Succession in riparian communities of the lower Yellowstone River, Montana
by Keith Webster Boggs

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biological Sciences
Montana State University

Abstract:
Riparian plant communities of the lower Yellowstone River between Glendive and Sidney, Montana, were studied during the Summers of 1980 and 1981. These communities originally colonized sand and gravel bars deposited along the River channel. New sand deposits were invaded by Salix spp. and Populus deltoides Marsh. seedlings. This original community developed sequentially to willow thickets, to young cottonwood forests, and to mature cottonwood forests after about 3, 7, 34 and 92 years, respectively. While the mature cottonwood community is usually replaced by a grassland community (principally Agropyron smithii Rydb.) via a shrub community (Rosa woodsii Lindl. and Symphori-carpos occidental is Hook.), it may be replaced by a Fraxinus Pennsylvania Marsh. plant community. Numbers of species with constancies of over 60% rose from 12 in the seedling community to. 18 in the mature cottonwood community and declined to 13 in the grassland. Composition changes are documented in releve tables. Populus deltoides density fell rapidly from 48/M2at 3 years to 0.02/M2 at 92 years; Salix spp. disappeared still more rapidly, with declines from 10/nr at 3 years to near 0/m2 at 34 years. Aboveground biomass rose from 0.2 kg/m2 at 3 years to 30 kg/nr at 60 years and declined to less than 0.5 kg/m2 in near-climax grasslands; most of the large mass observed at mid-sere is living wood.. Belowground biomass rose from about 7 kg/m2 at 3 years to over 30 kg/nr at 90 years and declined to about 19 kg/m2 in grasslands; over half of this biomass was soil organic, matter in every community. Root/shoot ratios declined from 3/1 in the seedling community to 1/2 in the mature cottonwood community and rose again to 10/1 in the grassland. K, Na and N contents of the communities and ecosystem rose and fell with the rise and fall in its biomass. In contrast, P rose more rapidly in early succession and continued to rise slowly through the grassland stage. Management implications of logging and altered Streamflow are discussed.

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APPROVAL

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Keith Webster Boggs

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Riparian plant communities of the lower Yellowstone River between Glendive and Sidney, Montana, were studied during the Summers of 1980 and 1981. These communities originally colonized sand and gravel bars deposited along the River channel. New sand deposits were invaded by _Salix_ spp. and _Populus deltoides_ Marsh. seedlings. This original community developed sequentially to willow thickets, to young cottonwood forests, and to mature cottonwood forests after about 3, 7, 34 and 92 years, respectively. While the mature cottonwood community is usually replaced by a grassland community (principally _Agropyron smithii_ Rydb.) via a shrub community (_Rosa woodsii_ Lindl. and _Symphoricarpos occidentalis_ Hook.), it may be replaced by a _Fraxinus pennsylvanica_ Marsh. plant community. Numbers of species with constancies of over 60% rose from 12 in the seedling community to 18 in the mature cottonwood community and declined to 13 in the grassland. Composition changes are documented in relevé tables. _Populus deltoides_ density fell rapidly from 48/m^2 at 3 years to 0.02/m^2 at 92 years; _Salix_ spp. disappeared still more rapidly, with declines from 10/m^2 at 3 years to near 0/m^2 at 34 years. Aboveground biomass rose from 0.2 kg/m^2 at 3 years to 30 kg/m^2 at 60 years and declined to less than 0.5 kg/m^2 in near-climax grasslands; most of the large mass observed at mid-sere is living wood. Belowground biomass rose from about 7 kg/m^2 at 3 years to over 30 kg/m^2 at 90 years and declined to about 19 kg/m^2 in grasslands; over half of this biomass was soil organic matter in every community. Root/shoot ratios declined from 3/1 in the seedling community to 1/2 in the mature cottonwood community and rose again to 10/1 in the grassland. K, Na and N contents of the communities and ecosystem rose and fell with the rise and fall in its biomass. In contrast, P rose more rapidly in early succession and continued to rise slowly through the grassland stage. Management implications of logging and altered streamflow are discussed.

INTRODUCTION

Recent studies of white-tailed deer (Odocoileus virginianus) on the lower Yellowstone River (Dusek 1981) required information about the riparian communities. A previous study of the area provided only qualitative data concerning plant communities (Stevens et al. 1978). The extent to which data from studies of similar floodplain vegetation in other localities (Everitt 1968, Hosner and Minckler 1963, Johnson et al. 1976, Keammerer et al. 1975, Ware 1949, Weaver 1960, Wikum and Wali 1974, Wilson 1970) could be applied to the lower Yellowstone River floodplain required determination.

The objectives of this study were to identify major riparian plant community types, qualitatively and quantitatively describe them, and describe their successional relationships. Community type descriptions were to include stand age, species lists with coverage estimates, woody plant densities, and plant and soil biomass and nutrient mass. The results of this study should be useful in the management of river flow, wildlife and agriculture on the floodplain.

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DESCRIPTION OF STUDY AREA

The Yellowstone River originates in northwestern Wyoming and flows north into Montana. It turns east and crosses the southern portion of Montana (Figure 1), then joins the Missouri River in western North Dakota. All major tributaries of the Yellowstone River have their origins in Wyoming and flow north. The tributaries, in the order in which they enter the Yellowstone, are the Clark Fork of the Yellowstone River, the Bighorn River, the Tongue River and the Powder River. The total drainage area of approximately 179,000 km^2 is nearly equally divided between Montana and Wyoming, with less than 1% lying in North Dakota (Stevens et al. 1978). The Yellowtail dam on the Bighorn River forms the only major reservoir in the Yellowstone drainage system.

Study sites were located on a 72 km stretch of floodplain between Glendive and Sidney, Montana (Figure 1). Specific study site locations are listed in Table 5. Elevations within the study area varied from 625 m above sea level at Glendive to 577 m at Sidney.

The Yellowstone River's main channel length in the study area is 101 km. Streamflow measurements obtained from a gauging station near Sidney (USGS Water Resources Data for Montana 1910 to 1980) show that the mean discharge is highest during the months of May, June and July and decreases dramatically between August and April (Figure 2). Average maximum discharge also peaks in May, June and July. The highest

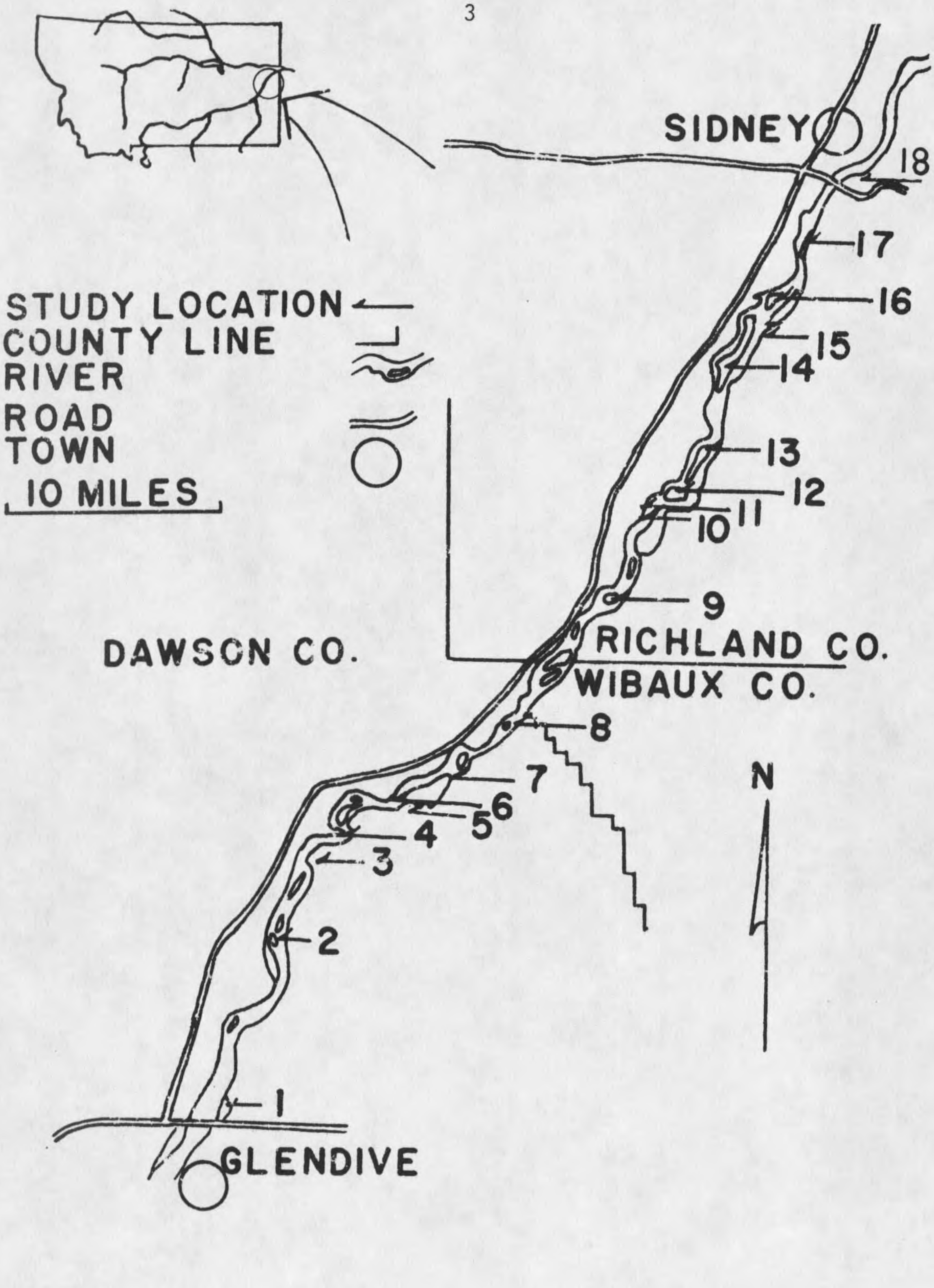

Figure 1. Map of the study area showing locations of specific study sites.

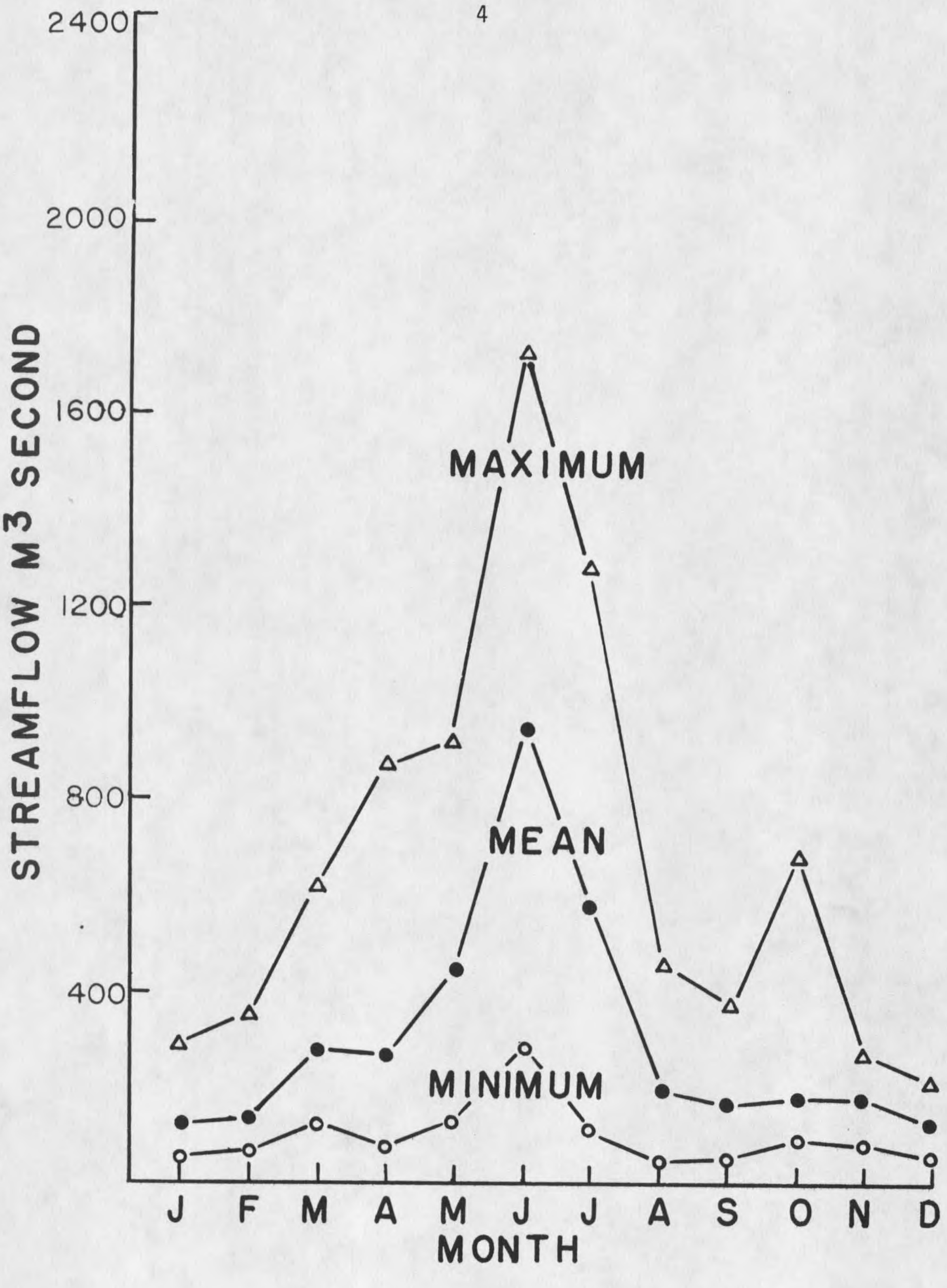

Figure 2. Mean, maximum and minimum Yellowstone River flow (m^3/sec) at Sidney, MT, in the 1910-1980 period (USGS, 1910-1980).

flow ever recorded was 4,502 m^3/s on June 2, 1921 and lowest flow was 13 m^3/s on April 17, 1961.

The lower Yellowstone Valley lies along the western margin of the Williston Basin, a "broad shelf-low relief" geologic feature (Alden 1932). Marine sediments were deposited in the Williston Basin during the Paleozoic, Mesozoic and early Tertiary times. The Fort Union Formation, the latest sediment layer, was formed during the Paleocene Epoch (Veseth and Montagne 1980) and consists of soft nonmarine floodplain sediments derived from erosion of western Montana during the Laramide orogeny. During the Pleistocene continental glaciation, a lobe of glacial ice blocked the River valley at Intake, impounding the River flow to form a glacial lake with resultant deposition of fine sediments upstream (Alden 1932).

