Composition of Canyon-Slope Woodlands in Zoar Valley, Western New York, as Associated with Slope Orientation and Elevation

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ABSTRACT. The 11 km long and 50-140 m deep Zoar Valley Canyon in western New York State represents a nearly undisturbed riparian ecosystem. Forest composition and age structure have previously been studied on riverside floodplains and raised terraces, but the slopes above were heretofore unexplored. The present study aimed to catalogue tree species distributions on 20-60 degree slopes that also tend to be solidly forested. Two major objectives were to evaluate the influence on forest composition of north vs. south slope orientation and elevation above the river bed. Additionally, multivariate Non-metric Multidimensional Scaling (NMDS) ordination was used to assess the relative roles of different slope communities in providing colonizers to the lower elevation fluvial landforms. A clinometer and laser range finder were used to measure slope angles and elevations of safe vantage points and of individual trees. Trees were identified to species and classified as understory, midstory, canopy, and emergent. South-facing slopes >40 m above the river supported xeric canopies, often <10 m in height, dominated by *Quercus rubra, Q. prinus*, and *Pinus resinosa* (57-93% of trees collectively). In contrast, north-facing slopes supported >30 m tall mesic canopies (*Acer saccharum, Fagus grandifolia, Tsuga canadensis*, *Fraxinus americana, Liriodendron tulipifera*) across their entire vertical profiles. Eastern hemlock was notably more abundant on mesic north-facing slopes than on terraces below (27-48% vs. 2-27%, respectively), especially above 40 m where it comprised 42-58% of trees. Ordination results suggest xeric communities play little role in floodplain/terrace colonization (communities were widely separated in ordination space), but that mesic slopes have variable influence on the flats below.

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INTRODUCTION

Old growth forest in the eastern United States has become quite rare today, which is especially true for riparian (river dominated) habitats. Riparian zones contain varied habitat types which can be temporally dynamic due to the forces of flowing water. The erosion and creation of land along with channel migration can provide opportunities for tree colonization and forest development. These colonizers inevitably come from more established surrounding habitats, and propagule pressure can thus influence floodplain woodland development. In the canyons of Zoar Valley, New York, some of these habitats (i.e. canyon slopes) have previously not been well studied. In the case of the forested canyon-slopes this can be attributed to steepness and inaccessibility. Tree community composition of the forested canyon-slopes provides a unique opportunity for study. This and propagule pressure influences from varied habits in a riparian system on developing floodplains provide an interesting study in the eastern old growth forests of Zoar Valley.

Zoar Valley is unique in that it contains eastern old growth forest, of which less than one percent is believed to remain (Frelich 1995). Human settlement, logging, and agriculture have greatly reduced old growth in the eastern forests since the time of European colonization. In Zoar Valley, old growth is present both on the terraces and on the forested slopes. One reason that Zoar Valley has never been logged is its inaccessibility due to its steeply sloping canyon walls.

Recent studies of the forests of Zoar Valley have focused mainly on the lowland terraces (Diggins and Kershner 2005). A focus of the current study was tree community composition and distribution on the canyon-slopes, which are likely quite different from that of the better studied terraces. The present study analyzed the species composition as well as diversity and size distributions of the trees in the canyon-slope forests, and compared these results with data already obtained from the canyon bottom terraces (Diggins and Kershner 2005). Comparisons were made between slopes of different aspect (north vs. south facing) and different elevations. Also investigated was the possible influence of propagules from the canyon-slope forests on the developing floodplains.

Trees in Zoar Valley are of broadly varying ages, as is often seen in old growth (Van Pelt *et. al*. 2006), and the oldest have been core dated to over 300 years old (Pfeil *et. al*. 2007). Other characteristics of old growth present in Zoar Valley include presence of snags, gaps in the canopy, and fallen dead wood. Openings in the canopy form when older trees die and fall (Van Pelt *et. al*. 2006). This is a normal process in established forests. New trees can become established in the gaps and contribute to the multi-aged nature of old growth forests. Fallen logs of various sizes are present in Zoar Valley, which are also of many different decay stages. These fallen logs can be an important aspect of the habitat as they often provide sites that are important for the establishment of tree seedlings (Pfeil *et. al*. 2007; Harmon *et. al*. 1986). Large specimens of economically valuable tree species, such as black walnut (*Juglans nigra* L.), are present in Zoar Valley. Thus, it is highly unlikely that even selective logging had occurred (Diggins and Kershner 2005). Zoar Valley provides a unique opportunity to study forest composition and dynamics in an eastern old growth system.

Zoar Valley contains numerous and varied habitats, including the lowland terraces, canyon-slope forests, and developing floodplains. The terraces are forested, relatively flat lowland areas in the canyon bottom. The creek itself is important in the formation and shaping of the terraces (Diggins and Kershner 2005). Terraces begin as floodplains and if enough tree seedlings can establish on these floodplains and survive periods of flooding a mature, flood-free terrace can eventually develop as more soil accumulates (Van Pelt *et. al.* 2006). The saplings can trap and stabilize the soil allowing floodplains to develop into mature terraces.

The canyon-slope forests appear to be structurally and compositionally quite different from the terraces primarily because of their situation on the relatively steep slopes (Diggins and Kershner 2005). Because of the steepness, they are likely better drained than the terraces. There are different habitats in different areas of the canyon-slopes. Because the canyon runs east to west, some slopes face north while others face south which can affect environmental conditions (insolation, water retention, soil conditions) on different slopes. North facing slopes face away from the sun and are more sheltered, and thus likely support a relatively moist, mesic habitat (Robertson *et. al*. 1978). The south facing slopes receive more direct sunlight, which leads to a relatively drier, somewhat xeric habitat (Robertson *et. al*. 1978).

Changes in elevation can lead to considerable changes in a forest community (Rubino and McCarthy 2003). In addition to aspect, several environmental factors change along a topographical gradient. Resource availability, including soil moisture, can change as elevation changes. Other factors that can vary with elevation include soil temperature, evaporation rate, wind velocity, and atmospheric moisture (Rubino and McCarthy 2003). These varying factors create different microclimates with changing elevation which leads to differences in forest community structure (Rubino and McCarthy 2003). Thus, several different climax states can exist in close proximity in an area with changing elevation (Braun 1950).

Succession is the development of an ecological community over time with primary succession being development on newly formed land (Hosner and Minckler 1963). In Zoar Valley, these are the newly deposited floodplains. Terraces in Zoar Valley range in geological age from newly formed to several centuries old (Diggins and Kershner 2005). The newest land, which may become terraces, is the young floodplains. Succession occurs in stages (Hefley 1937). Early successional species tend to be good colonizers, but fairly intolerant of shade (Van Pelt *et. al.* 2006). These species often have propagules that can spread well over larger distances. Examples of early successional tree species common to Zoar Valley include tulip tree (*Liriodendron tulipifera* L.), sycamore (*Platanus occidentalis* L.), and cottonwood *(Populus deltoides* Marsh.). Later successional species tend to be better competitors, and also are more shade tolerant (Van Pelt *et. al.* 2006). These species often arrive to a community later, but can grow in the shade of the early successional species and eventually replace them. Later successional tree species common to Zoar Valley include sugar maple (*Acer saccharum* Marsh.), American beech (*Fagus grandifolia* Ehrh.), and eastern hemlock (*Tsuga canadensis* (L.) Carr.). Young, early successional forests often have densely packed trees of similar ages. Later, the forest becomes less dense as weaker trees are out competed and die off. Lastly, a multi-aged forest develops as old trees occasionally die and young ones take their place (Lindsey *et. al*. 1961).

Several important factors can affect succession in an area. Nutrient and moisture availability as well as soil type are among these (Small and McCarthy 2005). Other stochastic factors including unusual weather events such as storms and floods can play a role (Lindsey *et. al*. 1961). One very important factor is propagule source. This concerns the types of seeds that are available to colonize an area.

In Zoar Valley, tree propagules can arrive on forming floodplains from three main sources: 1) previously established terraces, 2) from Cattaraugus Creek, and 3) the forested canyon-slopes above. The creek can deposit propagules transported by it from upstream areas.

Neighboring trees, either on other terraces or the canyon-slopes, also provide propagules in differing numbers. The number of propagules and their order of arrival are important factors in the successional development of a community. In addition, variations in a site's spatiotemporal habitat conditions influence which species can colonize the site (Naiman and Decamps 1997; Van Pelt *et. al*. 2006).

Tree propagules can be spread by a number of different means. One method of propagule dispersal employed by several species is wind dispersal (Hewitt and Kellman 2002). Species that use this method often have light propagules (known botanically as samaras) that bear one or more wings. In Zoar Valley wind dispersed species include white ash (*Fraxinus americana* L.), eastern hemlock (*Tsuga canadensis* (L.) Carr.), tulip tree (*Liriodendron tulipifera* L.), and multiple species of maple (*Acer*) and pine (*Pinus*). Other species rely on dispersal by animals (Moran *et. al.* 2009). These species usually have large seeds (dry nuts or fleshy berries) that animals (squirrels, chipmunks, birds) can use as a food source. These animals often cache large quantities of these propagules at several sites for use as winter food. Some of these sites are forgotten and can facilitate seed dispersal (Hewitt and Kellman 2002). Animal dispersed tree species in Zoar Valley include American beech (*Fagus grandifolia* Ehrh.), black cherry (*Prunus serotina* Ehrh.), and several species of oak (*Quercus*) and hickory (*Carya*). Due to the steep slopes of Zoar, gravity also may play a role in transporting propagules from the canyon-slopes to the floodplains and terraces.

The forest communities found in Zoar Valley are diverse for a northern hardwood forest at more than 40 degrees north latitude. This conclusion is based on previous studies that were conducted on the terraces of Zoar Valley by Diggins and Kershner 2005, which found 21 tree species that contributed to the middle and overstory of the canopy (>20 cm diameter at breast height, DBH). The understory of the forest was also quite diverse with 15 tree species.

Objectives

This study expanded research into the habitats of the canyon-slope zones of Zoar Valley. Of interest here was to explore the habitats of an undisturbed eastern riparian zone's slope habitats and how they may influence floodplain woodland succession. One of the objectives of this study was 1) to assess species composition and diversity in the canyon-slope forests of Zoar Valley, as potentially influenced by slope aspect and elevation. Another objective of this study was 2) to analyze compositional differences between the terraces, floodplains, and canyon-slopes. Differences in tree species composition between different slope habitats and canyon bottom habitats were compared. The final objective 3) was to determine the role of different habitats as propagule sources for early successional floodplains. An interest was how different established communities effect developing floodplains by providing propagules. The 3 likely propagule sources to the developing nacent floodplains are the slopes, older terraces, and the creek.

METHODS

Study area

Zoar Valley is located in the western part of New York State and runs from east to west along the border of Cattaraugus and Erie counties about 50 kilometers south of Buffalo (fig. 1). Located near the town of Gowanda, Zoar Valley is owned by the State of New York and has been designated a Multiple Use Area. Thus, it is used for hiking, hunting, fishing, and other recreational activities (Diggins and Kershner 2005).

This canyon is a riparian system, centered along a channel of flowing water, Cattaraugus Creek. Over extended periods of time the channel that the creek occupies changes course (Shelford 1954). The edges of some terraces are gradually eroded while new soil is gradually deposited at the edges of other terraces, which eventually builds up and creates areas of new land (Shelford 1954). This gradual process can be accelerated at times by floods. The most recent major flood occurred in August of 2009. The new land that forms provides opportunities for primary succession.

Cattaraugus Creek is the waterway that flows from east to west through the canyon of Zoar Valley, and has a watershed of approximately 1430 square km, with more than 80% upstream from Zoar Valley (Diggins and Kershner 2005). The South branch of the Cattaraugus Creek converges with the Main branch within the canyon and drains into Lake Erie. This creek plays a very important role in the landscape and ecology of Zoar Valley (Diggins and Kershner 2005).

