Estimated moose harvest per capita among regions of Alaska during 1990-2018

Thomas F. Paragi and Graham G. Frye, Alaska Department of Fish and Game, Division of Wildlife Conservation, Fairbanks, 7 October 2020

Game harvest statistics can be useful for understanding the contribution of wild, free-ranging species in meeting human desires for acquiring protein. Per capita harvest is a ratio (number of animals harvested / human population) that describes trends in food supply scalable to size of communities or regions. Changes in both the numerator and denominator over time help interpret causation of ratio trends. An increasing ratio over time can reflect increasing harvest for a stable human population or stable harvest for a decreasing human population, whereas a decreasing ratio may reflect the opposite effects. A stable ratio over time represents offsetting factors (e.g., decreasing harvest for decreasing population), indicating stable provisioning of wild meat for a defined population segment based on their reported harvest.

Moose are among the most widespread big game species in Alaska, found in 68 of 72 Game Management Units (GMU; Appendix A) and are a close second to caribou as the dominant land species of wild meat yield (number of animals harvested x dressed carcass weight in pounds: Paragi et al. 2010). Moose are also a focal species of Intensive Management programs[1] intended to increase harvest for residents of Alaska and non-residents by enhancing ungulate habitat or limiting predation (ADF&G 2011). A recent summary of wild food harvest in Alaska that included land mammals such as moose calculated meat yield for communities grouped by U.S. Census areas (ADF&G 2019). Community group designations in Alaska are used for summarizing food yield because they reflect a degree of cultural distinction, adjusted for circumstances such as legal definitions of game harvest allocation based on cultural geography.

Implementation of Intensive Management began in 2003 in selected areas (Appendix A). As a first step in understanding how moose harvest patterns may have changed among communities or regions in specific years, , we matched reported moose kill by hunter community with community population size estimated from U.S. Census data during 1990-2018 among 17 community groups in Alaska (Table 1). Moose kill by state residents averaged 89% (annual range: 83-92%) of total moose kill in Alaska during this period (unpublished ADF&G data).

Methods

Census areas define segments of human population for estimates of demographic characteristics over time (U.S. Census Bureau, n.d.). In Alaska the boundary of boroughs and the Municipality of Anchorage are the primary census areas, further subdivided into subareas in some instances, and then into incorporated communities, unincorporated communities (Census Designated Place; CDP), and remaining portions (census area "balance"). Portions of boroughs or municipalities are designated as non-subsistence (NS) areas for purposes of harvest allocation (Table 1).

[1] http://www.adfg.alaska.gov/index.cfm?adfg=intensivemanagement.programs

Based on consultation with the Division of Subsistence (J. Fall, ADF&G, Anchorage), we followed the general geographic groupings in Alaska Department of Fish and Game (2019) but adjusted 2 Census areas to reflect management considerations for moose. First, we separated the Copper River subarea (13 communities) from the Valdez-Cordova Census Area because of a long history of complex regulations for harvest allocation in GMU 13. Second, we shifted the Aniak subarea of the Bethel Census Area (10 communities) to the Western Interior group that includes GMU 19. Based on consultation with Division of Wildlife Conservation staff in Anchorage and Palmer, we also divided the Anchorage Nonsubsistence Area into Anchorage, Kenai, and Matanuska-Susitna (Matsu) portions to reflect different hunter populations and GMUs in the most populated region of the state (Fig. 1).

We queried resident moose harvest from the WinfoNet harvest database based on hunter residency = 'R' AND (state = 'AK' OR zip = 96508 OR zip = 98733). Those specific zip codes were chosen to ensure that resident hunters on military bases were included. We used the mailing address community ("city") of hunter licenses to match moose kill to human population estimates based on decadal U.S. Census data and annual estimates for Alaska available back to 1990[2]. We included obvious city spelling variants (coding mistakes) and reconciled 5 name changes (e.g., most recent being Utqiagvik replacing the former name Barrow). Changes in human population resulted in Census Designated Places being discontinued or added with each Census, but annual tallies of population among analysis groups were close to statewide estimates (Table 1). Harvest on federal permit hunts was included in WinfoNet for 1990-2009. We obtained federal hunt results from the Office of Subsistence Management, U.S. Fish and Wildlife Service for 2010-2018, assigning harvest for a few residence communities to the closest mailing address city in the WinfoNet data for consistency in grouping.

Because of census area adjustments each decade, we separately compiled each community group, metric, and Census decade for plotting a line of least squares regression and the average annual change. We did not assign significance values to trends because moose harvest and human population represent attempted censuses, not samples, and the number of data points within each decade was limited. The vertical axis remained constant within metric and community group to enable comparison over time, with statewide total represented by "all."

Results

Reported moose harvest tended to vary more strongly from one year to the next in groups composed of 1 community or a few communities in a small number of GMUs (Table 1) compared with groups where harvest was compiled across several communities and GMUs or in large population centers with access to many GMUs on the road system (Appendix B). Human population trends tended to have lower variation than harvest of the same period but in some groups varied more strongly from the end of one Census decade to the start of the next (Appendix C). This variation often reflected adjustments in CDPs that were split among the geographic groups we defined previously. This validates our decision to evaluate trends within decade instead of across the entire period.

[2] Source: Alaska Department of Labor and Workforce Development, Research and Analysis Section.

Per capita moose harvest statewide has varied between 0.009 and 0.012 since 1990 with slight linear increases each decade (Fig. 2). Licensed hunters composed only about 12% of Alaska residents in 2018 (unpublished), so per capita harvest is a much smaller rate than the hunting success rate for resident moose hunters (avg. 24%; unpublished). Western Alaska had the highest group rate in 2018, having doubled from about 0.015 to 0.03 in the middle period. This was possible during an increasing human population because of the more rapidly increasing harvest that doubled from 2000 to 2018. The Western Interior also had a near doubling of per capita rate beginning in the 2000s to around 0.012 by 2015. This occurred as harvest more than doubled while human population declined. The Southeast rate nearly doubled through a steady increase, driven by increasing harvest during a period of relatively stable human population. The Southwest rate nearly tripled in the 1990s and has remained relatively steady since based on increased harvest and declining human population.

In contrast to increases in per capita moose harvest, the North Slope and Seward Peninsula experienced decreases in per capita harvests during the 1990s without subsequent recovery in subsequent decades. Rural Southcentral communities had increases and decreases that balanced one another in the first two decades but maintained a relatively low rate in the last decade, with these trends driven more by harvest (Appendix B) than human population (Appendix C). The Fairbanks Nonsubsistence Area exhibited a recent decline to per capita harvest levels achieved in the early 1990s, driven by declining harvests of moose and a stable human population in much of the last decade since 2010.

Other community groups had more modest changes in per capita harvest, with less decadal variation in the latter two periods since 2000 compared with the first period in the 1990s. The MatSu subarea of the Anchorage Nonsubsistence Area maintained a slow increase in rate, despite the greatest absolute gains in population of any group, by steadily increasing harvest.

Discussion

We recognize that moose is only one land species utilized by Alaska residents as food and expect its importance to vary across the state as other more regionally common land species assume greater proportion in the human diet (e.g., deer in Southeast, caribou on North Slope). Using the boned out carcass weight of moose in the Alaska hunting regulations (564 lbs.), for 2017 we found that the meat weight of reported moose harvest was much higher in the Interior and Southcentral than in Southeast, Southwest, or northern Alaska (Table 3).

Differences in reported harvest among years likely reflects a variety of factors. Hunting opportunity (regulations) among GMUs may change based on deliberations by the Alaska Board of Game when it considers changes in estimated moose abundance (harvestable surplus) or decides on different allocation among users. Weather and hunter access may also affect harvest among years, again with localized effects having potential for greater change in smaller community groups. Some weather events are more widespread, such as the severe winter of 1989-90 that reduced opportunity in the Anchorage and MatSu nonsubsistence areas in fall 1990 and the snowfall and ice formation in mid-September 1992 that likely reduced harvest in the Fairbanks Nonsubsistence Area and the Eastern Interior (Appendix B). Our compilation of per

capita harvest by community where entire GMUs are included (Table 1) may not exactly match reported kill tally among GMUs in Division of Wildlife Conservation management reports[3] because a small number of records are missing community or community is assigned to an incorrect GMU.

The two greatest increases and highest rates of per capita moose harvest were in Western and Western Interior groups. The GMU 18 moose population in the Western group area increased dramatically during this period, following hunt closures on the lower Yukon River starting in 1988 (6 years) and the lower Kuskokwim River starting in 2004 (5 years). Also, shrubs that provide winter forage to moose have been spreading into tundra-dominated areas of western Alaska in recent decades (Van Lanen et al. 2018). Presently the Yukon drainage portion of Unit 18 has a 9-month hunting season with a 2 moose bag limit, the only such liberal opportunity in the state. This increasing moose abundance upriver in Unit 18 has likely spread into adjacent portions of GMUs 19A and 21E, which could provide greater harvest opportunity for the Western Interior group (Appendix A) even with moose hunting closed in much of the eastern portion of Unit 19A since 2006 (Seavoy 2008:296). The steadily increasing per capita harvest for Southeast was caused by increasing harvest, especially in Units 1C and 3, while population in the community group slowly declined since 2000.

Many factors affect regional harvest statistics and complicate direct comparisons among regions. For example, estimates of harvest and, thus, per capita harvest may be biased low in remote areas of Alaska, where harvest reporting tends to be lower than along the road system (Anderson and Alexander 1992, Schmidt and Chapin 2014). Additionally, since 1990 there has been net migration by residents from rural to urban Alaska for economic and other opportunities (Howell 2015). Census data indicated that the proportion of Alaska Natives or American Indians living in urban areas of Alaska increased from 30% in 1990 to just over 50% by 2010.[4] Both factors can increase per capita harvest for the remaining residents of rural community groups over the same period. However, the degree of reciprocity with sharing meat from rural to urban areas and of urban people hunting with family members in their rural "home" community complicates interpretation of per capita harvest based on community grouping alone. Further comparisons or contrasts among regions is beyond the scope of our analysis.

Per capita harvest in this analysis is historic yield for community groups that can inform strategies to achieve desired future harvest based on anticipated trends in human population. Future harvest might be increased by managing game nutritional condition or mortality factors (habitat enhancement, predation), regulatory strategies (allocation, methods and means), or public access during open hunting seasons. Even if the per capita rate cannot be substantially increased, management actions that can decrease year-to-year variation may be a positive outcome for greater reliability of wild meat supply as a component of food security (Fall and Kostick 2018).

