In-depth analysis of deer management in NS: Critique of current policy and suggestions for future management approaches Final Report to the Nova Scotia Habitat Conservation Fund 2013-2014

Executive Summary

In Nova Scotia, white-tailed deer (*Odocoileus virginianus*) data are collected from hunters, as well as through various programs within the Department of Natural Resources. There are, however, many improved survey methodologies and new statistical analysis approaches that can help assess management strategies. This multi-year project is helping to guide future management and policy decisions for deer in Nova Scotia through looking at efficient survey methodologies and statistical analysis approaches. The objectives of this ongoing project have included: critiquing current NS DNR deer management policy and suggesting improvements where necessary; evaluating current deer data collection and identifying information gaps, in particular assessing the effectiveness of Pellet Group Inventories (PGI's) for deer density and population estimates; investigating the development and application of population indices and population surveys; and investigating the development and application of population models. A detailed review of deer management policy and statistical methodology has been completed with an associated progress report already submitted for 2012-13 Habitat Conservation Funding.

In this 2013-14 report, we report a summary of our work involving application of stochastic population dynamics (SPD) models to PGI data to obtain reliable deer population density estimates. Although DNR has been constructing confidence intervals for zone-specific deer densities, the methodology employed here is far more superior because (i) the prediction intervals are based on a rigorous statistical methodology using a biologically plausible population growth model, (ii) the intervals are narrower even though the fitted model is quite complex, and (iii) model allows accurate prediction of deer abundance during the moose survey years (*missing* years).

With current year funding, we are now working on using deer age-at-harvest data in conjunction with PGI data to produce age-structured abundance estimates. Furthermore, we are formulating a survey sampling plan for collecting a representative sample of age-at-harvest data (jawbones data). The main focus of this research is to provide DNR with a statistical analysis framework that provides a reliable and detailed profile of deer population based on existing data sources. We are achieving this by employing state-of-the-art statistical methodology to synthesizing various datasets, e.g. PGIs, annual harvest counts and age-at-harvest data. This will assist NS DNR in making objective, data-driven deer harvest decisions and will promote an informed population monitoring program. We are also developing a user-friendly computer software programs to implement the proposed methodology. This will provide NS DNR with a platform to analyze deer related in subsequent years.

Background and Objectives

Viability of wildlife populations is one of the fundamental objectives of wildlife management agencies. This is even more crucial for exploited populations, i.e. species that are subjected to regulated and/or unregulated harvesting. In Nova Scotia, Department of Natural Resources (DNR) is responsible for regulating white-tailed deer harvest across the whole province. Apart from a keystone species of the local fauna, white-tailed deer provide a valuable aesthetic and recreational resource for human residents. Harvesting also provides a management tool to maintain the deer herd size at levels tolerable for farmers and other factions of the society. However, if unchecked, overhunting can endanger the viability of the deer population. As both overabundant and low deer abundance levels can have disparate impact on various stakeholders, DNR has the responsibility to maintain a healthy and viable herd size. This requires DNR managers to employ state-of-the art management practices and statistical tools to collect and analyze data on key demographic variables of the deer herd.

Currently, DNR uses pellet group inventory (PGI) data as the primary information source to assess white-tailed deer abundance trends in Nova Scotia. Pellet group inventory surveys have been consistently conducted since 1983 on randomly located transect strips throughout the province. Given the amount of resources currently invested in conducting these surveys, key objectives of the ongoing research project are to (i) evaluate sufficiency of PGI data in estimating abundance trends, and (ii) develop new PGI based statistical models to reliably estimate deer herd size while simultaneously integrating other auxiliary data sources into the analysis. In this summary we present PGI data analysis based on a new stochastic population dynamics (SPD) modeling approach.

Methods and Materials

Pellet Group Inventories Program

A PGI survey generates a particular type of transect sampling data by traversing a line transect and counting number of pellet groups present on the transect strip. For the white-tailed deer herd in Nova Scotia, DNR staff throughout the province survey some 460 randomly selected transects, each 2 m wide and 1 km long, in spring, after the snow melts and prior to green-up. There are three key assumptions associated with resulting PGI counts: (i) pellet groups present on a given transect at the time of the survey were deposited sometime during the snow cover period (known as the number of inventory days), (ii) no pellet groups decayed during the inventory days, and (iii) observers detect all the pellet groups located on the strip at the time of the survey. The last assumption implies that PGI data are distance sampling data with probability of pellet detection given as 1.

It should be noted that in order to more closely monitor Nova Scotia's Moose (*Alces alces americana*) population, a decision was made in year 2000 to transfer staff effort every third year, from the deer PGI program to conducting a moose PGI in selected focal areas of mainland Nova Scotia. In the remaining areas of the province, deer PGI counts are maintained to provide some trend information in these years. We emphasize that the new modeling approach developed herein reliably predicts deer abundance the *missing* moose years.

Furthermore, the winter inventory days approximately start at the end of the deer hunting season, e.g. the current year's hunting season ends on December 13. This implies that the PGI based abundance estimates roughly correspond to the postharvest deer herd living through the oncoming snow cover/winter period.

Abundance Estimation using PGI Data

Estimation of an SPD model requires that a time series of true abundance values, N_t, are observed without any measurement error. This however happens extremely rarely as we mostly employ some sort of sampling method to estimate actual abundance. These sampling methods normally involve direct surveying of the animals. On the other hand, PGI surveys observe objects whose number is only proportional to the actual abundances. In order to relate the PGI observation process to stochastic growth, we need a more advanced methodology known as hierarchical modeling. Below is a simple outline of a novel modeling framework that we have developed in the ongoing research work.

There are a number of advantages of this new modeling approach, listed as follows: (i) It allows for estimation of the SPD component without the knowledge of the true abundance values. This, in general, is a difficult problem in statistical inference. Here we have shown for the first time that SPD models can be estimated from PGI data alone. (ii) The model allows for prediction of future density levels under various hypothetical harvest scenarios on the future viability of the population. Future prediction is valuable from management perspective as it allows for studying viability of deer herd. (iii) We can predict the deer density levels during the moose years as well. That is, the model works even when PGI surveys are skipped at regular time intervals. This allows for allocating transects and human resource to monitoring other species in the skipped years.

Results

We fitted our hierarchical model outlined above to about three decades of PGI data ranging from 1983-2014. Here we present the corresponding zonal deer density estimates obtained from the SPD model. Figures reported in the Appendix depict estimates of zonal densities and those of total abundance in Zones 1-10 during the years 1983-2014 (see Appendix Map). We are currently working on a different approach to analyze data for Zones 11-12 owing to much lower PGI counts observed therein. Therefore, this analysis summary only includes results for Zones 1-10.

Except for Zone 2, it is evident that white-tailed deer abundance in Nova Scotia saw a remarkable surge during early to mid-eighties, pushing the population density to higher than natural carrying capacity. This growth spurt was followed by a subsequent gradual population decline that spanned almost over a decade (Appendix Figure: Total Abundance). Since about 1995, the population saw a sizable recovery until 1999. The population appeared to decline again afterwards. However, it is encouraging to note that deer densities are bouncing back in most of the province (Appendix: Zones 1-3, 6-9).

