Cattle, Cadaster, & Conflict:

Colonial Growth and Social Conflict During King Philip's War

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Abstract

Property rights are secure and violence can be avoided when the treatment and delineation of land are consistent, stable, and salient to each party. However, it is possible for each party to have a fundamentally different understanding about ownership over the same tract of land. How are divergent conceptions of ownership strained when one party (or group) is perceived as asymmetrically and rapidly accumulating property at another's expense? Adapting Baker's model of contest-success functions, I examine the relationship between English settlement growth and the likelihood of conflict in 17th century colonial New England. Colonial growth halted when conflict erupted with surrounding Algonquian tribes during King Philip's War in 1676. One of the factors that spurred conflict was the perception (by Metacomet and the Wampanoag) of unanticipated, unchecked colonial growth. I use probate data covering 56 settlements in colonial New England to measure the growth of farmers as a proxy for territorial growth. After accounting for initial settlement size, English townships that doubled in farmer population were 10% more likely to be damaged or destroyed during the conflict.

JEL: D23, D74, N41, O1, Q34, R14

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Institutions such as norms and rules define property rights and resolve property conflicts. They also reduce the likelihood and severity of violence over land. These institutions have been relegated to formal states (Acemoglu & Robinson, 2019; Johnson & Koyama, 2017; and Dinecco & Katz, 2016) or stateless channels of resolution (Candela & Geloso, 2020). The violence-reducing characteristics of these institutions include: 1) defining property rights over space and time, 2) adjudicating contests over property, and 3) enforcing those resolutions after adjudication. Areas with little to no formal state institutions, such as the early colonial period in North America between European settlers and Algonquian Indians, mostly relied on the first characteristic. During the proceeding period of rapid colonial expansion during the mid-17th century, the mutually perceived definitions of land use between settlers and Algonquians changed. Rapid colonial population growth and expansion after the arrival of the *Mayflower* in New England made the process of defining and redefining property rights between Algonquian tribes and English settlers costly through peaceful means. The sharp change in relative growth (between the English and Algonquians) lowered the cost of violence compared to other, less violent appeals to trade or negotiation.

This paper examines how rapid population growth relates to the likelihood and severity of violent conflict in areas without clearly defined property rights and areas without a mutually-agreed regime to resolve conflict over land. How did colonial expansion in New England confound the treatment of property rights between settlers and Algonquians? Did rapid colonial expansion in New England mitigate or exacerbate conflict?

What was the relationship between early colonial expansion and the likelihood of conflict with Algonquians during King Philip's War?

The type of institution used to address and resolve potential conflict over land impacted the likelihood and severity of violence in colonial North America. The French colonial experience with Acadians and Mikmaqs in North America saw little to no conflict. The rules of collective decision-making for settling land disputes favored consensus and greatly reduced the returns to conflict (Candela & Geloso, 2020). All parties had to come to a collective agreement which eschewed the formation of special interests who could potentially benefit from fighting, thus spilling the external costs of collateral damage onto the rest of the population.

Initial settlements and competing interests over natural resources, such as the beaver, constrained the types of institutions that emerged in Canadian North America. European settlements around Hudson Bay had competing interests and varying property rights institutions. Native Americans in Fort Albany and York Factory faced competition in the beaver fur trade from the French (Carlos & Lewis 1993, 1999, 2001). Hudson Bay Company managers increased the price of furs in those areas which led to more Native Americans to enter the market and deplete the beaver population more quickly. Fort Churchill did not face the same level of competition in the supply of beaver pelt. Prices for furs in that region were more stable, and the beaver population was not depleted as quickly (ibid).

Both colonial episodes in French Acadia and the Hudson Bay Company demon-

strate how initial settlements, endowments, and incentives impacted the evolution of institutions that helped define property rights and resolve property conflicts. The types of institutions that evolved had varying success at mitigating violent conflict over land and managing natural resources. The colonial New England experience was characterized by an inchoate delineation of land use. New England also had higher colonist population growth in close proximity to Native Americans. In contrast to the French Acadia experience, colonial New England did not have an institution to resolve property conflict. New England also had a faster increase in settler population.

Recent empirical economic literature has looked at the reverse relationship between land conflict and contract choice in a modern context. Lee Alston and Bernardo Mueller (2010) analyze how land conflict and initial property endowments impact subsequent contract choice in Brazil. They use the extent of Catholic Church presence - measured by the number of priests - as an instrument for identifying the presence of farms without an official title. Their research looks at the impact of conflict on subsequent contract choice and the type of tenancy arrangement chosen. Similarly, Conning and Robinson (2007) examine how property insecurity impacts the type of agricultural organization selected among competing claimants. They use a model of potential land reform to demonstrate how an agent's expectations of property insecurity, instigated by the likelihood of land reform, are likely to modify their current choice of contract. Both papers measure the impact of property insecurity on subsequent contract choice.

After Jamestown was founded in 1607, early English settlements arose in the

colonies of Plymouth and Massachusetts Bay. Pilgrims and later Puritan settlers - separatists of the Church of England - left Holland and England to escape religious-conformity restrictions imposed by the state religion of their home country. Disheartened by religious persecution, they wished to preserve their English identity and brought with them their own form of self-governance and legal framework (Winslow, 1646). The attitude of European colonizers towards *terra nullius* ("land with no owners") was varied (Pagden, 2015) and more ambiguous than their Dutch and French counterparts. The land had to be tilled, sown, harvested, or grazed. A legal justification for agricultural development (a more land-intensive mode of food production) as well as a formal expression of property rights for English settlers in the Americas had been established.

The area of land spanning the coastline of Maine to Long Island Sound included many Algonquian peoples from the Massachusett around Massachusetts Bay, to the Wampanoag around Cape Cod Bay, and the Narragansett to the west in modern day Rhode Island (Washburn, 1989). Over the course of the 17th century, English settlers established various diplomatic, commercial, and religious connections with surrounding tribes, sachems (male leaders), and sunk-squaws (female leaders with great authority). Settlers and Natives conversed, intermarried, and formed treaties (Schultz, 1999 and Warren, 2018).

