Springs in time:

Comparison of present and historical flows

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Abstract

The study reported here developed in response to published and anecdotal evidence suggesting some springs in Oklahoma either had dried up or were experiencing significantly diminished flow volumes in recent decades. Owing to scarcity of long-term data on spring flows however, the study focused primarily on groundwater levels based on time series of well level measurements which are longer in time, more reliable, and abundant over space. The change in focus is justified on the basis that groundwater level in aquifers is related to spring discharge. The study analyzed annual time series for 429 wells distributed throughout Oklahoma. The distribution-free, non-parametric Mann-Kendall trend test and Sen's slope estimates were used to investigate occurrence of trends in the groundwater level time series. Somewhat unexpectedly, the results indicate that 58% (248 wells) of wells are experiencing statistically significant (α=0.05) positive trends, 25% (109 wells) are experiencing significant negative trends, and 17% showed no change in groundwater elevation during the study period (1970-2003). On average, the trend magnitude for rising wells was 0.43ft/yr (median=0.328 ft/yr) compared to 0.992ft/yr (median=0.661 ft/yr) for declining wells. Consequently, groundwater level in many wells throughout Oklahoma has risen about 12 feet higher during the preceding 28 years but declined approximately 27 feet in other wells during the same time period. Most of the groundwater level decline is occurring in the Ogallala aquifer in the Oklahoma Panhandle. However, the eastern part of the aquifer is experiencing significant groundwater level rise. Groundwater rise predominates elsewhere in the state but especially in the western part between longitudes 98°-100° west. Wells with no change in groundwater level are sprinkled among those with upward water level rises and consequently display no coherent spatial pattern.

To investigate the possible cause of groundwater level change, we analyzed annual precipitation time series (1970-2004) at103 gauging sites throughout Oklahoma using the same trend procedure. The results indicate 16% of the annual precipitation time show statistically significant (α=0.05) positive trends but there is no clearly discernible pattern to their spatial distribution. The average magnitude of precipitation trend rise is 0.28 in./yr or 7.84 in. over 28 years, which represents a rise of 0.95%. Assuming aquifer specific yield of 5.4%, such precipitation increase could theoretically account entirely for the average observed groundwater level rise of 12 feet.

However, more rigorous analysis is needed to discover the specific causes and relative contributions of groundwater changes as well as their possible agricultural, recreational and economic impacts.

The study also surveyed invertebrates and fish in 23 Oklahoma springs because springs sustain unique ecosystems by virtue of their near constant temperature and flow discharge. Seven species of fish and three species of crayfish were found in the springs. The springs in the Arbuckle-Simpson aquifer had the greatest diversity of species but none of the sampled Central Oklahoma Aquifer springs had fish. No rare or spring-endemic crayfishes were found. With only 5 out 60 taxa, Sulphur spring is the most taxonomically unique of the study springs.

While many studies have reported previously on precipitation and runoff trends, this study is to our knowledge, among a very few that have examined widespread groundwater level change over such a large area. Critical outstanding issues are identified. It is suggested that further research is needed for developing a comprehensive and definitive reference source on Oklahoma's changing water resources

Keywords: Aquifer, Groundwater, Oklahoma, Precipitation, Springs.

Students supported by the project

Student Status	Number*	Disciplines
Undetrgraduate	4	Biology, Geography
M.S.	3	Biology, Geography
Ph.D.	2	Geography
Post Doc		
Total		

*** Includes students supported for any duration of time on project funds. For example, one Ph.D student was supported for two weeks.**

Publications

Faulkner, M; A.Tarhule and E. Bergey 2004. Springs in Time: Comparison of Present and Historical Flows. Paper presented at the Annual Meeting of the Southwestern Association of American Geographers, Stephen F. Austin University, Nacodoches, Texas, November 12-13.

Tarhule A. and E. Bergey (2006). Springs in Time: Comparison of Present and Historical Flows. Paper presented at the Annual Meeting of the Oklahoma Water Resources Board, Feb 06, Oklahoma City.

Tarhule, A. Groundwater level trends in Oklahoma. Manuscript in preparation for *Journal of the American Water Resources Association*.

Problem and Research Objectives

This is the final report of the study *Springs in time: comparison of present and historical flows.* The study builds upon the findings of an earlier OWRRI award to Dr. Elizabeth Bergey (Co-PI on this proposal) titled: *Springs in Peril: Have changes in groundwater input affected Oklahoma Springs?* (Bergey 2002). Bergey's study uncovered anecdotal evidence from landowners as well as published reports suggesting several springs draining major aquifers in Oklahoma or aquifers shared between Oklahoma and surrounding states had either gone dry or were experiencing significantly diminished flow volumes. For example, major changes in discharge have been reported for some springs in the Chickasaw National Recreation Area (OWRB 1990). In nearby Texas, up to one-half of springs no longer flow (Brune 1981) and additional springs are drying up (Clark Hubbs, personal communication).

Oklahoma springs have a very diverse fauna that includes both common, widespread species and spring specialists (Matthews et al. 1983). The study of spring faunas is important because of their intimate connection with groundwater and mineral resources, their interest to science, and their rarity. Several imperiled (G1-G2) animal species listed in the Natural Heritage Program and several species in the Oklahoma Department of Wildlife Conservation's Species of Greatest Conservation can be found in springs. The future success of these species relies heavily on the 'health' of springs and their groundwater sources.

Diminished spring discharge rates signify major changes in the groundwater aquifers that feed the affected springs. Knowledge concerning the magnitudes and spatial patterns of such changes is critical because groundwater is important to Oklahoma's economy, tourism, agriculture, and ecosystem health. For example, groundwater accounts for approximately 54% of total freshwater withdrawals in the state (Tortorelli, 2000). Most of the withdrawn groundwater is used for irrigation (80%) and municipal and household water supply (17%; Tortorelli, 2000). Groundwater is also vital for wildlife and for maintaining the high-quality outdoors environment of Oklahoma. Groundwater feeds natural springs and river environments that constitute the central features at several recreational areas and state parks including Chickasaw National Recreation Area, Boiling Springs State Park, and Roman Nose State Park among many others).

More recently, there have been concerns that contentions over groundwater resources by competing stakeholder interests as well as proposals for extensive groundwater abstraction to supply major municipalities, such as the proposed Arbuckle-Simpson aquifer water sale (see, http://www.owrb.state.ok.us/studies/groundwater/arbuckle_simpson/arbuckle_study.php), may lower aquifer levels and adversely affect discharge into associated springs and streams.
Even if impacted springs do not dry up entirely, these changes could affect the springs discharge, temperature and water quality significantly beyond the range of natural variability, which may, in turn, disrupt the unique spring-fed ecosystems that are highly susceptible to these variables (see also Mattson et al. 1995; P. Rakes, cited in Shute et al. 1997). There is a need, therefore, to analyze changes in spring flow volumes and aquifer levels in Oklahoma.

Study Objectives

The specific objectives of the present study are to:

(i) Determine whether spring discharge in five selected aquifers are experiencing negative trends;

(ii) Place short-term observations of spring flow and groundwater level changes in the context of long-term patterns of variability over space and time; and

(iii) Document further the faunal biodiversity of Oklahoma spring-fed streams and habitats to increase the knowledge status of these unique ecosystems and to identify species possibly susceptible to spring flow changes.

The information produced contributes to on-going efforts to document further Oklahoma's groundwater dynamics. The study aquifers selected initially for investigation are those identified from Dr. Bergey's research as experiencing declining flow rates including the Ogallala Formation, Trinity Group, Vamoosa Formation, and the Garber Sandstone/Wellington Formation. Additionally, it was also decided to add to the list of study aquifers the Simpson-Arbuckle aquifer because of the large-scale water sales plan that has been proposed for this aquifer. For reasons that will become apparent in this report however, the study has been extended to cover nearly all major aquifers throughout Oklahoma.

Methodology and Data

To investigate temporal changes in spring discharge [i.e. Objective (i) above], it was proposed originally to analyze the long-term (≈ 20 years) trends in instrumental time series records of spring discharge. The USGS spring database lists 609 springs throughout Oklahoma. However, no discharge measurement exists for the vast majority (76%) of these. Of the remaining springs with discharge records, the data is fragmentary, discontinuous, unsystematic, or comprises only *ad hoc* one time measurement. Upon further search, we discovered, and subsequently added to the database, previously undigitized spring discharge readings for more than 10 locations during the 1930s and early 1940 but these too were spotty and fragmented. Indeed, while discharge records of various lengths and completeness were found for over 60 springs, only two (Byrds Mill Spring; 46 years and Antelope Spring; 20 years) had discharge records sufficiently long and continuous to yield robust and reliable statistical trend parameters.

Given this data situation, it was apparent that even adding a few more flow measurements (as originally proposed) would still not produce definitive trend estimates (direction and magnitude). As an alternative, it was decided to analyze trends in well levels in the aquifers feeding the springs. The following section describes the rationale for this approach.

Springs, by definition, are points where groundwater flows to the surface. Springs occur primarily (although not exclusively) in areas underlain by soluble karstic rocks notably limestone, gypsum, or dolomite. In Oklahoma, two major types of springs dominate. The more common of these, contact springs, occur where the water table intersects the surface. Artesian springs - where the water reaches the surface under pressure from a confined or semi-confined aquifer also occur but are far less common. There does not exist at the present time a good inventory or database of Oklahoma spring geology and flow characteristics.

Springs that originate or discharge near the top of an aquifer may experience rhythmic flow fluctuations in response to the up and down movement of the groundwater table (Fig 1). In contrast, springs discharging near the base of an aquifer tend generally to experience steady flow characteristics including volume and temperature. These characteristics are very important for the unique fauna that springs foster and support. However, these springs may in fact be of only limited utility as indicators of groundwater level changes, both because they occur only in a few geologic environments and because they show only moderate response to aquifer head change.

The above considerations suggest that historical well level measurements, which are temporally longer and spatially better distributed than springs discharge measurement points, provide the best means for analyzing the temporal and spatial patterns of groundwater resources change in Oklahoma. Consequently, water table elevations for selected wells were obtained from the USGS Oklahoma City Office. The selection criteria was that the wells should have continuous annual (i.e. at least one record per year) water level measurements for at least 20 years. To avoid possible complications introduced by intra-seasonal variations, only those wells with water level measurements in the winter months (December –March) when anthropogenic withdrawals are lowest are analyzed. Strictly speaking therefore, the data analyzed is the winter groundwater level elevations in Oklahoma. Finally, to address the problem of missing data, only those wells with no more than an arbitrarily set cutoff threshold of 15% consecutive missing values were selected. A total of 429 wells satisfied these criteria and were selected.

For a given watershed, changes in groundwater level or storage (ΔS) could be investigated by rearranging the water budget equation so that:

$$\Delta S = \text{Input} - \text{Output} \tag{1}$$

or

$$\pm\Delta S = P - \{E+R\} \tag{2}$$

Where P is precipitation, E is evapotranspiration and R is runoff. The above simplified version of the water budget equation assumes that groundwater inflows from, and outflows to, adjoining watersheds is negligible. In general, $\Delta S \rightarrow 0$ if the system is in dynamic equilibrium and the time period analyzed is sufficiently long ($\approx$ 10years). The conservative nature of this equation dictates that for a system without significant anthropogenic impacts, increasing or decreasing trends in groundwater storage are the results of corresponding trends in either water input into the basin (i.e. precipitation), or water output from the basin through evapotranspiration and/or runoff. Because precipitation data is more readily available and reliable than evapotranspiration and runoff data, we examine only for trends in precipitation as a possible cause of groundwater level change. Thus, the time series of annual precipitation totals (1970-2005) were obtained from the Oklahoma Mesonet for 103 stations distributed throughout the state.

To investigate trends in the groundwater level and precipitation time series, we employed the Mann-Kendall test and Sen's slope estimate method (Salmi et al 2002). In common with non-parametric methods generally, the Mann-Kendall test requires no assumptions about the nature of the probability distribution characterizing the time series. Furthermore, by working only with the ranked values of the time series, it minimizes the impacts of single data errors or outlier events on trend direction and magnitude.

For a time series of annual values of length n, the test statistic, S, is calculated using the formula (Salmi et al 2002, p.9)

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k) \qquad (3)$$

Where x_j and x_k are the annual values in years j and k, j<k, and

$$\operatorname{sgn}(x_j - x_k) = \begin{cases} 1 & if \quad x_j - x_k > 0 \\ 0 & if \quad x_j - x_k = 0 \\ -1 & if \quad x_j - x_k < 0 \end{cases} \qquad (4)$$

If n ≤ 9 the absolute value of S is compared directly to the theoretical distribution of S derived by Mann and Kendall (Gilbert, 1987). For n ≥ 10, the variance of S is computed from:

$$\mathrm{VAR(S)} = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5) \right] \qquad (5)$$

Where q is the number of tied ranks and t_p is the number of points in the p^{th} group. Finally, the Z statistic is used to test for the significance of a trend. The statistic (Z) has a normal distribution and is calculated as (Salmi et al 2002):

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & if \quad S < 0 \end{cases} \tag{6}$$

For a two-tailed test, the null hypothesis is rejected if the absolute value of Z is greater than $Z_{1-\alpha/2,}$ where α is a specified significance or probability level.

The above procedure detects only the presence and statistical significance of a trend. Slope magnitude is then estimated using Sen's method. First, the slopes (Q_i) of all data value pairs are obtained as:

$$Q_i = \frac{x_j - x_k}{j - k} \tag{7}$$

Where j>k.

For a time series of length, n, eq. 7 above produces N=n(n-1)/2 slope estimates, Q_i and the median value of N is the Sen's slope estimate. The slopes obtained are comparable to those produced from linear regression modeling.

Spring Inventories

The methods used to sample springs were those used by Bergey (2002) and included the following components:

- Site description, including TRS coordinates, GPS readings, a site sketch, photos, local land use, modifications of the spring, and directions for re-finding the site.
- Discharge information (flow width, depths, and mean velocities). Velocity was measured with a Marsh-McBirney electromagnetic flow meter.

- An owner questionnaire to get information on land use changes, changes in discharge, and historical use of springs.
- Fish sampling, using seines or dipnets. Only one or two fish of each species were collected in springs with fish.
- Invertebrates sampling, using hand nets for qualitative sampling and a small corer for quantitative sampling. Samples were preserved in the field and returned to the laboratory for sample sorting and invertebrate identification.
- Invertebrate identification is ongoing.

Principal Findings and Significance

Figure 2 shows the location and distribution of the 429 wells analyzed for this study. A majority of the wells are concentrated in western Oklahoma, reflecting greater importance of groundwater in this semi-arid part of the state. Both rainfall and runoff are much more abundant in the sub-humid to humid eastern half of Oklahoma and consequently, there is less reliance on groundwater.

Figure 3 is a classification of the study wells in terms of length of records. The series ranged in length from 17 years to 38 years with an average of 28 years. The most recent year for which data is analyzed is 2003. Hence, the average well series covers the period from 1975-2003. Similarly, depth to water table (in feet below ground surface, ft.b.g.s.) shows also a wide range, from as little as 4 ft.b.g.s. to a maximum of 345 ft, with an average of 95 ft. In general, the deepest wells occur in the west, especially in the panhandle region, which experiences the driest climate and is therefore more dependent on groundwater to support a thriving irrigated agricultural sector.

Observed Changes in Groundwater Elevations

Application of the non-parametric Mann-Kendall trend test indicates that of the 429 wells analyzed, 58% (248 wells) showed statistically significant (α=0.05) positive trends or rise in groundwater elevations, 25% (109 wells) showed statistically significant negative trends or drop in groundwater elevations, and 17% (74 wells) experienced no change over the study period (Figure 4). Appendix A contains the complete output of the Mann-Kendall analysis. The above result was largely unanticipated. As stated previously, an important motivation for this study was to investigate anecdotal evidence and complaints about failing springs and falling ground water levels from landowners, which appeared to come from across the state. It came as a complete surprise therefore that from a random sample of wells across Oklahoma, the number of wells experiencing water level rises out number by a margin of better than 2:1 those experiencing water level declines. Table 1 summarizes the characteristics of the wells showing statistically significant water table rises and declines.

Table 1. Statistical characteristics of wells showing water elevation rise and decline.

	Wells Showing Water Level Rises	**Wells Showing Water Level Declines**
Number of Wells	248 (57.8%)	109 (25.4%)
Average Depth (ft. b.g.s.)	64.71	192.66
Median Depth (ft. b.g.s.)	45.92	201.25
Average Slope Magnitude	+0.429 ft/yr (5.15 in/yr)	-0.992 ft/yr (11.90 in/yr)
Median Slope Magnitude	+0.328 ft/yr (3.94 in/yr)	-0.661 ft/yr (7.93 in/yr)
Standard Deviation	0.363	0.847
Minimum Slope	+0.090 ft/yr (1.08 in/yr)	-0.067 ft/yr (0.804 in/yr)
Maximum Slope	+1.901 ft/yr (22.81 in/yr)	-3.984 ft/yr (47.81 in/yr)

Spatial distribution of Trends

Figure 5 presents the spatial distribution of groundwater level trends. The figure reveals that wells with statistically negative trends (red inverted triangles) occur predominantly in the Oklahoma panhandle although a few isolated wells elsewhere in the state show also negative trends. Rising wells (green, upright triangles) are concentrated largely in the area between longitudes 98° -100° west but also in the panhandle. Finally, there appears to be no spatial coherence in the distribution of wells with no change (open circles) in groundwater level during the study period. Indeed principal component analysis failed to segregate among the wells. In addition to the general pattern noted above, occurrence in close proximity of all three types of wells may indicate that well trends are function of water use intensity rather than climatic changes.

Trend Magnitudes and Temporal Changes

Table 1 indicates that for those wells in which the water table is rising, the rate of rise is about one-half foot per year compared to a decline of nearly a foot per year for wells with falling water tables. Over a twenty year period therefore, we would expect, on average, the water table to be 10 feet closer to the ground surface, and 20 feet deeper respectively for rising and declining wells (see section on precipitation trends below).

Figure 6 presents the distribution of trend magnitude for various slope class intervals only for those wells showing statistically significant water level rises or declines. About 63% are rising wells with slope magnitudes between +0.1 to +1.5 ft/yr compared to 25% declining wells with -0.1 to -1.5 ft/yr.

Furthermore, the average depth to the water table in rising wells is about 65 feet below ground surface, compared to 193 feet for declining wells (Table 1). Figure 7 illustrates further the relationship between slope magnitude and well depth.

Figures 8-10 provide illustrative examples of the three types of temporal patterns of water level changes in Oklahoma i.e. rise, drawdown, and no change. For the purpose of clarity only, both rising and falling walls were divided into moderate and severe rises/declines. Moderate rises/declines have trend magnitudes near the median value for the group (Table 1) and the wells grouped as severe have trend magnitudes near the high end for each type. It is important to note that the wells in Figs 8-10 were selected randomly within each specified trend range.

Figure 8a (median rising wells) shows a very linear and steady pattern of water level rise for all illustrative wells. For example, despite a few missing measurements, it is clear that well 9437 rose steadily from a depth of 68.6 ft.b.g.s. in 1965 to 56.4 ft.b.g.s. in 2000, a rise of 12 ft in 35 years (≈ 0.343 ft/year). The rate of rise in the other wells is comparable but this may be a function of the fact that they were all selected within a specified range of trend magnitudes.

Two observations could be made with respect to severe rising wells (Fig. 8b). First, they show more variability than the moderate rising wells. Thus, for many well time series, shorter scale upward spikes and downward dips are superimposed on the generally rising trends. Second, the rate of rise appears to have peaked in the late 1990s for some well time series and several wells in fact show relative declines after that period. It is not clear whether this marks a turning point from the pattern prevalent during the preceding 20 to 30 years, or whether is represents only short term fluctuations around the overall trend.

Similar patterns apply to declining wells (Fig. 9). The magnitude of water table drawdown is truly astonishing in some of these wells. For example, well 1111 dropped from 163 ft.b.g.s. in 1965 to 297 ft.b.g.s. in 2003 or 134 ft in all over 38 years (3.5 ft./year). While it is among the highest observed, such drawdown rate is clearly unsustainable in the long-run. Finally, Figure 10 shows several wells where the overall trend is not significantly different from zero ($\alpha = 0.05$), despite short term fluctuations.

Observed Groundwater Level Changes in Major Aquifers

It is important to identify the specific aquifers being tapped by the study wells and to discover the type and magnitude of groundwater level change in the various aquifers. Figure 11 overlays the major groundwater aquifers in Oklahoma on the study well locations (Fig. 2). Using GIS, the wells contained within each aquifer were identified and their characteristics summarized in Table 2.

Table 2 shows that aquifers experiencing water table rises are distributed widely throughout Oklahoma while the Ogallala is, essentially the only aquifer experiencing widespread falling water table. Unfortunately, the number of wells in some aquifers is too few to make definitive statements about the direction and magnitude of groundwater elevation change. Among those aquifers with at least five wells, the Garber-Wellington, Enid Isolated Terrace, Rush Springs, and Blaine Formation aquifers are experiencing the fastest rates of groundwater level rise.

The groundwater level changes in the Ogallala appear almost paradoxical but may hold the key to understanding groundwater dynamics throughout the state. On the one hand 96 of study wells show declines but an almost equal number (89) show statistically significant rises and the time series for 25 wells remained statistically flat during the study period.

Table 2. Summary of groundwater level change by aquifer

Aquifer	Groundwater Level Rise						No change	Groundwater Level Decline					
	N	Average	Median	Stdev	Min	Max	N	N	Average	Median	Stdev	Min	Max
Antlers	5	0.510	0.253	0.491	0.147	1.334	1	1	-1.300				
Arbukcle-Simpson	1	1.394											
Arkansas	1	0.076											
Blaine	13	0.615	0.353	0.453	0.082	1.562	1						
Canadian River	5	0.576	0.208	0.574	0.116	1.416	1						
Cimarron River	16	0.330	0.303	0.216	0.066	0.661	1						
Enid Isolated Terrace	7	0.837	0.893	0.342	0.165	1.312							
Garber-Wellington	5	1.125	0.923	0.812	0.296	2.265	4	2	-0.468				
Getty Sand	1	0.500											
North Canadian River	17	0.331	0.328	0.217	0.087	1.031	4						
North Fork (Red River)	16	0.448	0.365	0.341	0.137	1.614	7	1	-0.261				
Ogalalla	89	0.324	0.260	0.278	0.034	1.901	25	96	-1.057	-0.840	0.869	-0.984	-0.027
Roubidoux	1	0.317											
Rush Springs	16	0.771	0.742	0.438	0.110	1.753	3						
Tillman Terrace	11	0.485	0.450	0.209	0.168	0.812	1						
Vamoosa-Ada	2	1.196											
Washita River	1	0.352											

Again, wells with groundwater level rises are juxtaposed in spaced within the same aquifers with wells showing significant declines or no change over time. This suggests the cause of groundwater level change could be anthropogenic, rather than climatic. Furthermore, it may imply that the cones of depression are accentuated around well points. Over time, outward expansion and coalescence of the cones of depression will drive down the water table in the aquifer as a whole.

The above explanation is unsatisfactory however, with respect to rising water tables. Recharge mounds around well points make sense only if an artificial groundwater recharge program is being implemented, otherwise we must conclude that the water level rise is aquifer-wide. Three types of scenarios can theoretically account for this situation; (i) rising precipitation and groundwater recharge, (ii) declining runoff, and (iii) declining evapotranspiration. A possible anthropogenic cause could be decreased water withdrawals but investigating such scenario is beyond the scope of this study.

Several studies (Garbrecht and Rossel 2002; Garbrecht et al. 2004; Hu et al. 1998) have documented an upward trend in precipitation for the Great Plains as a whole including some watersheds in Oklahoma. Their results are consistent with larger studies for the continental USA obtained by Karl et al. (1996), Karl and Knight (1998), and Easterling et al. (2000) among many others. On the other hand, Zume and Tarhule (in press) found no statistically significant upward trends in the annual precipitation time series for Northwestern Oklahoma. This study employed the Mann-Kendall test to investigate trends in 103 annual precipitation time series throughout Oklahoma.

Observed Trends in Annual Precipitation Time Series

The distribution of the precipitation time series analyzed appears in Figure 12. The well-known east to west precipitation gradient is reproduced accurately in Fig. 12 reflecting generally excellent distribution of the precipitation gauging sites (except, perhaps, in the panhandle region). The Mann-Kendall trend test identified 27 sites (26%) with statistically significant (α=0.1) positive trends. Using the more stringent 0.05 criterion, 16 sites (15.5%) are statistically significant. Only one site, Buffalo, in Harper County (36°51′ N, 99°63′) had a statistically significant negative trend (α=0.1). Figure 13 plots the temporal pattern of precipitation variability for five illustrative sites. Notice only the time series at Gates has a statistically significant trend (superimposed). Finally, figure 14 plots the distribution of precipitation sites showing positive trends (α=0.1; green triangles). The average trend magnitude is 0.28 in. per year with a maximum of 0.39 at Pawhuska (Osage County, 36°40′ N, 96°21′ W).

Most precipitation sites showing upward trends appear to be in the northern half of the state and all four gauging sites analyzed for the panhandle have statistically significant upward trends. Recall that the panhandle is the area experiencing largely negative groundwater trends (Fig. 6), which supports further the earlier observation that the anthropogenic influence supersedes the climatic signal in the panhandle. Beyond these weak and highly generalized patterns, there appears to be no spatial coherence to the distribution of precipitation sites showing positive trends.