We also conducted a simulation study using our modeling approach to examine the adequacy of the PGI data in estimating deer abundance. Our results indicate that the number of transects currently being used in all zones, except for Zone 2, provide sufficiently accurate prediction intervals. It is clear that Zone 2 density intervals (see Appendix) are much wider than for the rest of the zones. We are therefore currently investigating optimal number of required transects in Zone 2.

Although DNR has been constructing confidence intervals for zone-specific deer densities, the methodology employed here is far more superior because (i) the prediction intervals are based on a rigorous statistical methodology using a biologically plausible population growth model, (ii) the intervals are narrower even though the fitted model is quite complex, and (iii) model allows accurate prediction of deer abundance during the moose survey years (*missing* years). Note that the DNR's earlier method was incapable of estimating abundance during these missing years.

One of the current focal point in our research is to understand the mechanisms that led to the population declines observed during the last three decades. Also, we are investigating abundance decline in the eastern part of the province (Zones 11-12). We believe that the ensuing insights will help maintain a sustainable deer herd in the province.

Next Steps

In the next part of this research project, we are developing a new modeling framework that relies on the routinely collected age-at-harvest data to estimate age-distribution of the harvested animal. This approach also allows integration of age-at-harvest data and the PGI based population abundance estimates for white-tailed deer, obtained via the SPD modeling framework described above. Notice that, unlike other reconstruction techniques, our proposed methodology does not require estimation/inclusion of survival probabilities. This has important implications for wildlife management as estimation of survival probability requires expensive radiotelemetry studies. Furthermore, we are working on an algorithm to estimate optimal sample size of age-at-harvest data in the context of our proposed model. This will reduce operational cost in monitoring the population, as aging the entire harvest (via jawbone collection) is prohibitively expensive.