They also exchanged goods and land. As the children and grand-children of England's first "Great Migration" came of age, by 1670 the English population burgeoned to over 60,000 people, almost double the Native New England population (Silverman,

2019). The population boom was not the direct source of conflict; nor was conflict *prior hoc* inevitable. Early interactions between Algonquians and the English (1620-1670) were pacific. What sparked tensions and, later, violent conflict was the rapid rise of English pastures and farms for husbandry - a dramatic increase in the demand for land. English settlers attempted to purchase land through various exchanges like manufactured goods or wampum, a string of beads used by Algonquian tribes as a form of currency (Brooks, 2018; Schultz, 1999). These trades often took a strategic tone in the greater context of internecine power relations among European powers and rival Algonquian tribes (ibid). The source of conflict resulted from poorly defined property rights - the perceived encroachment or illegitimate purchase of land between English settlers and the Wampanoag, Narragansett, and Nipmuck.

From the perspective of English settlers, an open expanse of land, a significantly depopulated Algonquian territory devastated by disease prior to the arrival of the English (Steckel et. al., 2002), and initial comity with the Wampanoag made the subject of contract choice relatively simple. Under consent and charter from the Crown[1], most English requests for land were made through purchase (Pagden, 2015 and Roback, 1992). Challenges over occupancy with surrounding Native American tribes were generally met through treaty, gift, or exchange[2]. However, poorly defined property rights, ambiguous land-use arrangements between English settlers and Algonquian tribes, and rapid growth

[1]Sovereignty is not the same as individual right to property.

[2]Since their arrival, English settlers treated native land as *de facto* sovereign territory of American Indians. It would not be until the Treaty of Paris when the Royal Proclamation of 1763 formally ceded *de iure* autonomy to "several Nations or Tribes of Indians".

in settler population and land-intensive animal husbandry set the stage for one of the most devastating conflicts between the English and Algonquians in the Americas.

1 Historical Background

The Wampanoag, Narragansett, and Nipmuck settled in-land, away from the coastlines, and also along well-protected rivers and marshes (Washburn, 1989). Algonquian tribes had a deep knowledge of the terrain and exposed points of attack along coastlines where English colonists predominately settled. Generally, Algonquian forces were mobile and used their knowledge of the land to their advantage while the English typically fought in fixed points of defense near their settlements (Schultz, 1999).

The introduction of livestock, expansion of land-intensive agriculture, and rapid settlement growth characterized early colonial development in New England. Four years after the arrival of the *Mayflower* in 1620, Edward Winslow, one of the early Pilgrim Fathers, brought from England "three heifers and a bull, the first of any cattle of that kind in the land" (Anderson, 1994, p. 602). The task of improving the land was met as a general measurement of their prosperity. By 1627, Plymouth Colony had accumulated - either through husbandry or import - up to "fifteen animals, whose muscle power increased agricultural productivity" (Anderson, 1979 & PARP). In order to accommodate this land-intensive form of agriculture, Plymouth began expanding its borders beyond the boundaries of the compact village first established at the time of the first Thanksgiving. They traded

manufactures and agricultural products with Massasoit, sachem of the Wampanoag and father of Metacomet, in exchange for more land.

The most lethal (and politically potent) of these manufactured goods were matchlock and flintlock firearms. The proliferation of guns was initially spurred by early colonizers (Silverman, 2016). Colonial governments were late to enforce the arms trade; and even when they began imposing restrictions on the movement of guns, black markets rose. The arms build up - predominantly spurred by Dutch, French, and English arms traders - revolutionized warfare for the Wampanoag. Metacomet, who the English called King Philip, saw the colonies as attempting to drive them off their land. Exacerbating tribal agitation, colonial governments banned the arms trade entirely and began confiscating arms from the Wampanoag (Lepore, 1998 and Silverman, 2016). The confiscation of arms and the perception of conquest came at a time of increased tensions between English colonists and the Wampanoag, Nipmuck, and Narragansett[3]. John Sassamon, a Wampanoag raised by an English family, was a mediator with significant influence in both societies. Harvard educated and a convert to Christianity, he also served as an advisor to Metacomet and was in the best position to ease the rising tensions. It was not until Sassamon was found dead in Assawompset Swamp in the winter of 1676 when conflict erupted. While the nature of Sassamon's death has never been confirmed, three of Metacomet's closest advisors were arrested, tried, and executed by Plymouth colonists for Sassamon's murder later that

[3]The Narragansett remained neutral at the outset of King Philip's War and entered the conflict after peace negotiations with New England militias broke down.

summer (ibid). Metacomet understood the colonists' summary judgement and execution as a threat. It meant the Wampanoag were a subject people and beholden to a foreign form of justice (Silverman, 2016). King Philip's War had begun.

2 Theory

Disagreements over land-use can either be resolved by jointly defining property rights in which both parties come to resolution; or the dispute could lead to violent conflict. In a setting with unclear property rights and no mutually-agreed authority to resolve disagreements over land-use, the likelihood of conflict is determined by the returns and costs to fighting. (See Figure 1). Returns to fighting over land are equal to the net present value of the land, natural resources, and strategic importance[4], R_F, less the cost of fighting, C_F.

