EFFECTS OF DEER BROWSE ON WOODY VEGETATION IN FORESTS AT CORALVILLE LAKE, IOWA: FINAL REPORT – 1998 TO 2002

SUMMARY

Submitted to:
Army Corps of Engineers
Coralville Lake Project
Iowa City, Iowa

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1. A study examining the effects of deer herbivory on woody forest vegetation was undertaken by the Army Corps of Engineers at Coralville Lake in Johnson County, Iowa. Four sites each with paired 15 x 15 m plots were established: one plot (exclosure) within an 8 foot high wire fence and the other (browse) adjacent and outside the fence. The density of woody vegetation in the plots was measured in three structural layers (seedling-sprouts, shrubs, and saplings) over a 4 year period, beginning in June 1998 (the summer after exclosures were constructed) and ending in May 2002. Effects of browsing on density and richness were assessed by comparing the exclosure plot with the browse plot.

2. A total of 37 woody taxa, including 7 exotic species, were observed in the plot inventories at the Coralville study sites. Most of these were tree species, either canopy (15) or understory (7), a little over a fourth were shrub species (10) and the rest were liana species (5). The most common woody taxa observed included the native species bittersweet (*Celastrus scandens*), black cherry (*Prunus serotina*), gooseberry (*Ribes* sp.), dogwood (*Cornus* sp.), elm (*Ulmus* sp.), poison ivy (*Toxicodendron radicans*), ash (*Fraxinus* sp.), hard maple (*Acer nigrum*) and the exotic species multiflora (*Rosa multiflora*) and autumn olive (*Elaeagnus* sp.).

3. Considerable variation in forest structure and composition occurred among the study sites from the beginning. Total seedling-sprout densities ranged from 2 stems/m^2 at Turkey Creek to 17 stems/m^2 at West Overlook and Lindner West. Total shrub densities ranged from 0.5 stems/m^2 at Turkey Creek to 6 stems/m^2 at West Overlook, and total sapling densities ranged from 500 stems/ha at Turkey Creek to 8,000 stems/ha at West Overlook. The principal vegetation gradient appeared to be a successional pattern represented by a dense, early successional community with high exotic species richness at West Overlook to a relatively mature, fairly sparse community lacking exotic species at Turkey Creek. A secondary vegetation gradient was recognized that encompassed a change from shrub species in the shrub and sapling layers at Lindner East exclosure to tree species in the shrub and sapling layers at Lindner West browse. These initial differences in forest composition and structure are important factors affecting both the intensity of deer herbivory that occurred and the response of the forest vegetation to herbivory.

4. Three types of browse effects were investigated: 1) effects on forest structure and diversity, 2) effects on population growth, and 3) effects on community composition. Many browse effects were demonstrated, some of which could be described as detrimental to forest biodiversity, others were observed that could be described as beneficial to forest biodiversity. Some effects were widespread and similar among all four sites, but more often effects tended to be site specific.

5. The most evident and uniform browse effects shown were a decrease in native shrub density (LSM 2.1 stems/m^2 for browse and 2.8 stems/m^2 for exclosure, 25% decrease) and a decrease in native shrub richness (LSM 2.8 for browse and 8.5 for exclosure, 67% decrease). These detrimental effects were countered by some beneficial effects in that exotic shrub density and richness also decreased (over all four sites for density and locally on three sites for richness). The inhibitory browse effect was stronger on exotic density than it was on native density, resulting in an increase in relative native density on browse plots. In contrast, the inhibitory browse effect was weaker on exotic richness than it was on native richness, and promoted a decrease in quality based on the richness index (LSM 1.63 for browse and 4.11 for exclosure, 60% decrease).

** LSM is a least square mean - a mean for spring 2002 adjusted for the initial differences in spring 1998

6. Browse effects on seedling-sprouts and saplings were more variable and site dependent. The most consistent browse effects on seedling-sprouts were a decrease in exotic density (a beneficial effect, LSM 1.37 stems/m^2 for browse and 1.59 stems/m^2 for exclosure, 14% decrease) and an increase in the seedling-sprout/shrub ratio (a detrimental effect, LSM 4.0 for browse and 3.3 for exclosure, 21% increase). Increases in the seedling-sprout/shrub ratio reflect a condition in which seedling-sprouts are more numerous than shrubs, potentially because topping of shrub stems decreases their height and converts shrubs back to seedling-sprouts. Total native density of seedling-sprouts increased at Lindner East (LSM 7.5 stems/m^2 browse and 5.7 stems/m^2 exclosure, 32% increase), but decreased at Turkey Creek (LSM 4.0 stems/m^2 browse and 9.4 stems/m^2 exclosure, 57% decrease). The low initial density of seedling-sprouts at Turkey Creek

compared to Lindner East could have contributed to greater impact on the seedling-sprout layer due to deer herbivory. The native richness of seedling-sprouts decreased at West Overlook (LSM 15.8 for browse and 20.6 for exclosure, 23% decrease), and increased at Turkey Creek (LSM 9.0 for browse and 6.0 for exclosure, 50% increase). At relatively mid-successional sites such as Lindner East and West, browse effects on seedling-sprouts tended to be slightly more beneficial than detrimental, while at the relatively late-successional site, Turkey Creek, browse effects on seedling-sprouts tended to be slightly more detrimental than beneficial.

7. In the sapling layer, the most consistent browse effect was an increase in total density at the Lindner sites (both sites exhibited decreases in both plots, but the decreases in the browse plots were less). Native richness of saplings and the sapling richness quality index decreased in response to browsing at Lindner West and Turkey Creek (negative?), but both sapling variables increased at Lindner West (positive?). Overall, the seedling-sprout and sapling layers were slightly more often affected in a beneficial way (beneficial defined as increased native components and detrimental defined as decreased native components) than in a detrimental way. Some of these effects could be a direct outcome of browsing, while others, perhaps the majority, result from indirect effects, such as changes to the shrub layer.

