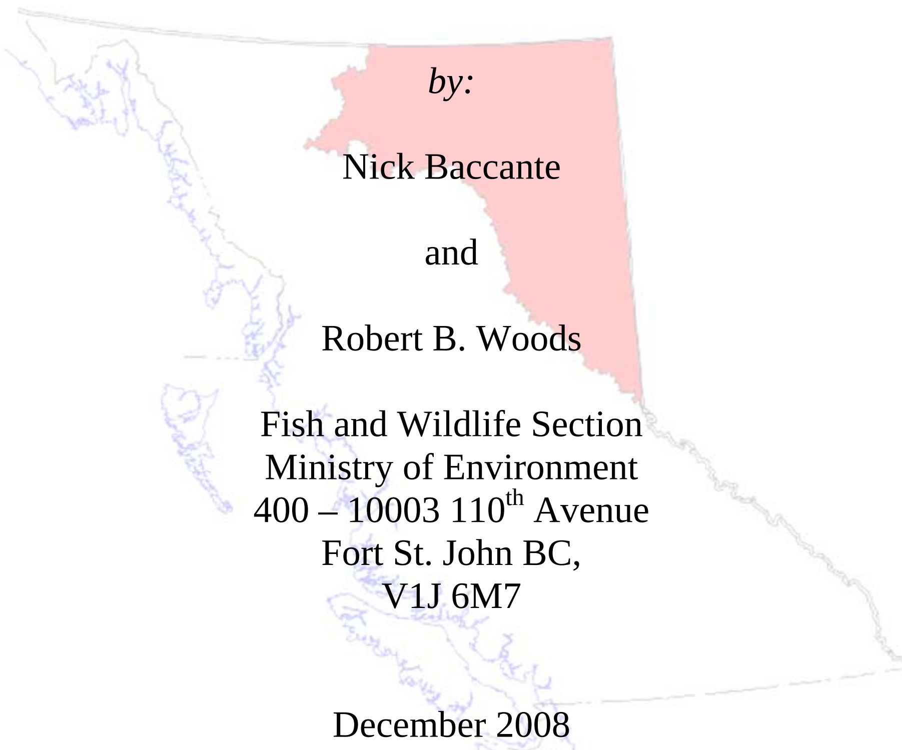
PEACE· REGION · TECHNICAL · REPORT

Relationship between weather factors and survival of mule deer fawns in the Peace Region of British Columbia



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INTRODUCTION

Mule deer (*Odocoileus hemionus*) are relatively abundant in the large agricultural area surrounding the Peace River valley in north-eastern British Columbia. They are important economically, as a game species, and ecologically, as part of the richly diverse ecosystems in this area. Mule deer, like other cervids, rut during the fall and fawns are born in June. Survival of fawns into the next year is greatly affected by snow and temperature conditions through their first winter.

A number of studies have measured fawn survival through their first winter with the use of recapture data collected by collaring animals (Pojar and Bowden 2004; Bishop et al. 2005; Lomas and Bender 2006). Our study does not measure survival directly, rather, we report annual counts of fawns as a relative measure of survival at the juvenile stage, and relate those differences to winter weather conditions just prior to birth. We do not track survival of these fawns over time.

METHODS

Annual spring counts of mule deer in the Peace Region have occurred since 1991. Counts are done by driving a vehicle along selected transects (Figure 1), these are roads that have good vantage points and cover known areas of high use by mule deer. Timing of the survey usually ranges from about mid-April to the first week in May. The vehicle is stopped whenever deer are observed and observers (1-2 people) use spotting scopes to count and classify deer by sex and age class. From 1991 to 2003 five transects were sampled varying in length between 12 and 16 km. In 2004 an additional transect 31 km. long was added, and in 2005 one more transect 100 km long was added. The number of transects has remained unchanged since 2005, and we don't anticipate adding any more.

Weather data, consisting of monthly summaries of mean, maximum and mean air temperatures, and snow precipitation, was obtained from the Environment Canada website (http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html). The data used is for the Fort St. John, B.C. airport, which is the closest station to the study area.

Following a methodology used by Ian Hatter (Ministry of Environment, Victoria, B.C., pers. comm.), we calculated a Winter Severity Index (WSI). The WSI integrates snowfall (centimetres) and air temperature (^{o}C) to quantify the impact of winter on fawns. The WSI is calculated by multiplying the snow precipitation (SNOW) by a factor which is dependent on temperature (TEMP):

$$WSI = 4 \times (SNOW) \text{ if } TEMP < -25\ ^{o}C$$

$$WSI = 3 \times (SNOW) \text{ if } TEMP < -15\ ^{o}C$$

$$WSI = 2 \times (SNOW) \text{ if } TEMP < -5\ ^{o}C$$

$$WSI = 1 \times (SNOW) \text{ if } TEMP > 5\ ^{o}C$$

Online weather data was available back to 1976, and temperatures, snowfall and WSI values were summarized monthly for the period starting November 1 to April 30 for each year. It is important to note that, the WSI represents the integration of weather data starting in November of one calendar year, to the end of April the following calendar year. For example, the year 1977 would represent the winter of 1976-1977, but in the figures and tables it would be represented as 1977. Lower values of the WSI represent milder winters, with lower snow precipitation and/or milder temperatures.

RESULTS

Data showing the total number of mule deer counted each spring, for all transects, are summarized in Table 1. Table 2 provides a further breakdown of the data by year, sex class and transect numbers. Winter Severity Index (WSI) values were calculated from weather data for the years that deer counts are available, and summarized in Table 3.