The landscape of the Williston Basin now consists of gently rolling hills, wide valleys, and flat divides with sandstone and clinker beds forming ridges and buttes (Veseth and Montagne 1980). Erosion by the Yellowstone River has formed a broad flat floodplain with an average width of 4.4 km in the study area. The floodplain broadens with distance downstream. The narrowest segment in the study area was 2.4 km at Glendive, the widest was 8.0 km at Elk Island.

Soils on the floodplain and low terraces are of the Trembles-Havrelon-Lohler association. This association is described by Pescado and Brockmann (1980) as "deep, nearly level and gently sloping, well drained and moderately well drained fine sandy loams, silt loams, silty clay loams, and clays underlain by stratified fine sandy loam to silty clay alluvium". This soil association forms a substrate for the plant communities identified below.

In the River, initial sedimentation leading to the formation of permanent land normally occurs with the formation of point bars. These originate on convex curves within the confines of the river channel. The opposing concave bank is cut, providing sediment for deposition on convex curves downstream (Matthes 1941). The channel thus meanders laterally across the floodplain. The channel width remains constant as vegetation colonizes the point bars and islands. Surface heights of new deposits rise as sediments are deposited on them by waters flowing over them at high-water times.

The lower Yellowstone River passes through a region which has a semi-arid climate (Thornwaite 1941). Climatic records for Glendive illustrate the precipitation and temperature fluctuations of the region (Figure 3, Ruffner 1971). Average monthly precipitation is highest in early summers with 8.1 cm falling in June, and drops during winters to 0.8 cm in December. The average annual precipitation is 30 to 35 cm. Temperatures fluctuate about an average monthly high of 23.7 degrees C in July to an average monthly low of minus 7.4 degrees C in February.

The present floodplain is occupied mainly by deciduous forests, grasslands and cultivated land. Immediately adjacent to the River, Salix spp. and Populus deltoides Marsh. (willow and cottonwood) seedlings and thickets are dominant. Mature Populus deltoides stands, grasslands (principally Agropyron smithii Rydb.) and shrublands (Rosa woodsii Lindl. and Symphoricarpos occidentalis Hook.) are scattered throughout the floodplain. Fraxinus pennsylvanica Marsh. (Green Ash)

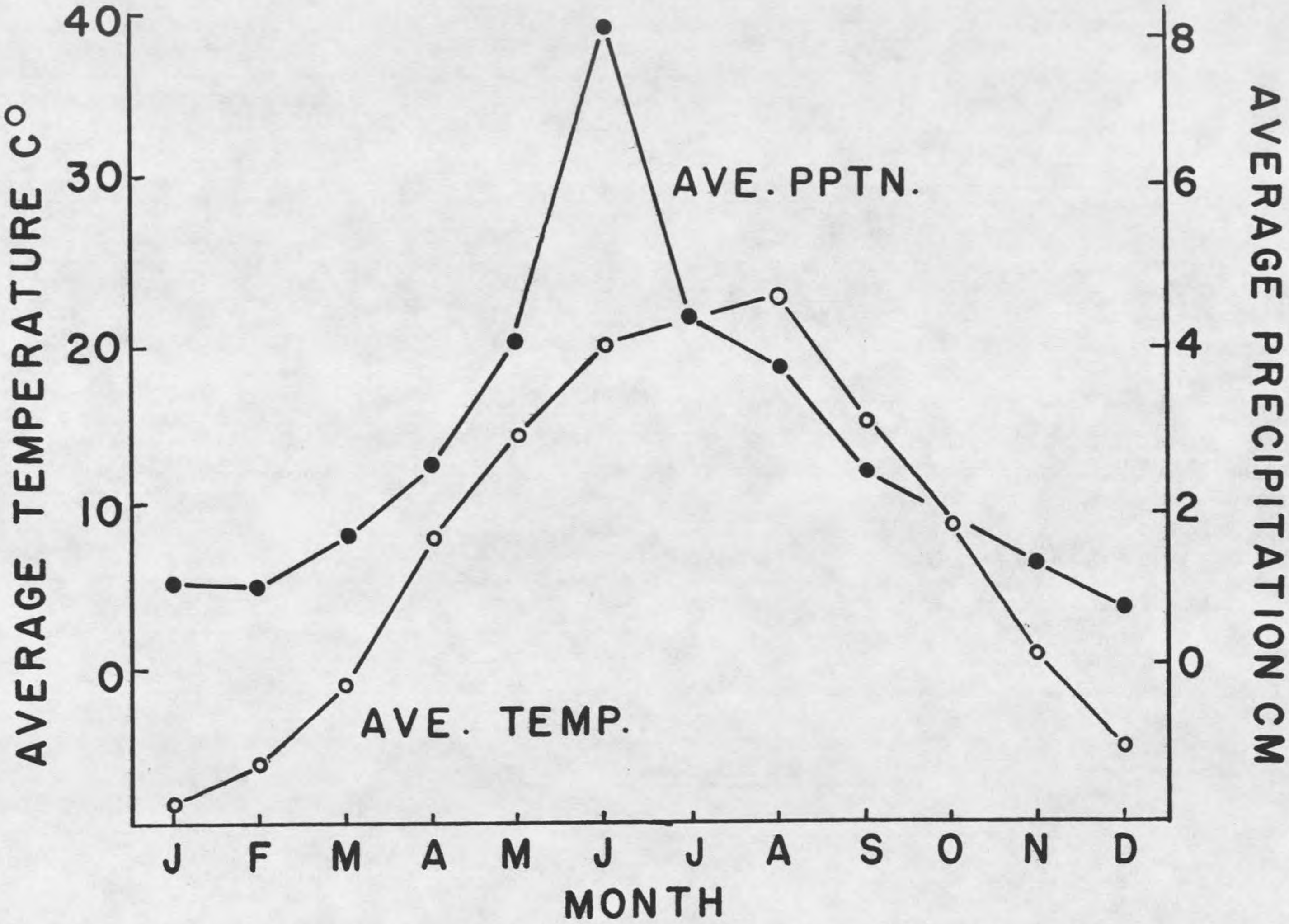

Figure 3. The average monthly temperature and precipitation at Glendive, MT (Ruffner 1971). The vertical scales are adjusted so evapotranspiration exceeds precipitation whenever the temperature line rises above the precipitation line (Walter 1973).

stands are commonly found at the edge of the floodplain. Marshes, which also occur here, were not studied. The semi-arid climate dominates floodplain vegetation where deep soil deposits lift the soil surface well above the water table, but ground water and flooding have a significant effect where soil deposits are shallow.

Man's impact on the floodplain vegetation stems mainly from agricultural use. Many once-forested lands, shrublands and grasslands have been cleared for cultivation. Most land not cultivated is used by sheep or cattle.

MATERIALS AND METHODS

Reconnaissance during the early Summer of 1980 identified 12 major physiognomic plant community types. Seventy sites representing the major communities were selected for analysis. These were: 19 in the "sandbar" type, 9 "seedling" type, 8 "thicket" type, 9 "young cottonwood" type, 6 "mature cottonwood" type, 9 "shrub" type, 9 "grassland" type, 7 "green ash" type, 3 "willow-shrub" type and 1 "peach-leaved willow" type. A species list (Table 6) was also made for three "marsh" community types. Stand selection criteria were that each site represented one of the major community types indicated above, and that the sites showed no evidence of disturbance by fire, logging, recent grazing or other agricultural use. Measurements were taken to characterize each community type with respect to species composition, age, soil height, stand stratification and height, community composition (cover and/or density), biomass and nutrient masses.

Species Composition

Complete plant species lists were kept for all sites. Species encountered in sites not sampled, including marshes, were separately recorded. Scientific names of plants follow Booth (1972) and Booth and Wright (1966) or, for species not listed by Booth, Van Bruggen (1976).

Site Age

The age of forested sites was estimated by counting the annual rings of the largest Populus deltoides present. Growth rings were observed by cutting seedlings and saplings, or coring older trees at breast height. Four years were added to each core count to compensate for the time the tree took to grow to breast height (Wilson 1970).

Stand Height

The height of the soil surface above the River water level was determined with a level and measuring tape. Since soil elevations were recorded at different times of the summer and since the River level varied throughout the summer, soil elevations are only approximate indicators of true height of the soil above the River level.

Plant Cover

Horizontal cover was recorded for understory, shrub and overstory plants on a transect crossing the community perpendicular to the River. Graminoids, forbs, Artemisia ludoviciana Nutt., Toxicodendron rydbergii (Small) Greene, and vines were sampled with sixty step-points and presented as percent cover (Evans and Love 1957). Shrub cover was measured by calculating canopy coverage (pi.r2) of each shrub present in density plots (described below), summing and expressing the shrub coverage as a percent of the total plot area. Tree and sapling coverages were based upon ocular estimates.

Density of Woody Plants

Plots to sample the density of tree and willow species were located at three equally-spaced points on the cover transect. The number of trees and willows of each species was recorded in each plot. Seedlings, saplings and trees were defined by basal diameter as follows: seedlings were less than or equal to 0.5 cm, saplings were less than or equal to 6 cm, and trees were greater than 6 cm. Basal diameter was recorded for all saplings and the diameter at breast height (dbh) was recorded for all trees. Plot sizes used in various communities were as follows: seedling community 1 x 0.5 m; thicket community 2 x 3 m; young cottonwood community 5 x 5 m; mature cottonwood community 20 x 20 m; shrub community 1 x 5 m; willow-shrub community 4 x 10 m; the green ash and peach-leaved willow plots were 4 x 30 m. Thirty meter ash-willow plots were cut short if 20 trees were recorded before 4 x 30 m was reached and the actual plot length was recorded.

Density plots for shrubs (except *Artemisia ludoviciana*, *Toxicodendron rydbergii* and vines) were also placed at equidistant points along the transect. The minimum size of each plot was 1 x 5 m and the maximum size was 2 x 20 m, depending on which came first: 20 total shrubs or a maximum area of 40 square meters. Each shrub's crown diameter was recorded in one-decimeter units as the average of the widest crown measure and the crown measure perpendicular to it at its midpoint. Standing dead shrubs were not counted.

Aboveground Biomass

Biomass was measured only in communities representing the sandbar through grassland sere. Time limitations prohibited measurements in the willow-shrub, peach-leaved willow and green ash communities.

Biomasses of graminoids, forbs, Artemisia ludoviciana, Toxicodendron rydbergii and vines were measured by harvest methods. All material in five 1 x 0.5 m plots equally spaced along the cover transect was clipped at ground level, combined, dried to constant weight at 60 degrees C and weighed. Biomasses of Populus deltoides and Salix spp. were measured similarly in the seedling community.

Tree and shrub biomasses were estimated by summing the weights of individual plants in each density plot. Because only a limited number of shrubs and trees could be harvested, weights of trees were determined from regressions relating weights of plant parts to a plant dimension (Whittaker and Woodwell 1968a). The method is outlined in the following six paragraphs.

Large, medium and small specimens of the shrubs Symphoricarpos occidentalis, Rosa woodsii and Artemisia cana Nutt. were collected in each of three sites. Crown diameter was measured and each shrub was separated into leaves, wood (branches) less than 0.5 cm in diameter and wood greater than 0.5 cm in diameter. These components were dried and weighed and their weights were regressed against crown diameter (Weaver 1977).

Nine specimens each of Salix fluviatilis Nutt. and Salix amygdaloides Anders. were collected from three locations. The basal diameter of each Salix individual was recorded. Salix spp. were separated into leaves, wood less than 1 cm in diameter and wood greater than 1 cm in diameter. Each component was then dried and weighed. Subsamples of the larger specimens were used to determine the dry weight/wet weight ratios needed to convert wet weights to dry weights.

Similarly, five small Populus deltoides from the seedling and thicket communities were measured for basal diameter and the dbh of five Populus deltoides collected from the young cottonwood and mature cottonwood communities were measured. All specimens were separated into leaves, wood less than 1 cm in diameter, wood greater than 1 cm and less than 10 cm, wood greater than 10 cm in diameter, and weighed while wet. Subsamples were used to determine dry weight. Dry weights were regressed against diameters.

For each species, the logarithm of dry weight was regressed against the logarithm of diameter to create the graphs needed to estimate weights from an easily measured diameter (Whittaker and Woodwell 1968a). The regression parameters used to predict plant part masses are presented in Table 25 according to the formula $y=mx+b$ where $y=\log 10$ of the part weight in grams, b=the y intercept, m=the change in mass with changing diameter and $x=\log 10$ of the plant diameter in cm. Plant diameter was canopy diameter for shrubs, basal trunk diameter for Salix spp. and small (0-6 cm basal diameter) Populus deltoides, and diameter at breast height for Populus deltoides larger than 6 cm basal diameter.

To measure the closeness of fit between two variables along a regression line, the correlation coefficient (r, Snedecor and Cochran

1980) and the estimate of relative error for a logarithmic regression (E, Whittaker and Woodwell 1968a) were calculated (Table 25).

Total biomass estimates of trees and shrubs in communities older than the thicket community are underestimated slightly because infrequently encountered species such as Juniperus scopulorum Sarg., Elaeagnus angustifolia L., Fraxinus pennsylvanica, Ribes spp. and Cornus stolonifera Michx. were not included.

Aboveground Dead Biomass

Litter mass was measured by harvesting three 1 x 0.5 m plots equally spaced along the cover transect, drying and weighing. Litter included all dead organic matter, including leaves and dead wood less than 10 cm in diameter lying on the ground or standing in the plot and reasonably distinct from the underlying soil.

Weights of dead Populus deltoides, whether standing or lying on the ground, were estimated by multiplying their pre-death weights, estimated with the weight-diameter regressions determined as described above, by a factor correcting for loss due to decomposition and subtracting weights of branches apparently lost to the litter component described above. This method is elaborated below.

To correct for decomposition, the dead trees were assigned to one of three categories: rotten, half-rotten or solid. The wood of rotten trees was weathered, rotted and could be kicked apart; half-rotten trees exhibited at least some sign of rot but the wood could not be kicked apart; solid trees showed no outward evidence of rot. Three to five samples for the 1-10 cm and greater than 10 cm diameter size classes were collected from the rotten, half-rotten and solid categories. The samples were dried and weighed, their volumes were determined and wood density (gm/cc) was calculated. A mean for all the samples in each category was calculated. The ratio of rotten, half-rotten or solid wood density to live wood density provided a factor used to correct for decomposition.