8. Detrimental effects of deer browsing on the population growth of seedling-sprouts was exhibited for three species – bitternut hickory during winter 1998-99 (LSM browse 0.11 stems/m^2 and exclosure 0.28 stems/m^2, 61% decrease), oak from 1998 to 2002 (LSM browse 0.001 stems/m^2 and exclosure 0.087 stems/m^2, 98% decrease), and elm during winter 1998-99 (LSM browse 0.27 stems/m^2 and exclosure 0.65 stems/m^2, 58% decrease). Two seedling-sprout species exhibited increased population growth from browsing – black cherry during the summers of 1998 and 1999 (LSM browse 1.17 stems/m^2 and exclosure 0.70 stems/m^2, 81% increase) and dogwood during winter 1998-99 (LSM browse 0.32 stems/m^2 and exclosure 0.16 stems/m^2, 100% increase). Multiflora seedling-sprouts increased in the browse plots relative to the exclosure during the summer of 1998, but then both changed in similar ways until the winter of 2001-02, when there was a significant decrease in growth on the browse plots. Overall, from 1998 to 2002 multiflora rose seedling sprouts showed a significant decrease in population growth due to browsing.

9. Detrimental effects of deer browsing on the population growth of shrubs was exhibited for two species – black cherry during winter 1998-99 (LSM browse 0.11 stems/m^2 and exclosure 0.30 stems/m^2, 63% decrease) and dogwood between 1999 and 2001 (LSM browse 0.002 stems/m^2 and exclosure 0.15 stems/m^2, 98% decrease). The increases in these species are opposite the effects of browse on seedling-sprouts of these species, which illustrates that browse effects can be age/size specific. Two shrub species displayed increases in population growth due to browsing – bittersweet during winter 2001-02 (LSM browse 1.9 stems/m^2 and exclosure 1.4 stems/m^2, 36% increase) and multiflora rose during summer of 1998 (LSM browse 0.21 stems/m^2 and exclosure 0.14 stems/m^2, 50% increase). Gooseberry and blackberry/raspberry shrubs both exhibited variable responses to browsing, increasing in population growth at times and decreasing in population growth at other times.

10. Responses to browsing at the community level were not strongly evident. For all four sites, much of the change in species composition (i.e., variation) in both plots over the study occurred in a similar direction and magnitude. The trajectory of the browse and exclosure plots over time at West Overlook and Turkey Creek were very similar and parallel, indicating very little divergence (i.e., no separation). At the Lindner sites, browse and exclosure plots were initially quite different and the trajectories over time were more erratic and somewhat divergent (i.e., suggesting some browse effects on community composition). At the Lindner sites and to a lesser extent West Overlook, changes in species composition in both plots from 1998 to 2002 was associated with an increasing tendency for tree species to be in the understory shrub and sapling layers rather than shrub species. The plots at the more mature Turkey Creek site exhibited a change in species composition from 1998 to 2002 that was associated with a tendency to become more mid-successional (i.e., retrogressive succession).

Figure 2. Color infrared aerial 2002 photograph of the dam area at Coralville Reservoir, showing the locations of the deer herbivory study sites.

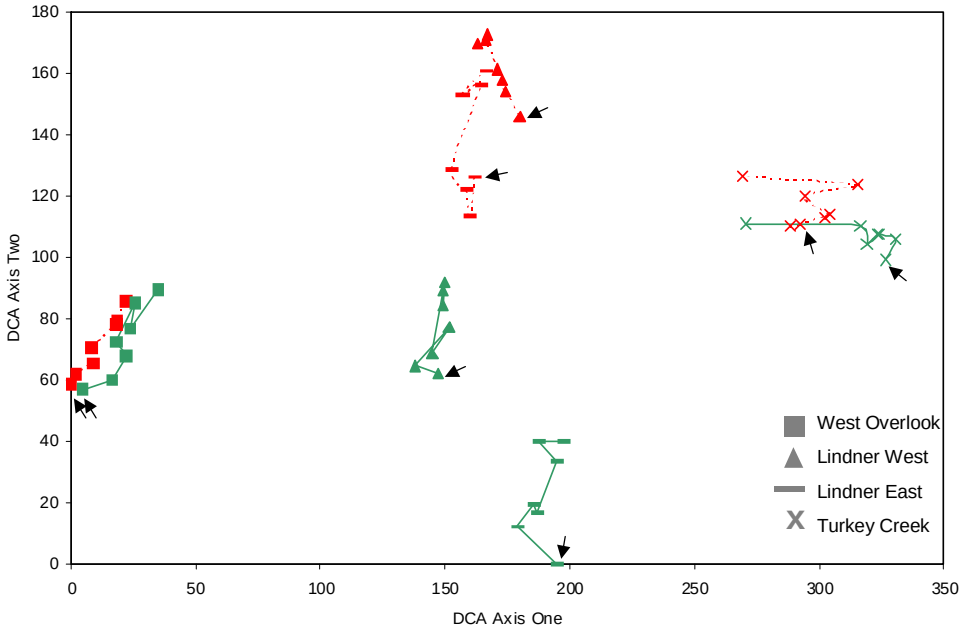

Fig. 4. DECORANA ordination of browse plots (red) and exclosure plots (green) at all Coralville study sites on all seven sample dates. Arrows indicate the first sample date (June 1998); sequential sample dates occur in order along the line connecting the points.