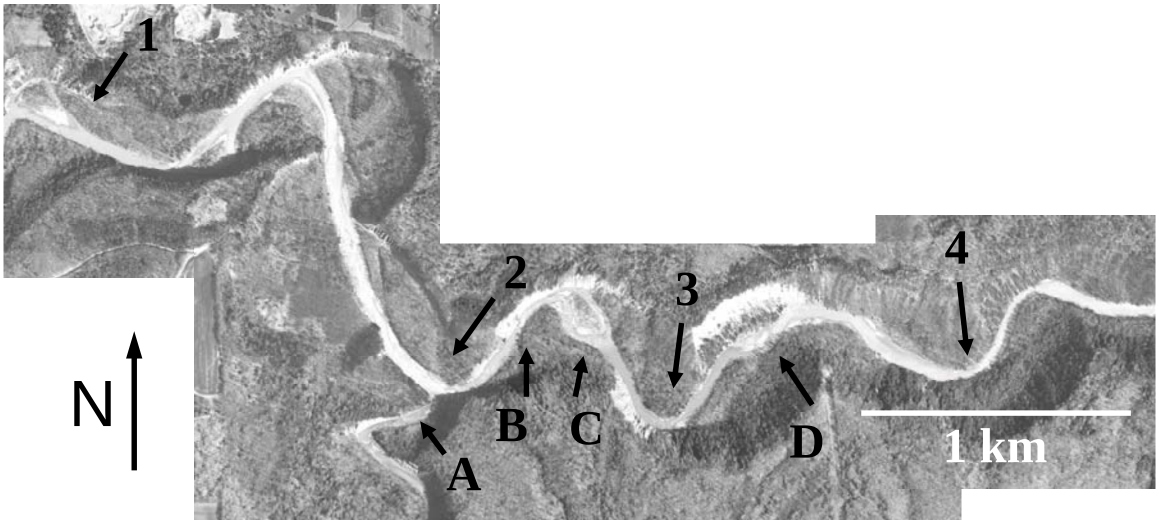
The Zoar Valley Canyon is the second deepest canyon in New York State, with a depth of up to 140 meters. The main branch of the canyon is approximately 11 km long and the south branch approximately 8 km long (Diggins and Kershner 2005). The canyon is walled by impressive 60 to 90 degree cliffs in some areas (Diggins and Kershner 2005). In many areas, however, more modest slopes range from 20 to 60 degrees (Diggins and Kershner 2005). Slopes in this range are able to support trees and are the area in which the canyon-slope forests are found. These canyon-slope forests can greatly vary from one area to another due to the effects of orientational aspect and elevation. These differences include species composition and tree density and canopy height.

Profile locations

The following map of Zoar Valley (fig. 2) shows the locations of the 8 vertical profiles used in this study. Four of these were on south facing slopes and are labeled with numbers (1-4) and run from west to east. The 4 north facing profiles are labeled with letters (A-D) and also run from west to east.

Figure 1- study area

Figure 2- profile locations



Data collection and analysis

This study used vertical profiles to catalogue the trees of the slopes. These vertical profiles were approximately twenty meters wide and ran from the base of the slope at the terraces to the top of the slope. Several of these vertical profiles were taken as randomly as possible from both the north facing and south facing slopes, but a fully random design was not possible due to the dangerous nature of the terrain. A total of 8 vertical profiles were taken. Four of these were on south facing slopes and four were on north facing slopes. Data were collected in the vertical profiles by visually identifying and cataloguing trees from vantage points scanning either up or down the slope. Slopes were either ascended or descended to the vantage points taking the safest possible route. The vertical heights of vantage points above terrace level (or above or below another vantage point) were obtained by sine triangulation using a laser range finder and a clinometer. The angle of slope in each section was found using a clinometer. The straight-line distance from the vantage point to each tree in the section was measured with a range finder. The vertical height above terrace level for each tree was obtained by triangulation of the distance and slope. In addition to vertical position, the species and size class for each tree were also recorded. Because most trees could not be physically reached and measured, four qualitative categories were used for size class: understory, midstory, canopy, and emergent. The understory class was omitted from the final data set as this study focuses on reproductively mature trees.

In order to statistically compare different landforms in Zoar Valley with regard to tree species composition NMDS (Non-metric Multidimensional Scaling) ordination was used. Comparisons were made with data obtained on slope tree distributions obtained in the present study. The data for comparisons with canyon bottom tree communities was obtained from Diggins unpublished data (floodplains) and Diggins and Kershner 2005 (terraces). This statistical method is often used when comparing ecological data as seen here. It is considered reliable when analyzing indirect gradients of species distributions as seen in this data set. It is said to be robust in the face of non-monotonic data distributions (Diggins and Newman 2009). NMDS was used to create ordinations and identify patterns of similarity or dissimilarity in different slope tree communities and between tree communities in the slopes with those in the canyon bottoms. Ordination figures were created using this method to accomplish this goal.

RESULTS

List of trees in this study

Abbreviation	**Common name**	**Scientific name** (from Rhoads and Block 2007)
ACNE*	boxelder (ashleaf maple)	*Acer negundo* L.
ACRU	red maple	*Acer rubrum* L.
ACSA	sugar maple	*Acer saccharum* Marsh.
ALRU*	speckled alder	*Alnus rugosa* (Du Roi) Spreng.
AMAR	downy serviceberry	*Amelanchier arborea* (Michx. f.) Fern.
BEAL	yellow birch	*Betula alleghaniensis* Britton (*B. lutea* Michx. f.)
BELE	sweet birch	*Betula lenta* L.
CACA	American hornbeam	*Carpinus caroliniana* Walt.
CACO	bitternut hickory	*Carya cordiformis* (Wang.) K. Koch
CAOV	shagbark hickory	*Carya ovata* (Mill.) K. Koch
COFL*	flowering dogwood	*Cornus florida* L.
FAGR	American beech	*Fagus grandifolia* Ehrh.
FRAM	white ash	*Fraxinus americana* L.
HAVI	witch hazel	*Hamamelis virginiana* L.
JUNI	black walnut	*Juglans nigra* L.
JUVI	eastern redcedar	*Juniperus virginiana* L.
LITU	tuliptree	*Liriodendron tulipifera* L.
MAAC	cucumber magnolia	*Magnolia acuminata* L.
OSVI	eastern hop hornbeam	*Ostrya virginiana* (Mill.) K. Koch

PIRE	red pine	*Pinus resinosa* Ait.
PIST	eastern white pine	*Pinus strobus* L.
PLOC*	American sycamore	*Platanus occidentalis* L.
PODE*	cottonwood	*Populus deltoides* Marsh.
POGR	bigtooth aspen	*Populus grandidentata* Michx.
POTR	quaking aspen	*Populus tremuloides* Michx.
PRSE	wild black cherry	*Prunus serotina* Ehrh.
QUAL	white oak	*Quercus alba* L.
QUCO	scarlet oak	*Quercus coccinea* Muenchh.
QUPR	chestnut oak	*Quercus prinus* L.
QURU	northern red oak	*Quercus rubra* L.
ROPS	black locust	*Robinia pseudoacacia* L.
SANI*	black willow	*Salix nigra* Marsh.
TIAM	American basswood	*Tilia americana* L.
TSCA	eastern hemlock	*Tsuga canadensis* (L.) Carr.
ULAM*	American elm	*Ulmus americana* L.
ULRU	red elm	*Ulmus rubra* Muhl.

*not found in slope profiles but present in canyon bottom

Note: *Acer pensylvanicum* L. found in slope profiles but only in understory

Whole slope profiles

The data in figures 3-10 show graphically the trees that were catalogued on the slopes. The most abundant or habitat specific trees are shown. Figures 3-6 show the data that were collected from south facing slopes, while figures 7-10 show the profiles that represent the north facing slopes. Each figure represents a separate vertical profile, which were 20 m wide and ran from the crest of the slope down to the point at which it meets the terrace. Each tree counted and identified in the profiles represents a reproductively mature individual in the midstory or canopy. Each profile was divided into 10 meter intervals in ascending elevation above terrace level. Twenty-nine tree species were found as mature trees in the 8 vertical profiles.

The five most abundant tree species on each slope ranged from 75-90 % of total mature individual trees on the individual slopes. The tree species that were most abundant (top 5) on at least one slope were *Acer rubrum, Acer saccharum, Betula alleghaniensis, Carya cordiformis, Fagus grandifolia, Fraxinus americana, Liriodendron tulipifera, Populus grandidentata, Quercus prinus, Quercus rubra, Tilia americana, and Tsuga canadensis* (Appendix A-1 to A-8). Of these, four species stood out in their abundance on the whole slope profiles. These species were *Acer saccharum, Quercus prinus*, *Quercus rubra*, and *Tsuga canadensis.* These were the only species to be at least 25% of the trees in a slope for a single species. Combined, these four species comprised 65-83% of the trees catalogued in the whole slope profiles. The most abundant species in all but one of the south facing profiles was either *Quercus prinus* (profiles 2 and 3, figs. 4 and 5) or *Quercus rubra* (profile 4, fig. 6), while profile 1 (fig. 3) had *Acer saccharum* as most abundant with *Quercus prinus* second. The most abundant species on all the north facing profiles was either *Acer saccharum* or *Tsuga canadensis*. They each were most abundant on two profiles (*Acer saccharum* on profiles B and C, figs. 8 and 9, and *Tsuga canadensis* on profiles A and D, figs. 7 and 10). Every profile but one (profile A) had the other species as second most abundant.

Slopes compared with upper and lower divisions

Species distributions and abundances were found to differ in different sections of the slopes. The slopes were divided into different sections according to orientation and elevation. Figures 3-10 show typical tree distributions with increasing elevation in the surveyed slope profiles. Figures 3-6 show the south facing and figures 7-10 show the north facing profiles. The four divisions of the slopes were south facing upper, south facing lower, north facing upper, and north facing lower. The upper and lower divisions were made at the midpoint in elevation of each slope. Tree species abundances were found to differ among different sections of the slopes. Appendix B-1 to B-8 show tree distributions based on these divisions.

Both the north and south facing lower slopes were quite similar in tree community composition. The most abundant species in each of the lower slope profiles ranged from 26-55% of total trees in that profile. *Acer saccharum* was most abundant in the majority of the lower slope profiles (5 of 8 profiles: 1, 4, B, C, D, figs. 3, 6, 8, 9, 10), with three being north facing and two being south facing. *Tsuga canadensis* was most abundant in two lower slope profiles, one north (profile A, fig. 7) and one south (profile 2, fig. 4) facing. The remaining south facing lower slope (profile 3, fig. 5) had *Fagus grandifolia* as the most abundant species. However, all three species were present in all eight lower slope profiles. Though less frequently found, *Acer rubrum, Betula alleghaniensis, Carya cordiformis, Fraxinus americana, Ostrya virginiana,* and *Tilia americana* were found on some lower slope profiles on both the north and south facing sides. Some small differences were observed between the lower slopes of different aspect*. Liriodendron tulipifera* was present, though infrequent, on all north facing lower slope profiles and absent on all those facing south. *Quercus prinus* and *Quercus rubra* were more common (though not necessarily abundant) on the south facing lower slope profiles then on their north facing counterparts.

The upper south facing slopes in Zoar Valley differ significantly from the other slope tree communities. In 3 of the 4 south facing upper profiles (profiles 2, 3, and 4) more than 50% of the trees were *Quercus prinus* and *Quercus rubra*, with *Quercus prinus* most abundant in two south facing upper profiles (profiles 2 and 3, figs. 4 and 5) and *Quercus rubra* in one (profile 4, fig. 6). In the remaining south facing upper profile (profile 1, fig. 3) *Acer saccharum* was the most abundant with *Quercus prinus* second. This was one of the lowest of the south facing slopes, which may have been a factor in this difference. In the other 3 south facing upper profiles *Acer saccharum* was infrequent or absent. *Tsuga canadensis* was infrequent or absent in all 4 of these profile sections. Though infrequent, *Pinus resinosa* was found on 3 of these sections (all but profile 1) and was only found on the upper south facing slopes, usually near the crest of the slope.

By far the most abundant species in the upper north facing slope profiles was *Tsuga canadensis* (figs. 7-10). Its abundance ranged from 44-62% of total trees in the north facing upper profiles and was most abundant in all four. *Acer saccharum* was found on all four of these upper north facing profile sections, but was considerably less abundant than on the lower sections of these slopes. Its abundance on the north facing upper profiles ranged from 5-20%. *Fagus grandifolia* was also found on all four upper north facing profiles and its abundance was less than 10% on only one (profile D). Though infrequent, *Ostrya virginiana* and *Betula alleghaniensis* were found in all four upper north facing slope profiles.