Acknowledgement

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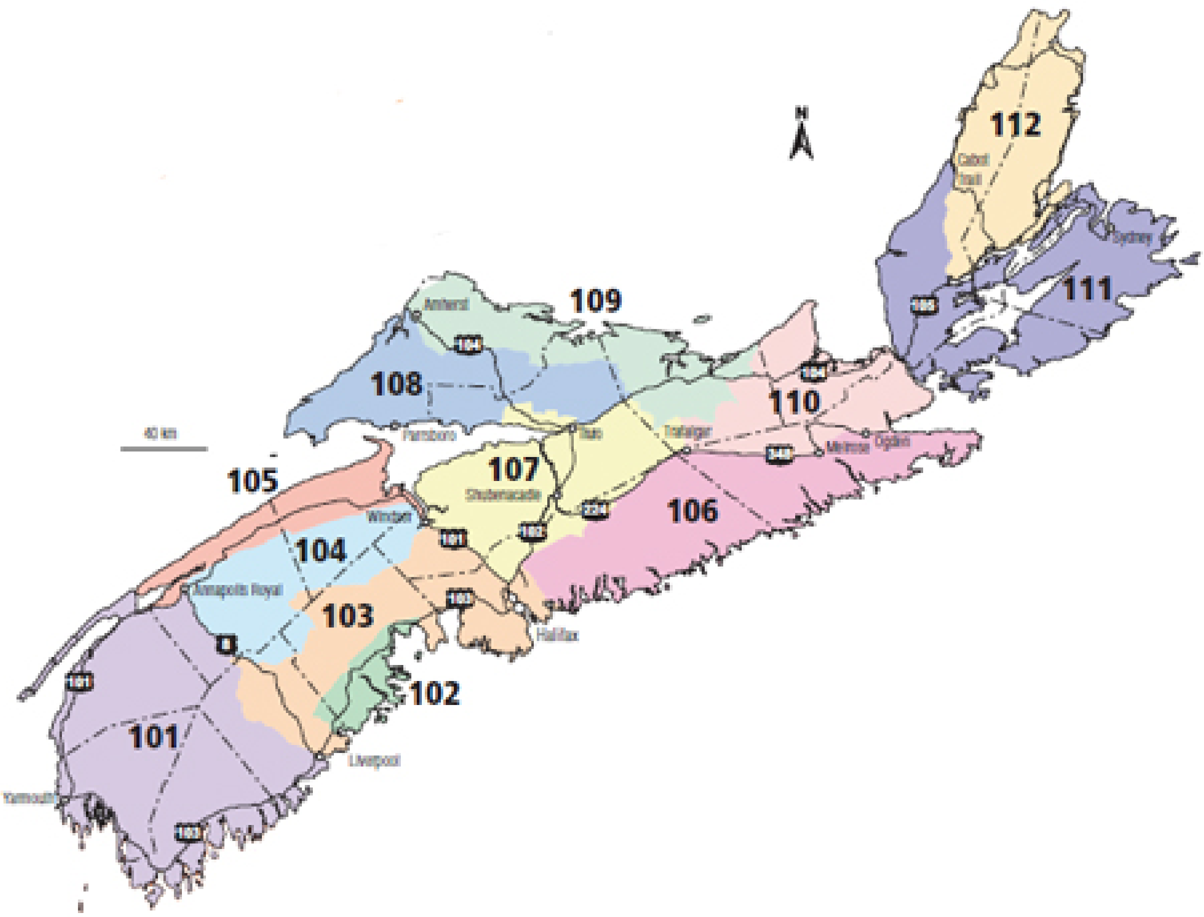
Appendix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