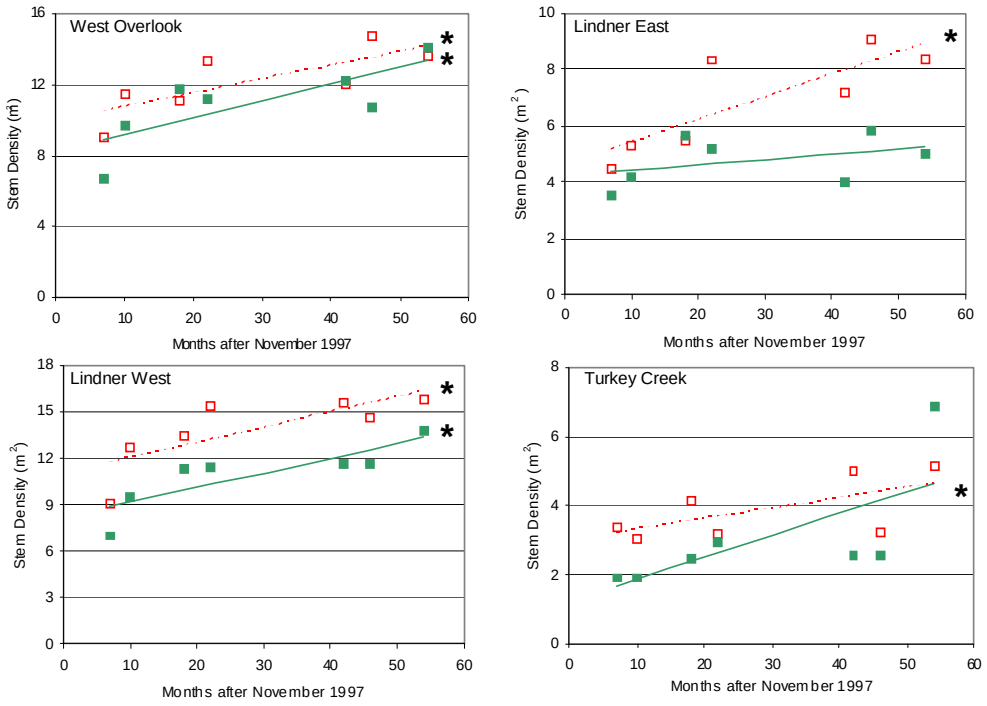

Fig. 5. Total density of native woody seedling-sprout species at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 4. Significant linear regressions ($p<0.10$) are indicated with (*).

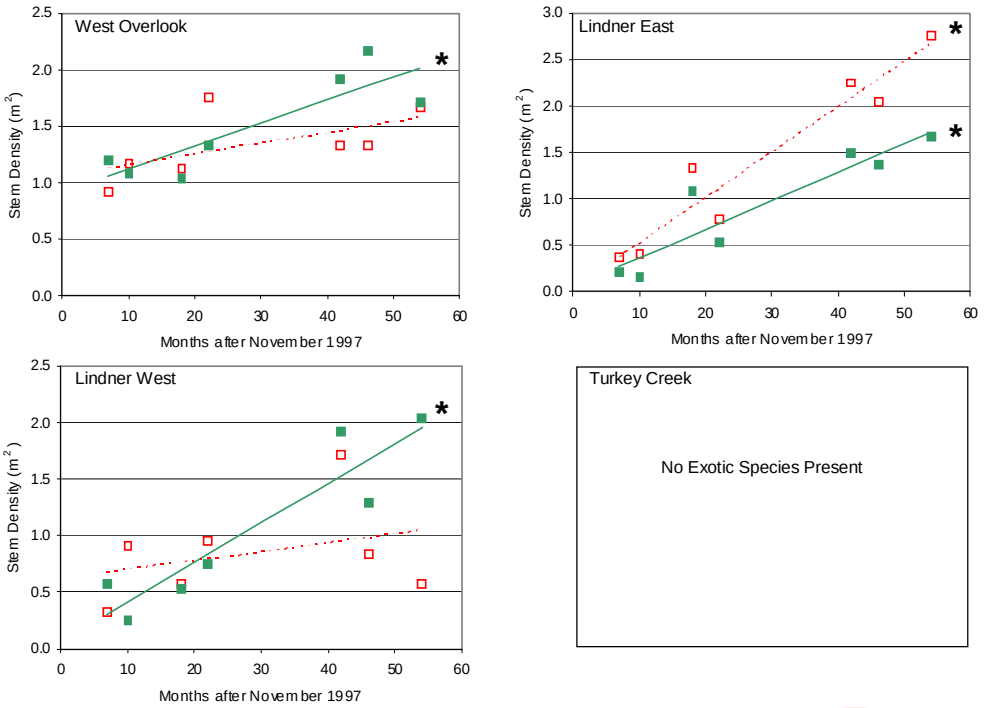

Fig. 6. Total density of exotic woody seedling-sprout species at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 4. Significant linear regressions ($p<0.10$) are indicated with (*).

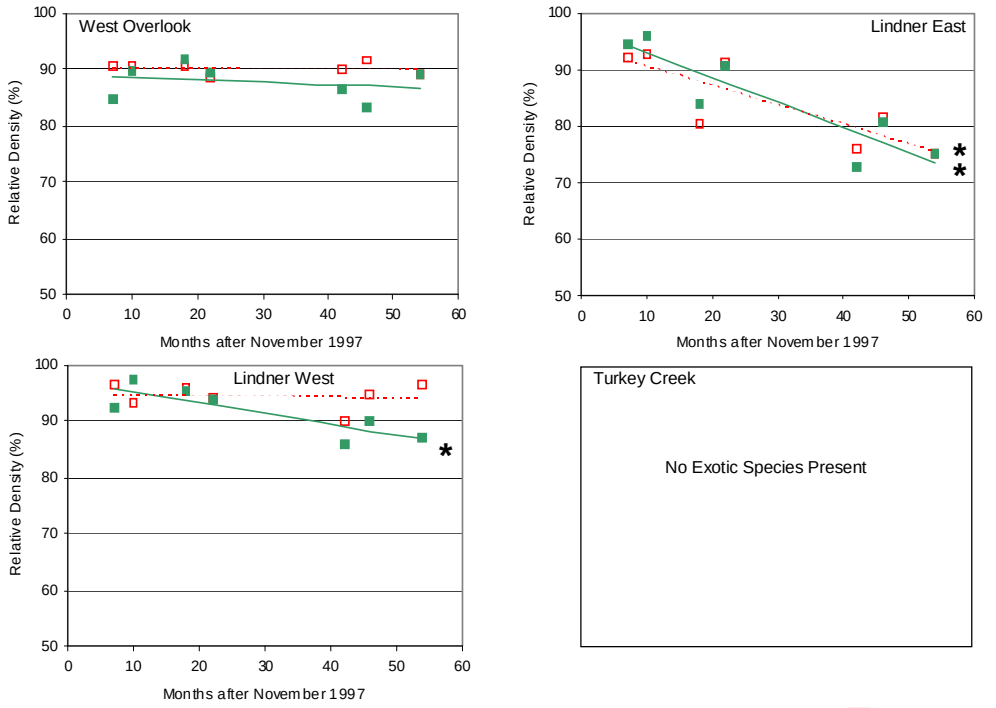

Fig. 7. Relative density of native woody seedling-sprout species at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 4. Significant linear regressions ($p<0.10$) are indicated with (*).