Possible Causes of Groundwater Changes

Falling groundwater levels in the Ogallala aquifer are not unusual and have been the subject of much research over the past four decades (Bittinger and Green 1980, McAda 1985, Holmes and Petrulis 1988, Kromm and White 1992). There is general consensus among these studies that declining groundwater level in the Ogallala aquifer is the result of excessive groundwater extraction for irrigated agriculture. Thus, our study confirms continuing declining trends in the Oklahoma portion of the Ogallala. It is important to reiterate the point that on the eastern margin of the aquifer, groundwater levels are rising significantly. As precipitation trends have not increased over the same period, it may be assumed that changes in the intensity of groundwater exploitation and use are responsible for this trend but further investigation is needed to establish definitively both the cause and possible implications.

The magnitude of rising groundwater levels appears rather dramatic. As stated previously, the average groundwater level trend is 0.43 ft/yr (5.15 in/yr) or a rise of about 12 ft (3.67m) over 28 years. Simple calculations based on assumed values suggest such increase is entirely within the limits of natural variability. For example, the average precipitation trend is 0.28 in/yr or a total of 7.84 in during the study period (28 years). This increase represents 0.95% if the average annual precipitation is considered to be 30 in. Such precipitation increase is sufficient to account entirely for the groundwater level rise if aquifer storativity or specific yield is assumed to be 5.4%, which is on the low end of yield range.

It is important to point out the many qualifications and assumptions inherent in the above estimate. First, increased precipitation trends are isolated, not general, across the study area. Second, specific yield is estimated from observed precipitation and groundwater level trends and may not therefore represent actual yields. Third, and finally, other relevant variables including evapotranpiration, runoff, and baseflow trends have not been considered. Even so, the significance of the exercise is to draw attention to the fact that the observed groundwater level changes could have been caused by small increases in precipitation. Further studies are needed to establish the specific causes.

Spring Inventories

Twenty-three springs were surveyed (Table 3). Thirteen of the springs were in the Arbuckle area and included springs in the following counties:

- Johnston County: 4 springs
- Pontotoc County: 5 springs
- Coal County: 2 springs (1 of these was a sulphur spring)
- Murray County: 1 spring.

Three springs were in sandstone areas east of Oklahoma City and were located in two counties:

- Lincoln County: 1 spring.
- Pottawatomie County: 2 springs.

The remaining seven springs were in Ellis County.

Spring characteristics

Arbuckle-Simpson springs are karst/limestone springs. Springs emanating from the same water source should have very similar mean annual temperatures and, indeed, most of the Arbuckle springs are 18.0 to 18.5 ^{o}C (Table 3). Exceptions result from water being warmed by retention in a small reservoir (Wildcat Spring) or through water exchange with the adjacent Pennington Creek in a stream-associated spring. The cooler temperatures of Sheep Creek Spring, the nearby Shipes Spring and Coal Spring may signal a different source within the aquifer or shallower source of water.

Table 3. Characteristics of Springs Surveyed in 2004-2005.

Aquifer	Code	Site Name	County	Month Sampled	Q (l/s)	T (°C)	pH	C (μS/cm)	Crayfish	Fish	Notes
Arbuckle-Simpson	SPR04-01	Lowrance Spring	Murray	Jun-04	90.62	18.3	7.2	160	Y	Y	
	SPR04-10	Sheep Creek Spring	Pontotoc	Jul-04	44.04	17.1	7.2	513	Y	Y	Fish were only below weir
	SPR04-06	Rutherford Spring	Johnston	Jul-04	15.53	18.3	6.9	660	N	Y	
	SPR04-08	Viola Spring	Johnston	Jul-04	11.38		7.1	1,580	Y	N	
	SPR04-03	Three Spring	Johnston	Jul-04	7.08	18.0	7.2	513	Y	Y	
	SPR04-04	Wolf Spring	Johnston	Jul-04	3.17	18.1	7.3	485	Y	Y	
	SPR04-02	Pennington Creek Spring	Johnston	Jun-04	2.34	20.6	7.2	544	Y	Y	Between channels of Pennington Creek
	SPR04-11	Shipes Spring	Pontotoc	Jul-04	2.33	17.0	7.2	522	Y	N	In yard
	SPR04-12	Wildcat Spring	Pontotoc	Aug-04	1.82	19.4	6.9	496	N?	Y	Dammed up; fish stocked?
	SPR04-05	Logsdon Spring	Pontotoc	Jul-04	0.67	18.1	7.2	604	Y	N	
	SPR05-01	Coal Cave Spring	Pontotoc	May-05	0.19	16.8	7.1	576	Y	Y	
	SPR04-09	Houghtubby Spring	Coal	Jul-04	0.08	18.5	7.1	620	N	N	
AVERAGE					**14.94**	**18.2**	**7.1**	**606**			
Sulphur spring	SPR04-07	Rotten Egg Spring	Coal	Jul-04	0.52	20.5	6.9	11,370	N	N	Sulphur spring
Central Oklahoma	SPR05-02	Doddehl Spring	Lincoln	May-05	0.50	14.8	6.6	207	N	N	Wooded
	SPR05-04	Nash Spring	Pottawatomie	May-05	0.15	16.6	7.3	725	Y	N	Drips into pool from bluff
	SPR05-03	Trevor Spring	Pottawatomie	May-05	0.08	16.2	6.0	101	Y	N	Crayfish in spring box
Average					**0.24**	**15.9**	**6.6**	**344**			
High Plains	SPR05-05	West Creek Spring	Ellis	Jun-05	NA*	24.4	8.1	635	Y	NA	Seeps along stream
	SPR05-07	Word Spring	Ellis	Jun-05	NA*	20.6	7.8	718	N	NA	Seeps in channel + a small hill slope seep
	SPR05-11	Dugger Spring	Ellis	Jun-05	NA*	25.0	8.1	693	Y	NA	Seeps along stream.
	SPR05-08	McCorkle Seep	Ellis	Jun-05	13.12	22.1	7.7	389	N	Y	Very large seep area
	SPR05-09	Bowman Seep	Ellis	Jun-05	5.00	25.9	7.8	700	N	N	Hill slope seep
	SPR05-10	Reininger Spring	Ellis	Jun-05	1.18	20.6	7.4	577	N	Y	Spring in lower floodplain
	SPR05-06	West Creek Seep	Ellis	Jun-05	0.13	27.9	7.6	944	N	Y	Large seep/wetland
Average					**4.86**	**23.8**	**7.8**	**665**			

The pH among most Arbuckle springs was similar (6.9 to 7.3 μS/cm; Table 3), as is expected because of the buffering by limestone. Conductivity of most springs ranged between 485 and 660 μS/cm. Lowrance Springs had a much lower conductivity (160 μS/cm), whereas Viola Spring had a much higher conductivity (1580 μS/cm). The conductivity of Rotten Egg Spring was well beyond the range of the other sampled Arbuckle springs; but this is a sulphur spring emanating from an apparent bore hole. The water temperature of this sulphur spring was higher than the other Arbuckle springs.

The sandstone springs associated with the Central Oklahoma Aquifer included two springs with somewhat acidic waters (pH 6.0-6.6; Table 3) and low conductivity. Nash Spring had higher pH and conductivity than the nearby Trevor Spring. Water temperatures of the sandstone springs tended to be lower than temperatures of the Arbuckle-Simpson limestone springs.

The sampled High Plains springs were of two types: linear springs along streams and hillslope seeps that typically drained into a nearby stream. Patches of water cress (*Nasturtium officinale*) were used to indicate spring upwellings in streamside springs.

High Plains springs were warmer than the springs from the Arbuckle-Simpson and Central Oklahoma Aquifers (means of 23.8, 18.4, and 15.9 ºC; respectively). Warmer spring temperatures may indicate a deeper source of water (Scott Christianson, personal communication), as would be expected in this portion of the High Plains Aquifer (Pete Thurmond, personal communication). These springs also had relatively high pH (7.4 to 8.1).

Spring fauna

Seven species of fish were found in the springs (Table 4). Arbuckle springs had the greatest diversity of species. The central stoneroller *Campostoma anomalum* and young bluegill *Lepomis macrochiris* were found in a spring pool within the lower floodplain of Pennington Creek, and one mid-sized, probably stocked, smallmouth bass *Micropterus salmoides* was observed in a concreted pool at Wolf Spring. The mosquitofish *Gambusia affinis* was especially widespread and abundant; other fish were darters, which comprised three species plus some individuals that were apparently hybrids. None of these fishes are rare or are spring specialists.

Spring discharge varied greatly, even between nearby springs. Discharge affects habitat 'space' and is related to the presence/absence of larger animals. Fish were present in 8 of the 23 springs (Table 3) and the discharge of springs with fish averaged 15.79 l/s. Crayfish were more frequently encountered, inhabiting 12 of 23 springs and the discharge of springs with crayfish averaged 15.89 l/s. The discharge of springs lacking both crayfish and fish averaged only 1.53 l/s (Table 3).

None of the sampled Central Oklahoma Aquifer springs had fish. These three streams were either distant from or well uphill from their corresponding mainstem streams, which are a common source of fish. The only fish seen in the isolated High Plains Aquifer springs were *Gambusia affinis*, which is the most common fish species in Oklahoma springs. The fish in streams with springs along the edges were not collected because these fish were not associated with the springs themselves.

At least three species of crayfishes were found (Table 4; collections of juveniles could not be identified). *Orconectes palmeri longimanus* is known only in Oklahoma and Arkansas, but is common within its range (G5, S5; NatureServe web site and Bergey et al 2005). Its presence in three springs in the Arbuckles may add two new county records (Coal and Pontotoc

Counties). *Orconectes virilis* is common throughout the Arbuckles. *Procambarus simulans* is common and fairly widespread in Oklahoma. No rare or spring-endemic crayfishes were found.

Occasionally, cave-adapted crustaceans are encountered in springs. Two of the surveyed Arbuckle springs had cave isopods. One spring is associated with a cave that has an identified population of cave isopods; the second spring is a new location. The two specimens from the second spring await identification by a taxonomic expert.

The identification of invertebrate samples is ongoing and not all groups have been identified. Identifications are provisional. Thus far, sixty taxa of invertebrates (exclusive of crayfish) have been identified. Several No beetles or worms have been identified and these two taxa, in particular, will increase the taxonomic list.

The springs in each aquifer were biologically diverse. Full data are given as an appendix and summarized in Table 5. More taxa were found in the Arbuckle-Simpson Aquifer than either of the other two aquifers; however, there were also more springs surveyed in this aquifer and the high aquifer diversity may be an artifact of the area sampled. Individual High Plains aquifer springs were the most diverse. Central Oklahoma Aquifer springs were apparently the least diverse, both at the aquifer-wide scale and at the single-spring scale.

Invertebrate assemblage composition was compared among springs using the ordination technique of Non-metric Multidimensional Scaling (NMDS). In this technique, samples (springs) are plotted on a graph and the distance between any two 'springs' indicates the similarity of their two assemblages. The most taxonomically unique spring is the sulphur spring in the Arbuckle-Simpson area. Only five taxa have been identified from this spring. Graphically, there is a clear difference among the groups of springs. The Central Oklahoma aquifer springs are the most distinct and are characterized by the absence of three groups that are typically found in Oklahoma springs: soldier flies (Stratiomyidae), flatworms (Planaria), and amphipods (especially *Hyalella* sp.). Other than the subterranean amphipods, no rare invertebrates have been identified in any of the springs.

Aquifer	Code	Site Name	County	Month Sampled	Q (l/s)	T (°C)	pH	C (μS/cm)	Crayfish	Fish	Notes
Arbuckle-Simpson	SPR04-01	Lowrance Spring	Murray	Jun-04	90.62	18.3	7.2	160	Y	Y	
	SPR04-10	Sheep Creek Spring	Pontotoc	Jul-04	44.04	17.1	7.2	513	Y	Y	Fish were only below weir
	SPR04-06	Rutherford Spring	Johnston	Jul-04	15.53	18.3	6.9	660	N	Y	
	SPR04-08	Viola Spring	Johnston	Jul-04	11.38		7.1	1,580	Y	N	
	SPR04-03	Three Spring	Johnston	Jul-04	7.08	18.0	7.2	513	Y	Y	
	SPR04-04	Wolf Spring	Johnston	Jul-04	3.17	18.1	7.3	485	Y	Y	
	SPR04-02	Pennington Creek Spring	Johnston	Jun-04	2.34	20.6	7.2	544	Y	Y	Between channels of Pennington Creek
	SPR04-11	Shipes Spring	Pontotoc	Jul-04	2.33	17.0	7.2	522	Y	N	In yard
	SPR04-12	Wildcat Spring	Pontotoc	Aug-04	1.82	19.4	6.9	496	N?	Y	Dammed up; fish stocked?
	SPR04-05	Logsdon Spring	Pontotoc	Jul-04	0.67	18.1	7.2	604	Y	N	
	SPR05-01	Coal Cave Spring	Pontotoc	May-05	0.19	16.8	7.1	576	Y	Y	
	SPR04-09	Houghtubby Spring	Coal	Jul-04	0.08	18.5	7.1	620	N	N	
AVERAGE					**14.94**	**18.2**	**7.1**	**606**			
Sulphur spring	SPR04-07	Rotten Egg Spring	Coal	Jul-04	0.52	20.5	6.9	11,370	N	N	Sulphur spring
Central Oklahoma	SPR05-02	Doddehl Spring	Lincoln	May-05	0.50	14.8	6.6	207	N	N	Wooded
	SPR05-04	Nash Spring	Pottawatomie	May-05	0.15	16.6	7.3	725	Y	N	Drips into pool from bluff
	SPR05-03	Trevor Spring	Pottawatomie	May-05	0.08	16.2	6.0	101	Y	N	Crayfish in spring box
AVERAGE					**0.24**	**15.9**	**6.6**	**344**			
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	SPR05-07	Word Spring	Ellis	Jun-05	NA*	20.6	7.8	718	N	NA	Seeps in channel + a small hill slope seep
	SPR05-11	Dugger Spring	Ellis	Jun-05	NA*	25.0	8.1	693	Y	NA	Seeps along stream.
	SPR05-08	McCorkle Seep	Ellis	Jun-05	13.12	22.1	7.7	389	N	Y	Very large seep area
	SPR05-09	Bowman Seep	Ellis	Jun-05	5.00	25.9	7.8	700	N	N	Hill slope seep
	SPR05-10	Reininger Spring	Ellis	Jun-05	1.18	20.6	7.4	577	N	Y	Spring in lower floodplain
	SPR05-06	West Creek Seep	Ellis	Jun-05	0.13	27.9	7.6	944	N	Y	Large seep/wetland
AVERAGE					**4.86**	**23.8**	**7.8**	**665**			

* Discharge (Q) is unavailable for springs located in the channel of flowing streams.

Table 4. Crayfish and fish species found during the 2004-2005 springs survey. (*O.* = *Orconectes*, *P.* = *Procambarus*, *G.* = *Gambusia*, *E.* = *Etheostoma*; *Etheostoma* sp. = unidentified specimens, possibly hybrids).

Site name	Crayfishes	Fishes
Lowrance Spring	*O. virilis*	*G. affinis, E. radiosum, E. gracile, Etheostoma* sp.
Pennington Crk spring	*O. virilis*	*G. affinis, Campostoma anomalum, E. spectabile, Lepomis macrochirus*
Three Springs	*P. simulans*	
Wolf Spring		*G. affinis, E. spectabile, Micropterus salmoides*
Logsdon Spring	unidentified juvenile	
Rutherford Spring		*G. affinis*
Rotten Egg Spring		
Viola Spring	*O. palmeri longimanus*	
Houghtubby Spring		
Sheep Creek Spring	*O. palmeri longimanus*	Fish blocked by weir; below weir: *C. anomalum, E. radiosum, Etheostoma* sp.
Shipes Spring	unidentified juvenile	
Wildcat Spring		a small reservoir: *G. affinis*
Coal Spring	*O. palmeri longimanus, P. simulans*	*E. radiosum*
Doddehl Spring		
Trevor Spring	*P. simulans*	
Nash Spring	*P. simulans*	
West Crk spring	unidentified juvenile	NA*
West Crk seep		*G. affinis*
Word Spring		NA*
McCorkle Spring		*G. affinis*
Bowman Seep		
Reininger Spring		*G. affinis*
Dugger Spring	unidentified juvenile	NA*

* fish were present in the contiguous stream and were not sampled

Table 5. Taxonomic diversity of macroinvertebrates in springs, based on identifications of select taxa.

Aquifer	# of springs	Taxa in aquifer	Mean taxa/spring	Range among springs
Arbuckle-Simpson	12	47	14.8	11-23
Central Oklahoma	3	22	12.7	10-15
High Plains	7	43	17.0	12-24
Arbuckle-Simpson (sulphur spr)	1		5	

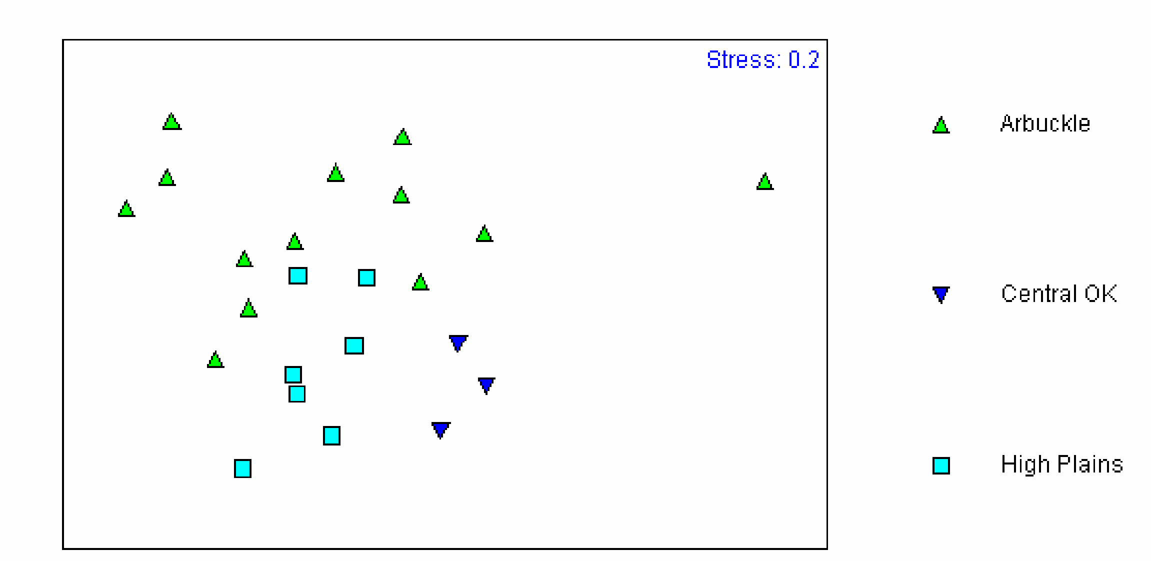

Figure 14. Non-metric multidimensional scaling ordination of invertebrate assemblages of 23 Oklahoma springs.

Summary and Conclusions

This study was motivated by anecdotal and other evidence that several springs in Oklahoma have experienced significantly diminished flow volumes or have ceased to flow altogether in recent years. Springs are a "window" into groundwater resources. As a result, adverse changes in spring flow dynamics foretell possible adverse impacts on groundwater resources. Hence, the study was designed to analyze the spatial and temporal patterns of spring flow variability in Oklahoma. Insufficiency of long-term and continuous instrumental records of spring flows however compelled a shift of focus to groundwater level analysis for which data is more abundant. Because groundwater aquifers feed spring flows, this shift does not compromise the overarching goal of the study.

The major findings emerging from the study could be summarized as follows:

1. Analysis of trends for groundwater level time series in 429 wells throughout Oklahoma reveals that 58% are experiencing statistically significant upward trends (indicating groundwater table rise), 25% show statistically significant downward trends (indicating groundwater table decline), and 17% show no change. The average trend magnitude is +0.43 ft/yr (5.15 in/yr) for water table rise and -0.992 ft/yr (11.90 in/yr) for water table decline. Consequently the water table has risen, on average, 12 ft over the 28 year study period in some wells and declined nearly 28 ft in others.
2. Groundwater decline is occurring primarily in the panhandle region of the Ogallala aquifer. Elsewhere in the state, a few isolated wells show declining trends but with no coherent spatial pattern. Groundwater level rise is occurring along the eastern part of the Ogallala aquifer and indeed most of western Oklahoma. Wells with no change in groundwater level are interspersed, and sometimes in close proximity with wells showing either rises or declines. As a measure of the level of spatial mixing, principal component analysis failed to segregate among the different types of wells.
3. The mixed spatial distribution of wells showing rises or declines raises important questions about the possible cause of groundwater level variations. Analysis of precipitation times

series found that 26% (of 103 precipitation gauging sites) show statistically significant upwards trends. Only one site had a significant negative trend. However the precipitation sites showing positive trends are widely distributed and interspersed with stations showing no change over the study period.

4. The result of trend analysis presented here appear to contradict some previously published research suggesting that precipitation time series in Oklahoma is on the rise, like the rest of the great plains or Central United States. Because of the significance of precipitation to agriculture and other activities in Oklahoma, it is critical that a reliable and definitive estimate of the precipitation trends is established to facilitate water resources planning and management.

5. A precipitation increase on the order of 1% during the study period is sufficient theoretically to account for observed groundwater level rise if aquifer specific yield is assumed to be 5.4%. Such precipitation increase has in fact occurred at several stations throughout Oklahoma but the results cannot be assumed to be applicable generally because other intervening station series did not experience similar rise. Nevertheless, the important point to emphasize is that observed groundwater level rise in Oklahoma could be explained by natural precipitation increase without the need to invoke anthropogenic factors.

6. Seven species of fish were found in the springs but none are rare or spring specialists. Fish were present in 8 of the 23 springs sampled and crayfish in 12. Arbuckle springs had the greatest diversity of species. The discharge of springs containing fish averaged 15.79 l/s similar to the discharge in springs with crayfish (15.89 l/s). Springs with average discharge around 1.5 l/s had neither fish nor crayfish.

7. None of the sampled Central Oklahoma Aquifer springs had fish or crayfish. In fact, the only fish seen in the isolated High Plains Aquifer springs were *Gambusia affinis*, a very common fish species in Oklahoma springs.
8. At least three species of crayfishes were found, along with a few cave-adapted crustaceans. Two of the surveyed Arbuckle springs had cave isopods.
9. Sixty taxa of invertebrates (excluding crayfish) have been identified thus far and work continues on identifying others. The most taxa were found in the Arbuckle-Simpson Aquifer but individual High Plains aquifer springs were the most diverse and the Central Oklahoma Aquifer springs were apparently the least diverse. Sulphur spring in the Arbuckle-Simpson area is the most taxonomically unique spring.
10. The study has not disproved the claim that the discharge volumes in some springs may be declining. Rather it uncovered the interesting paradox that groundwater levels are declining in some aquifers even as they are rising in others. A follow up study that attributes these changes to specific causal mechanisms is solely needed to provide a comprehensive reference source for research as well as water resources planning and management in Oklahoma.

Directions for Future Research

Several important questions emanating from the study need to be investigated more rigorously and systematically. For example, there is a need for a comprehensive analysis of the causes of groundwater level dynamics in Oklahoma. Specifically;

(i) Are other hydroclimatic time series in Oklahoma (i.e. precipitation, stream discharge, baseflow, evapotranspiration, soil moisture index) generally experiencing positive or negative trends? If so, what are the magnitudes, spatial patterns, and reasons for these changes?

(ii) To what extent are observed changes in groundwater levels in Oklahoma climatically induced or the result of anthropogenic processes and what is the relative contribution of both processes?

(iii) Is the observed change temporary or part of a more permanent trend?

(iv) Is the present trend unique or part of a low frequency oscillatory behavior in groundwater variability?

(v) What are the possible impacts of changes in groundwater storage on the unique spring-fed ecosystems that rely on the groundwater?

(vi) What are the impacts and long term implications of observed changes in Oklahoma's water resources on various agricultural, recreational, economic, and other sectors in Oklahoma?

Further research is needed for developing a comprehensive and definitive reference source on Oklahoma's changing water resources.

Acknowledgements

This study was funded by the Oklahoma Water Resources Research Institute. We acknowledge gratefully the support and understanding of the Director Dr. Will Focht and the Coordinator Mr. Michael Langston. We thank our numerous field assistants: Magan Lersch, Barret Phillips, and Rebecca Zimola helped with field work and sample processing; Shane Jones identified the crayfish; and Paulette Reneau and personnel at the Sam Noble Oklahoma Museum of Natural History identified the fish. Janice Spurlock helped with project administration. Mark Faulkner compiled and analyzed the spring and well flow time series and developed several GIS layers. Joseph Zume and Daniel Sambu carried out further statistical and GIS analysis. We appreciate especially the landowners and managers who allowed access to springs. Additional funding for identifications and the 2005 sampling was provided by the Oklahoma Department of Wildlife Conservation.