[3] http://www.adfg.alaska.gov/index.cfm?adfg=librarypublications.wildlifemanagement
[4] https://www.nativefederation.org/alaska-native-peoples/ (accessed 21 July 2020).

Standardizing game harvest to human population provides context for comparing different hunting systems. Some Alaskan hunters have aspired to the much larger moose harvests in Fennoscandia. However, per capita harvest for in 2003 Alaska was 0.011 statewide in the presence of large predators (Fig. 2), which is close to estimates of 0.08 in Norway and 0.12 in Sweden at that time with fewer predators, greater human population, and greater road density (Table 2). Another factor is that reported harvest does not include wounding loss, which can vary among systems. Boertje et al. (2020) estimated that 32% of hunter kills of radio-marked moose near the road system in the Interior were unrecovered carcasses (wounding loss of 2.6-7.5% among age-sex classes) or illegal harvest during 1997-2019. A study from Norway, which requires hunters to demonstrate shooting proficiency and have access to tracking dogs for recovering wounded game[5], estimated wounding loss of ≤4.5% for moose age classes (Stokke et al. 2012). Improving proficiency in marksmanship and acquiring greater skill in judging characteristics of legal animals and tracking recovery of wounded game plausibly could increase harvest in Alaska for existing moose density and hunter access.

This analysis does not evaluate kill location or change over time in the degree to which community groups hunted among GMUs. Hunting and harvest often occur in proximity to the residence community of a hunter, but kill location can vary greatly based on perceived game abundance, opportunity (i.e., regulatory constraint), tradition, hunter conflict avoidance, transportation costs relative to expendable income, and other factors related to hunter goals (trophy selection, visiting a new area, etc.). Case studies of Intensive Management programs may allow harvest inference for communities within program areas where predator control was done to enhance abundance and harvest of moose and caribou (Appendix A).

Acknowledgments

We appreciate thoughtful review comments on earlier drafts by C. Brown, J. Fall, and J. Van Lanen (Division of Subsistence) and D. Bruning (Division of Wildlife Conservation).

Literature cited

Alaska Department of Fish and Game. 2011. Intensive Management protocol. Division of Wildlife Conservation, Juneau.

Alaska Department of Fish and Game. 2019. Estimated harvests of fish, wildlife, and wild plant resources by Alaska region and Census areas, 2017. Division of Subsistence.

Andersen, D.B., and C.L. Alexander. 1992. Subsistence hunting patterns and compliance with moose harvest reporting requirements in rural Interior Alaska. Technical Paper No. 215. Alaska Department of Fish and Game, Division of Subsistence.

Boertje, R.D., G.G. Frye, and D.D. Young Jr. 2020. Lifetime sex-specific moose mortality during an intentional population reduction. Journal of Wildlife Management 84:6-19.

[5] https://www.face.eu/sites/default/files/norway_en.pdf (accessed 7 October 2020)

Fall, J.A., and M.L. Kostick. 2018. Food security and wild resource harvests in Alaska. Alaska Department of Fish and Game, Division of Subsistence.

Howell, D. 2015. Rural and urban migration. Alaska Department of Labor and Workforce Development, Juneau. https://laborstats.alaska.gov/trends/may15art2.pdf (Accessed 21 July 2020)

Lavsund, S., T. Nygren, and E.J. Solberg. 2003. Status of moose populations and challenges to moose management in Fennoscandia. Alces 39:109-130.

Paragi, T.F., S.C. Gerlach, and A.M. Meadow. 2010. Security of the red meat supply in Alaska. Agroborealis 41:36-37.

Schmidt, J.I., and F.S. Chapin III. 2014 Relationship of community characteristics to harvest reporting: comparative study of household surveys and harvest tickets in Alaska. Human Dimensions of Wildlife 19:334-346.

Seavoy, R.J. 2008. Units 19A, 19B, 19C, and 19D moose. Pages 285-324 *in* P. Harper, editor. Moose management report of Survey and Inventory activities 1 July 2005 to 30 June 2007. Alaska Department of Fish and Game. Project 1.0. Juneau, Alaska.

Stokke, S., Arnemo, J. M., Söderberg, A. & Kraabøl, M. 2012. Skadeskyting av rovvilt Begrepsforståelse, kunnskapsstatus og kvantifisering. NINA Report 838. 48 pp. [Wounding of carnivores: Understanding of concepts, status of knowledge and quantification. In Norwegian with English abstract: https://brage.nina.no/nina-xmlui/bitstream/handle/11250/2643010/838.pdf?sequence=2&isAllowed=y (accessed 7 October 2020)

U.S. Census Bureau. No date. Geographic areas reference manual, chapter 2 (geographic overview) https://www2.census.gov/geo/pdfs/reference/GARM/Ch2GARM.pdf (Accessed 19 June 2020).

Van Lanen, J.M., G. Neufeld, and C. McDevitt. 2018. Traditional ecological knowledge of the Mulchatna caribou herd: Phenology, habitat change, subsistence use, and related species interactions in Game Management Units 9B-C, 17, 18, and 19A-C, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 441.

Figure 1. Grouping areas for moose harvest analysis based on U.S. Census boundaries with some adjustments (Table 1) based on moose management boundaries (Appendix A) or legal definitions for rural subsistence qualification. Non-subsistence areas for Juneau, Ketchikan, and Valdez are too small to be shown at this map scale.

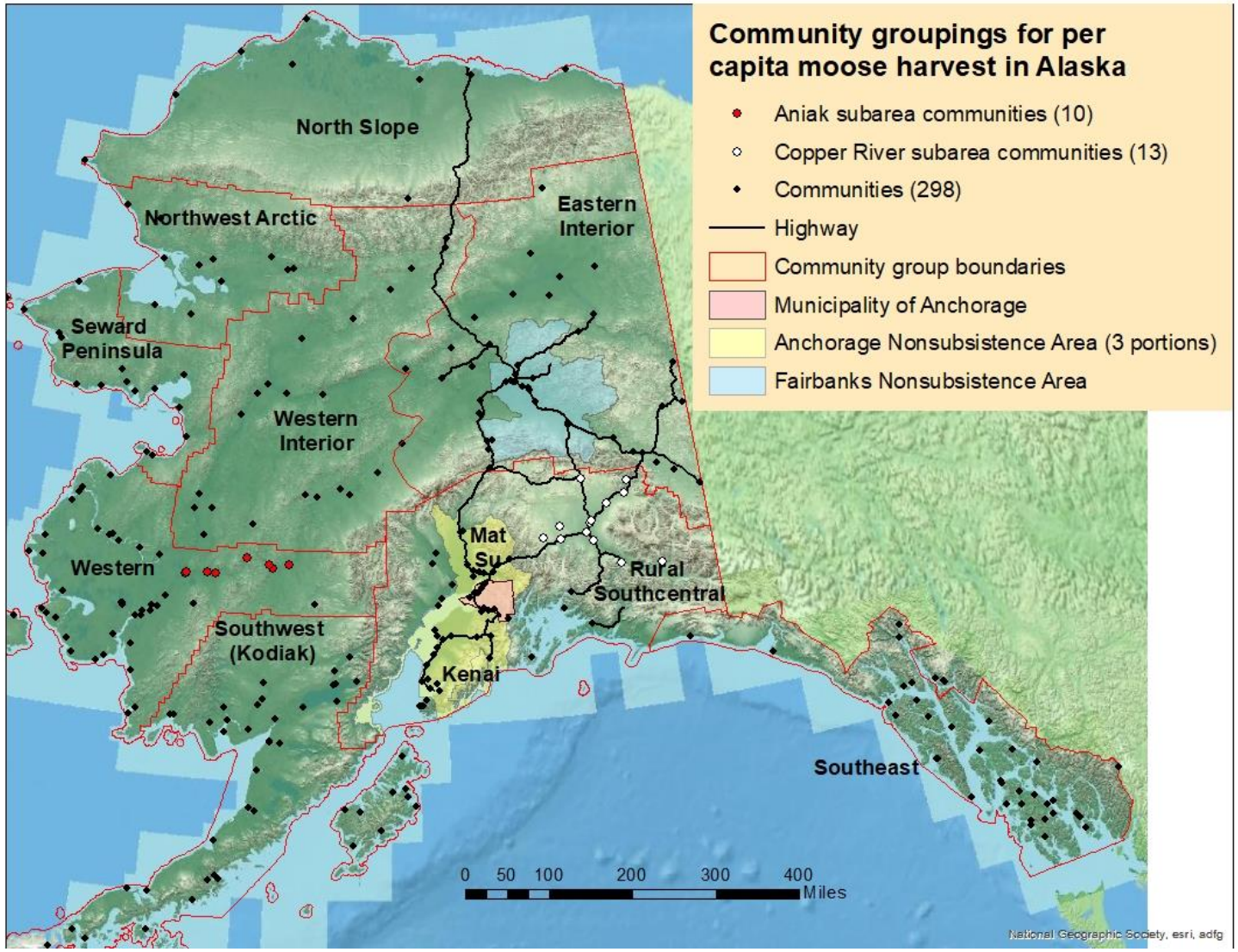


Table 1. Grouping areas for 278 communities (mailing address "cities") of licensed hunters who reported moose harvest in Alaska during 1990-2018. Nonsubsistence (NS) areas were designated by the Joint Board of Fisheries and Game using criteria in AS 16.05.258(C) and defined in 5 AAC 99.015. The Anchorage NS area was subdivided further for this analysis as described below.

Grouping area	Borough, or U.S. Census area or subarea, or portion thereof	Game Management Units	Number of mail "cities"	2010 Census population tally[1]
North Slope	North Slope Borough	26	9	9430
Northwest Arctic	Northwest Arctic Borough	23	12	7547
Seward Peninsula	Nome Census area	22	15	9468
Western	Bethel Census area excluding Aniak subarea and Wade Hampden Census area	18	38	23,543
Western Interior	Portion of Yukon-Koyukuk Census area including Aniak subarea of Bethel area	19, 21, 24	28	4388
Eastern Interior	Portions of Denali Borough and Southeast Fairbanks and Yukon-Koyukuk Census areas excluding the Fairbanks NS area	Portions of 12, 20, 25	27	8947
Fairbanks NS area	Portions of Denali and Fairbanks North Star Boroughs	Portions of 20A, 20B, 20C, 20D, 25C	12	102,050
Rural Southcentral	Portion of Kenai Peninsula and Matanuska-Susitna boroughs, and Valdez-Cordova Census area excluding the Anchorage NS area, Mat-Su portion	Portions of 6, 9, 11, 12, 13, 15, 16	13	5516
Copper River subarea	Copper River subarea of Valdez-Cordova Census area	Portions of 11, 13	13	1838

[1] Tally by community, CDP, and "balance" areas differ from 2010 Census areas based on integrating changes in census boundaries in 2000 and 2010 over the entire period for consistency. Annual tally among all regions was within 14-861 (max. 0.13%) of statewide population estimates among all years.