To correct for loss of branches, dead trees were recorded as branchless (only the bole of the tree present), half-branched (the bole plus about half of the branches present) or fully-branched (the bole and most of the crown present). Weights of trees in the branchless category were calculated as wood greater than 10 cm in diameter from the Populus deltoides regression lines. Weights of trees in the half-branched category included the total of wood greater than 10 cm plus one-half of the 1-10 cm size class. Weights of trees in the fully-branched category included all wood larger than 1 cm in diameter. If the dbh of the tree was less than 1 dm, fully branched included all the 1-10 cm diameter wood, half-branched equaled three-fourths of the 1-10 cm wood and branchless equaled one half of the 1-10 cm wood.

The weights of individual dead Populus deltoides in the density plots were then determined by first calculating the weight of each dead tree as if it were alive by using the Populus deltoides tree regressions. Depending on which category the tree was recorded in--branchless, half-branched or fully-branched--some weight of the tree was subtracted from the overall weight. The weight of each tree was then multiplied by the appropriate dead weight/live weight ratio to convert these data to rotten, half-rotten or solid weights. All dead tree weights were totaled for each plot.

Non-woody vegetation samples were dried in ventilated ovens (60 C) for two weeks, then weighed to the nearest gram. All woody biomass collected was weighed wet in the field to the nearest gram, or pound for large samples, then dried in ventilated ovens (60 C) for four weeks and reweighed. Dry weight/wet weight ratios were calculated to convert field weights of wet wood to dry weights.

Belowground Biomass

Belowground biomass consisted of four categories: root crowns and large roots greater than 1 cm, roots 1 cm to 0.1 cm in diameter, finer roots and soil organic matter. Due to pre-analysis grinding, soil organic matter included roots less than 1 cm in diameter.

Weights of large roots were measured by dimension analysis (Whittaker and Woodwell 1968a). Root systems of six *Populus deltoides* trees were either excavated or found pre-washed on gravel bars. Roots of each individual tree were separated into 1 to 10 cm and 10 cm or greater diameter classes, dried and weighed. Wherever systems were too large to dry, wet weights were converted to dry weights by multiplying by dry weight/wet weight ratios calculated from subsamples. A logarithm weight-logarithm diameter regression (Table 25) was prepared. Weights of roots greater than 1 cm diameter of all trees in each stand were estimated in a fashion paralleling the calculation of shoot biomasses.

Biomass of roots less than 1 cm in diameter, soil organic matter and soil nutrient concentrations were estimated from soil cores in the 0-10, 10-30 and 30-150 cm horizons. Five cores equally spaced along the cover transect were pooled for each horizon sampled. When the king tube sampler could not be driven beyond 120 cm, comparable samples were removed from the sides of a soil pit. Each sample was dried at 60 degrees C, mixed, weighed and subsampled (25% by weight) for laboratory analysis of elements and organic material present.

Biomasses of small roots (less than 1 cm in diameter) in the 0-10, 10-30 and 30-150 cm soil horizons were estimated by weighing, on an ash-free basis, volumetric samples washed from soil cores and expanding that value appropriately. Roots larger than 1 cm were discarded since they were separately estimated by dimension analysis. Roots and detritus were washed from the samples following the methods of Jackson (1956), except that soils were not presifted with a 6 mm screen. Roots, detritus and soil remaining on the washing screen were placed on pre-weighed Whatman 42 ashless filter paper. Roots, soil, detritus and filter paper were dried at 60 degrees C for two days. Roots and detritus were separated into size classes less than or equal to 1 mm and greater than 1 mm in diameter. Because roots and detritus greater than 1 mm in diameter were rare, they were combined across all stands of a type to calculate average biomass. Percent root in the sample remaining was ocularly estimated. The entire sample was then weighed, ashed and reweighed. Ash-free root biomass was calculated as (organic matter + filter paper + soil traces - filter paper - ash) times the percentage of root in the sample (Weaver 1982).

The organic matter content of soils acquired in volumetric cores was calculated as percent organic matter (gm/100 gm) times soil bulk density times volume of the soil layer considered. Organic matter contents were colorimetrically determined by the Montana State University Soil Testing Laboratory after dichromate oxidation (Sims and Haby 1970). Soil organic matter was estimated as total organic matter minus small root (0-1 cm diameter roots) organic matter.

System Nutrient Mass

Plant parts, litter and soils were analyzed for nitrogen, phosphorus, organic phosphorus of soil, potassium and sodium by the Montana State University Soil Testing Laboratory. The analytical results are summarized in Appendices K, M, N, O, P and Q. Only roots greater than 1 cm in diameter were removed from the soil samples, thus soil analysis also includes roots less than or equal to 1 cm in diameter.

Soil nutrient masses in each horizon were estimated by multiplying nutrient concentrations (gm/100 gm) by soil bulk density by the volume of soil in the horizon concerned. Stand-by-stand bulk density data are summarized in Table 26. Litter nutrient masses were determined by multiplying nutrient concentrations by litter weight.

Nutrient masses of plant parts were estimated by multiplying the nutrient concentration by plant part biomasses. Neither roots nor dead *Populus deltoides* were analyzed for nutrient contents (%). To adjust for this, fine root contents (0-1 cm) were assumed to equal twig (0-1 cm) contents of *Populus deltoides* and coarse root contents (1 cm+) were assumed equal to those of 1-10 cm wood. Similarly, nutrient content (%) in live Populus deltoides wood greater than 10 cm in diameter was also used as an estimate of the nutrient content of dead trees.

Total nitrogen in both soils and plant material was measured by the Kjeldahl method (Bremner 1965). Potassium, sodium and phosphorus contents of plant material were measured by ashing samples and determining the quantities of elements released by spectrophotometric (P) or atomic absorption (K and Na) methods. Potassium and sodium were extracted from soils with 1 M ammonium acetate and measured by atomic absorption (Pratt 1965). Inorganic phosphorus was extracted with a 1 M sulfuric acid solution and measured spectrophotometrically (Olson and Dean 1965). Total soil phosphorus was determined by ashing, extracting with 1 M H_2SO_4 and reading spectrophotometrically (Olson and Dean 1965). Organic phosphorus was assumed to be total phosphorus minus inorganic phosphorus (Saunders and Williams 1955).

RESULTS AND DISCUSSION

Riparian communities of the Yellowstone River floodplain were readily distinguishable. These ranged from bare sandbars to willow thickets, to cottonwood forests and green ash forests, to grasslands. Data from my studies are used below to characterize these communities by composition, describe their seral relationships, speculate on forces driving the seral changes and measure changes in ecosystem contents of organic matter, nitrogen, phosphorus, potassium and sodium.

Figures 4 and 5 summarize the successional relations of the 12 plant communities which appear in the four seres identified, and which will be described below. The sere leading to the regional dry grassland climax dominates the floodplain. It began with Populus deltoides and Salix spp. seedlings colonizing newly-formed River sandbars together. The Salix spp. initially attained stature exceeding Populus deltoides seedlings, but they died out after about 20 years.. Populus deltoides then assumed dominance but also disappeared after about 100 years because dying trees were not replaced by seedlings. Disappearance of Populus deltoides allowed a shrub community to invade and, eventually, a grassland community to assume dominance.

The green ash sere shared the sandbar through mature cottonwood communities (Figure 4) with the grassland sere but apparently has a green ash community climax. Fraxinus pennsylvanica first appeared in the young cottonwood community and steadily became more common up

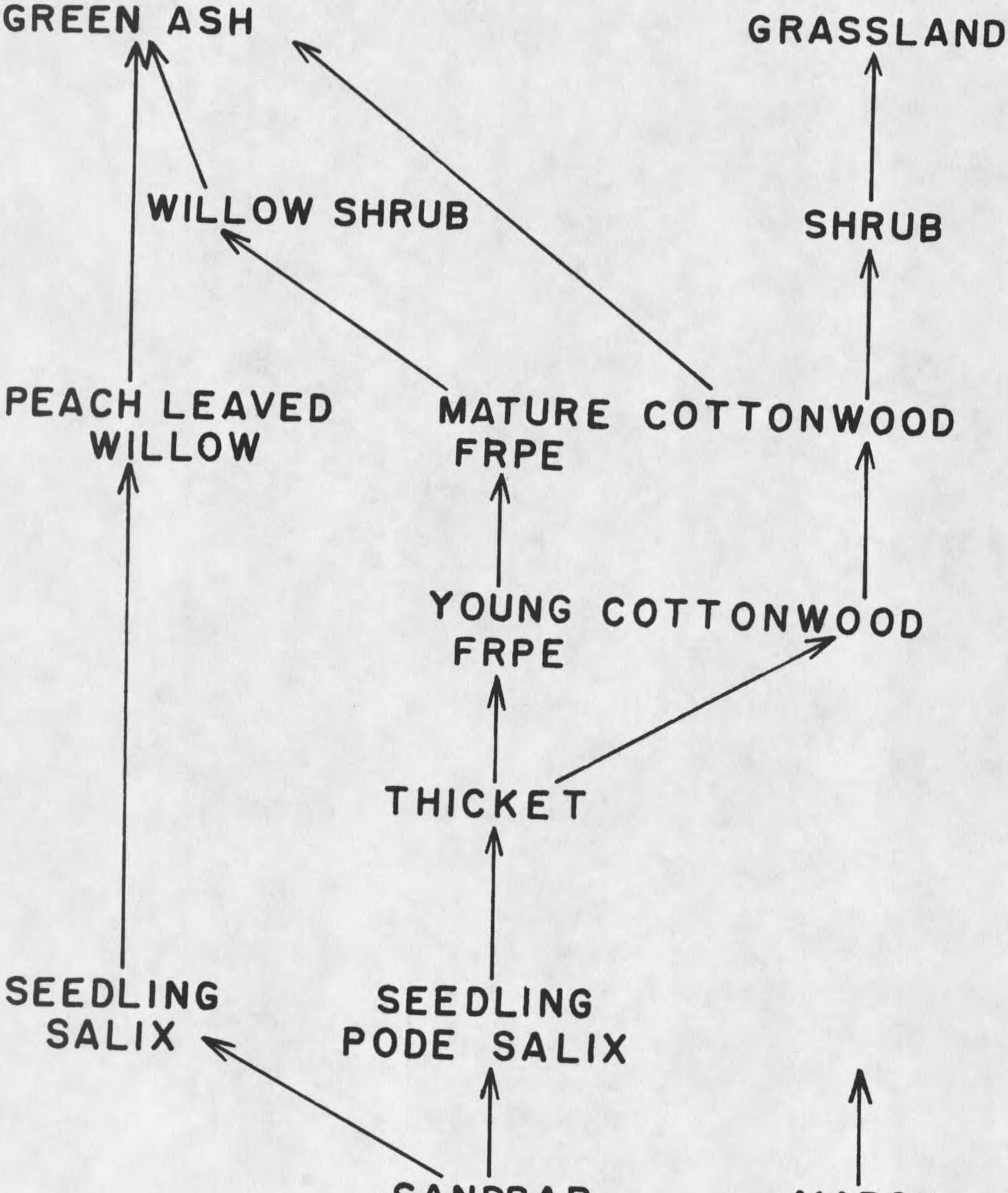

Figure 4. Flow chart summarizing successional changes observed in the lower Yellowstone River floodplain. Four letter scientific name abbreviations are *Fraxinus pennsylvanica* (FRPE) and *Populus deltoides* (PODE).

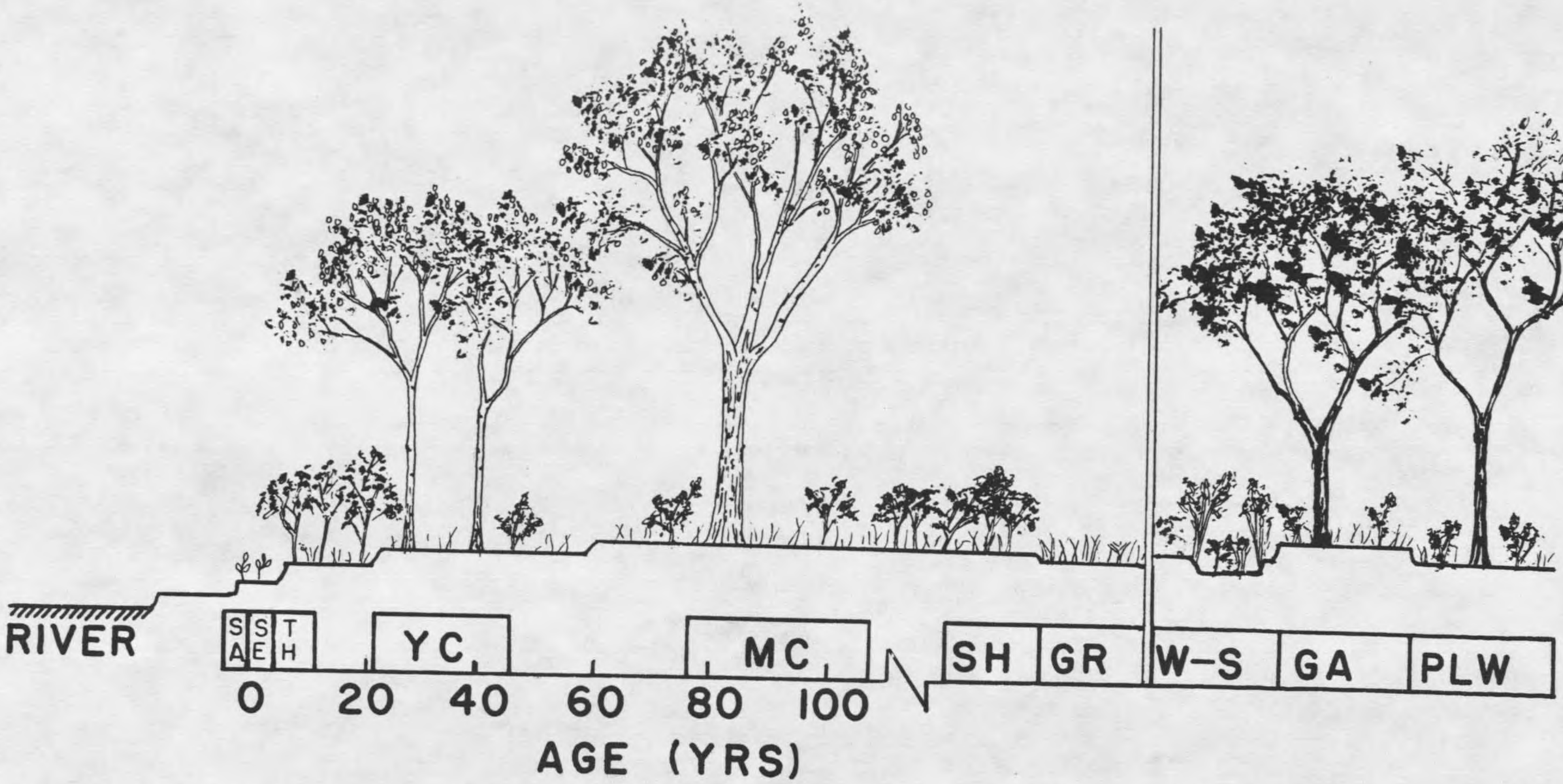

Figure 5. Age range and physiognomy of community types. Bar segments represent community types: sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S), green ash (GA) and peach-leaved willow (PLW).

through the shrub community. When the *Populus deltoides* trees reached senescence, *Fraxinus pennsylvanica* trees invaded, apparently to persist indefinitely on sites usually found near the floodplain's edge.