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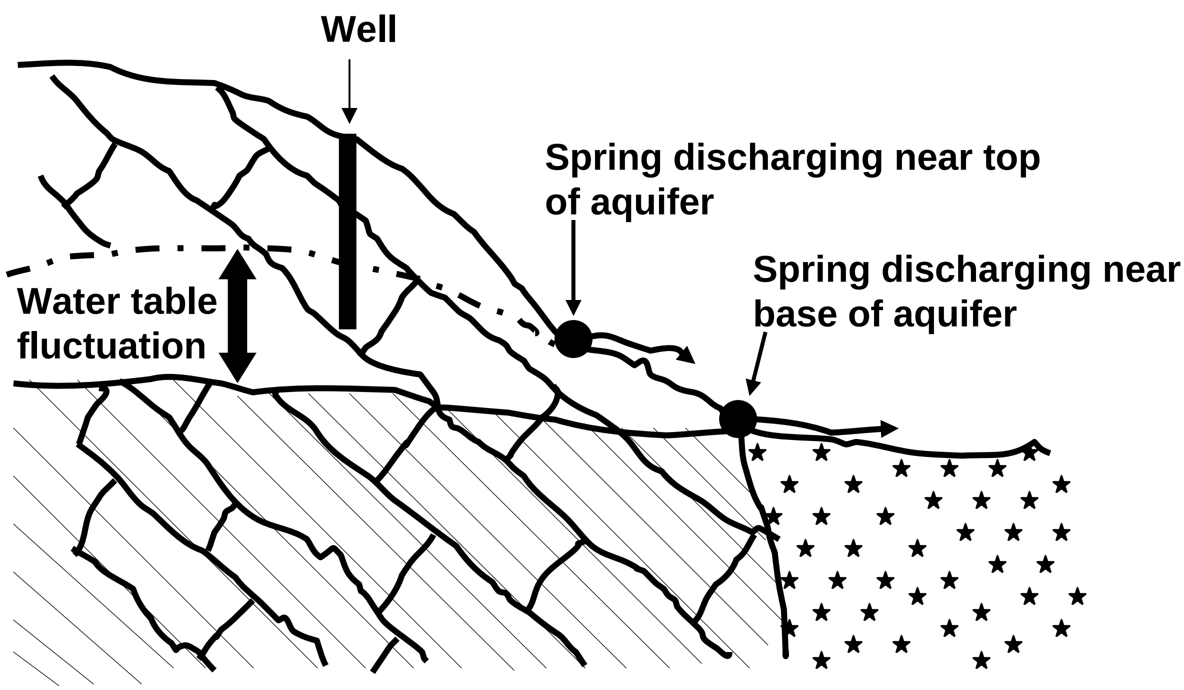


Figure 1. Conceptual illustration of aquifer water table fluctuations and changes in spring flow

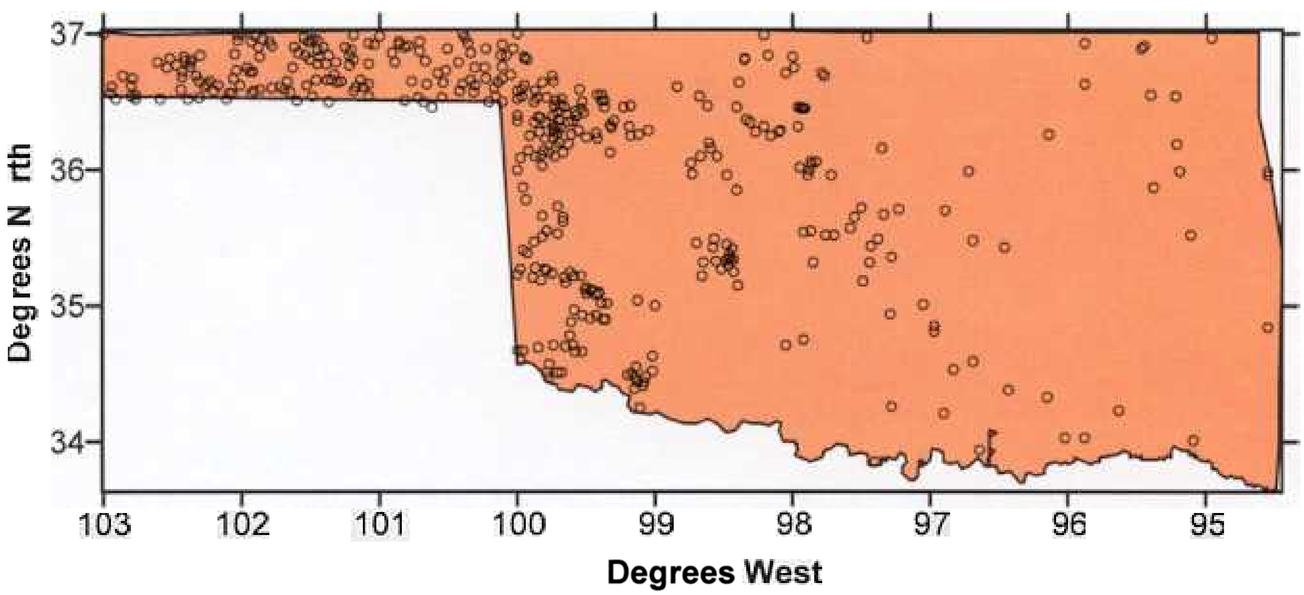


Figure 2. The locations the 429 well points analyzed

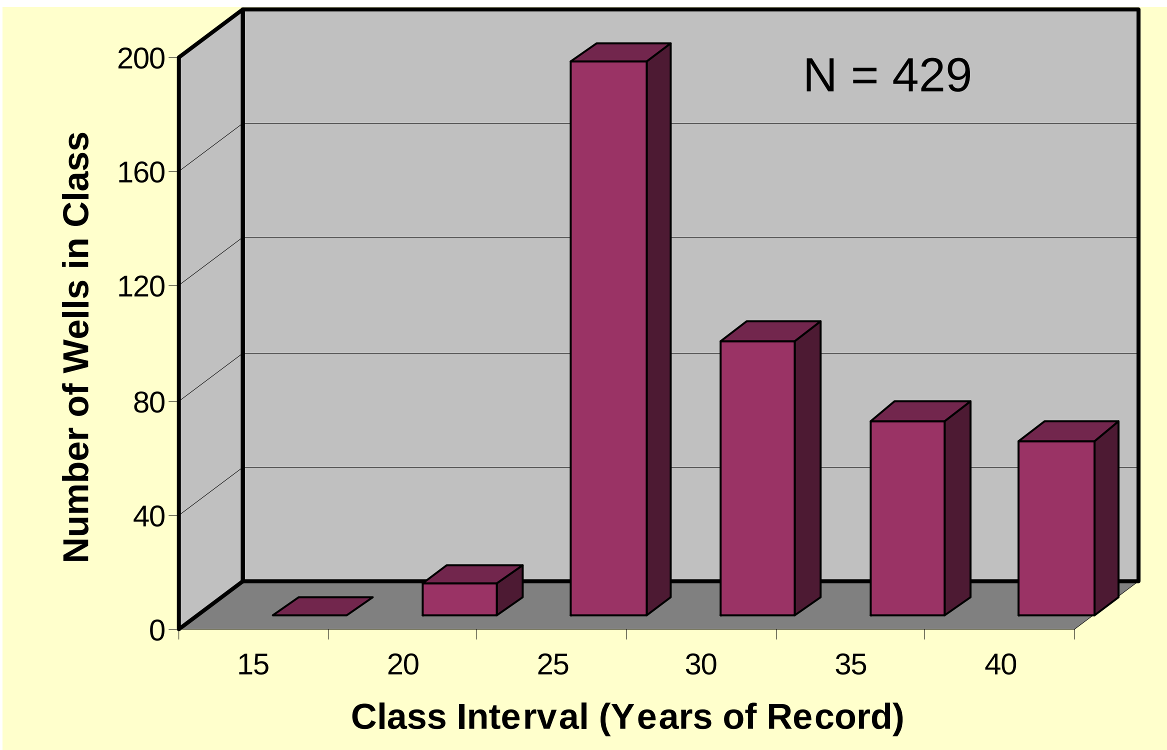


Figure 3. Length of annual well level time series analyzed and the frequency of wells in each class interval. The series ranged from 17 to 38 years with an average of 28 years.

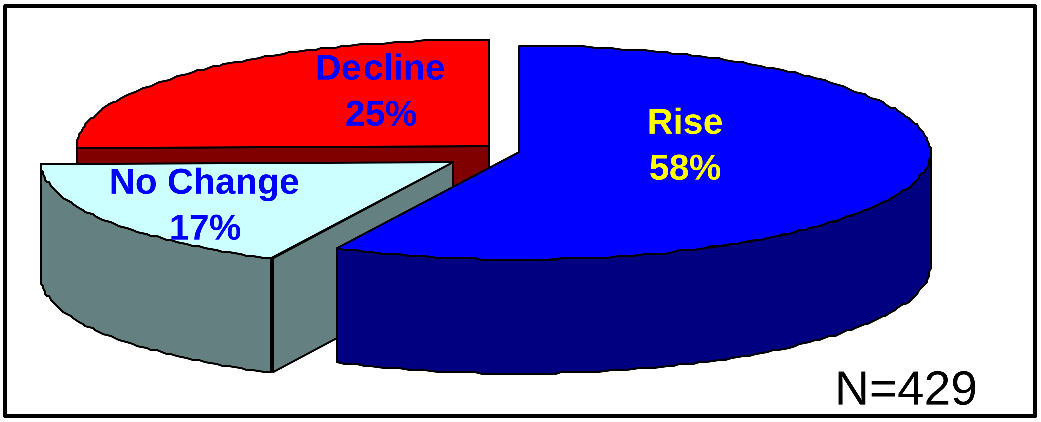


Figure 4. Percentage distribution of wells showing statistically significant (α=0.05 water level rise, decline, and no change. Total number of wells is 429.

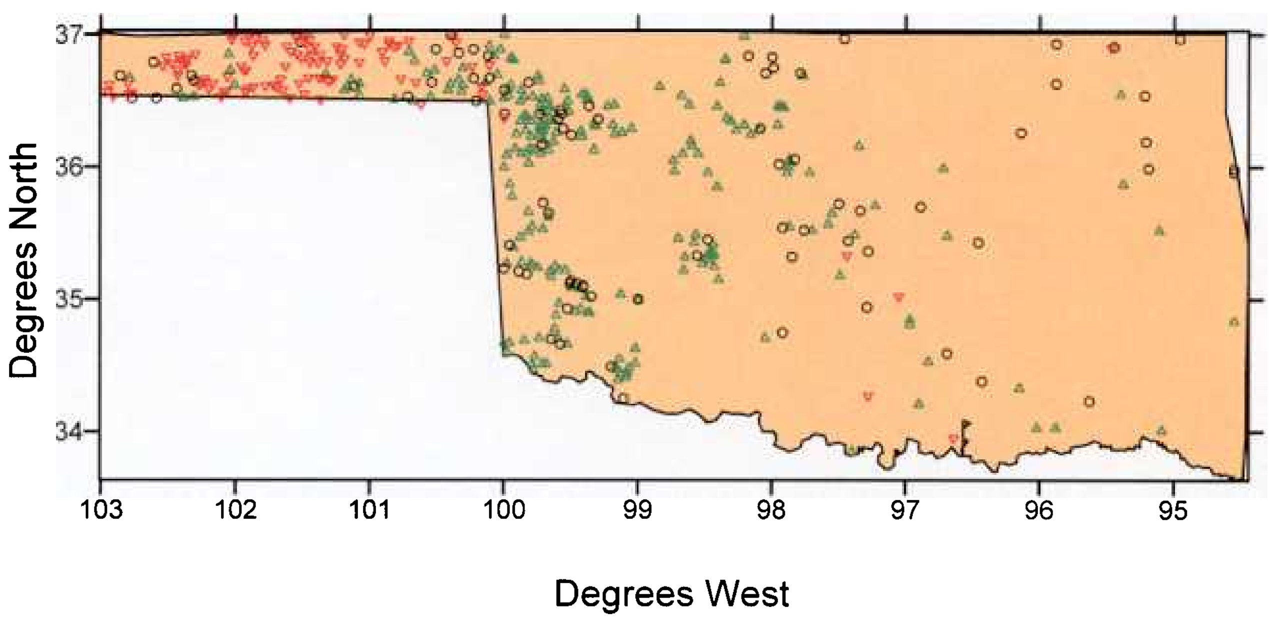


Figure 5. Spatial distribution of groundwater level trends. Inverted red triangles are wells showing statistically significant negative declines, upright green triangles are wells showing statistically positive rises, and open circles are the wells with no change in groundwater level during the study period.

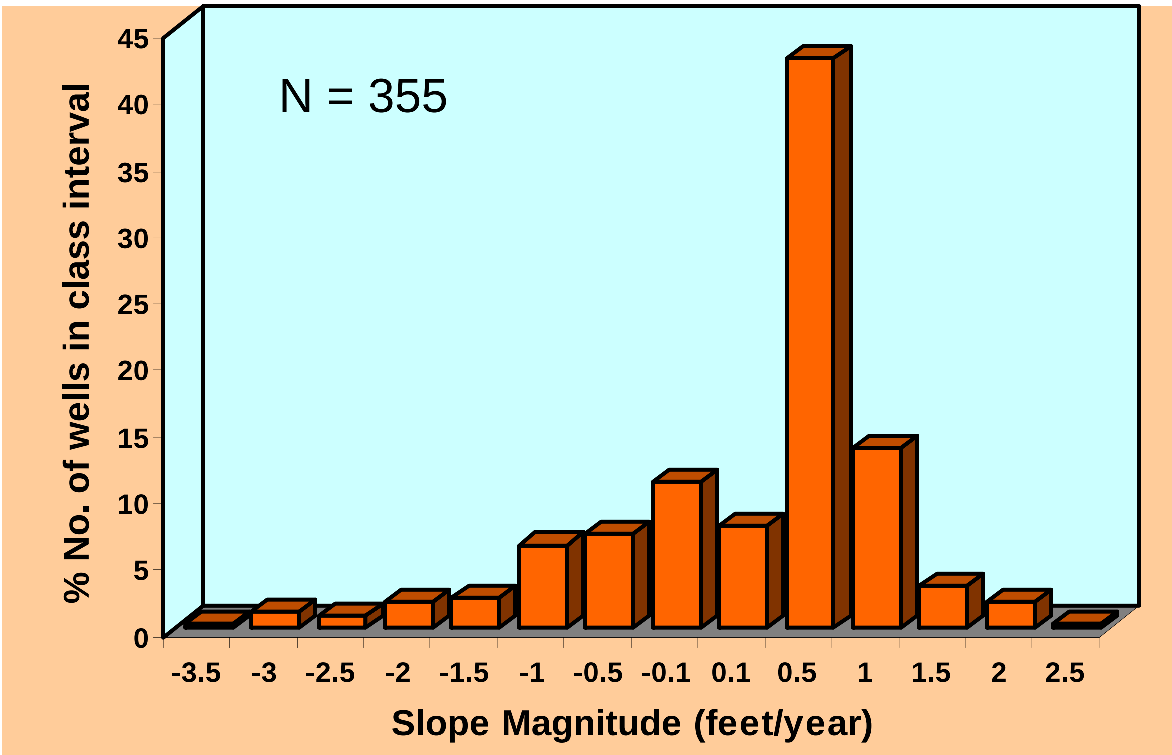


Figure 6. Number of wells in various slope magnitude classes. All wells are statistically significant at α=0.05. Total number of well time series is 355.

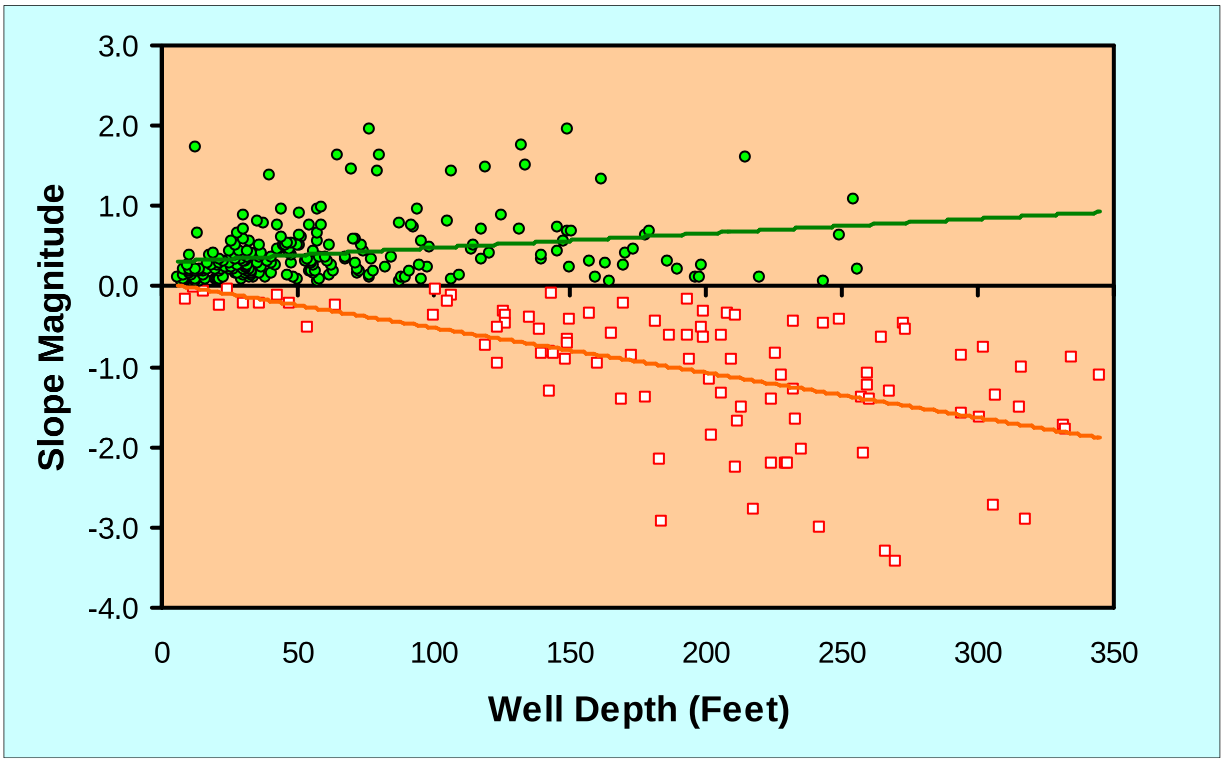


Figure 7. Relationship between slope magnitude and well depth. Notice most deep wells (open red squares) show negative trends and most wells showing positive trends (filled green circles) cluster around a depth of 45 feet below ground surface.

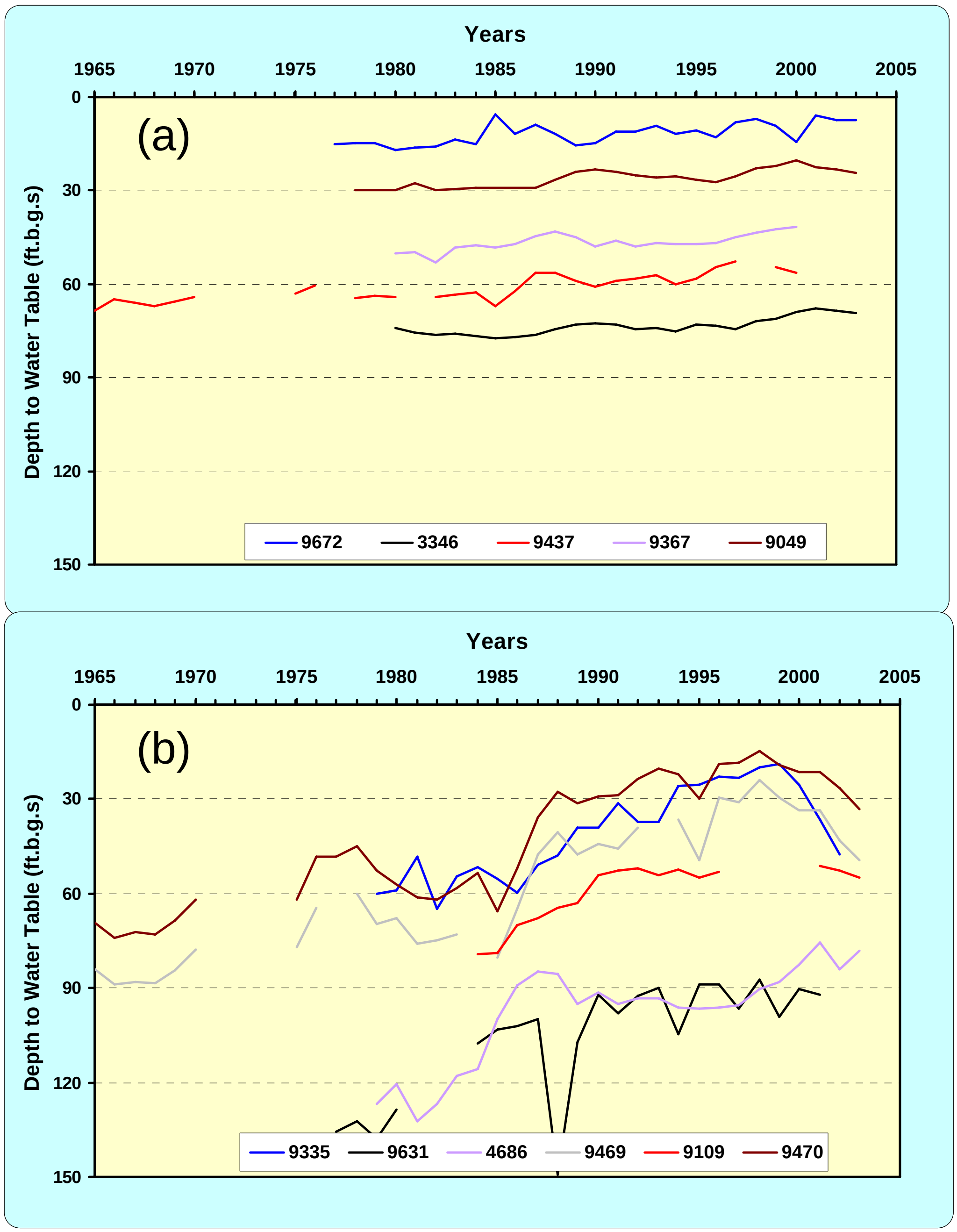


Figure 8. (a) Illustrative wells showing median slope positive magnitudes (i.e. about +0.328 ft/yr) and (b) Wells with high positive slope magnitudes.

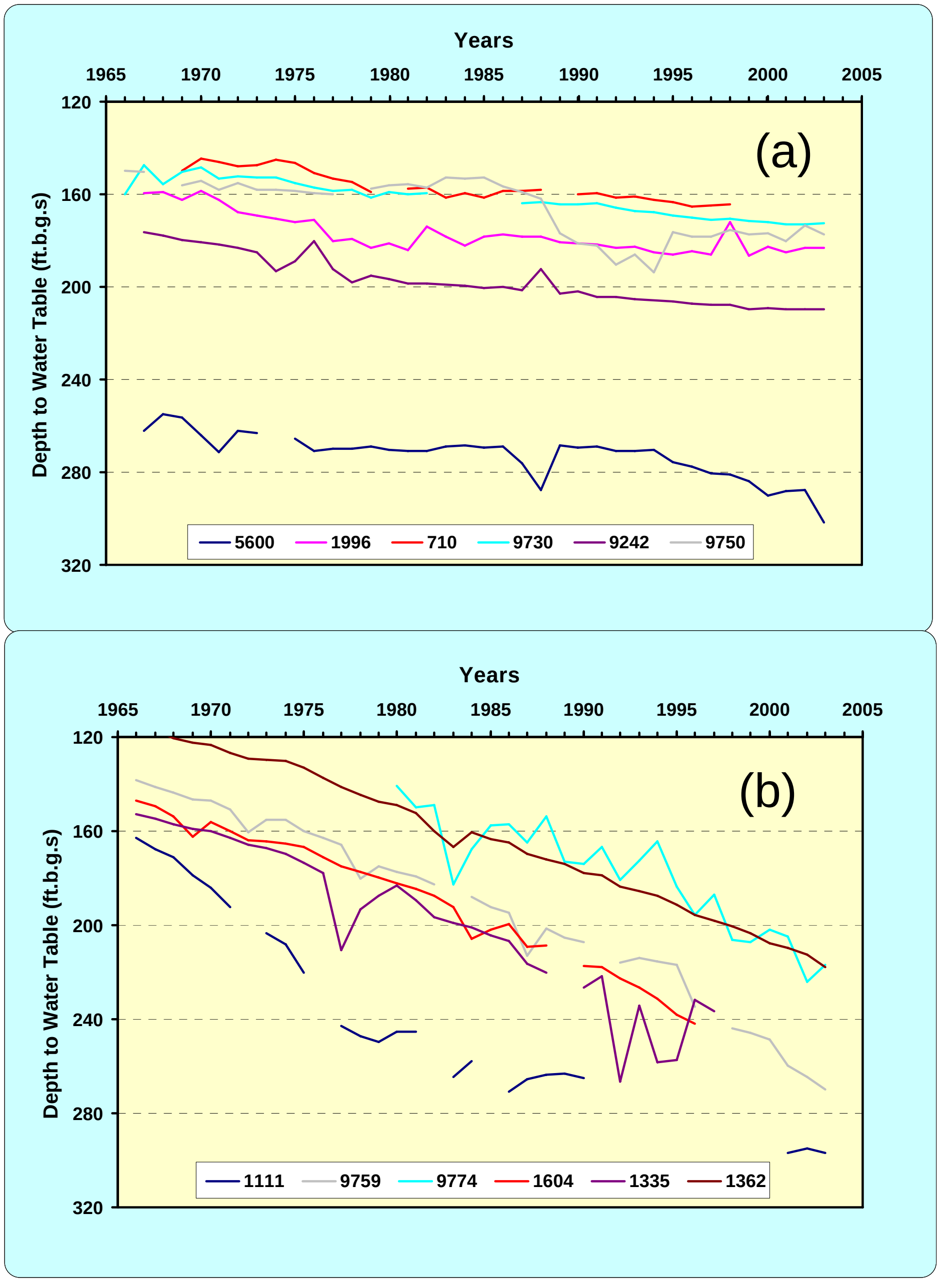


Figure 9. Illustrative wells showing median negative slope magnitudes (i.e. about -0.661ft/yr) and (b) Wells with high negative slope magnitudes.