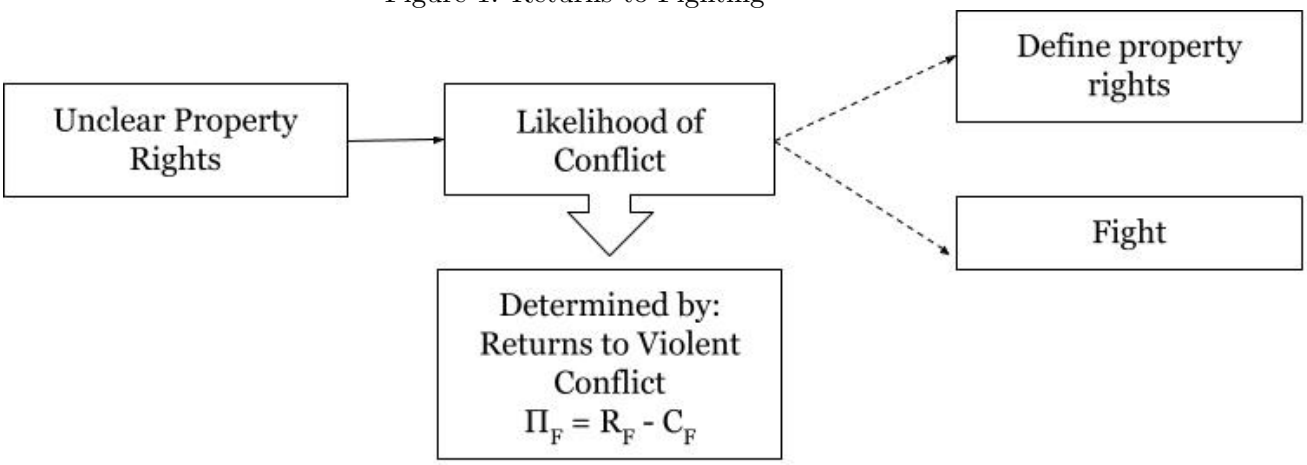
$$\Pi_F = R_F - C_F$$

Determinants for the cost of fighting in this historical context include the relative size of each population and relative level of technology (both in terms of weaponry and knowledge of the terrain). The relative values of each of those components are assumed to have constant returns to scale with respect to the cost of fighting such that $\alpha + \beta = 1$ and:

$$C_F = \left[\frac{N_{Colonists}}{N_{Algon}}\right]^{\alpha} \left[\frac{A_{Colonists}}{A_{Algon}}\right]^{\beta}$$

[4]For the purposes of the paper, the value of land is considered constant over time.

Figure 1: Returns to Fighting



Where N is population and A is military technology. Assuming the relative technologies of each group stays the same and the population of American Indians holds constant over time, the change in the cost of fighting will mostly be determined by the change in the population of colonists such that:

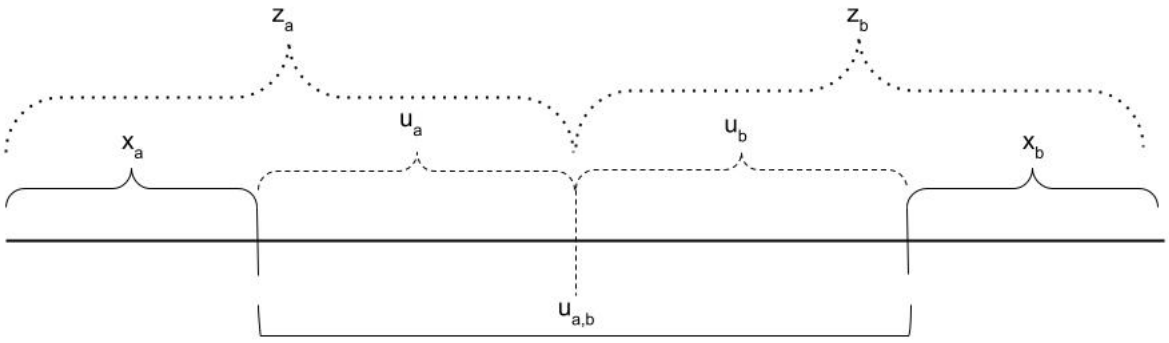
$$\frac{\delta N_{Colonists}}{\delta N_{Algon}} > 1$$

This framework assumes the likelihood of conflict has a direct relationship with the relative cost of fighting. All else constant, including the returns to fighting, did the relative change in growth of the English settler population result in a lower cost to fighting?

Hunter-Gatherer Land Tenure Model

In order to model the stylized facts of rapid colonial expansion and subsequent

Figure 2: Depiction of Land Tenure and Conflict



conflict with surrounding Algonquian tribes, I rely on Baker's model of land tenure and conflict for hunter-gatherer societies (2003). Baker makes general assumptions about ecological parameters, resource density, resource predictability (the change in harvest of game or crops over time), and situational ownership to develop a contest-success function that models predictions about ownership changes, investment in defensive technologies, and land tenure regimes (2003).

The adapted contest-success model is laid out as follows:

1. Fixed amount of land, z
    - Each player, a and b, is endowed a certain amount of land, z_a and z_b, respectively
    - The two players exhaustively lay claim to all contested land such that $z = z_a + z_b$
    - Average density of resources
    - Each fixed unit of land yields a predictable output
2. Each player has an assigned production technology and preferred value of the land
3. Players decide how much land to defend, x_i

4. Any uncertainty with respect to how much land x_i is apportioned to whom is due to undefined or unrecognized property rights
5. Each player invests in defensive, d_i, & offensive, g_i, capabilities
6. Groups observe the amount and quality of land the other groups have defended as well as their defensive investments
    - Groups make intrusive/offensive investments to gain access to undefended, u_i, and then defended, d_i, territories of the other group
7. Simultaneous intrusive investments on land left undefended
8. Groups receive payoffs according to the outcomes of the interaction between each group's offensive and defensive investments. Random variables related to the resource level are realized. The model allows for entry and exit after the first round of play.

Figure 2 illustrates the relationships between these variables - endowment z_i, defended land x_i, undefended land u_i, as well as defensive investment d_i and intrusive investment g_i. Each player elects to defend some subsection of their endowed parcel of land, $x < z$. A marginal cost attributable to defensive and intrusive capabilities such as weapon technology, "fighting ability, policing, marking boundaries [cadaster], and negotiation" is assumed to be constant and identical for both groups, c (ibid.).

Putting all of these pieces together, the share of endowed land that defending groups choose to defend (x_i) - indicative of the relative cost of fighting for group i - is

given by:

$$f_i(d_i, g_j) = \frac{1}{1 + (\phi g_j / d_i)}, \quad i = a, b;\ j = b, a. \tag{1}$$

Where $\phi \in (0, 1)$ is a constant parameter of the relative strength of j's offensive capability relative to i's defensive capability. Specifically, I am estimating the relationship between colonial population growth g_j on the cost of fighting $f_i(d_i, g_j)$ which is proxied as the likelihood and severity of conflict in a colonial settlement.