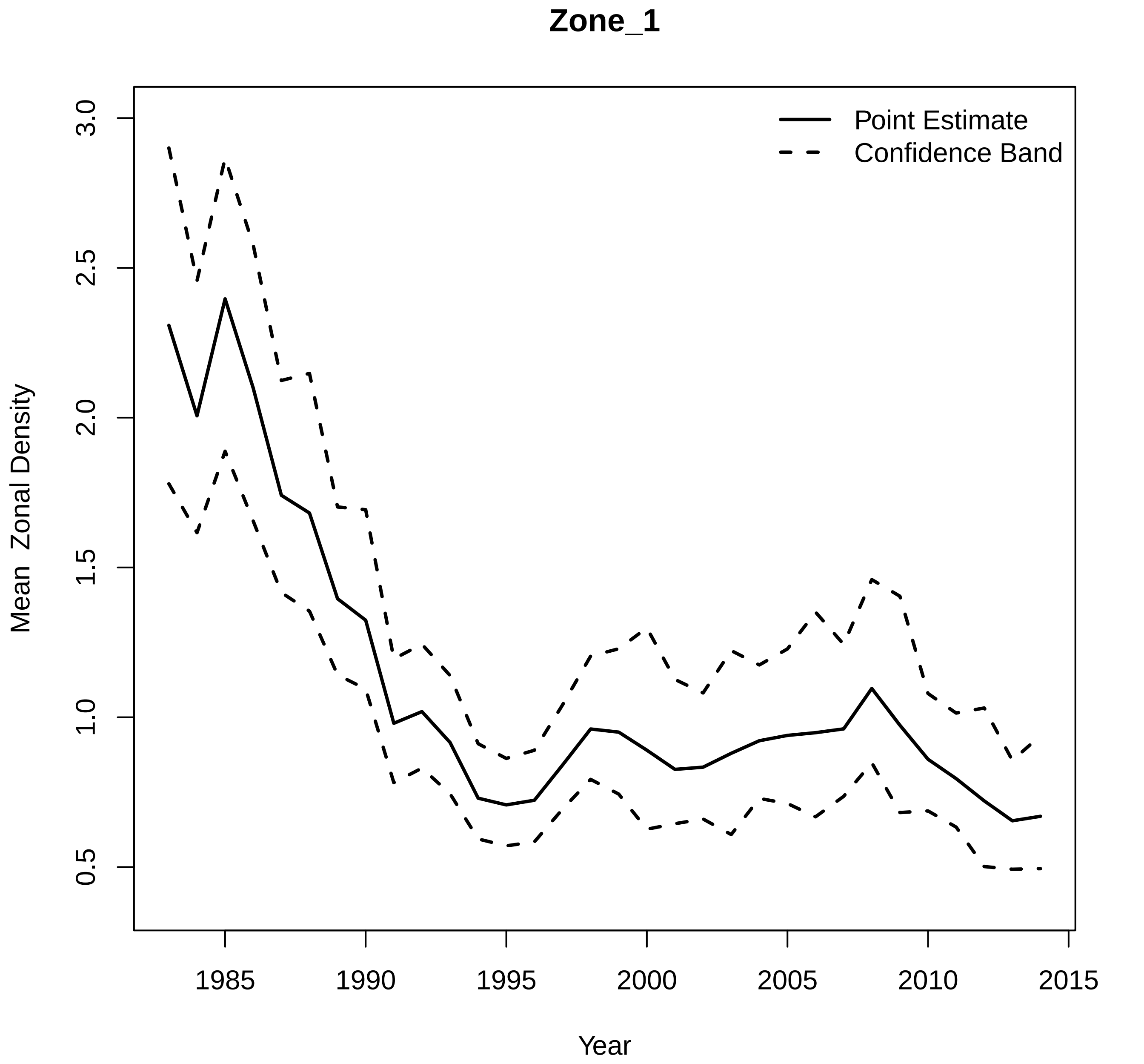
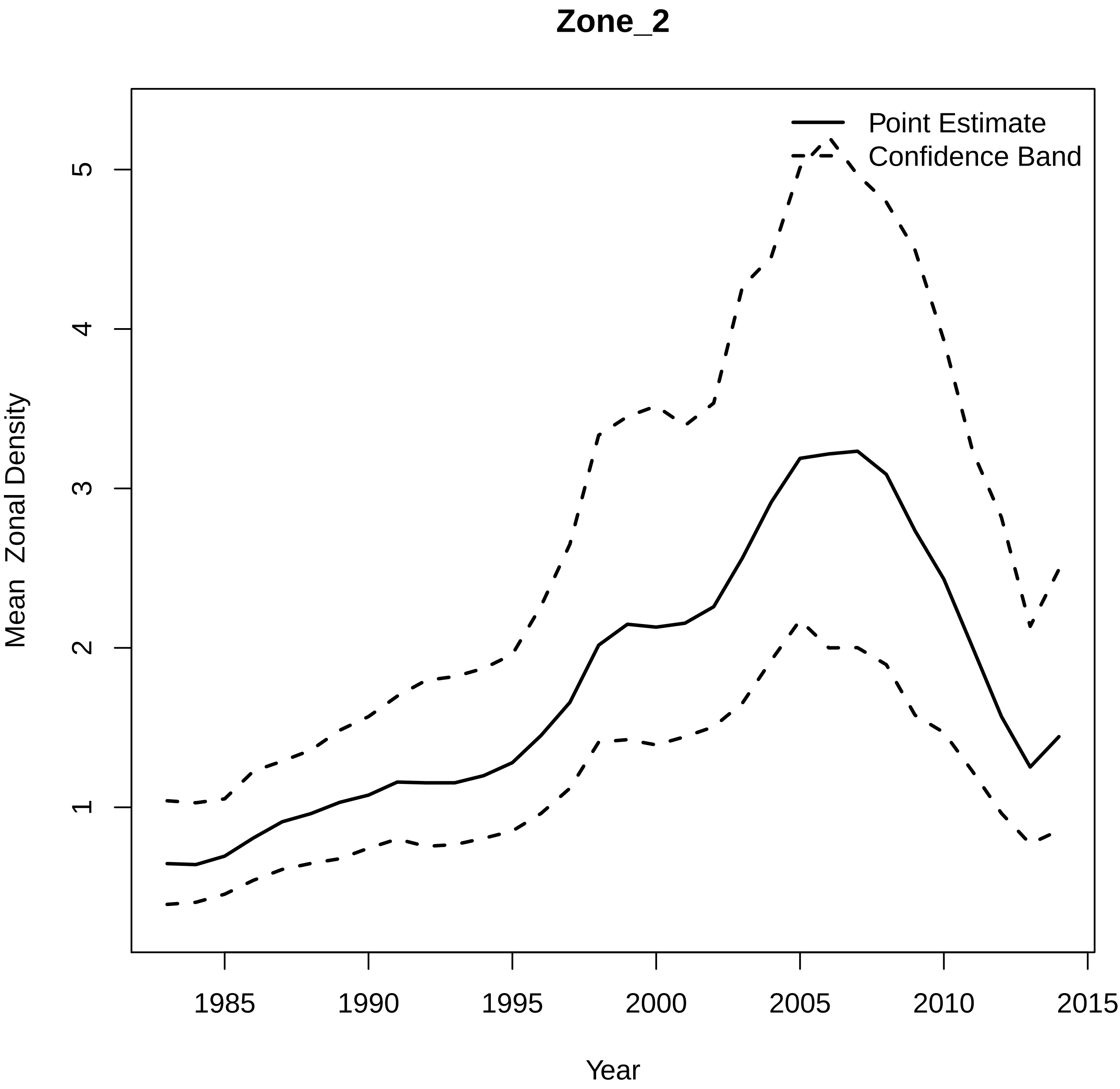
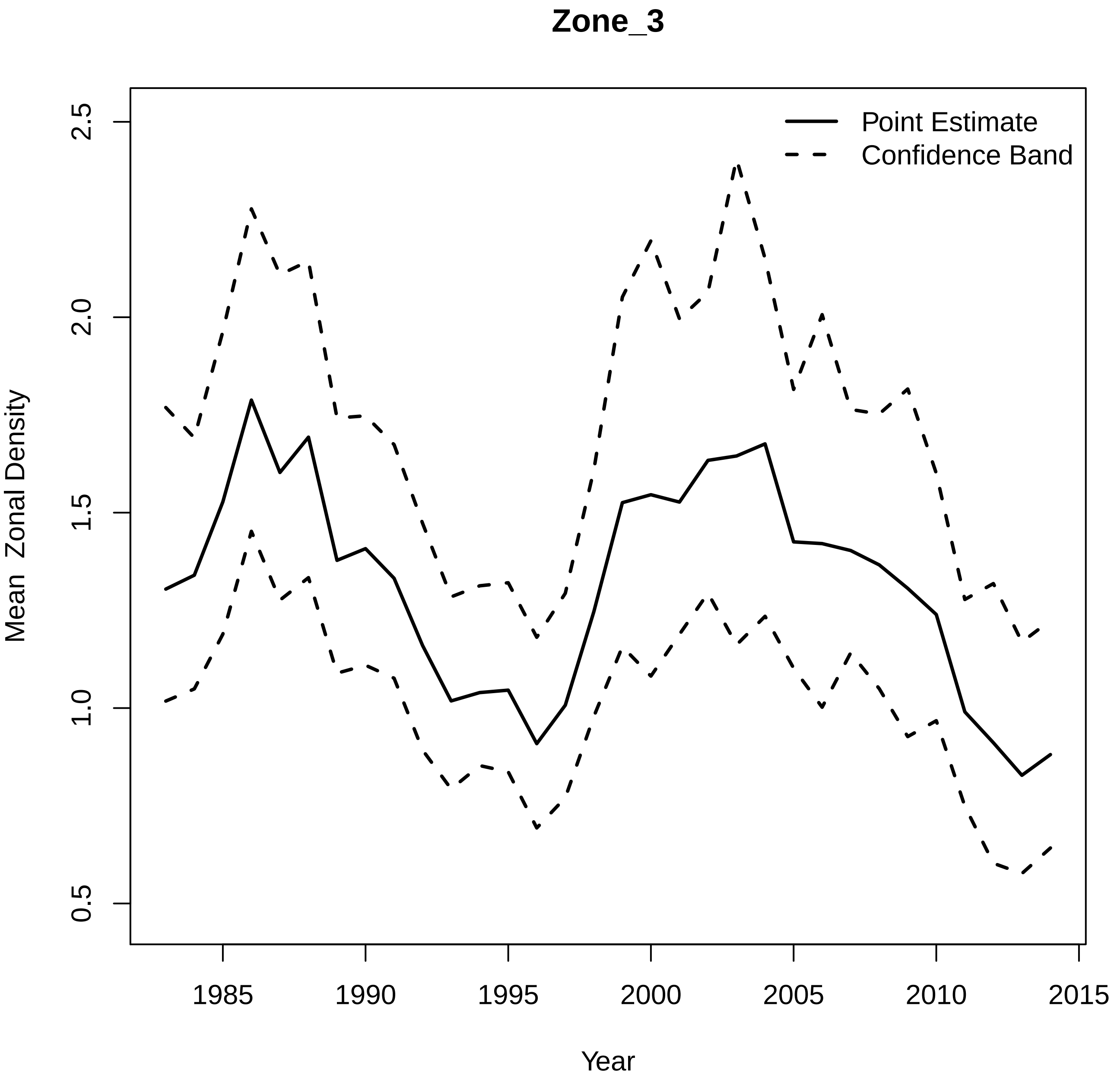
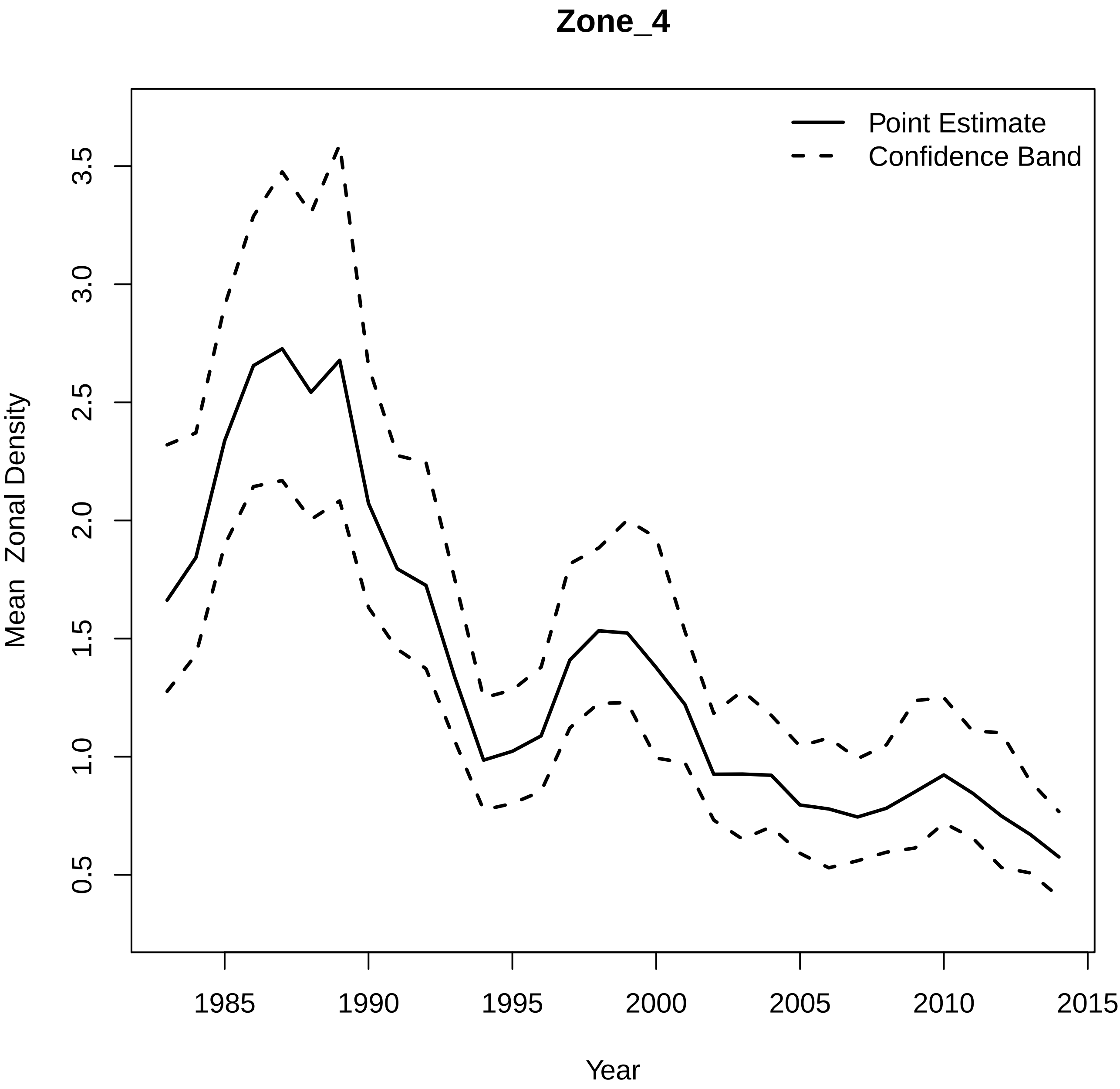

