# The Impact of Horse Adoption on Native American Nations

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# Introduction and Motivation

- The path of Indigenous nations was shaped by the rapid spread of European diseases and the speed of recovery likely shaped their interactions with European colonizers
- We seek to understand how a potentially mitigating factor, the **diffusion of the horse** across North America, may have impacted the recovery of these nations
- What suggests there might have been a meaningful impact?
  - Indigenous peoples in the Great Plains were arguably the "tallest people in the world" (Prince and Steckel, 2001) & the horse was known to be valuable to many of these peoples, transforming hunting & trade
  - It granted significant military advantages in combat on the open plains (Kumagai, 2022)

# Brief Historical Background

- The horse originated in the Americas, but was driven to extinction roughly 12,000 years ago, likely as a result of climate change or overhunting
- The animal was reintroduced to the Americas by European colonizers in the late 15th and early 16th centuries and spread rapidly (Delsol et al 2022)
- After re-introduction, the animal spread in the plains and the west primarily through **Indigenous trading routes** rather than through trade with Europeans (Taylor et al., 2023)
- By the time of European encroachment into the Great Plains, there were many well-established Indigenous, horse-dependent nations using the animal for hunting, travel, and warfare

# What We Do

- We empirically test whether the horse had short run impacts on population & food production and longer run impacts on heights, income, & land cessions
- In this early stage of research, we:
  1. Digitize historical maps of the spread of the horse in North America and interpolate the presence of the animal Horse Map
  2. Estimate the relationship between horse adoption and Indigenous populations
  3. Consider the effects of horse adoption on food production, height, income and land cessions
  4. Interpret the results through the lens of a Malthusian-style model with technology Model Summary

# Expected Impacts

- From the qualitative literature:
  - Improvements in transportation and hunting, leading to richer communities
  - Strengthened Indigenous power relative to colonial states, leading to later land cessions & more favourable treaty terms
- From our model:
  - Population booms, particularly in the short run
  - Greater specialization in subsistence modes
  - Limited long run improvements in well-being

# Data and Methods

**Data:**

- **Sample:** 150 Indigenous nations in or around the Great Plains using map from 1600s (Martin & O'Leary, 1990)
- **Horse adoption:** Wissler (1914), Haines (1938) , Jacobsen & Eighmy (1980), and others $\rightarrow$ interpolated horse presence
  Interpolation
- **Outcomes:** population (Smithsonian Handbook and Statistical Records of Native North Americans), food production (Murdock 1967), heights (Jantz 1995), land cessions (BAE 1899), income (Leonard et al 2020) Population
  Descriptive Statistics

**Methods:**

- TWFE and event study specifications for population
- OLS and IV for cross-sectional outcomes LCP with Water Bodies

# Panel Results: Population & Horse Adoption

| | (1) | (2) | (3) |
|---|---|---|---|
| Horse | 0.211** | 0.221*** | 0.210*** |
| | (0.08) | (0.076) | (0.078) |
| Epidemic | | -0.130* | -0.124* |
| | | (0.069) | (0.068) |
| Dummy 1776 | | | 0.208** |
| | | | (0.085) |
| Dummy 1830 | | | -0.179 |
| | | | (0.158) |
| Regional Controls | No | No | Yes |
| Observations | 448 | 448 | 448 |
| R-squared | 0.105 | 0.12 | 0.124 |
| Number of nations | 67 | 67 | 67 |

Clustered standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Event Study (540-1860)

# Cross-sectional Analysis: Endogeneity

- Understanding that, a nation with more dependency on hunting may have had an incentive to adopt horses, leading to earlier adoption
- We proceed with two distinguished methodologies to address the issue:
    1. First, assessed the exogenous variation in *Year With Horses* (YWH) explained by exogenous geographical characteristics
    2. Second, an instrumental variable approach, using exogenous variation in YWH explained by the least cost path augmented by water bodies

# Cross-sectional Results: Foods & Horse Adoption OLS

| | Hunting | Gathering | Fishing | Animal | Agriculture |
|---|---|---|---|---|---|
| Years with Horse | 0.03* | 0.02 | -0.01 | -0.01 | -0.03 |
| | (0.02) | (0.02) | (0.01) | (0.00) | (0.02) |
| Years with Horse Sqr. | -0.00** | -0.00 | 0.00 | 0.00 | 0.00* |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Geo. Controls | Yes | Yes | Yes | Yes | Yes |
| Adjusted $R^2$ | 0.29 | 0.35 | 0.62 | 0.31 | 0.41 |
| Observations | 120 | 120 | 120 | 120 | 120 |

