THE TSUUT'INA VOCALIC SYSTEM

SANTIAGO BARREDA
University of Alberta

1 Introduction

Tsuut'ina (sometimes referred to as Sarcee or Sarsi) is an Athapaskan language spoken mainly by residents of the Tsuut'ina Nation, a native reserve located approximately 30 km southwest of Calgary, Alberta. Although the exact number of speakers is not known, it is a highly endangered language with only a handful of fluent speakers, the majority of which are over the age of 50. Cook (1984) estimated that there were several dozen native speakers of Tsuut'ina, all in their 40s and 50s, residing on the Tsuut'ina reserve and that the total population of the reserve was approximately 700 people.

At the time of the 2001 Canada census, the population of the Tsuut'ina reserve was 1,982; and increase of almost 500 over the 1996 population. Only 196 residents are under the age of 5, suggesting that the increase in population is fueled mostly by the movement of people into the community. The census indicates that 230 residents are 55 or older and 210 residents have a first language other than English or French. The correspondence of these numbers reinforces the observation made by people who work with speakers of the language that its speakers tend to be older. This is not to suggest that all 210 residents with a first language other than English or French speak Tsuut'ina, or that there are no speakers of Tsuut'ina living in other communities, but it does offer a ceiling for estimating the number of speakers of the language in the community with the highest concentration of speakers. Additionally, since the increase in population was fueled mostly by an influx of residents, it seems reasonable to think that some of these people might have been Tsuut'ina speakers, thereby increasing the number of speakers on the reserve.

It is extremely difficult to find any information on the Tsuut'ina language. In a study of Tsuut'ina verb stems, Li (1930) briefly discusses the vocalic system of Tsuut'ina and claims that the language has a four vowel system consisting of vowels similar to those in the English words *it*, *put*, *law* and a velarized version of the final vowel. In her extensive review of literature on the indigenous languages of North America, Mithun (1999) cites mostly the work of Eung-Do Cook when discussing Tsuut'ina. The culmination of Cook's work with Tsuut'ina is an extensive

grammar of the language published in 1984. Cook (1984) suggests that the Tsuut'ina vocalic system consists of four vowels: / i, a, o, u /. Cook states that the front vowel in Tsuut'ina is a front high vowel that it tends to be lowered to / e / or / ɛ /, and that "the nearer to final position the syllable is, the more likely [the lowering rule] is to apply" (16).

Although the analysis provided by Cook is very thorough in some places, the grammar's treatment of the vocalic system has some shortcomings. The grammar does not provide any acoustic information regarding the vowels of the language and refers to them using only symbols which are themselves not rigorously defined. The purpose of this paper is to investigate the vocalic system of Tsuut'ina. This study will limit itself to a description of steady-state properties of the vowels with the intention of arriving at a basic description of the size and organization of the vocalic system. Some possible phonological effects will also be considered. Finally, there will be a brief examination of a possible tone or pitch accent system.

2 Data Collection

An adult male speaker, HC, participated in an interview session on two separate days. Excerpts corresponding to roughly the first 30 minutes of each session were used for this paper. Formant frequencies (F1, F2, F3) and f0 were collected from the midpoint of each vowel in the recordings. All vowels were plotted according to their F1 and F2 values, as demonstrated in Figure 1. A visual inspection suggested that there were between 3 and 4 vowel phonemes in Tsuut'ina: a front vowel, a back vowel and one or two low vowels (the low vowel looks a bit like two, almond-shaped distributions that meet on F2).

In order to assume as little as possible about the Tsuut'ina vocalic system, all vowels were coded as belonging to one of three possible vowel categories. All front vowels were labeled *i*, all low vowels were labeled *a* and all back vowels were labeled *u*. The general vowel category a token belonged to was determined by jointly considering Tsuut'ina orthography (if available), and the author's impressions of the vowels.

