Northern Arizona vowels

Citation for published version:
Hall-Lew, L, Eiswirth, M, Valentinsson, M-C & Cotter, W 2017, 'Northern Arizona vowels' American Speech, vol. 92, no. Supplement (102)1, pp. 59-82. DOI: 10.1215/00031283-4295288

Digital Object Identifier (DOI):
10.1215/00031283-4295288

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
American Speech

Northern Arizona Vowels[1]

Lauren Hall-Lew, Mirjam Eiswirth,
Mary-Caitlyn Valentinsson, and William Cotter

Abstract
Previous work on BOOT and BOAT in Northern Arizona English (Hall-Lew 2004, 2005) found that younger townspeople and older ranchers both front BOOT, arguably due to dialect contact between the so-called Southern Shift (Labov 1994) and the so-called California Vowel Shift (Eckert 2004). Subsequent analysis on a subsample of Northern Arizona men (Hall-Lew et al. 2015b) found that townspeople produced a backer BAT vowel than ranchers, again hinting at a possibly Californian pattern in the town and a possibly Southern pattern for the ranchers. This paper builds on these findings, examining the whole front vowel system as well as the low back vowels in two different corpora collected between 2002-2006. The results of mixed-effect models based on normalized single point F1 and F2 Hz values find some evidence of other changes associated previously with California: BIT and BET lowering and backing and a 'nasal split' for the BAT vowel (Eckert 2004, 2008). However, data are inconclusive for BOT and BOUGHT as well as for the town/ranch contrast. One new finding that emerges in this analysis is a year of birth correlation among women for the raising of the BAIT vowel, which does not appear among the men.

Key terms: Arizona, vowels, sound change, variation, the Southwest

1 Introduction

Arizona's settlement history is typical of the other Southwestern states and California, with early indigenous populations coming into contact first with Spanish speaking settlers, and later with non-Hispanic European American migrants coming from the South, the East, and Midwest, and later still from California (Sheridan 1995, 154). Because of this pattern of settlement and its geographical location, Arizona (like New Mexico), is also situated in an interesting dialectological position. The speech of Arizonans has likely been born out of and influenced by both the well-documented vocalic patterns of the Southern US (e.g., Feagin 2003) as well as the vocalic mergers and other changes often collectively referred to as the California Vowel Shift (Eckert 2004). In the present chapter, we consider both these sources of influence and sketch out a basic foundation for understanding vowel variation in the state of Arizona.

As this collection demonstrates, there has been a general lack of systematic investigation of the dialects of the Western US, including Arizona. Earlier work (Hall-Lew 2004, 2005) found significant social effects of age, gender, and an urban versus rural social orientation in the fronting of the BOOT and BOAT vowels for residents of Flagstaff, Arizona, the urban center of the northern half of the state. In this chapter we continue to examine vocalic changes taking place in Arizona by looking at some of the other vowels, including BEET, BIT, BAIT, BET, BOT, and BOUGHT, but especially focusing on variation in the BAT vowel and its pre-nasal counterpart, BAN. In California, /æ/ is undergoing raising and fronting before nasals and lowering and backing elsewhere (Eckert 2008; Hall-Lew et al. 2015a; Cardoso et al. to appear). This is true even in the relatively more rural Central Valley of California, overall,

[1] We would like to thank participants at NWAV44 for their feedback on an earlier version of this study. We would also like to thank the University of Arizona's Graduate and Professional Student Council for funding to obtain data from *StoryCorps, Inc.* (RSRCH-712FY'15), and we thank *StoryCorps, Inc.* for their interest in our project and willingness to share their incredibly valuable resource.

with the exception of male speakers and those speakers interviewed in the Merced area of the Central Valley who retain relatively fronter BAT realizations (D'Onofrio et al. forthcoming). A lack of a nasal split and a fronter pronunciation of BAT is also characteristic of the so-called Southern Vowel Shift (Labov 1994), where all three front short vowels tense and raise, collectively in-gliding while the front up-gliding vowels lax and lower (Baranowski 2008; see also Koops 2014).

The present chapter analyzes data collected from two different sources. The '2002' recordings are the 44 sociolinguistic interviews that formed the basis for previous analysis by Hall-Lew (2004, 2005). The '2006' recordings are interviews created by *StoryCorps Inc*., "a nationwide initiative to record and collect oral history interviews,"[2] who have provided our research team with access to all of the interviews recorded in the state of Arizona at the time of writing. In this paper we focus on only those five interviews that were recorded in Flagstaff with an interviewee who was a life-long resident of Flagstaff. The results show evidence of change in progress in the directions expected based on previous work in California, but also a number of complicating factors.

1.1 Settlement in (Northern) Arizona: from California and the South

Figure 1: Flagstaff, Arizona, in its regional context

[2] https://storycorps.org/ (Date accessed February 8, 2016)

Diverse and numerous Native American groups[3] originally populated the region that is now known as Arizona. While their influence on regional varieties of English is a pressing area for future work, we concentrate here on those speakers of European ancestry who comprised the majority of Arizona's population in the 20th century and into the present day. Among these, we also leave aside for now the variation in English pronunciation by speakers of Hispanic heritage, whose settlement in Arizona dates back to the late 1600s (Sheridan 1995, 31). Instead, we focus on the speech of those Arizonans whose demographic and biographic histories are similar to most of the other communities in this volume: non-Hispanic European American settlers who arrived in the Western states from regions to the East. For Arizona, this stream of settlement came in the 1800s with railroad, lumber, agriculture, and mining booms drawing migration from the Southern and Midwestern states. With the Gadsden Purchase in 1853, much of the territory that makes up the current state of Arizona was officially acquired by the US (Sheridan 1995, 56). In the years that followed, the logging and ranching industries in particular experienced tremendous growth in Northern Arizona, leading to the founding of Flagstaff as the primary urban center in that region. In 2010 the population of Flagstaff was 65,870. 73% of the population was recorded as 'White', with American Indians accounting for 12% of the population, and 17% 'Hispanic of any race' (http://www.flagstaff.az.gov/index.aspx?NID=1095).

Like many of the Western states, "only in the late 20th century could a sizeable population of European Americans claim multigenerational affiliation to the Western US" (Hall-Lew 2004, 1). A 1890 census recorded 964 residents in Flagstaff (out of 88,243 for Arizona as a whole); the city's population rose 32% to 1,271 at the turn of the 20th century (Moffatt 1996).~~The first census in 1890 recorded 964 residents, with the percentage of European Americans rising 32% to 1,271 at the turn of the 20th century (Moffatt 1996).~~ Flagstaff's population growth has been steady with periods of bursts, first in the 1910s (a 95% increase between 1910 and 1920) and then again in the 1950s (a 138% increase between 1950 and 1960, in part due to the post-World War II baby boom). This latter period also marked a turning point in where new in-migrants came from. In 1950, 3% of Arizona residents had been born in California, whereas 14% were originally from the southern states of Texas, Oklahoma, and Arkansas. For example, "[d]uring the Great Depression of the 1930s, thousands fleeing the dust bowl of Oklahoma streamed across northern Arizona to California" (Babbitt and DeGraff 2009, 8). But by 2012, this trend was beginning to show a reversal, with less than 4% of Arizona residents coming from Texas, Oklahoma, or Arkansas, and 9% of Arizonans originally born in California (Source: NYT Migration Maps).[4] The logging and ranching industries gradually waned in importance during the 20th century, and Flagstaff became more known as a center for tourism, astronomy, and higher education (Mangum and Mangum 2003).