Robust standard errors are clustered at the language level. *** p<0.01, ** p<0.05, * p<0.1

# Cross-sectional Results: Foods & Horse Adoption IV

| | Hunting | Gathering | Fishing | Animal | Agriculture |
|---|---|---|---|---|---|
| Years with Horse | 0.14*** | -0.37 | -11.72** | -2.6*** | -5.67 |
| | (0.05) | (0.02) | (0.05) | (0.02) | (0.14) |
| Years with Horse Sqr. | -0.00** | -0.26 | 4.32** | 1.14*** | 2.80 |
| | (0.00) | (0.02) | (0.00) | (0.05) | (0.10) |
| First-Stage F-Stat (Second Endo. Var.) | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| Observations | 120 | 120 | 120 | 120 | 120 |

First-stage F-statistics are calculated for each endogenous variable, *** $p<0.01$, ** $p<0.05$, * $p<0.1$ IV: First Stage

# Cross-Sectional Results: Horse Adoption & Heights

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Time since Horse Adoption | 0.0156 | 0.0239 | 0.00973 | 0.0364 | 0.00500 | 0.0294 |
| | (0.025) | (0.044) | (0.023) | (0.043) | (0.030) | (0.055) |
| Individual Controls | X | X | X | X | X | X |
| Spatial and Nation Controls | | X | | X | | X |
| Men | X | X | | | X | X |
| Women | X | X | X | X | | |
| Observations | 11487 | 10348 | 4242 | 3861 | 7245 | 6487 |
| Adjusted $R^2$ | 0.864 | 0.868 | 0.859 | 0.863 | 0.877 | 0.883 |
| N_clust | 113 | 108 | 108 | 103 | 109 | 104 |

Clustered standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

# Cross-Sectional Results: Horse Adoption & Land Cessions

| | (1) | (2) | (3) |
|---|---|---|---|
| Time since Horse Adoption | -0.417*** | -0.382*** | 0.102 |
| | (0.134) | (0.110) | (0.187) |
| Bison dependence | | -8.473* | -11.569*** |
| | | (4.963) | (4.031) |
| Regional dummies | No | No | Yes |
| Observations | 321 | 321 | 252 |
| R-squared | 0.042 | 0.081 | 0.380 |

Clustered standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

# Cross-sectional Results: Horse Adoption and Income

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Time since Horse Adoption | 0.00179 | 0.00763* | 0.00129 | 0.00820*** | 0.00232 |
| | (0.002) | (0.004) | (0.002) | (0.002) | (0.002) |
| Year Dummies | X | X | X | X | X |
| Spatial Controls | | X | | | |
| Cultural Controls | | | X | | |
| Colonial Controls | | | | X | |
| Disruptive Controls | | | | | X |
| Observations | 634 | 634 | 634 | 634 | 634 |
| R-squared | 0.574 | 0.596 | 0.618 | 0.629 | 0.586 |

Clustered standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

# Discussion and Conclusion

- Horse adoption is strongly associated with a rapid re-population of Indigenous nations and selection into hunting for food production
- We observe limited long run impacts on height and income
- However, nations with earlier horse access are more successful at resisting colonial powers, ceding their lands at later dates
- We hypothesize that this economic boom, and the associated positive military shock, likely delayed the time of conquest for these nations and increased the likelihood that these peoples persist into the present, although this work remains in progress
- Future work: consider occupational, income, and reservation size outcomes, link to cultural aspects of westward expansion

# Future Work: Conflicts and Horse Adoption

- Data on bilateral and multilateral conflicts All Conflicts
- Data on Indigenous nation and colonial conflicts Conflicts with Colonial Powers
- Intertribal conflicts after horse adoption Post-horse Conflicts
- Digitization of gun frontier maps

## Renewable Resource Dynamics

Back to What We Do

- Assuming the production sector, the resource stock at time $t$ is $S(t)$. It evolves according to:

$$\frac{dS}{dt} = G(S) - H \tag{1}$$

- Hunting is carried out according to the Schaefer harvesting production function:

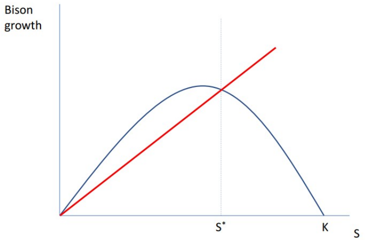
$$H^p = \alpha S L_H \tag{2}$$

- This implies that the unit labor requirement in hunting is:

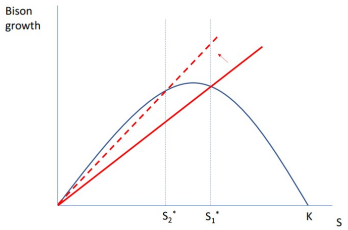
$$a_{LH}(S) = \frac{L^H}{H^P} = \frac{1}{\alpha S} \tag{3}$$

# Renewable Resource Dynamics and Steady State

Back to What We Do




The Steady State number of Bison




The effect of Horse adoption on Bison stock

# Utility Maximization Approach

Back to What We Do

- Consumer can maximize utility

$$u = h^{\beta} m^{1-\beta} \qquad \text{s.t} \qquad ph + m = w \tag{4}$$

yields the following for both commodities

$$h = w\frac{\beta}{p} \qquad \text{and} \qquad m = w(1-\beta) \tag{5}$$

Here, $F = \phi\frac{H}{L}$ is fertility function, where $\phi$ is a positive constant,considering $\frac{H}{L} = \alpha\beta S$ from (10), equation (12) can be rewritten as:

$$\frac{dL}{dt} = L(b - d + \phi\alpha\beta S) \tag{6}$$

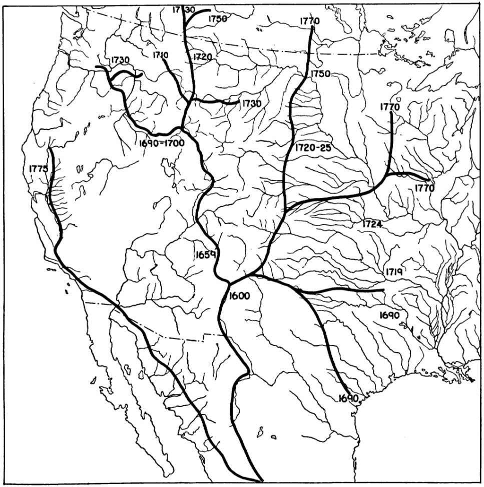
## Steady State

Back to What We Do

- Proposition 1: The Ricardo-Malthus model exhibits three steady states. Steady state 3 is an interior solution
- Proposition 2: The steady-state resource stock:
  1. rises if the mortality rate rises, the birth rate falls, or fertility responsiveness falls;
  2. falls if there is technological improvement in hunting
- Proposition 3: The steady-state population level:
  1. rises equiproportionately with an increase in the intrinsic rate of resource growth, $r$;
  2. falls when the hunting technology improves if $S < \frac{K}{2}$ and rises if $S > \frac{K}{2}$;

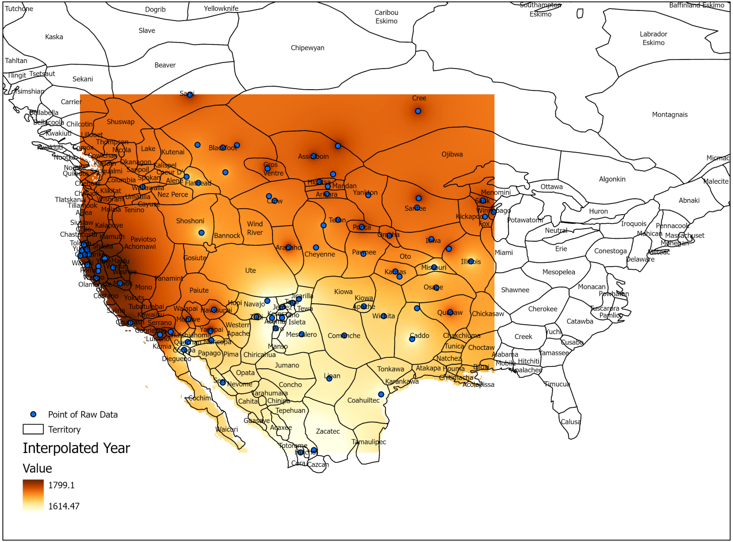
# The Diffusion of the Horse (Haines, 1938)