A settlement with a larger initial defended territory, x_i (or initial settlement), requires a lower subsequent population growth rate to induce conflict. I later test this relationship controlling for initial settlement size. The value of the land being defended may be more intersubjective and dependent on the perceptions held by Algonquian tribes and English settlements. The initial settlement size is also subject to intergenerational perceptions across both groups of people. In conjunction with the narrative summary in Appendix A, (see "Interactions Prior to King Philip's War" Table in Appendix A), I relay various sources of interactions prior to conflict that either exacerbated or dampened the relationship between colonial growth and the likelihood of conflict.

3 Macro Analysis

From the perspective of Algonquian tribe, i, the model describes how changes in a nearby[5] English settler population, g_j, impacts the cost of fighting, $f(\cdot)$ (Equation 1) as observed

[5] Within z distance from i

through the likelihood of fighting. An increase in g_j, all else constant, would decrease the cost (and increase the likelihood) of fighting. In an attempt to measure the magnitude of the expansion, I examine the relationship between the rate of colonial expansion and the likelihood of conflict at the township level. I first quantify the magnitude of early colonial expansion across all settlements in colonial New England and identify whether that township was damaged or destroyed during King Philip's War. I projected estimates of the likelihood of conflict using a logistic *LOGIT* regression which is typically used for identifying the relationship of a binary outcome variable - the probability of a town being damaged or destroyed. Descriptions of the models, data, and results are below.

Models

A first-best measurement of colonial expansion would be the change in land area of each township over the preceding decades. Growth in settlement area would propagate interaction between the English and surrounding tribes, and according to the contest-success function model's hypothesis, increase the likelihood of conflict. Unfortunately, data on cadastral [6] size and development for each township is not available at the macro level. Instead, I use the growth rate in the population of farmers since the decade of initial founding as a proxy for land growth over the same time period. The following model is used to illustrate the relationship between colonial expansion and the likelihood

[6]The formal surveying and public assignment of cadasters do not begin historically until later in the 17th century. Throughout this paper, I use the term "cadaster" simply as a publicly salient delineation of property.

of conflict:

$$(1) \quad Log(TownDamaged_i) = a + \beta_0 * FarmerGrowth_i * WGT_{InitFarmerPop_i} + \epsilon$$

Where and $WGT_{InitFarmerPop_i}$ is the population upon initial settlement.

Data

The data for farmer population and real estate value come from a sample of colonial New England probate records from 1620 to 1675 (Main, Main & Lindert, 2013). The universe covers all deceased individuals - including landowners and landless tenants - in southern New England over this time period. The probate data also include categories for each individual's occupation, value of real property, wealth [7], debt, age, and sample weight by age group [8].

The size of a township cadaster is a *stock* measurement of land; the number of deceased individuals reported in the probate is a *flow* measurement of the colonial population. To account for this discrepancy, I aggregated the farmer population[9] by decade.

The benefit of aggregating probate records by decade comes at the cost of fewer observations and less variation. Annualized growth rates had many gaps, were too variable, carried too much noise, and did not reasonably represent changes in the stock of colonized

[7] Wealth measurements include real property as well as other types of capital.

[8] The weight equals the inverse of the probability of selection for a deceased individual of a certain age group reported in the sample. For example, a deceased individual is more likely to be older than younger. The probability of a sample probate listing an older person is higher than a younger person.

[9] Each record represents a deceased individual. The farmer population of a given township equals the sum of the sample weights across all individuals listed as a farmer, artisan-farmer, or laborer. See: Occupational codes listed in the probate codebook.

land. The model assigns one decennial growth rate to each township, *i*. The decennial growth rates were computed using a straight-line approach:

$$Decennial\ Growth\ Rate\ =$$

$$\frac{1670\ to\ 1676\ Total - First\ Settlement\ Decade\ Total}{First\ Settlement\ Decade\ Total} * \frac{100}{Number\ of\ Decades}$$

I consider the measurement of farmer population to be more economically representative of land growth relative to real estate value. Seventeenth century frontier farming in the American Colonies is best described as a factor minimizing production function between land (capital) and labor: $F(K, N) = min[K, N]$. This type of production function treats land and labor as complements. It assumes that a given acre of land cannot yield more output (or be anymore productive) by substituting towards more labor. Given that assumption, any increase in agricultural production would need to be met with a one-to-one increase in *both* factors.

Figure 3 in Appendix A highlights in red or yellow each of the townships that were damaged or destroyed during King Philip's War. The source for township damage comes from a collection of accounts from the war portrayed in Figure 1, Appendix A (American History Online). For this analysis, I assigned a binary variable of 1 to any township that was either damaged or destroyed during the war. Although the map distinguishes between destroyed and damaged towns, the relative magnitude of destruction is unknown. I consider

any sign of war-related property damage as sufficient for indicating conflict. Figure 7 in Appendix A is a magnified map showing tribal settlements in yellow and "Indian praying towns" (Christian missions) in black.

Results

Table 1 shows the estimates and standard errors for models (1) through (5)[10]. The dependent variable of interest is a binary indicator of a town being damaged or destroyed during King Philip's War. A *LOGIT* model accounts for this binary relationship and bounds the predicted values to between zero and one. Model (5) is a logistic regression measuring the relationship between the population growth rate with the likelihood of the township being damaged or destroyed. Rewriting equation (5) with the parameters in column (5) of Table 1, the relationship between farmer population growth and the likelihood of conflict can be expressed:

$$P(TownDamaged_i) = \frac{1}{1 + e^{2.37 - 0.09 * GrowthRate_i}}$$

According to Model (5), a settlement that doubled in size over the period of initial settlement to 1670 was 10% more likely to be damaged or destroyed during King Philip's War. Townships with higher growth rates *decrease* the denominator which *increases* the probability of a town being damaged or destroyed. Future testing will include additional parameters such as other distances to the nearest tribal settlement, measures of resource value, and investment in defense.

[10] I had originally limited the analysis to Hampshire and Plymouth counties where the fighting occurred. Increasing the coverage to span all colonial New England townships dampened the effect but increased precision.