1.2 Northern Arizona English

The Atlas of North American English groups Arizona with most of the rest of the Western United States (Labov, Ash and Boberg 2006), based on the presence of the

[3] In Northern Arizona these were the "Hopi, then later Apache, Hualapai, Havasupai, Navajo, and Paiute peoples" (Babbit & DeGraff 2009, 7).

[4] See also: "Californians biggest segment of Ariz. newcomers," published November 22, 2002; data accessed February 12, 2016: http://azdailysun.com/californians-biggest-segment-of-ariz-newcomers/article_248c9d3f-b060-5694-87e1-b4dadfd1ee80.html

BOT-BOUGHT (near-)merger among the speakers sampled, including one speaker from Flagstaff. The perceived lack of variation in the West, and particularly in Arizona, has resulted in little linguistic research being conducted in the state, despite its particularly interesting settlement history.

Previous work on Arizona English (Hall-Lew 2004, 2005) argued that the changing patterns of migration in the region mean that both 'Californian' features and 'remnants of Southern speech' may be found in the English of Northern Arizonans. As Labov et al. (2006, 279) note, "It is well known that settlement of the southwestern United States involved contributions from the South, with a strong component from Texas and Oklahoma." They further suggest that "[t]he phonological consequences of this settlement pattern are not enough to extend the South westward beyond Texas, but effects are found in several scattered remnants of Southern speech." Cline's (1994, 224) history of Flagstaff specifically notes that "...cattlemen and sheepmen...shared …elements of the livestock cultures of Texas and the South. The Southern drawl became the trademark of both cowboys and bosses, as in the movies." Earlier work (Hall-Lew 2004, 2005) argued that the Flagstaff area can be considered "a location of two /uw/-fronting varieties of American English" (Hall-Lew 2004, 1; see also Koops 2010) due to dialect contact between the SVS and the so-called California Vowel Shift (CVS; Eckert 2004). Our preliminary analysis (Hall-Lew et al. 2015b) of some of the data presented in the current paper investigated variation in the BAT vowel among 30 men, eight of them RANCH affiliated (ranchers/ranch-hands/cowboys) and 22 of them TOWN affiliated (with no ranch affiliations), interviewed in 2002. The results showed a significant difference in F2, with rancher men producing a fronter vowel than town men. Qualitatively, this was also true for the age-matched subset of women (one RANCH and four TOWN). Furthermore, we found no BAT-BAN split (characteristic of the CVS) amongst the RANCH affiliates, but some evidence for the split among the non-ranchers.

However, due to space constraints, and the lack of female ranchers in our data sample, the TOWN/RANCH difference examined by Hall-Lew et al. (2015b) will not be investigated here. Instead, we consider the possibility that older Arizonans' vowels might be more influence by the SVS than younger speakers'. We will then focus on what are predicted to be relatively newer sound changes, considering especially the patterns shown for California (Cardoso et al. to appear; D'Onofrio et al. to appear; Eckert 2004, 2008; Kennedy & Grama 2012; Hall-Lew 2013, et al. 2015; Podesva 2011, et al. 2015), as well as the Pacific Northwest (Becker et al. to appear, Wassink to appear) and Nevada (Kendall and Fridland, this volume).

Table 1 sketches out our predictions for each vowel and each major input variety, based on previous literature. Note that the predictions for BOT and BOUGHT are not entirely clear; while Hall-Lew (2013) and McLarty et al. (to appear) found the BOT-BOUGHT near-merger to proceed via BOUGHT lowering and fronting, D'Onofrio et al. (to appear) found it occurring via BOT raising.

Table 1: Predicted patterns for Northern Arizona English vowels

Vowel	CVS predictions	SVS predictions
BEET	stable	lowering/backing
BIT	lowering/backing	raising/fronting
BAIT	stable	lowering/backing
BET	lowering/backing	raising/fronting

BAN	raising/fronting, away from BAT	raising/fronting, like BAT,
BAT	lowering/backing, away from BAN	raising/fronting, like BAN
BOT	raising *or* stable	stable
BOUGHT	lowering/fronting *or* stable	stable

Because migration into Arizona from California and other Western states has been surpassing migration from Southern states, particularly in cities, we take the Californian patterns to be indicative of the likely direction of change within urban Arizona, while the Southern patterns are expected among older speakers and/or residents of rural Arizona. Note that, while some have noted a reversal in the Southern pattern in the South (Dodsworth and Kohn 2012), we do not expect contemporary changes to the Southern vowel system to impact older, rural speakers in Arizona.

2 Methodology

The 2002 and 2006 corpora were collected under different conditions and provide differing amounts and types of data. The methods of data collection for the 2002 corpus are described in detail by Hall-Lew (2004). One crucial difference between these and the *StoryCorps* interviews from 2006 is that the 2002 speakers were all interviewed by the first author, whereas the five 2006 speakers were all interviewed by different people with a different relationship to each speaker, namely: a mother, an adult student, a friend, a wife, and a *StoryCorps* representative. The 2006 interviews were also all conducted with a *StoryCorps* representative present as a known auditor,[5] and the fact that the recordings would be archived at the Library of Congress and possibly made publically available online is known and commented on by some of the participants, such that an absent third party is sometimes addressed (cf. Schilling-Estes 1998). The interview questions are also different: the 2002 interview questions focused on the individual's life experiences in Flagstaff, and their views on how the town had changed during their lifetime. While the 2006 interviews often touch on very similar themes for the four older speakers, the one teenager was interviewed solely on the topic of his exceptional family circumstances (having a sister with autism). Aside from those differences, most of the interviews in both corpora took place in the speakers' homes or places of work, and lasted from about 30-45 minutes each.

2.1 Participants

The complete sample of 49 speakers is shown in Table 2. In 2002-2003, the first author interviewed a range of men and women born and raised in Flagstaff (N=35) and the surrounding ranchlands (N=9). The five *StoryCorps* interviewees were selected from the oral history archive as the only speakers (at time of writing) born and raised and living in Flagstaff at the time of their interview; one was interviewed in 2005, the other four in 2006. All speakers in both corpora are of non-Hispanic European descent, and represent a range of ages and social classes. Only interview style speech is analyzed here.

[5] In 2016 *StoryCorps* released an app that allowed people to record their own interviews on their own without a representative present, but all interviews prior to this year have an auditor present.