Zone_1
Point Estimate
Confidence Band
Mean Zonal Density
3.0
2.5
2.0
1.5
1.0
0.5
1985
1990
1995
2000
2005
2010
2015
Year

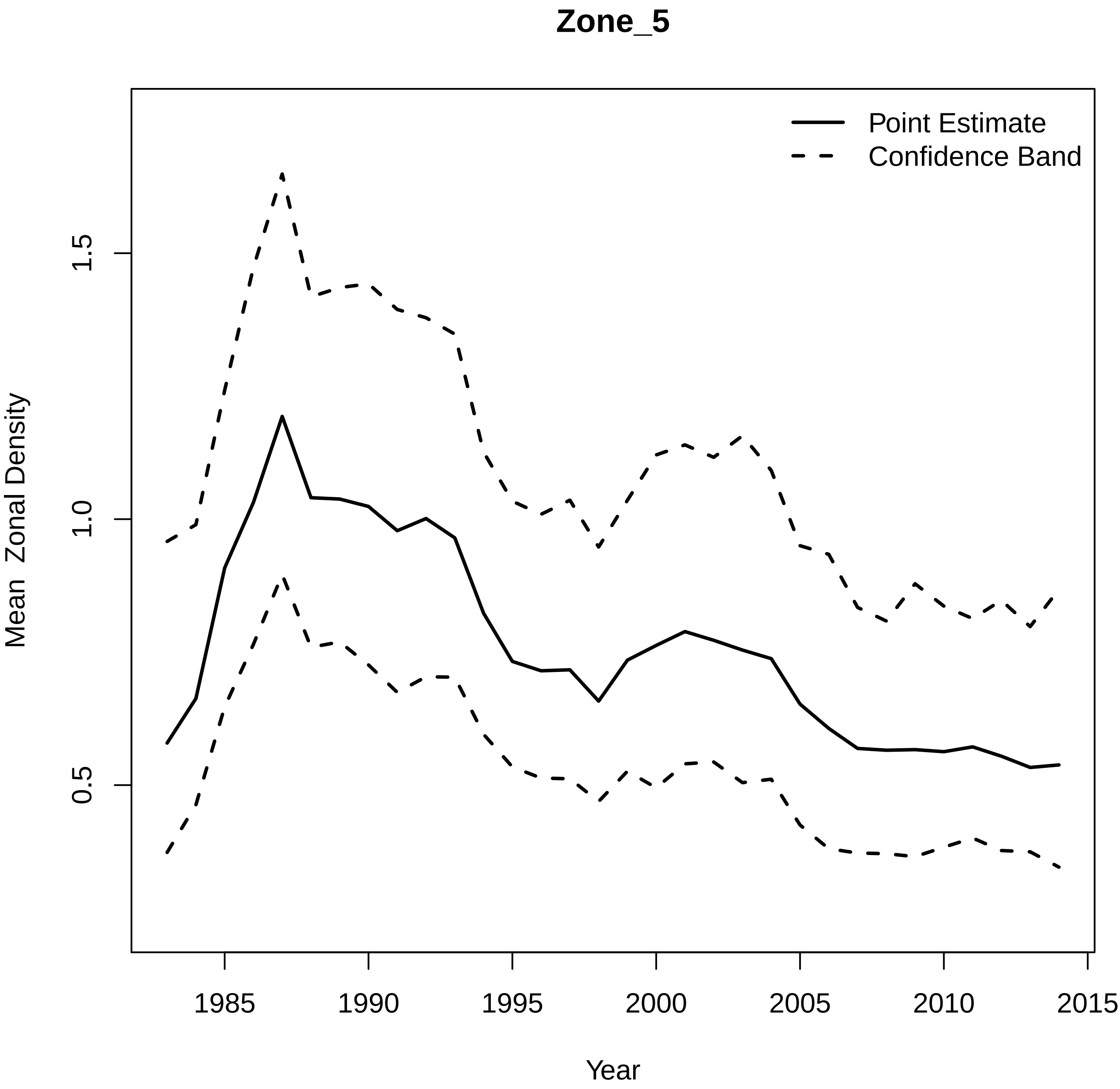

Zone_2
Point Estimate
Confidence Band
Mean Zonal Density
1
2
3
4
5
Year
1985
1990
1995
2000
2005
2010
2015



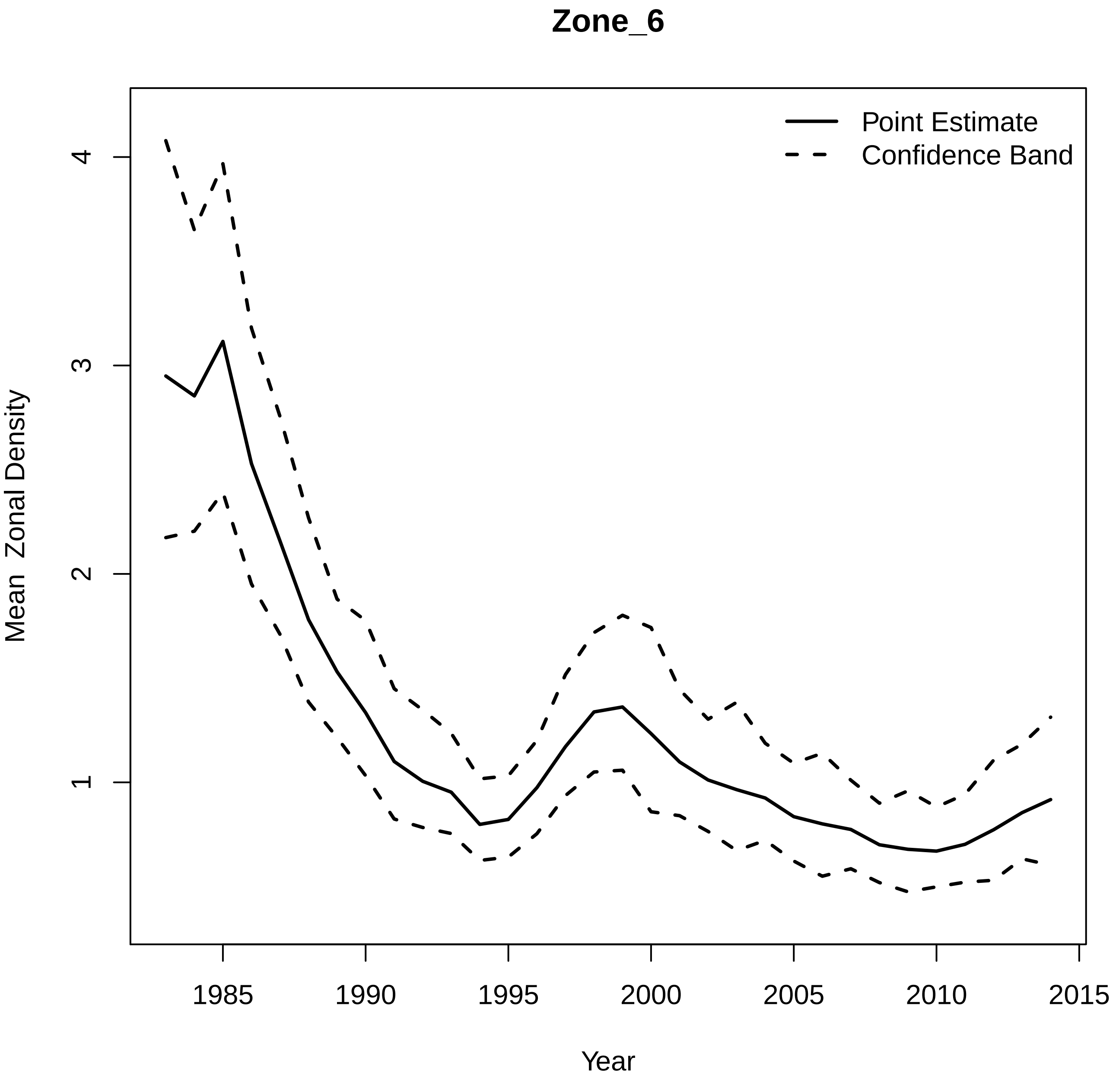
Zone_3
Point Estimate
Confidence Band
Mean Zonal Density
2.5
2.0
1.5
1.0
0.5
1985
1990
1995
2000
2005
2010
2015
Year