Table 1: Model Results

	Town Damaged				
	OLS				*Logistic*
	(1)	(2)	(3)	(4)	(5)
Farmer Growth	0.009**	0.008**	0.004	0.022**	0.091***
	(0.003)	(0.003)	(0.003)	(0.009)	(0.025)
Initial Farmer Population (Hundreds)		0.003	−0.001		
		(0.002)	(0.002)		
W/in 20 miles of Indian Settlement			0.532***		
			(0.102)		
Constant					−2.371***
					(0.147)
Observations	56	56	56	56	56
R^2	0.108	0.131	0.425	0.104	
Adjusted R^2	0.091	0.098	0.393	0.088	
Log Likelihood					-235.442
Akaike Inf. Crit.					474.884
Residual Std. Error	0.337 (df = 55)	0.336 (df = 54)	0.276 (df = 53)	1.118 (df = 55)	
F Statistic	6.636** (df = 1; 55)	4.053** (df = 2; 54)	13.067*** (df = 3; 53)	6.373** (df = 1; 55)	
Note:					*p<0.1; **p<0.05; ***p<0.01

4 Micro Analysis

The macro analysis suffers from an absence of data on the growth of land in English settlements, measured in terms of surface area (e.g. acres or hectares). In order to corroborate the magnitude of the growth rates observed in the macro analysis (which solely relied on the population of farmers that entered probate), I also looked at archaeological data on livestock (and pasture size) over the same time period for Plymouth township to see whether the growth in livestock reconciles with the proxy variables used in the macro analysis. Using United States Department of Agriculture (USDA) guidance on pasture size capacity, I imputed the total number of pasture acres required to accommodate the number of livestock reported in the archaeological site.

Plymouth Archaeological Rediscovery Project

Craig Chartier and other members of the Plymouth Archaeological Rediscovery Project used faunal analysis to catalogue and substantiate the number of cattle reported in select probate records across three sites within Plymouth township (Chartier, PARP). The faunal results reported in Figure 5 of Appendix A show the total stock of cattle for each decade. Ratios of other types of livestock relative to each cow were also confirmed in the archaeological analysis. I applied those ratios to the total stock of cattle to derive the total number of livestock for each decade. The total number of livestock and decennial growth rate in the number of livestock are reported in the last two columns of the lower table in Figure 5.

Pasture Size

Using the USDA formula, I then imputed the pasture size required to accommodate the livestock reported in Figure 5. The USDA formula is adapted for small-scale farm use and mixed operations including foraging and crop rotation (NRCS, USDA). These assumptions are more relevant for 17th century agriculture and English farming methods. I scaled down the average size of each animal (assuming scrawnier 17th century livestock) as well as reduced the utilization rate and average yield per acre to reflect a level of farm productivity that is closer to subsistence. For the purpose of this analysis, an accurate estimate of absolute land size is not as important as the decennial growth rate. The growth rate is entirely driven by the growth in cattle reported from archaeological evidence and the ratios of livestock weight.

The total number of acres required to house each type of livestock are reported by decade in Figure 6. The assumptions I made for average livestock weight, utilization rate, grazing days per year, and average yield per acre are listed on the top left. The pasture size imputations reported in Figure 6 are constructed using the USDA formula and total livestock figures reported in Figure 5. The decennial growth rate in pasture size for Plymouth township is reported in column 7 of Figure 6. The highlighted records in Figure 6 compare the decennial growth rates of the micro analysis to the growth in farmer population and real estate value reported for Plymouth derived from the probate records used in the macro analysis. The growth rates show a similar pattern: a rapid expansion

in 1630-1640, moderate growth in 1650-1660, followed by a decline resulting from King Philip's War in the later part of the 1670's.

5 Additional Tests and Future Research

- Research demography literature on population growth accounting with incomplete, lagged probate data
- Test colony/county-wide fixed effects, e.g. First settlement date during Republican Period?
- Replace map of conflict areas with Washburn Handbook of North American Indians. Other data sources for areas of conflict? Krech?
- Provide summary statistics of probate data
- Run revised LOGIT model and include PROBIT model.
- Collect ArcGIS information on soil fertility, amount of precipitation, and other time invariant geographical information on quality of land
- Consider instruments or other proxy variables for land growth / "potential for land confrontation"

6 Conclusion

Many factors contributed to the onset of King Philip's War: colonial expansion, disparate treatment of property, the proliferation of guns, inter-colonial and inter-tribal rivalries, and

- as is the case for every conflict - the failure of diplomacy. It was clear that property rights enforcement and the perception of justified expansion were not shared between English settlers and Algonquian tribes. But the absence of shared property enforcement does not inevitably lead to conflict.

Colonial growth in New England was very significant and geographically heterogenous in early to mid 17th century. Townships grew by as small as a factor of 2 to as high as a factor of 20. Threats such as weapons confiscation and perceived loss of land drove the Wampanoag and other Algonquian tribes to violence. After accounting for proximity to the nearest surrounding Algonquian tribal settlement, townships that grew more rapidly during the early stages of colonization were more likely to be targeted during the war.