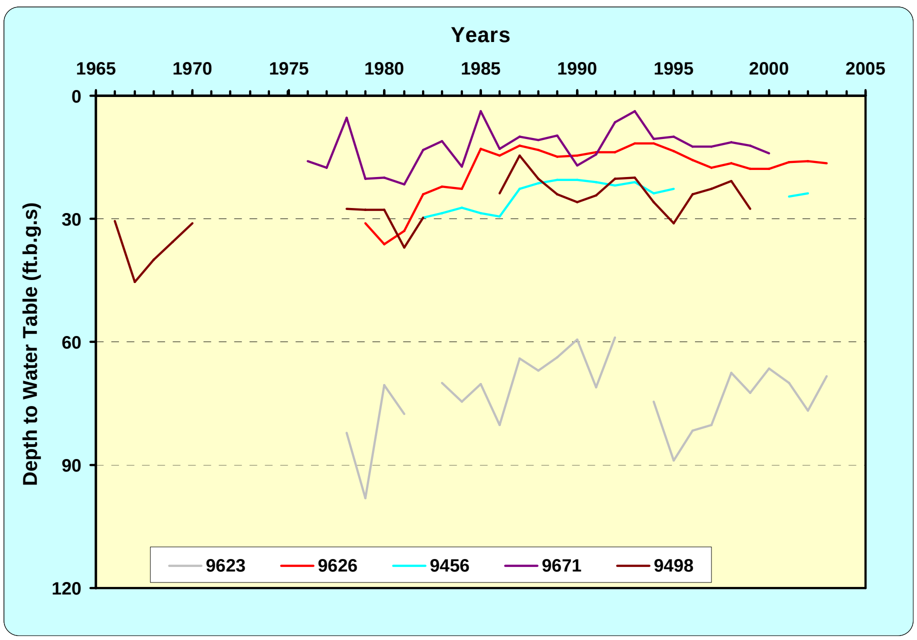


Figure 10. Illustrative wells showing no change in groundwater elevation during the study period.

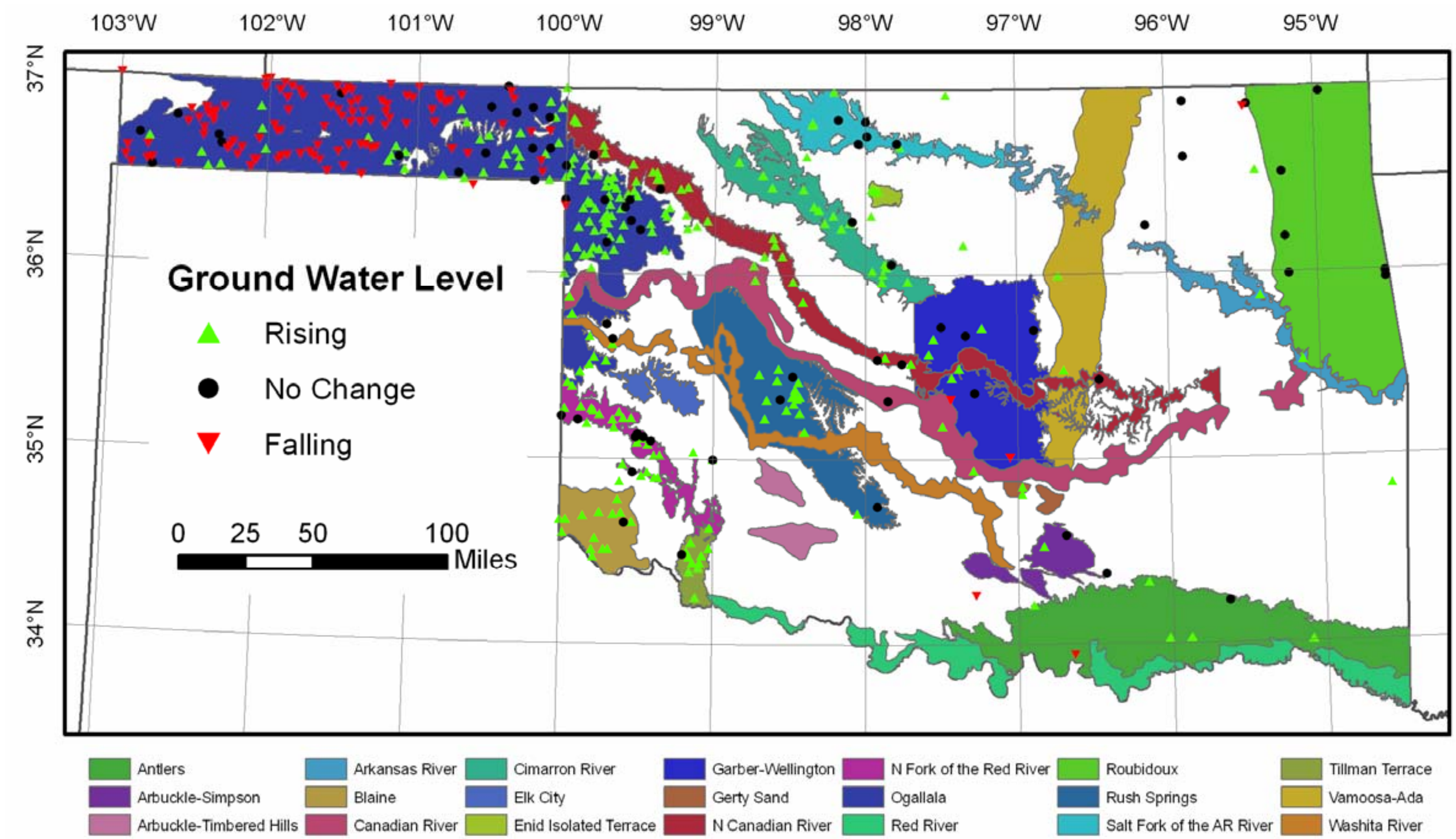


Figure 11. Major groundwater aquifers in Oklahoma and distribution of wells showing water level rise, decline, and no change.

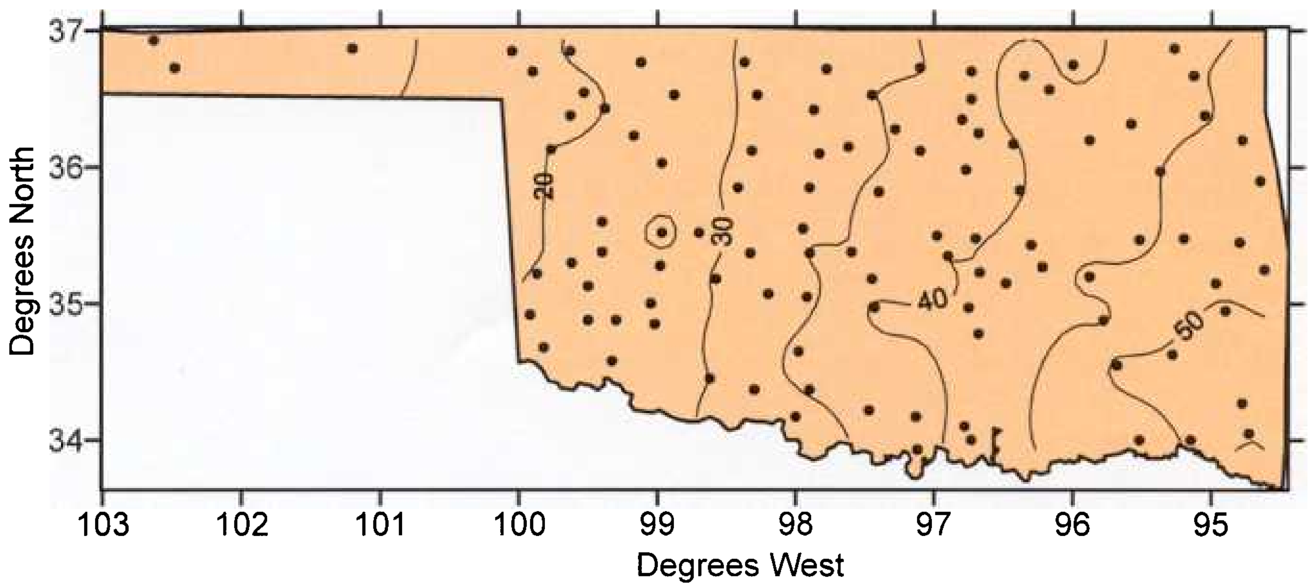


Figure 12. Distribution of the 103 precipitation gauging sites for which time series have been analyzed.

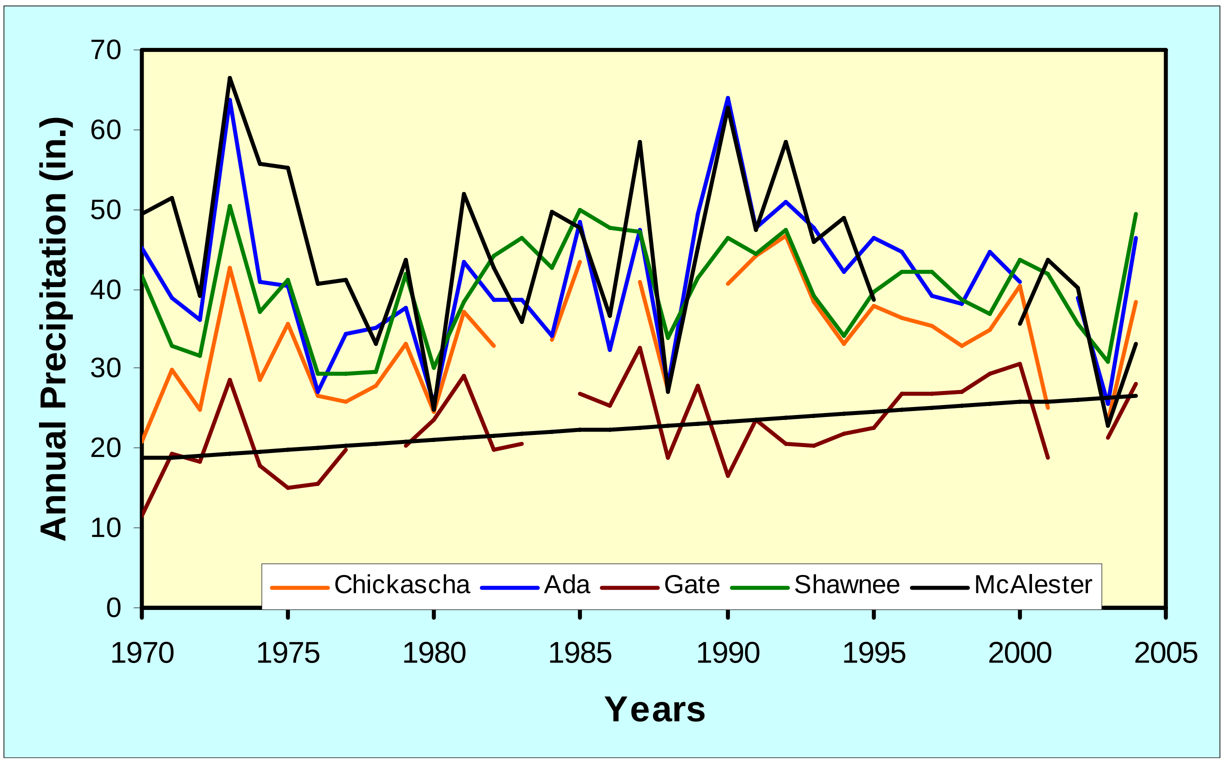


Figure 13. Temporal pattern of annual precipitation variability at five illustrative gauging sites.

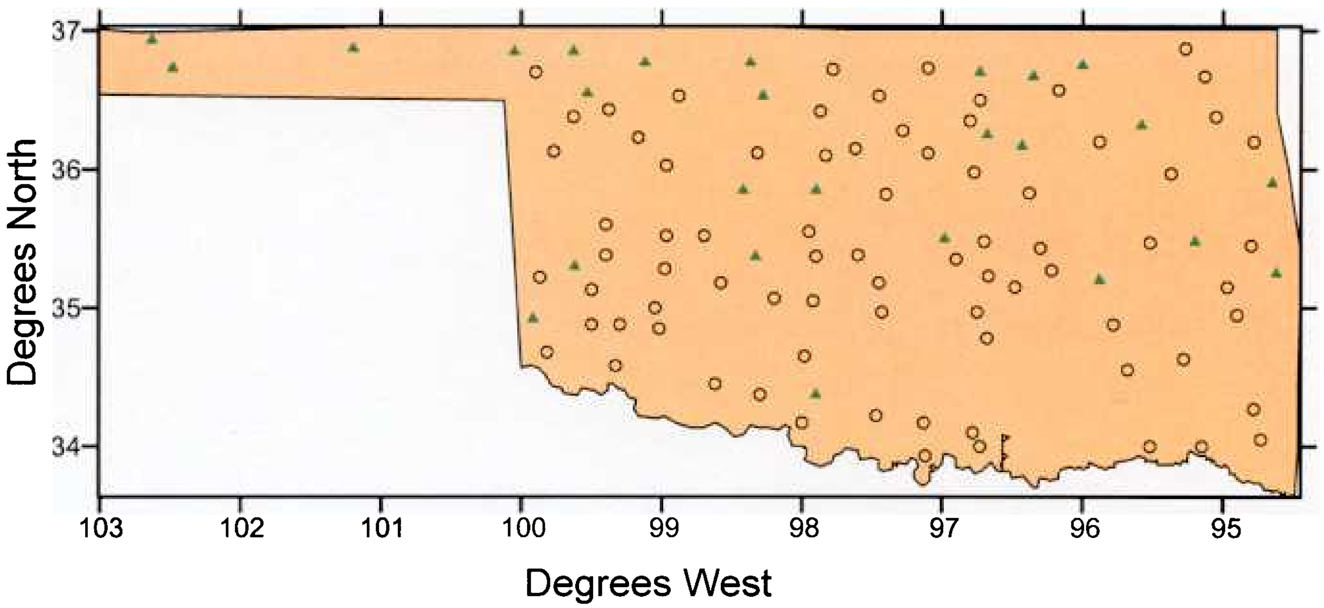


Figure 14. Distribution of precipitation gauging sites showing positive trends (green triangles).

APPENDIX A

Result of Mann-Kendall Analysis for Groundwater Level trends for Wells in Oklahoma

	Ground Water						M-K Trend		Sen's slope estimate											
S/NO	SITE_ID	Lat	Lon	First year	Last Year	n	Test Z	Signific.	Q	Q(final)	Label*	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
1	9569	33.85	-97.40	1980	2001	21	-2.929	**	-0.404	0.404	1	-0.674	-0.050	-0.608	-0.139	49.540	55.468	40.476	54.084	42.362
2	9595	34.01	-95.09	1976	2003	28	-2.509	*	-0.147	0.147	1	-0.299	0.017	-0.258	-0.026	74.168	77.475	70.549	76.536	71.437
3	9131	34.03	-96.02	1977	2003	27	-5.859	***	-1.334	1.334	1	-1.572	-0.883	-1.506	-0.971	167.264	171.549	164.179	170.193	164.443
4	9174	34.03	-95.88	1976	2003	27	-3.919	***	-0.253	0.253	1	-0.373	-0.130	-0.344	-0.151	29.450	32.525	26.940	32.009	27.599
5	9504	34.21	-96.90	1977	2003	26	-2.601	`	-0.223	0.223	1	-0.532	-0.002	-0.442	-0.050	31.631	38.393	25.824	36.110	27.148
6	9803	34.25	-99.11	1977	2003	27	-1.876	+	-0.168	0.168	2	-0.419	0.074	-0.369	0.012	31.882	37.208	26.134	35.815	28.036
7	9010	34.33	-96.15	1976	2003	28	-2.509	*	-0.595	0.595	1	-1.460	0.044	-1.207	-0.148	46.228	74.148	33.808	66.419	37.322
8	9811	34.39	-99.15	1974	2003	29	-6.622	***	-0.387	0.387	1	-0.469	-0.297	-0.451	-0.329	40.756	42.586	38.965	42.035	39.714
9	9812	34.41	-99.09	1975	2003	28	-6.342	***	-0.804	0.804	1	-0.926	-0.639	-0.901	-0.683	61.745	64.108	58.243	63.667	59.332
10	9818	34.44	-99.13	1965	2003	36	-4.931	***	-0.472	0.472	1	-0.658	-0.281	-0.609	-0.336	28.085	30.951	25.448	30.087	26.200
11	9816	34.44	-99.08	1968	2003	32	-4.849	***	-0.397	0.397	1	-0.535	-0.232	-0.477	-0.274	28.640	31.334	26.723	30.166	27.542
12	9823	34.47	-99.15	1981	2003	22	-2.116	*	-0.514	0.514	1	-1.119	0.123	-0.952	-0.051	28.884	43.164	9.959	40.217	15.060
13	9494	34.47	-99.78	1978	2000	23	-2.007	*	-0.284	0.284	1	-0.454	0.075	-0.432	-0.018	79.735	84.175	71.592	83.756	73.975
14	9824	34.48	-99.07	1974	2003	28	-2.904	**	-0.410	0.410	1	-0.641	-0.064	-0.593	-0.169	29.585	34.772	19.991	33.624	23.784
15	9828	34.50	-99.17	1974	2003	29	-4.671	***	-0.812	0.812	1	-1.080	-0.619	-1.004	-0.681	42.253	48.973	37.787	46.917	39.025
16	9464	34.51	-99.79	1976	2003	26	-2.094	*	-0.315	0.315	1	-0.634	0.059	-0.564	-0.049	21.680	28.908	10.556	27.160	14.318
17	9495	34.51	-99.68	1965	2000	30	-4.372	***	-0.293	0.293	1	-0.405	-0.159	-0.371	-0.195	34.523	36.408	32.127	35.771	32.770
18	9463	34.51	-99.71	1965	2003	35	-5.341	***	-0.240	0.240	1	-0.340	-0.162	-0.310	-0.183	16.732	18.643	15.267	18.070	15.600
19	9829	34.52	-99.02	1974	2003	29	-3.452	***	-0.239	0.239	1	-0.425	-0.082	-0.382	-0.120	18.944	23.091	15.562	22.083	16.311
20	9599	34.53	-96.83	1976	2003	28	-2.490	*	-1.394	1.394	1	-3.035	0.053	-2.663	-0.393	119.961	156.477	82.843	149.966	97.656
21	9831	34.55	-99.14	1975	2003	27	-3.544	***	-0.450	0.450	1	-0.702	-0.216	-0.629	-0.276	34.270	40.108	28.406	38.230	30.122
22	9465	34.57	-99.77	1976	2003	27	-2.377	*	-0.736	0.736	1	-1.406	0.116	-1.243	-0.124	44.671	61.459	22.849	56.081	30.469
23	9466	34.60	-99.98	1966	2003	33	-2.619	**	-0.082	0.082	1	-0.199	-0.002	-0.165	-0.023	34.218	36.542	32.734	35.870	33.253
24	9835	34.63	-99.02	1977	2003	27	-4.525	***	-0.689	0.689	1	-0.904	-0.446	-0.831	-0.524	34.433	39.632	28.596	37.835	30.647
25	9497	34.66	-99.53	1965	2003	35	-3.139	**	-0.353	0.353	1	-0.608	-0.102	-0.523	-0.161	38.264	42.500	33.154	41.392	33.990
26	9469	34.67	-100.00	1965	2003	32	-5.497	***	-1.642	1.642	1	-1.994	-1.156	-1.910	-1.290	90.719	95.010	83.709	93.812	84.045
27	9470	34.67	-99.96	1965	2003	35	-5.709	***	-1.562	1.562	1	-1.881	-1.106	-1.824	-1.261	74.682	77.841	63.144	76.364	67.779
28	9471	34.69	-99.85	1965	2002	31	-4.521	***	-1.333	1.333	1	-1.785	-0.839	-1.685	-0.970	67.570	73.923	59.512	71.931	61.336
29	9499	34.70	-99.65	1978	2003	23	-1.717	+	-0.349	0.349	2	-0.753	0.105	-0.654	0.033	26.210	35.451	11.064	32.777	13.235
30	4686	34.71	-98.05	1979	2003	25	-3.947	***	-1.753	1.753	1	-2.375	-0.690	-2.275	-0.899	143.397	156.238	111.521	154.331	116.635
31	9472	34.71	-99.74	1965	2003	35	-3.380	***	-0.974	0.974	1	-1.657	-0.328	-1.474	-0.446	75.634	85.178	65.828	84.076	68.336
32	9501	34.71	-99.60	1976	2003	26	-3.086	**	-0.818	0.818	1	-1.348	-0.176	-1.243	-0.339	50.030	63.551	35.094	60.534	38.300
33	9436	34.78	-99.62	1966	2003	32	-3.487	***	-0.657	0.657	1	-1.018	-0.231	-0.935	-0.355	41.755	48.239	33.003	46.627	35.054
34	9424	34.81	-96.97	1975	2003	28	-3.536	***	-0.293	0.293	1	-0.430	-0.087	-0.396	-0.154	75.096	78.921	69.433	78.192	71.245
35	9557	34.84	-94.55	1980	2003	24	-4.589	***	-1.112	1.112	1	-1.755	-0.686	-1.594	-0.760	61.234	78.559	49.343	74.029	51.479
36	9425	34.85	-96.97	1975	1999	24	-3.349	***	-0.500	0.500	1	-0.853	-0.160	-0.762	-0.224	36.892	44.748	28.791	42.921	30.279
37	9437	34.88	-99.61	1965	2000	29	-5.346	***	-0.340	0.340	1	-0.467	-0.243	-0.438	-0.270	67.691	70.281	65.677	69.586	66.399
38	9438	34.90	-99.36	1980	2003	24	-4.093	***	-0.622	0.622	1	-0.879	-0.286	-0.815	-0.390	39.271	45.357	29.816	43.939	32.984
39	9439	34.90	-99.38	1980	1999	20	-4.804	***	-0.418	0.418	1	-0.558	-0.261	-0.503	-0.308	37.415	40.868	33.326	39.717	34.571
40	9442	34.91	-99.47	1965	2003	29	-4.408	***	-0.252	0.252	1	-1.495	-0.115	-0.597	-0.136	32.730	70.083	29.299	43.140	29.777
41	9444	34.93	-99.43	1980	2002	23	-4.014	***	-0.195	0.195	1	-0.275	-0.095	-0.265	-0.109	30.900	32.852	28.551	32.564	28.862
42	9591	34.94	-97.29	1976	2003	27	-1.960	+	-0.206	0.206	2	-0.481	0.075	-0.411	0.001	12.240	18.515	4.920	17.257	6.823
43	9448	34.97	-99.59	1980	2003	24	-2.332	*	-0.239	0.239	1	-0.390	0.014	-0.360	-0.034	33.105	36.578	25.928	35.875	27.314
44	9834	35.00	-99.00	1965	2003	35	-3.665	***	-0.159	0.159	1	-0.267	-0.068	-0.243	-0.093	14.356	15.809	12.670	15.629	13.306
45	9451	35.02	-99.39	1980	2001	22	-2.425	*	-0.404	0.404	1	-0.679	0.034	-0.621	-0.093	39.092	45.965	28.147	44.382	31.753
46	9450	35.02	-99.35	1980	2003	24	-1.860	+	-0.137	0.137	2	-0.321	0.066	-0.272	0.019	29.763	34.540	24.160	33.408	25.391
47	9554	35.04	-99.13	1976	2003	26	-2.535	*	-0.067	0.067	1	-0.157	0.006	-0.141	-0.015	19.903	21.764	18.117	21.372	18.541
48	9454	35.08	-99.43	1980	2003	23	-2.535	*	-0.343	0.343	1	-0.705	0.005	-0.619	-0.103	25.421	34.072	15.494	32.411	18.942
49	9458	35.09	-99.50	1980	2002	23	-2.324	*	-0.478	0.478	1	-1.024	0.076	-0.874	-0.077	48.226	63.895	33.277	59.682	37.398