Despite the breadth of individuals sampled, the basic demographic representation is not balanced for either corpus: both corpora over-represent men, the 2002 corpus does not have any older women, and the 2006 corpus does not have any younger women. Despite that imbalance, the 2006 data are analyzed separately from the 2002 data here because of major methodological differences in vowel coding and formant extraction (see section 2.2). Due to space constraints, the TOWN/RANCH difference examined by Hall-Lew et al. (2015b) will not be investigated here, and the 2002 speakers will always be analyzed together as a single dataset. Of the five speakers in 2006, the man born in 1937 was a former rancher; the other four do not have direct connections to ranching.

Table 2: Speaker sample and demographics

	2002 Townspeople		**2002 Ranchers**		**2006 *StoryCorps***		**Total**
	N	*YOB*	*N*	*YOB*	*N*	*YOB*	
Female	13	1948-1983	1	1958	2	1923, 1926	16
Male	22	1927-1984	8	1930-1983	3	1927, 1937, 1987	33
Total	35		9		5		49

2.2 Measurement, Normalization, and Modeling

The methodological difference between the 2002 and 2006 corpora is most significant in terms of vowel measurement. The data from 2002 analyzed here are taken from the same measurement process described by Hall-Lew (2004); for reasons of time, the 44 interviews were not recoded. In contrast, the data from 2006 were obtained with FAVE-align and FAVE-extract (Rosenfelder et al. 2014). For the 2002 data, measurements of F1 and F2 were taken by hand at the approximate midpoint, or highest F1 value, of the vowel nucleus. For the 2006 data, measurements of F1 and F2 are automatically extracted at approximately a third of the way through the vowel. This means that any vowel with even a minor amount of spectral change is likely to be realized slightly differently between the two corpora.

The differences in vowel measurement also mean that there are more vowels represented in the FAVE-extracted data than the hand-coded data. The 2006 dataset contains 7799 vowel tokens: 1000 of BEET, 1038 of BIT, 752 of BAIT, 839 of BET, 894 of BAN, 1137 of BAT, 606 of BOT, and 371 of BOUGHT. In contrast, the 2002 dataset contains 3145 vowel tokens: 354 of BEET, 481 of BAIT, 431 of BAN, 576 of BAT, and no tokens of BIT, BET, BOT, or BOUGHT. Further, the differences in vowel measurement resulted in speakers being not equally represented between the corpora: for example, there is an average of only 10 tokens of the BAN vowel per speaker in the 2002 corpus versus 179 tokens of BAN per speaker in the 2006 corpus. Despite these differences in measurement methods and token numbers, seeing similar trends will indicate that both corpora are relatively representative of Flagstaff speech.

Measurements were normalized in R (R Core Team 2013) using the Lobanov method in the VOWELS.R package (Kendall and Thomas 2009-2014). Before analysis, all rhotic tokens were excluded, as well as all tokens with durations below 60ms, tokens with non-primary stress, and tokens immediately followed by a vowel or glide. The word-final tokens were then manually coded for following phonological environment (using FAVE's PLT_PLACE output) and the durations (for the 2006 corpus) were log transformed. To exclude extreme outliers, the standard deviations and means were calculated for F1 and F2 for each vowel class across all speakers and all tokens with values above or below two standard deviations from the mean were deleted.

Linear mixed-effect models were built using by-hand drop-one ANOVA comparisons of mixed effect logistic regression models built using *lme4* (Bates et al. 2014) in R. The dependent variables for all models were normalized F1 and F2 measurements (analyzed separately). The linguistic constraints in each initial maximal model included FOLLOWING PHONOLOGICAL context and LOG DURATION (for the 2006 data). The levels for the variable 'following' were modeled on those used in Cardoso et al. (to appear), and group (where relevant) PLACE, MANNER, and VOICING features into one factor: *lateral, nasal_apical, nasal_labial, nasal_velar, oral_apical, oral_labial, oral_vd_velar, oral_vl_velar, palatal,* and *pause*. The social constraints included in each initial maximal model depended on the dataset. All included a continuous factor of YOB (speaker year-of-birth), although this is treated with caution for the 2006 data given the ages of the speakers. Models included speaker (binary) GENDER and speaker (continuous) YEAR-OF-BIRTH as predictors, and a GENDER*YOB interaction effect where possible. In all models, random effects included SPEAKER and WORD intercepts (slopes rarely converged).

Note that the 2002 corpus is better suited than the 2006 corpus for studying the effects of *social* constraints because it has nine times as many speakers and is much better balanced for speaker year of birth. That said, the 2006 corpus is better suited than the 2002 corpus for studying the effects of *linguistic* constraints because the linguistic environments represented are much richer, and durations were not recorded in the 2002 data.

3 Results

Figure 2 shows the average vowel spaces for the two Flagstaff, Arizona corpora: '2002' (44 speakers interviewed by the first author; hand-extracted formants) and '2006' (5 speakers from *StoryCorps*; FAVE-extracted formants). Vowels that occur in the 2006 data but not in the 2002 data are excluded for purposes of comparison and presented instead in Figure 3.

Looking at Figure 2 we can see suggestive evidence for the beginnings of a BAT-BAN split of the sort that has been described in California. We also see a highly variable and rather fronted BOOT vowel (highly variable in large part because the preceding coronal environment is combined with other environments here). However, we see a less-fronted BOAT vowel than what had been described previously for Northern Arizona on a subset of these same 2002 data (Hall-Lew 2004, 2005). In general, the (2 StDev) ellipses are larger for 2002 than 2006, presumably because of the much larger number of speakers and greater range of demographic difference in the former. Aside from this, the two datasets show remarkably similar distributions, despite the major differences between them.

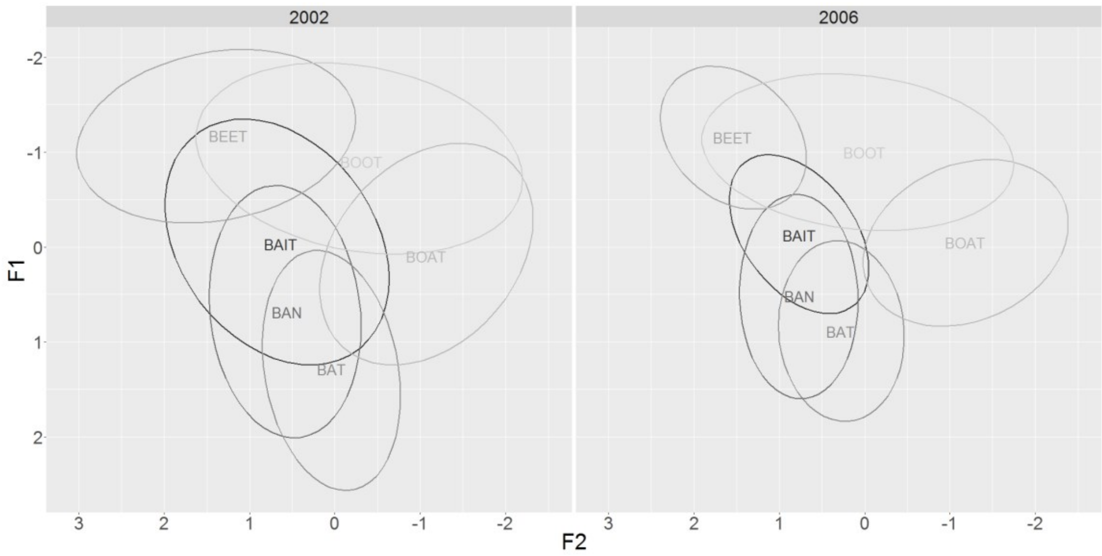

Figure 2: Vowel ellipses (2 StDevs) for the 2002 & 2006 corpora. Lobanov normalized formant values.