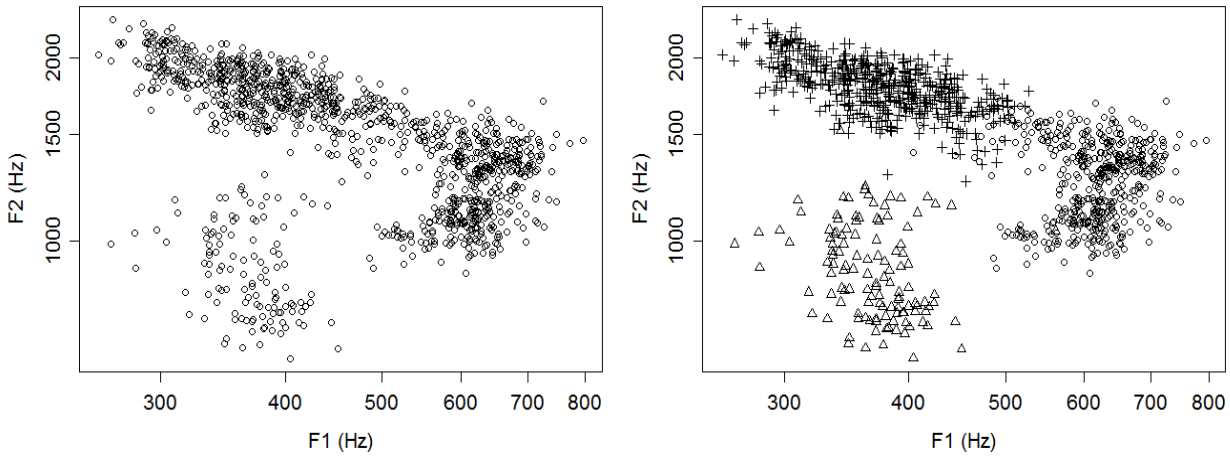

Figure 1 –All vowel tokens collected for speaker HC. In the right panel, vowels are labeled according to gross type: low vowel 'a' (circle), front vowel 'i' (cross), back vowel 'u' (triangle).

All vowels were plotted on an F1-F2 plane, labeled according to their general vowel category. The plot was inspected visually to see if there were any tokens that were dramatically different from vowels of the same category. Most measurement errors were a result of overly breathy, whispered, quiet or muttered vowels. This is partly a result of the way in which the data was collected, with the speaker frequently searching for the correct word or form. All words containing at least one vowel from which measurements could not be reliably collected were removed from the analysis. Words containing vowels with 'inconvenient' but accurate measurements were left in.

3 Analysis

The analysis will proceed in the following manner: Section 3.1 will offer an overview of the vocalic system, first generally and then for each vowel category in turn. Section 3.2 will offer a brief look at the possible tone system in light of the data collected.

3.1 Overview of the vocalic system

A total of 1118 vowels were collected in total, across both sessions. The distribution of these vowels across sessions and vowel types can be seen in Table 1. The distribution of vowel tokens within each session can be thought of as a (nearly-)random sample of the vowels of the language and, because of this, should approximate the true distribution of vowels in the language with a good degree of accuracy. As seen in Table 1, there is basically the same distribution of vowel categories within each of the two sessions, save for the more frequent occurrence of *u* in the second session.

	Session 1	**Session 2**	**Total**	**Single-word**
i	282 (50%)	247 (44%)	529 (47%)	132 (48%)
a	242 (43%)	226 (40.6%)	468 (42%)	119 (43%)
u	37 (6.6%)	84 (15%)	121 (11%)	24 (8.7%)
Total	561	557	**1118**	275

Table 1 –Number of occurrences of each category, split by session. Percentages are the proportion of tokens of a type in a column. The single-word column counts vowels only once for each unique word, ignoring repetitions.

Deviation from true random sampling is introduced, in part, by the fact that some words were repeated more than others, and the number of repetitions of each word varied across sessions. To correct for this, instances of each vowel were counted only once for each unique word across both sessions. The result of this is presented in the Single-word column of Table 1. The single-word vowel ratios are very close to the overall ratios. This suggests that the under-representation

of back vowels in the language seems to be an inherent property of the language and not a chance occurrence.

3.1.1 Front Vowels

To see if the front vowel in Tsuut'ina has a relatively higher F1 (meaning it is a lower vowel) when it is nearer to the end of the word, all front vowels were given a score corresponding to how far (in syllables) they appeared from the final syllable of the word. This will be referred to as the end-distance. As seen in Table 2, the number of front vowels with and end-distance of 3 is much smaller than the number of vowels with an end-distance of 2. Furthermore, the number of unique words which contain these tokens tends to be quite small for end-distances higher than 2. Finally, vowels with end-distances higher than 2 make up only 5% of all front vowels (26 out of 529). In order to prevent drawing conclusions from very small samples, only front vowels with end-distances of 2 or less were considered in the rest of this section (503 of 529, 95%).