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A Appendix

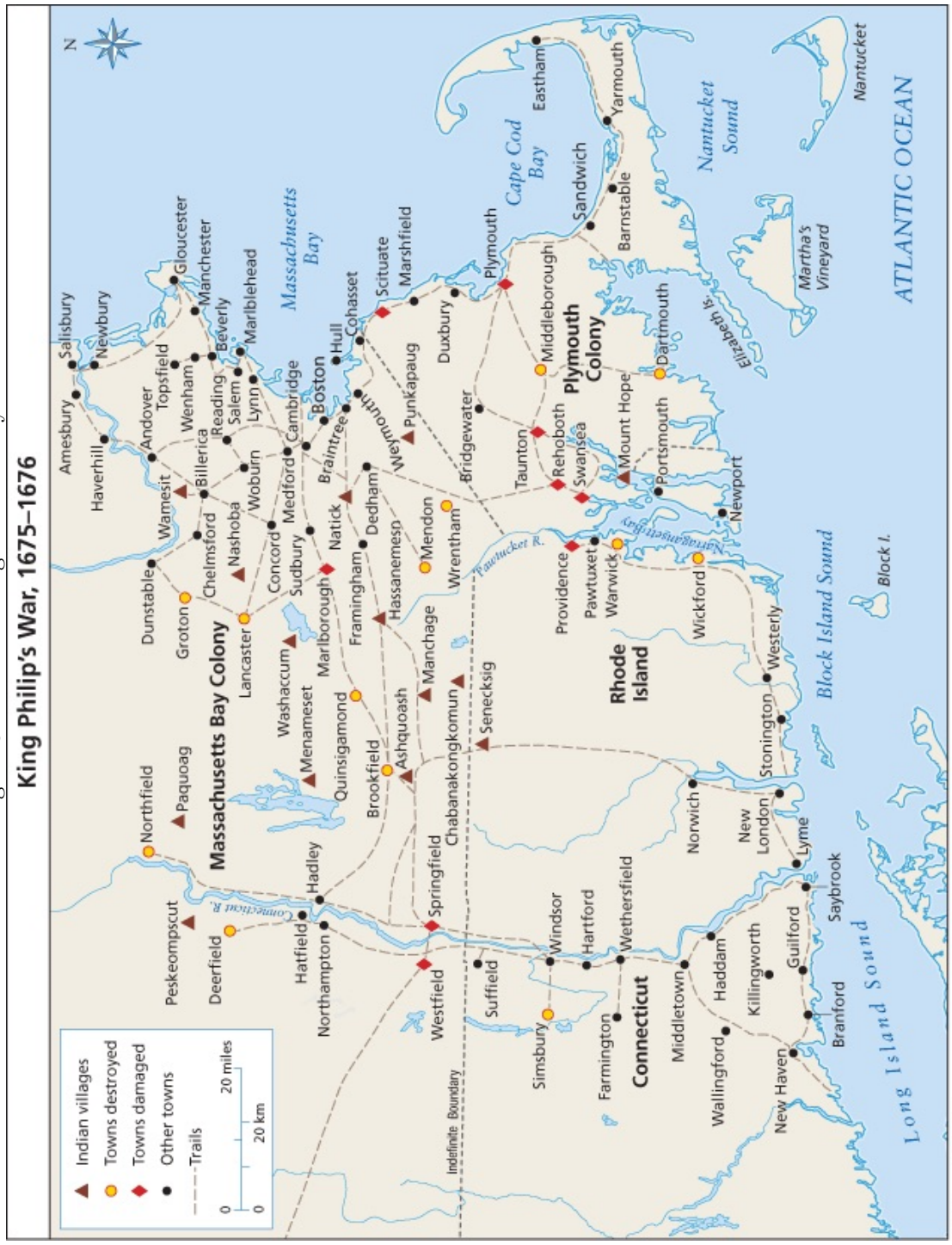
Interactions Prior to King Philip's War

Type of Interaction	Time Period	Algonquian People\Tribes	English People\Settlements	Summary of Findings	Source
Trade	1500s-1600s	Narragansett	European Traders	Trading, fishing, exploring. Narragansett prized European manufactured goods. Europeans demanded furs, wampum - shifting Narragansett production from commercial hunting to crafting. Beaver population depleted. Rise of wealthy Narragansett wealthy "middlemen".	Schultz, 1999
Land Use	1627	Wampanoag	Gov. William Bradford, Plymouth Colony	English colonists desired additional farmland farther away from close-knit Plymouth settlement. A second grand of land was made to every resident of Plymouth to satisfy their desire for more land.	Schultz, 1999
Politics & Diplomacy	1622	Massasoit, Pokanoket	Plymouth Colony	Negotiated peace treaty (era of peace) guaranteeing English colonists' security. New ally for Wampanoag contra Narragansett.	Schultz, 1999
Land Use	1651	Pocasset (Nonaquaket)	Richard Morris, RI	English colonists graze cattle on salt marsh grasses confined by water on both sides in a peninsula harvested by the Pocasset. Early test of diplomatic rhetoric, writing, and English legal discourse.	Brooks, 2018
Land Use & Trade	1651	Weetamoo, Squa-Sachem of Pocasset	Portsmouth (Plymouth)	Portsmouth settlers relied on planting in fields. Weetamoo (Namumpum) held the role of "cultivator of diplomacy" working with other tribes and English settlers teaching cultivation methods.	Brooks, 2018

Type of Interaction	Time Period	Algonquian People\Tribes	English People\Settlements	Summary of Findings	Source
Land Use; Legal Chicanery	1651	Wamsutta & Weetamoo of Pocasset	Plymouth	English men "were somewhat uncomfortable in dealing with women in land transactions". English settlers strongly enforced *couverture*, the legal principle that all of a woman's property is transferred to her husband upon marriage, to limit the number of negotiating parties.	Brooks, 2018
Politics & Diplomacy	1662	Pokanoket	Colony of Rhode Island (RI)	Death of Ousamequin, Massasoit "great sachem" of Pokanoket. End of peaceful English-Indian relations in New England	Schultz, 1999
Politics, Diplomacy & Trade	1675	Narragansett	Roger Williams (RI)	Establish commercial and military relations with Narragansett (involved in sporadic conflict with Wampanoag)	Schultz, 1999
Disease	1600-1675	New England Native Tribes	European colonists	Southern New England's native population declined from 90,000 in 1600 to 10,750 in 1675. Masachusett tribe warriors declined from 3,000 to 300.	Schultz, 1999
Legal Chicanery	1676	New England Native Tribes	Francis Jennings, Plymouth	Attempts to secure land from New England natives in a legal manner. Fraudulent methods: Impose absurd amount of fines to forfeit lands in lieu of payment; allow livestock to ruin native crops; threats of violence; induce drunkenness so a native would sign a deed he was unable to understand.	Schultz, 1999