Table 1 (continued)

Area	Borough, or U.S. Census area or subarea, or portion thereof	Game Management Units	No. mail "cities"	2010 Census population tally[2]
Valdez NS area	Valdez City	6D	1	3976
Anchorage NS area, Mat-Su portion	Portion of Matanuska-Susitna Borough within the Anchorage NS area	14A, 14B, 16A	9	88,343
Anchorage NS area, Anchorage portion	Anchorage Municipality within the Anchorage NS area	14C	10	291,826
Anchorage NS area, Kenai Peninsula portion	Portion of Kenai Peninsula Borough within the Anchorage NS area	7; portion of 15	16	52,402
Southwest	Aleutians East, Kodiak Island, and Lake and Peninsula Boroughs; Aleutians West and Dillingham Census Areas	8, 10, 17; portion of 9	44	29,290
Southeast	Haines Borough; City and Borough (Sitka, Wrangell, Yakutat City); Census areas (Hoonah-Angoon, Petersburg, Prince of Wales-Hyder); Skagway Municipality; excluding Juneau and Ketchikan NS areas	2, 3, 4, 5; portion of 1	26	31,782
Juneau NS area	Juneau City and Borough	1C	3	31,275
Ketchikan NS area	Portion of Ketchikan Gateway Borough	1A	2	8050

[2] Tally by community, CDP, and "balance" areas differ from 2010 Census areas based on integrating changes in census boundaries in 2000 and 2010 over the entire period for consistency. Annual tally among all regions was within 14-861 (max. 0.13%) of statewide population estimates among all years.

Figure 2. Per capita moose harvest and estimated annual change by decade and Alaska community group, 1990-2018.

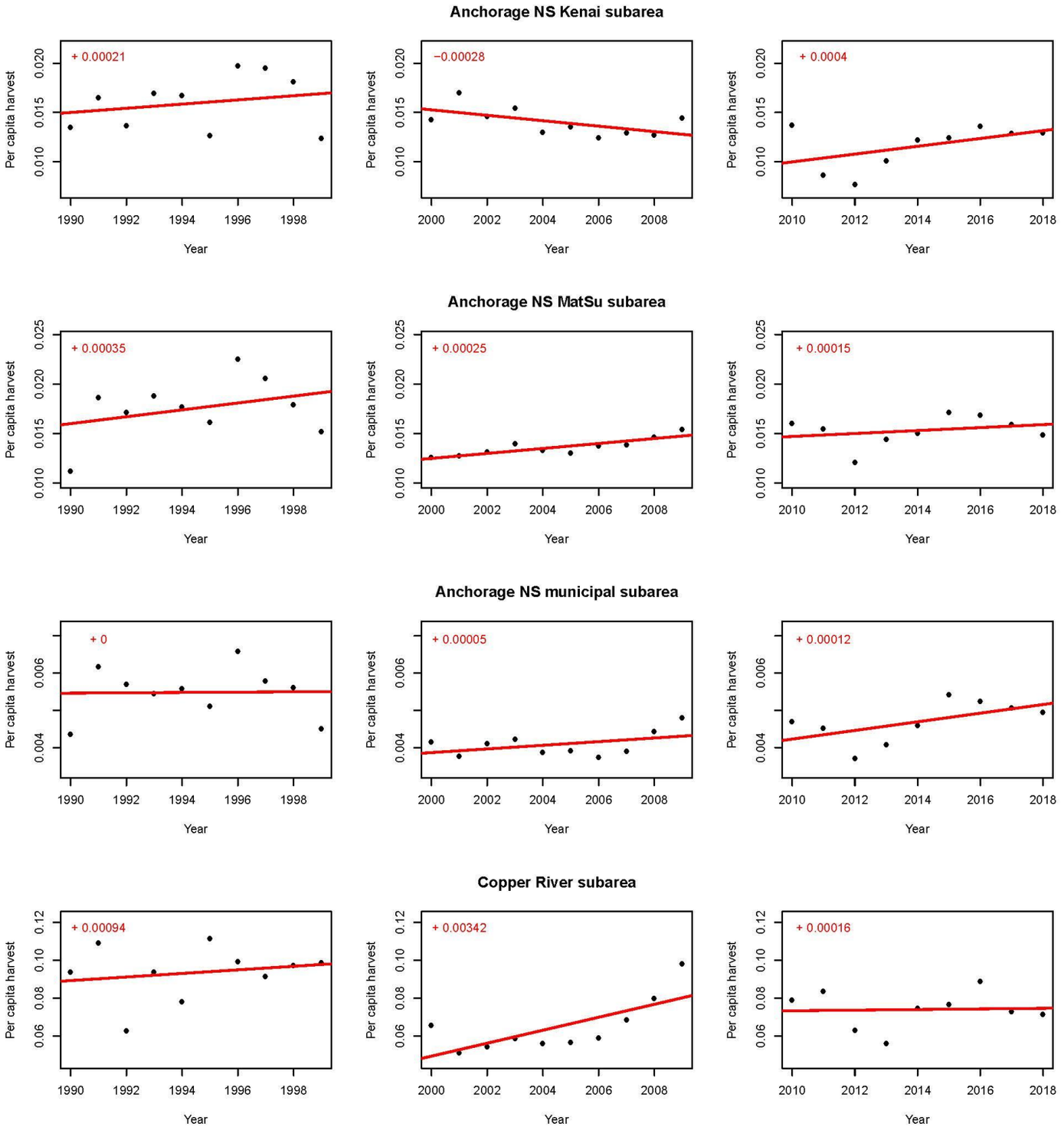


Figure 2. Per capita moose harvest (cont.)

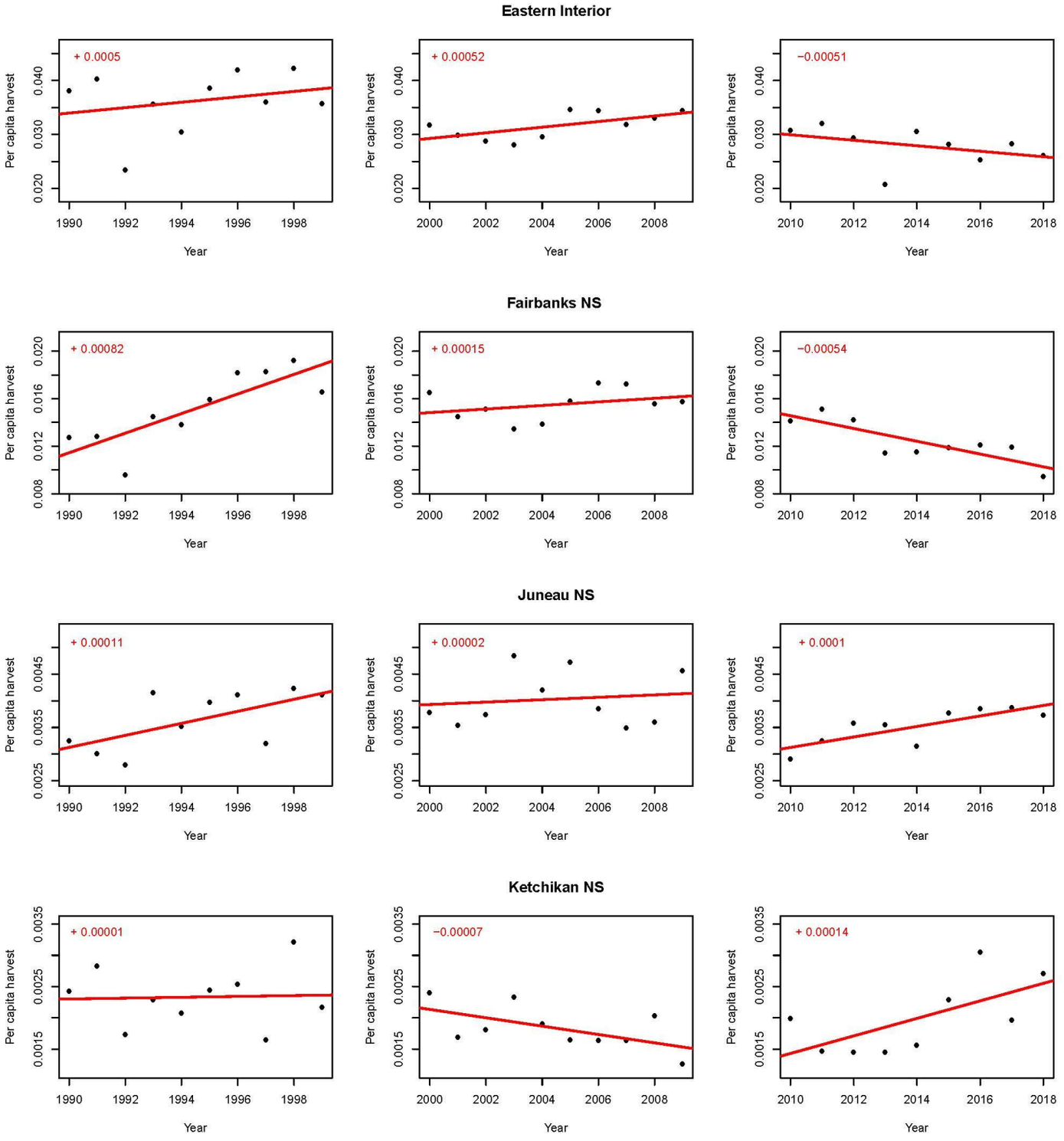


Figure 2. Per capita moose harvest (cont.)