Back to What We Do



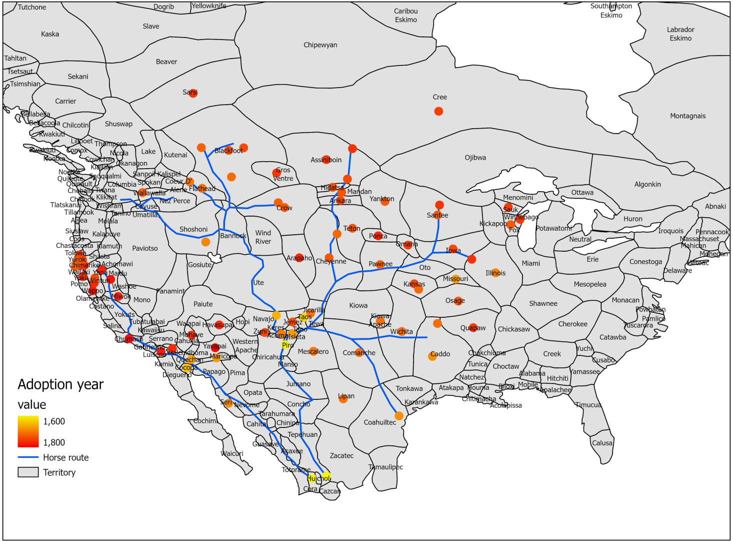
# Homelands

Back to Data and Methods



# Digitization and Interpolation

Back to Data and Methods



# Population

Back to Data and Methods

| Region | Nation | Year | Population | Source | Literature |
|---|---|---|---|---|---|
| Plains | Hidatsa | 1700 | 5000 | Wood and Thiessen, 1985_David Thompson(1797-98:146) | Matthews, W. (1877). Ethnography and philology of the Hidatsa Indians (No. 7). US Government Printing Office. |
| Plains | Hidatsa | 1720 | 3500 | Wood and Thiessen, 1985_David Thompson(1797-98:159) | Lowie, R. H. (1913). Societies of the Crow, Hidatsa and Mandan Indians (Vol. 11). The Trustees. |
| Plains | Hidatsa | 1780 | 2500 | Mooney 1928:138 | Mooney, J. (1928). The aboriginal population of America north of Mexico. Smithsonian miscellaneous collections. |
| Plains | Hidatsa | 1797 | 1730 | Stewart(1975:78-80) | Stewart, F. H. (1974). Mandan and Hidatsa villages in the eighteenth and nineteenth centuries. Plains Anthropologist, 19(66), 287-302. |
| Plains | Hidatsa | 1805 | 2700 | Lewis and Clark (1806:26, 1814, 1:130) | Stewart, F. H. (1976). Hidatsa Origin Traditions Reported by Lewis and Clark. Plains Anthropologist, 21(72), 89-92. |
| Plains | Hidatsa | 1820 | 4000 | Bower(1965:36,287)Chardon (1932:126,145) | Hanson, J. R. (1993). HIDATSA ETHNOHISTORY: 1800-1845. The Phase I Archeological Research Program for the Knife River Indian Villages National Historic Site: Ethnohistorical studies, (27), 131. |

# Descriptive Statistics: Panel Analysis

Back to Data and Methods

Panel Analysis

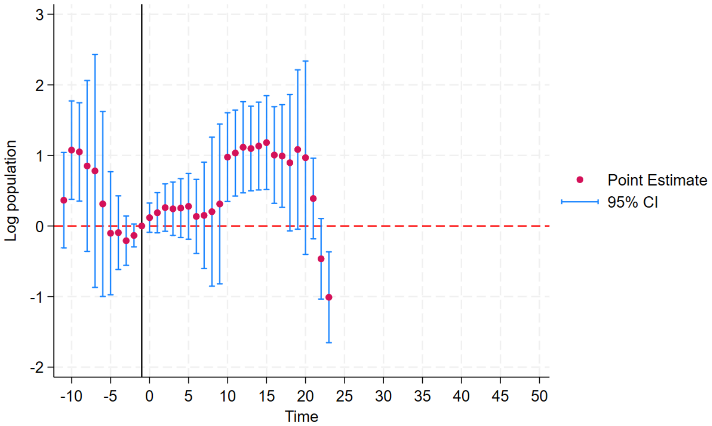
| | Obs | Means | Stand Dev. | Min | Max |
|---|---|---|---|---|---|
| Nations | 82 | – | – | – | – |
| Year | 1089 | 1823 | 85.94 | 1540 | 1980 |
| Horse Adoption Year | 1089 | 1742 | 0.5713 | 1740 | 1743 |
| Population | 1089 | 3204 | 5413 | 19 | 62000 |
| Land Cession Year | 839 | 1897 | 67.34 | 1784 | 2010 |

Cross Sectional Analysis

| | Obs | Means | Stand Dev. | Min | Max |
|---|---|---|---|---|---|
| Nations | 115 | – | – | – | – |
| Horse Adoption Year | 161 | 1734 | 18.67 | 1676 | 1771 |
| Gathering | 161 | 23 | 16 | 0 | 60 |
| Hunting | 161 | 33 | 17 | 1 | 90 |
| Fishing | 161 | 26 | 20 | 0 | 80 |
| Animal Husbandry | 161 | 6 | 3 | 0 | 30 |
| Agriculture | 161 | 15 | 23 | 0 | 80 |
| Homeland area 1600 | 254 | 75,717 | 133,497 | 737.5 | 1,246,482 |
| Pop density in 1600 | 72 | 0.35 | 0.41 | 0 | 65 |