Both WSI and fawn-to-doe ratios are plotted in Figure 2. The fawn-to-doe ratio is regressed against WSI in Figure 3. The plot shows a significant relationship with a negative slope of the fitted line, indicating higher fawn numbers in milder winters. Approximately 59 percent of the variation in fawn-to-doe ratios is explained by variations in the WSI. Categories are shown on the graph with dotted lines to indicate values of good fawn survival and mild, moderate and severe winter, based on the WSI. Using categories shown in Figure 3, during mild winters, characterized by WSI values of less than 350, the average ratio of fawns per 100 does is 43. During moderate winters, WSI between 350 and 700, the average ratio is 18, and in severe winters, above 700, the average ratio is 14.

Comparisons of plotted values of fawn-to-doe ratios over time, for each of the transects, indicate that trends are fairly similar for transects 1 through 4 (Figure 5). This is indicative of the fact that all of these transects are located along the Peace River, therefore have very similar habitats and weather conditions. Transect 5, which is located away from the river valley, in different habitats, shows some different trends from the others. Transects 6 and 7 don't yet have sufficient long-term data to identify trends.

DISCUSSION

The data from this study support the widely accepted notion among wildlife managers, that early spring survival of mule deer fawns is higher following mild winters. The relationship between fawn-to-doe ratio and WSI supports this hypothesis, with higher fawn ratios in years of less severe winters. There are a few data points that deviate from the fitted line more than others, so we attempted to explain these differences based on available weather data. Figure 6 is a plot of fawn-to-doe ratios against WSI, showing the fitted line and the 95 percent confidence intervals around the line. Most of the observations fall within or close to these confidence limits, four of the observations are well-outside these limits. These points correspond to data from the years 1994, 1996, 1999 and 2007.

There are certainly many other factors that influence the fawn-to-doe ratios, but weather does appear to play a significant role. In 1994 the fawn-to-doe ratio was higher that expected for the corresponding WSI. For the other three years the ratios were lower than expected. We would therefore expect winter conditions to be milder during 1994 and harsher for 1996, 1999 and 2007. More detailed examination of the available weather data show that 1994 had the least amount of snowfall during March and April, compared to all other years. It also had the third-warmest temperatures for March and April. It also had the highest snowfall in January and one of the coldest Januarys compared to other years. Based on these observations, it appears that, despite cold temperatures and high snowfall in January, if conditions in early spring are favourable, it can result in higher fawn-to-doe ratios in the spring.

Conversely, the other three years, 1996, 1999 and 2007, ranked in the top 23 percent of all the years, based on total snowfall for the period November to April. Also, 1996 and 1999 were colder and snowier than normal in January, while 2007 was colder than normal in March and April. Additionally, 1999 had above average snowfall in March and April. These results suggest that the WSI can likely be refined by using different combinations of weather data rather then the combination outlined in the Methods. This will require more detailed analysis beyond the scope of this report.

Long-term analysis of weather data suggests that winter weather conditions in the Peace Region are favourable for mule deer survival. We calculated WSI values from available weather data (1976 – 2008) and found that, the probability of mild winters (based on WSI categories shown in Figure 3) is much higher than moderate or severe. Figure 7 shows the predicted occurrences of mild, moderate and severe winters over a 100-year period, are 60, 37 and 3, respectively.

The statistically significant relationship between WSI and fawn-to-doe ratios allows us to back-extrapolate and predict these ratios for years with no observations, other than weather data. Figure 8 shows a plot of observed fawn-to-doe ratios and those predicted using the regression line between WSI and fawn-to-doe ratios. The figure shows that, for the period for which we have available weather data, the occurrence of high fawn-to-doe ratios (>=30, n=43, as categorized in Figure 3), is about twice as many as lower ratios (<30, n=23). This suggests that, high survival of mule deer fawns in this area of the Peace Region occurs twice as many times as lower survival.

It will be interesting to continue monitoring this pattern of survival in light of the current anticipated changes to temperatures at a global scale. In an attempt to detect long-term changes in the severity of winter seasons, we plotted the frequency of occurrence of WSI categories, by decade (Figure 9). No apparent trend is visible in this graph, but it will serve as a basis for further monitoring and comparison.

CONCLUSIONS

- Survival of deer fawns is higher after mild winters.
- Weather conditions in March and April likely more important than winter conditions in determining survival.
- Winter Survival Index (WSI) is a good integrator of snow and temperature conditions.
- WSI is a statistically reliable predictor of fawn survival.
- Ratios equal to, or greater than 30 fawns per 100 does are indicative of mild winters.
- Based on available weather data, over a 100-year period, 60 years are likely to be mild, 37 moderate and 3 severe.
- Using WSI as a predictor of fawn survival, over a 100-year period, 65 years are likely to have fawn per 100 does ratios >= 30.
- WSI data by decade does not suggest any obvious trends, so far.
- Similar pattern of survival is observed among the survey transects.
- This project provides very valuable long-term survival data, it will also provide evidence of effects from potential climate change.

RECCOMENDATIONS

- Continue project indefinitely. The cost is extremely low, relative to the benefits.
- Besides using these data for management of mule deer, some ideas for future analysis could include:
  - Trends in other age and sex classes.
  - Relationship between fawn survival and hunting success in subsequent years.
  - Effects of climate change.

ACKNOWLEDGEMENTS

Thanks to Ian Hatter, Ministry of Environment, Victoria, B.C. for putting together the Peace Mule Deer Harvest Management Strategy, which includes some of the weather and survival analysis. Also thanks to Conrad Thiessen, Rod Backmeyer and others who have participated in the surveys over the years, Jessica Baccante for entry and analysis of weather data and Heather Hopkins for maintaining our wildlife library.