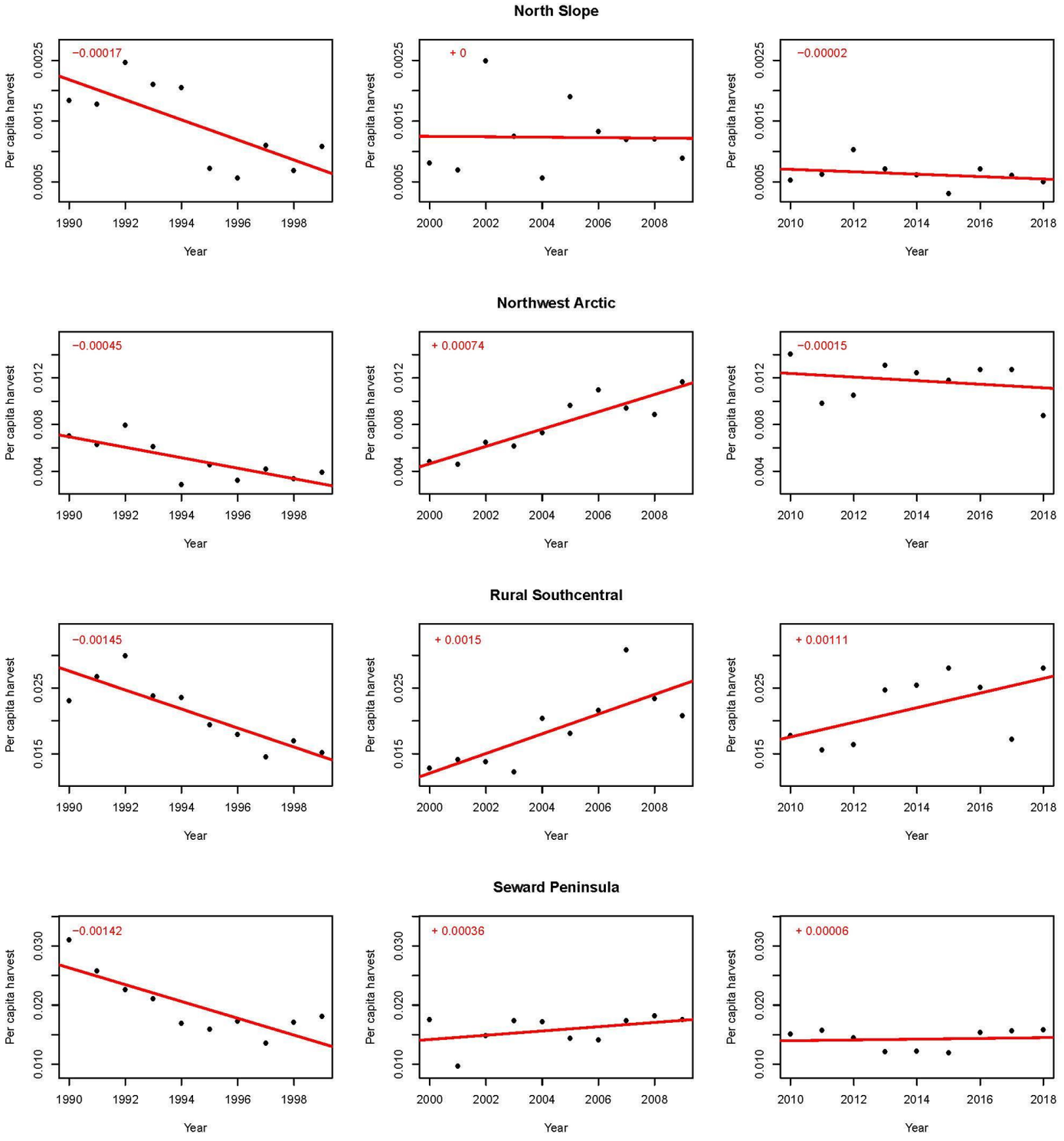


Figure 2. Per capita moose harvest (cont.)

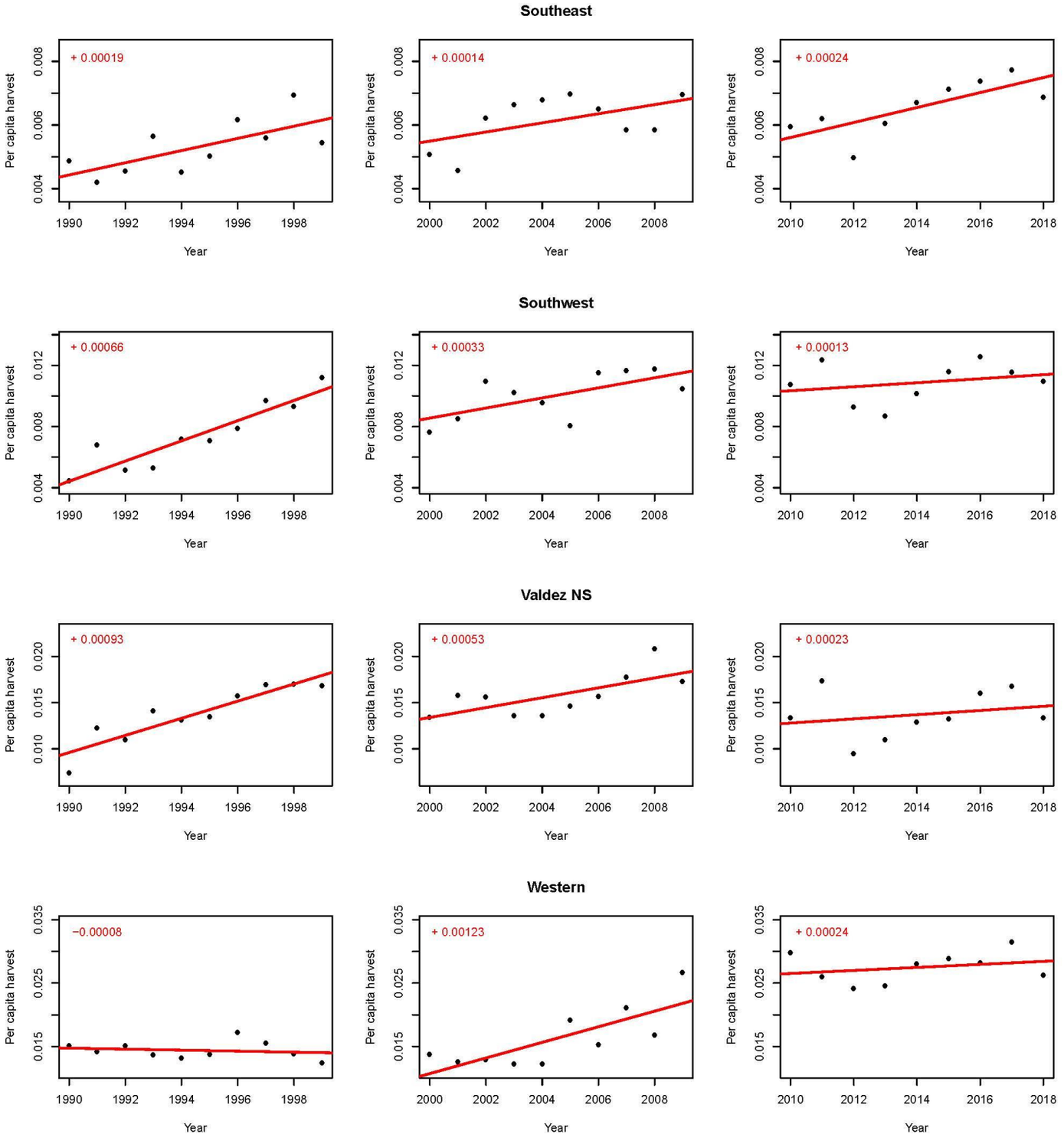


Figure 2. Per capita moose harvest (cont.)

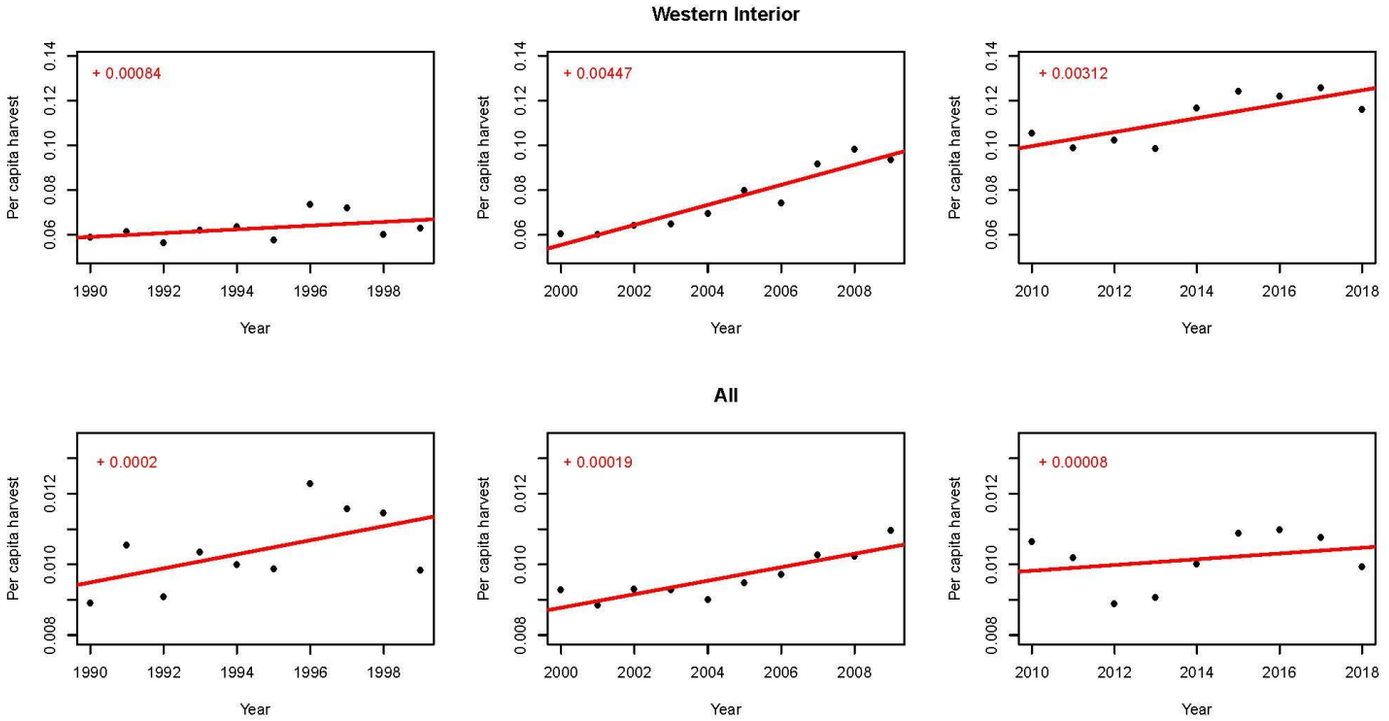


Table 2. Per capita moose harvest and management characteristics of Alaska, Norway, and Sweden in 2003. Hunter and harvest data for Norway and Sweden are from Lavsund et al. (2003).