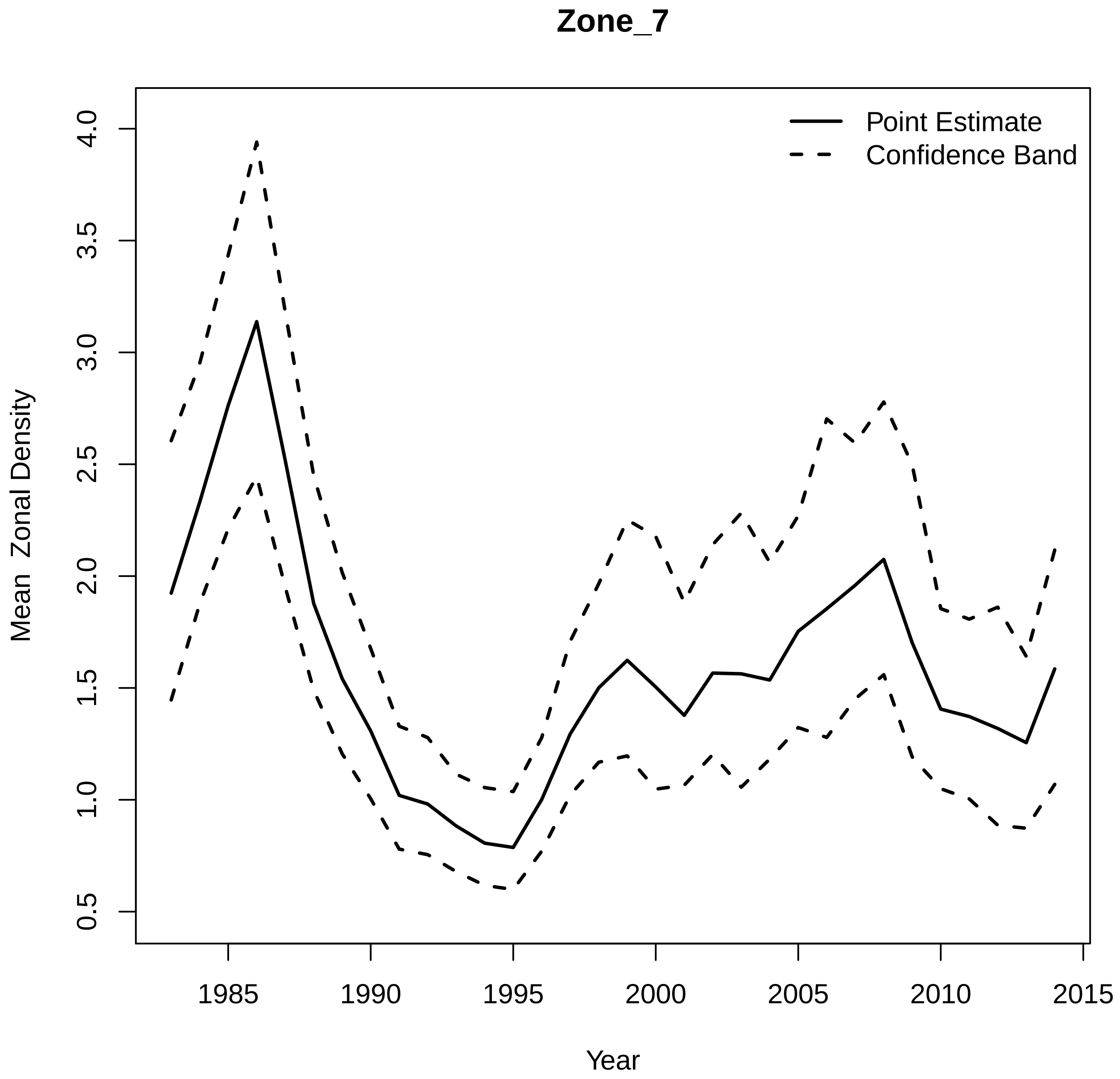


Zone_4
Point Estimate
Confidence Band
Mean Zonal Density
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1985
1990
1995
2000
2005
2010
2015
Year