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Table 1. Summary of observed mule deer counted and classified during the spring of each year. No counts were done in 1995.

Year	Number of Transects	Total Transect Length (km)	Total Males	Total Females	Total Fawns	Total Unclassified	Total Number of Deer	Total Fawns per 100 females	Total Bucks per 100 females
1991	5	74.1	59	201	86	30	376	43	29
1992	5	74.1	79	240	99	6	424	41	33
1993	5	74.1	74	355	192	9	630	54	21
1994	5	74.1	45	202	71	0	318	35	22
1995	no surveys done								
1996	5	74.1	49	339	25	3	416	7	14
1997	5	74.1	48	265	37	0	350	14	18
1998	5	74.1	45	240	82	0	367	34	19
1999	5	74.1	18	235	31	0	281	13	8
2000	5	74.1	27	218	86	0	331	39	12
2001	5	74.1	27	231	124	0	382	54	12
2002	5	74.1	73	320	66	2	461	21	23
2003	5	74.1	78	262	78	2	420	30	30
2004	6	105.3	87	248	104	0	439	42	35
2005	7	205.3	125	395	170	0	690	43	32
2006	7	205.3	141	359	181	12	693	50	39
2007	7	205.3	89	277	15	11	392	5	32
2008	7	205.3	105	285	87	13	490	31	37

Table 2: Summary of observed mule deer by year, transect number and sex classification.

		Transect Number							
Year	**Sex Class**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Totals**
1991	Male	10	7	21		21			**59**
	Female	34	41	47		79			**201**
	Fawns	12	19	18		37			**86**
	Unclassified	13	4	4		9			**30**
1992	Male	14	18	15		32			**79**
	Female	37	68	51		84			**240**
	Fawns	20	26	25		28			**99**
	Unclassified	0	0	4		2			**6**
1993	Male	8	11	26	14	15			**74**
	Female	53	61	86	83	72			**355**
	Fawns	22	36	47	50	37			**192**
	Unclassified	0	0	2	0	7			**9**
1994	Male	6	3	19	12	5			**45**
	Female	47	37	53	17	48			**202**
	Fawns	10	8	21	9	23			**71**
	Unclassified	0	0	0	0	0			**0**
1996	Male	3	25	5	5	11			**49**
	Female	38	77	62	30	132			**339**
	Fawns	4	6	1	2	12			**25**
	Unclassified	0	2	1	0	0			**3**
1997	Male	4	14	11	5	14			**48**
	Female	42	73	60	49	41			**265**
	Fawns	11	16	2	6	2			**37**
	Unclassified	0	0	0	0	0			**0**
1998	Male	7	7	7	7	17			**45**
	Female	45	52	66	47	30			**240**
	Fawns	22	20	24	13	3			**82**
	Unclassified	0	0	0	0	0			**0**
1999	Male	6	1	3	1	7			**18**
	Female	43	38	73	37	44			**235**
	Fawns	6	3	10	2	10			**31**
	Unclassified	0	0	0	0	0			**0**
2000	Male	3	6	6	1	11			**27**
	Female	53	45	60	14	46			**218**
	Fawns	26	17	27	8	8			**86**
	Unclassified	0	0	0	0	0			**0**
2001	Male	4	3	8	3	9			**27**
	Female	35	72	61	25	38			**231**
	Fawns	20	39	32	13	20			**124**
	Unclassified	0	0	0	0	0			**0**
2002	Male	18	8	8	11	28			**73**
	Female	33	52	63	73	99			**320**
	Fawns	13	8	18	9	18			**66**
	Unclassified	0	0	0	1	1			**2**
2003	Male	14	11	18	5	30			**78**
	Female	47	50	72	41	52			**262**
	Fawns	12	6	26	14	20			**78**
	Unclassified	0	0	0	0	2			**2**
2004	Male	13	8	25	5	24	12		**87**
	Female	32	35	80	20	54	27		**248**
	Fawns	9	16	33	10	27	9		**104**
	Unclassified	0	0	0	0	0	0		**0**
2005	Male	15	14	26	13	19	19	19	**125**
	Female	34	57	68	59	57	66	54	**395**
	Fawns	17	30	17	28	19	30	29	**170**
	Unclassified	0	0	0	0	0	0	0	**0**
2006	Male	3	5	28	28	41	15	21	**141**
	Female	34	30	73	46	42	55	79	**359**
	Fawns	23	15	42	20	23	18	40	**181**
	Unclassified	0	1	0	0	0	0	11	**12**
2007	Male	12	6	12	12	25	14	8	**89**
	Female	51	24	60	47	23	59	13	**277**
	Fawns	3	2	4	1	2	3	0	**15**
	Unclassified	2	2	2	0	5	0	0	**11**
2008	Male	9	12	17	19	33	8	7	**105**
	Female	37	30	53	49	39	56	21	**285**
	Fawns	15	13	11	17	10	14	7	**87**
	Unclassified	5	0	1	3	4	0	0	**13**
Male Totals		**149**	**159**	**255**	**141**	**342**	**68**	**55**	**1169**
Female Totals		**695**	**842**	**1088**	**637**	**980**	**263**	**167**	**4672**
Fawn Totals		**245**	**280**	**358**	**202**	**299**	**74**	**76**	**1534**
Unclassified Totals		**20**	**9**	**14**	**4**	**30**	**0**	**11**	**88**

Table 3. Winter Severity Index (WSI) values for the years that we have deer counts data.