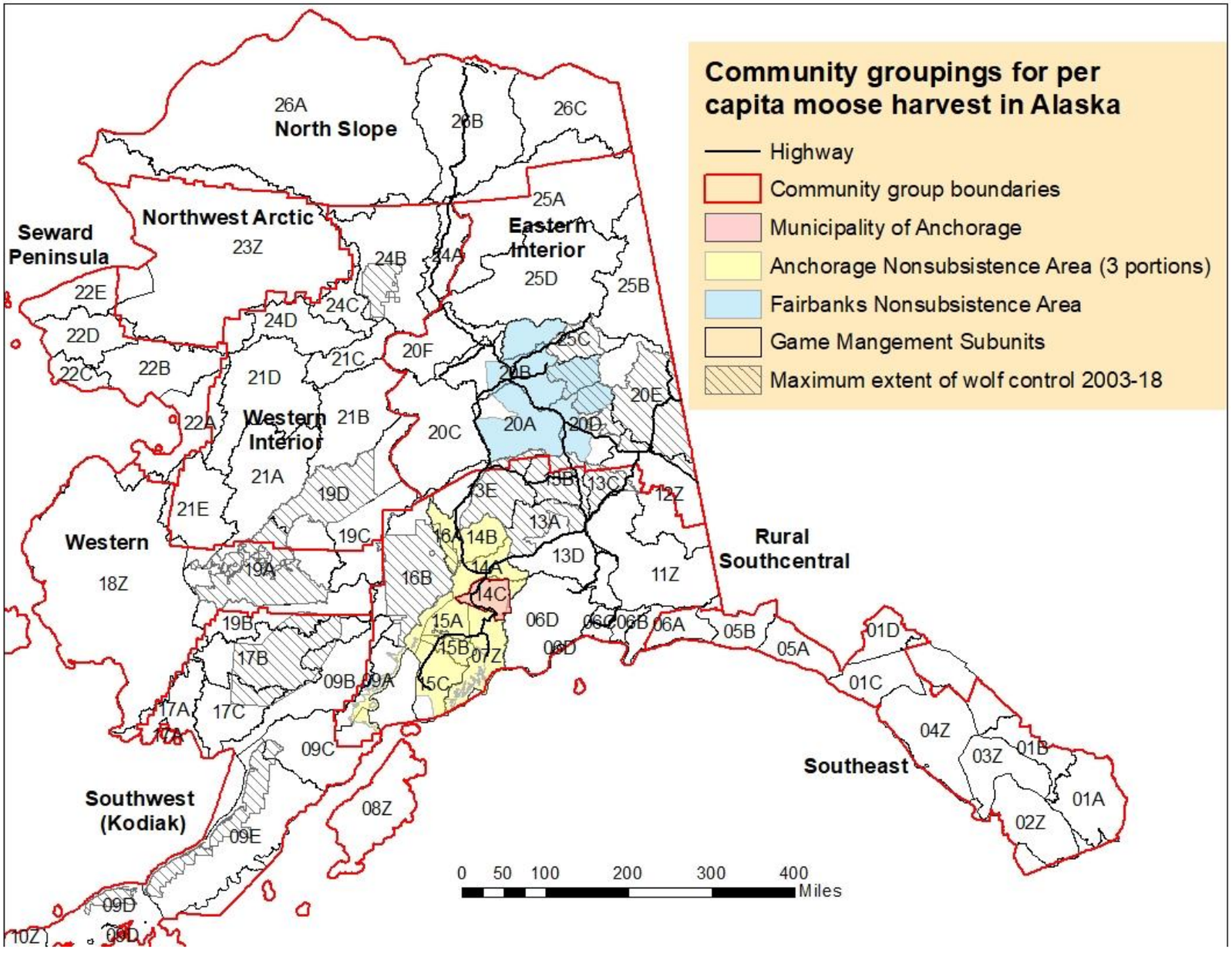
Management factor	Alaska	Norway	Sweden
Human population[8]	0.65 million	4.57 million	8.95 million
Urban population (percent)[9]	71	77	84
Land (miles squared)[10]	571,951	118,860	158,430
Public roads (miles)[11]	4167	57,789	254,989
Road miles per square mile	0.007	0.49	1.61
Large predators	Present	Recovering	Recovering
Moose hunters	28,000	56,000	240,000
Moose harvest	6908	38,600	103,185
Moose harvest per capita	0.011	0.008	0.012

[8] Norway and Sweden from www.populationpyramid.net.
[9] Norway and Sweden from www.macrotrends.net.
[10] www.worldatlas.com
[11] https://en.wikipedia.org/wiki/Norwegian_national_road (Norway); https://www.indexmundi.com/g/g.aspx?c=sw&v=115 (Sweden)

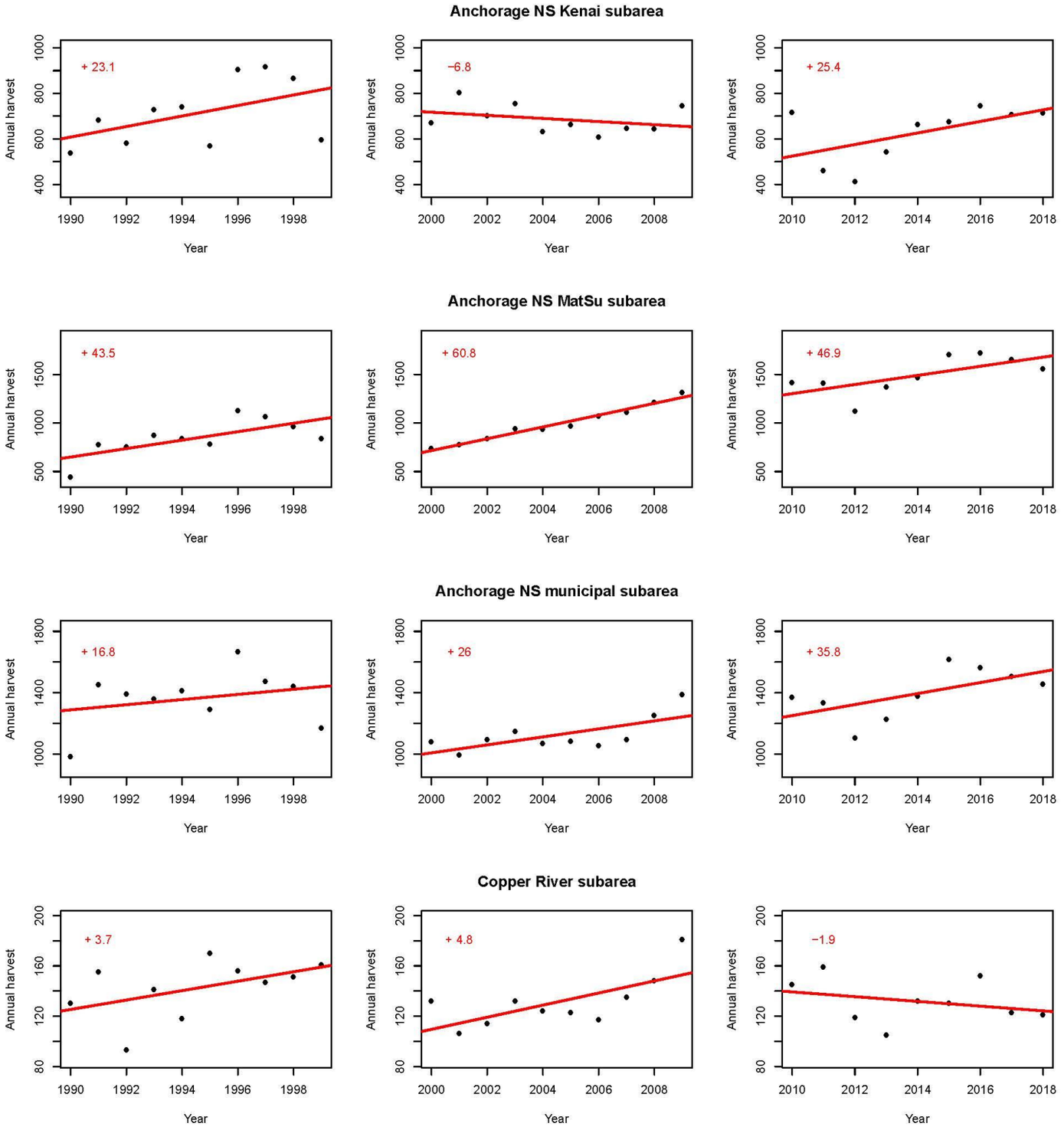
Table 3. Reported harvest weight of moose per capita (this study) compared with household survey estimates of land mammal per capita (ADF&G 2019) for community groups in Alaska in 2017.