Comparisons and relationships among all landforms

Figures 11-15 show NMDS ordination plots of the four slope community types (south facing lower, south facing upper, north facing lower, north facing upper) and the floodplain and terrace (canyon bottom) community types. These plots show how similar or dissimilar different communities are, with closer points being more similar. Figures

11-15 show which communities are the most similar in ordination space. The north and south facing lower slopes, terraces, and floodplains are all fairly similar in tree community composition and are loosely clustered in ordination space. Terraces and floodplains seem to be more similar to each other than either is to the lower slopes (figure 14). Some species, including *Populus deltoides, Platinus occidentalis*, and *Robinia pseudoacacia*, are essentially absent from the slopes, but present in the terraces and especially floodplains which results in their increased similarity and slight differences when compared with the lower slopes. However, all lower slopes, floodplains, and terraces, in most cases, have *Acer saccharum* as their most abundant species and may result in all these community types being similar, loosely clustered in ordination space (figure 15).

The slope communities seem to diverge from the canyon bottom communities in ordination space. This is most evident on the upper slopes. The upper slopes diverge from the other tree communities in Zoar Valley, with the south facing upper slopes being most divergent as they are furthest from any other landforms in NMDS ordination space. Figures 11 and 13 show how the upper slopes diverge from their lower slopes, which are fairly similar to canyon bottom landforms. The north and south facing upper slopes also diverge from one another, also seen in figures 12 and 13. These divergences in the slopes seem to reflect both aspect and elevation. South and north facing slopes diverge along separate axes at nearly a right angle. Also, upper slope profiles are further out in ordination space along these axes then lower slope profiles are.

Figures 16-19 show the three main axes along which the various tree communities align. Figure 17 shows the axis that the north facing slopes tend to follow, with the most influential species being *Tsuga canadensis*. The upper north facing profiles align furthest out along this axis, showing that they diverge from their lower sections. The south facing slopes are highlighted in figure 18, with the upper portions of these slopes most divergent along the axis and most influenced by *Quercus prinus, Quercus rubra*, and *Pinus resinosa*. The lower slopes, terraces, and floodplains, most influenced by *Acer saccharum*, are shown in figure 19. These communities form a loose cluster around this axis, showing that they may share similarities in tree community composition.

Figures 3-10 show slope profile tree distributions with increasing elevation

Figure 3

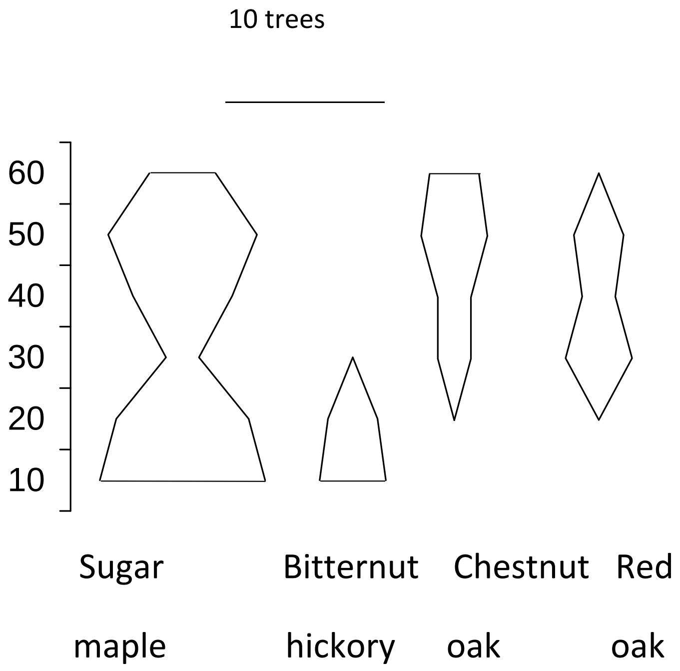


Figure 3 shows a graphic representation of tree community shifts with elevation on south facing profile 1.

Figure 4

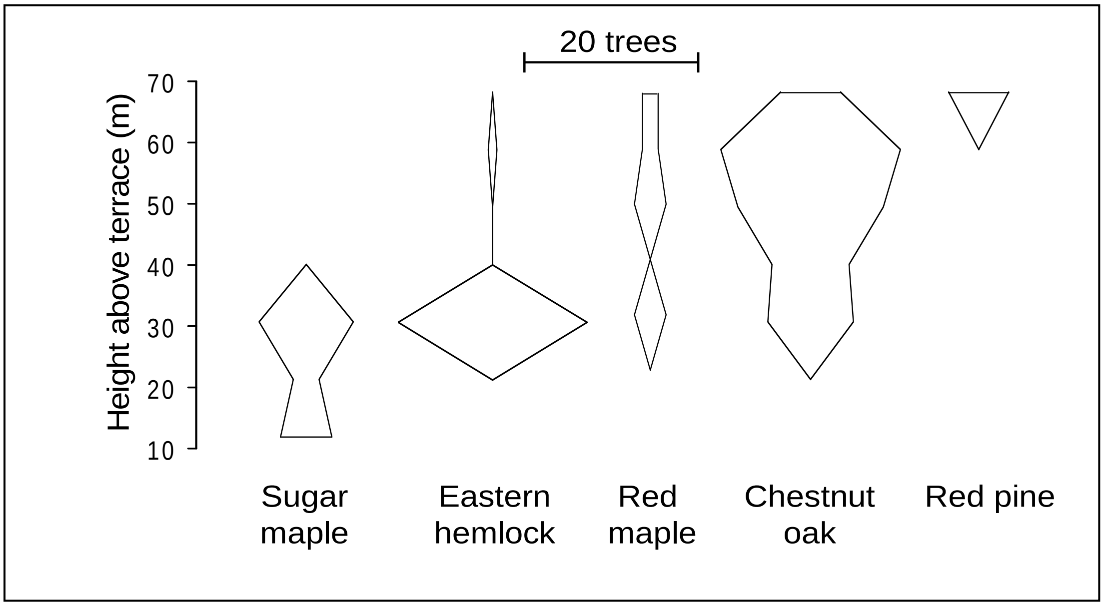


Figure 4 shows a graphic representation of tree community shifts with elevation on south facing profile 2.

Figure 5

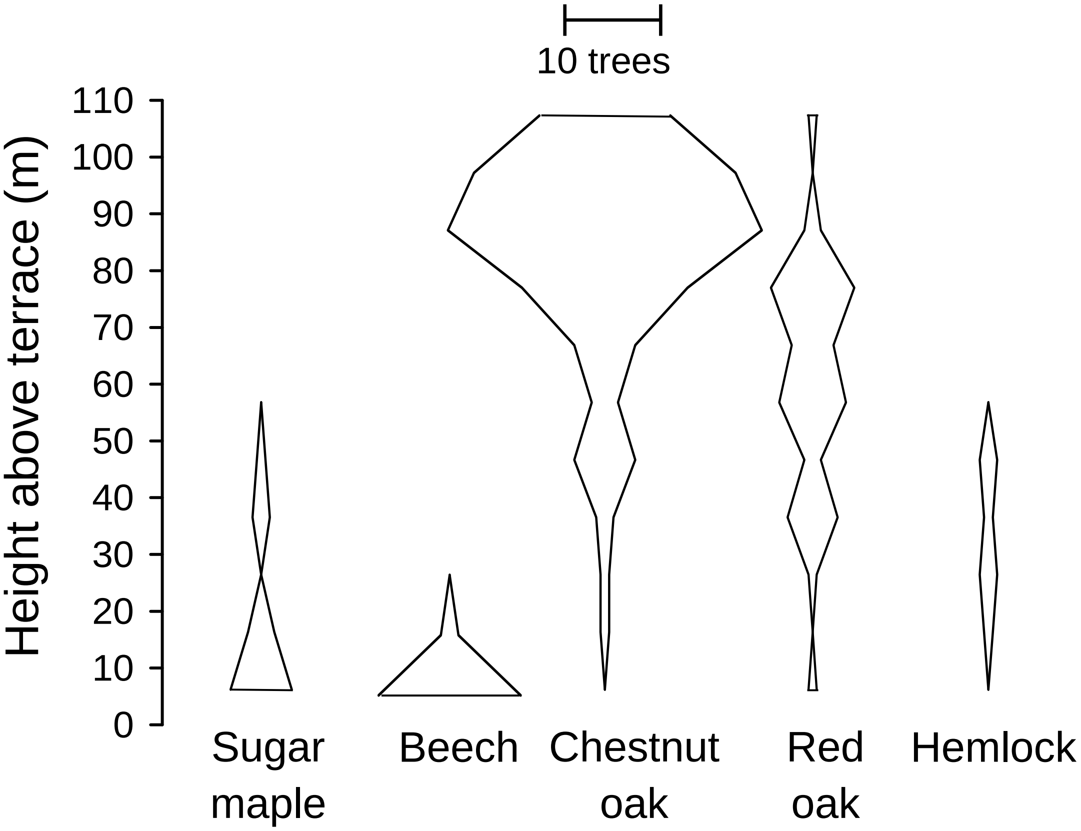


Figure 5 shows a graphic representation of tree community shifts with elevation on south facing profile 3.

Figure 6

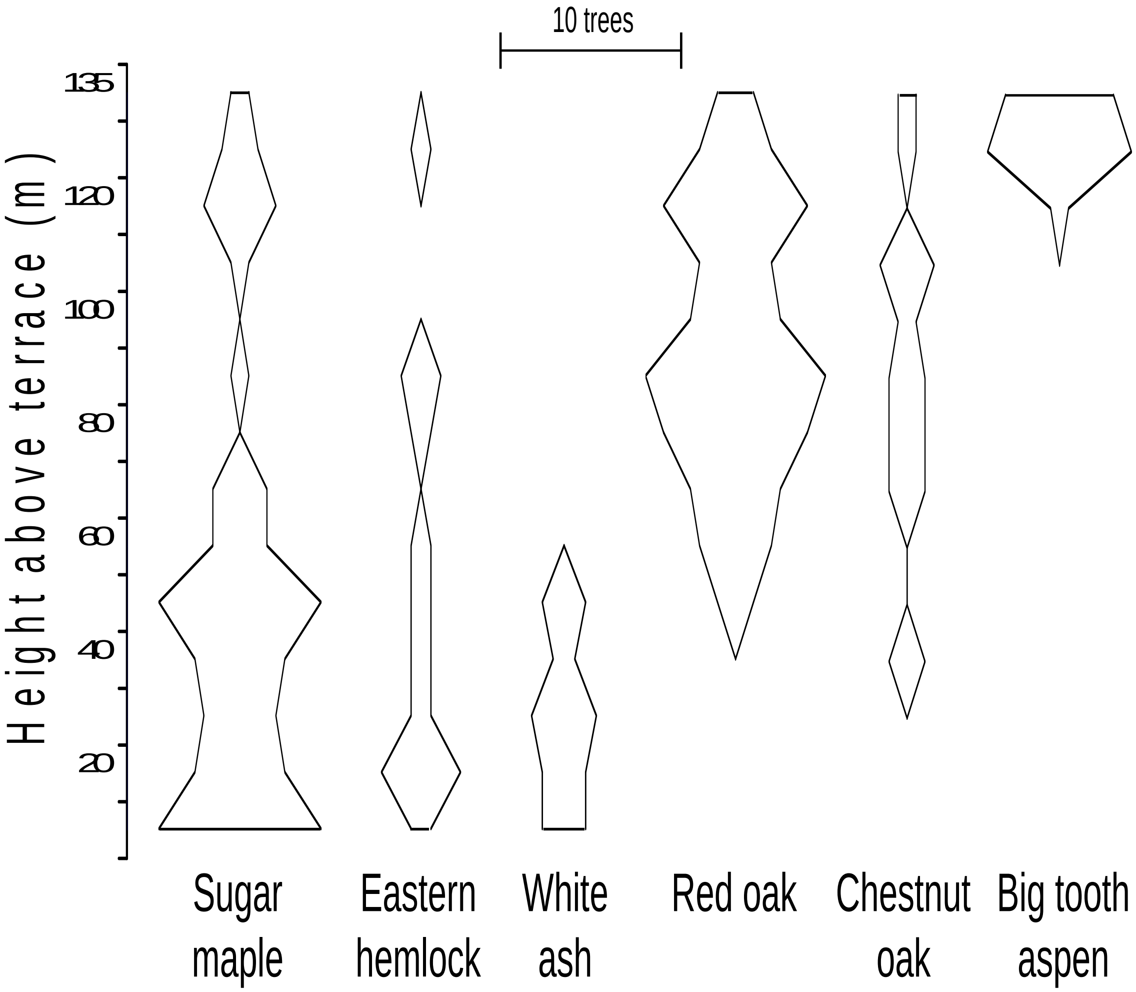


Figure 6 shows a graphic representation of tree community shifts with elevation on south facing profile 4.