Year	WSI
1991	330
1992	350
1993	186
1994	534
1995	258
1996	486
1997	717
1998	204
1999	400
2000	206
2001	129
2002	408
2003	394
2004	349
2005	303
2006	207
2007	544
2008	302

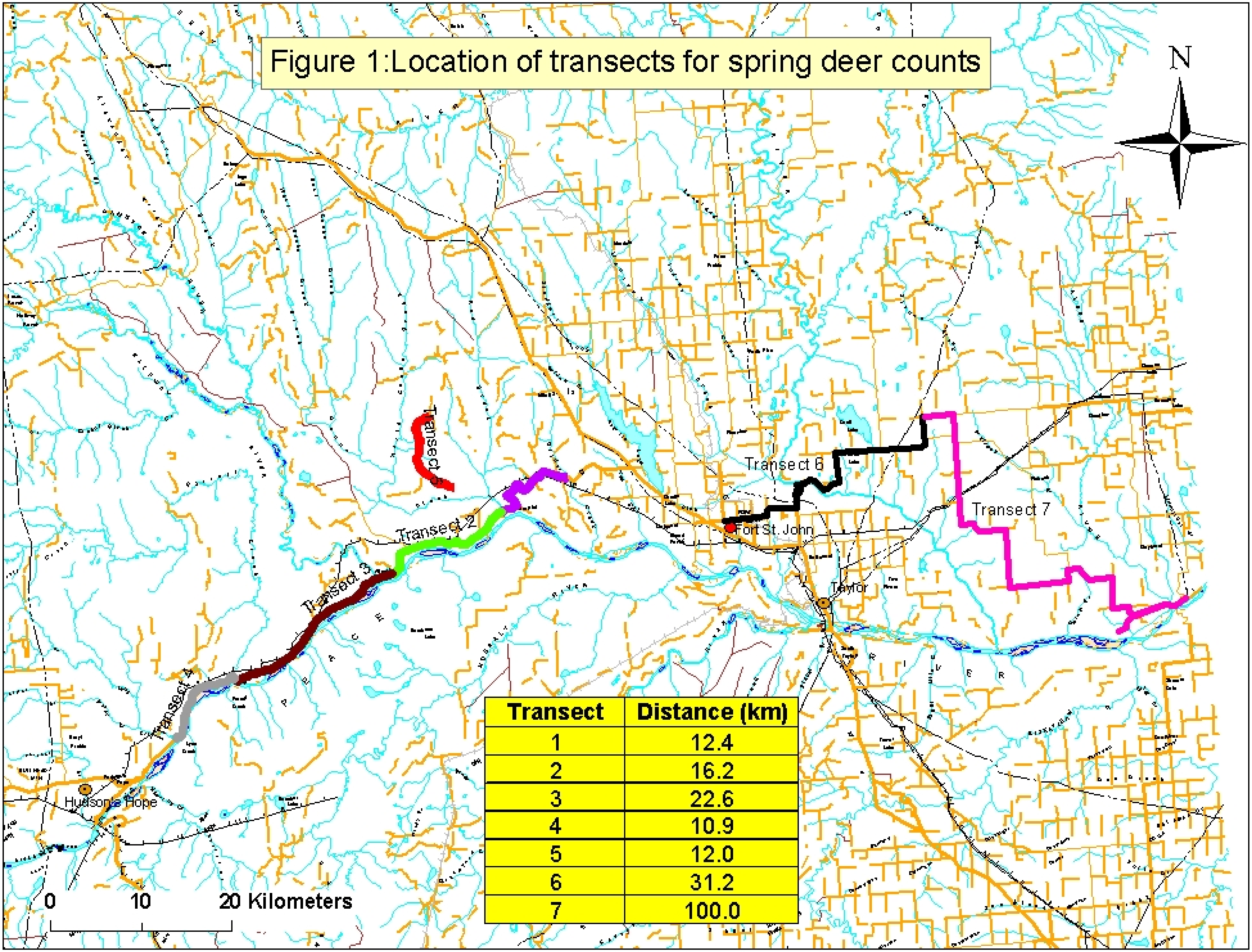

Figure 1:Location of transects for spring deer counts

Transect	Distance (km)
1	12.4
2	16.2
3	22.6
4	10.9
5	12.0
6	31.2
7	100.0

Figure 2: Winter Severity Index (WSI) and Fawn:Doe ratios for the survey period 1991 to 2008.