Figure 3 plots the vowels from the 2006 corpus by speaker, labelled by their year of birth. The speakers born from 1923-1927 represent the oldest speakers in this paper, and are[6] ‘Katherine’ (1923), whose grandparents settled in Flagstaff in the 1880s and was interviewed by a friend; ‘Margie’ (1926), who was interviewed by a student, and ‘Calvin’ (1927), who was interviewed by a *StoryCorps* representative. The speaker born in 1937, ‘Henry’, is a retired cattle rancher who was interviewed by his wife, and ‘Rob’ is the one young speaker in the corpus, born in 1987 and interviewed as a teenager by his mother. These FAVE-extracted data include the four vowels that were not coded for in the 2002 dataset: BIT, BET, BOT, and BOUGHT.

[6] The StoryCorps were released for research purposes to the research team in 2015. Although participants release non-anonymous data to StoryCorps, data were released for research purposes under conditions of anonymity, and therefore participants are referred to here by pseudonyms.

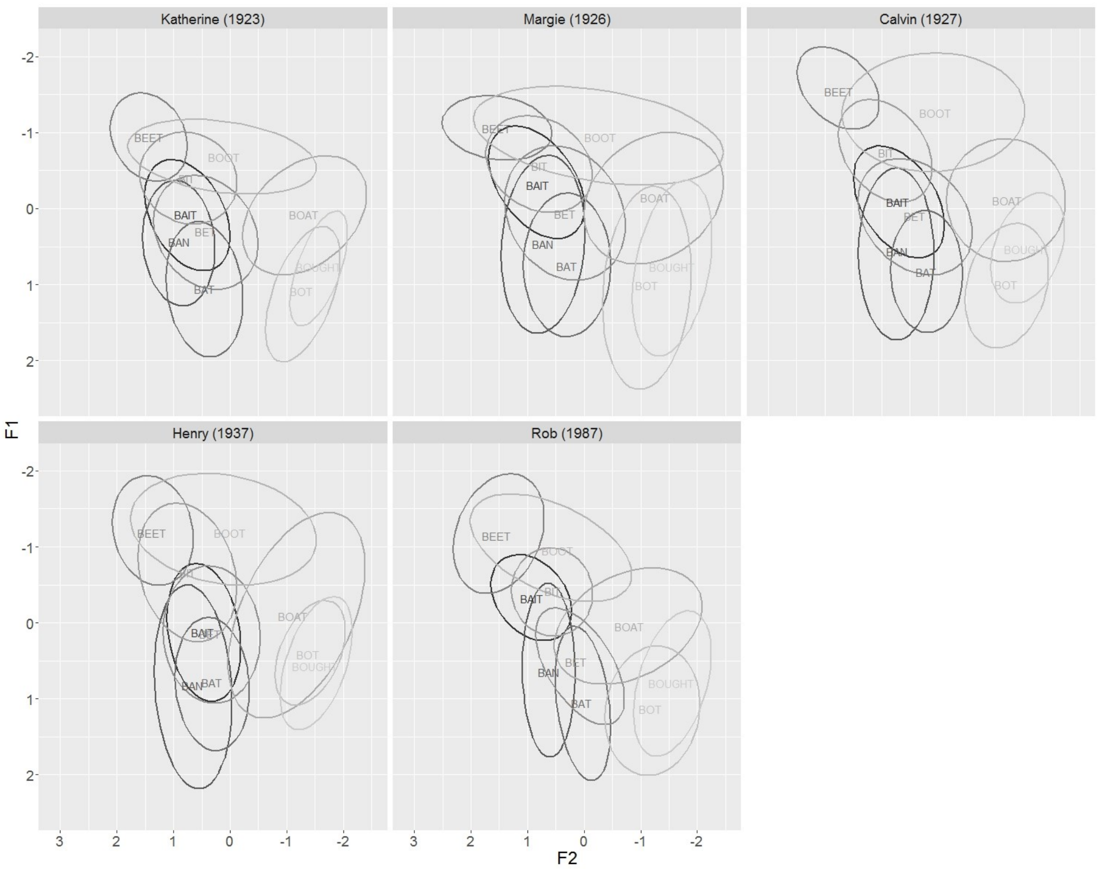

Figure 3: Vowel ellipses (2 StDevs) for the 2006 corpora, by speaker

Figure 3 shows some suggestive similarities and differences across these five speakers. All show a rather fronted BOOT vowel, suggesting that /uw/-fronting is a relatively old sound change. All speakers also show BAN and BAT to be overlapping, but not entirely. Katherine shows a surprisingly CVS-like BAN/BAT split which we return to later in the analysis. The women's high vowels appear generally lower (in the system) than the men's. Henry, unlike the other four speakers, seems to show a near complete overlap between BOT and BOUGHT. The fact that the low back near-merger is not a feature of the SVS suggests that ranchers' vowel systems are not straightforwardly 'Southern' ones. In contrast, Rob, who is 50 years younger than Henry, has a distribution of BOT and BOUGHT that indicates some distinction, which is perhaps surprising given his age.[7] Less surprising is that Rob has slightly fronter BOOT and BOAT than the other four speakers, which is in line with previous work (Hall-Lew 2004, 2005; Labov et al. 2006). Rob's BET vowel is noticeably lower and backer in the vowel space than it is for the older speakers, overlapping quite a bit with his BAT distribution while for the others it overlaps more with BAIT. The difference between Rob's BAN and BAT vowels seems relatively large as well. While these patterns seem to indicate parallels with Californian sound changes, with such a small number of speakers these findings are highly preliminary and call for further exploration.

[7] There are seven speakers represented for Arizona in the ANAE (Labov et al. 2006), one from Flagstaff, three from Phoenix, and three from Tucson. In terms of low back vowels, the Flagstaffian, one Phoenician, and two Tucsonans are classified as 'merged' in both production and perception; the other three speakers are classified as 'transitional'.

Recall that social factors are much better represented in the 2002 dataset while linguistic factors are much better represented in the 2006 dataset. Since the representation of linguistic factors is quite sparse and unbalanced for former, and the social factors are similarly sparse and unbalanced for the latter, both are excluded from the best-fit models of their respective datasets. Tables 3 presents the results from separate best-fit models built for each vowel formant for the 2002 dataset (social predictors only. Note that gender is coded as a binary factor, 'female' and 'male', and the intercept models have 'female' as their reference level. Only those factors with *p*-values less than 0.05 are included.