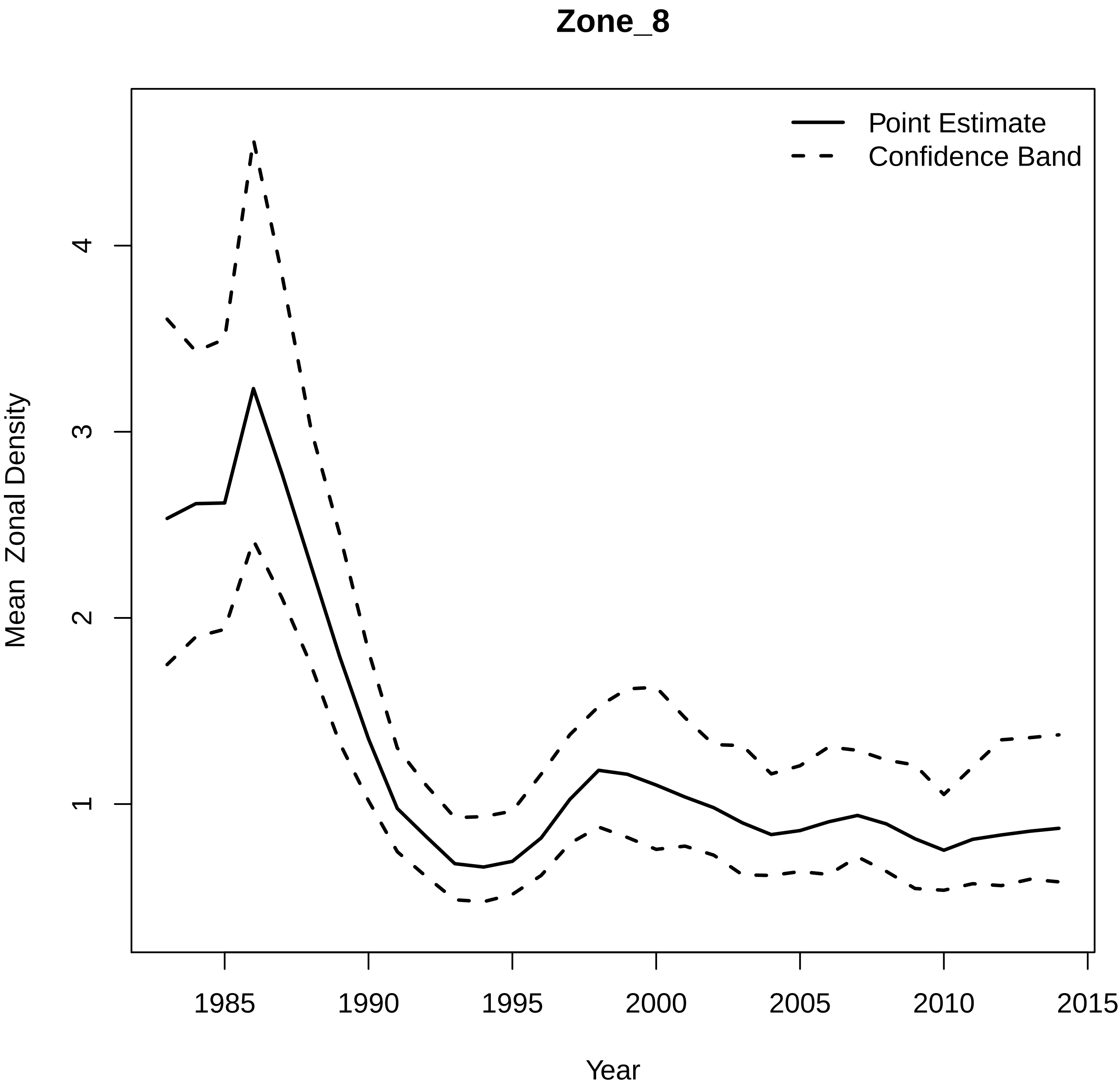


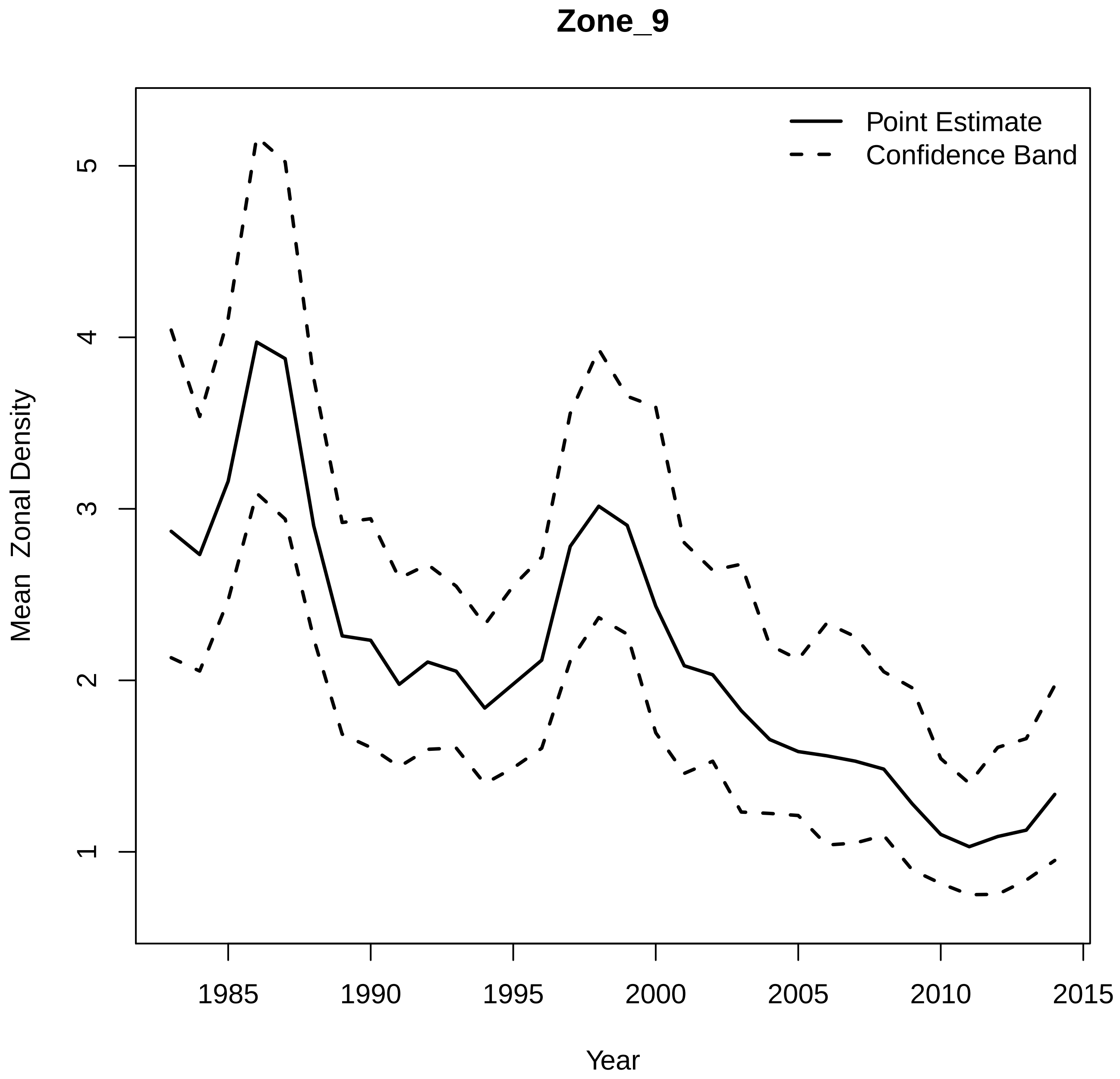
Zone_5
Point Estimate
Confidence Band
Mean Zonal Density
0.5
1.0
1.5
1985
1990
1995
2000
2005
2010
2015
Year


Zone_6
Point Estimate
Confidence Band
Mean Zonal Density
1
2
3
4
1985
1990
1995
2000
2005
2010
2015
Year