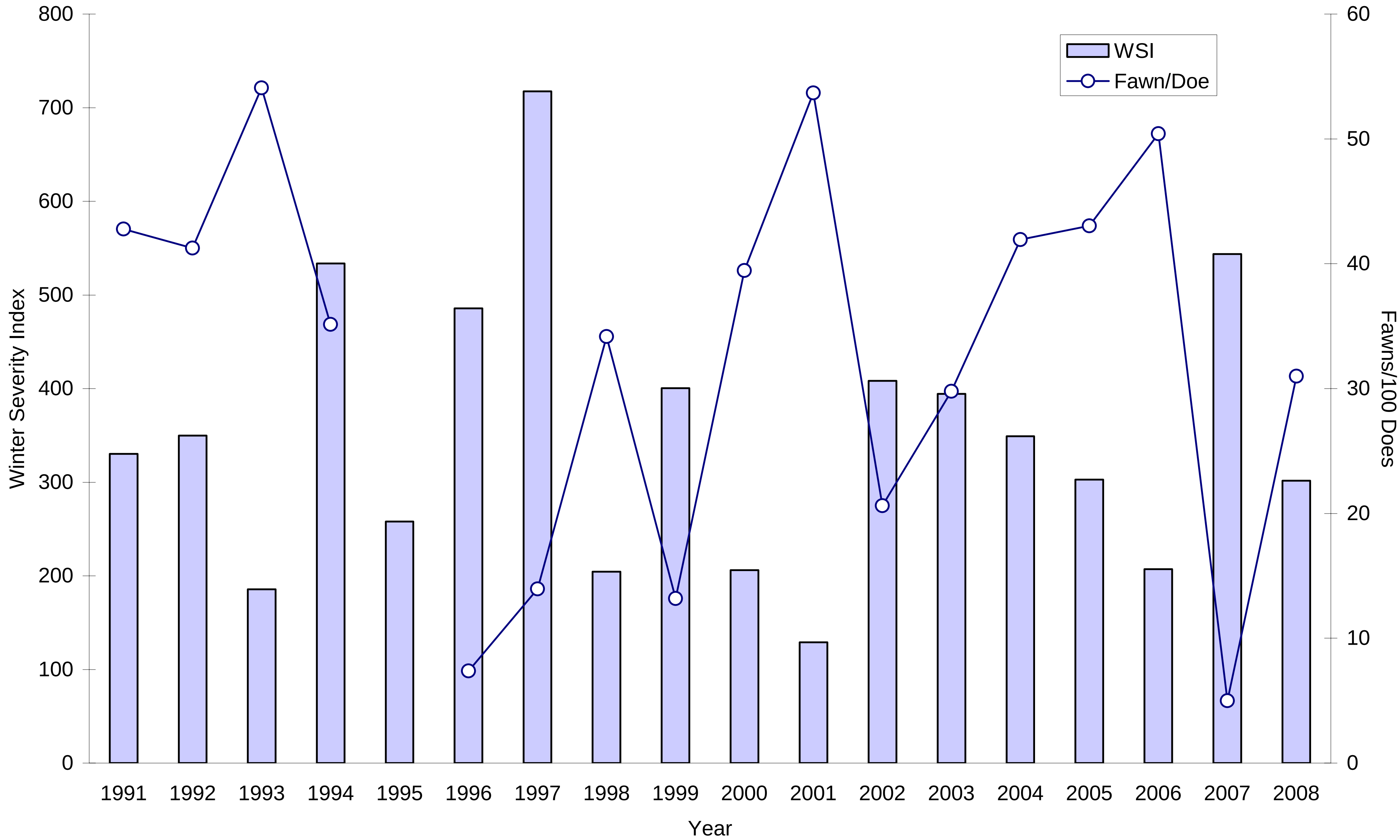

Figure 3. Plot of Fawn:Doe ratio against WSI. Fitted line and regression equation are also shown. Categories for each variable are shown with dotted lines.