Figure 7

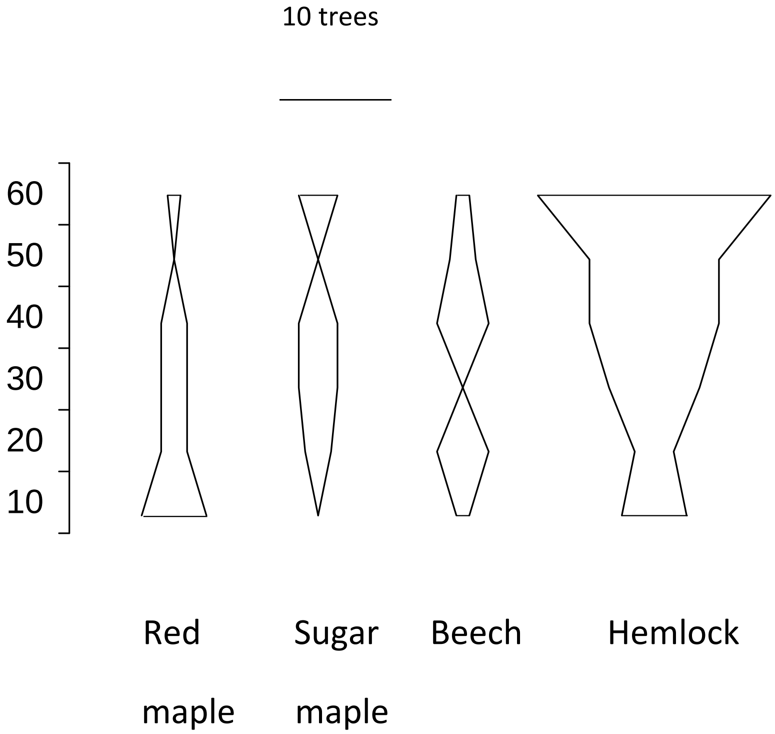


Figure 7 shows a graphic representation of tree community shifts with elevation on north facing profile A.

Figure 8

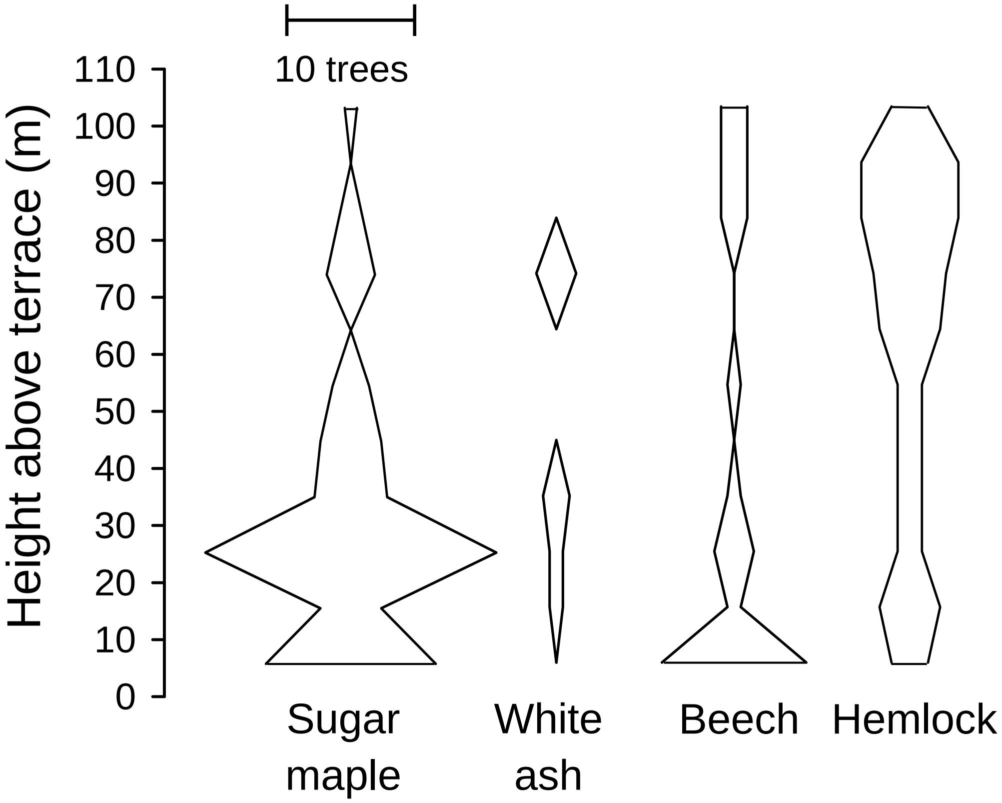


Figure 8 shows a graphic representation of tree community shifts with elevation on north facing profile B.

Figure 9

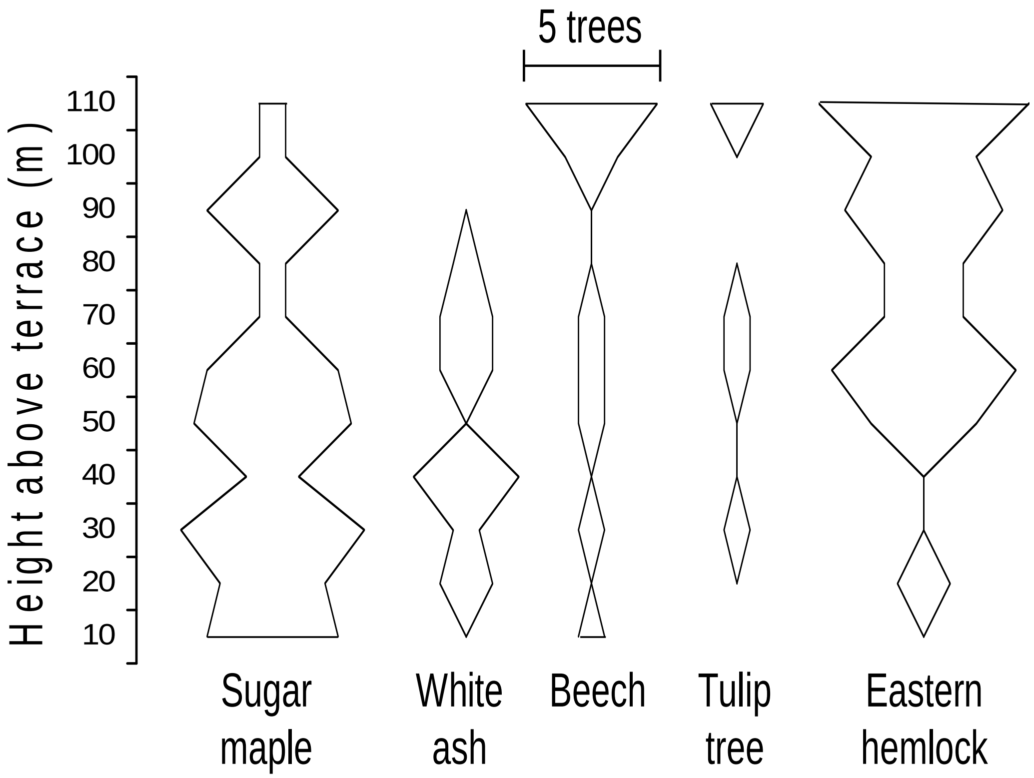


Figure 9 shows a graphic representation of tree community shifts with elevation on north facing profile C.

Figure 10

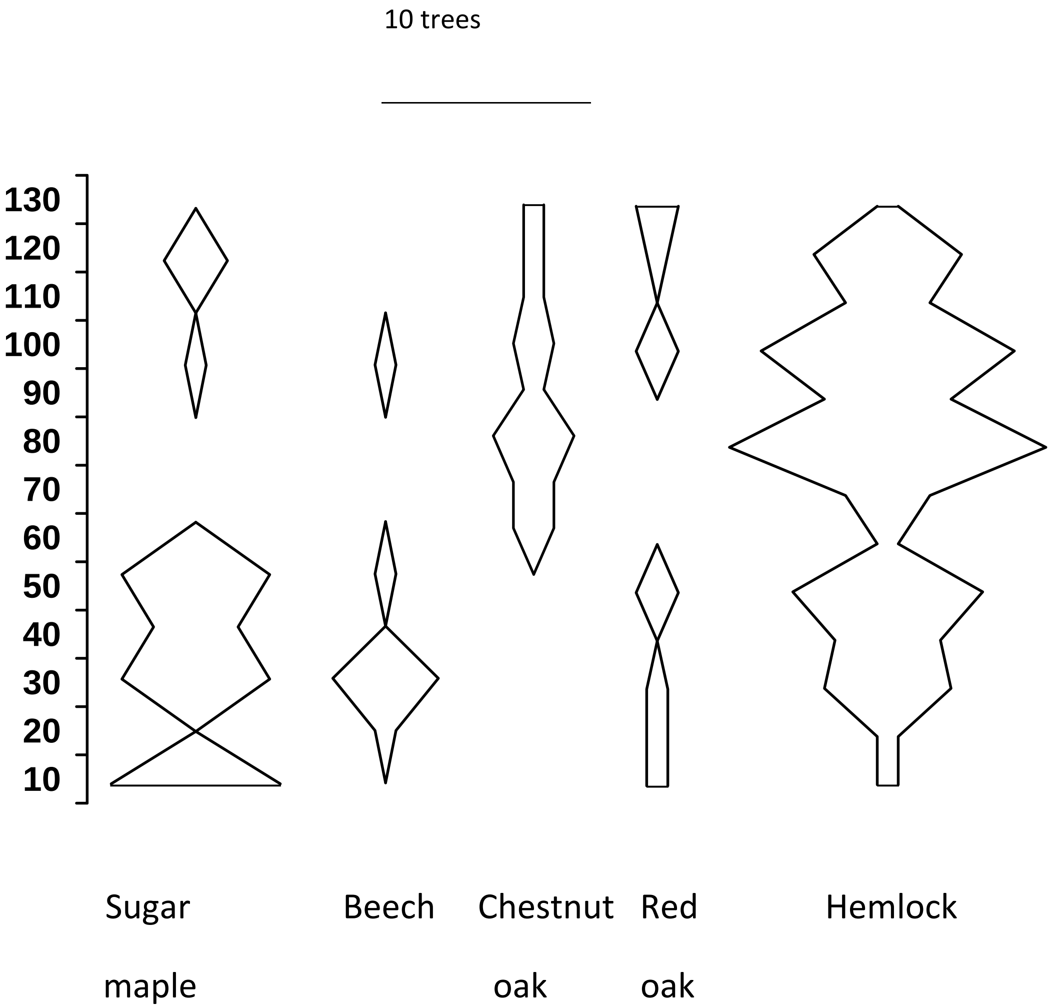


Figure 10 shows a graphic representation of tree community shifts with elevation on north facing profile D.

