation from traditional agriculture over time(Mollison, 1995). But, the two modes of agriculture don't necessarily need to compete for space. While traditional agriculture requires land that is reasonably flat and free of rocks, known as 'tillable land', forest gardens do not require machine operation, so less desirable farmland can be used. If nothing else, forest gardens could serve as a supplemental food source, increasing the resilience of our food system, while helping us address the epidemic of type 2 diabetes (landinstitute.org).

CONCLUSION:

From hunter-gatherer societies to present day America, humans have undergone a drastic change in diet and lifestyle. Accompanying this change, exacerbated especially over the last thirty years by the increased separation between modern living environments and human genetics, type 2 diabetes has increased in prevalence as well as the condition of obesity. Their prevalence, marked by a considerable lifestyle risk factor component of high fat, high GI diet and lack of exercise, is potentially controllable. By establishing edible forest gardens, food production models can better mirror the food consumption of our hunter-gather ancestors. The lower GI nature of these foods can potentially lower obesity levels, and specific nutrients such as inulin can confer protection against diabetes type 2. The work involved in the establishment and maintenance of edible forest gardens can contribute to increased activity levels and the re-establishment of the outdoors as a living space and food producing space.

Two things standing in the way of the establishment of forest gardens in 21st century America are the appreciation that this is a possible direction for American culture, and the understanding that individuals and communities have the power to work towards public health in local ways which combined with the local efforts of millions of people around the world, can change the behavior and health outcomes of civilization at large.

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