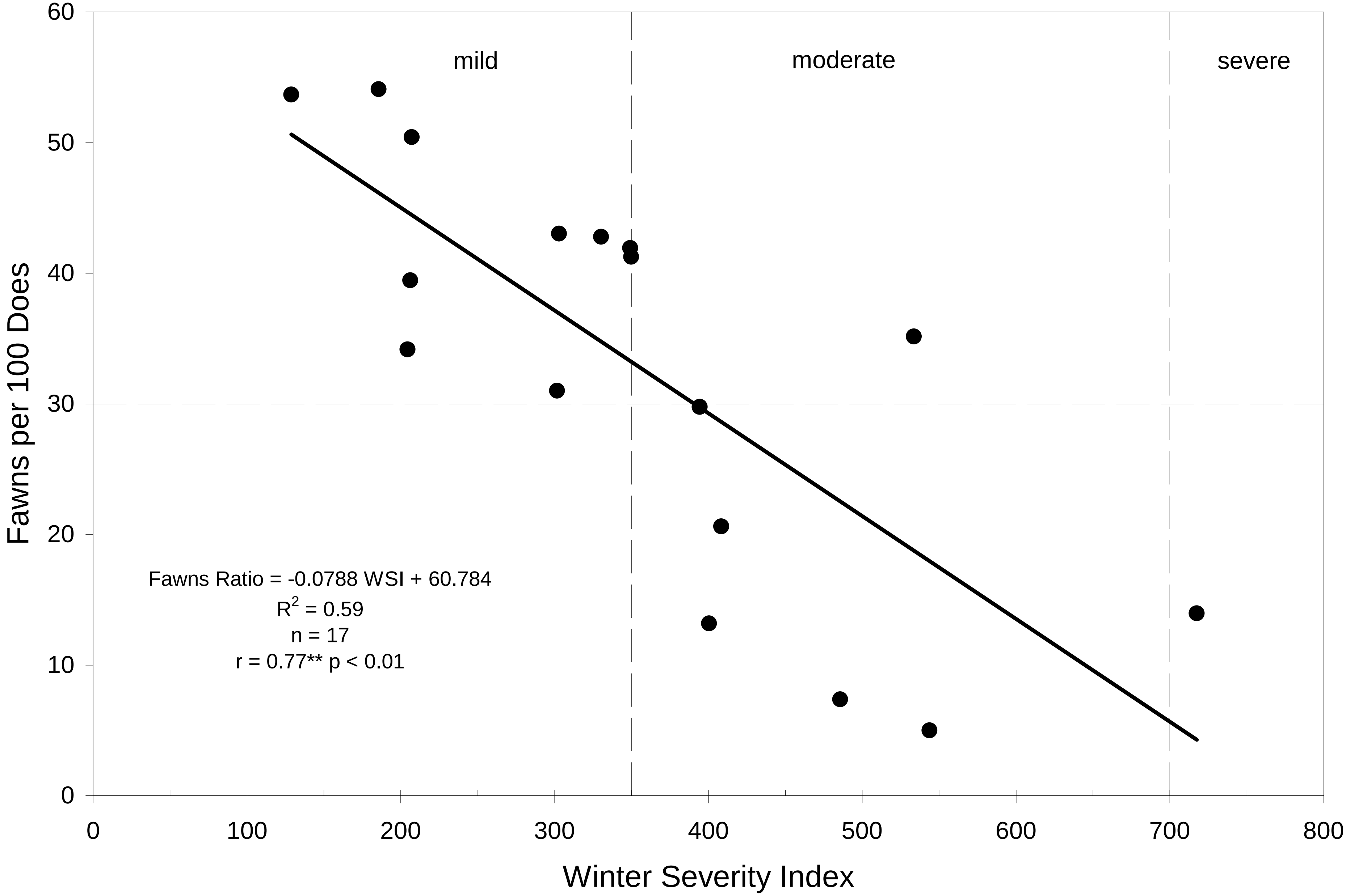

Figure 4. Plots of observed fawn-to-doe ratios, by year, for each of the transects.

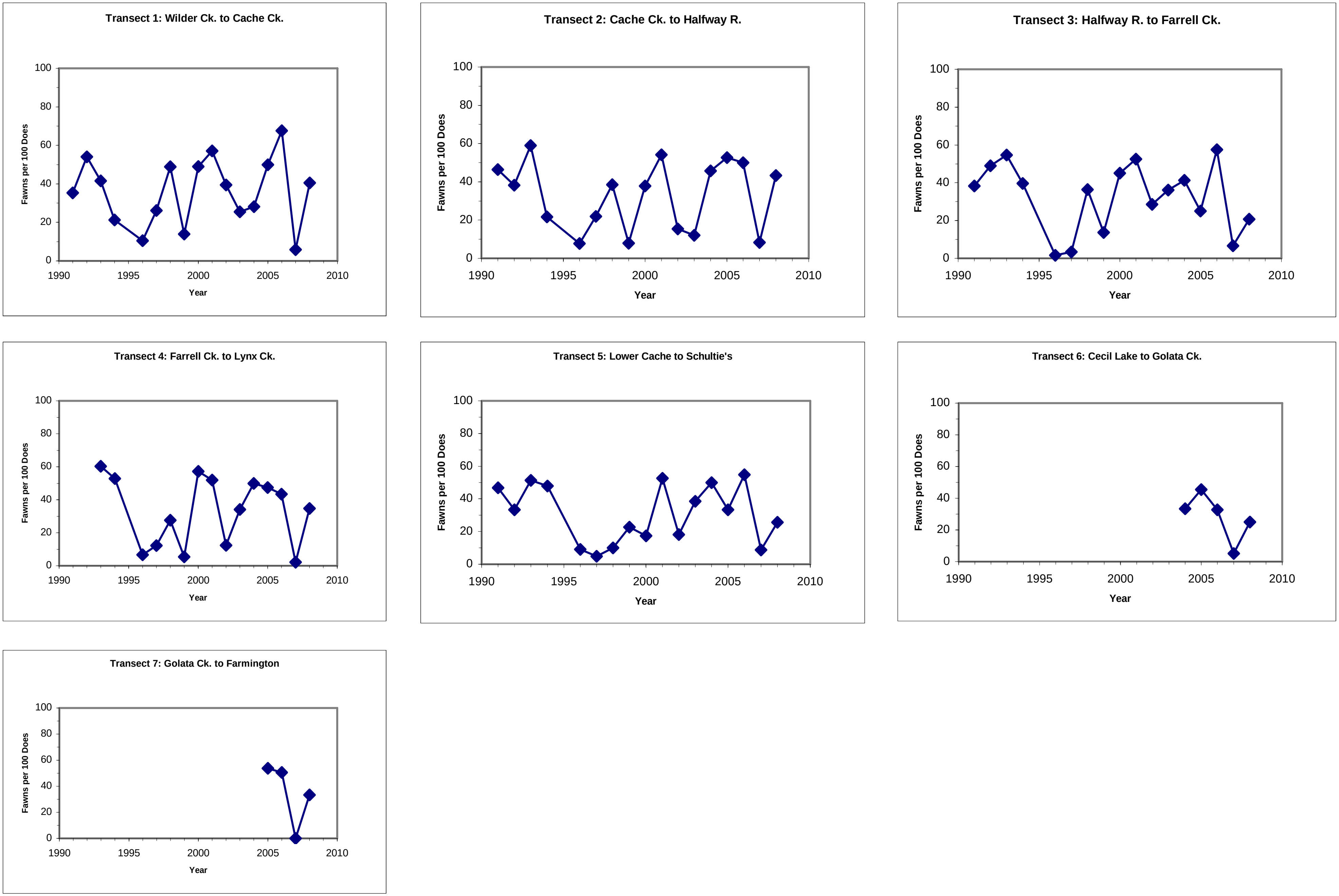

Figure 5. Plot of mean fawn-to-doe ratios for each transect, by year. The dotted line joins average values for each year.