	End-distance						
	0	1	2	3	4	5	6
# of Front vowels	168	244	91	13	3	8	2
# of Unique words	41	56	24	4	2	3	1

Table 2 - Number of front vowels at each end-distance. Number of unique words refers to the number words which have at least one vowel with a given end-distance.

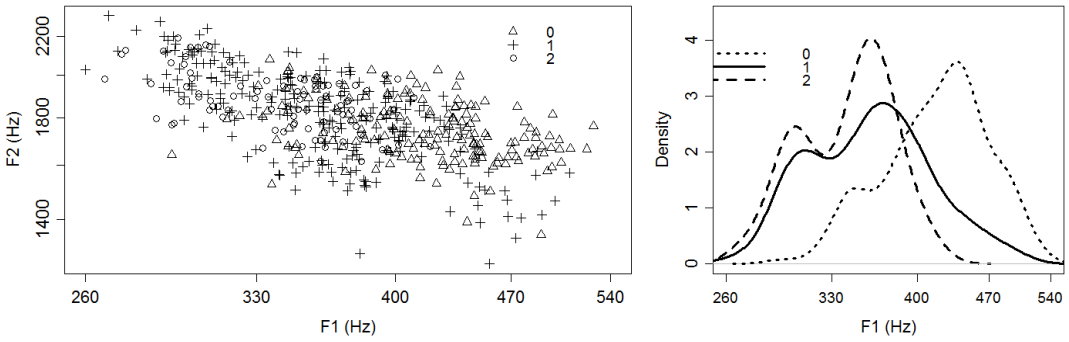

Figure 3 – Left Panel: Front vowels plotted according to their distance from the end of the word. Zero syllables from end (triangles), one syllable from end (crosses) and two syllables from the end (circles). Right Panel: Kernel density plots of vowels, grouped by distance from the end of the word (in syllables).

Figure 3 shows the Tsuut'ina front vowels plotted on F1-F2 and labeled according to their end-distance. Vowels at the end of words (triangles), tend to have higher F1s than vowels two syllables from the end of a word (circles). The right panel of Figure 3 presents kernel density estimates for vowel F1, grouped by end-distance. The densities of vowels with end-distances of 1 and 2 overlap to a great extent, however, the distribution of word final vowels (end distance = 0)

is higher along F1. Both of these observations support the claim that the Tsuut'ina front vowel tends to get lowered when it is nearer to the end of the word. Another possibility is that, rather than being progressively lower as they are found closer to the end of the word, there is simply a phonological distinction between word-final and non-word-final vowels.

In order to test this, a series of linear mixed-effects model was fit to each vowel's F1 frequency. The word which included the vowel and the unique repetition of the word were included in all models as random effects. The models differed from each other only in terms of their fixed effects. Random slopes and intercepts were calculated for all fixed effects for all models. The first model was an intercept-only model. This model will be able to account for random differences in F1 resulting from the word and repetition a vowel is found in, but not for any variation resulting from the position of the vowel in the word. This will be the best-fitting model if the Tsuut-ina front vowel shows no systematic variation of front vowel F1 by word-position. The second model included an intercept term and also information regarding whether the vowel was word-final or not. This will be the best-fitting model if front vowels tend to be lowered in final position, but there is no progressive lowering of vowels as they approach the end of the word. The final model included an intercept, and information about the exact distance between the vowel and the end of the word, measured in syllables (end-distance). This will be the best-fitting model if front vowels get progressively lower when they are nearer to the end of the word. A comparison of these three models is provided in Table 3.

Model fixed-effects	**AIC**	**Log Likelihood**	**d.f**	**P value**
Intercept only	5268	-2630.0	4	--
Intercept + final vowel	4958	-2470.1	9	<.00001
Intercept + end distance	4905	-2436.5	16	<.00001

Table 3 - Comparison of three models fit to front vowel F1 frequencies. Differing fixed-effects between models are described in the table. In all cases, random-effects are word and repetition. P values result from likelihood ratio tests.

The model which predicts front-vowels F1 frequency on the basis of the distance between the vowel and the end of the word provides a significantly better fit than any of the other models. These results confirm Cook's (1984) assertion the front vowel is significantly lowered as it gets closer to the end of the word, and that this process is gradual, rather than a final vs. non-final vowel distinction.