Figures 11-19 show NMDS ordination plots comparing the different landforms

Figure 11

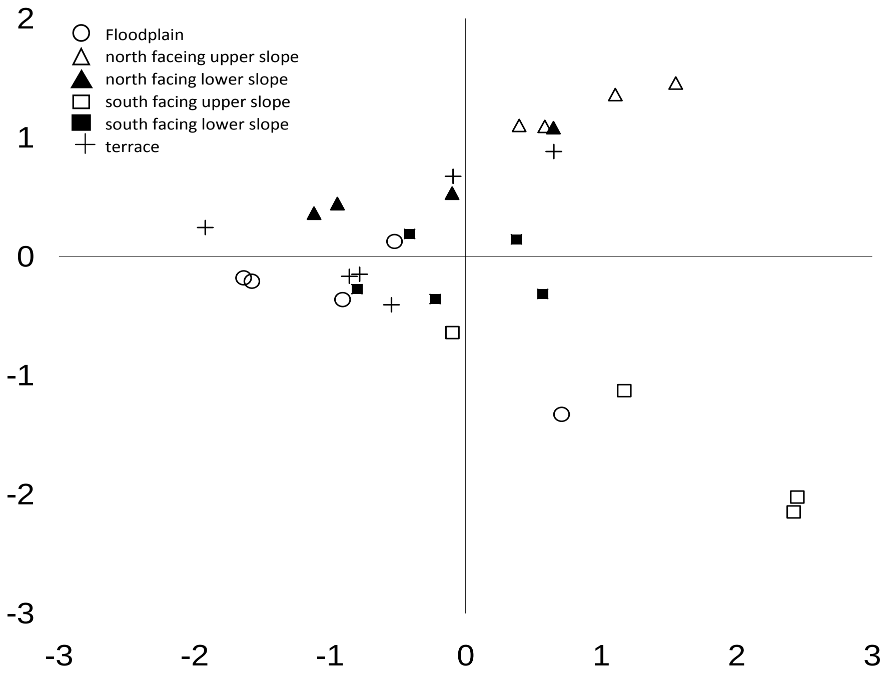


Figure 11 shows an NMDS ordination plot of the slope and canyon bottom landforms in Zoar Valley.

Figure 12

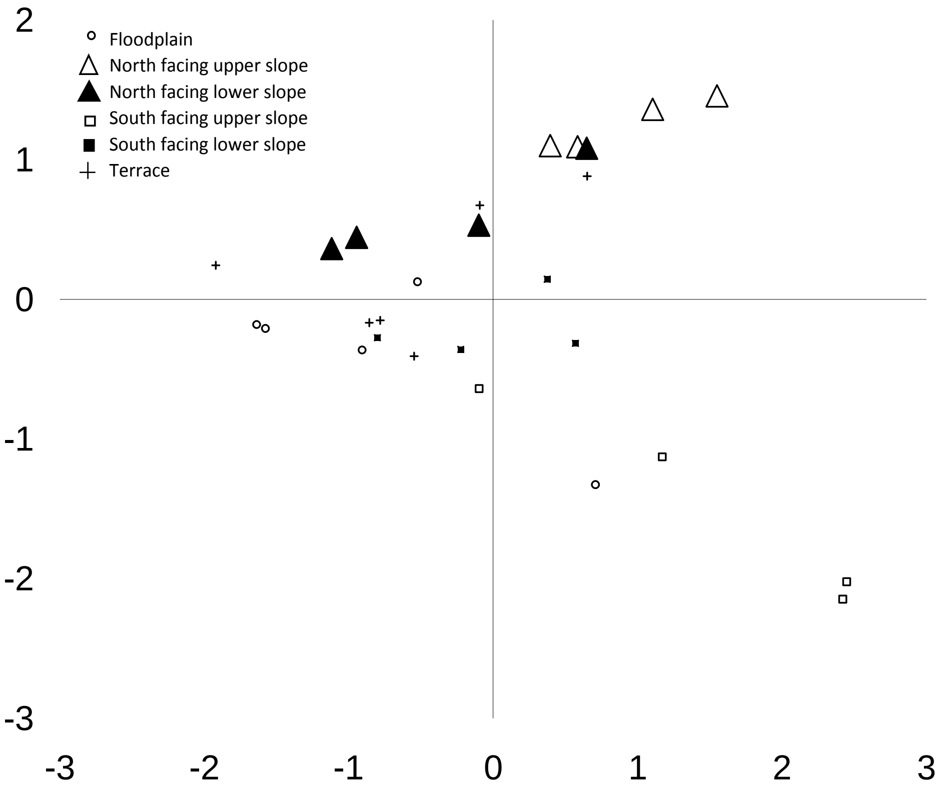


Figure 12 shows an NMDS ordination plot of the landforms in Zoar Valley with the north facing slopes highlighted.

Figure 13

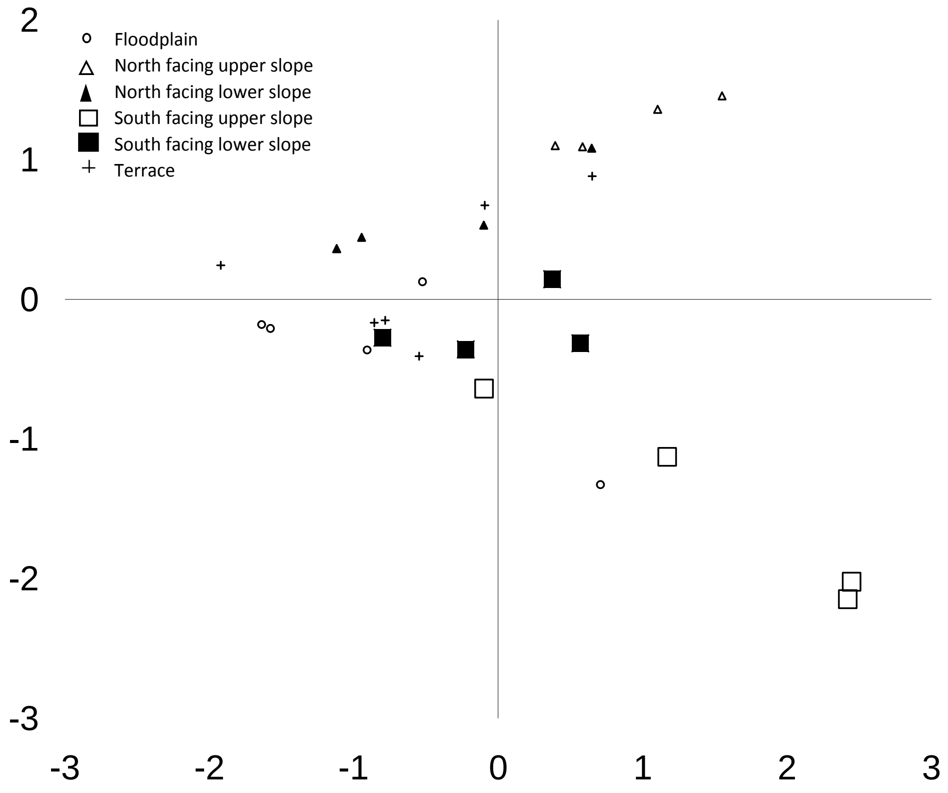


Figure 13 shows an NMDS ordination plot of the landforms in Zoar Valley with the south facing slopes highlighted.

Figure 14

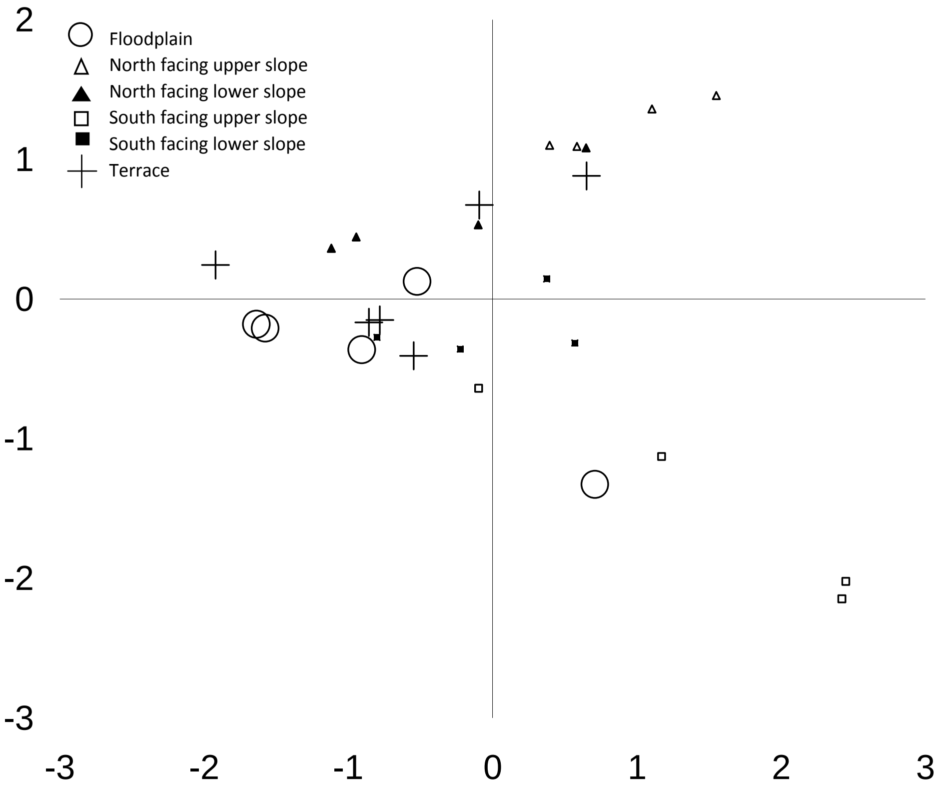


Figure 14 shows an NMDS ordination plot of the landforms in Zoar Valley with the terraces and floodplains highlighted.

Figure 15

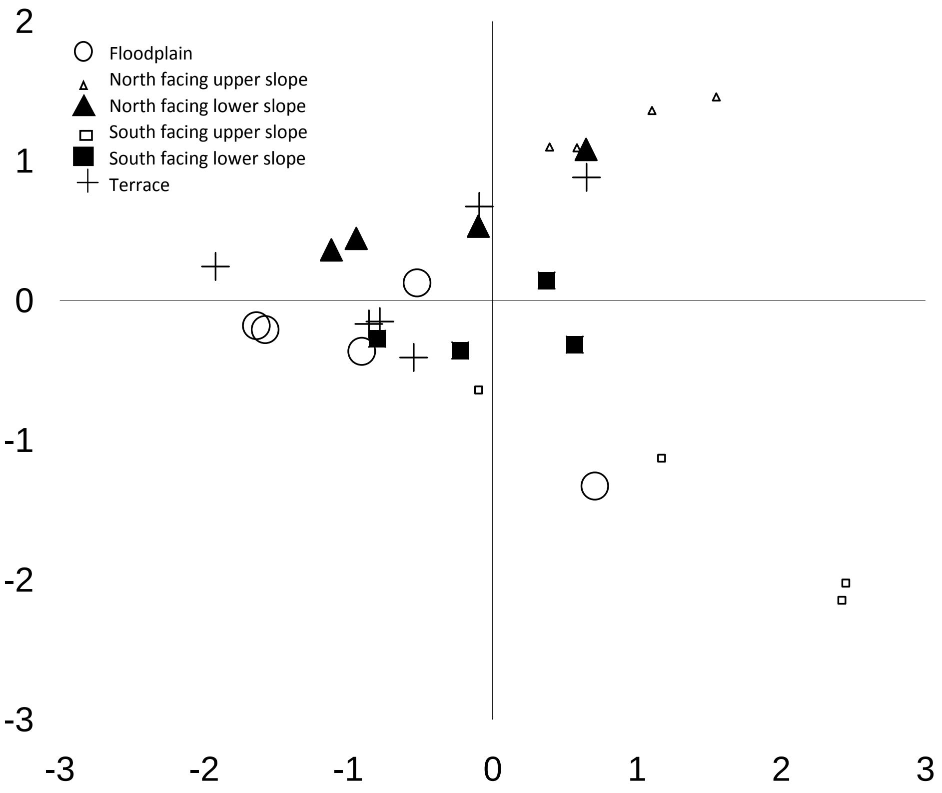


Figure 15 shows an NMDS ordination plot of the landforms in Zoar Valley with the lower slopes, terraces, and floodplains highlighted.