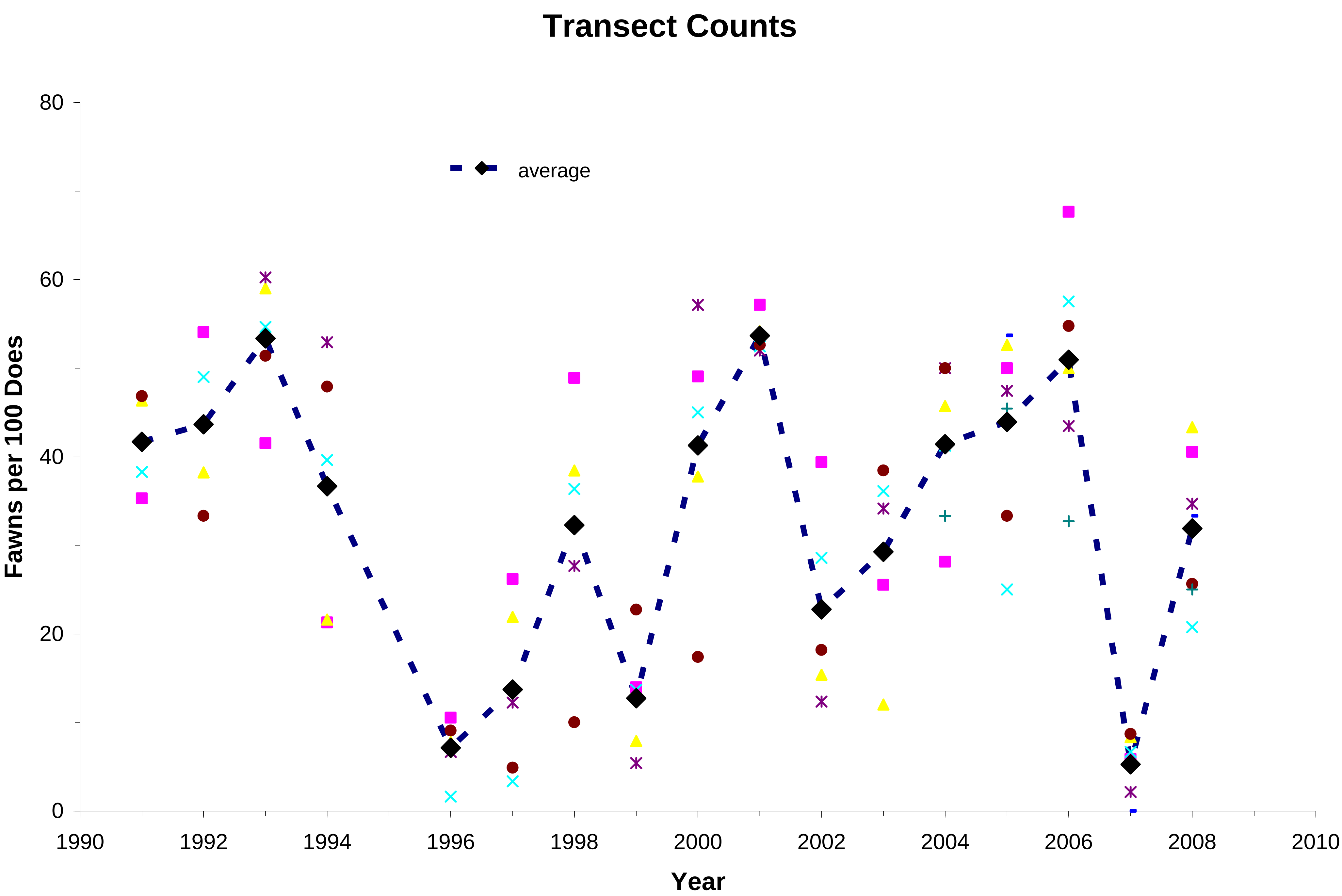

Figure 6. Plot of fitted line by regression to fawn-to-doe ratios against WSI. Vertical bars represent 95% confidence limits and selected years are indicated by labels besides the data points.