3.1.2 Low Vowels

To determine whether Tsuut'ina has more than one low vowel phoneme, the mass of low vowels was divided into two groups, those that had a F2 higher than 1212 Hz, the *a*-group, and those that had a F2 lower than 1212 Hz, the *o*-group[1]. A vertical line showing this split is plotted in

[1] The seemingly odd value of 1212 Hz was initially set when viewing the vowels in a log Hertz space. 1212 Hz has a natural logarithm of 7.1. This value was meant to provisionally set the boundary between the two masses of vowels but ended up providing good separation of the two hypothesized low-vowel categories.

each panel of Figure 4. This line was chosen because it visually bisects the mass of low vowels. For the sake of brevity, low vowels with a F2 higher than 1212 Hz will be referred to as *a* while those with a F2 lower than 1212 Hz will be referred to as *o*. Figure 4 plots the low vowels with F1 along the y-axis and F2 along the x-axis. The first two formants were represented on different axes for this chart to maximize the difference between the two hypothesized clusters given that they vary mostly along F2. The bottom panel of Figure 4 shows the density of all low vowels along F2. The vowels are distributed bimodally in a manner which supports the notion that could there are two separate, low-vowel phonemes.

To test whether the low vowels sampled could be said to come from two different phoneme populations, I looked at which words contained each of the two hypothesized vowels, *a* and *o*. The reasoning behind this was that if the sets of words that contained each of the two low vowels were disjoint then they could be said to belong to separate categories. In the case where one word contained two low vowels, if any given vowel belongs to either one or the other set on a consistent basis then two low vowel categories would also be supported.

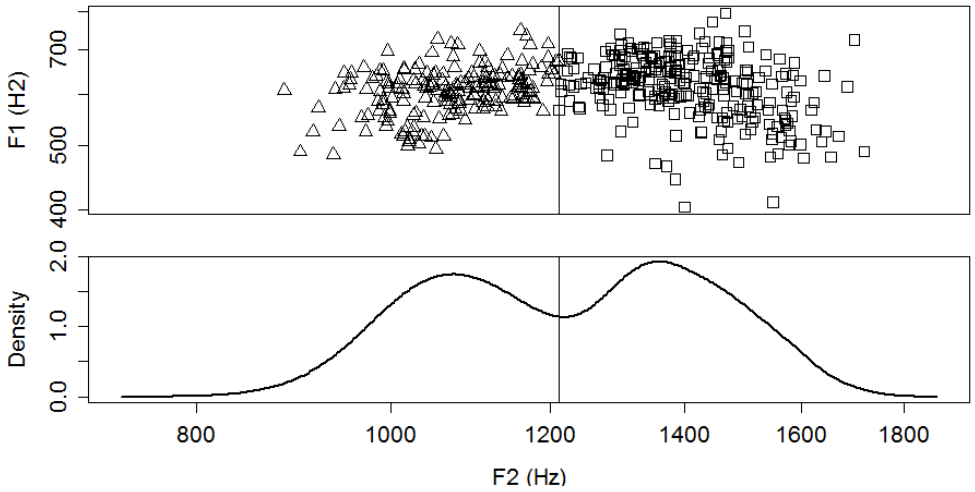

Figure 4 – Top Panel: Low vowels plotted with a tentative phonemic dividing line at F2 = 1212. Vowels with F2s lower than this have been indicated with triangles, those with higher F2s with squares. Hz. Bottom Panel: Kernel density estimates of values of F2 for low vowels with the same tentative phonemic dividing line at 1212 Hz.

Lists were created of all the unique words contained which contained at least one instance of either *a* or *o*. These two lists were compared yielding three different classes of words: 38 which only contain *a*, 15 which only contain *o*, and 25 which contain both vowels. Only ten of the 25 words that contain both *a* and *o* were repeated at least three times; these are presented in Table 4. Words will be presented using Tsuut'ina orthography, which is based on English orthography. Tsuu'tina words presented as examples will not be glossed for the most part.

The words in Table 4 can be split into two classes: those that show a clear preference for either *o* or *a* and those that show variation between the two. The first group has been placed on the left side of Table 4 while the second group has been placed on the right side of the Table. To investigate this variation further, the five words which exhibit low-vowel variation were plotted so that this variation could be investigated visually. Only the low vowels within each word were

plotted and the vowels were labeled with numbers that correspond to the syllable in which the vowel is found. This was done to see if words that contained multiple low vowels had a clear preference for one vowel to be *o* and for another to be *a*. Additionally, a horizontal line was placed at 1212 Hz. These plots are presented in Figure 5.

	a	**o**		**a**	**o**
dasha	1	10	sinahanilada	15	5
disha	1	11	nik'ada	14	12
nasaa	9	1	nahila	3	3
nitsit'a	1	3	nina	3	5
siza	4	1	tsa	10	6

Table 4 – All words containing both /a/ and /o/ that were repeated at least three times.