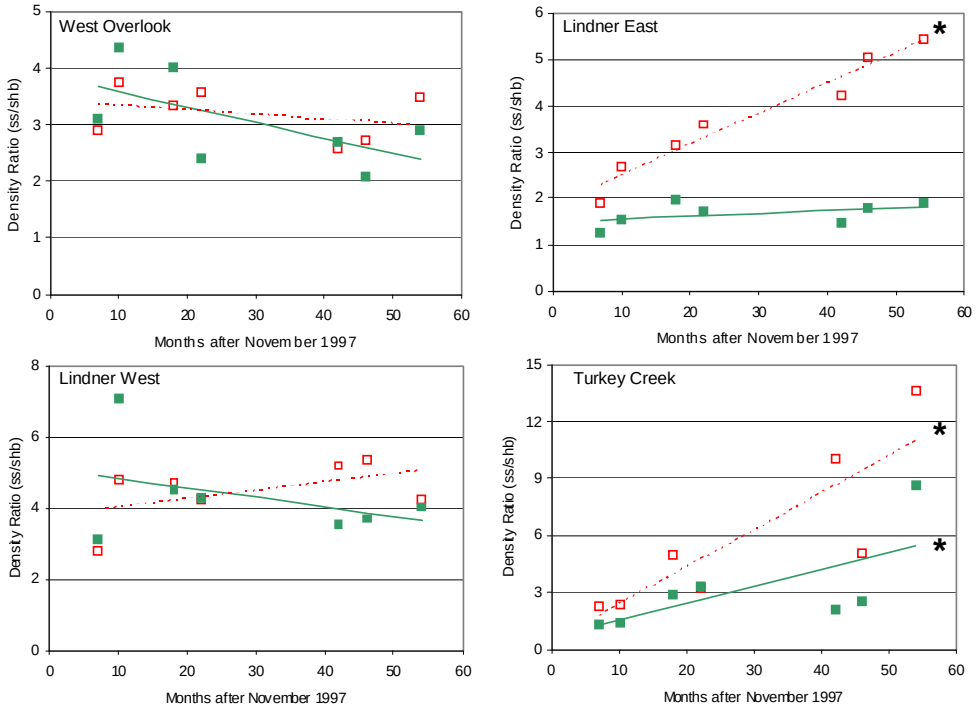

Fig. 8. Ratio of total seedling-sprout density to total shrub density at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 4. Significant linear regressions ($p<0.10$) are indicated with (*).

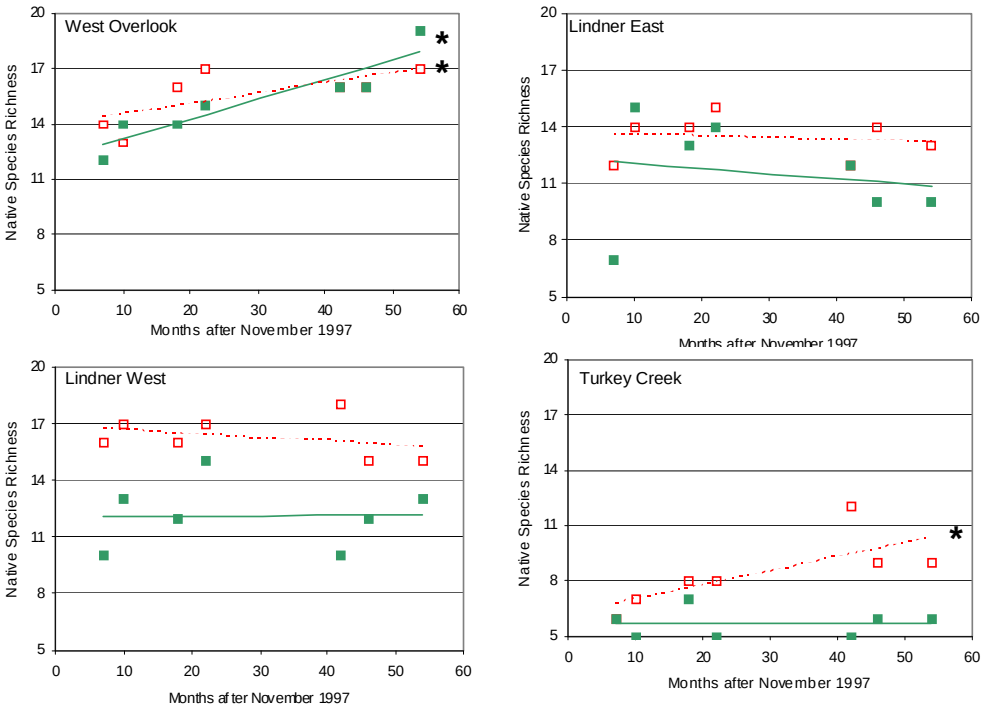

Fig. 9. Native species richness of seedling-sprouts at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 4. Significant linear regressions ($p<0.10$) are indicated with (*).