Figure 16

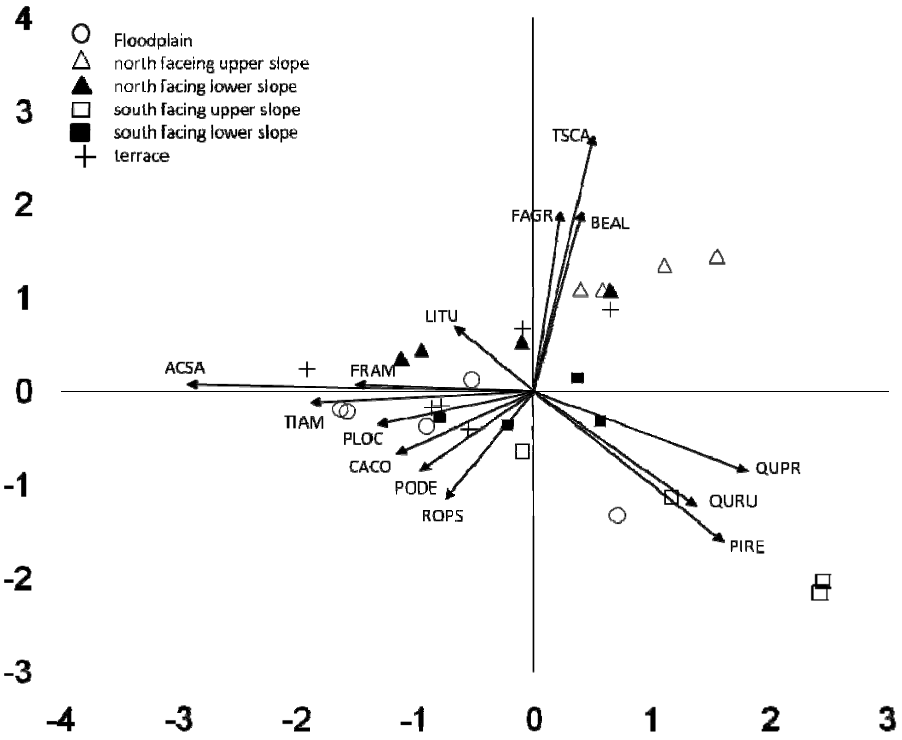


Figure 16 shows the various landforms in NMDS ordination with axes representing the most frequent tree species.

Figure 17

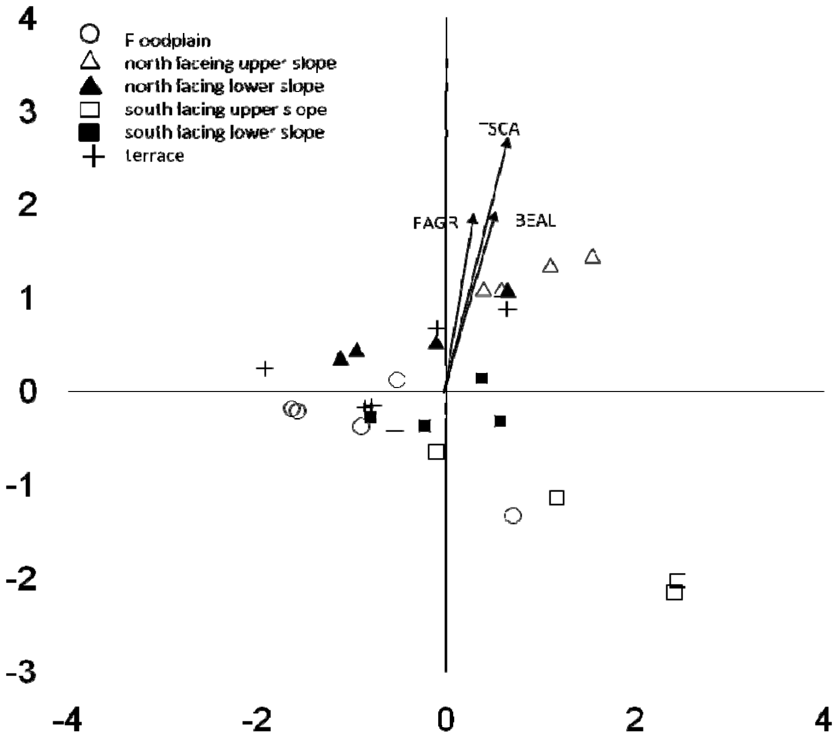


Figure 17 shows the various landforms in NMDS ordination with the tree species that are most influential in the upper north facing slope community shown as axes.

Figure 18

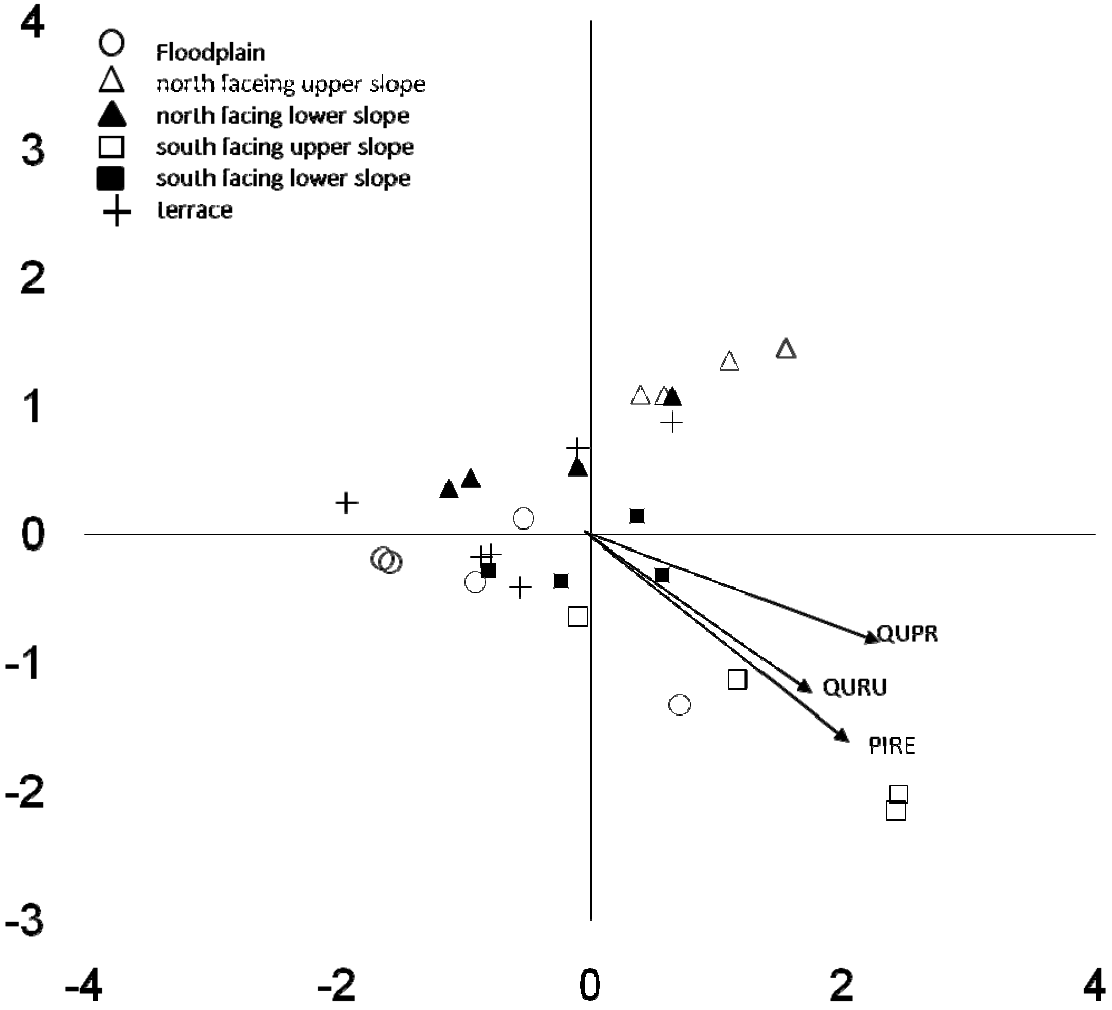


Figure 18 shows the various landforms in NMDS ordination with the trees most influential in the upper south facing slope community shown as axes.

Figure 19

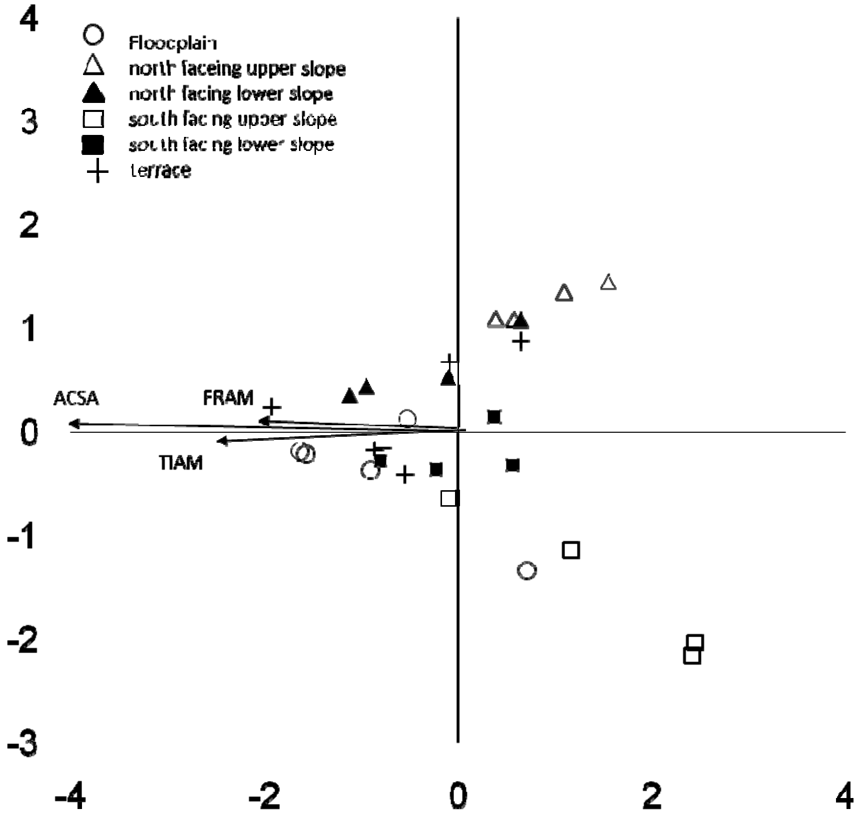


Figure 19 shows the various landforms in NMDS ordination with typically abundant lower canyon species shown as axes.

DISCUSSION

Slope orientation and elevation effects on tree community composition

As suggested by the results, orientation (aspect) clearly has an influence on tree community composition on the slopes of Zoar Valley. As hypothesized, substantial differences were observed between south facing and north facing slopes. These differences were most pronounced on the upper portions of the slopes. As expected, tree communities on the south facing slopes (especially upper sections) displayed generally xeric tree communities. Oaks (*Quercus prinus* and *Quercus rubra*) were typically most abundant, with *Pinus resinosa* present in considerable numbers in a few spots. These species are shade intolerant and fairly well adapted to sunnier and drier (xeric) conditions, often seen on south facing slopes (Burns and Honkala 1990). Also, trees on the south facing upper slopes were often stunted with much reduced canopy heights (5-15 m) then that was found in other areas.

North facing slopes, in contrast, showed considerably more mesic characteristics. *Acer saccharum* and *Tsuga canadensis* were typically most abundant on the north facing slopes. These trees are shade tolerant and generally better adapted to shadier and slower drying conditions (Burns and Honkala 1990). Also, only a slight reduction in canopy heights was observed on the upper north facing slopes, with canopy heights of approximately 25 m.

Several different environmental factors are known to change in topographically complex locations as seen here. Some of these major influences include soil and air temperature, evaporation rate, daily insolation, wind velocity, soil type, and atmospheric moisture, as demonstrated by Wolfe *et. al*. 1949 and Cantlon 1953 in the Central Appalachians and Central Hardwoods Region. Daily insolation seems to be an especially important factor in community composition on slopes of differing aspect, and can affect moisture and temperature gradients in sloped environments in riparian systems. Similar studies have been done on herbaceous understory species in temperate deciduous environments with topographical variation, and similar slope affected distributions (as with tree species) were found (Albrecht and McCarthy 2009; Small and McCarthy 2005). This research, done in temperate deciduous forests in southern Ohio, found that understory herb communities shift with changing moisture gradients associated with topographical change. This work suggested that other environmental variables (light and nutrient availability, soil type) also vary with topographical gradients, and can affect herbaceous species distributions (Albrecht and McCarthy 2009; Small and McCarthy 2005). In the present study, these changes were observed in the tree communities of a riparian old growth forest. These environmental influences (insolation, moisture availability, soil conditions) are speculated to be major factors in the differences in tree community composition seen between south and north facing slopes in Zoar Valley.

On both the south and north facing slopes elevational change had an influence on tree community composition. Elevational shifts in tree community composition were evident on both south and north facing slopes, although, different community shifts were observed on the north facing as opposed to south facing slopes. Some species increased while others decreased in their abundance with increasing elevation on the canyon-slopes of Zoar Valley. Shifts in abundance from *Acer saccharum, Tsuga canadensis*, and *Fagus grandifolia* to *Quercus prinus* and *Quercus rubra* were usually observed on south facing slopes. On north facing slopes, shifts from *Acer saccharum* to strong abundance of *Tsuga canadensis* was usually seen.