50	9461	35.11	-99.47	1980	2000	21	-2.325	*	-0.346	0.346	1	-0.687	0.040	-0.583	-0.081	32.519	39.649	22.016	37.674	25.281
51	9133	35.15	-98.40	1974	2003	27	-3.461	***	-0.723	0.723	1	-1.139	-0.359	-1.037	-0.450	85.553	93.002	78.972	90.572	81.000
52	9090	35.17	-99.65	1980	2003	24	-3.150	**	-0.431	0.431	1	-0.757	-0.073	-0.696	-0.190	22.205	29.773	12.318	28.520	15.305
53	9593	35.18	-97.49	1976	2003	27	-2.168	*	-0.208	0.208	1	-0.396	0.037	-0.341	-0.028	12.058	16.557	5.694	15.553	7.628
54	9091	35.19	-99.83	1980	2003	23	-1.796	+	-0.436	0.436	2	-0.909	0.217	-0.829	0.013	49.681	60.486	32.329	59.240	37.948
55	9096	35.21	-99.66	1980	2003	22	-4.568	***	-0.675	0.675	1	-0.895	-0.461	-0.849	-0.533	37.325	42.442	31.299	41.327	33.307
56	9842	35.22	-98.66	1979	2003	24	-6.573	***	-1.448	1.448	1	-1.699	-1.201	-1.631	-1.271	104.558	110.995	97.357	109.185	99.207
57	9098	35.22	-99.54	1980	2003	24	-4.390	***	-0.505	0.505	1	-0.779	-0.237	-0.714	-0.277	49.747	56.702	41.748	55.072	42.766
58	9100	35.22	-99.59	1981	2003	23	-3.222	**	-0.311	0.311	1	-0.472	-0.064	-0.441	-0.133	72.124	76.254	66.027	75.721	67.832
59	9108	35.24	-99.75	1980	2003	24	-4.490	***	-0.455	0.455	1	-0.599	-0.266	-0.561	-0.315	53.142	56.218	48.148	55.367	49.667
60	9109	35.25	-99.62	1980	2003	18	-3.864	***	-1.614	1.614	1	-2.303	-0.441	-2.161	-0.839	100.235	113.959	69.290	110.828	81.758
61	9138	35.25	-98.43	1974	2003	27	-3.357	***	-0.760	0.760	1	-1.320	-0.240	-1.123	-0.402	83.560	93.159	77.620	89.705	79.616
62	9114	35.26	-99.79	1980	2003	24	-4.242	***	-0.522	0.522	1	-0.758	-0.210	-0.680	-0.304	32.368	38.152	23.143	35.887	25.827
63	3899	35.27	-98.52	1974	2003	26	-2.998	**	-0.604	0.604	1	-1.036	-0.137	-0.917	-0.280	48.338	57.862	38.209	55.433	42.044
64	9119	35.27	-99.98	1980	2003	23	-4.888	***	-0.385	0.385	1	-0.489	-0.265	-0.458	-0.313	60.805	62.795	58.816	62.188	59.576
65	1918	35.27	-99.80	1980	2003	24	-2.902	**	-0.341	0.341	1	-0.575	-0.040	-0.521	-0.153	40.710	44.947	34.895	44.014	37.436
66	9120	35.28	-99.87	1980	2003	23	-3.433	***	-0.193	0.193	1	-0.449	-0.064	-0.378	-0.091	47.250	52.359	44.431	50.901	45.095
67	4093	35.30	-98.47	1975	2000	24	-3.696	***	-0.857	0.857	1	-1.481	-0.410	-1.362	-0.519	108.160	123.926	97.202	121.079	99.865
68	9844	35.32	-98.65	1979	2003	25	-2.966	**	-0.110	0.110	1	-0.176	-0.022	-0.158	-0.048	6.020	7.739	3.733	7.276	4.398
69	9145	35.33	-98.45	1978	2003	25	-4.648	***	-1.065	1.065	1	-1.465	-0.645	-1.392	-0.743	102.328	109.514	94.752	107.751	96.531
70	4039	35.34	-98.48	1977	2003	26	-3.703	***	-0.632	0.632	1	-0.988	-0.221	-0.889	-0.311	100.363	109.559	89.696	106.904	92.063
71	9147	35.34	-98.43	1974	2003	26	-2.513	*	-0.500	0.500	1	-1.132	0.067	-0.916	-0.097	70.910	81.979	64.653	77.050	65.340
72	4017	35.35	-98.46	1974	2003	27	-2.585	**	-0.703	0.703	1	-1.280	-0.029	-1.097	-0.185	121.047	136.335	103.312	130.918	106.686
73	9151	35.38	-98.46	1974	2003	28	-3.536	***	-0.767	0.767	1	-1.406	-0.361	-1.241	-0.477	138.138	150.982	131.007	147.950	132.077
74	9122	35.39	-99.93	1980	2003	23	-3.169	**	-0.220	0.220	1	-0.377	-0.069	-0.329	-0.098	21.370	24.320	19.118	23.545	19.558
75	9123	35.41	-99.96	1980	2003	23	-1.770	+	-0.068	0.068	2	-0.188	0.054	-0.157	0.013	9.552	11.823	7.220	11.483	8.247
76	9156	35.42	-98.44	1974	2003	29	-4.485	***	-1.103	1.103	1	-1.506	-0.617	-1.430	-0.686	93.147	101.004	85.396	99.992	86.568
77	9157	35.43	-98.58	1974	2003	29	-4.335	***	-0.207	0.207	1	-0.310	-0.116	-0.287	-0.132	91.123	92.882	89.450	92.531	89.777
78	9608	35.44	-97.43	1975	2003	27	-1.918	+	-1.620	1.620	2	-4.129	0.475	-3.553	0.105	223.040	290.416	161.825	277.743	174.535
79	9847	35.46	-98.70	1979	2003	25	-5.395	***	-0.914	0.914	1	-1.187	-0.673	-1.107	-0.757	53.557	61.118	46.609	58.946	49.114
80	9335	35.47	-99.88	1979	2002	24	-4.738	***	-1.901	1.901	1	-2.576	-1.144	-2.358	-1.350	66.562	77.015	56.029	72.378	59.427
81	9558	35.48	-96.69	1980	2003	22	-4.906	***	-0.587	0.587	1	-0.777	-0.400	-0.714	-0.446	77.825	82.878	73.317	81.570	74.218
82	9611	35.49	-97.38	1979	2003	24	-3.795	***	-0.522	0.522	1	-0.791	-0.206	-0.718	-0.290	46.479	53.877	37.477	51.860	39.996
83	9160	35.49	-98.57	1974	2003	29	-2.532	*	-0.186	0.186	1	-0.458	0.003	-0.361	-0.050	68.931	74.176	65.589	71.949	66.638
84	9647	35.51	-99.82	1980	2003	24	-3.920	***	-0.174	0.174	1	-0.280	-0.087	-0.249	-0.106	22.170	25.190	20.002	24.337	20.545
85	9672	35.52	-95.11	1977	2003	27	-3.794	***	-0.317	0.317	1	-0.443	-0.133	-0.409	-0.190	18.984	22.615	14.680	21.728	16.114
86	9164	35.52	-97.70	1977	2003	25	-2.103	*	-0.152	0.152	1	-0.337	0.035	-0.300	-0.009	7.573	11.371	4.349	10.694	4.904
87	9649	35.53	-99.71	1980	2003	24	-4.390	***	-0.197	0.197	1	-0.290	-0.097	-0.274	-0.135	13.712	15.789	10.757	15.386	11.901
88	9650	35.55	-99.79	1980	2003	23	-4.595	***	-0.343	0.343	1	-0.485	-0.224	-0.442	-0.262	65.637	69.179	62.481	68.106	63.383
89	9167	35.55	-97.87	1977	2003	27	-2.064	*	-0.183	0.183	1	-0.401	0.080	-0.343	-0.010	11.517	14.968	6.790	13.981	8.312
90	9624	35.57	-97.58	1976	2003	23	-2.060	*	-0.296	0.296	1	-0.682	0.075	-0.568	-0.025	69.058	77.764	58.637	74.982	61.069
91	9328	35.62	-99.67	1976	2002	23	-4.067	***	-0.352	0.352	1	-0.533	-0.187	-0.486	-0.234	10.852	12.460	8.738	12.121	9.302
92	9619	35.65	-97.55	1976	2000	25	-5.142	***	-0.923	0.923	1	-1.157	-0.715	-1.082	-0.773	102.366	107.675	97.496	106.042	99.165
93	9657	35.66	-99.82	1980	2003	24	-3.226	**	-0.121	0.121	1	-0.226	-0.029	-0.198	-0.052	61.893	64.875	60.065	64.067	60.583
94	9622	35.71	-97.23	1977	1999	21	-2.084	*	-2.265	2.265	1	-3.900	0.202	-3.424	-0.143	88.796	127.435	17.541	117.400	27.557
95	9664	35.78	-99.94	1980	2002	21	-3.657	***	-0.301	0.301	1	-0.563	-0.107	-0.448	-0.153	42.364	48.580	38.326	46.754	39.101
96	5131	35.85	-98.41	1976	2003	26	-5.181	***	-0.461	0.461	1	-0.730	-0.290	-0.600	-0.331	26.388	32.927	22.065	29.659	23.021
97	9666	35.87	-99.96	1980	2003	21	-5.103	***	-0.116	0.116	1	-0.154	-0.080	-0.143	-0.092	7.290	8.357	6.210	8.028	6.593
98	9838	35.87	-95.38	1976	2000	25	-3.014	**	-0.076	0.076	1	-0.142	-0.015	-0.131	-0.028	7.878	9.347	6.558	9.154	6.762
99	9127	35.96	-98.48	1977	2003	27	-4.503	***	-0.345	0.345	1	-0.454	-0.193	-0.427	-0.234	54.105	55.939	51.349	55.456	52.035
100	9515	35.96	-97.89	1975	1999	24	-2.084	*	-0.196	0.196	1	-0.410	0.050	-0.379	-0.018	13.150	18.695	6.534	18.136	8.122
101	9512	35.96	-97.72	1975	2003	28	-2.016	*	-0.066	0.066	1	-0.195	0.025	-0.147	-0.002	19.157	21.975	16.655	21.008	17.599
102	9288	35.97	-98.73	1976	2003	26	-5.995	***	-1.416	1.416	1	-1.667	-1.185	-1.589	-1.255	109.407	113.880	105.855	112.374	107.042
103	9631	35.99	-96.72	1977	2001	23	-4.226	***	-1.805	1.805	1	-2.660	-0.804	-2.459	-1.095	148.765	166.041	120.428	162.671	127.713
104	9303	36.00	-100.00	1980	2003	23	-4.331	***	-0.370	0.370	1	-0.532	-0.214	-0.471	-0.278	85.671	89.029	84.046	87.560	84.370

105	3307	36.00	-100.00	1980	2003	24	-4.589	***	-0.297	0.297	1	-0.541	-0.157	-0.449	-0.186	150.876	156.405	147.612	154.428	148.295
106	3302	36.00	-100.00	1980	2003	23	-4.729	***	-0.260	0.260	1	-0.332	-0.180	-0.315	-0.209	98.290	100.113	96.209	99.560	96.955
107	9521	36.00	-97.88	1975	2003	27	-3.210	**	-0.220	0.220	1	-0.347	-0.072	-0.319	-0.113	16.900	20.183	12.774	19.413	14.148
108	9522	36.02	-97.95	1975	2003	27	-1.939	+	-0.123	0.123	2	-0.261	0.034	-0.221	0.000	25.520	29.109	20.857	28.331	21.993
109	9297	36.03	-99.82	1980	2003	24	-3.027	**	-0.234	0.234	1	-0.375	-0.065	-0.344	-0.130	24.365	26.655	22.180	26.079	22.804
110	9524	36.04	-97.86	1975	2003	28	-4.129	***	-0.463	0.463	1	-0.677	-0.225	-0.625	-0.297	36.731	42.483	29.928	41.384	32.055
111	9289	36.05	-98.74	1979	2003	25	-6.096	***	-0.935	0.935	1	-1.065	-0.731	-1.035	-0.812	61.733	63.586	59.301	63.095	60.513
112	9526	36.06	-97.87	1975	2003	24	-2.060	*	-0.090	0.090	1	-0.198	0.018	-0.173	-0.003	8.040	10.459	5.132	9.798	5.756
113	9301	36.09	-99.98	1980	2003	22	-4.342	***	-0.379	0.379	1	-0.537	-0.194	-0.500	-0.217	172.232	174.275	170.011	173.800	170.213
114	9306	36.10	-99.73	1980	2003	24	-5.680	***	-0.579	0.579	1	-0.797	-0.490	-0.768	-0.522	153.419	156.168	152.169	155.765	152.679
115	9128	36.10	-98.55	1978	2003	24	-5.531	***	-0.557	0.557	1	-0.688	-0.418	-0.663	-0.473	34.352	36.431	32.237	35.961	32.986
116	9291	36.10	-98.67	1979	2003	22	-3.752	***	-0.328	0.328	1	-0.450	-0.150	-0.429	-0.188	27.594	29.115	25.317	28.781	26.147
117	9302	36.10	-99.87	1980	2002	21	-2.992	**	-0.270	0.270	1	-0.470	-0.062	-0.427	-0.099	68.334	70.686	66.201	70.214	66.688
118	3012	36.11	-99.83	1980	2003	24	-3.970	***	-0.200	0.200	1	-0.331	-0.100	-0.290	-0.132	25.868	28.748	23.572	27.835	24.338
119	2990	36.13	-99.77	1980	2003	24	-5.707	***	-0.700	0.700	1	-0.897	-0.493	-0.848	-0.529	159.708	164.814	155.342	163.556	156.192
120	9383	36.13	-99.67	1980	2003	22	-3.779	***	-0.676	0.676	1	-0.921	-0.237	-0.848	-0.454	180.685	183.573	176.580	182.856	178.421
121	9293	36.13	-99.33	1980	2002	21	-5.559	***	-0.461	0.461	1	-0.554	-0.336	-0.528	-0.361	63.513	65.011	62.277	64.633	62.663
122	9315	36.14	-99.81	1980	2003	23	-4.912	***	-0.510	0.510	1	-0.721	-0.132	-0.660	-0.196	116.450	120.038	112.922	118.993	113.602
123	9313	36.14	-99.92	1980	2003	23	-4.490	***	-0.425	0.425	1	-0.678	-0.207	-0.598	-0.250	170.030	174.899	167.408	173.470	167.990
124	9130	36.16	-98.60	1976	2003	25	-3.854	***	-0.343	0.343	1	-0.504	-0.147	-0.441	-0.195	22.727	24.584	19.230	23.891	20.253
125	9636	36.16	-97.35	1977	1999	21	-3.536	***	-0.088	0.088	1	-0.255	-0.033	-0.176	-0.044	8.754	12.626	7.371	10.648	7.582
126	9322	36.19	-99.63	1980	2003	22	-5.583	***	-0.648	0.648	1	-0.758	-0.512	-0.731	-0.560	181.634	183.583	179.641	183.173	180.452
127	9323	36.20	-99.70	1980	2003	24	-5.432	***	-0.754	0.754	1	-0.925	-0.545	-0.882	-0.602	62.854	65.800	60.682	64.933	60.938
128	9571	36.20	-98.61	1979	2003	25	-5.513	***	-0.447	0.447	1	-0.539	-0.330	-0.520	-0.355	27.786	29.820	25.222	29.229	26.031
129	3043	36.23	-99.80	1980	2003	23	-4.676	***	-0.545	0.545	1	-0.713	-0.339	-0.685	-0.402	52.740	56.886	47.854	55.982	49.034
130	9867	36.23	-99.42	1980	2001	22	-5.418	***	-0.495	0.495	1	-0.604	-0.370	-0.588	-0.383	121.701	124.162	119.276	123.735	119.574
131	4315	36.24	-99.74	1980	2002	22	-3.869	***	-0.399	0.399	1	-0.547	-0.199	-0.509	-0.258	15.971	19.174	10.647	18.051	12.172
132	9334	36.25	-99.91	1980	2003	23	-3.856	***	-0.500	0.500	1	-0.658	-0.275	-0.617	-0.345	74.790	76.973	70.996	76.304	72.178
133	9575	36.25	-98.16	1965	2003	35	-5.368	***	-0.495	0.495	1	-0.618	-0.352	-0.589	-0.378	22.520	25.213	18.832	24.800	19.506
134	9390	36.25	-99.18	1977	2003	27	-4.836	***	-0.262	0.262	1	-0.353	-0.189	-0.330	-0.210	198.052	199.336	196.974	198.917	197.170
135	9871	36.26	-99.12	1977	2003	25	-4.321	***	-0.350	0.350	1	-0.616	-0.197	-0.522	-0.233	36.034	38.957	33.732	37.999	34.325
136	9367	36.26	-99.61	1980	2000	21	-3.714	***	-0.313	0.313	1	-0.598	-0.112	-0.511	-0.166	51.164	56.038	48.742	53.963	49.451
137	3097	36.27	-99.71	1980	2003	24	-3.349	***	-0.213	0.213	1	-0.314	-0.067	-0.270	-0.109	55.973	58.377	52.327	57.586	53.483
138	9870	36.27	-99.43	1980	2003	24	-2.332	*	-0.163	0.163	1	-0.253	0.032	-0.227	-0.046	43.924	45.234	40.765	45.056	41.963
139	9412	36.28	-98.10	1975	2003	27	-4.044	***	-0.661	0.661	1	-1.018	-0.242	-0.915	-0.406	28.236	36.784	19.409	34.707	22.355
140	3143	36.28	-99.84	1980	2003	24	-3.795	***	-0.575	0.575	1	-0.824	-0.331	-0.757	-0.402	49.790	56.025	44.453	54.251	45.972
141	9578	36.28	-98.27	1977	2003	26	-3.306	***	-0.202	0.202	1	-0.430	-0.059	-0.353	-0.088	20.347	26.389	16.974	24.167	17.658
142	9345	36.28	-99.73	1980	2003	24	-3.150	**	-0.103	0.103	1	-0.182	-0.026	-0.162	-0.047	37.830	38.827	36.852	38.618	37.230
143	9872	36.29	-99.05	1978	2000	23	-5.233	***	-0.304	0.304	1	-0.380	-0.225	-0.362	-0.246	79.587	80.420	78.718	80.184	78.923
144	9366	36.30	-99.74	1979	2002	24	-2.902	**	-0.151	0.151	1	-0.270	-0.022	-0.230	-0.061	38.872	40.720	37.437	40.237	37.954
145	5385	36.31	-99.32	1980	2003	23	-4.067	***	-0.289	0.289	1	-0.346	-0.169	-0.319	-0.214	34.539	35.816	31.542	35.304	32.684
146	9353	36.31	-99.69	1980	2003	24	-2.606	**	-0.190	0.190	1	-0.360	0.000	-0.319	-0.045	55.108	57.087	52.605	56.745	53.404
147	9580	36.32	-98.21	1976	2003	27	-3.169	**	-0.559	0.559	1	-0.867	-0.134	-0.791	-0.273	31.106	38.561	19.770	37.005	24.518
148	9314	36.32	-97.96	1977	2003	24	-3.894	***	-0.255	0.255	1	-0.397	-0.119	-0.359	-0.148	22.573	26.205	19.320	25.225	20.066
149	9876	36.32	-99.19	1975	2000	21	-3.839	***	-0.183	0.183	1	-0.320	-0.089	-0.290	-0.117	8.343	9.277	6.760	9.059	7.364
150	9356	36.32	-99.72	1980	2003	24	-3.597	***	-0.120	0.120	1	-0.173	-0.050	-0.157	-0.070	32.643	33.495	31.582	33.281	31.890
151	9877	36.33	-99.33	1980	2003	24	-3.001	**	-0.257	0.257	1	-0.409	-0.045	-0.377	-0.109	10.027	12.301	6.115	11.730	7.327
152	9581	36.35	-98.31	1976	2003	27	-5.003	***	-0.610	0.610	1	-0.726	-0.428	-0.690	-0.498	31.370	34.113	26.276	33.255	28.391
153	9364	36.35	-99.63	1980	2003	24	-3.845	***	-0.487	0.487	1	-0.737	-0.242	-0.662	-0.320	51.610	54.662	48.494	53.817	49.596
154	9362	36.35	-99.80	1980	2003	23	-3.328	***	-0.162	0.162	1	-0.288	-0.048	-0.262	-0.077	74.322	75.644	73.166	75.362	73.349
155	3244	36.35	-99.88	1981	2003	23	-2.271	*	-0.093	0.093	1	-0.198	0.012	-0.163	-0.011	218.528	220.834	216.110	220.069	216.669
156	9880	36.36	-99.30	1975	2003	28	-1.719	+	-0.060	0.060	2	-0.128	0.033	-0.116	0.008	3.830	4.948	3.036	4.784	3.302
157	9583	36.37	-98.34	1978	2003	26	-4.408	***	-0.562	0.562	1	-0.734	-0.274	-0.685	-0.345	36.232	40.460	28.271	39.447	30.033
158	9368	36.37	-99.70	1980	2001	21	-2.265	*	-0.111	0.111	1	-0.205	0.034	-0.187	-0.017	22.114	23.480	19.937	23.202	20.701
159	9372	36.38	-99.83	1980	2003	24	-4.343	***	-0.154	0.154	1	-0.268	-0.068	-0.252	-0.088	72.566	73.928	71.514	73.692	71.863

160	9884	36.39	-99.85	1978	2003	25	-4.816	***	-0.242	0.242	1	-0.370	-0.131	-0.348	-0.175	30.408	31.561	28.895	31.344	29.602
161	9378	36.41	-99.64	1980	2003	24	-3.497	***	-0.175	0.175	1	-0.281	-0.070	-0.258	-0.094	15.284	16.792	13.580	16.364	13.957
162	9887	36.42	-99.52	1978	2003	25	-4.461	***	-0.439	0.439	1	-0.549	-0.208	-0.514	-0.294	44.678	46.270	41.786	45.632	42.879
163	9380	36.42	-99.71	1980	2003	22	-2.820	**	-0.267	0.267	1	-0.532	-0.031	-0.452	-0.082	55.603	60.015	52.110	58.783	52.883
164	5558	36.43	-99.58	1981	2003	23	-1.902	+	-0.189	0.189	2	-0.420	0.046	-0.361	0.005	10.248	16.068	3.915	14.875	5.022
165	9417	36.45	-97.92	1975	2003	29	-6.434	***	-1.312	1.312	1	-1.569	-0.956	-1.514	-1.073	54.510	61.323	43.927	59.673	47.692
166	9418	36.45	-97.93	1975	2003	29	-5.534	***	-0.954	0.954	1	-1.198	-0.683	-1.125	-0.730	61.995	68.162	55.527	66.455	56.180
167	9419	36.45	-97.94	1975	2003	29	-5.984	***	-0.908	0.908	1	-1.147	-0.686	-1.084	-0.761	60.043	65.686	55.673	64.337	56.980
168	9415	36.45	-97.94	1975	2003	29	-5.854	***	-0.893	0.893	1	-1.141	-0.627	-1.069	-0.703	56.539	62.244	51.329	60.588	52.584
169	9616	36.45	-97.91	1975	2003	28	-6.263	***	-0.859	0.859	1	-1.058	-0.647	-1.018	-0.698	39.358	43.963	33.969	43.070	35.133
170	5552	36.45	-99.54	1980	2003	24	-4.341	***	-0.441	0.441	1	-0.588	-0.254	-0.531	-0.302	29.747	33.475	25.516	31.906	26.586
171	9422	36.46	-97.94	1975	2003	27	-6.546	***	-0.770	0.770	1	-0.890	-0.665	-0.852	-0.706	44.667	48.183	42.647	47.055	43.356
172	5523	36.46	-99.23	1978	2003	24	-4.886	***	-0.707	0.707	1	-0.890	-0.397	-0.848	-0.509	50.926	54.734	43.093	53.786	46.163
173	3270	36.46	-99.66	1980	2003	24	-3.771	***	-0.271	0.271	1	-0.401	-0.111	-0.355	-0.142	64.602	67.744	61.528	66.580	62.288
174	9423	36.46	-97.96	1975	2003	29	-3.940	***	-0.165	0.165	1	-0.244	-0.064	-0.230	-0.089	10.104	12.316	7.594	11.940	8.230
175	9587	36.46	-98.41	1976	2003	27	-2.335	*	-0.080	0.080	1	-0.177	0.020	-0.146	-0.022	8.260	10.725	5.747	10.001	6.651
176	9387	36.47	-99.73	1980	2003	23	-5.388	***	-0.467	0.467	1	-0.611	-0.357	-0.565	-0.388	101.641	103.583	99.887	103.040	100.468
177	5514	36.47	-99.18	1978	2003	26	-4.608	***	-0.306	0.306	1	-0.445	-0.170	-0.396	-0.210	68.918	71.809	65.499	70.990	66.505
178	9848	36.47	-98.62	1979	2003	25	-2.336	*	-0.093	0.093	1	-0.209	0.010	-0.183	-0.018	6.536	9.249	4.022	8.768	4.804
179	3266	36.48	-99.69	1980	2003	23	-3.514	***	-0.245	0.245	1	-0.430	-0.070	-0.398	-0.099	65.415	69.711	61.545	69.062	62.273
180	9031	36.50	-100.11	1968	2003	34	-4.240	***	-0.649	0.649	1	-0.921	-0.361	-0.851	-0.440	147.369	153.103	141.275	151.247	143.403
181	45	36.50	-100.68	1977	2003	20	-5.548	***	-0.435	0.435	1	-0.776	-0.292	-0.706	-0.340	252.321	257.635	248.514	256.674	250.147
182	9895	36.50	-99.53	1980	2003	24	-3.398	***	-0.356	0.356	1	-0.588	-0.116	-0.506	-0.185	35.744	38.854	31.142	37.813	32.795
183	3296	36.50	-99.88	1980	2003	23	-4.701	***	-0.207	0.207	1	-0.284	-0.128	-0.271	-0.149	192.784	194.712	191.153	194.384	191.682
184	9897	36.51	-99.39	1978	2001	24	-5.135	***	-0.431	0.431	1	-0.530	-0.310	-0.501	-0.330	53.125	54.217	51.430	53.954	51.695
185	9352	36.51	-99.72	1980	2002	21	-4.620	***	-0.368	0.368	1	-0.506	-0.194	-0.462	-0.227	140.451	143.310	138.073	142.425	138.499
186	9896	36.51	-99.37	1977	2000	23	-2.747	**	-0.130	0.130	1	-0.354	-0.019	-0.285	-0.038	33.220	35.312	31.969	34.313	32.198
187	9015	36.51	-100.82	1968	2003	33	-3.409	***	-0.084	0.084	1	-0.121	-0.016	-0.110	-0.046	242.776	243.586	241.184	243.319	241.953
188	3348	36.52	-100.00	1980	2003	24	-5.383	***	-0.353	0.353	1	-0.432	-0.255	-0.412	-0.277	122.676	124.640	120.686	124.113	121.150
189	9398	36.52	-99.68	1980	2003	24	-2.753	**	-0.213	0.213	1	-0.409	-0.021	-0.341	-0.065	33.087	37.834	28.872	35.851	30.000
190	9186	36.52	-102.39	1967	2003	34	-4.344	***	-0.100	0.100	1	-0.162	-0.048	-0.146	-0.061	104.429	105.550	103.606	105.336	103.898
191	9018	36.53	-100.55	1967	1999	31	-3.535	***	-0.284	0.284	1	-0.449	-0.124	-0.402	-0.153	224.367	228.138	221.034	227.261	221.622
192	9399	36.53	-99.86	1981	2003	23	-4.912	***	-0.254	0.254	1	-0.321	-0.170	-0.306	-0.192	174.217	176.004	172.110	175.601	172.667
193	9400	36.53	-99.79	1981	2001	20	-4.220	***	-0.121	0.121	1	-0.171	-0.074	-0.158	-0.092	47.740	48.940	46.681	48.645	47.125
194	9192	36.53	-102.31	1968	2003	36	-3.065	**	-0.060	0.060	1	-0.110	-0.008	-0.097	-0.020	193.110	193.755	191.811	193.594	192.104
195	9852	36.54	-98.68	1977	2003	25	-3.620	***	-0.472	0.472	1	-0.793	-0.164	-0.683	-0.274	37.966	44.902	31.733	42.376	34.368
196	3346	36.54	-99.97	1980	2003	24	-3.944	***	-0.336	0.336	1	-0.463	-0.162	-0.442	-0.201	81.681	85.126	77.768	84.678	78.634
197	9687	36.54	-101.08	1966	2003	38	-3.118	**	-0.054	0.054	1	-0.104	-0.011	-0.092	-0.022	12.232	13.110	11.226	12.930	11.467
198	9898	36.55	-99.39	1978	2003	26	-4.673	***	-0.511	0.511	1	-0.674	-0.265	-0.642	-0.370	46.346	48.978	42.715	48.427	44.576
199	9669	36.55	-95.40	1979	2003	25	-2.499	*	-0.297	0.297	1	-0.619	0.007	-0.527	-0.087	23.189	30.820	15.467	28.897	18.337
200	9899	36.55	-99.42	1978	2002	23	-3.937	***	-0.242	0.242	1	-0.400	-0.104	-0.358	-0.137	31.010	33.583	29.783	32.835	30.046
201	9025	36.57	-100.32	1981	2003	23	-4.067	***	-0.128	0.128	1	-0.177	-0.057	-0.157	-0.075	161.255	162.558	159.733	161.969	160.105
202	911	36.58	-101.19	1966	2003	36	-5.353	***	-0.399	0.399	1	-0.580	-0.250	-0.523	-0.288	133.425	137.830	129.820	136.632	130.747
203	107	36.58	-100.42	1967	1999	31	-3.161	**	-0.225	0.225	1	-0.631	-0.027	-0.467	-0.054	224.554	232.045	221.359	228.599	221.894
204	9409	36.58	-99.87	1980	2003	24	-2.134	*	-0.105	0.105	1	-0.205	0.019	-0.177	-0.020	13.106	15.505	9.868	15.020	10.855
205	9473	36.59	-99.97	1980	2003	21	-2.808	**	-0.161	0.161	1	-0.274	-0.010	-0.247	-0.051	58.483	61.680	55.340	61.031	56.310
206	9900	36.59	-99.55	1980	2003	20	-2.888	**	-0.153	0.153	1	-0.272	-0.021	-0.250	-0.050	9.377	11.148	7.725	10.900	8.264
207	9208	36.59	-102.44	1967	2003	31	-1.938	+	-0.068	0.068	2	-0.128	0.025	-0.115	0.001	103.469	104.254	100.770	103.979	101.599
208	9703	36.61	-101.17	1966	2003	36	-4.045	***	-0.419	0.419	1	-0.592	-0.152	-0.549	-0.220	177.545	181.637	171.038	180.628	173.065
209	9857	36.61	-98.84	1977	2002	25	-4.694	***	-0.387	0.387	1	-0.666	-0.173	-0.612	-0.227	45.397	51.635	41.697	50.195	42.482
210	9710	36.62	-102.01	1967	2003	35	-3.579	***	-0.290	0.290	1	-0.406	-0.089	-0.375	-0.144	211.404	214.090	205.906	213.308	207.798
211	9034	36.62	-100.31	1980	2003	24	-5.432	***	-0.210	0.210	1	-0.387	-0.102	-0.344	-0.116	153.735	159.081	150.074	157.770	150.528
212	9475	36.62	-99.95	1977	2000	24	-3.077	**	-0.182	0.182	1	-0.320	-0.035	-0.294	-0.083	37.311	40.863	34.278	40.160	35.287
213	9711	36.63	-101.08	1966	2003	36	-2.561	*	-0.391	0.391	1	-0.777	0.003	-0.696	-0.101	147.396	155.729	139.700	153.850	142.402
214	9035	36.63	-100.40	1967	2003	33	-5.843	***	-0.080	0.080	1	-0.113	-0.054	-0.103	-0.059	85.684	86.630	84.980	86.340	85.146