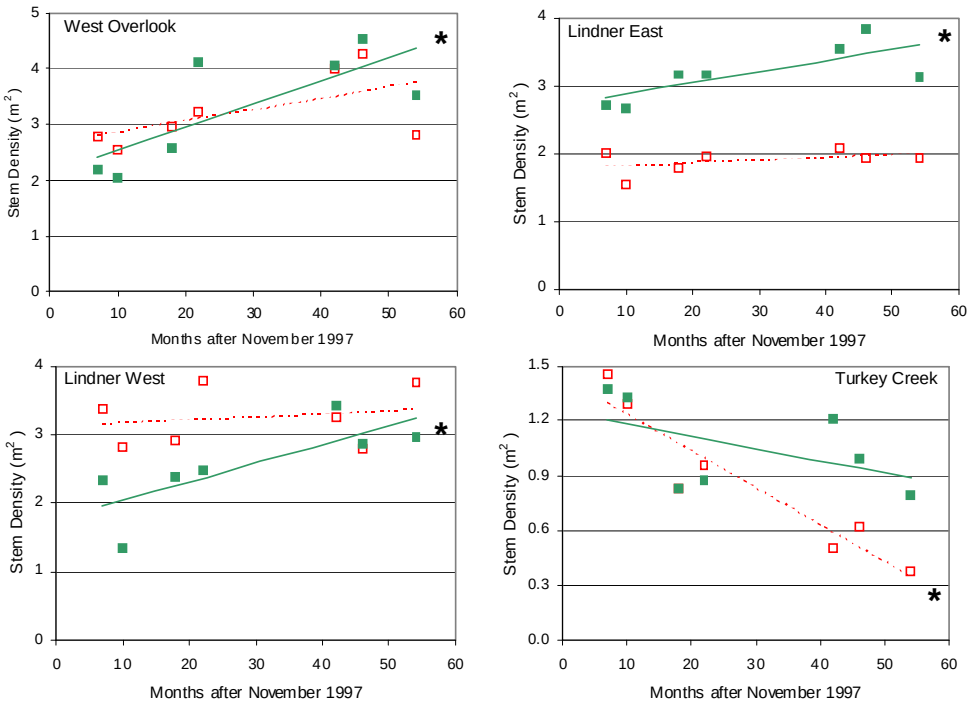

Fig. 10. Total density of native shrubs at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 6. Significant linear regressions ($p<0.10$) are indicated with (*).

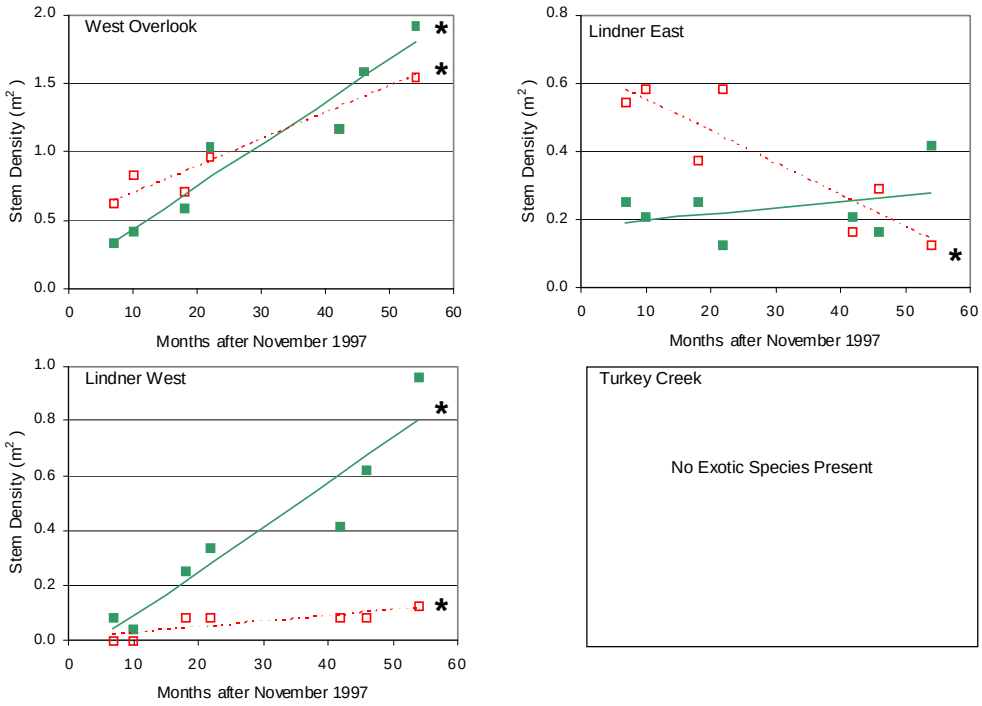

Fig. 11. Total density of exotic shrubs at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 6. Significant linear regressions ($p<0.10$) are indicated with (*).

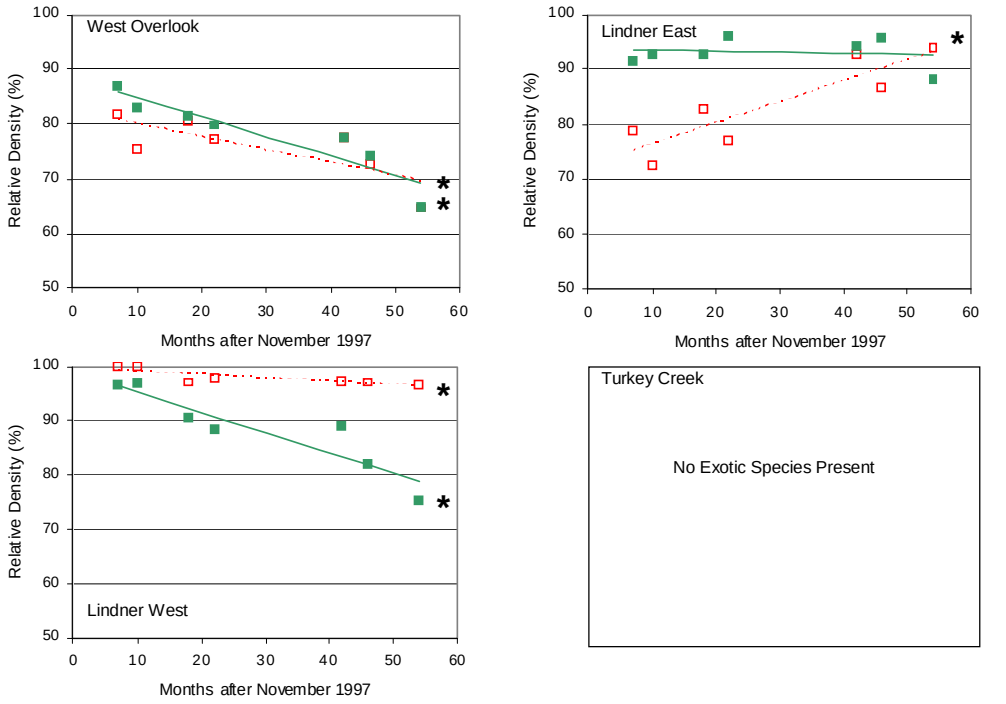

Fig. 12. Relative density of native woody shrub species at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 6. Significant linear regressions ($p<0.10$) are indicated with (*).