The peach-leaved willow sere appeared to begin when *Salix* spp. established without *Populus deltoides* on newly-formed sandbars (Figure 4). *Salix amygdaloides* developed into stands of trees which would probably be replaced by a green ash community since *Fraxinus pennsylvanica* seedlings appear in the understory.

Although the marsh vegetation was not analyzed, a species list was compiled (Table 17). In the very long term, accumulating soil would presumably allow a green ash or grassland community to establish on these sites.

Grassland Sere Community Descriptions

The grassland sere began with the formation of sandbars along the River. The soil surface was a sand containing some gravel and debris left by high water (Appendix F.1). Soil height averaged 0.8 m above the River water level for new deposits (Figure 6).

Populus deltoides and *Salix fluviatilis* typically were the first plants to establish and the dominant species of the seedling community; their principal associates are listed in Table 1. The canopy height of this community averaged 3 dm (Figure 7). *Populus deltoides* and *Salix* spp. cover averaged 27%. Forb and graminoid cover averaged 8% and formed only a minor component of total cover in any of the communities to be described except grassland (Table 2). The remaining soil surface cover was 61% sand and 4% litter. Soil height averaged 1.3 m (Figure 6).

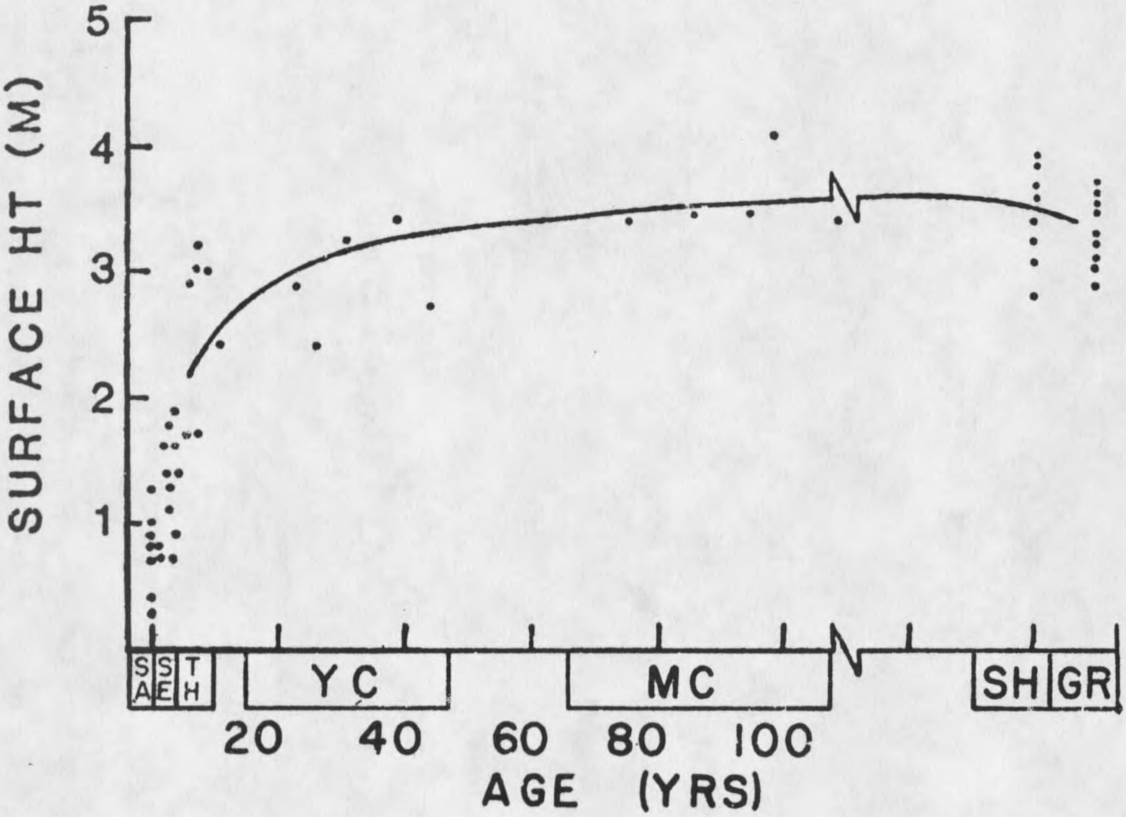

Figure 6. The elevations of the soil surface above the Yellowstone River surface for communities of increasing age. Bar segments represent community types: sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

TABLE 1. Coverage (%) of common species in ten communities.[1] The species are listed in approximate order of water requirements. The communities are listed horizontally in seral order except for unusual types, i.e., green ash, willow-shrub and peach-leaved willow. This table summarizes Tables 10 through 17.

Community types N[3] Plant species		SE[2] 9 X̄±SE[4]	TH 8 X̄±SE	YC 9 X̄±SE	MC 6 X̄±SE	SH 9 X̄±SE	GR 9 X̄±SE	W-S 3 X̄±SE	GA 7 X̄±SE	PLW 1 X̄±SE
Polygonum coccineum	(F)[5]	2±1	-	-	-	-	-	-	-	-
Echinochloa crusgalli	(G)	1±1	+	-	-	-	-	-	-	-
Rumex maritimus	(F)	1±0	+	-	-	-	-	-	-	-
Salix fluviatilis	(Se)	5±2	-	-	-	-	-	-	-	-
Salix fluviatilis	(Tr)	-	30	-	-	-	-	-	-	-
Salix amygdaloides	(Se)	1±1	-	-	-	-	-	-	-	-
Salix amygdaloides	(Tr)	-	5	+	+	-	-	20±3	-	60
Populus deltoides	(Se)	21±3	-	-	-	-	-	-	-	-
Populus deltoides	(Tr)	-	30	66±4	40±4	+	-	-	+	-
Melilotus officinalis	(F)	+	1±0	+	1±1	+	+	1±0	+	-
Agropyron repens	(G)	-	3±1	5±2	1±1	+	1±0	3±3	4±2	-
Elymus canadensis	(G)	+	2±1	7±1	6±2	2±1	2±2	3±1	5±2	-
Muhlenbergia racemosa	(G)	-	2±1	7±2	5±2	4±2	3±2	3±2	1±1	-
Glycyrrhiza lepidota	(F)	+	+	2±0	1±0	1±1	1±1	4±4	+	2
Bromus inermis	(G)	-	+	2±1	2±2	+	2±2	12±8	12±10	23
Toxicodendron rydbergii	(S)	-	-	+	12±3	3±1	+	2±1	1±1	+
Vitis riparia	(V)	-	-	+	4±2	-	-	1±1	+	+
Ribes aureum	(S)	-	-	+	+	+	-	-	+	-
Parthenocissus quinquefolia	(V)	-	-	+	1±0	+	+	1±1	2±2	-
Ribes setosum	(S)	-	-	-	-	+	-	+	1±1	-
Rosa woodsii	(S)	-	-	+	12±3	14±2	+	11±5	3±3	9
Fraxinus pennsylvanica	(Se)	-	-	+	+	+	-	+	+	+
Fraxinus pennsylvanica	(Tr)	-	-	-	+	+	-	-	58±10	-
Symphoricarpos occidentalis	(S)	-	-	+	6±2	8±1	+	6±2	7±4	1
Ulmus americana	(Se)	-	-	-	-	-	-	-	+	-
Ulmus americana	(Tr)	-	-	-	-	-	-	-	+	-
Medicago lupulina	(F)	-	-	-	-	-	-	-	2±1	-
Artemisia ludoviciana	(S)	-	+	+	+	+	2±1	1±1	+	-
Artemisia cana	(S)	-	-	-	-	-	1±0	-	-	-
Calamovilfa longifolia	(G)	-	+	+	-	-	11±4	-	-	-
Agropyron smithii	(G)	-	1±0	1±0	1±1	3±1	17±5	-	1±1	-

[1] A common species is one which occurred in over 60% of the stands of any community type.
[2] Community types are seedlings (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S), green ash (GA) and peach-leaved willow (PLW).
[3] The number of stands of each community type sampled.
[4] The mean ($\overline{X}$) and standard error (SE) of each species' coverage.
[5] Species habits are forb (F), grass (G), vine (V), shrub (S), tree seedling (Se) and tree (Tr).

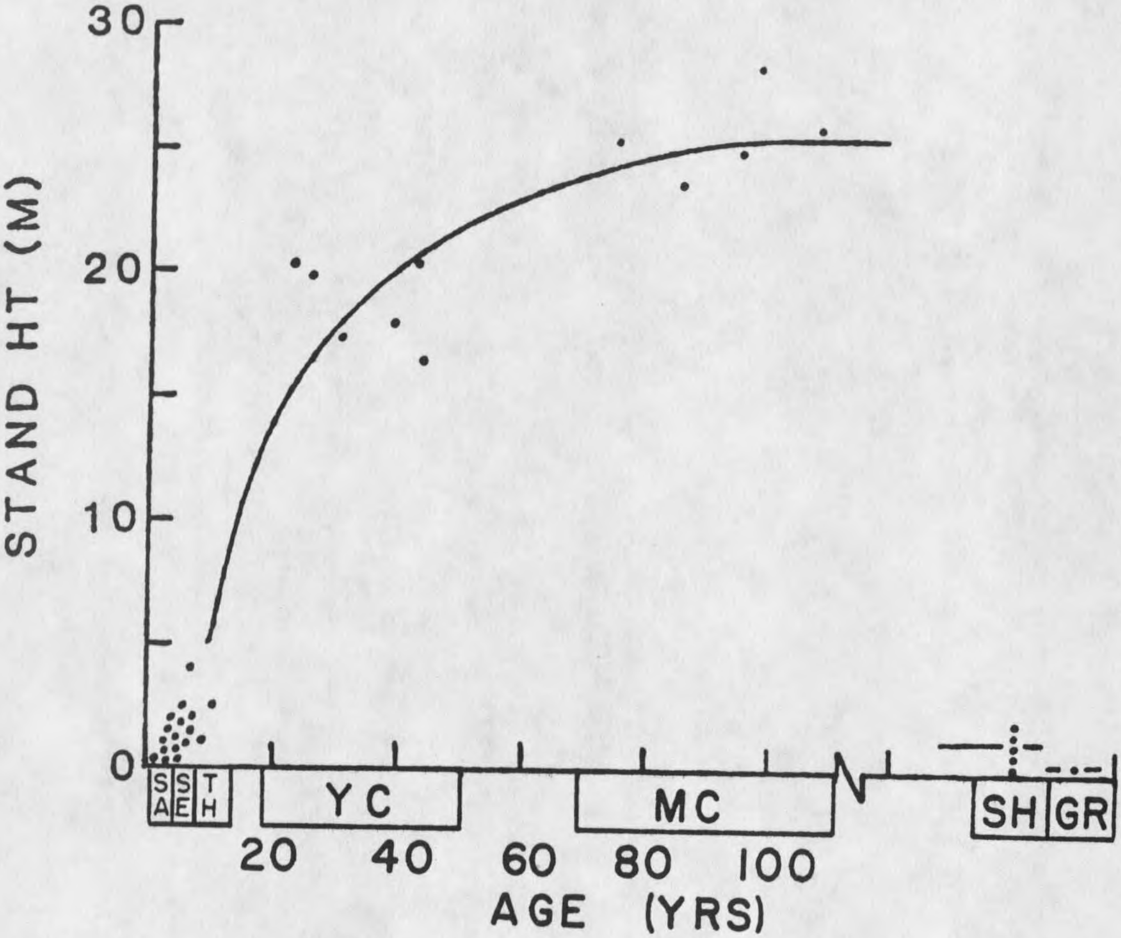

Figure 7. Height of the upper canopy surface, relative to the ground surface, in communities of increasing age. Bar segments represent community types: sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

TABLE 2. Plant coverage, species richness and cummunity height in nine community types of the lower Yellowstone River floodplain. This table summarizes data found in Appendices F.1 through F.8 and E.

Community types[1]	SE $\bar{X}$±SE[2]	TH $\bar{X}$±SE	YC $\bar{X}$±SE	MC $\bar{X}$±SE	SH $\bar{X}$±SE	GR $\bar{X}$±SE	W-S $\bar{X}$±SE	GA $\bar{X}$±SE	PLW $\bar{X}$±SE
COVER (%)									
N[3]	9	8	9	6	9	9	3	7	1
Herb	8±2	28±6	37±3	39±5	29±6	67±3	44±11	41±7	57
Shrub[4]	27±5	+	1±0	19±4	23±2	2±0	15±5	23±3	32
Canopy	-	62[5]	66±4	40±4	+	-	20±3	58±10	60
SPECIES RICHNESS									
N	9	8	9	6	9	9	3	7	1
Total[6]	32	53	36	32	35	56	30	63	17
20%[7]	17	26	25	21	20	28	30	36	-
60%[8]	12	14	18	18	17	13	15	21	-
N	9	8	9	6	6	-	2	7	-
Community height (m)	0.3±0.2	2±0	19±1	25±2	1±0	-	2±1	13±2	-

[1]Community types are seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S), green ash (GA) and peach-leaved willow (PLW).
[2]The mean ($\bar{X}$) and standard error (SE) of each species coverage.
[3]The number of stands of each community type sampled.
[4]Shrub (%) coverage includes seedlings of all tree and Salix spp.
[5]Thicket canopy coverage was estimated after the fact.
[6]Species richness includes the total number of plant species recorded in each stage.
[7]The number of species occurring in at least 20% of the stands sampled.
[8]The number of species occurring in at least 60% of the stands sampled.

In the thicket community, Salix spp. and Populus deltoides continued to be the dominant species. Canopy height increased to 2.2 m (Figure 7). Populus deltoides and Salix spp. cover averaged 65% and herb cover increased to 28% (Table 2). Only 24% of the soil surface was covered by sand due to increased litter cover. Soil height increased to an average of 2.5 m (Figure 6).