Table 3: Significant fixed effects in all best-fit models from the 2002 corpus of Northern Arizona English: Social factors (44 speakers, hand-coded formant data)

Vowel	**Formant**	**Fixed Effect**	**Estimate**	**StdError**	**t-value**	***p*-value**
BEET	F1	*n.s.*	--	--	--	--
	F2	*n.s.*	--	--	--	--
BAIT	F1	(Intercept)	32.146	14.215	2.262	0.024
		YOB	-0.016	0.007	-2.270	0.023
		gender	-30.023	15.169	-1.979	0.048
		YOB:gender	0.015	0.008	1.990	0.047
	F2	(Intercept)	0.860	0.075	11.456	< 0.001
		gender	-0.216	0.083	-2.612	0.009
BAN	F1	(Intercept)	16.148	6.561	2.461	0.014
		YOB	-0.008	0.003	-2.392	0.017
		gender	0.252	0.125	2.020	0.043
	F2	*n.s.*	--	--	--	--
BAT	F1	(Intercept)	-10.090	5.106	-1.976	0.048
		YOB	0.006	0.003	2.288	0.022
		gender	-0.217	0.097	-2.232	0.026
	F2	(Intercept)	15.370	2.787	5.514	< 0.001
		YOB	-0.008	0.001	-5.568	< 0.001
		gender	0.164	0.053	3.098	< 0.001

Table 3 shows that the social factors of speaker (binary) gender and speaker age (year of birth) influenced English vowel production in Northern Arizona in 2002-2003. These effects were usually independent but one case shows a small interaction effect. The results that are closest to resembling a classic sound change-in-progress, with young women leading the change, are for BAN and BAT. Women and younger speakers favor a higher BAN vowel and a lower BAT vowel, and young women also show a backer BAT vowel. However, social effects do not reach significance for how front or back BAN is, here.

We also find that BEET is stable with respect to social factors, but that BAIT is fronter among women than among men. The most interesting, unanticipated finding to emerge from these data is for BAIT height. Overall men have a slightly higher BAIT vowel than women, but crucially we find a apparent change-in-progress only among the women: younger women have a significantly higher BAIT vowel than older women. This finding aligns Northern Arizona with other newly emerging evidence of young women raising BAIT in Nevada, Inland California, Kansas, and Seattle, Washington (Fridland and Kendall, this volume; Van Hofwegen et al. 2016; Kohn and Stithem 2016; Wassink 2015). We will also see that, in the 2006 data, BAIT is highest before palatals and non-nasal apicals and lowest before /g/ and laterals.

FAVE-extraction of the *StoryCorps* corpus vowels allows for the modeling of the linguistic constraints. And although the social factors are not well represented, we can consider them cautiously for insight into future directions of research, especially for those vowels not represented in the 2002 dataset: BIT, BET, BOT, and BOUGHT. We can also draw comparisons between 2002 and 2006 for the other vowels. The results from the 2006 corpus are presented in Table 4a-4e. The intercept models are built with a following pause as the reference level for phonological environment.

Table 4a: Significant fixed effects in best-fit model for the BET vowel from the 2006 corpus of Northern Arizona English (5 speakers, FAVE-extracted data)

Vowel	Formant		Estimate	Std. Error	t value	p value
BET	F1	(Intercept)	136.763	21.680	6.308	< 0.001
		fol_apical	0.777	0.360	2.158	< 0.001
		fol_labial	0.815	0.361	2.259	< 0.001
		fol_lateral	0.861	0.362	2.376	< 0.001
		fol_nasal_apical	0.607	0.360	1.683	< 0.001
		fol_nasal_labial	0.631	0.364	1.732	< 0.001
		fol_palatal	0.783	0.375	2.086	< 0.001
		fol_vd_velar	0.844	0.390	2.160	< 0.001
		fol_vl_velar	0.990	0.364	2.719	< 0.001
		YOB	-0.071	0.011	-6.336	< 0.001
		gender	-150.739	21.762	-6.927	< 0.001
		YOB:gender	0.078	0.011	6.922	< 0.001
	F2	(Intercept)	54.700	22.005	2.486	0.013
		fol_apical	0.340	0.368	0.926	0.354
		fol_labial	0.408	0.368	1.109	0.267
		fol_lateral	0.194	0.371	0.523	0.601
		fol_nasal_apical	0.624	0.368	1.694	0.090
		fol_nasal_labial	0.490	0.372	1.317	0.188
		fol_palatal	0.659	0.387	1.703	0.089
		fol_vd_velar	0.628	0.404	1.553	0.120
		fol_vl_velar	0.400	0.374	1.069	0.285
		log-duration	1.076	0.098	10.987	<0.001
		YOB	-0.029	0.011	-2.435	0.015
		gender	-47.080	22.092	-2.131	0.033
		YOB:gender	0.024	0.011	2.130	0.033

In terms of placing Arizona relative to other regions in the Western US, there are some interesting effects of following phonological environment for BET and BAT

(Table 4a, 4b). The BET vowel is highest before nasals and is lowest before velars (there were no nasal velars in the data). The latter effect is opposite to the now famous pattern found in the Pacific Northwest, which shows pre-velar raising (e.g., Becker et al. to appear, Wassink to appear). It is also distinct from the San Francisco, California pattern, where BET before non-velar nasals is slightly lowered and before /g/ is slightly raised (Cardoso et al. to appear). With respect to F2, BET is furthest front before palatals and furthest back before laterals, as expected articulatorily. As for BAT (without BAN included), we see a somewhat similar pattern for height: BAT is highest before palatals, apicals, and laterals, and lowest before velars and labials. While this again opposite to the Pacific Northwest pre-velar raising pattern, we note that in the 2002 dataset BAT is actually highest before /g/. This is the finding for which the two corpora most obviously contradict one another, but recall that phonological environment is not well-represented in the 2002 corpus. In short, the status of pre-velar vowels deserves more attention in future work. With respect to F2, the 2006 data show that BAT is further front before palatals, apicals, and labials and further back before velars and laterals.