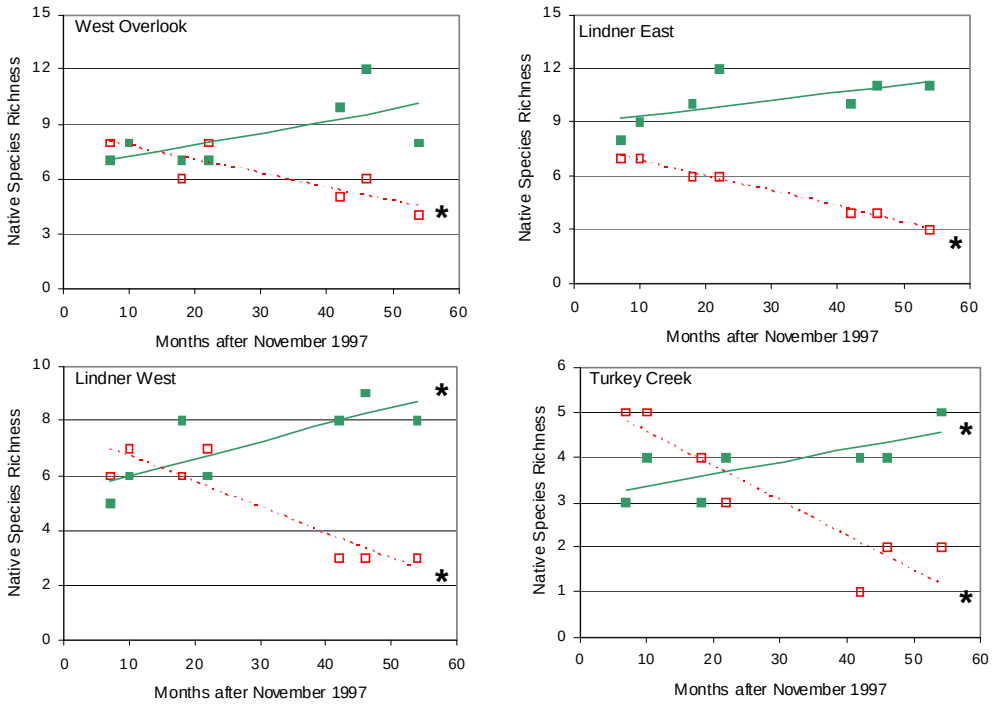

Fig. 13. Native species richness of shrubs at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 6. Significant linear regressions ($p<0.10$) are indicated with (*).

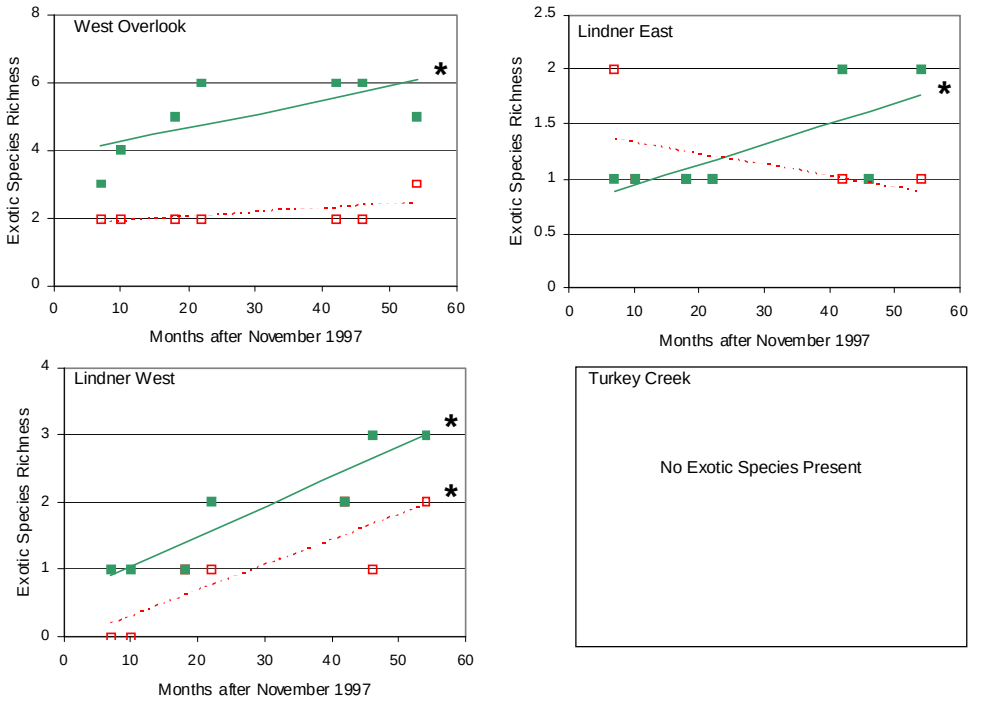

Fig. 14. Exotic species richness of shrubs at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 6. Significant linear regressions ($p<0.10$) are indicated with (*).