The young cottonwood community was dominated by Populus deltoides trees, since most Salix plants had died out (Table 1). The canopy height (Figure 7) tripled over the thicket community and canopy cover averaged 66% (Table 2). The understory remained sparse, with a combined herb and shrub cover of 37% (Table 2). The soil surface was mostly covered (66%) by litter and in all later communities it covered the majority of the soil surface not covered by vegetation. Soil height increased substantially over the thicket community to 3.1 m (Figure 6).

The mature cottonwood community was characterized by widely-spaced towering Populus deltoides and a dense shrub-herb understory. Canopy height of Populus deltoides increased to an average of 24.6 m and the canopy cover fell to an average of 40% (Table 2). Trees commonly contained dead branches and large dead trees were frequently encountered. Shrub cover increased to 19% and herb cover was 39% (Table 2). Soil height increased markedly, to 3.8 m (Figure 6).

In the shrub community, Rosa woodsii and Symphoricarpos occidentalis dominated. No trees were present in the stands sampled although seedlings and/or saplings of Fraxinus pennsylvanica were present at 5 of the 9 sites (Table 14). The shrub height averaged 1.3 m and shrub cover averaged 23% (Table 2). While few dead shrubs were observed in the mature cottonwood community, ocular estimates indicated that 20% to 50% of the shrubs in the shrub community were dead (Table 14). Standing dead shrubs were not included in either density or coverage calculations, consequently density and percent cover do not fully characterize the prevailing dense shrub aspect. Herbaceous cover decreased to 29% (Table 2) and the soil height decreased slightly to 3.4 m (Figure 6).

Agropyron smithii and Calmovilfa longifolia (Hook) Scribn. dominate the grassland community (Table 1), where the average graminoid and forb cover was 67% as compared with a range of 8% to 39% in the earlier communities (Table 2). Artemisia cana Nutt. had the highest shrub percent cover at 1% (Table 1). The average soil height dropped to 3.3 m. The grassland community apparently represents the climatic climax (Clements 1936). That is, if all disturbances were removed from the floodplain (e.g., erosion, flooding), vegetation similar to that occurring on adjacent prairie (Küchler 1964) would eventually develop.

Green Ash Sere Community Descriptions

In the green ash sere the sandbars through young cottonwood communities were similar to that of the grassland sere. Fraxinus pennsylvanica seedlings and saplings appeared, however, in the young cottonwood community and small trees were occasionally recorded in the mature cottonwood community. Thus, I speculate that the Fraxinus pennsylvanica seedlings would develop under the Populus deltoides forest canopy and ultimately replace dying Populus deltoides. Stands characterizing the green ash community were dominated by _Fraxinus pennsylvanica_ trees, with an average height (13.3 m) half that of a mature cottonwood forest and canopy coverage (58%) similar to a vigorous cottonwood stand (Table 2). They also contained trees, saplings and seedlings of _Ulmus americana_ L. and _Acer negundo_ L. Regeneration of all three species was patchy, i.e., where any seedlings occurred there were many. _Elymus canadensis_ L., _Muhlenbergia racemosa_ (Michx.) BSP., _Rosa woodsii_ and _Symphoricarpos occidentalis_ were the most common understory associates (Table 1). The soil height averaged 4.3 m, the highest elevation recorded for any community.

The willow-shrub community may be an intermediate between the cottonwood community and green ash community in ephemeral stream channels or flatland adjacent to the River. _Rosa woodsii_, _Symphoricarpos occidentalis_ and _Salix amygdaloides_ are the dominant species (Table 1). In the ephemeral stream channels, _Salix amygdaloides_ normally occurs on the banks with _Rosa woodsii_ and _Symphoricarpos occidentalis_ in the channel bed. Where the community occurred on level land near the River, these shrubs were intermixed. The canopy height of willow-shrub sites averaged 2.1 m (Table 2). Shrub cover averaged 15% and herb cover 44% (Table 2). Soil height averaged 3.9 m.

Peach-leaved Willow Community Description

In the peach-leaved willow stand sampled, _Rosa woodsii_ and _Bromus inermis_ both had high cover values and were the dominant understory species (Table 1). I saw no _Salix amygdaloides_ regeneration, but

Fraxinus pennsylvanica seedlings were common (Table 2). The stands were typically long and narrow.

Evidence for Successional Relations

The seral scheme described above was supported by observations of *Populus deltoides* ages, soil heights above the River water and overlaps of community composition. The most solid evidence for the seral scheme was provided by the annual rings of *Populus deltoides* trees in the various community types in which they occurred: average tree ages increased from 3 to 7 to 34 to 92 years in the seedling, thicket, young cottonwood and mature cottonwood communities, respectively (Table 3). Unfortunately, this chronology cannot be extended to other community types.

The rapid increase and then leveling of soil height through succession provided supporting evidence (Figure 6). Soil height would be expected to increase rapidly in early succession due to accumulation of sand and silt during flooding. Conversely, flooding of older communities would occur less frequently as soil height increased and less silt would be deposited. My data indicated that soil height increased steadily in early succession from an average sandbar height of 0.8 m to 3.8 m in the mature cottonwood community (Figure 6), a total change of 3.0 meters. In older communities, average ground level varied from a low of 3.3 m in the grassland community to a high of 4.3 m in the green ash community, a difference of only 1.0 m, reflecting a relatively stable soil level.

TABLE 3. Mean age and diameter of *Populus deltoides* trees found in four community types. This table summarizes data found in Appendices C and E.

Community types	Seedling	Thicket	Young Cottonwood	Mature Cottonwood
N[1]	9	8	6	5
	$\bar{X}\pm SE$[2]	$\bar{X}\pm SE$	$\bar{X}\pm SE$	$\bar{X}\pm SE$
Age (years)	3.2±0.2	7.1±0.7	34.1±3.3	92.2±5.1
Diameter (cm)[3]	<1.0	4.3±0.7	23.2±1.4	64.8±4.4

[1] The number of stands of each community type sampled.
[2] The mean ($\bar{X}$) and standard error (SE) of *Populus deltoides* age and diameter.
[3] Basal diameter was recorded in the seedling and thicket communities and diameter at breast height was recorded in the young cottonwood and mature cottonwood communities.

Community description emphasized vegetational linkage of successive communities. To reiterate, Salix spp. and Populus deltoides seedlings established together, with Salix spp. decadence Populus deltoides assumed dominance, and the decadence of Populus deltoides allowed establishment of a shrub community, followed by either a grassland or a green ash community. The peach-leaved willow sere began when Salix amygdaloides established on sandbars and eventually developed into a stand of peach-leaved willow trees.

Species Numbers

A complete list of vascular plant species in each community appears in Table 6. The total number of species found (Table 2) increased from the seedling community (32) to the thicket community (53), decreased to the mature cottonwood community (32) and then rose again in grassland or green ash communities (56-63). In contrast, numbers of plants with high constancy (60%+, Table 2) increased from early seral communities (12-14) to young and mature cottonwood communities (19-18) and then either fell to the grassland community (13) or continued upward to the green ash community (21) (Table 2).

Density of Trees and Shrubs

Populus deltoides and Salix spp. established in vast numbers on moist sandbars and died out rapidly through time (Table 4). Salix fluviatilis, which established at densities of about nine seedlings per square meter, maintained its numbers through the thicket community but was entirely absent at the beginning of the young cottonwood community.

TABLE 4. Density (number/100 m^2) of woody plant species in nine community types. This data summarizes data found in Appendices G.1 through G.4.

Community types[1]		SE	TH	YC	MC	SH	GR	W-S	GA	PLW
N[2]		9	8	9	6	9	9	3	7	1
Plant species		$\bar{X}$±SE[3]	$\bar{X}$±SE	$\bar{X}$±SE	$\bar{X}$±SE	$\bar{X}$±SE	$\bar{X}$±SE	$\bar{X}$±SE	$\bar{X}$±SE	$\bar{X}$±SE
Salix fluviatilis	(Se)[4]	879±279	-	-	-	-	-	-	-	-
Salix fluviatilis	(Sa)	-	995±218	-	-	-	-	-	-	-
Salix amygdaloides	(Se)	167±71	-	-	-	-	-	-	-	-
Salix amygdaloides	(Sa)	-	130±106	+	+	-	-	-	-	-
Salix amygdaloides	(Tr)	-	-	+	+	-	-	-	-	7
Populus deltoides	(Se)	4815±787	-	-	-	-	-	-	-	-
Populus deltoides	(Sa)	-	519±125	-	-	-	-	-	-	-
Populus deltoides	(Tr)	-	-	22±3	2±0	+	-	-	+	-
Cornus stolonifera	(S)	-	-	12±7	+	-	-	30±14	3±3	174
Ribes aureum	(S)	-	-	12±11	49±31	18±8	-	-	3±3	-
Symphoricarpos occidentalis	(S)	-	-	73±36	793±155	1614±264	40±14	565±281	615±214	40
Rosa woodsii	(S)	-	-	8±5	311±65	601±68	12±8	312±119	326±206	176
Ribes setosum	(S)	-	-	-	-	4±3	-	+	40±16	-
Ulmus americana	(Se)	-	-	-	-	-	-	-	20±18	-
Ulmus americana	(Tr)	-	-	-	-	-	-	-	+	-
Fraxinus pennsylvanica	(Se)	-	-	-	1±1	38±3	-	132±95	73±43	7
Fraxinus pennsylvanica	(Sa)	-	-	5±5	+	18±1	-	3±1	4±2	-
Fraxinus pennsylvanica	(Tr)	-	-	-	+	+	-	-	11±2	-
Artemisia cana		-	-	-	-	-	47±20	-	-	-

[1] Community types are seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S), green ash (GA) and peach-leaved willow (PLW)
[2] The number of stands of each community type sampled.
[3] The mean ($\bar{X}$) and standard error (SE) of each species' density.
[4] The tree species are divided into three size classes: seedlings less than 0.5 cm basal diameter (Se), saplings less than 6 cm basal diameter (Sa) and trees greater than 6 cm basal diameter (Tr).

Populus deltoides, which was initially more numerous (48 plants per square meter) declined steadily in density through the end of the mature cottonwood community.

Several shrub species invaded as the willow thickets thinned and disappeared when grasslands became established (Table 4). The sum of their densities was zero in the thicket community, rose to 1.1, 11.5 and 22.4 per square meter in the young cottonwood, mature cottonwood and shrub communities, respectively, and fell to 0.6 per square meter in the grassland community (Table 4). Symphoricarpos occidentalis and Rosa woodsii were the major shrubs in all but the grassland stage where Artemisia cana became established after other shrub and tree species began to disappear.

In the green ash sere, Fraxinus pennsylvanica density increased from 5 plants per square meter in the young cottonwood community to 88 plants per square meter in the green ash community (Table 4). The highest densities of Fraxinus pennsylvanica seedlings and saplings (132 per square meter) occurred in the willow-shrub community, providing evidence for eventual succession to green ash (see Appendix G for complete list and size classes).

Discussion of Seral Causes and Relations

The observed seral changes apparently reflect changes in water availability. Establishment of Populus deltoides seedlings is dependent on a moist soil surface for their first week of life (Moss 1938, Hosner 1957). Salix fluviatilis and Salix amygdaloides seedlings also establish along with Populus deltoides. During Spring high water, the previous year's seedlings are inundated and sometimes buried under a fresh layer of silt, however, both Populus deltoides and Salix spp. seedlings can survive long periods of inundation and send up fresh stems and leaves (Hosner 1958). The seedlings stabilize the sandbars and silt accumulates. Consequently, soil height above the River level rises rapidly (Figure 6).

As the soil height rises above the River level, species such as Populus deltoides and Salix fluviatilis, which are dependent on wet substrates for establishment, fail to regenerate. The original colonizers thin (Table 4) because they gradually die and do not replace themselves under their own canopies. This may be due to old age and competition for available water, sunlight and nutrients.

The increase in shrub cover as the Populus deltoides stand thins may have been due to lowered competition for available nutrient and water supplies. As the Populus deltoides canopy opens (Table 2), increased light may also contribute to the increase in shrub growth. After the Populus deltoides canopy disappears, the shrubs eventually decline, perhaps due to water stresses associated with increased insolation and wind flow. Only relic shrub populations appear in the grassland community. Species such as Agropyron smithii and Fraxinus pennsylvanica, which are not directly dependent on river water for growth, then may establish and subsequently dominate the vegetation.

In the green ash sere, Fraxinus pennsylvanica seedlings first appear in the young cottonwood community and increase in density through the shrub stage. These seedlings are found to germinate and grow over a wide range of soil nitrogen, phosphorus and potassium concentrations and available water content values (Johnson et al. 1976), although seedling densities have been found to be higher in nutrient-rich, moist areas. I did not measure available moisture content. However, I suspect that lack of available water is the factor which prevents a more general Fraxinus pennsylvanica establishment on the floodplain. That water which occurs is restricted to areas near the floodplain's edge where runoff stored in organic-rich soils may provide enough moisture for seedling growth. These sites may also be sheltered from drying winds.

The willow-shrub community may be an intermediate between cottonwood communities and the green ash community type. These areas possibly are more mesic than sites occupied by other late successional communities due to either flooding or Spring stream flow. Fraxinus pennsylvanica seedlings and saplings are present in all transects (Table 17) indicating possible succession to a green ash community.

Changes in Aboveground Biomass Through Succession

Several studies have dealt with the temporal and spatial changes of above- and belowground biomass during succession. Typically, aboveground biomass increased during forest succession (Egunjobi 1979, Gosz 1980, Grier et al. 1981, Long and Turner 1975). I studied changes in biomass in the grassland sere and also found a pattern of increasing forest biomass as the cottonwood community aged. However, total biomass fell in the ensuing shrub and grassland communities (Figure 8).