Table 4b: Significant fixed effects in best-fit models for BAN and BAT from the 2006 corpus of Northern Arizona English (5 speakers, FAVE-extracted data)

Vowel	Formant		Estimate	Std. Error	t value	p value
BAN	F1	(Intercept)	0.963	0.119	8.110	<0.001
		log-duration	0.423	0.104	4.078	<0.001
	F2	(Intercept)	48.776	16.620	2.935	0.003
		log-duration	0.595	0.058	10.251	<0.001
		YOB	-0.0247	0.009	-2.855	0.004
		gender	-45.830	16.620	-2.758	0.006
		YOB:gender	0.0238	0.009	2.752	0.006
BAT	F1	(Intercept)	175.491	125.916	1.394	<0.001
		fol_apical	0.312	0.223	1.398	<0.001
		fol_labial	0.511	0.227	2.254	<0.001
		fol_lateral	0.249	0.245	1.019	<0.001
		fol_palatal	0.253	0.235	1.077	<0.001
		fol_vd_velar	0.456	0.250	1.828	<0.001
		fol_vl_velar	0.569	0.228	2.498	<0.001
		log-duration	0.615	0.081	7.543	<0.001
		YOB	-0.091	0.065	-1.384	<0.001
		gender	-185.862	126.051	-1.474	<0.001
		YOB:gender	0.096	0.065	1.473	<0.001
	F2	(Intercept)	9.950	2.423	4.106	<0.001
		fol_apical	-0.429	0.186	-2.309	<0.001
		fol_labial	-0.410	0.189	-2.171	<0.001
		fol_lateral	-0.573	0.202	-2.836	<0.001
		fol_palatal	-0.461	0.192	-2.407	<0.001
		fol_vd_velar	-0.648	0.208	-3.115	<0.001

		fol_vl_velar	-0.620	0.190	-3.268	<0.001
		log-duration	0.546	0.060	9.038	<0.001
		YOB	-0.005	0.001	-3.621	<0.001

In general, vowel duration is a frequently significant and strong predictor of vowel quality, which is phonetically expected. When duration predicts variation in F2, the vowel is always more peripheral with longer durations. When duration predicts variation in F1, the vowel is always lower with longer durations. There are several cases where vowel duration obtains significance but following phonological environment does not, and some of these are a bit surprising. Previous work on English in San Francisco, for example, has found that BAN is lower before /m/ than before /n/ and /ŋ/ (Cardoso et al. to appear), and that BOT and BOUGHT are also influenced by the following phonological context (e.g., Hall-Lew 2013). Here we only see an effect for the F1 of BOT – following /g/ favors a higher vowel, following labials a lower vowel (Table 4c). In all other cases it appears that the effect of duration is so strong in these data as to override these factors. On the other hand, the lack of younger speakers in the sample might also have an influence, in that these effects of phonological environment are found for more advanced variants of those sound changes.

Table 4c: Significant fixed effects in best-fit models for BOT and BOUGHT from the 2006 corpus of Northern Arizona English (5 speakers, FAVE-extracted data)

Vowel	Formant		Estimate	Std. Error	t value	p value
BOT	F1	(Intercept)	1.397	0.286	4.885	<0.001
		fol_apical	0.212	0.250	0.846	<0.001
		fol_glottal	-0.110	0.487	-0.226	<0.001
		fol_labial	0.355	0.257	1.385	<0.001
		fol_lateral	0.064	0.262	0.245	<0.001
		fol_nasal_apical	0.087	0.256	0.341	<0.001
		fol_nasal_labial	-0.017	0.273	0.061	<0.001
		fol_palatal	0.316	0.293	1.078	<0.001
		fol_vd_velar	-0.192	0.317	-0.605	<0.001
		fol_vl_velar	0.308	0.266	1.159	<0.001
		log-duration	0.662	0.130	5.070	<0.001
	F2	(Intercept)	-1.649	0.084	-19.565	<0.001
		log-duration	-0.430	0.084	-5.101	<0.001
BOUGHT	F1	(Intercept)	1.052	0.143	7.382	<0.001
		log-duration	0.412	0.141	2.929	<0.001
	F2	(Intercept)	-1.837	0.087	-21.135	<0.001
		log-duration	-0.309	0.091	-3.409	<0.001

Comparing the results of social factors in both corpora (Tables 3 and 4), the effects are never exactly the same for any variable. For example, while BAT F1 is modeled by both speaker GENDER and YOB in both corpora, in the 2006 data there is a significant interaction effect between the two that is not there in the 2002 data. This, and the other corpus-based differences in social factors between models, are mostly likely due to one speaker, who is in fact the oldest speaker in the whole study: Katherine. Katherine seems to have what we would characterize as 'advanced' CVS vowels. For example, she has by far the furthest fronted BAN vowel out of all five speakers in the 2006 dataset. The possible reasons for this are beyond the scope of this paper, but because of her consistently unusual production patterns, and because she is one of only two women in the 2006 corpus, five separate GENDER*YOB interaction effects emerge showing that 'older women' (N=1, Katherine) and 'younger men' (N=1, Rob) show significantly advanced variants: BIT F1, BET F1 and F2, BAN F2, and BAT F1. While we are able to defer to the 2002 corpus for better understanding of the social effects on BAN and BAT, neither BIT nor BET are represented in those data. Therefore, although the backing and lowering of BIT and BET seem to align Northern Arizona English with previously observed patterns in California, the results are still only suggestive at this stage. Neither speaker gender nor speaker age was a significant predictor of BOT or BOUGHT variation, which is again left for future research. Finally, note that neither social predictor correlates with BAIT variation either; given that the change identified in the 2002 data, like most sound changes-in-progress, was led by young women, the lack of young women in these data may be one reason.

Table 4d: Significant fixed effects in best-fit models for the BEET vowel from the 2006 corpus of Northern Arizona English (5 speakers, FAVE-extracted data)

Vowel	Formant		Estimate	Std. Error	t value	p value
BEET	F1	(Intercept)	-0.979	0.130	-7.506	< 0.001
		fol_apical	-0.034	0.032	-1.070	< 0.001
		fol_glottal	0.057	0.040	1.403	< 0.001
		fol_labial	-0.039	0.040	-0.968	< 0.001
		fol_lateral	0.073	0.045	1.639	< 0.001
		fol_nasal_apical	0.124	0.044	2.803	< 0.001
		fol_nasal_labial	0.044	0.053	0.835	< 0.001
		fol_palatal	-0.100	0.047	-2.138	< 0.001
		fol_vd_velar	0.012	0.068	0.173	< 0.001
		fol_vl_velar	0.029	0.044	0.659	< 0.001
		gender	-0.312	0.164	-1.899	< 0.001
	F2	(Intercept)	2.101	0.105	20.047	<0.001
		fol_apical	0.020	0.046	0.423	0.672
		fol_glottal	0.090	0.055	1.652	0.098
		fol_labial	-0.028	0.058	-0.481	0.630
		fol_lateral	-0.186	0.062	-3.013	0.003
		fol_nasal_apical	0.100	0.064	1.573	0.116
		fol_nasal_labial	0.015	0.074	0.196	0.844
		fol_palatal	0.116	0.068	1.708	0.088
		fol_vd_velar	0.085	0.090	0.942	0.346
		fol_vl_velar	0.108	0.062	1.742	0.082
		log-duration	0.656	0.076	8.578	<0.001

Table 4e: Significant fixed effects in best-fit models for BIT and BAIT from the 2006 corpus of Northern Arizona English (5 speakers, FAVE-extracted data)