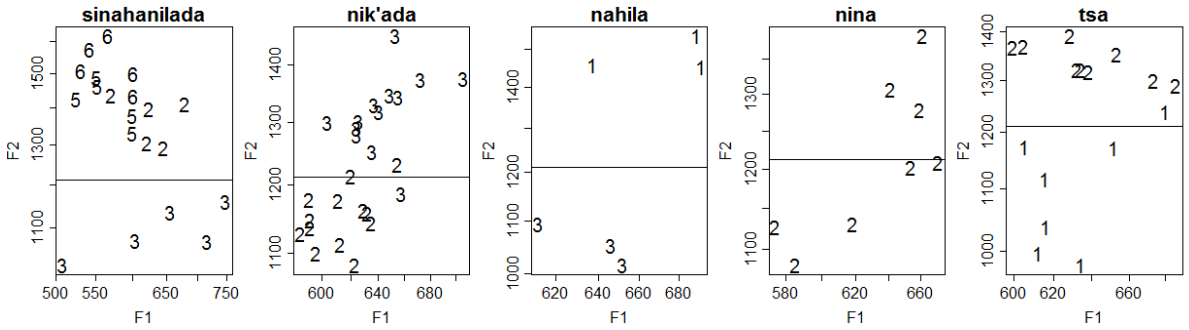

Figure 5 – Plots of the low vowels for multiple repetitions of selected words. In the first four panels, labels correspond to the syllable a vowel is found in, counting from the beginning of the word. In the final panel, labels correspond to the session in which the vowel was collected.

The first three words, *sinahanilada*, *nik'ada* and *nahila* show clear preferences for one vowel or another in specific syllable positions. The case of *sinahanilada* is particularly interesting because a vowel in the middle of the word is consistently different, over five repetitions, from the other three low vowels that surround it. Furthermore, *nik'ada* preferentially has an *a* in final position while *nahila* preferentially has an *o* in final position. These three words taken together offer strong evidence that there are two different low-vowel phonemes in Tsuut'ina.

The fourth pane in Figure 5, containing the word *nina*, does not show a clear preference for either *a* or *o*. This word is also the only word containing a long final vowel. Inspection of spectrograms reveals no significant movement of the second formant during most of the vowel's duration. Although the vowels tend to have a significantly higher, initial second formant (1500 Hz) this quickly falls and remains stable at approximately 1212 Hz. There are several possible explanations for this. Long, low-vowels in Tsuut'ina, might have a natural F2 that is between those that might be expected of short *o* and *a*. Another possibility is that the latter part of the long vowel might be intended to be an *o* and might remain in acoustic territory that would normally be considered *a* as a result of undershoot; it might sound more *o*-like in comparison to the initial position of the vowel making more movement unnecessary.

The final word in Figure 5, *tsa*, might at first seem to go against the idea that there are two low vowel phonemes in Tsuut'ina. However, repetitions of this word are actually made up of two similar words, *tsa*, which means 'ear' and *tso* which means 'hair'. Instances of the low vowels in the final pane of Figure 4 have been coded according to the session in which they were collected. The majority of instances of this word that contain an *o*-like vowel come from the first session and were recorded in succession. All words that contain an *a*-like vowel come from the second session and also come in quick succession. When we collected these words, we frequently asked the speaker to repeat the same word multiple times and tried to focus on different vocabulary from session to session. This makes is very likely that the mass of vowels above and below the dividing line represent repetitions of different words within different sessions. Repetitions of these two words were coded as containing *a* (low vowel) to avoid any assumptions regarding the existence of one or two low vowel phonemes but at this point sufficient evidence exists to make the claim that there are in fact two low vowel phonemes in Tsuut'ina and that *tsa-tso* are a minimal pair that highlights this distinction.

3.2 Tones

The description of the use of pitch in this section will be largely exploratory and carried out in a style similar to that used in the previous sections. While this method may not be suitable for a fine-grained analysis of a possible tone or pitch accent system, it should be enough to determine whether the language might have one of these prosodic systems rather than a simple stress system.