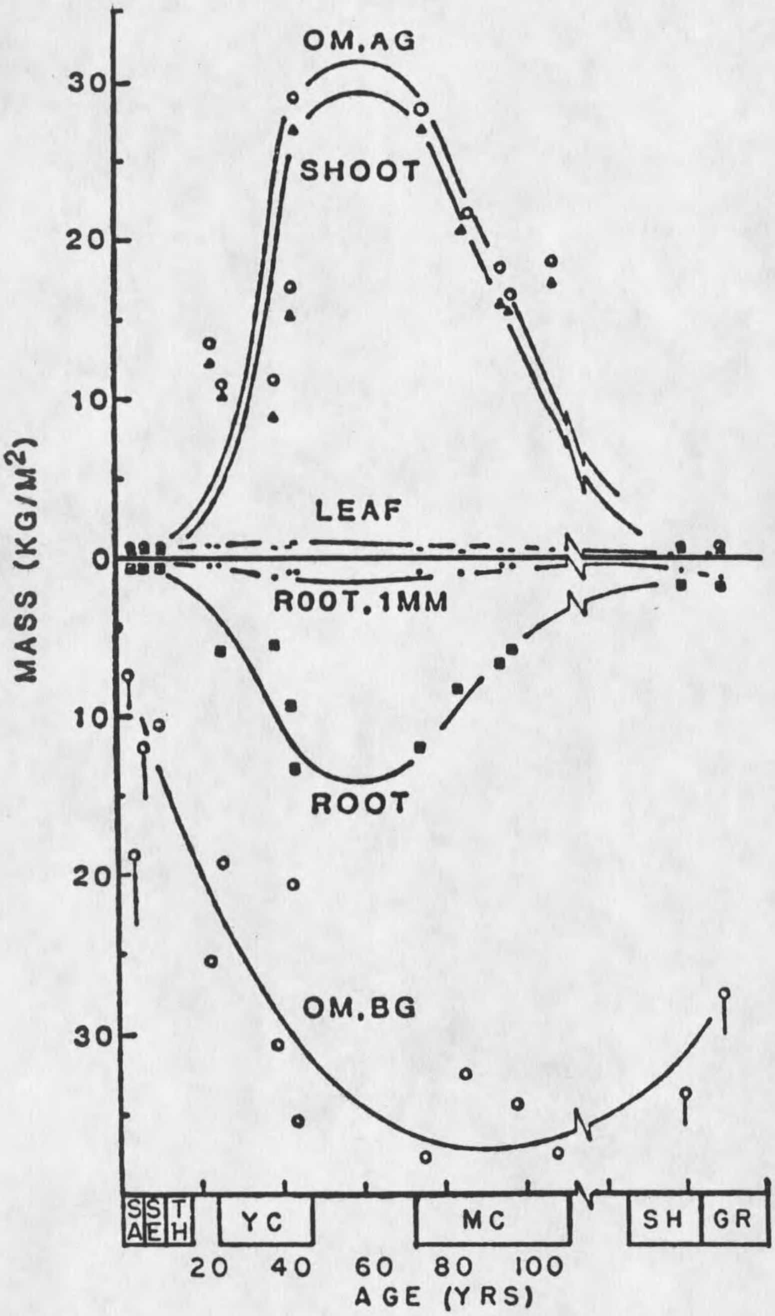

Figure 8. Above and belowground biomasses of communities of increasing age, grassland sere. Upper lines indicate leaf mass, total living shoot mass (including leaves) and total aboveground organic matter. The lower lines indicate masses of roots with diameters less than 1 mm, total root mass (including small ones), and total belowground organic matter. Bar segments represent community types: sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

Total aboveground biomass rose steadily from 164 grams per square meter in the seedling community to 20695 grams per square meter in the mature cottonwood community, and then dropped to 784 and 505 grams per square meter in the shrub and grassland communities, respectively (Figure 8).

Total live biomass (shoot plus leaf) followed the same trend, rising from 118 grams per square meter in the seedling community to 19348 in mature cottonwood community and then decreasing to 140 and 169 grams per square meter in the shrub and grassland communities, respectively (Figure 8).

The dramatic rise and fall of aboveground biomass reflected the development and decline of the Populus deltoides trees (Figure 9). The contribution of Populus deltoides to the total aboveground live biomass increased from 36% in the seedling community to 99% in the mature cottonwood community, then declined due to the death and decomposition of Populus deltoides trees and the lack of tree regeneration (Table 4). Salix spp. were important only in the seedling and willow communities where they constituted 32% and 57% of aboveground biomass, respectively (Figure 9). Shrubs such as Rosa woodsii and Symphoricarpos occidentalis made only a minor contribution to total biomass until the shrub community, where they provided 87% of the aboveground live biomass. Shrubs also comprised 20% of the aboveground live biomass in the grassland community. Graminoid and forb biomass constituted 11% of the total live aboveground biomass in the seedling community, dropped to 1% in the young cottonwood stage and increased to 80% during the grassland

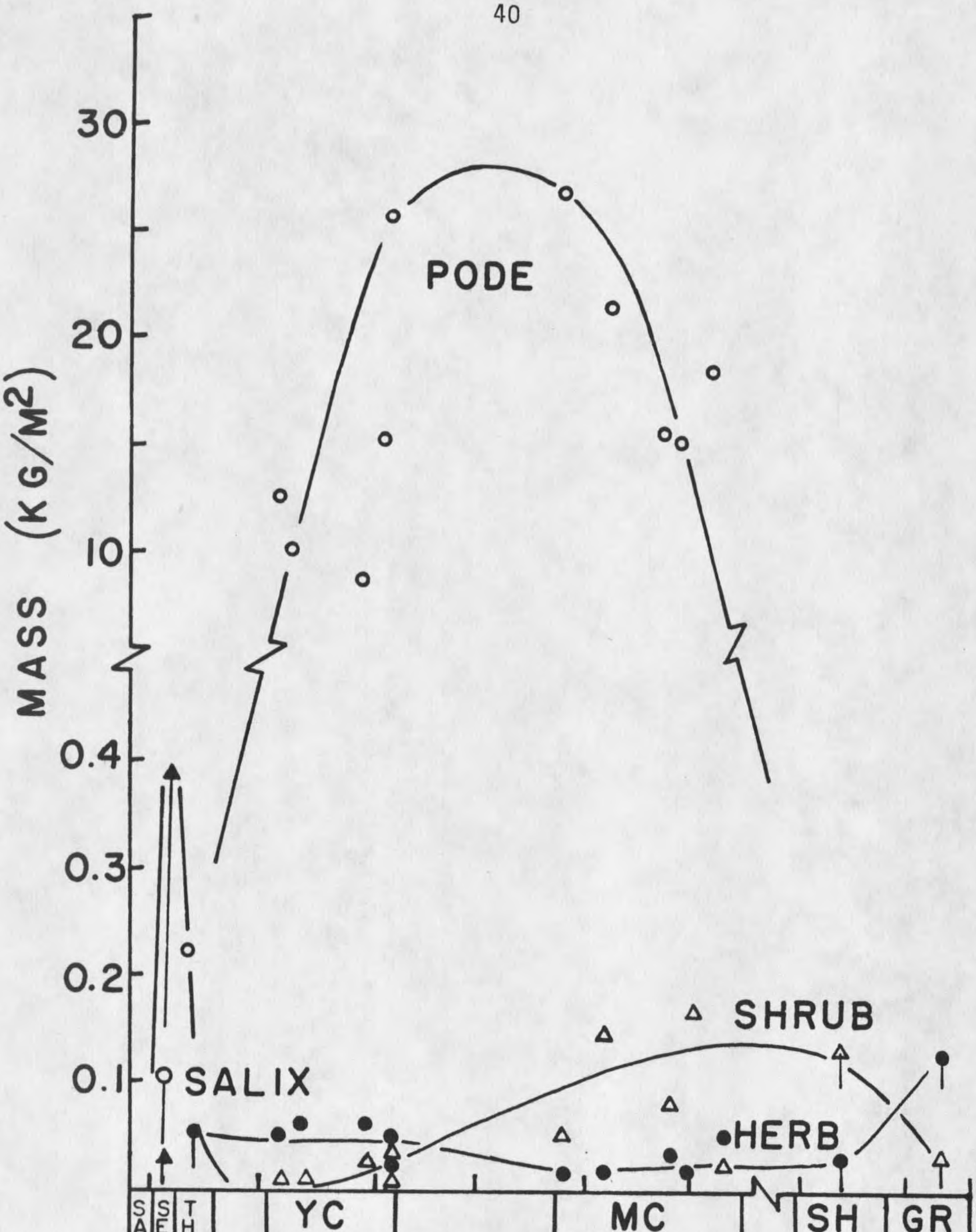

Figure 9. Aboveground masses of Salix spp., Populus deltoides, shrubs and herbs in communities of increasing age, grassland sere. Bar segments represent community types: sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

community (Figure 9; see Table 34 for a complete list of biomasses by stand and structural component).

Overall, Populus deltoides dominated the seedling through mature cottonwood communities, except in the thicket community where Salix fluviatilis briefly contributed a greater percentage of the total live biomass. Shrubs comprised the bulk of live biomass in the shrub community and graminoids dominated the grassland community (Figure 9).

Biomass of wood greater than 1 cm in diameter and wood less than 1 cm in diameter followed the rise and fall of total aboveground biomass (Figure 8). This again was due primarily to the growth and decline of Populus deltoides trees (Table 4). Wood greater than 1 cm nearly disappeared as the Populus deltoides trees died, occurring only in the main stems of large shrubs. Wood biomass less than 1 cm in diameter persisted into the grasslands as the structural wood of shrubs (Figure 9). Leaf mass varied considerably and peaked while the cottonwood communities were relatively young (Figure 8).

Changes in Belowground Biomass Through Succession

Studies of forest soil organic matter through time have shown rapid increases during early succession followed by stabilization in later stages (Dickson and Crocker 1954c, Grier et al. 1981, Johnson et al. 1976, Olson 1958, Switzer and Nelson 1979, Syers et al. 1970). My results showed the same trend (Figure 8). Soil organic matter rose from 3097 grams per square meter on sandbars to 29204 grams per square meter in the mature cottonwood and grassland communities (Figure 8). This rapid early successional rise in soil organic matter reflects the production and decomposition of roots and, to a lesser extent, of leaf-branch litter. Total belowground organic matter was especially high in the mature cottonwood community because of biomass stored in large Populus deltoides roots and buried trunk bases. Roots alone comprised less than 10% of belowground organic matter in all communities except the young cottonwood and mature cottonwood, where they constitute approximately 30% of belowground organic matter (Figure 8).

Masses of roots less than 1 mm in diameter rose from an average of 0.22 kg per square meter in the seedling community to 1.22 kg per square meter in the grassland community. The biomass of roots greater than 1 mm in diameter increased from an average of 0.13 kg per square meter in the seedling community to 7.55 kg per square meter in the mature cottonwood community, then declined to 0.49 kg per square meter in the grassland community (Figure 7). A major proportion of root biomass greater than 1 mm in diameter consisted of Populus deltoides root crowns and buried trunk bases. Buried trunk bases were pooled with roots because of their location below the soil surface. Burial occurred during early succession when silt was deposited by flood waters in developing cottonwood communities.

Changes in Nutrient Content Through Succession

The ecosystem content of several elements was measured to determine their changes through succession. Elements studied were chosen on the basis of ecosystem flow characteristics hypothesized below. Inorganic solutes (sodium, potassium and phosphorus) enter the ecosystem in precipitation (Duvigneud and Danaeyer-de Smet 1970), on sediments

(Jenny 1941) and in river solution. River deposits should accumulate rapidly in early succession when flooding is common (Syers et al. 1970, Switzer and Nelson 1979). As the land surface rises above the River water level, ion-rich capillary and flood water become less available. Similarly, with the passage of time, these elements are filtered by the roots, organic matter and clays in increasing amounts of horizontally-intervening soils. Consequently, sodium, potassium and phosphorus inputs decrease through succession. As the availability of River and ground water decreases, stores of inorganic solutes should stabilize or even decrease if losses from leaching, fires and plant harvesting exceed imputs. The rate of fall is hypothesized to decline from sodium to potassium to phosphorus since the binding capability to soil particles increases over this series (Jenny 1941). Carbon content, measured as biomass, should rise with biomass development (Wright et al. 1959, Switzer and Nelson 1979) in moist early successional communities because carbon enters the system from the air and thus the source is unlimited. Actual uptake, however, is determined by water availability via stomate aperture. Water is abundant in early seral communities but, as the ground level rises and the River becomes more distant, the community becomes more dependent on scarce rainfall (Figure 3). This decrease in available water limits carbon fixation so that, when community respiration exceeds carbon fixation, the overall community carbon content will fall toward that of the regional climax. Nitrogen content was hypothesized to parallel carbon content. Nitrogen can enter the communities from unlimited supplies in the air through nitrogen fixing prokaryotes. Since it is covalently bound to carbon in biomass, leaching should be minimal so long as total biomass is increasing. However, later in succession when net organic matter decomposition occurs, the nitrogen released is volatilized or leached from the community. These hypotheses were tested in the grassland sere.

Inorganic solutes, in fact, rose rapidly in early succession and then either leached out or stabilized. Sodium rose from a mean total mass of 0.1 kg per square meter in the sandbar community to 0.6 kg per square meter in the mature cottonwood community, then dropped to 0.4 kg per square meter in the grassland community (Figure 10). Potassium rose similarly from a mean total mass of 50 g per square meter in the sandbar community to a high of 348 g per square meter in the mature cottonwood community, then dropped to 235 g per square meter in the grassland community (Figure 10). The loss of sodium and potassium in the late seral communities was mainly from the 3-15 dm soil layer. They remained relatively stable in the 0-3 dm layer (Appendices Q and P). Both elements may be removed from the 3-15 dm layer by leaching downward, as well as through upward wicking by plants transpiring and/or capillary rise. The upward wicking apparently prevents decline by replenishing the nutrient mass in the 0-3 layer lost by leaching. Late in succession, loss in the 3-15 dm layer was aggravated by decomposition of organic ion exchange sites which held both sodium and potassium (Jenny 1941, Fortesque and Martin 1970). In contrast, phosphorus rose from a mean total mass of 0.74 kg per square meter on sandbars to approximately 1.00 kg per square meter in the young cottonwood community but failed to show the late succession decline (Figure 10) exhibited by the more mobile ions. In plant material, all three inorganic solutes

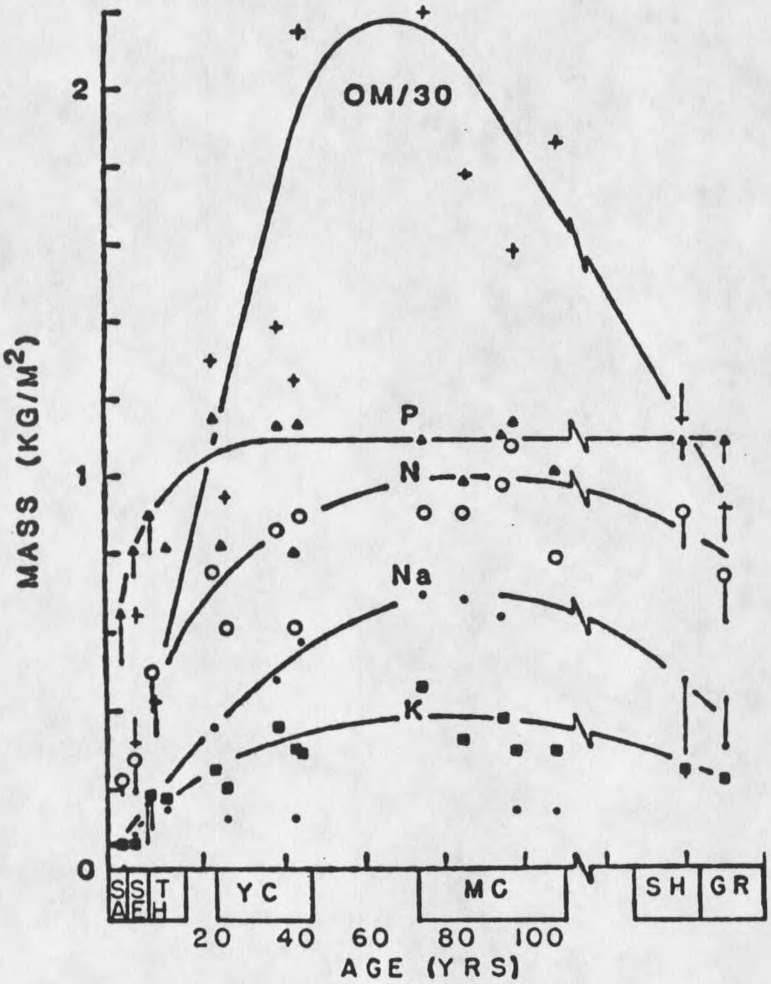

Figure 10. Total ecosystem contents of organic matter (OM), phosphorus (P), nitrogen (N), sodium (Na) and potassium (K). Totals include contents of soil and plant materials both living and dead and above and below ground. Bar segments represent community types: sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

followed the gain and loss of biomass due to storage of the elements in woody vegetation and subsequent loss as the Populus deltoides mass decomposed (Figure 11).