Vowel	Formant		Estimate	Std. Error	t value	p value
BIT	F1	(Intercept)	100.439	17.023	5.900	< 0.001
		YOB	-0.052	0.009	-5.927	< 0.001
		gender	-111.375	17.066	-6.526	< 0.001
		YOB:gender	0.058	0.009	6.512	< 0.001
	F2	(Intercept)	9.126	3.115	2.930	0.003
		log-duration	0.669	0.079	8.472	<0.001
		YOB	-0.004	0.002	-2.475	0.013
BAIT	F1	(Intercept)	0.574	0.114	5.050	< 0.001
		fol_apical	-0.152	0.051	-2.963	< 0.001
		fol_glottal	0.180	0.073	2.469	< 0.001
		fol_labial	-0.082	0.059	-1.386	< 0.001
		fol_lateral	-0.055	0.083	-0.657	< 0.001
		fol_nasal_apical	0.095	0.068	1.395	< 0.001
		fol_nasal_labial	-0.069	0.069	-0.996	< 0.001
		fol_palatal	-0.150	0.065	-2.300	< 0.001
		fol_vd_velar	-0.118	0.158	-0.746	< 0.001
		fol_vl_velar	0.061	0.070	0.867	< 0.001
		log-duration	0.633	0.079	8.010	< 0.001
	F2	*n.s.*	--	--	--	--

Table 5 presents the results with respect to the predictions in Table 1, glossing over the specific differences between F1 and F2 in order to talk about the changes more generally.

Table 5: Prediction matching for Northern Arizona English vowels by corpus (year); 'yes'/'no' answer: "Do the data fit the predictions?"

Vowel	CVS predictions	2002	2006	SVS predictions	2002	2006
BEET	stable	Yes	Yes	lowering/backing	No	No
BIT	lowering/backing	*N/A*	Yes	raising/fronting	*N/A*	No
BAIT	stable	No	Yes	lowering/backing	No	No
BET	lowering/backing	*N/A*	Yes	raising/fronting	*N/A*	No
BAN	raising/fronting, away from BAT	Yes	Yes	raising/fronting, like BAT,	No	No
BAT	lowering/backing, away from BAN	Yes	Yes	raising/fronting, like BAN	No	No
BOT	raising *or* stable	*N/A*	stable	stable	*N/A*	stable
BOUGHT	lowering/fronting *or* stable	*N/A*	stable	stable	*N/A*	stable

Overall, in line with our expectations about parallels with California sound changes, BEET does not vary with speaker year-of-birth, while BIT, BET, BAN, and BAT do. The changes all go in the direction expected, with women and/or younger speakers leading the shifts in the direction previously described for Californian Englishes. More data are needed for BIT and BET, however. Also, contrary to our expectations, neither BOT nor BOUGHT correlates with speaker year-of-birth; the status of that near-merger awaits further analysis with a larger dataset. Meanwhile, BAIT, which we expected to be stable, does show a possible apparent time trend: in Northern Arizona, younger women in 2002 were producing a significantly more raised BAIT vowel than older women.

4 Discussion

The present paper took an unusual approach in utilizing two different data sources to ask the same research question: What is the vowel system of Northern Arizona? On the one hand there are data from 44 speakers collected in 2002-2003, with vowel formant measurements collected by hand in 2003-2004, and on the other hand there are data from just five speakers collected in 2005-2006, with vowel formant measurements obtained by *FAVE-extract* in 2016. The comparison between the two is further complicated in that neither dataset is balanced in terms of speaker year-of-birth or gender, and that they are imbalanced in different ways. And since the 2006 dataset has significantly fewer speakers generally, the social factors in that corpus amount to just one or two speakers per 'group'. Even then, the 'young' group is entirely represented by the one speaker born in 1987: there are no young women in the *StoryCorps* dataset, which in part reflects the recording goals of an oral history project (e.g., seeking interviewees who have led full or otherwise exceptional lives means that fewer young speakers are sampled overall). Despite these differences, the general picture of the vowel space is quite similar when averaged across speakers (Figure 2). The direction of predictors was only very different between the corpora for BAT F1. The main weakness in the models of the 2002 data was the lack of vowel duration information. This, in addition to the limited representation of phonological environments, means that although the 2002 corpus is better for modeling social factors than the 2006 corpus, the effect of those factors is likely to be mitigated by internal factors in a way not captured by the models we have presented.

Overall, although the results are quite varied, we have some evidence to address our initial predictions. Based on known settlement patterns as well as previous research, we predicted that the vowels of Flagstaff, Arizona, would evidence a shift from older, 'Southern' patterns to newer, 'Californian' patterns. The picture with respect to the Southern Vowel Shift needs more data, and calls for further study. However the data do show some of the effects that we would expect with respect to Californian comparisons: according to the 2002 data, BAT was lowering and backing, and BAN was raising, and in all cases, women were the leaders of those changes. According to the 2006 data, BET and BIT were lowering and backing, BAT was lowering and backing, and BAN was fronting. These results are all consistent with patterns described in data from California. In contrast, we had expected to see change in either BOT or BOUGHT, or both, but the results were inconclusive. In addition, we found some unexpected patterns for vowels expected to be stable: both BEET and BAIT correlate with gender, with BEET being lower but fronter for women and BAIT higher and fronter for women. While neither formant of either vowel correlated with year-of-birth, we did find that BAIT is higher among younger than older women, in line with recent studies elsewhere in the Inland West and Pacific Northwest, perhaps pointing to the beginnings of a new sound change in this region.

Many of these questions could be answered more firmly with a larger, balanced dataset. A starting point would be FAVE-extracting the 2002 data in order to compare all vowels (especially BIT, BET, BOT, and BOUGHT) to the 2006 dataset on all measurements (including duration). Another future direction is to augment the 2006 data with more of the 168 other interviews recorded by *StoryCorps* in the state of Arizona, some of which include speakers born and raised in other parts of (Northern) Arizona outside of Flagstaff. That said, the variation we see here with respect to YOB and gender is in line with the results from similar studies in California (Kennedy and Grama 2012; Hall-Lew et al. 2015a; Cardoso et al. to appear), which show both vowels lowering and backing in apparent time. We take these results as suggestive evidence that Arizona was participating in these same changes as early as the mid-20th century, suggesting that the 'California' Vowel Shift extends beyond California (Becker et al. to appear; Hall-Lew 2004, 2005; McLarty et al. to appear).

5 Conclusions

This chapter has demonstrated how the vocalic system of Northern Arizona shows a number of interesting features that point to the position of the region relative to the rest of the Western US. While previous research had suggested possible evidence of 'Southern' vowel features in the speech of older and ranch-affiliated speakers, data in the present chapter are inconclusive. Data on the low back vowels are also inconclusive. More suggestive are results showing a number of features that have been previously described for Californian varieties of English: the lowering of the BIT and BET vowels and the split between /æ/ before nasals (BAN) and elsewhere (BAT). These data are based on speech recorded between 2002-2006, and future work should consider updated recordings, a more socially balanced dataset, and data from other areas of the state of Arizona.

6 References

Babbit, James E. and John G. DeGraff III. 2009. *Images of America: Flagstaff.* Charleston, SC: Arcadia Publishing.