215	9005	36.64	-98.39	1975	2002	25	-3.200	**	-0.150	0.150	1	-0.287	-0.043	-0.241	-0.076	7.894	10.512	5.569	9.622	6.268
216	9038	36.64	-100.14	1967	2003	36	-5.218	***	-0.054	0.054	1	-0.071	-0.036	-0.068	-0.041	10.363	10.761	9.941	10.690	10.049
217	9478	36.65	-99.74	1978	2003	21	-5.647	***	-1.031	1.031	1	-1.249	-0.748	-1.176	-0.858	53.450	59.477	45.371	57.359	48.646
218	9724	36.66	-101.14	1966	1999	29	-3.133	**	-0.238	0.238	1	-0.327	-0.068	-0.298	-0.124	96.932	98.002	94.043	97.683	94.827
219	9041	36.66	-100.34	1981	2003	23	-3.330	***	-0.053	0.053	1	-0.077	-0.025	-0.072	-0.034	58.123	58.748	57.351	58.624	57.677
220	9222	36.67	-102.79	1966	2003	38	-7.330	***	-0.242	0.242	1	-0.275	-0.215	-0.268	-0.222	149.823	150.416	149.320	150.354	149.424
221	9482	36.69	-99.75	1978	2003	24	-2.704	**	-0.341	0.341	1	-0.560	-0.015	-0.498	-0.069	19.553	25.571	9.311	23.977	11.014
222	9431	36.69	-97.77	1975	2003	29	-2.007	*	-0.224	0.224	1	-0.496	0.085	-0.429	-0.007	18.221	24.110	10.425	22.683	13.092
223	9726	36.70	-101.33	1966	2003	37	-8.253	***	-0.888	0.888	1	-0.956	-0.790	-0.938	-0.812	127.544	129.071	125.500	128.733	125.897
224	9049	36.70	-100.05	1978	2003	26	-4.585	***	-0.306	0.306	1	-0.441	-0.160	-0.401	-0.186	34.342	37.454	30.445	36.770	31.213
225	9051	36.71	-100.58	1980	2002	23	-3.169	**	-0.116	0.116	1	-0.209	-0.024	-0.180	-0.060	90.792	93.413	88.292	92.749	89.343
226	9052	36.73	-100.52	1968	2003	36	-5.489	***	-1.280	1.280	1	-1.803	-0.673	-1.709	-0.777	118.668	132.245	100.038	131.054	103.353
227	9232	36.73	-102.04	1967	2003	36	-2.002	*	-0.098	0.098	1	-0.251	0.033	-0.211	-0.004	189.632	193.077	187.231	192.175	187.762
228	9054	36.75	-100.31	1968	2002	35	-2.983	**	-0.050	0.050	1	-0.100	-0.007	-0.088	-0.016	84.400	85.880	83.530	85.517	83.658
229	9061	36.80	-100.67	1980	2003	24	-3.597	***	-0.300	0.300	1	-0.492	-0.127	-0.433	-0.157	32.857	37.513	28.454	35.831	29.092
230	9006	36.81	-98.35	1975	2003	27	-3.794	***	-0.244	0.244	1	-0.369	-0.083	-0.334	-0.133	12.055	14.967	9.617	14.306	10.694
231	9486	36.81	-99.93	1972	2003	28	-3.222	**	-0.087	0.087	1	-0.164	-0.019	-0.146	-0.035	8.465	9.994	6.892	9.450	7.088
232	9487	36.82	-99.95	1978	2003	24	-3.249	**	-0.230	0.230	1	-0.375	-0.039	-0.350	-0.093	28.481	31.327	23.404	30.691	25.022
233	9007	36.82	-98.35	1975	2003	28	-3.892	***	-0.222	0.222	1	-0.331	-0.085	-0.303	-0.116	11.276	13.492	8.493	12.559	8.975
234	9488	36.83	-99.95	1980	2001	20	-3.246	**	-0.360	0.360	1	-0.560	-0.037	-0.515	-0.148	34.030	38.150	24.126	37.327	27.759
235	9064	36.84	-100.08	1967	2003	36	-5.912	***	-0.150	0.150	1	-0.187	-0.113	-0.178	-0.120	57.194	57.900	56.100	57.726	56.251
236	9258	36.85	-102.05	1967	2003	36	-2.343	*	-0.047	0.047	1	-0.260	0.010	-0.181	-0.012	200.508	207.223	199.452	205.006	199.676
237	9069	36.87	-100.71	1967	2003	37	-1.962	*	-0.034	0.034	1	-0.080	0.015	-0.073	0.000	134.697	135.636	133.695	135.493	133.980
238	9072	36.89	-100.03	1968	2003	36	-5.244	***	-0.299	0.299	1	-0.434	-0.212	-0.405	-0.228	24.082	26.651	22.065	25.899	22.432
239	9080	36.92	-100.11	1980	2003	23	-5.757	***	-0.958	0.958	1	-1.155	-0.745	-1.101	-0.825	66.702	71.226	60.926	70.004	63.001
240	9509	36.97	-97.46	1975	2003	25	-1.729	+	-0.053	0.053	2	-0.115	0.026	-0.095	0.005	33.595	35.071	31.544	34.690	32.115
241	25024	36.99	-98.21	1975	2003	28	-3.004	**	-0.087	0.087	1	-0.169	-0.019	-0.150	-0.037	8.133	9.152	7.377	8.945	7.641
242	9483	37.00	-100.00	1980	2002	21	-4.137	***	-0.282	0.282	1	-0.490	-0.138	-0.428	-0.167	60.748	65.523	57.465	64.259	58.141
243	3327	37.00	-100.00	1981	2003	22	-2.596	**	-0.057	0.057	1	-0.179	0.000	-0.148	-0.022	20.687	23.161	19.270	22.530	19.835
244	9496			1965	2001	35	-4.260	***	-0.439	0.439	1	-0.601	-0.225	-0.576	-0.288	28.439	31.276	24.364	30.829	26.165
245	9552			1976	1996	20	-2.368	*	-0.364	0.364	1	-0.901	0.028	-0.719	-0.108	29.479	37.509	24.995	34.716	26.538
246	9511			1975	2003	28	-2.035	*	-0.089	0.089	1	-0.196	0.023	-0.172	-0.007	4.538	7.640	1.425	7.025	2.247
247	9644	34.23	-95.63	1980	2003	22	-1.044		-0.065	0.065	2	-0.237	0.124	-0.173	0.082	11.735	15.413	6.226	14.361	7.206
248	9505	34.38	-96.43	1979	2003	25	-1.285		-0.054	0.054	2	-0.176	0.064	-0.132	0.040	8.108	11.469	4.792	10.375	5.604
249	9825	34.49	-99.20	1974	2003	29	-1.632		-0.106	0.106	2	-0.276	0.096	-0.243	0.040	12.523	16.034	7.672	15.445	8.785
250	9638	34.59	-96.69	1977	2003	26	-0.529		-0.135	0.135	2	-0.770	0.386	-0.630	0.223	69.855	85.759	59.042	81.930	61.263
251	9498	34.66	-99.58	1976	1999	21	-1.419		-0.233	0.233	2	-0.575	0.188	-0.472	0.093	30.565	39.289	20.493	36.463	23.256
252	9427	34.75	-97.92	1979	2003	22	1.608		0.068	-0.068	2	-0.060	0.212	-0.020	0.180	11.025	13.843	7.119	12.945	8.021
253	9447	34.93	-99.53	1980	2003	24	0.174		0.009	-0.009	2	-0.289	0.351	-0.227	0.290	9.008	15.925	-1.057	14.562	0.933
254	9833	35.00	-99.00	1977	2003	26	-1.499		-0.087	0.087	2	-0.250	0.094	-0.203	0.037	15.613	19.681	10.897	18.480	12.542
255	9460	35.10	-99.41	1980	2003	24	-1.116		-0.078	0.078	2	-0.280	0.115	-0.237	0.058	28.223	33.225	22.468	32.417	24.089
256	9462	35.12	-99.51	1980	2002	17	-1.319		-0.218	0.218	2	-0.744	0.360	-0.537	0.181	31.188	44.152	16.280	38.587	22.263
257	9088	35.12	-99.46	1980	2003	24	-1.092		-0.118	0.118	2	-0.425	0.278	-0.350	0.161	23.902	31.132	12.908	29.280	16.189
258	9089	35.14	-99.50	1980	2003	24	-0.521		-0.068	0.068	2	-0.331	0.253	-0.240	0.144	20.065	26.743	11.842	24.218	14.503
259	9106	35.21	-99.89	1980	2003	24	-1.563		-0.151	0.151	2	-0.362	0.130	-0.315	0.050	13.943	19.589	6.688	18.338	9.015
260	9101	35.23	-100.00	1980	2003	23	-1.162		-0.159	0.159	2	-0.507	0.237	-0.404	0.122	43.974	53.092	32.756	51.052	36.107
261	9430	35.32	-97.85	1979	2003	24	0.719		0.055	-0.055	2	-0.171	0.321	-0.130	0.248	6.535	11.260	-0.440	10.548	1.867
262	9146	35.33	-98.56	1979	2003	24	-1.166		-0.183	0.183	2	-0.600	0.227	-0.455	0.114	72.942	79.262	64.073	77.018	66.981
263	9271	35.36	-97.28	1979	2003	22	-0.959		-0.086	0.086	2	-0.333	0.103	-0.269	0.066	9.170	13.404	5.126	12.199	5.899
264	9671	35.43	-96.46	1976	2000	25	-1.565		-0.235	0.235	2	-0.594	0.195	-0.487	0.077	18.431	27.222	6.582	24.179	10.000
265	9154	35.45	-98.48	1974	2003	28	-1.324		-0.091	0.091	2	-0.346	0.122	-0.282	0.066	134.629	139.304	131.728	137.693	132.317
266	9163	35.52	-97.76	1977	2003	26	-0.882		-0.077	0.077	2	-0.317	0.133	-0.267	0.079	11.611	15.418	7.736	14.647	8.819
267	9166	35.54	-97.92	1978	2003	26	-1.059		-0.061	0.061	2	-0.209	0.123	-0.175	0.055	18.988	20.944	15.508	20.623	16.704
268	2687	35.65	-99.67	1976	2003	25	-0.934		-0.053	0.053	2	-0.290	0.199	-0.245	0.117	30.573	36.502	24.286	35.552	26.145
269	9621	35.67	-97.34	1976	2003	28	0.138		0.009	-0.009	2	-0.124	0.183	-0.098	0.156	25.395	29.070	20.564	28.488	21.407

270	9559	35.70	-96.89	1980	2003	21	-1.057		-0.060	0.060	2	-0.562	0.177	-0.273	0.091	7.152	22.736	0.967	13.481	2.679
271	9623	35.72	-97.50	1976	2003	25	-1.518		-0.319	0.319	2	-1.240	0.277	-0.933	0.140	80.659	103.250	64.997	95.271	67.743
272	9658	35.73	-99.71	1976	2003	25	-0.304		-0.002	0.002	2	-0.040	0.030	-0.030	0.021	7.198	8.160	6.286	7.846	6.570
273	9000	35.96	-94.55	1980	2003	23	-1.109		-0.198	0.198	2	-0.777	0.422	-0.585	0.246	60.280	69.748	40.686	66.092	46.551
274	9172	35.99	-95.19	1979	2003	24	-1.141		-0.079	0.079	2	-0.353	0.168	-0.284	0.078	12.663	18.119	7.599	16.400	9.498
275	9001	35.99	-94.55	1980	2003	24	0.149		0.021	-0.021	2	-0.259	0.253	-0.166	0.200	12.302	19.215	6.006	16.427	7.496
276	9527	36.06	-97.83	1975	2003	25	-1.425		-0.105	0.105	2	-0.291	0.098	-0.235	0.034	9.476	13.357	4.646	12.481	6.173
277	3054	36.17	-99.72	1980	2003	23	-0.396		-0.049	0.049	2	-0.527	0.297	-0.350	0.233	120.114	130.155	109.967	126.532	111.887
278	9589	36.19	-95.21	1979	2003	25	0.070		0.002	-0.002	2	-0.156	0.185	-0.121	0.120	34.542	38.518	29.242	37.467	31.450
279	9869	36.24	-99.50	1980	2003	24	-0.670		-0.051	0.051	2	-0.207	0.178	-0.180	0.095	158.078	160.962	154.524	160.261	155.717
280	9626	36.26	-96.14	1979	2003	25	-0.981		-0.293	0.293	2	-0.863	0.199	-0.747	0.138	25.790	38.177	9.883	36.074	11.576
281	9873	36.29	-99.56	1980	2003	24	-1.514		-0.086	0.086	2	-0.160	0.039	-0.143	0.020	129.952	131.167	127.523	130.849	127.880
282	9413	36.29	-98.09	1975	2003	28	-0.494		-0.047	0.047	2	-0.276	0.150	-0.231	0.106	5.803	11.636	0.363	10.395	1.422
283	9882	36.36	-99.60	1977	1999	23	-0.792		-0.067	0.067	2	-0.234	0.247	-0.194	0.159	27.637	29.777	22.624	29.290	23.904
284	9885	36.40	-99.57	1980	2003	23	-1.268		-0.080	0.080	2	-0.279	0.131	-0.197	0.065	4.500	8.727	2.287	6.824	2.921
285	9375	36.40	-99.74	1980	2003	24	-0.397		-0.075	0.075	2	-0.318	0.280	-0.248	0.181	101.244	105.110	95.698	103.939	97.276
286	3251	36.40	-100.00	1980	2003	24	0.695		0.023	-0.023	2	-0.132	0.129	-0.090	0.095	54.101	57.293	51.588	56.463	52.380
287	9891	36.46	-99.37	1978	2003	25	-1.611		-0.079	0.079	2	-0.166	0.046	-0.139	0.017	12.116	13.551	9.600	12.983	10.183
288	9014	36.50	-100.21	1967	2003	33	0.759		0.014	-0.014	2	-0.041	0.073	-0.024	0.052	169.874	171.222	168.955	170.785	169.275
289	2041	36.52	-102.77	1967	2000	34	1.334		0.594	-0.594	2	-0.701	2.037	-0.315	1.697	151.894	165.550	130.478	160.607	135.649
290	9017	36.53	-100.72	1980	2003	24	0.670		0.006	-0.006	2	-0.026	0.034	-0.015	0.027	211.540	212.292	210.852	212.081	211.022
291	9278	36.54	-95.22	1979	2003	24	-1.415		-0.048	0.048	2	-0.153	0.060	-0.127	0.027	2.460	4.180	0.695	3.832	1.136
292	9410	36.58	-100.00	1980	2000	20	-1.006		-0.043	0.043	2	-0.236	0.084	-0.148	0.060	111.320	115.400	108.693	113.371	109.137
293	1156	36.61	-101.12	1966	2003	29	-0.694		-0.100	0.100	2	-0.518	0.293	-0.385	0.153	139.715	149.046	132.829	146.575	134.915
294	9839	36.63	-95.88	1979	2003	24	-1.463		-0.218	0.218	2	-0.493	0.180	-0.430	0.064	25.006	31.542	12.106	30.403	15.700
295	9477	36.64	-99.82	1977	2003	25	-0.257		-0.017	0.017	2	-0.120	0.107	-0.103	0.080	8.128	10.476	5.402	10.032	6.004
296	9037	36.64	-100.54	1967	2003	35	0.682		0.006	-0.006	2	-0.012	0.030	-0.007	0.023	12.654	12.942	12.320	12.881	12.403
297	2117	36.65	-102.31	1967	1993	23	0.317		0.021	-0.021	2	-0.204	0.260	-0.134	0.181	165.416	168.802	163.029	167.957	164.184
298	9042	36.67	-100.11	1967	2003	37	-0.105		-0.003	0.003	2	-0.049	0.042	-0.036	0.032	19.750	20.629	18.970	20.289	19.175
299	9045	36.67	-100.23	1969	2003	35	0.966		0.028	-0.028	2	-0.050	0.104	-0.032	0.088	57.165	59.354	55.533	58.905	56.053
300	2275	36.69	-102.33	1967	2003	36	1.553		0.054	-0.054	2	-0.050	0.142	-0.020	0.117	137.643	140.720	136.203	139.739	136.541
301	9227	36.69	-102.86	1967	2003	36	1.526		0.160	-0.160	2	-0.069	0.408	-0.021	0.320	23.153	28.497	16.526	27.730	19.183
302	9433	36.71	-97.79	1975	2002	25	-1.331		-0.115	0.115	2	-0.356	0.098	-0.312	0.045	13.033	18.545	7.597	17.206	9.348
303	9432	36.71	-98.05	1975	2000	20	0.000		-0.002	0.002	2	-0.177	0.378	-0.137	0.208	9.765	14.068	3.468	13.151	5.893
304	9434	36.75	-97.99	1975	2003	28	-1.620		-0.097	0.097	2	-0.306	0.072	-0.250	0.020	11.232	15.696	7.321	14.518	8.865
305	9245	36.79	-102.61	1967	2003	35	-0.199		-0.018	0.018	2	-0.257	0.180	-0.195	0.118	210.087	213.978	206.478	213.063	207.695
306	9435	36.83	-98.00	1975	2003	29	-1.257		-0.127	0.127	2	-0.361	0.120	-0.310	0.067	14.013	19.289	8.329	17.868	9.253
307	9008	36.84	-98.18	1975	2003	28	-1.225		-0.023	0.023	2	-0.090	0.036	-0.070	0.023	4.127	5.722	3.191	5.264	3.407
308	9063	36.84	-100.12	1980	2003	24	-0.347		-0.008	0.008	2	-0.082	0.071	-0.056	0.047	26.300	28.353	24.099	27.685	24.849
309	9066	36.86	-100.34	1980	2003	23	0.661		0.009	-0.009	2	-0.033	0.078	-0.019	0.057	67.019	67.890	65.479	67.657	65.984
310	9073	36.89	-100.51	1980	2003	23	-0.264		-0.030	0.030	2	-0.288	0.309	-0.191	0.233	20.350	25.256	12.160	23.381	14.064
311	9074	36.89	-100.23	1970	2003	28	1.028		0.057	-0.057	2	-0.051	0.120	-0.041	0.099	189.529	192.574	187.851	192.277	188.483
312	9602	36.91	-95.45	1979	2003	24	-1.612		-0.099	0.099	2	-0.228	0.074	-0.200	0.050	6.279	9.760	1.915	8.994	2.505
313	9841	36.93	-95.88	1979	2003	25	-1.542		-0.109	0.109	2	-0.366	0.080	-0.277	0.041	10.886	18.340	5.207	15.915	6.402
314	1874	36.94	-101.52	1966	2000	29	-1.594		-0.553	0.553	2	-1.090	0.413	-0.979	0.143	243.215	254.853	219.576	251.958	225.941
315	9627	36.97	-94.96	1979	2003	25	0.000		-0.002	0.002	2	-0.193	0.135	-0.140	0.109	3.116	7.440	-0.217	5.958	0.475
316	9087	37.00	-100.40	1980	2003	23	-1.004		-0.013	0.013	2	-0.038	0.023	-0.029	0.011	7.100	7.655	6.210	7.490	6.526
317	9840			1977	2003	27	-0.396		-0.011	0.011	2	-0.113	0.106	-0.090	0.074	12.611	15.357	9.460	14.810	10.318
318	9040			1965	1990	24	-0.422		-0.007	0.007	2	-0.099	0.083	-0.049	0.051	76.345	77.667	74.996	76.907	75.572
319	9813			1974	2003	28	1.028		0.036	-0.036	2	-0.075	0.128	-0.039	0.101	5.320	7.654	3.053	6.726	3.933
320	9456	35.09	-99.41	1980	2002	17	-1.277		-0.261	0.261	2	-0.918	0.210	-0.699	0.135	30.625	45.287	17.030	40.901	19.718
321	9588	33.94	-96.64	1978	2003	26	6.436	***	1.299	-1.299	3	1.169	1.432	1.190	1.387	94.946	98.584	91.721	98.083	92.585
322	9170	34.26	-97.28	1976	2003	28	2.667	**	0.607	-0.607	3	0.014	1.170	0.158	0.997	27.874	39.285	17.706	37.309	20.079
323	9639	35.01	-97.05	1978	2001	22	4.230	***	0.526	-0.526	3	0.247	0.805	0.300	0.736	35.974	43.590	29.841	41.935	31.234
324	9270	35.32	-97.44	1980	2003	22	4.173	***	0.410	-0.410	3	0.189	0.593	0.218	0.548	123.351	125.989	120.089	125.684	120.794