Ecosystem organic matter content increased rapidly, from a mean total of 3.1 kg per square meter in the sandbar community to 51.7 kg per square meter in the mature cottonwood community, but then decreased to 22.3 kg per square meter in the grassland community (Figure 10). If we assume that most of the organic matter is cellulose (glucose), it is approximately 53% oxygen, 40% carbon and 7% hydrogen. Total below-ground mass increased from 3.1 kg per square meter in the sandbar community to 30.0 kg per square meter in the mature cottonwood community (Figure 8). It then dropped when the Populus deltoides died and their roots decomposed. Aboveground total organic matter rose sharply as the Populus deltoides trees matured and dropped almost as sharply when the Populus deltoides senesced and shrub or grasslands invaded (Figure 8).

Nitrogen content increased from 0.23 kg per square meter on sandbars to 0.88 kg per square meter in the mature cottonwood community (Figure 10). It then fell to 0.74 kg per square meter in the grassland community. This loss in nitrogen content was principally from the 3-15 dm soil layer (Table 29). It was probably associated with the decomposition of organic matter. As with the other elements, nitrogen remained relatively stable in the 0-3 dm layer in late succession. As predicted, total plant nitrogen dynamics follow the changes in organic matter (Figure 11).

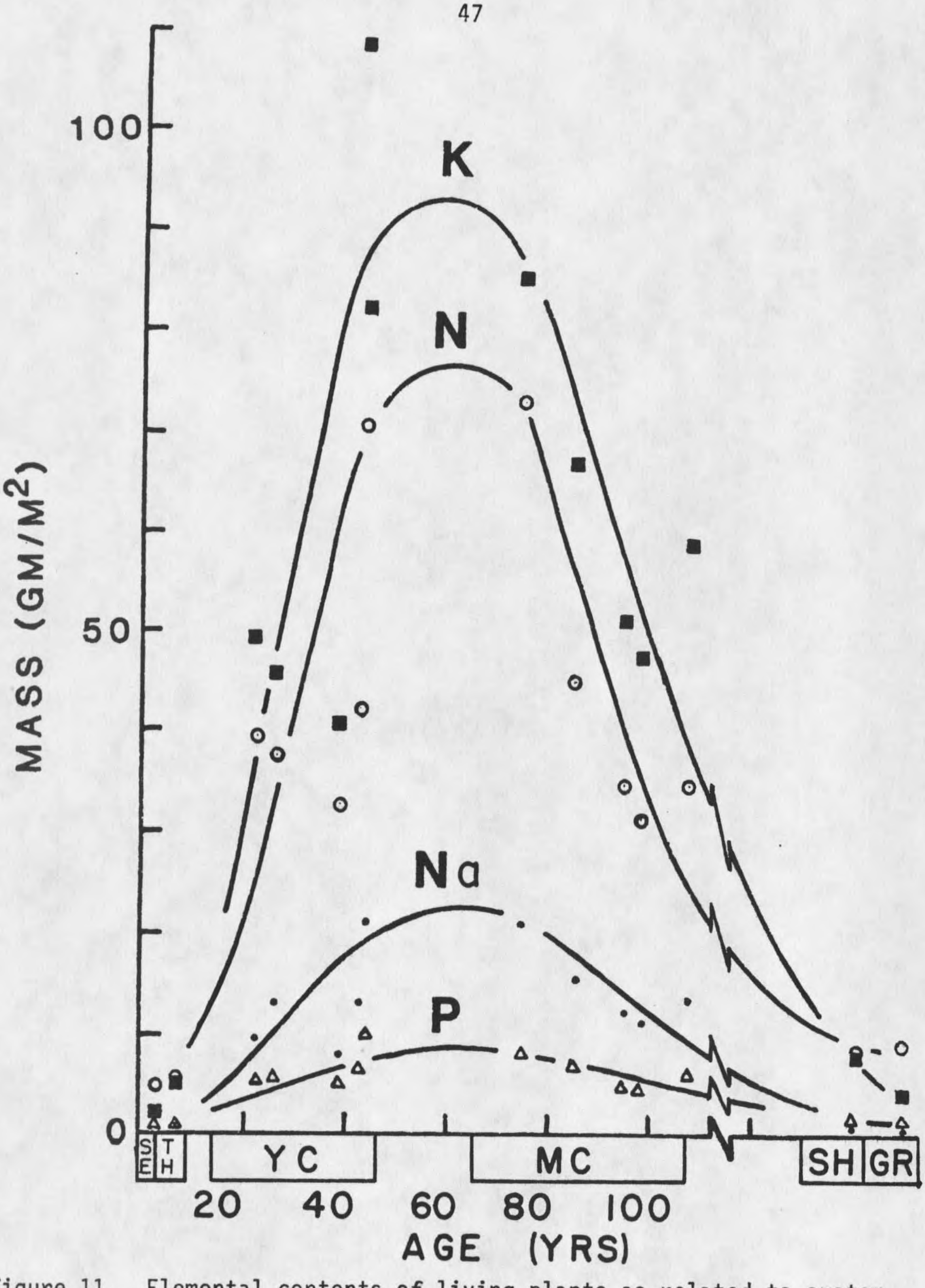

Figure 11. Elemental contents of living plants as related to system age. Bar segments represent community types: seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

In summary, the ecosystem contents of potassium, sodium, carbon and nitrogen rose and fell through time. Sodium and potassium contents rose in early succession and were then lost from the system as input supplies and storage capacity decreased. Similarly, carbon and nitrogen rose rapidly as biomass was accumulated and decreased with the demise of the *Populus deltoides* trees. In contrast, phosphorus showed a more rapid initial rise and no sign of eventual decline. I attribute the rise in phosphorus to deposition with silt and the failure to decline to the continued tight binding by the system.

MANAGEMENT IMPLICATIONS

Logging or burning of cottonwood communities may speed succession to serally advanced communities such as grasslands or green ash. This will occur since, if the land surface has risen well above the River level, Populus deltoides and Salix spp. seedlings cannot establish while grasses and Fraxinus pennsylvanica can.

If flooding is minimized by water impoundment or diversion, bank cutting will be reduced and consequently serally advanced communities may become more common at the expense of early seral communities. Channelization by concrete embankments or rip-rap would create the same result. Under these conditions, destruction of older communities by erosion will occur less frequently and new sandy deposits needed for colonization by early seral communities will be minimized.

If over-bank flooding is reduced by water impoundment or diversion, the land surface would be elevated less due to reduced silt deposition during high water. This may prolong the presence of plants dependent on shallow ground water. Also, River channels that are now flooded in the Spring but relatively dry in the Summer may remain permanently dry, allowing permanent plant colonization.

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APPENDIX

TABLE 5

Locations of Stands Studied

Location Number	Biomass Stand	Local Name	Township, Range and Section	Community Types Examined[1]
1	M, (N)	Glendive	T16N, R56E, S18, SW corner of NW 1/4 sec.	MC*,SH, GR*, (GR*), W-S
2	M	Glendive	T17N, R56E, S36, NW 1/4 section	SA,SE,TH*,YC, MC,SH*,GR
3		Gentry's land	T17N, R56E, S17 north half	GA
4		--	T17N, R56E, S5, SW corner of NW 1/4 sec.	GA
5		Above intake	T17N, R56E, S2, NW corner of SW 1/4 sec.	GA
6	N	Intake	T18N, R56E, S33, SW 1/4 section	SA,SE,YC*, SH*, GR
7		Downstream of intake	T18N, R57E, S31, SW corner of NW 1/4 sec.	GA
8	N	--	T18N, R57E, S20, SE corner	SA*,SE*,TH*, YC
9	M	Mary's Island	T19N, R58E, S20, SW corner of SW 1/4 sec.	SA*,SE*,TH, YC,SH,GR
10		--	T20N, R58E, S34, NW corner of NW 1/4 sec.	GA, W-S
11	O	Elk Island	T20N, R58E, S27, NW 1/4 section	MC*,SH*,GR*
12	(N), O	Elk Island	T20N, R58E, S26, NW 1/4 section	SA*,SE*,TH*, YC*,(MC*)
13		Crittendon Island	T20N, R58E, S12, NW corner of SE 1/4 sec.	SA,SE,TH,YC
14	K	--	T21N, R58E, S23	SA*,SE*,TH*, YC*,MC*,SH*, GR*,W-S,PLW
15		Seven Sisters Island	T21N, R58E, S13, SW corner of SW 1/4 sec.	GA
16	L	--	T21N, R58E, S12, NE corner of NW 1/4 sec.	SA*,SE*,TH*, YC*,MC*,SH*, GR*
17		--	T22N, R59E, S20, SW corner	SA,SE,TH,SH, GR
18	M	Sidney	T22N, R59E, S10, NW corner of SE 1/4 sec.	YC*

*Biomass was studied in community types marked with an asterisk.
[1]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S), green ash (GA) and peach-leaved willow (PLW).

TABLE 6

Composite Vascular Plant Species[1] List of the Lower Yellowstone River Floodplain

TREES		
Acer negundo L.		boxelder maple[2]
Elaeagnus angustifolia L.		Russian-olive
Fraxinus pennsylvanica Marsh.	(Frpe)[3]	green ash
Juniperus scopulorum Sarg.		Rocky Mountain juniper
Populus deltoides Marsh.	(Pode)	eastern cottonwood
Salix amygdaloides Anders.	(Saam)	peach-leaved willow
Salix fluviatilis Nutt.	(Safl)	sandbar willow
Ulmus americana L.	(Ulam)	American elm
SHRUBS, CACTI AND VINES		
Amelanchier alnifolia Nutt.		Saskatoon serviceberry
Artemisia cana Nutt.	(Arca)	silver sagebrush
Artemisia dracunculus L.		tarragon sagebrush
Artemisia frigida Willd.		fringed sagebrush
Artemisia ludoviciana Nutt.	(Arlu)	Louisiana sagewort
Cornus stolonifera Michx.	(Cost)	red-osier dogwood
Coryphantha viviparia (Nutt.) Britt. & Brown		cushion coryphantha
Cotoneaster sp.		cotoneaster
Gutierrezia sarothrae (Pursh.) B.& R.		broom snakeweed
Juniperus horizontalis Moench.		creeping juniper
Opuntia fragilis (Nutt.) Haw.		brittle pricklypear
Parthenocissus quinquefolia (L.) Planch	(Paqu)	Virginia creeper
Prunus virginiana Marsh.	(Prvi)	common chokecherry
Rhus trilobata Nutt.	(Rhtr)	fragrant sumac
Ribes aureum Pursh.	(Riau)	golden currant

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[1]Scientific names follow Booth (1972) and Booth and Wright (1966) or, for species not listed by Booth, VanBruggen (1976).
[2]Common names follow Scott and Wasser (1980).
[3]Four letter abbreviations of binomials presented in the text are also listed.