Baranowski, Maciej. 2008. "The fronting of the back upgliding vowels in Charleston, South Carolina." *Language Variation and Change* 20: 527–551. Accessed February 12, 2016. doi: 10.1017/S0954394508000136

Becker, Kara, Anna Aden, Katelyn Best, and Haley Jacobson. To appear, 2016. "Variation in West Coast English: The Case of Oregon." In *Speech of the West: Vol. 1.*, edited by Betsy Evans, Valerie Fridland, Tyler Kendall, and Alicia Wassink. Durham: Duke University Press.

Cardoso, Amanda, Lauren Hall-Lew, Yova Kementchedjhieva and Ruaridh Purse. To appear, 2016. "Between California and the Pacific Northwest: The Front Lax Vowels in San Francisco English." In *Speech of the West: Vol. 1.*, edited by Betsy Evans, Valerie Fridland, Tyler Kendall, and Alicia Wassink. Durham: Duke University Press.

Carver, Craig M. 1987. *American regional dialects: A word geography*. Ann Arbor: University of Michigan Press.

Cline, Platt. 1994. *Mountain Town: Flagstaff's First Century.* Flagstaff, AZ: Northland Publishing.
Cline, Platt. 1976. *They Came to the Mountain: The Story of Flagstaff's Beginning.* Flagstaff, AZ: Northland Publishing.
D'Onofrio, Annette, Penelope Eckert, Robert J. Podesva, Teresa Pratt, and Janneke Van Hofwegen. To appear, 2016. "The Low Vowels in California's Central Valley." In *Speech of the West: Vol. 1.*, edited by Betsy Evans, Valerie Fridland, Tyler Kendall, and Alicia Wassink. Durham: Duke University Press.
Dodsworth, Robin and Mary Kohn. 2012. "Urban rejection of the vernacular: The SVS undone." *Language Variation and Change* 24(2): 221-245. Accessed February 12, 2016. doi: 10.1017/S0954394512000105
Eckert, Penelope. 2004. *Vowel Shifts in Northern California and the Detroit Suburbs: Northern California Vowels.* http://web.stanford.edu/~eckert/vowels.html
Eckert, Penelope. 2008. "Where do ethnolects stop?" *International Journal of Bilingualism* 12(1&2): 25–42. Accessed February 12, 2016. doi: 10.1177/13670069080120010301
Feagin, Crawford. 2003. "Vowel Shifting in the Southern States." In *English in the Southern United States,* edited by Stephen J. Nagle, Sarah L. Sanders. Cambridge: Cambridge University Press.
Fridland, Valerie and Tyler Kendall. To appear, 2017. "Speech in the Silver State." In *Speech of the West: Vol. 2.*, edited by Valerie Fridland, Alicia Wassink, Tyler Kendall, and Betsy Evans. Durham: Duke University Press.
Hall-Lew, Lauren. 2004. "The Western Vowel Shift in Northern Arizona." Qualifying Paper, Stanford University, Stanford, CA.
Hall-Lew, Lauren. 2005. "One Shift, Two Groups: When fronting alone is not enough." *University of Philadelphia Working Papers in Linguistics 10.2: Selected Papers from NWAVE 32.*
Hall-Lew, Lauren, Amanda Cardoso, Yova Kemenchedjieva, Kieran Wilson, Ruaridh Purse, and Julie Saigusa. 2015(a). "San Francisco English and the California Vowel Shift." *Publication of the 18th International Conference of the Phonetic Sciences (ICPhS XVIII).* Glasgow, UK.
Hall-Lew, Lauren, Mirjam Eiswirth, Mary-Caitlyn Valentinsson, and Wiliam Cotter. 2015(b). "Northern Arizona: Sound Change and Dialect Contact." Presented at *New Ways of Analyzing Variation 44 (NWAV44)*, 22–25 October, Toronto, Canada.
Kennedy, Robert, and James Grama. 2012. "Chain Shifting and Centralization in California Vowels: an acoustic analysis." *American Speech* 87(1): 39–56. Accessed February 12, 2016. doi: 10.1215/00031283-1599950
Kohn, Mary and Carly Stithem. 2016. "H/o/me on the range: Back vowel fronting in Kansas." Paper presented at the 2016 American Dialect Society Meeting, Washington, D.C.
Koops, Christian. 2010. "/u/-Fronting is not Monolithic: Two Types of Fronted /u/ in Houston Anglos." *University of Pennsylvania Working Papers in Linguistics 16.2: Selected Papers from NWAV 38.* 16.2: 113-122. Accessed February 12, 2016. http://repository.upenn.edu/pwpl/vol16/iss2/14/
Koops, Christian. 2014. "Iconization and the timing of Southern vowels: A case study of/æ/." *University of Pennsylvania Working Papers in Linguistics* 20(2), 10. Accessed February 12, 2016. http://repository.upenn.edu/pwpl/vol20/iss2/10/
Labov, William. 1994. *Principles of linguistic change, vol. 1: Internal factors*. Oxford: Blackwell.
Labov, William, Sharon Ash, and Charles Boberg. 2006. *The Atlas of North American English: phonetics, phonology, and sound change: a multimedia reference tool*. Berlin: Mouton.
Mangum, Richard and Sherry Mangum. 2003. *Flagstaff: Past and Present.* Flagstaff, AZ: Northland Publishing.
McLarty, Jason, Tyler Kendall, and Charlie Farrington. to appear, 2016. "Investigating the development of the contemporary Oregonian English vowel system." In *Speech of the*

West: Vol. 1., edited by Betsy Evans, Valerie Fridland, Tyler Kendall, and Alicia Wassink. Durham: Duke University Press.

Moffatt, Riley. 1996. *Population History of Western U.S. Cities & Towns, 1850-1990*. Lanham: Scarecrow.

Podesva, Robert. J. 2011. "The California Vowel Shift and Gay Identity." *American Speech* 86(1): 32–51. Accessed February 12, 2016. doi: 10.1215/00031283-1277501

Podesva, Robert. J., Annette D'Onofrio, Janneke Van Hofwegen, and Seung Kyung Kim. 2015. "Country ideology and the California vowel shift." *Language Variation and Change* 27: 157–186. Accessed February 12, 2016. doi: 10.1017/S095439451500006X

Schilling-Estes, Natalie. 1998. "Investigating "self-conscious" speech: The performance register in Ocracoke English." *Language in Society* 27(1): 53–83. Accessed February 12, 2016. doi: 10.1017/S0047404500019722

Sheridan, Thomas. 1995. *Arizona: A history*. Tucson: The University of Arizona Press.

Van Hofwegan, Janneke, Teresa Pratt and Annette D'Onofrio. 2016. "Retraction in the front vowel system of California's Central Valley." Paper presented at the 2016 American Dialect Society Meeting, Washington, D.C.

Wassink, Alicia. 2015. Sociolinguistic Patterns in Seattle English. *Language Variation and Change* 27(1), 31–58.

Wassink, Alicia. To appear, 2016. "The Vowels of Washington State." In *Speech of the West: Vol. 1.,* edited by Betsy Evans, Valerie Fridland, Tyler Kendall, and Alicia Wassink. Durham: Duke University Press.