This suggests that elevation, in addition to aspect, has an influence on forest tree community structure. A number of environmental factors (insolation, water availability, soil conditions) change with increasing height of a slope. Higher slopes tend to have quicker runoff and are quicker to dry then lower slopes, regardless of aspect. For example, in a study done in southern Ohio (Waterloo Wildlife Research Station) Rubino and McCarthy 2003 found that tree communities changed with increasing slope elevation on both north and south facing slopes. With increasing slope height microenvironments often change. Changes in leaf litter depth and nitrogen content can also vary with slope height and steepness (Frelich *et. al.* 1993; Small and McCarthy 2002). This can affect the germination and survival of tree seedlings and whether they can become established in a specific community. A combination of these factors might explain the tree community with elevation changes as observed here.

Slope orientation and elevation both appear to affect tree community composition on the forested canyon-slopes of Zoar Valley. Since both are speculated to affect water retention (mainly by insolation and runoff, respectively) they appear to have combined effects on the tree communities of the slopes. Although tree communities change with elevation on north facing slopes (*Acer saccharum* lower, *Tsuga canadensis* upper as most abundant) they are dominated by mesic communities from top to bottom. However, it was where insolation and elevation are both highest (upper south facing slopes with stunted, partially open canopies) that xeric communities were predominant.

Distinct relationships can be seen between the profiles of the slopes with the same and different aspects. The slope profiles (north facing and south facing) align along two distinct axes in NMDS ordination space. These alignments show that orientation and elevation likely influence tree community composition in the slope profiles. The two axes, approximately at right angles from each other, indicate the affect that orientation has on the slope tree communities. This divergence between the two axes suggests that environmental factors associated with different slope orientation, mainly insolation and water retention, may influence tree community composition. The north and south facing slopes most strongly diverge in NMDS ordination space from one another in their upper portions. This suggests that these environmental influences may increase with increasing elevation in this system.

Slope, terrace, and floodplain comparisons and possible interrelationships

In a riparian system there are many varied and complex habitats in close proximity to one another. River dynamics (erosion and deposition) create floodplains and terraces of varying ages which help to create habitat complexity in the canyon bottoms (Naiman *et. al*. 2000; Van Pelt *et. al*. 2006). In addition to this, topographical complexity (orientation, steepness, elevation) creates a mosaic of habitats in the canyon slopes (Rubino and McCarthy 2003). Such a situation provides more opportunity for different habitats to interact than in less varied environments. Due to these varied habitats there is often fairly high species diversity in riparian zones (Naiman and Decamps 1997; Robertson *et. al.* 1978). In Zoar Valley, as in many riparian systems, there are floodplains and raised terraces at the canyon bottom which vary in age and successional development. There are also the canyon-slopes above these landforms. In this study several interesting similarities and differences were observed among the different landforms.

The terraces, floodplains, and lower slopes were compared using NMDS ordination. These are the landforms which are mesic in nature and usually have *Acer saccharum* as the most abundant species. A loose clustering can be seen of these landforms suggesting that they are fairly similar in tree community composition. However, closer associations appear to be between the terraces and floodplains (when lower slopes are omitted), suggesting that these canyon bottom landforms have similar tree community structure. Close associations can also be seen in the two groups of lower slopes (north and south facing) with those of like aspect when canyon bottom landforms are omitted. The lower south facing slopes are shown to group together quite well in ordination space. The lower north facing slopes also form a fairly tight group. Canyon bottom landforms (terraces and floodplains), lower north facing slopes, and lower south facing slopes all appear most similar with those of like type in ordination space. However, there is overlap among terraces, floodplains, and lower slopes in ordination space suggesting that they all share some similarities in tree community composition.

The terraces and floodplains, though of varying ages, are both flat areas in the canyon bottom, likely resulting in some of their similarity. Another reason that they would be similar is that the terraces began their existence as floodplains and are likely a later successional stage (Van Pelt *et. al*. 2006). In contrast, the lower slopes are not successionally connected to the floodplains and terraces, and are not later stages of either. They also have a slope profile as opposed to lying flat like the canyon bottom landforms, which may result in different water retention properties (Rubino and McCarthy 2003). However, all of these landforms (terraces, floodplains, and all lower slopes) are relatively low in the canyon and thus support mesic species. Despite the differences mentioned above, the canyon bottom and lower slope landforms seem to share much species composition.

A number of factors may explain the similarity among some of the landforms in this canyon system. In riparian systems, floodplains successionally progress to terraces while propagules from terraces reach the floodplains. This might result in cyclic interactions between these landforms. The slopes may also influence floodplain and terrace development by providing propagules. The diversity and complexity of these landforms can create multiple pathways and interactions (Naiman and Decamps 1997; Rubino and McCarthy 2003).

The colonization and development of the riparian floodplains in Zoar Valley is most likely influenced by multiple factors. Recipient habitat characteristics and external propagule pressures likely both influence which species colonize the floodplains. Several factors may explain the similarity between floodplains and terraces. These factors likely include terrace propagules are reaching the floodplains, terraces and floodplains share a similar habitat, and terraces are a latter successional stage of the floodplains and likely retain some of the same characteristics.

However, some evidence suggests that slopes, especially lower, may affect terrace and floodplain development. NMDS ordination shows considerable overlap among terraces, floodplains, and lower slopes. In addition to this, two of the terraces appear to be aligning with the north facing lower slopes. Also, late successional species such as *Acer saccharum* and *Tsuga canadensis* are present on the floodplains used in this study. Upper slopes, especially south facing, appear to be strongly divergent from floodplains and terraces and thus may not affect their development. Habitat differences between the upper slopes and the canyon bottoms very considerably and probably preclude such xeric species as *Quercus prinus* from establishing on the floodplains. Floodplain development in Zoar Valley appears to be influenced by multiple pathways, including riparian dynamics, habitat characteristics, and propagule dispersal. These factors all may interact to influence floodplain colonization and development in this system.

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Appendix A Slope Profile Tree Data (ranked in decreasing abundance)

A-1   slope-1 south facing

10-m intervals

Hgt. (upper bound)	ACSA	QUPR	QURU	CACO	TIAM	OSVI	FRAM	ROPS	TSCA	ULRU	FAGR	PRSE	CACA	JUNI	POGR	Total trees
62	4	3	0	0	1	5	1	2	0	1	1	2	0	0	0	
50	9	4	3	0	1	0	0	1	1	0	0	0	1	1	1	
40	6	2	2	0	0	0	1	0	0	0	0	0	0	0	0	
30	2	2	4	0	0	0	1	0	0	0	0	0	0	0	0	
20	8	0	0	3	2	0	0	0	2	1	1	0	0	0	0	
10	10	0	0	4	2	0	0	0	0	1	0	0	0	0	0	
SUM	39	11	9	7	6	5	3	3	3	3	2	2	1	1	1	96
PROPORTION	0.41	0.11	0.09	0.07	0.06	0.05	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	

A-2 slope-2 south facing

10-m intervals **Hgt. (upper bound)**	QUPR	TSCA	ACSA	ACRU	QURU	PIRE	AMAR	CAOV	FAGR	HAVI	OSVI	TIAM	Total trees
65	**7**	0	0	**2**	0	**7**	**1**	0	0	0	0	0	
60	**21**	**1**	0	**2**	0	0	0	0	0	0	0	0	
50	**17**	0	0	**4**	**5**	0	**4**	0	0	**1**	0	0	
40	**9**	0	0	0	0	0	0	0	0	0	0	0	
30	**10**	**22**	**11**	**4**	**4**	0	0	**1**	0	0	0	0	
20	0	0	**3**	0	**1**	0	0	0	0	0	0	**1**	
10	0	0	**6**	0	0	0	0	0	**1**	0	**1**	0	
SUM	**64**	**23**	**20**	**12**	**10**	**7**	**5**	**1**	**1**	**1**	**1**	**1**	**146**
PROPORTION	**0.44**	**0.16**	**0.14**	**0.08**	**0.07**	**0.05**	**0.03**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	

A-3 slope-3 south facing

10 m intervals

Hgt. (upper bound)	QUPR	QURU	FAGR	ACSA	AMAR	HAVI	ACRU	PIRE	TSCA	QUCO	PIST	OSVI	Total trees
110	15	1	0	0	1	4	4	0	0	0	0	0	
100	30	0	0	0	1	1	2	1	0	0	1	0	
90	36	2	0	0	3	0	0	2	0	0	1	0	
80	19	10	0	0	0	0	0	3	0	0	0	0	
70	7	5	0	0	0	0	0	0	0	0	0	0	
60	3	8	0	0	1	0	0	0	0	0	0	0	
50	7	2	0	1	0	1	0	0	2	0	0	0	
40	2	6	0	2	0	1	0	0	1	0	0	0	
30	1	1	0	0	2	0	0	0	2	3	0	0	
20	1	0	2	3	0	0	0	0	1	0	0	0	
10	0	1	16	7	0	1	0	0	0	1	0	1	
SUM	121	36	18	13	8	8	6	6	6	4	2	1	230
PROPORTION	0.53	0.16	0.08	0.06	0.03	0.03	0.03	0.03	0.03	0.02	0.01	0	

A-4 slope-4 south facing

Hgt. (upper bound)	QURU	ACSA	POGR	QUPR	TSCA	FRAM	FAGR	CACO	PIST	QUAL	PIRE	TIAM	BEAL	HAVI	JUVI	PRSE	Total trees
135	2	1	6	1	0	0	2	0	0	0	0	0	0	0	0	1	
130	4	2	8	1	1	0	0	0	2	0	1	0	0	0	0	0	
120	8	4	1	0	0	0	0	0	1	0	1	0	0	1	1	0	
110	4	1	0	3	0	0	0	0	0	1	0	0	0	0	0	0	
100	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
90	10	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	
80	8	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	
70	5	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	
60	4	3	0	0	1	0	0	0	0	2	0	0	0	0	0	0	
50	2	9	0	0	1	2	0	0	0	0	0	0	0	0	0	0	
40	0	5	0	2	1	1	0	3	0	0	0	0	0	0	0	0	
30	1	4	0	0	1	3	0	1	0	0	0	1	0	0	0	0	
20	0	5	0	0	4	2	3	0	0	0	0	1	0	0	0	0	
10	0	9	0	0	1	2	3	0	0	0	0	0	1	0	0	0	
SUM	**53**	**47**	**15**	**14**	**13**	**10**	**8**	**4**	**3**	**3**	**2**	**2**	**1**	**1**	**1**	**1**	**178**
PROPORTION	**0.3**	**0.26**	**0.08**	**0.08**	**0.07**	**0.06**	**0.04**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	

A-5 slope-A north facing

10 m intervals

Hgt. (upper bound)	TSCA	ACRU	FAGR	ACSA	QURU	QUPR	BEAL	LITU	HAVI	PIST	OSVI	POTR	Total trees
60	18	1	1	3	1	1	0	0	2	0	0	0	
50	10	0	2	0	1	3	1	0	0	2	1	0	
40	10	2	4	3	4	0	0	0	0	0	0	1	
30	7	2	0	3	0	0	0	2	0	0	0	0	
20	3	2	4	2	1	0	1	0	0	0	0	0	
10	5	5	1	0	0	0	1	1	0	0	0	0	
SUM	**53**	**12**	**12**	**11**	**7**	**4**	**3**	**3**	**2**	**2**	**1**	**1**	111
PROPORTION	**0.48**	**0.11**	**0.11**	**0.1**	**0.06**	**0.04**	**0.03**	**0.03**	**0.02**	**0.02**	**0.01**	**0.01**	

A-6 Slope-B North facing

10 m intervals

Hgt. (upper bound)