Community group	Moose harvest (lbs.)	Moose per capita (lbs.)	Land mammal per capita (lbs.)	Moose proportion of land mammal
Anchorage NS Kenai subarea	398,184	7.3	6.9	1.05
Anchorage NS MatSu subarea	930,600	9.0	9.4	0.95
Anchorage Muni. NS subarea	848,820	2.9	3.5	0.81
Copper River subarea	69,372	41.0	41.7	0.98
Eastern Interior	141,564	16.0	--*	--*
Fairbanks NS	688,080	6.7	7.9	0.85
Juneau NS	70,500	2.2	7.7	0.28
Ketchikan NS	9,024	1.1	7.1	0.16
North Slope	3,384	0.3	149	0.00
Northwest Arctic	56,400	7.2	133.3	0.05
Rural Southcentral	53,016	9.7	38.2	0.25
Seward Peninsula	87,984	8.8	50	0.18
Southeast	141,564	4.4	32.4	0.13
Southwest	187,248	6.5	38.7	0.17
Valdez NS	37,224	9.4	11.2	0.84
Western	450,636	17.8	71.5	0.25
Western Interior	300,048	71.0	--*	--*
*Interior combined	441,612	33.7	95	0.35
Statewide	5,611,236	7.6	15	0.51

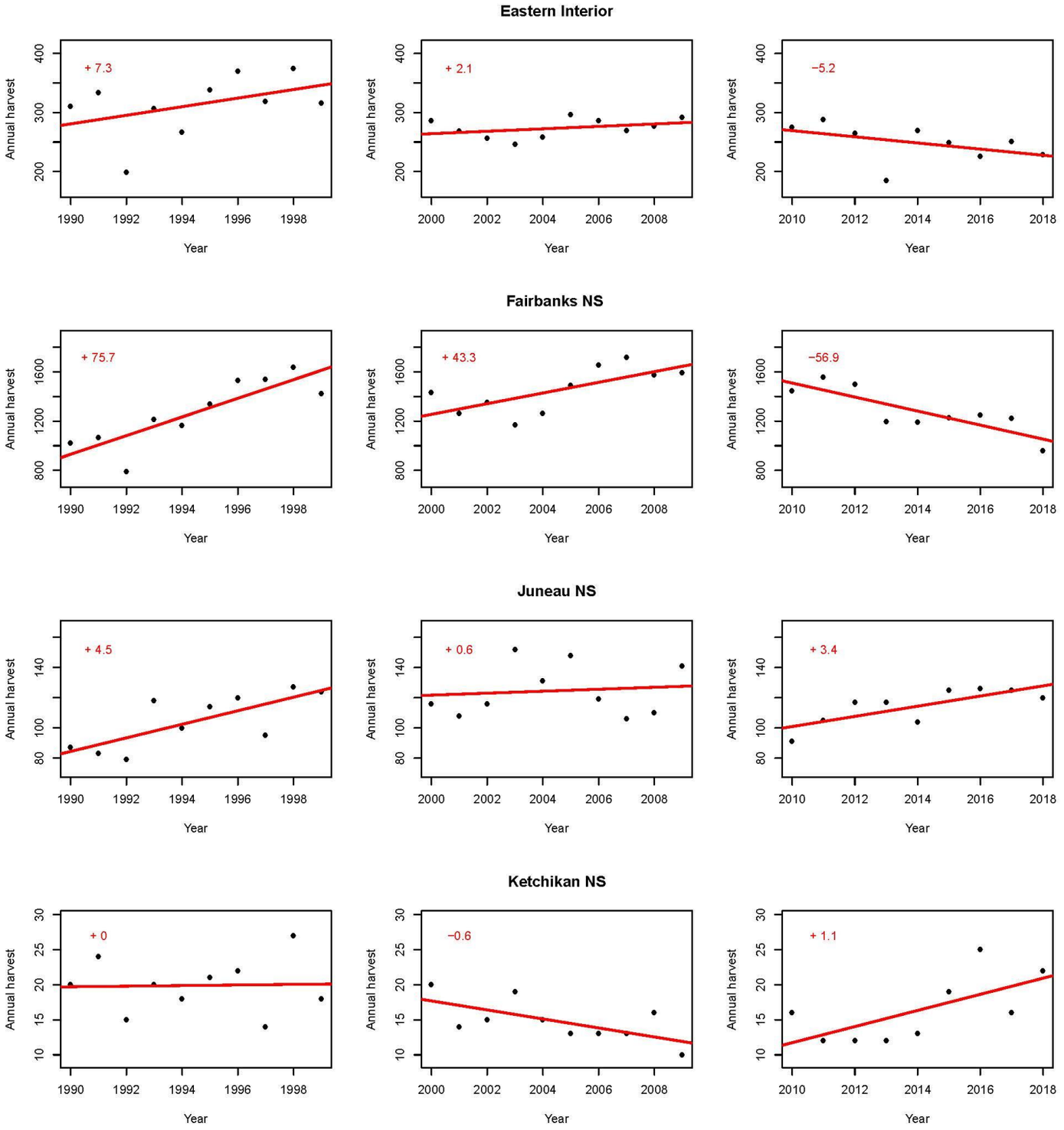
Appendix A. Location of Game Management Units (GMUs; subunits) and community grouping boundaries for per capita moose harvest in Alaska. Moose are absent from GMUs 2, 4, 8, and 10, but hunters from these areas have reported harvesting moose. Wolf control occurred on about 10% of the state during 2003-18, with bear control also in portions of GMUs 16A, 16B, 19A, 19D, and 20E. See Figure 1 for other details.



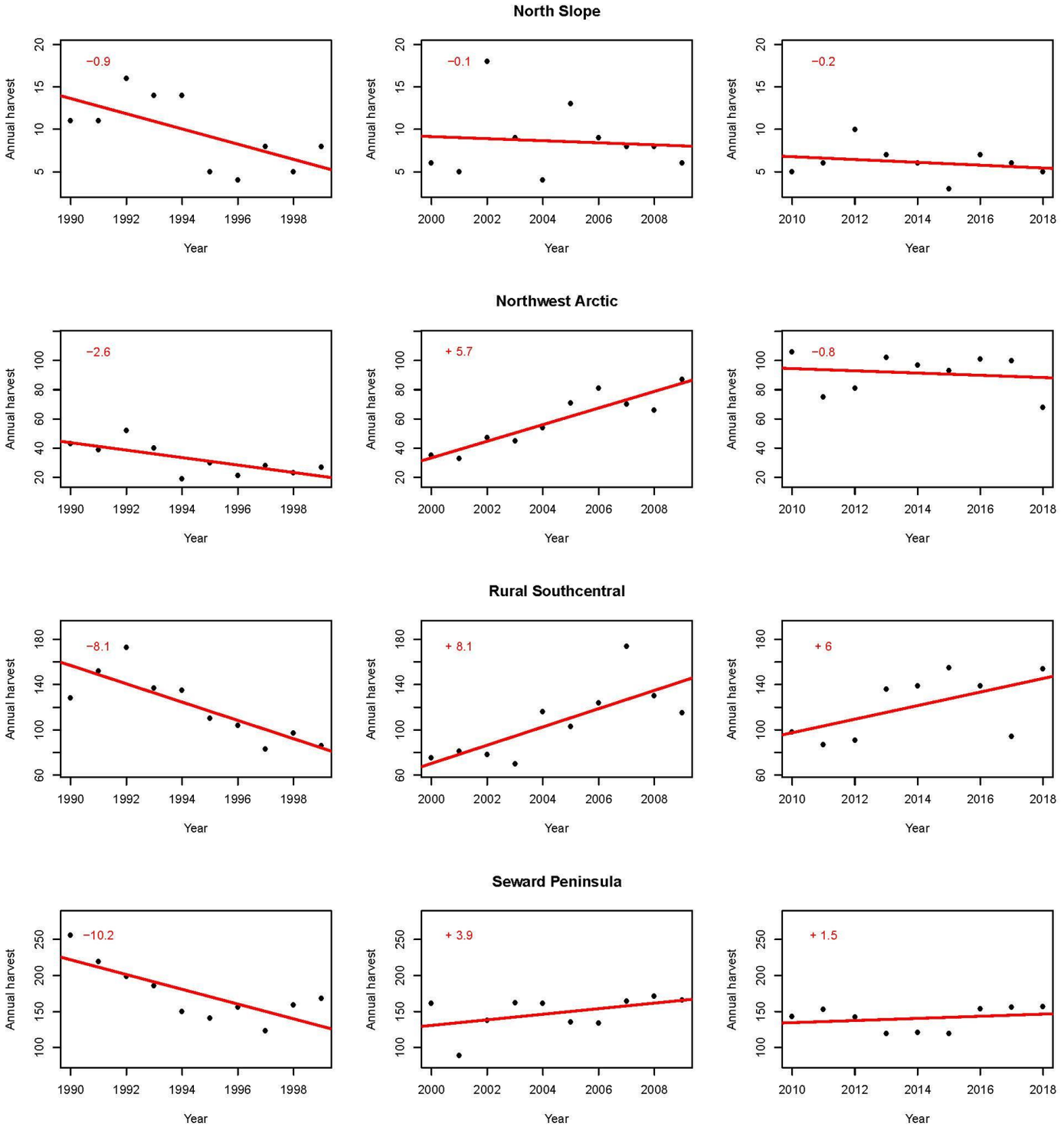
Appendix B. Moose harvest and estimated annual change by decade and Alaska community group, 1990-2018.



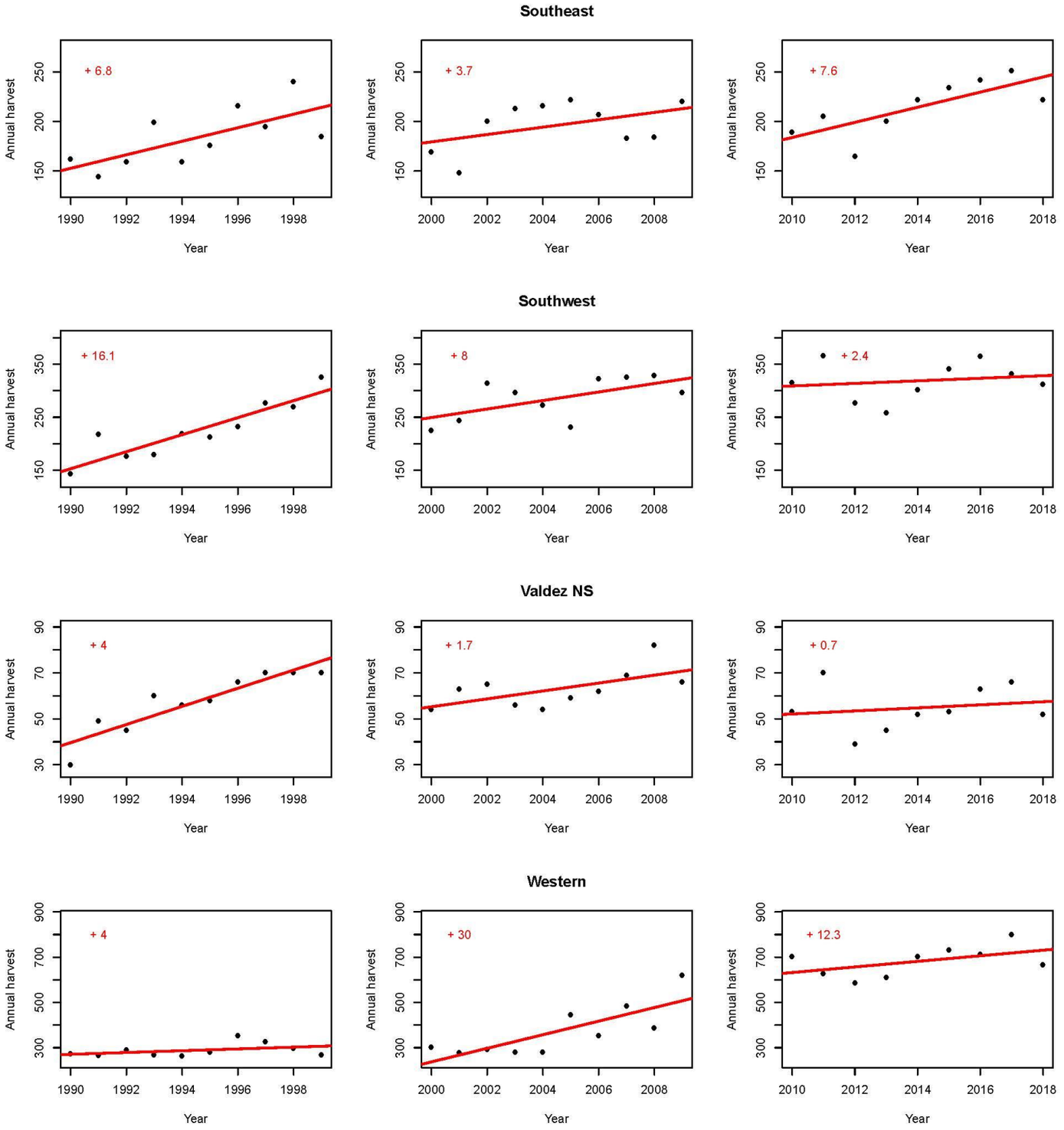
Appendix B. Moose harvest (cont.)