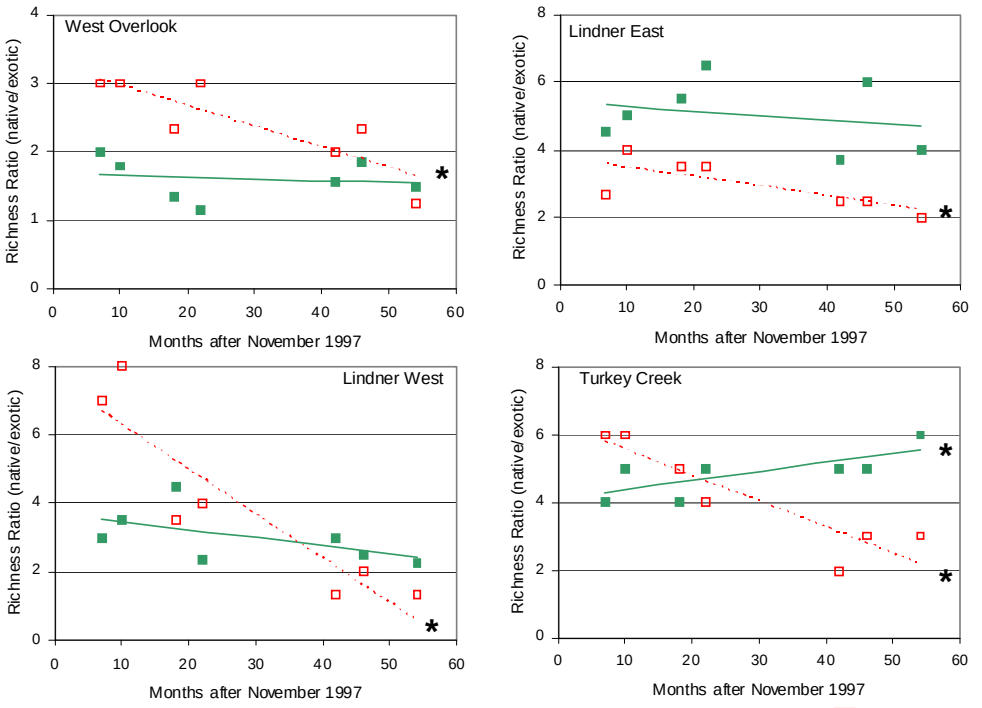

Fig. 15. Species richness quality ratio for shrubs at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 6. Significant linear regressions ($p<0.10$) are indicated with (*).

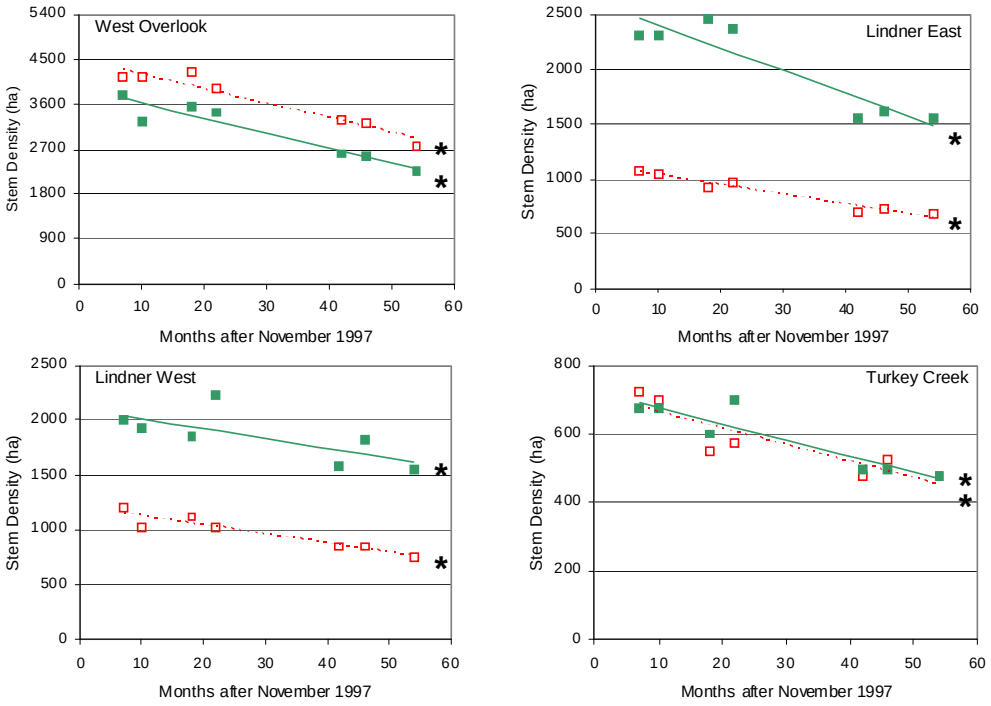

Fig. 16. Total density of native saplings at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 8. Significant linear regressions ($p<0.10$) are indicated with (*).