Word	Syll. 1	Syll. 2	Reps.	Pattern	Word	Syll. 1	Syll. 2	Syll. 3	Reps.	Pattern
k'a	105		10	L	k'lidati	94	99	104	5	LLL
tsa	122		16	H	ak'lika	128	96	101	5	HLL
sila	127	87	12	HL	diyada	107	128	87	7	LHL
ch'ata	95	92	8	LL	dishkashi	103	94	116	8	LLH
disha	99	110	12	LH	sinichu	132	127	122	7	HHH
siza	119	121	10	HH						

Table 5 – Average F0 in Hz across all repetitions (Reps.) of selected words, split by syllable (Syll.). Pattern refers to the inferred pattern of Low (L) and High (H) tones.

Since I am interested in describing the use of pitch as a lexically-indicated, phonological phenomenon, I looked for consistencies and differences in pitch across multiple repetitions of single words. To investigate this, a contingency table was created containing the average F0 for every word split up by syllable. Only words repeated at least five times were included in the contingency table both to make it a reasonable length and to avoid drawing conclusions from the smallest of samples. A general observation was made that this speaker tended to produce vowels at two levels of f0: a low tone at around 100 Hz, and a high tone at around 120 Hz. All words

were coded according to whether each syllable contained a high tone or a low tone (in the opinion of the author); results for selected words are provided in Table 5.

There appear to be two different preferred pitches in the two monosyllabic words in Table 5, a low and high tone. Two different preferred pitches are also observed in the four disyllabic words, as well as every combination of low and high. This would not be in line with a pitch accent system as it is generally conceived of in that there should not be multiple accented syllables in a word. However, the morphological makeup of the words might explain this; the above examples might all be composed of single-syllable morphemes in which case a single, complex word might well contain several accented syllables. Trisyllabic words also show several combinations of preferred low and high tones, including words with multiple high tones. It must be noted that f0s presented in Table 5 represent averages over all repetitions of a word. For this reason, it seems unlikely that these patterns are due to chance and they are likely indicative of a tone or pitch accent system of some kind.

Given that Tsuut'ina is a language with many syllable-length morphemes, it is difficult to determine whether it has a tone or pitch accent system. In fact, the only thing that would definitively differentiate the two is the existence of more than two possible tones. Cook (1971) and Sapir (1925) both state that Tstuut'ina has three tones: high, medium and low. Since the typical pitch range for the words collected is more roughly 95-125 Hz it doesn't seem likely that this range could accommodate three different level tones.

4 Conclusion

The data presented here generally supports Cook's (1984) assessment of the Tsuut'ina vocalic system. There is strong evidence to support the claim that Tsuut'ina, or at least the language as spoken by HC, has four phonemic vowels, / ɪ, a, ɒ, ʊ /. This system is similar to that proposed in Li (1930), save for the fact that the low vowels are not as far back as Li suggests. Furthermore, the notion that the front vowel is realized with a progressively higher F1 when it is closer to the end of the word is also well supported.

The distinct and consistent preferred pitch patterns exhibited by words support the claim that Tsuut'ina has some sort of prosodic system more complicated than simple stress. However, a more careful analysis which takes into account morphological composition and larger, phrase-level intonation patterns needs to be undertaken in order to better describe the system.

References

Cook, Eung-Do. (1971). Vowels and tones in Sarcee. *Language* 47: 164-179.

Cook, Eung-Do. (1984). *A Sarcee grammar* . Vancouver: University of British Columbia Press.

Community Profile: Tsuu T'ina Nation 145 (Sarcee 145) Indian Reserve, Alberta; Statistics Canada. Accessed online on July 9, 2009 at:
<http://www12.statcan.ca/english/Profil01/CP01/Details/Page.cfm?Lang=E&Geo1=CSD&Code1=4806804&Geo2=PR&Code2=48&Data=Count&SearchText=Tsuu%20T&SearchType=Begins&SearchPR=48&B1=All&Custom=>

Li, Fang-Kuei (1930). A study of Sarcee verb-stems. *International Journal of American Linguistics* 6: 3-27.

Mithun, Marianne (1999). *The languages of native North America*. Cambridge, UK: Cambridge University Press.

Sapir, E. (1925). Pitch accent in Sarcee. *Journal de la Societe des Americanistes de Paris* 17: 185-205.