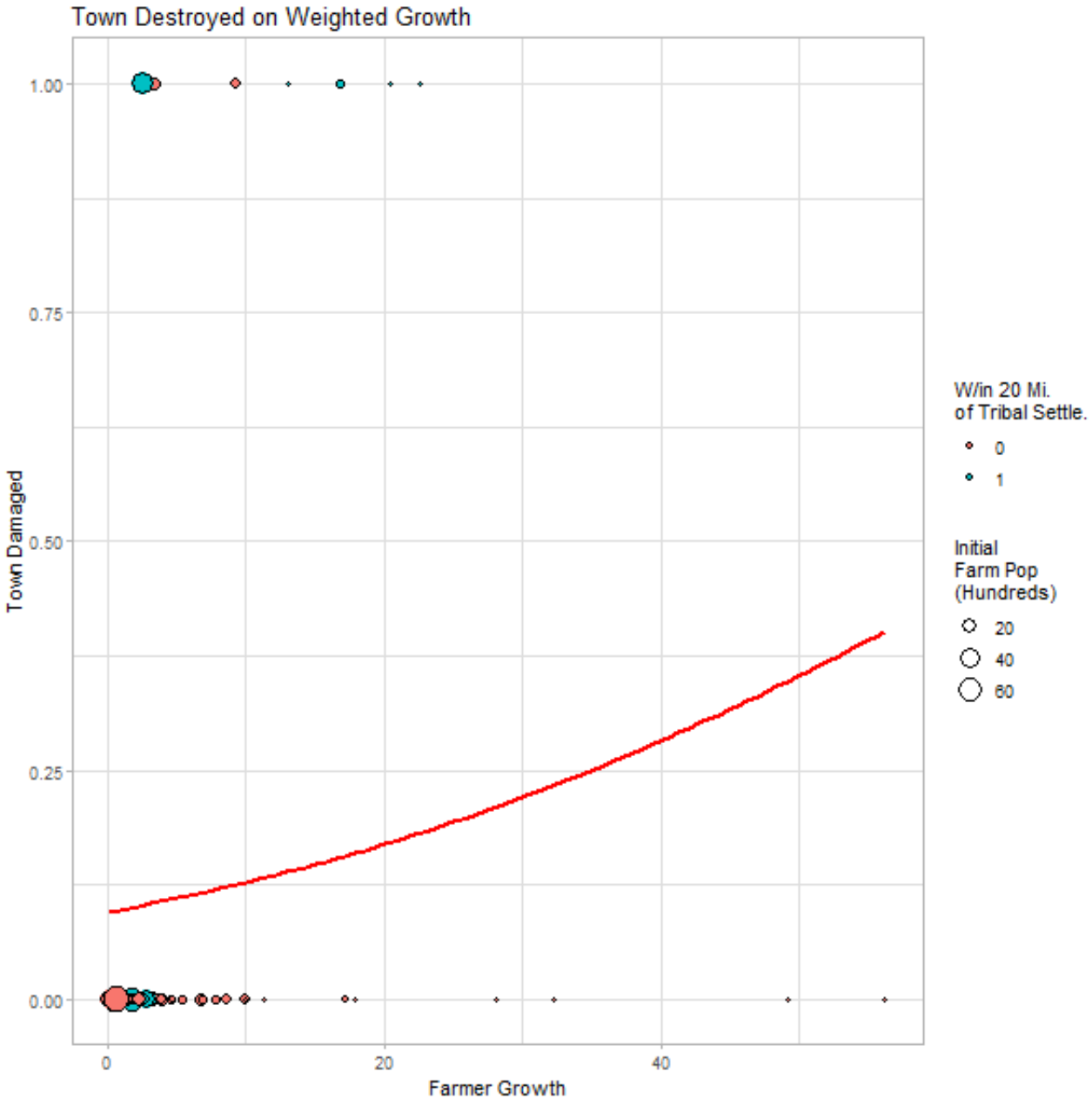
Type of Interaction	Time Period	Algonquian People\Tribes	English People\Settlements	Summary of Findings	Source
Trade & Demographics	1670	Wampanoag	New England settlements	Children and grand-children of the English "Great Migration" came of age and started looking for their own land to establish farms. Increased demand for New England beef and pork to feed enslaved people in burgeoning sugar plantations of the Caribbean. Colonist population reached 60,000 (about double the total number of Natives).	Silverman, 2019
Trade & Land Use	1650s	Narragansett	Dutch & Colonies of MA, CT, RI	Relative price of land shot up relative to wampum after the Dutch "flooded the with low-quality beads. Narragansett's most valuable asset was land." Colony of RI made an agreement to share land use to preempt large purchases by MA investors, particularly the Atherton Company "with malign intentions."	Warren, 2018
Politics & Diplomacy	1660-1662	Narragansett	New England Colonies	The restoration of the English monarchy in 1660 forced all New England colonies to renegotiate the terms and status of their settlements. RI was the first colony to recognize the new monarchy with the hopes of receiving sign-off on their charter. CT received an extremely favorable charter that included nearly all of Narragansett land agitating the neighboring colony of RI.	Warren, 2018
Conflict	June 8, 1675	Wampanoag	Plymouth	Three of King Philip's men were executed by Plymouth colony for the murder of the prominent Christian Indian, John Sassamon.	Warren, 2018

Figure 3: Towns Damaged or Destroyed



Source: American History Online

Figure 4: Logistic Regression Model



Corresponds to Model (5) in Table 1. Growth rates are weighted by initial population.

Figure 5: Faunal Statistics in Plymouth Colony

Cattle from Probate Records of Plymouth Colony

Decade	Under 1 yo	1 yo - 4 yo	+4 yo	Total	*Growth Rate Total*	*Growth Rate of 1-4*
1620	3	7	3	**13**		
1630	7	15	9	**31**	*138.5%*	*114.3%*
1640	46	51	69	**166**	*435.5%*	*240.0%*
1650	61	111	96	**268**	*61.4%*	*117.6%*
1660	105	178	171	**454**	*69.4%*	*60.4%*
1670	67	185	4	**256**	*-43.6%*	*3.9%*
1680	24	40	54	**118**	*-53.9%*	*-78.4%*