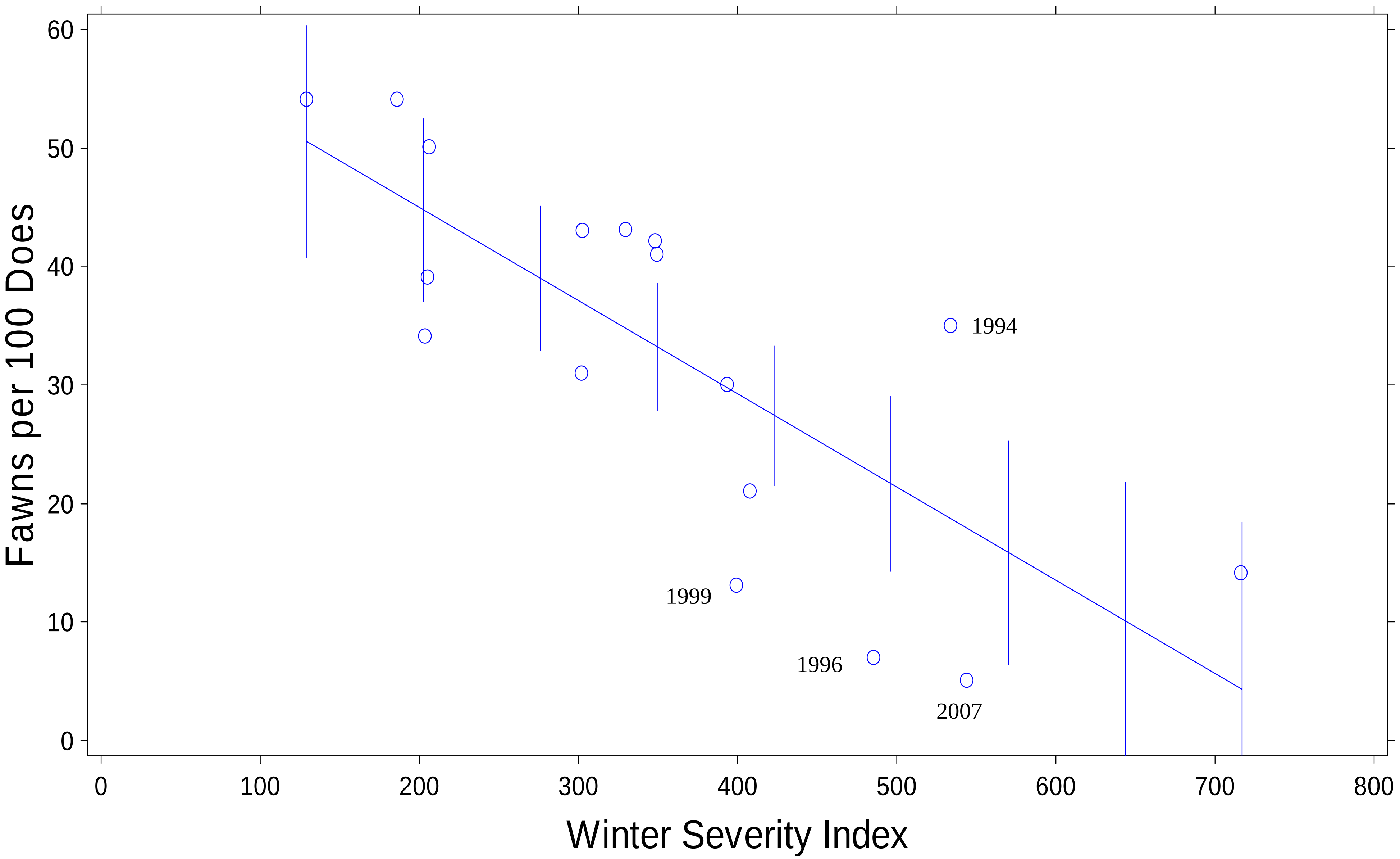

Figure 7. Predicted occurrence of WSI categories in the study area based on weather data from 1976 to 2008.

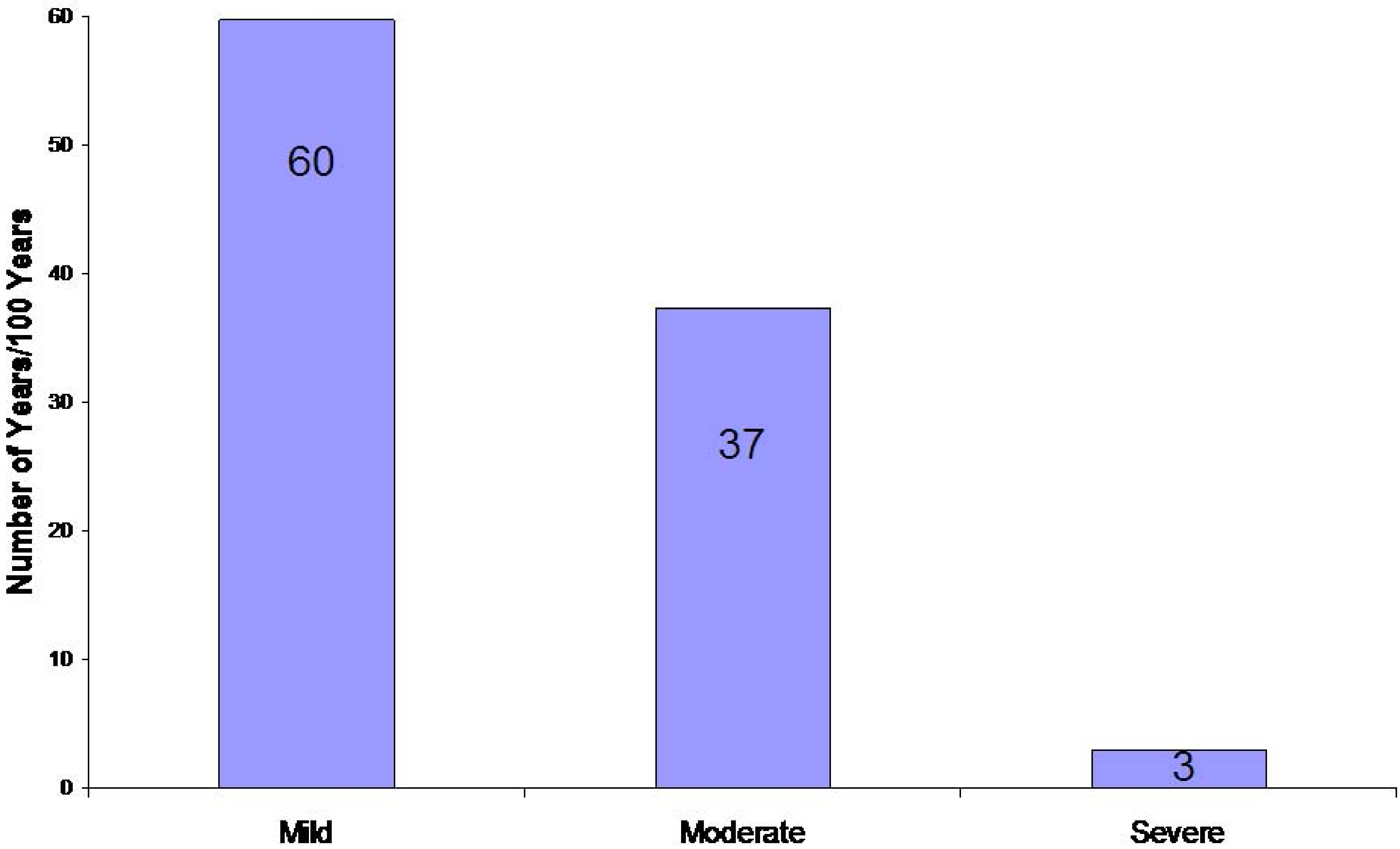

Figure 8. Predicted (triangles) fawn-to-doe ratios based on a regression against WSI. Observed values are represented by circles.