325	3257	36.36	-100.00	1980	2003	24	2.257	*	0.108	-0.108	3	-0.027	0.196	0.025	0.169	57.926	61.612	55.632	60.114	56.349
326	9085	36.46	-100.62	1967	2003	36	4.632	***	0.110	-0.110	3	0.065	0.151	0.078	0.143	102.842	103.880	101.916	103.529	102.094
327	9386	36.50	-101.37	1977	2003	27	4.858	***	0.615	-0.615	3	0.341	0.831	0.426	0.776	245.925	250.185	242.246	248.604	243.330
328	9385	36.51	-101.60	1977	2003	26	3.659	***	0.470	-0.470	3	0.190	0.905	0.248	0.810	217.290	221.740	207.826	220.933	210.207
329	9189	36.52	-102.59	1968	2003	35	1.704	+	0.111	-0.111	2	-0.052	0.251	-0.014	0.220	54.355	56.937	52.482	56.443	52.799
330	1996	36.52	-102.91	1967	2003	37	5.677	***	0.643	-0.643	3	0.368	0.835	0.452	0.763	165.320	171.525	160.986	169.226	162.792
331	2074	36.52	-102.11	1967	2003	37	7.520	***	1.012	-1.012	3	0.788	1.221	0.840	1.160	274.541	278.821	270.554	277.497	271.892
332	9020	36.54	-100.16	1967	2003	37	6.017	***	0.099	-0.099	3	0.065	0.139	0.072	0.132	38.522	39.290	37.957	39.151	37.999
333	2019	36.54	-102.80	1967	2003	37	3.754	***	0.546	-0.546	3	0.144	0.947	0.243	0.885	111.261	116.365	106.351	115.322	107.906
334	871	36.54	-101.49	1966	2003	31	7.512	***	0.988	-0.988	3	0.849	1.205	0.885	1.170	168.190	170.032	166.454	169.167	166.630
335	9198	36.55	-102.77	1969	2003	33	4.603	***	0.601	-0.601	3	0.198	0.945	0.312	0.887	98.104	103.261	93.880	102.381	94.463
336	1988	36.56	-102.95	1966	1999	32	5.287	***	0.417	-0.417	3	0.231	0.583	0.270	0.545	185.206	189.576	182.185	188.645	182.752
337	9202	36.56	-102.09	1970	2003	33	7.794	***	1.228	-1.228	3	1.050	1.436	1.074	1.415	261.143	265.763	255.337	265.266	255.805
338	9691	36.56	-101.93	1966	2003	37	8.671	***	1.602	-1.602	3	1.515	1.715	1.534	1.683	144.373	145.000	142.893	144.858	143.432
339	9201	36.56	-102.07	1969	2001	28	6.740	***	1.671	-1.671	3	1.445	1.799	1.497	1.772	271.722	276.973	268.770	275.958	269.120
340	9695	36.57	-101.65	1966	2003	38	8.775	***	1.487	-1.487	3	1.266	1.690	1.299	1.660	161.325	167.639	156.355	166.654	157.004
341	9207	36.58	-102.20	1967	2003	33	7.314	***	0.843	-0.843	3	0.780	0.944	0.797	0.899	302.894	303.916	301.809	303.728	302.078
342	812	36.58	-101.91	1966	2003	35	8.252	***	1.543	-1.543	3	1.382	1.718	1.422	1.680	147.135	149.435	144.500	148.550	145.378
343	949	36.59	-101.87	1966	2003	37	8.331	***	1.309	-1.309	3	1.177	1.466	1.215	1.434	150.663	152.781	147.871	152.175	148.513
344	988	36.59	-101.69	1966	1996	29	6.021	***	1.678	-1.678	3	0.898	2.262	1.165	2.056	188.311	204.589	180.823	197.382	182.461
345	9032	36.60	-100.17	1967	2003	33	2.976	**	0.027	-0.027	3	0.005	0.044	0.012	0.040	10.313	10.631	10.125	10.512	10.170
346	9702	36.60	-101.78	1966	2003	32	7.136	***	0.257	-0.257	3	0.239	0.275	0.243	0.269	18.282	18.701	17.921	18.588	18.056
347	9210	36.61	-102.94	1966	2001	34	3.529	***	0.050	-0.050	3	0.015	0.090	0.026	0.078	96.415	96.869	95.437	96.756	95.744
348	2127	36.61	-102.27	1967	2001	34	4.151	***	0.394	-0.394	3	0.170	0.633	0.240	0.555	225.177	228.483	220.715	227.920	221.671
349	953	36.61	-101.72	1966	2003	35	7.172	***	1.384	-1.384	3	0.900	1.797	1.030	1.710	246.866	259.475	236.957	255.877	238.654
350	9213	36.62	-102.80	1967	2002	35	3.366	***	0.298	-0.298	3	0.086	0.574	0.131	0.509	102.465	106.767	98.666	105.706	99.391
351	2146	36.62	-102.17	1967	2003	37	5.715	***	1.150	-1.150	3	0.864	1.385	0.937	1.330	295.380	300.747	291.212	298.941	292.042
352	9708	36.62	-101.53	1970	2003	32	7.703	***	1.850	-1.850	3	1.762	1.961	1.788	1.930	134.370	136.202	131.899	135.501	132.703
353	9036	36.63	-100.66	1967	2003	37	7.390	***	0.180	-0.180	3	0.164	0.194	0.167	0.190	98.640	98.902	98.242	98.827	98.316
354	5600	36.63	-102.25	1967	2003	36	5.244	***	0.661	-0.661	3	0.389	0.938	0.456	0.870	260.551	264.505	255.604	263.178	257.485
355	1120	36.64	-101.31	1966	2003	36	7.832	***	1.326	-1.326	3	0.875	1.786	0.966	1.698	185.150	198.045	174.436	195.359	176.580
356	9039	36.65	-100.77	1967	1999	33	7.066	***	0.383	-0.383	3	0.240	0.502	0.272	0.475	170.173	174.040	168.287	173.259	168.848
357	1135	36.65	-101.28	1966	2003	38	3.332	***	0.385	-0.385	3	0.107	0.630	0.173	0.577	182.715	188.773	177.362	187.197	178.154
358	9219	36.65	-102.23	1967	2001	35	7.328	***	0.846	-0.846	3	0.655	1.036	0.719	0.973	261.434	265.007	257.435	263.438	258.136
359	9715	36.65	-101.67	1966	2003	36	6.866	***	1.075	-1.075	3	0.846	1.273	0.921	1.217	212.508	218.330	208.864	216.436	209.853
360	9720	36.66	-101.46	1966	2003	31	7.750	***	2.344	-2.344	3	1.914	2.951	2.004	2.836	234.274	246.815	219.418	244.296	221.846
361	1106	36.66	-101.38	1966	1997	31	5.287	***	2.683	-2.683	3	1.166	3.726	1.433	3.388	233.888	269.678	220.780	262.630	222.469
362	1111	36.66	-101.35	1966	2003	24	6.005	***	3.984	-3.984	3	2.685	5.385	3.087	5.188	175.749	201.010	162.932	191.558	163.856
363	9221	36.67	-102.06	1967	2000	25	1.985	*	0.054	-0.054	3	-0.019	0.203	0.001	0.154	114.873	116.304	113.101	115.899	114.252
364	9223	36.68	-102.43	1967	2003	37	2.668	**	0.175	-0.175	3	0.005	0.406	0.080	0.323	131.665	136.091	128.030	133.485	129.828
365	1178	36.72	-101.94	1966	1999	33	7.856	***	0.549	-0.549	3	0.508	0.606	0.521	0.590	175.603	176.595	174.414	176.239	174.748
366	9730	36.72	-101.92	1966	2003	35	7.343	***	0.669	-0.669	3	0.593	0.728	0.615	0.713	149.164	150.893	147.710	150.408	148.060
367	9230	36.72	-102.43	1967	2003	36	6.907	***	0.836	-0.836	3	0.660	0.963	0.714	0.924	108.857	113.612	106.847	112.078	107.292
368	9734	36.75	-101.63	1966	1999	32	3.260	**	0.085	-0.085	3	0.028	0.119	0.047	0.111	61.595	62.253	60.875	62.080	61.102
369	9053	36.75	-100.24	1967	1995	23	2.483	*	0.253	-0.253	3	-0.007	0.390	0.050	0.361	12.556	19.402	10.591	17.940	10.821
370	9733	36.75	-101.96	1966	2002	37	6.997	***	0.530	-0.530	3	0.480	0.597	0.497	0.584	118.600	119.831	117.265	119.438	117.543
371	9237	36.75	-102.54	1968	2003	36	7.015	***	1.142	-1.142	3	0.789	1.568	0.870	1.453	196.794	204.501	190.065	202.576	191.297
372	9055	36.76	-100.11	1968	2003	34	5.841	***	0.579	-0.579	3	0.437	0.721	0.479	0.700	142.528	146.637	139.121	145.404	139.655
373	2231	36.76	-102.37	1967	2003	36	8.350	***	0.626	-0.626	3	0.457	0.819	0.480	0.787	98.794	103.230	94.743	102.510	95.089
374	2300	36.77	-102.47	1967	2003	37	6.212	***	1.346	-1.346	3	0.983	1.792	1.071	1.711	172.855	180.699	161.141	178.923	162.740
375	1421	36.77	-101.22	1966	2003	37	7.860	***	1.385	-1.385	3	1.234	1.563	1.280	1.503	128.864	132.545	126.444	131.419	126.915
376	9736	36.78	-101.08	1966	2003	38	6.286	***	0.587	-0.587	3	0.433	0.685	0.473	0.667	99.105	103.179	96.973	102.042	97.327
377	1354	36.78	-101.39	1966	2002	36	8.377	***	2.318	-2.318	3	2.204	2.387	2.231	2.370	131.945	133.615	130.369	133.151	130.820
378	1356	36.78	-101.45	1966	2001	35	7.527	***	2.390	-2.390	3	2.056	2.576	2.160	2.543	149.520	156.861	145.694	154.742	146.258
379	9059	36.79	-100.43	1967	2002	35	2.812	**	0.038	-0.038	3	0.005	0.072	0.012	0.061	21.999	22.464	21.433	22.346	21.640

380	2325	36.79	-102.37	1967	2003	37	4.329	***	0.348	-0.348	3	0.186	0.609	0.221	0.559	126.484	130.453	120.101	129.670	121.252
381	9058	36.79	-100.89	1967	1999	32	7.119	***	0.362	-0.362	3	0.275	0.425	0.297	0.404	113.739	115.896	112.474	115.315	112.844
382	1375	36.79	-101.32	1966	2003	34	5.071	***	0.395	-0.395	3	0.226	0.555	0.273	0.522	111.966	115.789	108.558	115.025	109.223
383	2319	36.80	-102.41	1967	2003	34	3.959	***	0.405	-0.405	3	0.138	1.000	0.200	0.771	170.813	178.015	160.255	176.550	163.434
384	9746	36.81	-101.51	1966	1999	33	2.727	**	0.168	-0.168	3	0.015	0.311	0.069	0.284	183.831	186.137	180.040	185.351	180.374
385	2354	36.81	-102.36	1967	2003	37	5.271	***	0.559	-0.559	3	0.336	0.793	0.381	0.743	161.971	167.733	157.384	166.364	158.453
386	1412	36.81	-101.19	1966	1996	31	7.037	***	2.170	-2.170	3	1.889	2.417	1.939	2.355	116.020	118.888	111.136	118.095	111.993
387	9251	36.82	-102.52	1967	2003	35	2.486	*	0.086	-0.086	3	-0.005	0.165	0.013	0.143	121.263	123.308	120.194	123.003	120.468
388	2305	36.83	-102.42	1967	1996	28	2.648	**	0.451	-0.451	3	0.013	1.049	0.163	0.813	204.277	213.459	198.531	209.700	200.264
389	9750	36.83	-101.87	1966	2003	36	4.427	***	0.827	-0.827	3	0.428	1.208	0.557	1.095	150.442	154.983	142.006	153.816	145.148
390	1335	36.83	-101.44	1966	1997	31	7.037	***	3.003	-3.003	3	2.741	3.479	2.786	3.342	147.920	151.875	142.824	151.221	144.176
391	9256	36.84	-102.30	1967	1999	30	3.818	***	0.295	-0.295	3	0.090	0.570	0.156	0.492	184.452	188.022	180.200	186.585	181.729
392	1387	36.84	-101.22	1966	2003	38	7.769	***	0.934	-0.934	3	0.788	1.052	0.835	1.018	116.958	119.757	115.073	118.709	115.759
393	1316	36.84	-101.54	1966	2003	38	8.649	***	2.043	-2.043	3	1.830	2.199	1.876	2.162	186.396	191.973	183.527	190.697	184.004
394	1362	36.84	-101.37	1966	2003	38	8.750	***	2.794	-2.794	3	2.689	2.872	2.712	2.855	110.972	113.092	109.192	112.774	109.597
395	572	36.86	-100.91	1968	2003	36	6.633	***	0.630	-0.630	3	0.380	0.861	0.412	0.809	126.631	132.911	121.775	132.176	122.560
396	1584	36.86	-101.59	1966	2002	35	7.498	***	1.362	-1.362	3	1.192	1.470	1.244	1.447	176.894	180.610	174.980	179.600	175.487
397	1679	36.88	-101.21	1966	2003	37	7.770	***	0.873	-0.873	3	0.780	0.966	0.802	0.946	111.558	113.479	109.684	113.034	110.174
398	9759	36.88	-101.45	1966	2003	35	8.095	***	3.215	-3.215	3	2.907	3.544	2.974	3.471	132.805	137.549	128.317	136.061	129.902
399	9601	36.89	-95.47	1979	2003	24	2.209	*	0.046	-0.046	3	-0.007	0.104	0.004	0.089	0.124	1.463	-1.391	1.159	-1.076
400	1675	36.90	-101.25	1966	2003	35	4.062	***	0.200	-0.200	3	0.080	0.285	0.107	0.268	125.820	128.731	123.273	128.500	123.830
401	613	36.90	-100.82	1967	1990	23	4.860	***	0.330	-0.330	3	0.243	0.411	0.277	0.385	149.830	151.088	148.520	150.612	148.983
402	9767	36.90	-101.88	1966	2003	36	6.415	***	1.070	-1.070	3	0.743	1.369	0.836	1.297	211.882	218.695	204.575	216.778	206.357
403	9766	36.90	-101.62	1966	1999	30	4.210	***	1.140	-1.140	3	0.517	1.732	0.677	1.595	220.090	231.103	211.256	227.227	212.763
404	1604	36.90	-101.41	1966	1996	30	7.529	***	3.015	-3.015	3	2.728	3.291	2.826	3.230	144.130	146.881	138.873	146.670	139.656
405	9077	36.91	-100.79	1967	2003	37	6.840	***	0.216	-0.216	3	0.157	0.262	0.169	0.249	160.176	161.740	159.496	161.422	159.552
406	1536	36.91	-101.78	1966	2003	38	6.789	***	1.378	-1.378	3	0.779	1.736	1.032	1.641	213.378	229.370	208.343	221.843	209.468
407	9079	36.92	-100.86	1968	2003	34	5.841	***	0.579	-0.579	3	0.437	0.721	0.479	0.700	143.686	147.511	140.563	146.361	141.055
408	9774	36.92	-101.04	1980	2003	24	4.886	***	3.097	-3.097	3	2.146	3.753	2.453	3.591	99.531	122.030	83.258	114.283	87.959
409	9081	36.93	-100.36	1967	2003	37	7.953	***	0.243	-0.243	3	0.209	0.273	0.218	0.264	56.017	56.903	55.624	56.677	55.753
410	9777	36.93	-101.08	1966	2003	35	6.078	***	2.749	-2.749	3	2.088	3.480	2.306	3.287	73.174	86.212	56.028	80.272	59.892
411	9083	36.94	-100.71	1980	2003	24	6.027	***	0.284	-0.284	3	0.195	0.402	0.218	0.368	186.094	188.121	183.320	187.595	184.274
412	710	36.94	-100.86	1967	1998	29	5.609	***	0.631	-0.631	3	0.424	0.794	0.480	0.742	145.078	149.831	142.019	148.740	143.120
413	1531	36.94	-101.80	1966	2001	36	4.699	***	1.274	-1.274	3	0.527	1.873	0.684	1.728	225.999	242.239	213.183	237.753	215.120
414	1745	36.94	-101.93	1966	2002	37	7.599	***	1.757	-1.757	3	1.412	1.992	1.536	1.932	271.519	279.237	265.298	276.229	267.005
415	9762	36.94	-101.50	1966	2000	33	2.185	*	1.903	-1.903	3	-0.651	2.870	0.195	2.657	212.180	240.151	204.440	228.850	206.685
416	9789	36.95	-102.03	1966	2003	37	6.291	***	0.465	-0.465	3	0.378	0.558	0.407	0.533	221.235	222.326	219.064	222.237	219.683
417	9786	36.95	-101.45	1980	2003	21	6.130	***	2.174	-2.174	3	2.044	2.360	2.072	2.310	147.839	150.968	143.062	150.476	144.157
418	1771	36.96	-101.85	1966	2003	38	5.533	***	1.382	-1.382	3	0.760	2.114	0.873	1.892	250.795	266.559	235.060	264.183	238.781
419	9792	36.96	-101.48	1966	2003	34	8.183	***	2.289	-2.289	3	2.137	2.522	2.175	2.444	176.480	180.000	174.456	178.959	175.149
420	9086	36.97	-100.38	1980	2003	24	4.962	***	0.172	-0.172	3	0.126	0.257	0.140	0.229	40.961	42.158	38.735	41.836	39.513
421	1855	36.97	-101.55	1966	2003	34	3.736	***	0.406	-0.406	3	0.129	0.700	0.178	0.627	227.400	233.363	221.990	232.051	223.567
422	9798	36.98	-101.00	1966	2003	36	7.205	***	1.060	-1.060	3	0.862	1.197	0.919	1.171	78.512	82.709	74.996	81.757	75.524
423	9799	36.98	-101.90	1967	2002	34	6.641	***	1.500	-1.500	3	1.109	1.874	1.181	1.782	261.395	271.230	256.861	269.155	257.369
424	1895	36.99	-101.19	1966	2003	37	6.056	***	1.006	-1.006	3	0.725	1.340	0.810	1.269	118.256	123.945	108.844	123.338	111.427
425	9800	36.99	-102.03	1970	2003	34	7.412	***	1.114	-1.114	3	0.967	1.275	1.009	1.235	183.356	185.891	179.750	185.029	180.523
426	9177	37.00	-102.00	1967	2003	37	3.440	***	0.277	-0.277	3	0.052	0.535	0.093	0.482	78.278	81.384	74.368	80.678	75.709
427	9242	37.00	-103.00	1967	2003	37	7.979	***	0.762	-0.762	3	0.615	1.009	0.633	0.969	184.039	188.266	177.708	187.673	178.581
428	9259	37.00	-102.00	1980	2001	21	5.949	***	1.405	-1.405	3	1.194	1.596	1.277	1.537	135.224	139.252	133.176	137.504	133.666
429	9769			1970	2003	33	5.996	***	0.476	-0.476	3	0.363	0.560	0.400	0.541	168.513	171.470	165.900	170.444	166.434

APPENDIX B

Result of Mann-Kendall Analysis for Annual Precipitation Trends in Oklahoma

	Annual Precipitation Time Series								M-K Test estimate												
S/NO	Site Name	COUNTY	LAT	LON	ELEV (ft)	First year	Last Year	n	Test Z	Signific.	slope Est	Label	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
1	ADA	PONTOTOC	34.78	-96.68	1014	*1970*	*2004*	*34*	0.623		0.083		-0.387	0.459	-0.231	0.383	39.455	48.315	32.937	45.261	34.106
2	ALTUS	JACKSON	34.58	-99.33	1379	*1970*	*2004*	*32*	1.038		0.119		-0.199	0.514	-0.125	0.416	25.198	30.864	20.091	30.058	21.099
3	ALTUS DAM	KIOWA	34.88	-99.30	1524	*1970*	*2004*	*31*	1.632		0.251		-0.152	0.684	-0.059	0.577	24.278	31.087	16.509	29.241	18.976
4	ANADARKO	CADDO	35.07	-98.20	1167	*1970*	*2004*	*29*	0.769		0.067		-0.238	0.367	-0.138	0.322	29.727	34.768	24.440	34.364	24.659
5	ARDMORE	CARTER	34.17	-97.13	879	*1970*	*2004*	*30*	0.571		0.106		-0.382	0.512	-0.245	0.420	34.316	41.153	26.102	38.280	27.233
6	ARNETT	ELLIS	36.13	-99.77	2464	*1970*	*2003*	*33*	1.286		0.117		-0.105	0.399	-0.051	0.321	22.702	26.914	19.599	25.959	20.456
7	BARNSDALL	OSAGE	36.57	-96.17	769	*1970*	*2000*	*30*	1.320		0.228		-0.237	0.729	-0.097	0.558	37.218	44.436	29.256	42.102	31.807
8	BARTLESVILLE PHILLI	OSAGE	36.75	-96.00	714	*1970*	*2004*	*33*	1.999	*	0.278	1	-0.130	0.613	0.014	0.484	33.538	38.686	26.888	37.272	29.950
9	BILLINGS	NOBLE	36.53	-97.45	999	*1970*	*2004*	*35*	0.596		0.057		-0.276	0.439	-0.187	0.349	33.827	38.242	26.377	36.196	27.544
10	BOISE CITY 2 E	CIMARRON	36.73	-102.48	4143	*1970*	*2004*	*32*	2.044	*	0.174	1	-0.041	0.416	0.010	0.343	15.576	18.621	11.472	17.530	12.645
11	BRISTOW	CREEK	35.83	-96.38	822	*1970*	*2004*	*30*	1.570		0.226		-0.196	0.601	-0.075	0.481	36.505	44.610	29.091	41.644	31.875
12	BROKEN BOW 1 N	MCCURTAIN	34.05	-94.73	474	*1970*	*2004*	*31*	1.088		0.176		-0.266	0.580	-0.139	0.515	47.884	55.664	39.148	52.770	40.204
13	BUFFALO	HARPER	36.85	-99.63	1794	*1970*	*2004*	*35*	-1.903	+	-0.243	1	-0.565	0.131	-0.484	0.009	27.334	33.715	23.931	31.889	24.568
14	BURBANK	OSAGE	36.70	-96.73	974	*1970*	*2004*	*32*	1.962	*	0.329	1	-0.084	0.667	-0.004	0.578	31.194	36.261	26.295	35.640	28.650
15	CARNEGIE 2 ENE	CADDO	35.18	-98.58	1480	*1970*	*2003*	*31*	1.632		0.301		-0.198	0.776	-0.044	0.632	25.529	33.093	18.552	29.986	21.391
16	CARTER TOWER	MCCURTAIN	34.27	-94.78	1299	*1970*	*2004*	*31*	0.714		0.096		-0.477	0.449	-0.306	0.369	48.338	62.246	42.248	57.322	44.108
17	CHATTANOOGA 3 NE	COMANCHE	34.45	-98.62	1153	*1970*	*2004*	*33*	0.418		0.054		-0.270	0.407	-0.191	0.296	28.263	34.099	22.483	32.654	24.880
18	CHECOTAH	MCINTOSH	35.47	-95.52	639	*1970*	*2003*	*34*	0.504		0.101		-0.377	0.493	-0.233	0.392	41.938	52.315	34.640	48.636	36.660
19	CHEROKEE	ALFALFA	36.77	-98.37	1179	*1970*	*2004*	*32*	2.481	*	0.380	1	-0.013	0.668	0.094	0.572	24.052	30.659	20.288	29.058	21.556
20	CHICKASHA EXP STN	GRADY	35.05	-97.92	1084	*1970*	*2004*	*31*	1.428		0.250		-0.148	0.559	-0.058	0.476	29.910	36.765	23.772	34.603	26.111
21	CLAREMORE 2 ENE	ROGERS	36.32	-95.58	587	*1970*	*2004*	*35*	2.017	*	0.298	1	-0.100	0.579	0.009	0.517	37.600	43.801	31.846	41.492	33.214
22	CLINTON	CUSTER	35.52	-98.97	1609	*1970*	*2004*	*32*	1.378		0.161		-0.189	0.589	-0.085	0.470	27.708	33.431	21.360	31.132	22.858
23	COMANCHE	STEPHENS	34.37	-97.90	979	*1970*	*2004*	*31*	2.108	*	0.339	1	-0.066	0.697	0.043	0.609	31.190	38.749	25.095	36.669	26.500
24	CORDELL	WASHITA	35.28	-98.98	1539	*1970*	*2004*	*34*	1.067		0.091		-0.270	0.489	-0.131	0.388	29.019	34.269	20.755	32.166	23.348
25	CUSHING	PAYNE	35.98	-96.77	949	*1970*	*2004*	*34*	0.771		0.080		-0.206	0.361	-0.132	0.304	34.875	39.212	30.865	38.384	31.313
26	DAISY 4 ENE	ATOKA	34.55	-95.68	754	1970	2004	32	0.146		0.02		-0.603	0.466	-0.461	0.353	50.343	63.058	40.953	59.303	42.220
27	EL RENO 1 N	CANADIAN	35.55	-97.95	1314	1970	2004	30	0.785		0.13		-0.347	0.519	-0.218	0.429	31.489	40.451	25.743	38.492	27.229
28	ELK CITY	BECKHAM	35.38	-99.40	1969	1970	2004	29	1.557		0.20		-0.110	0.590	-0.035	0.511	24.278	29.690	18.064	28.501	19.099
29	ENID	GARFIELD	36.42	-97.87	1244	1970	2004	29	0.431		0.07		-0.347	0.428	-0.245	0.344	30.331	36.940	25.522	36.158	26.391
30	ERICK	BECKHAM	35.22	-99.87	2059	1970	2004	33	0.728		0.07		-0.204	0.347	-0.142	0.272	23.646	28.311	19.258	26.582	21.025
31	FANSHAWE	LEFLORE	34.95	-94.90	544	1970	2004	31	1.258		0.25		-0.212	0.695	-0.109	0.550	48.071	55.562	40.367	52.061	42.965
32	FARGO	ELLIS	36.38	-99.63	2109	1970	2004	34	1.275		0.10		-0.105	0.314	-0.039	0.259	22.951	26.158	19.094	24.620	20.048
33	FORT SUPPLY DAM	WOODWARD	36.55	-99.53	2029	1970	2004	31	2.685	**	0.26	1	0.011	0.509	0.094	0.452	20.620	24.195	15.086	23.611	16.020
34	FREEDOM	WOODS	36.77	-99.12	1524	1970	2004	30	1.713	+	0.16	1	-0.121	0.363	-0.036	0.317	23.272	27.012	19.561	25.853	20.762
35	GATE	BEAVER	36.85	-100.05	2249	1970	2004	32	3.032	**	0.27	1	0.035	0.504	0.078	0.445	17.857	20.543	13.784	19.741	14.870
36	GUTHRIE	LOGAN	35.82	-97.40	1109	1970	2004	32	1.589		0.30		-0.156	0.608	-0.039	0.549	28.590	40.350	24.918	36.884	26.067
37	HAMMON 3 SSW	ROGER MILLS	35.60	-99.40	1819	1970	2004	33	1.550		0.17		-0.130	0.501	-0.029	0.428	23.602	28.180	19.203	27.428	20.086
38	HANNA	MCINTOSH	35.20	-95.88	678	1970	2001	32	1.930	+	0.31	1	-0.134	0.742	-0.003	0.627	38.686	48.084	33.081	45.268	34.917
39	HEALDTON	CARTER	34.22	-97.47	733	1970	2004	33	1.162		0.16		-0.257	0.430	-0.123	0.381	32.891	42.095	27.449	38.616	27.669
40	HELENA 1 SSE	ALFALFA	36.53	-98.28	1349	1970	2004	34	2.461	*	0.31	1	-0.013	0.589	0.063	0.524	25.630	31.256	21.306	29.951	22.358
41	HENNESSEY 4 ESE	KINGFISHER	36.10	-97.83	1149	1970	2004	31	1.564		0.19		-0.120	0.485	-0.044	0.423	29.326	36.352	24.028	34.519	26.154
42	HOBART MUNICIPAL A	KIOWA	35.00	-99.05	1551	1970	2004	30	1.463		0.17		-0.146	0.558	-0.060	0.457	25.379	29.045	20.671	28.072	21.284
43	HOLLIS	HARMON	34.68	-99.82	1620	1970	2004	30	0.321		0.05		-0.287	0.397	-0.211	0.328	24.806	29.918	19.444	28.796	20.512
44	HOLLOW	CRAIG	36.87	-95.27	909	1970	2003	29	0.544		0.09		-0.347	0.514	-0.278	0.353	39.210	49.357	32.872	48.048	35.892
45	HOOKER	TEXAS	36.87	-101.20	2994	1970	2004	30	1.820	+	0.17	1	-0.086	0.381	-0.024	0.342	14.781	18.722	11.026	17.927	11.617
46	HUGO	CHOCTAW	34.00	-95.52	569	1970	1998	29	1.407		0.32		-0.326	0.821	-0.123	0.662	40.542	49.675	34.942	49.162	36.807
47	JEFFERSON	GRANT	36.72	-97.78	1044	1970	2004	35	1.179		0.13		-0.250	0.478	-0.138	0.369	32.871	37.154	25.979	35.125	28.239
48	KANSAS 1 ESE	DELAWARE	36.20	-94.78	1179	1970	2004	33	0.031		0.02		-0.521	0.486	-0.373	0.348	48.142	57.662	39.175	54.705	40.278
49	KINGFISHER 2 SE	KINGFISHER	35.85	-97.90	1099	1970	2004	33	2.417	*	0.27	1	-0.015	0.510	0.045	0.446	28.230	32.929	24.347	31.669	25.200
50	KINGSTON	MARSHALL	34.00	-96.73	819	1970	2004	31	0.714		0.13		-0.402	0.684	-0.217	0.560	38.697	48.422	31.960	45.738	33.489
51	KONAWA	SEMINOLE	34.97	-96.75	974	1970	2004	34	0.445		0.06		-0.403	0.431	-0.287	0.328	38.234	47.296	31.427	45.419	33.337
52	LAVERNE	HARPER	36.70	-99.90	2099	1970	2004	33	1.565		0.11		-0.077	0.314	-0.029	0.264	19.286	23.573	17.066	22.604	17.762
53	LOOKEBA 2 ENE	CADDO	35.37	-98.33	1424	1970	2004	32	1.832	+	0.29	1	-0.125	0.632	-0.028	0.538	27.068	35.179	21.870	32.928	22.340
54	MADILL	MARSHALL	34.10	-96.78	709	1970	2004	32	1.184		0.22		-0.286	0.526	-0.171	0.439	36.926	46.192	31.202	43.541	32.208
55	MANGUM	GREER	34.88	-99.50	1594	1970	2004	32	1.216		0.16		-0.197	0.477	-0.121	0.392	25.444	30.318	21.353	28.707	22.550