Ratios of Cow:Pig:Sheep:Goat

Decade	Cow	Pig	Sheep	Goat	Cow	Pig	Sheep	Goat	Total Livestock	*Growth Rate*
1620	1	1.2	7.4	2.396	13	15.6	96.2	31.148	**156**	
1630	1	0.7	3.9	1.2	31	21.7	120.9	37.2	**211**	*35.2%*
1640	1	0.2	0.4	0.004	166	33.2	66.4	0.664	**266**	*26.3%*
1650	1	0.1	0.3	0.009	268	26.8	80.4	2.412	**378**	*41.8%*
1660	1	0.2	0.3	0	454	90.8	136.2	0	**681**	*80.3%*
1670	1	0.8	0.4	0.004	256	204.8	102.4	1.024	**564**	*-17.1%*
1680	1	0.6	0.3	0	118	70.8	35.4	0	**224**	*-60.3%*

Figure 6: Pasture Growth Rates in Plymouth Colony

Average Animal Weight

Cow	Pig	Sheep	Goat
1,000	130	250	200

Utilization Rate: 3%

Grazing Days: 300
Average Yield per acre: 5,000

							Plymouth Value of Real Estate			
Decade	Acres for Cows	Acres for Pigs	Acres for Sheep	Acres for Goats	Total Acres of Pasture	Decade-Over-Decade Pasture Growth Rate	Total Accumulated Real Estate (Unweighted)	Total Accumulated Real Estate (Weighted)	Decade-Over Decade Growth Rate (Unweighted)	Decade-Over-Decade Growth Rate (Weighted)
1620	23	4	43	11	82					
1630	56	5	54	13	129	57.8%	£ 303	£ 2,107		
1640	299	8	30	0	337	161.7%	£ 1,343	£ 6,440	342.9%	205.6%
1650	482	6	36	1	526	56.1%	£ 1,932	£ 30,212	43.8%	369.1%
1660	817	21	61	0	900	71.1%	£ 2,471	£ 32,398	27.9%	7.2%
1670	461	48	46	0	555	-38.3%	£ 2,619	£ 33,554	6.0%	3.6%
1680	212	17	16	0	245	-55.9%				

Sources: Plymouth Archaeological Rediscovery Project & USDA

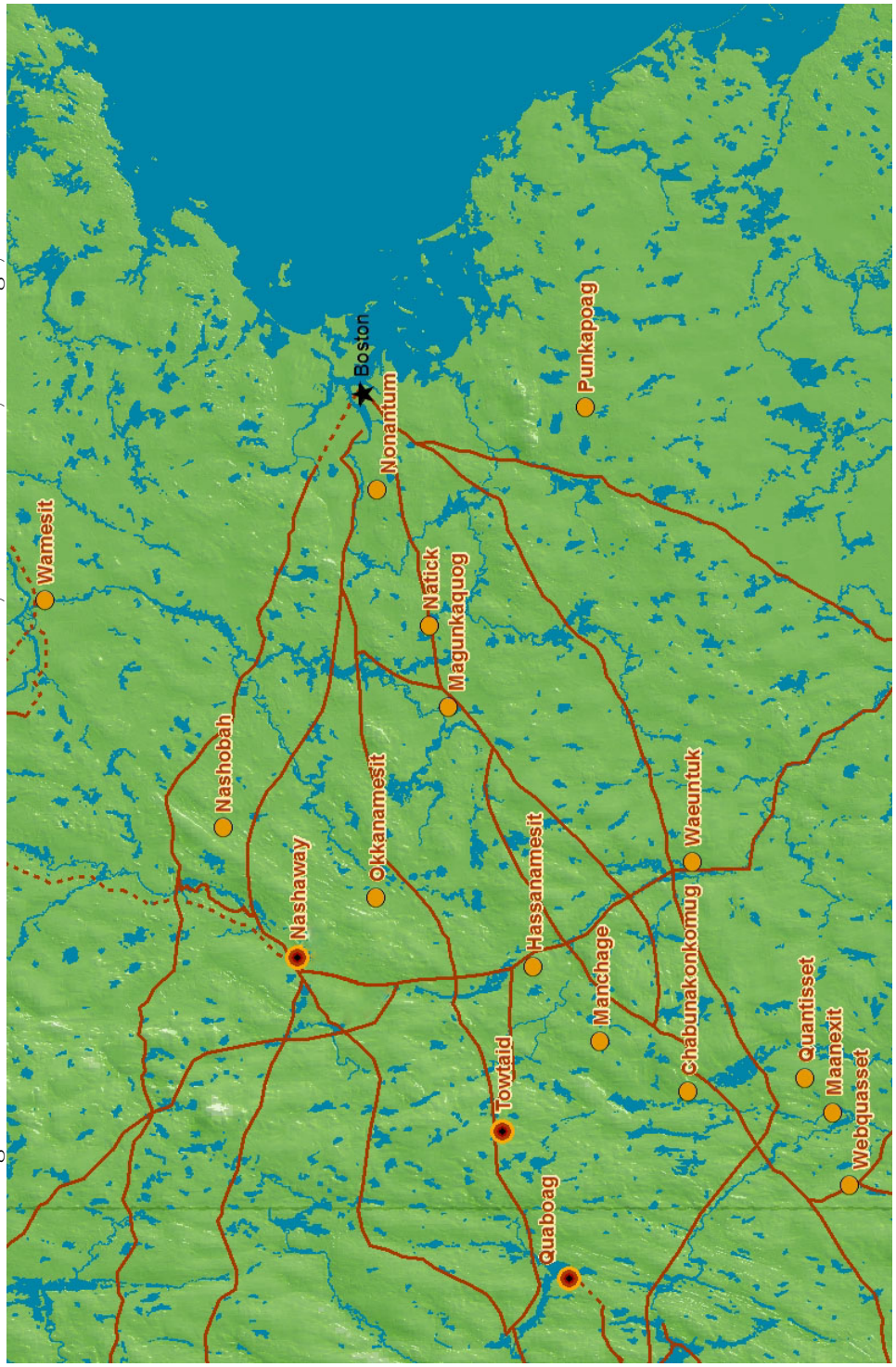


Figure 7: Hassanamesit and mission communities, with Missitekw, Cambridge, Boston

Source: Brown, Lisa. *Our Beloved Kin*. 2018.