	ACSA	TSCA	FAGR	BEAL	FRAM	QURU	LITU	OSVI	POGR	TIAM	BELE	CACO	PRSE	QUPR	Total trees
105	1	3	2	1	0	0	2	0	3	0	0	0	0	0	
100	0	8	2	1	0	2	1	1	1	0	0	0	0	1	
90	2	8	2	0	0	1	0	0	0	0	0	0	0	0	
80	4	6	0	1	3	0	0	1	0	0	0	0	0	0	
70	0	5	0	0	0	1	0	0	0	0	0	0	0	0	
60	3	2	1	1	0	1	0	0	0	0	0	0	0	0	
50	5	2	0	1	0	0	0	0	0	0	0	0	0	0	
40	6	2	1	1	2	0	0	0	0	0	0	0	0	0	
30	24	2	3	0	1	0	0	2	0	0	1	0	0	0	
20	5	5	1	2	1	0	0	0	0	1	0	1	0	0	
10	14	3	11	2	0	0	1	0	0	1	0	0	1	0	
SUM	**64**	**46**	**23**	**10**	**7**	**5**	**4**	**4**	**4**	**2**	**1**	**1**	**1**	**1**	**173**
PROPORTION	**0.37**	**0.27**	**0.13**	**0.06**	**0.04**	**0.03**	**0.02**	**0.02**	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	

A-7 slope- C north facing

10 m intervals

Hgt. (upper bound)	ACSA	TSCA	FAGR	FRAM	LITU	TIAM	BEAL	MAAC	OSVI	CACA	total trees
110	**1**	**8**	**5**	0	**2**	0	0	**2**	0	0	
100	**1**	**4**	**2**	0	0	0	**2**	0	0	0	
90	**5**	**6**	0	0	0	**1**	0	0	0	**1**	
80	**1**	**3**	0	**1**	0	**1**	0	0	0	0	
70	**1**	**3**	**1**	**2**	**1**	0	0	0	0	0	
60	**5**	**7**	**1**	**2**	**1**	0	0	0	**1**	0	
50	**6**	**4**	**1**	0	0	0	0	0	**1**	0	
40	**2**	0	0	**4**	0	0	0	0	0	0	
30	**7**	0	**1**	**1**	**1**	**2**	0	0	0	0	
20	**4**	**2**	0	**2**	0	0	0	0	0	0	
10	**5**	0	**1**	0	0	0	0	0	0	0	
SUM	**38**	**37**	**12**	**12**	**5**	**4**	**2**	**2**	**2**	**1**	**115**
PROPORTION	**0.33**	**0.32**	**0.1**	**0.1**	**0.04**	**0.03**	**0.02**	**0.02**	**0.02**	**0.01**	

A-8 slope-D north facing

10 m intervals

Hgt. (upper bound)	TSCA	ACSA	QUPR	QURU	FAGR	OSVI	LITU	ACRU	BEAL	PIST	TIAM	Total trees
128	**1**	0	**1**	**2**	0	**4**	0	0	0	**1**	0	
120	**7**	0	**1**	**1**	0	0	0	0	0	0	0	
110	**4**	**3**	**1**	0	0	0	0	0	0	**1**	0	
100	**12**	0	**2**	**2**	0	**1**	0	0	**1**	0	0	
90	**6**	**1**	**1**	0	**1**	0	0	0	0	0	0	
80	**15**	0	**4**	0	0	0	0	0	0	0	0	
70	**4**	0	**2**	0	0	0	0	0	0	0	0	
60	**1**	0	**2**	0	0	0	0	0	0	0	0	
50	**9**	**7**	0	**2**	**1**	0	0	0	**1**	0	0	
40	**5**	**4**	0	0	0	0	0	0	0	0	0	
30	**6**	**7**	0	**1**	**5**	0	**1**	**1**	0	0	0	
20	**1**	0	0	**1**	**1**	0	0	**2**	0	0	0	
10	**1**	**8**	0	**1**	0	0	**3**	0	**1**	0	**1**	
SUM	**72**	**30**	**14**	**10**	**8**	**5**	**4**	**3**	**3**	**2**	**1**	**152**
PROPORTION	**0.47**	**0.2**	**0.09**	**0.07**	**0.05**	**0.03**	**0.03**	**0.02**	**0.02**	**0.01**	**0.01**	

Appendix B Upper vs. Lower slope

In appendix B the vertical profiles were divided into upper and lower slopes. This was done at approximately the midpoint of the slope's height and is indicated in the tables. The tables correspond to the vertical profiles from Appendix A. These tables show the number of trees in each species and their proportions in the upper and lower section of each vertical profile.

B-1 slope-1 south facing

	UPPER > 30 m			LOWER 0-30 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPORTION**
ACSA	19	0.36	.	20	0.47
CACA	1	0.02	.	0	0
CACO	0	0	.	7	0.16
FRAM	2	0.04	.	1	0.02
FAGR	1	0.02	.	1	0.02
JUNI	1	0.02	.	0	0
OSVI	5	0.09	.	0	0
POGR	1	0.02	.	0	0
PRSE	2	0.04	.	0	0
QUPR	9	0.17	.	2	0.05
QURU	5	0.09	.	4	0.09
ROPS	3	0.06	.	0	0
TIAM	2	0.04	.	4	0.09
TSCA	1	0.02	.	2	0.05
ULRU	1	0.02	.	2	0.05

B-2 slope-2 south facing

	UPPER >30 m			LOWER 0-30 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPORTION**
ACRU	8	0.1	.	4	0.06
ACSA	0	0	.	20	0.31
AMAR	5	0.06	.	0	0
PIRE	7	0.09	.	0	0
QUPR	54	0.67	.	10	0.15
QURU	5	0.06	.	5	0.08
TSCA	1	0.01	.	22	0.34
CAOV	0	0	.	1	0.02
FAGR	0	0	.	1	0.02
HAVI	1	0.01	.	0	0
OSVI	0	0	.	1	0.02
TIAM	0	0	.	1	0.02

B-3 slope-3 south facing

	UPPER >50 m			LOWER 0-50 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPORTION**
ACRU	6	0.04	.	0	0
ACSA	0	0	.	13	0.19
AMAR	6	0.04	.	2	0.03
FAGR	0	0	.	18	0.26
HAVI	5	0.03	.	3	0.04
OSVI	0	0	.	1	0.01
PIRE	6	0.04	.	0	0
PIST	2	0.01	.	0	0
QUAL	1	0.01	.	0	0
QUCO	0	0	.	4	0.06
QUPR	110	0.68	.	11	0.16
QURU	26	0.16	.	10	0.15
TSCA	0	0	.	6	0.09

B-4 slope-4 south facing

	UPPER >70 m				LOWER 0-70 m	
SPECIES	**SUM**	**PROPORTION**			**SUM**	**PROPORTION**
ACSA	9	0.1	.	.	38	0.43
BEAL	0	0	.	.	1	0.01
CACO	0	0	.	.	4	0.05
FRAM	0	0	.	.	10	0.11
FAGR	2	0.02	.	.	6	0.07
HAVI	1	0.01	.	.	0	0
JUVI	1	0.01	.	.	0	0
POGR	15	0.17	.	.	0	0
PIRE	2	0.02	.	.	0	0
PRSE	1	0.01	.	.	0	0
PIST	3	0.03	.	.	0	0
QUAL	1	0.01	.	.	2	0.02
QUPR	10	0.11	.	.	4	0.05
QURU	41	0.46	.	.	12	0.14
TIAM	0	0	.	.	2	0.02
TSCA	4	0.04	.	.	9	0.1

B-5 slope-A north facing

	UPPER >30 m			LOWER 0-30 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPORTION**
ACRU	3	0.04	.	9	0.23
ACSA	6	0.08	.	5	0.13
BEAL	1	0.01	.	2	0.05
FAGR	7	0.1	.	5	0.13
HAVI	2	0.03	.	0	0
LITU	0	0	.	3	0.08
OSVI	1	0.01	.	0	0
PIST	2	0.03	.	0	0
POTR	1	0.01	.	0	0
QUPR	4	0.06	.	0	0
QURU	6	0.08	.	1	0.03
TSCA	38	0.54	.	15	0.38

B-6 Slope-B North facing

	UPPER >50 m			LOWER 0-50 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPORTION**
ACSA	10	0.14	.	54	0.53
BEAL	4	0.06	.	6	0.06
BELE	0	0	.	1	0.01
CACO	0	0	.	1	0.01
FRAM	3	0.04	.	4	0.04
FAGR	7	0.1	.	16	0.16
LITU	3	0.04	.	1	0.01
OSVI	2	0.03	.	2	0.02
POGR	4	0.06	.	0	0
PRSE	0	0	.	1	0.01
QUPR	1	0.01	.	0	0
QURU	5	0.07	.	0	0
TIAM	0	0	.	2	0.02
TSCA	32	0.45	.	14	0.14

B-7 slope- C north facing

	UPPER >50 m			LOWER 0-50 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPORTION**
ACSA	14	0.2	.	24	0.55
BEAL	2	0.03	.	0	0
CACA	1	0.01	.	0	0
FRAM	5	0.07	.	7	0.16
FAGR	9	0.13	.	3	0.07
LITU	4	0.06	.	1	0.02
MAAC	2	0.03	.	0	0
OSVI	1	0.01	.	1	0.02
TIAM	2	0.03	.	2	0.05
TSCA	31	0.44	.	6	0.14

B-8 slope-D north facing

	UPPER >60 m			LOWER 0-60 m	
SPECIES	**SUM**	**PROPORTION**		**SUM**	**PROPRTION**
ACRU	0	0	.	3	0.04
ACSA	4	0.05	.	26	0.36
BEAL	1	0.01	.	2	0.03
FAGR	1	0.01	.	7	0.1
LITU	0	0	.	4	0.05
OSVI	5	0.06	.	0	0
PIST	2	0.03	.	0	0
QUPR	12	0.15	.	2	0.03
QURU	5	0.06	.	5	0.07
TIAM	0	0	.	1	0.01
TSCA	49	0.62	.	23	0.32

Appendix C   Floodplain Tree Data

Appendix C shows tree data from the floodplains. These tables were composed using data supplied by Dr. Diggins (Diggins, Thomas P. unpublished data). A total of 5 floodplains were used from Zoar Valley. Since an interest was floodplain colonization, individuals of all ages were used from the floodplains. Since the floodplains are very young landforms, a couple decades at most, the trees here are small. The total number of individuals from each species as well as their proportions are reported here.

C-1 SD Floodplain

Species	**Total** # of individuals	**Proportion**
ACSA	38	0.40
FAGR	10	0.11
FRAM	1	0.01
TIAM	1	0.01
TSCA	10	0.11
Ulmus sp.	4	0.04
CACA	8	0.08
OSVI	4	0.04
PLOC	1	0.01
PODE	3	0.03
ROPS	4	0.04
Carya sp.	3	0.03
PIST	3	0.03
LITU	1	0.01
HAVI	2	0.02
BEAL	1	0.01
QURU	1	0.01

C-2 Burchfield Floodplain

Species	**Total** # of individuals	**Proportion**
ACSA	40	0.69
FAGR	1	0.02
QURU	4	0.07
PODE	2	0.03
PLOC	3	0.05
ROPS	1	0.02
PIST	1	0.02
TSCA	3	0.05
OSVI	1	0.02
CACO	2	0.03

C-3 FP Across South Branch Floodplain

Species	**Total** # of individuals	**Proportion**
ACSA	74	0.65
Ulmus sp.	9	0.08
ROPS	1	0.01
QURU	2	0.02
TSCA	3	0.03
PIST	2	0.02
TIAM	1	0.01
CACA	2	0.02
FAGR	3	0.03
Crataegus sp.	3	0.03
PLOC	3	0.03
LITU	2	0.02
FRAM	3	0.03
COFL	1	0.01
POTR	3	0.03
PODE	1	0.01

C-4 HID Floodplain

Species	**Total** # of individuals	**Proportion**
ACNE	7	0.18
Carya sp.	3	0.08
JUNI	5	0.13
CACA	10	0.26
PODE	5	0.13
ACSA	1	0.03
ULAM	2	0.05
LITU	1	0.03
ROPS	3	0.08
ALRU	1	0.03
QURU	1	0.03

C-5 NOR Floodplain

Species	**Total** # of individuals	**Proportion**
ACSA	66	0.45
FAGR	2	0.01
CACA	30	0.20
FRAM	5	0.03
CACO	3	0.02
COFL	3	0.02
QURU	6	0.04
PODE	10	0.07
PIST	1	0.01
JUNI	3	0.02
ROPS	6	0.04
SANI	2	0.01
ULAM	5	0.03
PLOC	1	0.01
TIAM	3	0.02
LITU	1	0.01