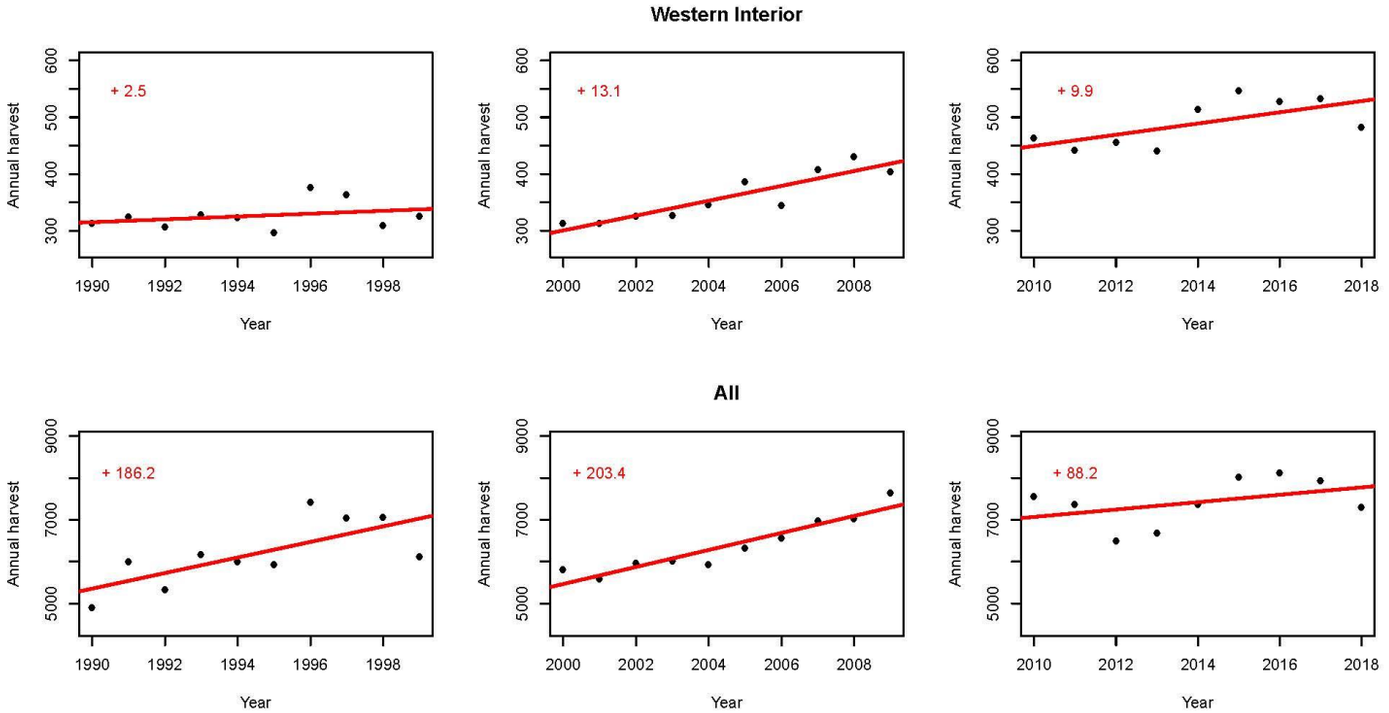
Appendix B. Moose harvest (cont.)



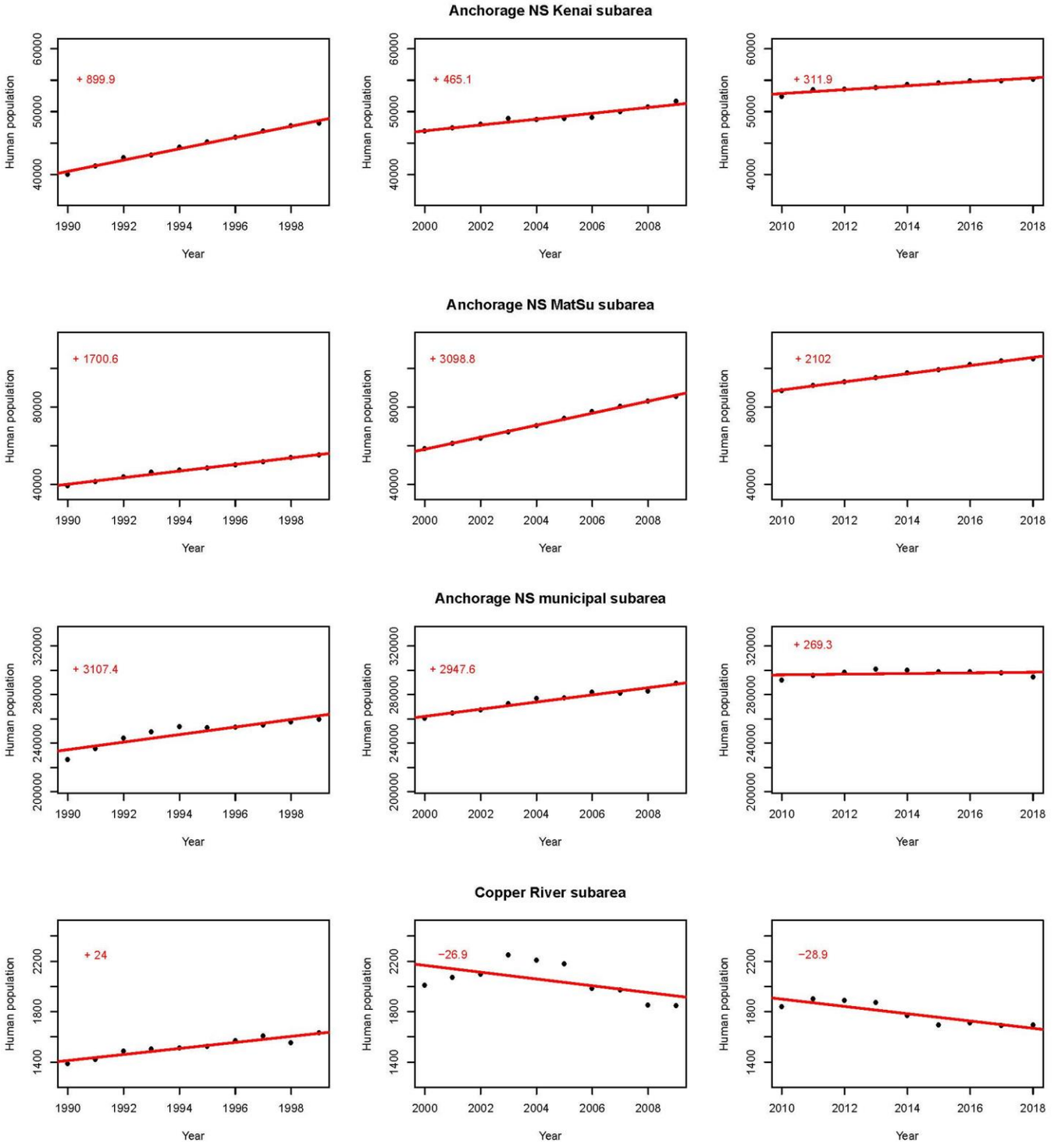
Appendix B. Moose harvest (cont.)