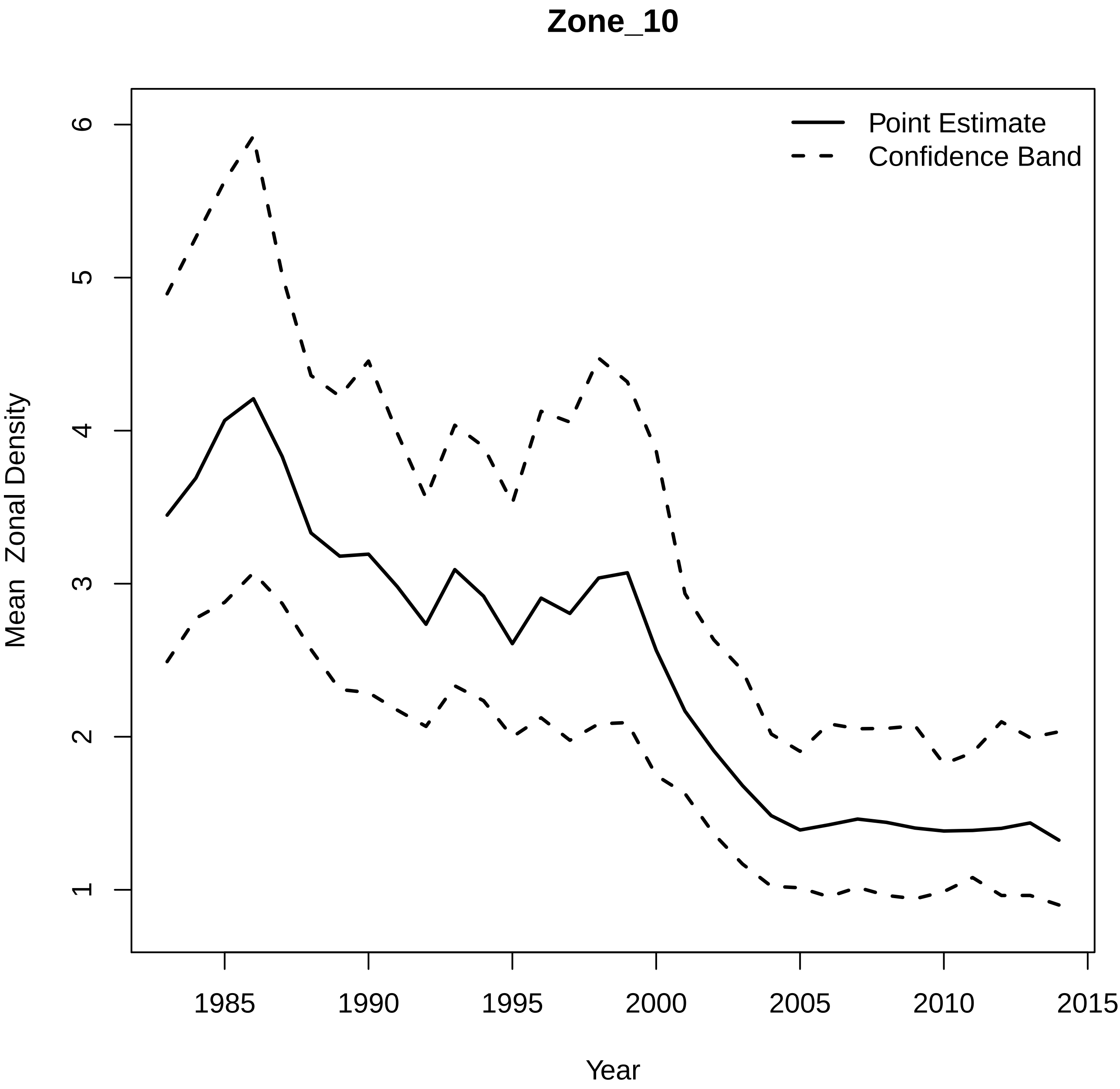


Zone_7
Point Estimate
Confidence Band
Mean Zonal Density
Year
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
1985
1990
1995
2000
2005
2010
2015

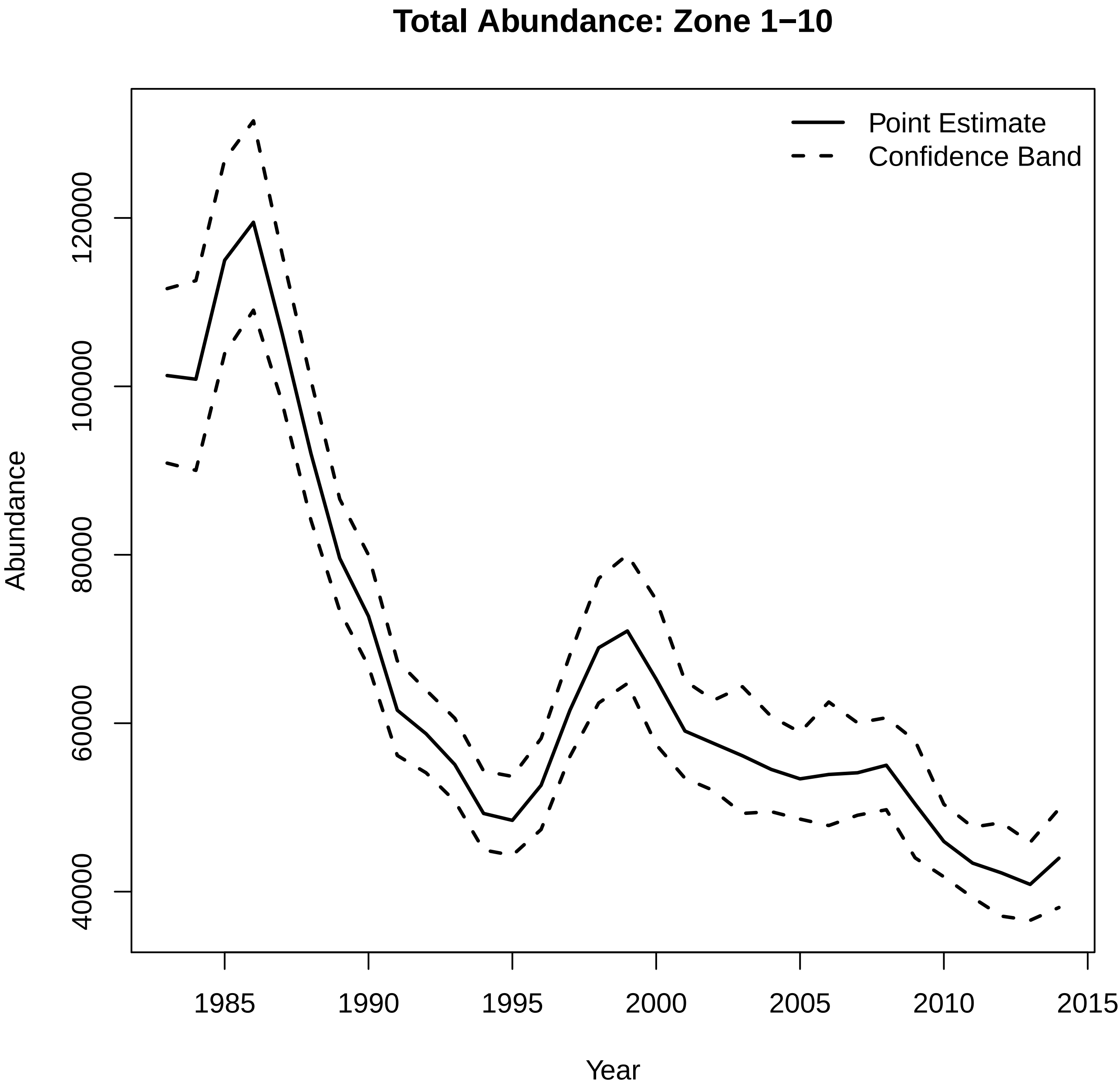

Zone_8
Point Estimate
Confidence Band
Mean Zonal Density
1
2
3
4
1985
1990
1995
2000
2005
2010
2015
Year



Zone_9
Point Estimate
Confidence Band
Mean Zonal Density
1
2
3
4
5
1985
1990
1995
2000
2005
2010
2015
Year



Zone_10
Point Estimate
Confidence Band
Mean Zonal Density
Year
1
2
3
4
5
6
1985
1990
1995
2000
2005
2010
2015


Total Abundance: Zone 1−10
Point Estimate
Confidence Band
Abundance
40000
60000
80000
100000
120000
Year
1985
1990
1995
2000
2005
2010
2015