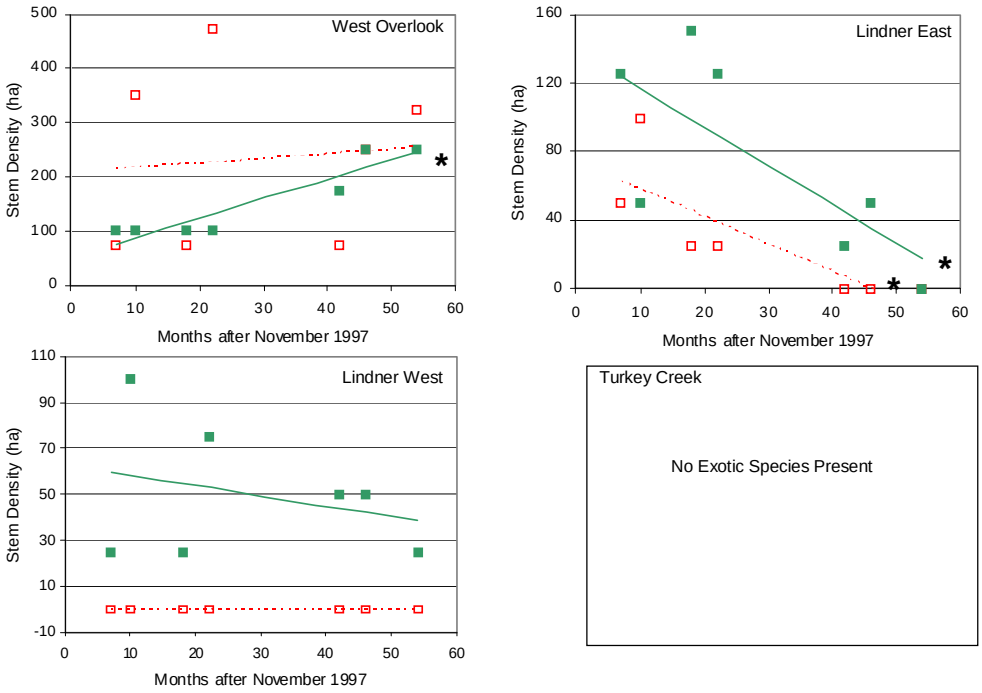

Fig. 17. Total density of exotic saplings at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 8. Significant linear regressions ($p<0.10$) are indicated with (*).

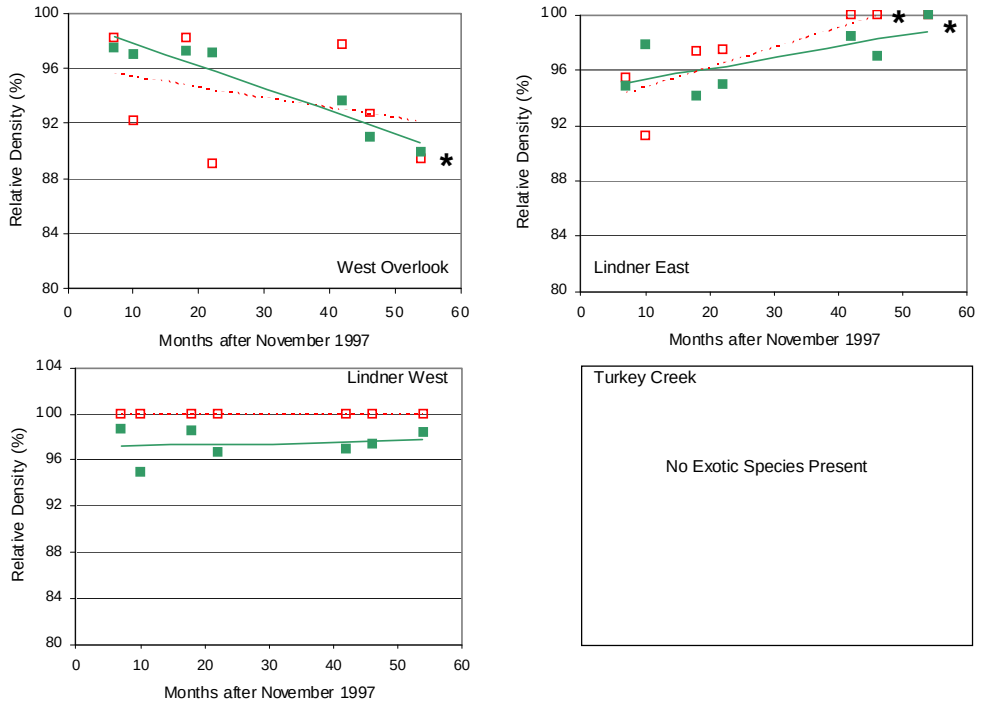

Fig. 18. Relative density of native woody sapling species at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 8. Significant linear regressions ($p<0.10$) are indicated with (*).

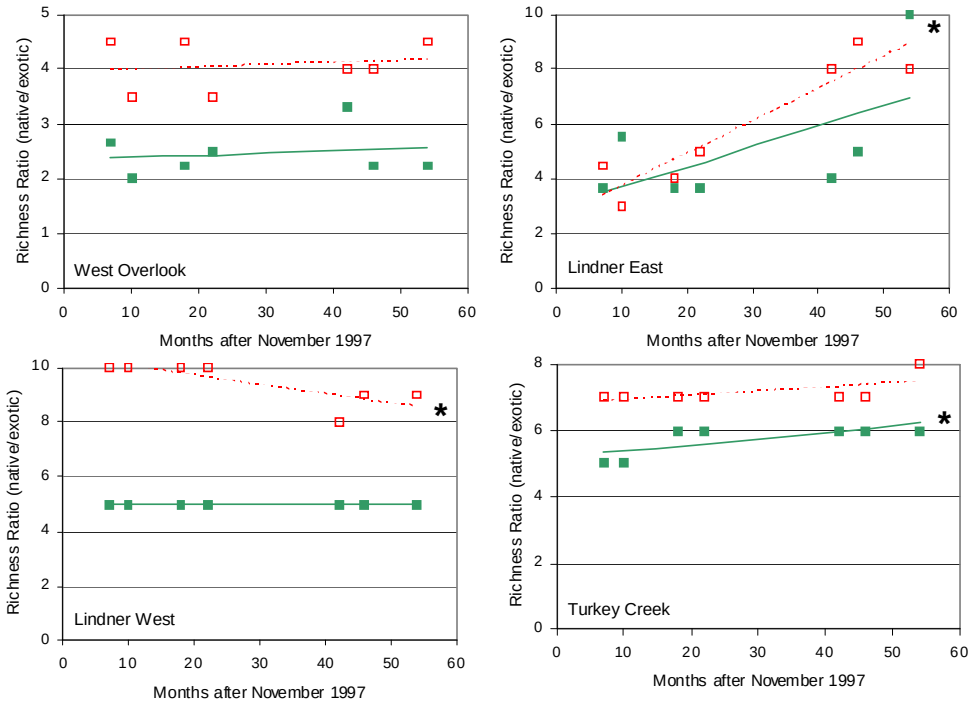

Fig. 19. Species richness quality ratio for saplings at Coralville study sites from June 1998 to May 2002. Slopes and p-values for regression lines are given in Table 8. Significant linear regressions ($p<0.10$) are indicated with (*).