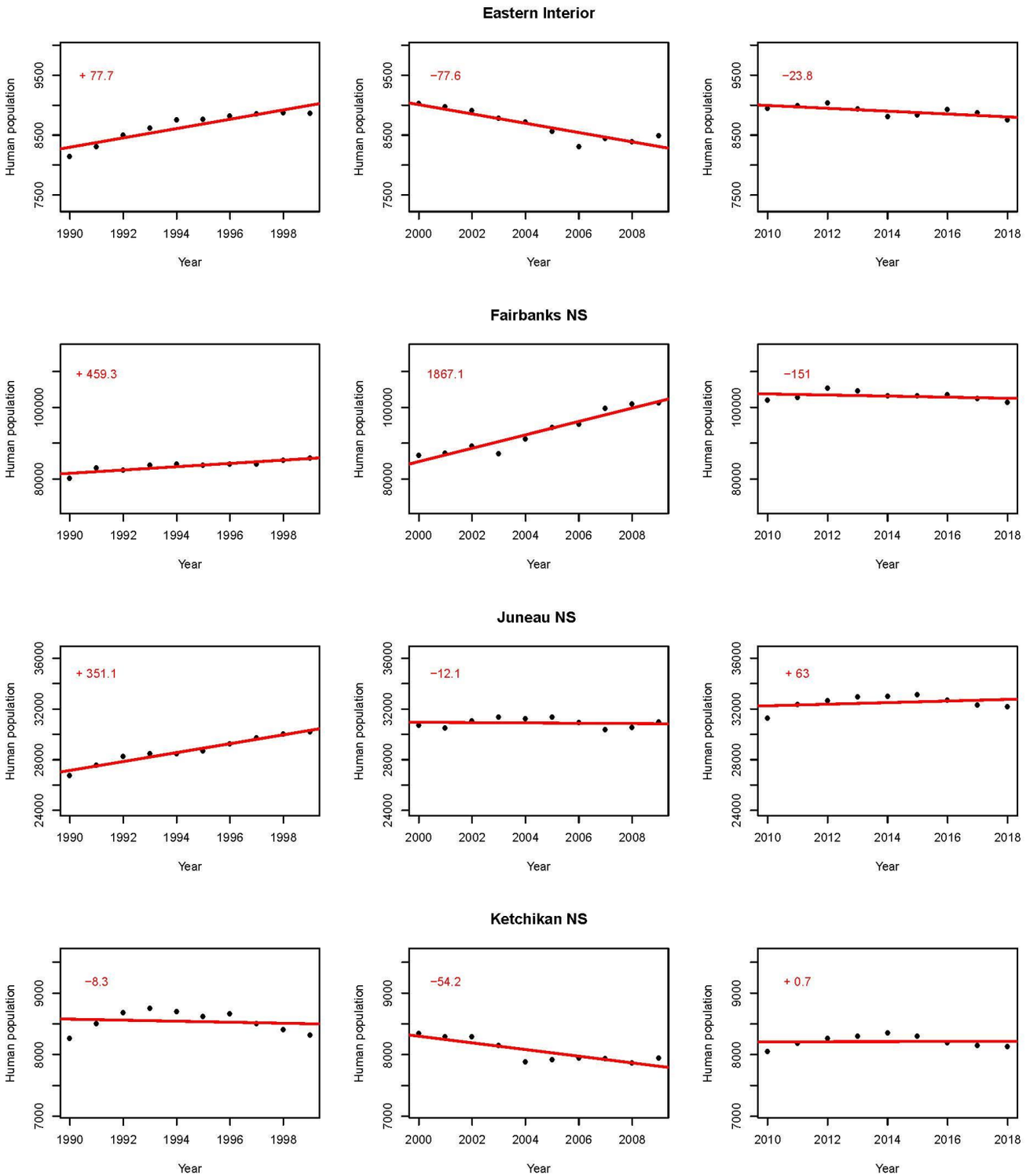
Appendix B. Moose harvest (cont.)



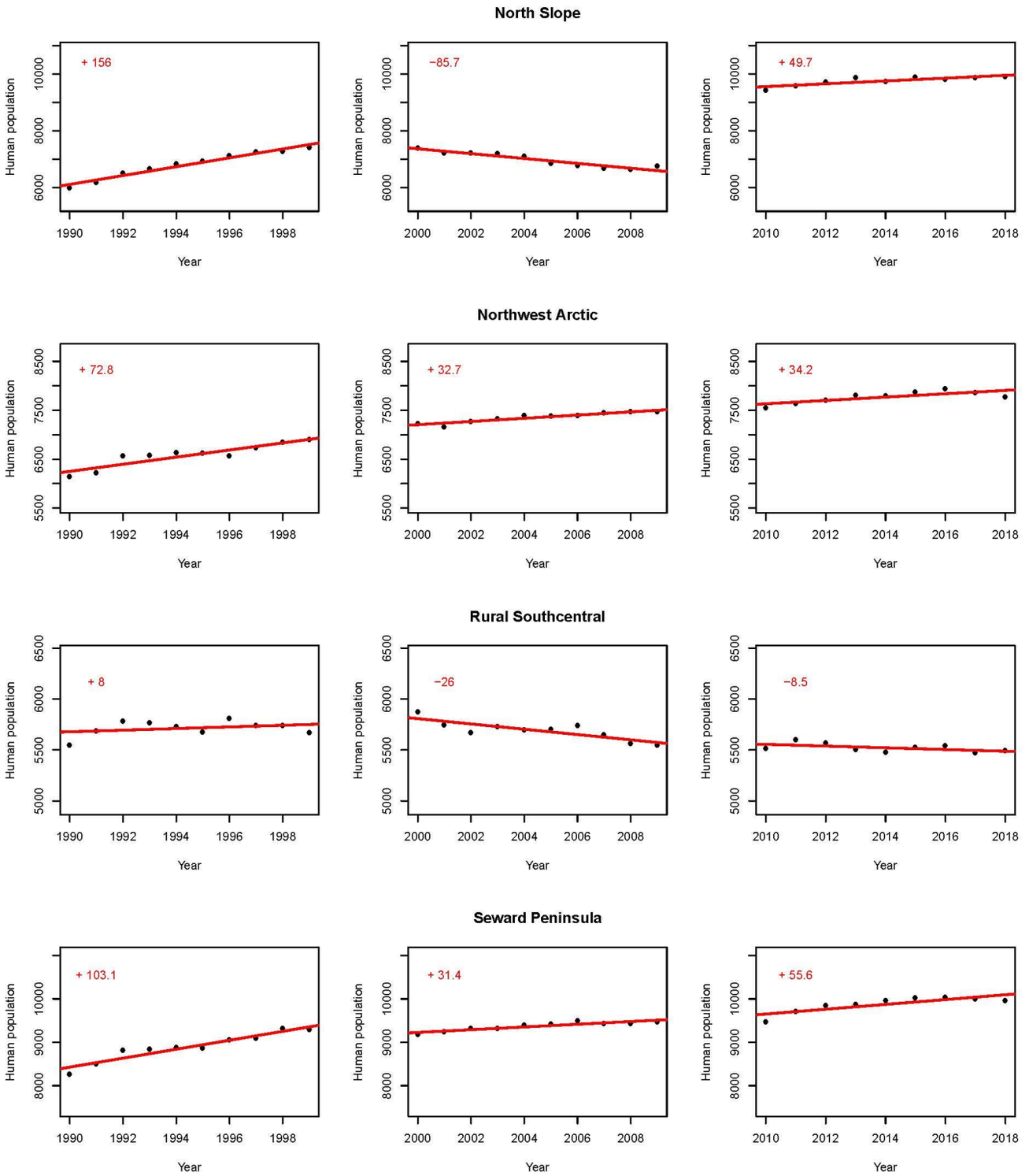
Appendix C. Human population and estimated annual change by decade and Alaska community group, 1990-2018.



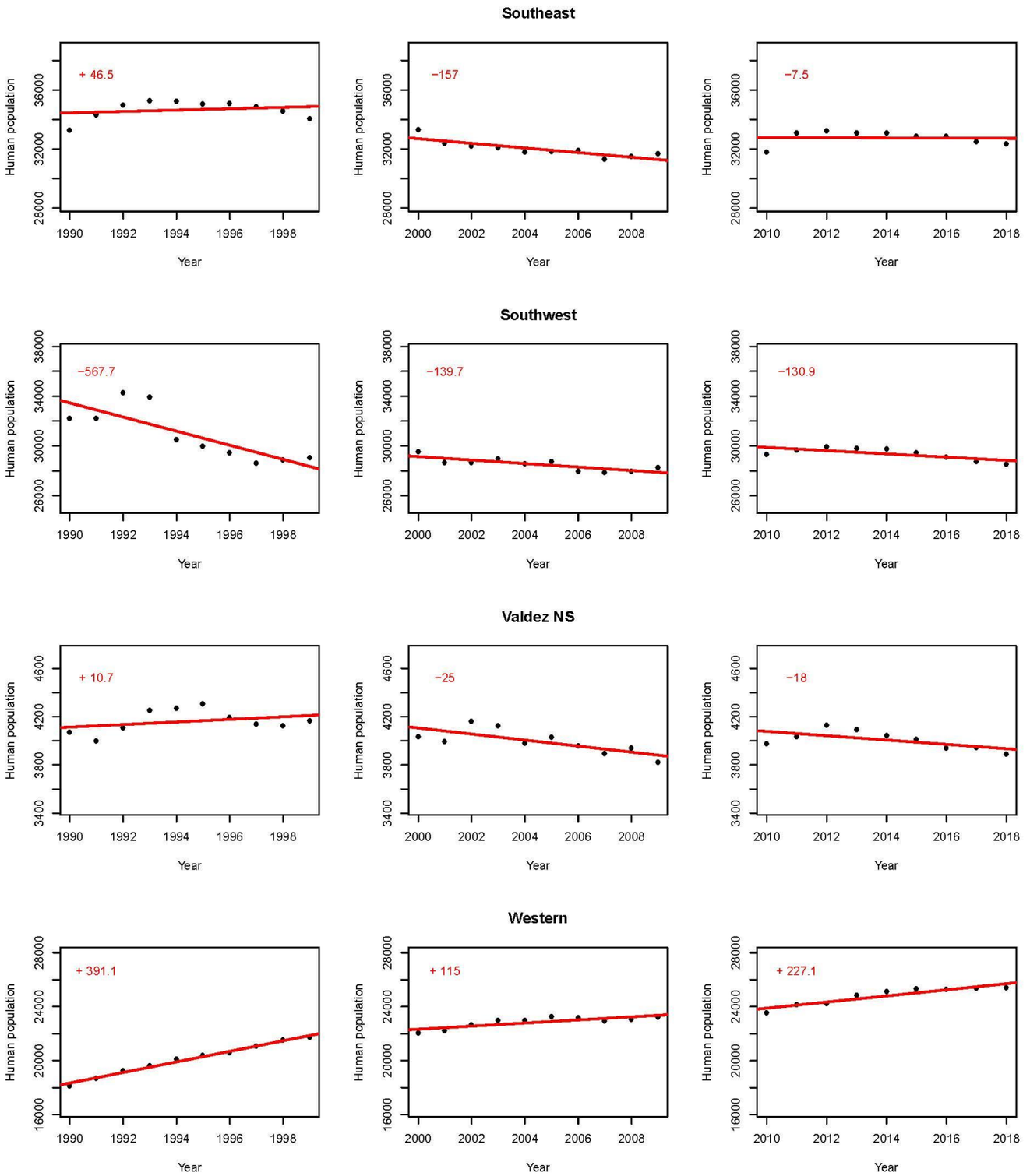
Appendix C. Human population (cont.)



Appendix C. Human population (cont.)



Appendix C. Human population (cont.)



Appendix C. Human population (cont.)