56	MANNFORD 6 NW	PAWNEE	36.17	-96.43	829	1970	2004	33	2.402	*	0.32	1	-0.035	0.703	0.035	0.611	33.619	40.213	26.613	39.176	28.589
57	MARAMEC	PAWNEE	36.25	-96.68	944	1970	2002	32	2.092	*	0.25	1	-0.096	0.624	0.029	0.523	34.273	39.022	29.971	36.669	31.670
58	MARIETTA	LOVE	33.93	-97.12	844	1970	2003	33	1.286		0.27		-0.233	0.624	-0.113	0.515	30.930	41.048	26.347	37.816	27.872
59	MARLOW 1 WSW	STEPHENS	34.65	-97.98	1249	1970	2004	35	1.108		0.15		-0.237	0.493	-0.136	0.434	34.607	39.810	26.306	39.509	27.713
60	MARSHALL	LOGAN	36.15	-97.62	1044	1970	2004	31	1.632		0.18		-0.129	0.458	-0.039	0.386	28.740	33.414	23.547	32.966	25.568
61	MCALESTER MUNI AP	PITTSBURG	34.88	-95.78	759	1970	2004	31	-1.581		-0.33		-0.815	0.297	-0.734	0.145	50.760	59.244	39.109	58.057	42.294
62	MCCURTAIN 1 SE	HASKELL	35.15	-94.97	658	1970	2004	34	1.038		0.14		-0.355	0.577	-0.203	0.444	48.143	53.585	37.512	51.976	39.780
63	MEEKER	LINCOLN	35.50	-96.98	924	1970	2001	28	2.153	*	0.27	1	-0.050	0.567	0.030	0.511	32.816	38.173	27.780	36.624	28.751
64	MORAVIA 2 NNE	BECKHAM	35.13	-99.50	1689	1970	2004	29	0.807		0.12		-0.235	0.453	-0.157	0.350	24.996	30.714	18.436	29.412	20.586
65	MUTUAL	WOODWARD	36.23	-99.17	1864	1970	2004	32	0.276		0.02		-0.218	0.278	-0.142	0.202	25.986	30.158	20.391	28.559	22.397
66	NORMAN 3 S	CLEVELAND	35.18	-97.45	1108	1970	2004	29	1.069		0.19		-0.265	0.618	-0.117	0.559	36.115	41.901	28.050	40.643	29.167
67	OKEENE	BLAINE	36.12	-98.32	1209	1970	2004	33	-0.294		-0.05		-0.324	0.321	-0.252	0.244	29.571	35.660	25.153	33.838	26.186
68	OKEMAH	OKFUSKEE	35.43	-96.30	934	1970	2004	33	1.379		0.20		-0.186	0.590	-0.088	0.479	36.652	43.616	30.433	41.861	33.097
69	OKLAHOMA CITY ROG	OKLAHOMA	35.38	-97.60	1303	1970	2003	32	0.276		0.03		-0.331	0.420	-0.248	0.342	35.326	41.716	27.430	41.092	28.839
70	PAWHUSKA	OSAGE	36.67	-96.35	834	1970	2004	34	2.402	*	0.39	1	-0.019	0.821	0.111	0.717	35.838	42.809	28.771	40.205	30.388
71	PAWNEE	PAWNEE	36.35	-96.80	834	1970	1998	23	1.637		0.43		-0.231	0.843	-0.100	0.697	32.370	39.735	26.870	39.082	27.791
72	PERRY	NOBLE	36.28	-97.28	1024	1970	2004	33	0.930		0.14		-0.220	0.471	-0.120	0.399	32.602	38.691	25.586	37.232	26.920
73	PONCA CITY MUNI AP	KAY	36.73	-97.10	998	1970	2004	35	0.511		0.07		-0.334	0.555	-0.231	0.448	32.938	40.163	25.067	38.819	27.081
74	PRAGUE	LINCOLN	35.48	-96.70	1009	1970	2004	35	0.028		0.01		-0.310	0.371	-0.202	0.287	40.034	46.370	33.823	43.505	35.280
75	PURCELL	MCCLAIN	34.97	-97.43	1042	1970	2001	30	1.641		0.31		-0.234	0.839	-0.093	0.697	35.604	46.308	28.162	43.958	30.391
76	RALSTON	PAWNEE	36.50	-96.73	824	1970	2004	34	0.964		0.14		-0.284	0.468	-0.171	0.398	35.795	42.217	30.319	40.251	31.467
77	REGNIER	CIMARRON	36.93	-102.63	4019	1970	2003	31	2.210	*	0.17	1	-0.033	0.385	0.038	0.344	12.536	15.531	10.294	14.747	10.621
78	ROOSEVELT	KIOWA	34.85	-99.02	1464	1970	2004	33	0.728		0.08		-0.196	0.350	-0.128	0.291	27.549	32.314	23.044	31.155	24.416
79	SALLISAW 2 NE	SEQUOYAH	35.45	-94.80	659	1970	2004	31	0.340		0.08		-0.459	0.455	-0.275	0.401	45.776	57.118	38.135	51.914	39.665
80	SAYRE	BECKHAM	35.30	-99.62	1899	1970	2004	35	1.875	+	0.16	1	-0.073	0.433	-0.005	0.368	21.923	26.428	18.603	25.104	19.660
81	SEMINOLE	SEMINOLE	35.23	-96.67	864	1970	2004	35	0.383		0.03		-0.378	0.454	-0.222	0.350	39.555	47.234	30.949	43.795	33.108
82	SHAWNEE	POTTAWATOMIE	35.35	-96.90	1049	1970	2002	33	0.945		0.10		-0.278	0.440	-0.166	0.357	39.315	46.443	32.430	43.347	32.931
83	SPAVINAW	MAYES	36.38	-95.05	684	1970	2003	31	0.544		0.11		-0.335	0.474	-0.237	0.398	40.529	50.546	34.730	49.858	36.412
84	SPIRO	LEFLORE	35.25	-94.62	494	1970	2004	33	1.658	+	0.21	1	-0.158	0.658	-0.063	0.562	44.736	49.382	35.344	48.232	36.733
85	STILLWATER 2 W	PAYNE	36.12	-97.10	894	1970	2004	33	0.759		0.14		-0.249	0.505	-0.142	0.381	32.744	40.914	28.700	38.046	29.823
86	STILWELL	ADAIR	35.90	-94.65	999	1970	2001	30	1.748	+	0.32	1	-0.224	0.896	-0.062	0.733	44.254	54.629	34.375	51.462	38.231
87	TALOGA	DEWEY	36.03	-98.97	1704	1970	2004	35	1.236		0.13		-0.125	0.358	-0.055	0.323	26.412	31.219	22.022	29.400	22.618
88	TULSA INTL AP	TULSA	36.20	-95.88	649	1970	2001	31	-0.850		-0.11		-0.599	0.332	-0.478	0.226	42.268	47.962	34.050	47.139	35.137
89	TUSKAHOMA	PUSHMATAHA	34.63	-95.28	599	1970	2004	32	0.924		0.22		-0.314	0.770	-0.192	0.588	43.301	55.836	35.923	53.080	38.166
90	UNION CITY 1 SE	CANADIAN	35.37	-97.90	1254	1970	2004	34	-0.623		-0.08		-0.469	0.260	-0.362	0.176	37.547	44.818	31.122	42.012	32.629
91	VALLIANT 3 W	MCCURTAIN	34.00	-95.15	478	1970	2004	33	0.480		0.11		-0.414	0.645	-0.279	0.557	50.023	60.007	38.116	58.029	40.097
92	VINITA 2 N	CRAIG	36.67	-95.13	734	1970	2001	29	-0.338		-0.06		-0.578	0.370	-0.446	0.255	43.656	51.456	38.035	50.441	40.460
93	VINSON	HARMON	34.92	-99.92	1944	1970	2004	34	2.002	*	0.18	1	-0.067	0.479	0.001	0.399	21.430	26.495	17.943	25.287	19.028
94	WAGONER	WAGONER	35.97	-95.37	589	1970	1999	30	0.464		0.04		-0.418	0.508	-0.268	0.411	45.485	49.134	35.821	48.082	37.111
95	WALTERS	COTTON	34.37	-98.30	1004	1970	2004	29	-0.581		-0.12		-0.504	0.326	-0.400	0.191	34.397	40.728	28.571	38.918	30.327
96	WATONGA	BLAINE	35.85	-98.42	1549	1970	1998	29	1.932	+	0.33	1	-0.135	0.795	-0.016	0.659	25.960	32.695	19.789	30.954	21.554
97	WAURIKA	JEFFERSON	34.17	-98.00	874	1970	2004	30	-0.357		-0.03		-0.430	0.254	-0.310	0.176	30.585	39.312	25.884	36.852	26.342
98	WAYNOKA	WOODS	36.53	-98.88	1449	1970	2004	33	1.100		0.12		-0.144	0.401	-0.100	0.345	25.397	31.783	19.257	31.100	20.189
99	WEATHERFORD	CUSTER	35.52	-98.70	1641	1970	2004	29	0.581		0.08		-0.312	0.456	-0.231	0.362	26.624	34.342	20.504	32.302	23.056
100	WEBBERS FALLS	MUSKOGEE	35.48	-95.20	549	1970	2001	28	1.758	+	0.35	1	-0.173	0.821	-0.037	0.706	40.765	52.029	33.138	49.390	35.210
101	WETUMKA 3 NE	HUGHES	35.27	-96.22	709	1970	2004	35	1.591		0.24		-0.171	0.623	-0.067	0.536	38.975	46.149	32.971	43.541	34.721
102	WEWOKA	SEMINOLE	35.15	-96.48	829	1970	2003	31	0.884		0.14		-0.342	0.606	-0.238	0.484	37.670	46.641	30.253	44.640	31.592
103	WOODWARD	WOODWARD	36.43	-99.38	1899	1970	2003	32	0.454		0.05		-0.217	0.357	-0.143	0.273	23.150	27.386	19.322	26.037	20.430

Appendix C

Preliminary taxonomic list of macroinvertebrates from 23 Oklahoma springs (in part)

		Year	2004	2004	2004	2004	2004	2004	2004	2004	2004
		County	Murray	Johnston	Johnston	Johnston	Johnston	Johnston	Pontotoc	Pontotoc	Pontotoc
		site number	1	2	3	4	6	8	5	10	11
Group	Family	Genus									
Diptera	Ceratopogonidae	*Atrichopogon*	x				x				
		Bezzia/Palpomyia	x						x		
		Ceratopogon									
		Culicoides	x			x		x			
		Dasyhelea									
		Forcipomyia									
		Mallochohelea									
		Probezzia	x	x							
		Serromyia	x	x	x						
		Stilobezzia									
	Chironomidae	Chironominae	x	x	x	x	x		x		
		Orthocladinae	x			x		x		x	x
		Tanypodinae	x	x	x	x				x	x
		Tanytarsini	x	x	x	x				x	x
	Culicidae	*Anopheles*		x	x			x	x	x	x
		Culex									
	Dixidae	*Dixa*						x			
		Dixella	x			x			x	x	x
	Empididae	*Hemerodromia*									
	Psychodidae	*Psychoda*	x								
	Ptychopteridae	*Ptychoptera*									
	Simuliidae	*Simulium*	x								
		Twinnia									
	Stratiomyidae	*Myxosargus*				x	x	x	x		x
		Odontomyia/Hedriodiscus	x								
		Stratiomys				x					
	Tabanidae	*Chrysops*			x	x					
	Tipulidae	*Holorusia*								x	
		Limonia									
		Pseudolimnophila							x		
		Tipula	x	x			x	x			
		Ulomorpha									

		Year	2004	2004	2004	2004	2004	2004	2004	2004	2004
		County	Murray	Johnston	Johnston	Johnston	Johnston	Johnston	Pontotoc	Pontotoc	Pontotoc
		site number	1	2	3	4	6	8	5	10	11
Group	Family	Genus									
Hemiptera	Belostomatidae	*Belostoma/Abedus*	x								
	Corixidae	*Trichocorixa*	x		x	x	x	x	x	x	
		unid. (small)									
	Gerridae	*Aquarius*	x	x	x	x	x	x	x	x	
		Gerris		x	x			x			
		Limnoporus									
		Rheumatobates									
		Trepobates		x	x	x	x	x	x	x	x
	Hebridae	*Merragata*									
	Hydrometridae	*Hydrometra*									
	Macroveliidae	*Oravelia*									
	Mesoveliidae	*Mesovelia*	x								
	Notonectidae	*Notonecta*			x			x			
	Veliidae	*Microvelia*			x	x	x	x	x	x	x
		Platyvelia	x	x		x					
		Rhagovelia		x			x	x			
Odonata	Coenagrionidae	*Argia*									
		Enallagma			x						
		Enallagma/Ishnura			x						
	Lestidae	*Archilestes*			x						
Amphipoda	Hyalidae	*Hyalella*	x	x	x		x	x	x	x	
Isopoda	Asellidae	*Lirceus sp*									
Gastropoda	Lymnaeidae	*Fossaria*			x		x				
		Radix auricularia	x	x							
	Physidae	*Physella*	x	x	x	x	x			x	x
	Planorbidae	*Gyraulus*			x						
Tricladida	Dugesiidae	*Dugesia dortocephala*								x	x
		Dugesia sp.A	x			x	x	x	x		x

		Year	2004	2005	2004	2004	2005	2005	2005
		County	Pontotoc	Pontotoc	Coal	Coal	Lincoln	Pottawatomie	Pottawatomie
		site number	12	1	7	9	2	3	4
Group	Family	Genus							
Diptera	Ceratopogonidae	*Atrichopogon*							
		Bezzia/Palpomyia	x	x		x		x	
		Ceratopogon							
		Culicoides	x						
		Dasyhelea							x
		Forcipomyia		x					
		Mallochohelea	x	x					
		Probezzia							
		Serromyia		x			x		
		Stilobezzia							
	Chironomidae	*Chironominae*	x	x	x	x	x	x	x
		Orthocladinae	x	x		x	x	x	x
		Tanypodinae	x	x		x	x	x	x
		Tanytarsini	x	x	x	x	x	x	x
	Culicidae	*Anopheles*		x					x
		Culex						x	x
	Dixidae	*Dixa*							
		Dixella		x					
	Empididae	*Hemerodromia*							
	Psychodidae	*Psychoda*							x
	Ptychopteridae	*Ptychoptera*							
	Simuliidae	*Simulium*					x		
		Twinnia							
	Stratiomyidae	*Myxosargus*							
		Odontomyia/Hedriodiscus				x			
		Stratiomys			x				
	Tabanidae	*Chrysops*							
	Tipulidae	*Holorusia*				x			
		Limonia							x
		Pseudolimnophila							
		Tipula		x		x		x	x
		Ulomorpha							

		Year	2004	2005	2004	2004	2005	2005	2005
		County	Pontotoc	Pontotoc	Coal	Coal	Lincoln	Pottawatomie	Pottawatomie
		site number	12	1	7	9	2	3	4
Group	Family	Genus							
Hemiptera	Belostomatidae	*Belostoma/Abedus*							
	Corixidae	*Trichocorixa*				x			
		unid. (small)						x	
	Gerridae	*Aquarius*				x		x	
		Gerris	x	x				x	
		Limnoporus		x			x		
		Rheumatobates							
		Trepobates	x	x					
	Hebridae	*Merragata*	x						
	Hydrometridae	*Hydrometra*							
	Macroveliidae	*Oravelia*							
	Mesoveliidae	*Mesovelia*	x		x				
	Notonectidae	*Notonecta*							
	Veliidae	*Microvelia*		x		x	x	x	x
		Platyvelia							
		Rhagovelia							
Odonata	Coenagrionidae	*Argia*			x		x	x	
		Enallagma							
		Enallagma/Ishnura							
	Lestidae	*Archilestes*							
Amphipoda	Hyalidae	*Hyalella*	x						
Isopoda	Asellidae	*Lirceus sp*						x	x
Gastropoda	Lymnaeidae	*Fossaria*							
		Radix auricularia							
	Physidae	*Physella*	x	x			x	x	x
	Planorbidae	*Gyraulus*						x	
Tricladida	Dugesiidae	*Dugesia dortocephala*							
		Dugesia sp.A							

		Year	2005	2005	2005	2005	2005	2005	2005
		County	Ellis	Ellis	Ellis	Ellis	Ellis	Ellis	Ellis
		site number	5	6	7	8	9	10	11
Group	Family	Genus							
Diptera	Ceratopogonidae	*Atrichopogon*							
		Bezzia/Palpomyia				x			
		Ceratopogon			x	x			
		Culicoides							
		Dasyhelea				x			
		Forcipomyia							
		Mallochohelea							
		Probezzia				x			
		Serromyia		x					
		Stilobezzia				x			
	Chironomidae	*Chironominae*	x		x	x	x		x
		Orthocladinae	x	x	x	x			x
		Tanypodinae	x	x	x	x	x	x	x
		Tanytarsini	x	x	x	x	x	x	x
	Culicidae	*Anopheles*	x			x		x	
		Culex			x				
	Dixidae	*Dixa*							
		Dixella	x		x	x	x	x	
	Empididae	*Hemerodromia*	x						
	Psychodidae	*Psychoda*			x		x		
	Ptychopteridae	*Ptychoptera*					x		
	Simuliidae	*Simulium*	x		x	x			
		Twinnia			x				
	Stratiomyidae	*Myxosargus*							
		Odontomyia/Hedriodiscus				x			
		Stratiomys			x	x	x		
	Tabanidae	*Chrysops*	x	x					x
	Tipulidae	*Holorusia*							
		Limonia							
		Pseudolimnophila							
		Tipula			x				
		Ulomorpha						x	x

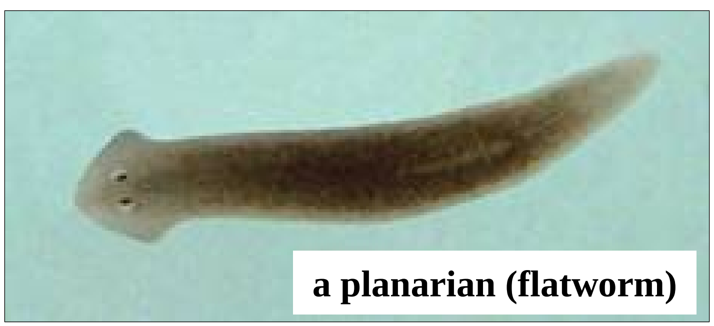
		Year	2005	2005	2005	2005	2005	2005	2005
		County	Ellis	Ellis	Ellis	Ellis	Ellis	Ellis	Ellis
		site number	5	6	7	8	9	10	11
Group	Family	Genus							
Hemiptera	Belostomatidae	*Belostoma/Abedus*		x	x	x	x		x
	Corixidae	*Trichocorixa*							x
		unid. (small)							
	Gerridae	*Aquarius*		x	x	x			x
		Gerris		x					x
		Limnoporus							
		Rheumatobates							x
		Trepobates			x	x			x
	Hebridae	*Merragata*				x			
	Hydrometridae	*Hydrometra*				x			
	Macroveliidae	*Oravelia*						x	
	Mesoveliidae	*Mesovelia*				x			
	Notonectidae	*Notonecta*							
	Veliidae	*Microvelia*	x	x	x	x	x	x	x
		Platyvelia					x		
		Rhagovelia	x						
Odonata	Coenagrionidae	*Argia*	x	x	x		x	x	
		Enallagma							
		Enallagma/Ishnura							
	Lestidae	*Archilestes*			x				
Amphipoda	Hyalidae	*Hyalella*	x	x	x	x	x	x	x
Isopoda	Asellidae	*Lirceus sp*							
Gastropoda	Lymnaeidae	*Fossaria*	x	x			x		
		Radix auricularia							
	Physidae	*Physella*	x	x	x	x	x	x	x
	Planorbidae	*Gyraulus*		x				x	
Tricladida	Dugesiidae	*Dugesia dortocephala*							
		Dugesia sp.A	x	x	x	x	x	x	x

Supplementary Images: Sampling Springs during the study

Supplementary Images: Oklahoma springs as aquatic refugees for biota and fauna


watercress


aquatic sowbug


a planarian (flatworm)


amphipods

Supplementary Images: Images of Oklahoma springs