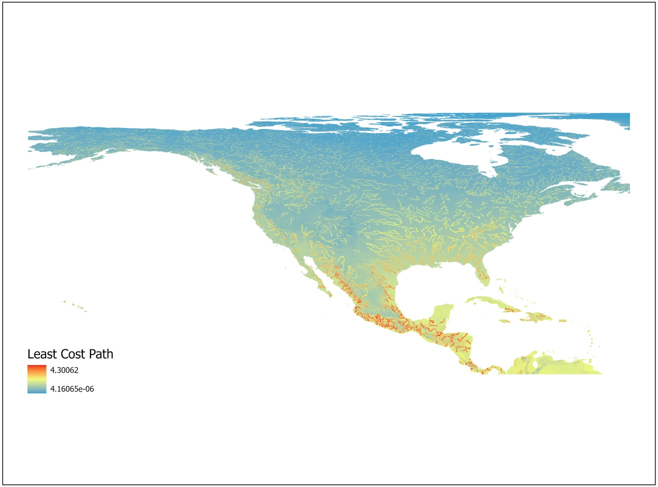
# Event Study: Pre & Post Horse Adoption

Back to Panel Results: Population & Horse Adoption



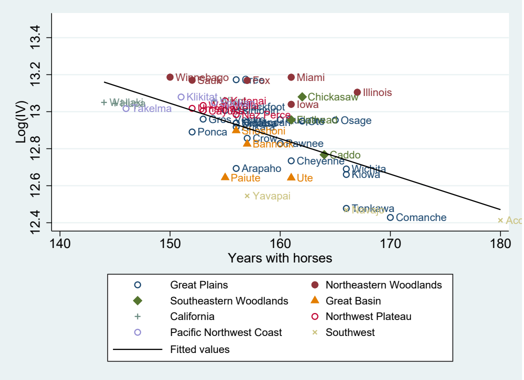
# An instrument: Least Cost Path with Water Bodies

Back to Data and Methods



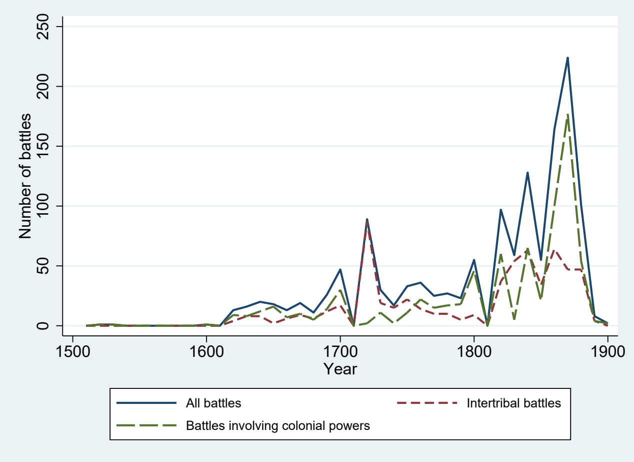
# IV First Stage

Back to Cross Sectional Results: Foods & Horse Adoption IV



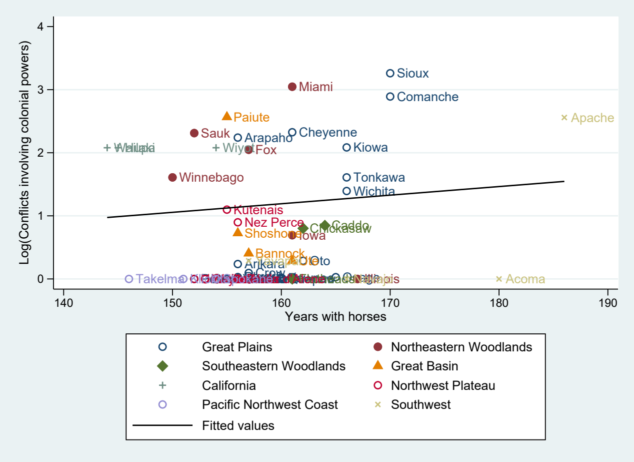
# All Conflicts

Back to Future Work: Conflicts and Horse Adoption



# Conflicts with Colonial Powers

Back to Future Work: Conflicts and Horse Adoption



# Post-horse Conflicts

Back to Future Work: Conflicts and Horse Adoption