TABLE 6--Continued

Ribes setosum Lindl.	(Rise)	redshoot gooseberry
Rosa woodsii Lindl.	(Rowo)	woods rose
Shepherdia argentea Nutt.	(Shar)	silver buffaloberry
Symphoricarpos occidentalis Hook.	(Syoc)	western snowberry
Tamarix chinensis Loureiro		tamarisk
Toxicondendron rydbergii (Small) Greene	(Tory)	common poison-ivy
Vitis riparia Michx.	(Viri)	riverbank grape
GRAMINOIDS		
Agropyron cristatum (L.) Gaertn.		crested wheatgrass
Agropyron repens (L.) Beauv.	(Agre)	quackgrass
Agropyron smithii Rydb.	(Agsm)	western wheatgrass
Agropyron trachycaulum (Link) Malte		slender wheatgrass
Agrostis alba L.		redtop bentgrass
Agrostis diegoensis Vasey		
Andropogon hallii Hack.		sand bluestem
Beckmannia syzigachne (Steud.) Fernald		American sloughgrass
Bouteloua gracilis (H.B.K.) Lab.		blue grama
Bromus inermis Leys.	(Brin)	smooth brome
Bromus japonicus Thunb.		Japanese brome
Calamovilfa longifolia (Hook.) Scribn.	(Calo)	prairie sandreed
Carex brevior (Dew.) Macken.		
Carex lanuginosa Michx.		
Distichlis stricta (Torr.) Rydb.		inland saltgrass
Echinochloa crusgalli (L.) Beauv.	(Eccr)	common barnyardgrass
Eleocharis palustris (L.) R.& S.		common spikerush
Elymus canadensis L.	(Elca)	Canada wildrye
Elymus junceus Fisch.		
Elymus virginicus L.		
Eragrostis hypnoides (Lam.) B.S.P.		
Eragrostis pectinacea (Michx.) Nees.		
Hordeum jubatum L.		foxtail barley

TABLE 6--Continued

Juncus balticus Willd.	Baltic rush
Muhlenbergia racemosa (Michx.) B.S.P.	(Mura)
Oryzopsis hymenoides (R.& S.) Ricker	Indian ricegrass
Panicum capillare L.	witchgrass panicum
Phalaris arundinacea L.	reed canarygrass
Poa palustris L.	
Poa pratensis L.	Kentucky bluegrass
Poa reflexa Vasey & Scribn.	
Polypogon monospeliensis (L.) Desf.	
Scirpus americanus Pers.	American bulrush
Scirpus validus Vahl.	softstem bulrush
Setaria glauca (L.) Beauv.	yellow bristlegrass
Setaria viridis (L.) Beauv.	green bristlegrass
Spartina gracilis Trin.	alkali cordgrass
Sporobolus cryptandrus (Torr.) Gray	sand dropseed
Stipa comata Trin. & Rupr.	needle-and-thread
Stipa viridula Trin.	green needlegrass
Vulpia octoflora (Walt.) Rydb.	sixweeks annual Fescue
FORBS	
Abronia fragrans Nutt.	
Achillea millefolium L.	common yarrow
Amaranthus powellii Wats.	
Ambrosia psilostachya DC.	western ragweed
Arabis holboelii Horn.	rockcress
Arctium lappa L.	
Asclepias speciosa Torr.	
Asclepias verticillata L.	
Asparagus officinalis L.	Asparagus
Aster chilensis Nees.	Pacific aster
Aster ericoides L.	heath aster
Aster oblongifolius Nutt.	
Aster pansus (Blake) Cronq.	
Bidens frondosa L.	devils beggarticks
Chenopodium album L.	lambsquarters goosefoot
Chenopodium leptophyllum Nutt.	slimleaf goosefoot
Chrysopsis villosa (Pursh.) Nutt.	hairy goldenaster
Cirsium arvense (L.) Scop.	Canada thistle
Clematis ligusticifolia Nutt.	

TABLE 6--Continued

Cleome serrulata Pursh.		Rocky Mountain beeplant
Convolvulus sepium L.		bindweed
Conyza canadensis (L.) Cronq.		Canada horseweed
Cycloloma atriplicifolium (Spreng.) Coult.		tunble ringwing
Equisetum arvense L.		field horsetail
Equisetum laevigatum A.Br.		smooth horsetail
Euphorbia esula L.		leafy spurge
Euphorbia glyptosperma Engelem.		
Galium triflorum Michx.		sweet-scented bedstraw
Gaura coccinea Pursh.		scarlet gaura
Gaura parviflora Dougl.		
Glycyrrhiza lepidota (Nutt.) Pursh.	(Glle)	American licorice
Gnaphalium palustre Nutt.		
Grindelia squarrosa (Pursh.) Dural.		curlycup gumweed
Helianthus petiolaris Nutt.		prairie sunflower
Iva axillaris Pursh.		poverty sumpweed
Iva xanthifolia Nutt.		rag sumpweed
Kochia scoparia (L.) Schrad.		fireweed summercypress
Lactuca pulchella (Pursh.) DC.		chicory lettuce
Lactuca serriola L.		prickly lettuce
Lappula echinata Gilib.		European stickseed
Lappula redowskii (Hornem.) Greene.		western stickseed
Lepidium densiflorum Schrad.		prairie pepperweed
Linum perenne L.		
Linum rigidum Pursh.		
Lygodesmia juncea (Pursh.) D. Don		rush skeletonplant
Lysimachia ciliata L.		
Medicago lupulina L.	(Melu)	black medic
Medicago sativa L.		alfalfa
Melilotus alba Desv.		white sweetclover
Melilotus officinalis (L.) Lam.	(Meof)	yellow sweetclover
Mentha arvensis L.		field mint
Mentzelia nuda (Pursh.) T.& G.		
Nepeta cataria L.		
Oenothera albicaulis Pursh.		
Oenothera biennis L.		common evening primrose
Physalis heterophylla Nees.		clammy groundcherry
Plantago major L.		common plantain
Plantago patagonica Jacq.		woolly plantain

TABLE 6--Continued

Polygonum aviculare L.		prostrate knotweed
Polygonum coccineum Muhl.	(Poco)	marsh knotweed
Polygonum lapathifolium L.		curlytop ladysthumb
Potentilla anserina L.		silverweed cinquefoil
Potentilla paradoxa Nutt.		
Psoralea argophylla Pursh.		silverleaf scurfpea
Ratibida columnifera (Nutt.) Woot. & Standl.		
Rorippa sinuata (Nutt.) Hitchc.		
Rumex maritimus L.	(Ruma)	
Sagittaria cuneata Sheld.		
Salsola kali L.		common Russianthistle
Sisymbrium altissimum (L.) Britt.		common tumblemustard
Sisymbrium loeselii L.		
Smilacina stellata (L.) Desf.		starry solomonplume
Smilax herbacea L.		carrionflower greenbrier
Solanum rostratum Dural.		buffalobur nightshade
Solanum nigrum L.		black nightshade
Solidago gigantea Ait.		
Solidago missouriensis Nutt.		Missouri goldenrod
Solidago mollis Bartl.		
Solidago occidentalis (Nutt.) T.& G.		
Sonchus asper (L.) Hill.		
Tanacetum vulgare L.		tansey
Taraxacum laevigatum (Willd.) DC.		common dandelion
Thalictrum venulosum Trel.		veiny meadowrue
Thlaspi arvense L.		field pennycress
Tradescantia occidentalis (Britt.) Smyth.		prairie spiderwort
Tragopogon dubius Scop.		yellow salsify
Trifolium fragiferum L.		
Verbascum thapsus L.		flannel mullein
Verbena bracteata L.& R.		bracted verbena
Verbena hastata L.		
Veronica americana Schwein.		American speedwell
Veronica catenata Penn.		
Viola canadensis L.		
Xanthium strumarium L.		common cocklebur

TABLE 7

Ages of Representative *Populus deltoides* and *Salix fluviatilis* in Stands Studied[1]

Community types	Seedling		Thicket		Young Cottonwood	Mature Cottonwood
Species[2]	Pode	Safl	Pode	Safl	Pode	Pode
Location number[3]						
1	-	-	-	-	-	108
2	2	2	4	4	44	-
6	4	3	-	-	-	-
8	3	3	11	7	26	-
9	3	3	6	4	31	-
11	-	-	-	-	-	98
12	3	3	7	5	-	85
13	4	2	6	6	-	-
14	3	3	9	9	23	95
16	4	2	7	7	43	75
17	3	2	7	4	-	-
18	-	-	-	-	39	-

[1]Ages were determined by sectioning or coring the trees and counting the annual rings.
[2]Species are *Populus deltoides* (Pode) and *Salix fluviatilis* (Safl).
[3]Locations are identified in Table 5.

TABLE 8

Elevation (m), Relative to the River Surface, of Stands Studied[1]

Community type[2] / Location number[3]	SA	SE	TH	YC	MC	SH	GR	W-S	GA
1	-	-	-	-	3.4	3.9	3.5/3.3[4]	3.7	-
2	0.9	1.6	1.9	3.4	4.5	3.9	3.5	-	-
3	-	-	-	-	-	-	-	-	4.0/ 4.0
4	-	-	-	-	-	-	-	-	5.0
5	-	-	-	-	-	-	-	-	5.0
6	1.0	1.4	-	2.7	-	3.7	3.6	-	-
7	-	-	-	-	-	-	-	-	3.7
8	1.3	1.4	2.4	2.4	-	-	-	-	-
9	0.3	1.1	1.7	3.2	-	3.6	3.1	-	-
10	-	-	-	-	-	-	-	4.0	4.4
11	-	-	-	-	4.1	3.0	3.1	-	-
12	0.7	1.8	1.7	3.4	3.5	-	-	-	-
13	1.0	1.6	2.9	2.9	-	-	-	-	-
14	-	1.4	3.0	2.9	3.5	2.8/3.3	3.3	-	-
15	0.8	-	-	-	-	-	-	-	4.3
16	0.8	0.9	3.2	3.3	3.4	3.5	2.9	-	-
17	0.4	0.7	3.0	-	-	3.1	3.6	-	-
18	-	-	-	3.4	-	-	-	-	-

[1]Elevations (soil height) were measured with a hand level and a rod.
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S), and green ash (GA).
[3]Locations are identified in Table 5.
[4]Two transects were studied at the same locality. The elevations are presented in the same order as in the 'Presence of Species' Appendix (Tables 10-17).

TABLE 9

Height (m)[1] of the Upper Canopy Surface and Diameter (cm)[2] of Populus deltoides in Stands Studied

Community type[3]	SE	TH		YC		MC		SH	W-S	GA
Parameter[4]	ht	ht	dia	ht	dia	ht	dia	ht	ht	ht
Location number[5]										
1	-	-	-	-	-	25.8	80	1.0	2.4	-
2	0.3	2.0	3	15.3	23	17.0	-	1.7	-	-
3	-	-	-	-	-	-	-	-	-	21.3/[6] 13.9
4	0.4	-	-	-	-	-	-	-	-	10.7
5	-	-	-	-	-	-	-	-	-	11.3
6	0.3	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	12.0
8	0.8	2.5	4	19.9	18	-	-	-	-	-
9	0.3	2.0	6	17.3	22	-	-	-	-	-
10	-	-	-	-	-	-	-	-	4.0	8.7
11	-	-	-	-	-	28.5	60	0.9	-	-
12	-	2.0	7	-	-	23.8	63	-	-	-
13	0.2	2.5	3	-	-	-	-	-	-	-
14	0.6	1.0	1	20.3	26	27.0	70	1.8/ 1.7	-	-
15	-	-	-	-	-	-	-	-	-	15.8
16	0.2	4.0	4	20.2	29	25.3	51	0.9	-	-
17	0.1	1.5	6	-	-	-	-	-	-	-
18	-	-	-	17.9	21	-	-	-	-	-

[1]Height of the upper tree canopy surface was measured with an Abney level.

[2]Diameter of representative Populus deltoides trees used for age were measured at their bases in the thicket community type and at breast height in the young cottonwood and mature cottonwood community types.

[3]Community types are seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH), grassland (GR), willow-shrub (W-S) and green ash (GA).

[4]Parameters are height (ht) and diameter (dia).

[5]Locations are identified in Table 5.

[6]Two transects were studied at the same locality. The heights are presented in the same order as in the "Presence of Species" Appendix (Tables 10 - 17).

TABLE 10

Presence (% Coverage)[1] of Species in the Seedling Community Type

Location number[2]	16	9	12	13	8	17	2	6	14	Present[3]
Bare ground	23	72	63	55	40	69	74	72	79	-
Litter	3	5	3	8	7	8	-	-	-	-
TREE SPP.										
Populus deltoides	37	17	15	30	25	15	18	13	20	-
Salix amygdaloides	2	+	3	2	3	+	2	-	+	-
Salix fluviatilis	18	2	2	5	12	+	5	+	2	-
SHRUB SPP.										
Artemisia ludoviciana	-	-	-	-	-	-	-	-	-	+
Gutierrezia sarothrae	-	-	-	-	-	-	-	-	+	-
GRASS SPP.										
Agropyron repens	-	-	-	-	-	-	-	-	-	+
Bouteloua gracilis	-	-	-	-	-	-	-	-	-	+
Distichlis stricta	-	-	-	-	-	-	-	-	-	+
Echinochloa crusgalli	8	+	+	+	5	-	+	+	-	-
Eleocharis palustris	2	-	-	+	-	-	-	-	-	-
Elymus canadensis	-	+	2	-	-	-	-	-	-	-
Eragrostis hypnoides	-	+	+	-	-	-	-	-	-	-
Eragrostis pectinacea	-	-	-	-	-	-	-	-	-	+
Hordeum jubatum	-	+	+	-	-	-	-	-	-	-
Muhlenbergia racemosa	-	-	-	-	-	-	-	-	-	+
Oryzopsis hymenoides	-	-	-	-	-	-	-	-	-	+
Panicum capillare	-	-	-	-	-	-	-	+	-	-
Poa pratensis	-	+	-	-	-	-	-	-	-	-
Polypogon monospeliensis	-	-	-	-	-	-	-	-	-	+
Setaria glauca	-	-	-	-	-	-	-	-	-	+
Setaria viridis	-	-	+	-	-	-	-	-	-	-
Sporobolus cryptandrus	-	-	-	-	-	-	-	-	-	+
FORB SPP.										
Aster chilensis	-	-	-	-	-	-	-	-	-	+
Aster pansus	-	-	-	-	2	-	-	-	-	-
Bidens frondosa	-	-	-	-	-	-	-	-	-	+
Chenopodium album	-	2	-	-	+	-	-	+	-	-
Cleome serrulata	-	-	-	-	-	-	-	-	-	+

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[1] Grass and forb coverage were estimated by the step-point method, shrub cover by calculating canopy coverage (pi-r^2) of each shrub present in density plots, and tree coverage was based upon ocular estimates.

[2] Locations are identified in Table 5.

[3] Species found in the same community type, but not sampled.

TABLE 10--Continued

Location number	16	9	12	13	8	17	2	6	14	Present
Convolvulus sepium	-	-	-	-	-	-	-	-	-	+
Conyza canadensis	-	+	2	-	-	-	-	-	-	-
Cycloloma atriplicifolium	-	+	+	-	2	-	-	-	-	-
Euphorbia glyptosperma	-	-	-	-	-	-	-	-	-	+
Glycyrrhiza lepidota	-	-	-	-	-	+	-	-	-	-
Gnaphalium palustre	-	-	-	-	-	-	-	-	+	-
Grindelia squarrosa	-	+	-	-	-	-	-	-	-	-
Helianthus petiolaris	-	-	-	-	-	-	-	2	-	-
Iva axillaris	-	-	-	-	-	-	-	-	-	+
Melilotus alba	-	2	-	-	-	-	-	-	-	-
Melilotus officinalis	-	+	-	-	-	-	-	-	-	-
Mentha arvensis	-	-	-	-	-	-	-	-	-	+
Oenothera biennis	-	+	3	-	-	-	-	-	-	-
Physalis heterophylla	-	-	-	-	-	-	-	-	-	+
Polygonum aviculare	-	+	+	-	-	+	-	13	-	-
Polygonum coccineum	5	-	-	+	2	5	2	+	-	-
Polygonum lapathifolium	-	-	+	-	-	-	-	-	-	-
Potentilla anserina	-	-	3	-	-	-	-	-	-	-
Potentilla paradoxa	-	2	3	+	-	+	-	-	+	-
Rorippa sinuata	-	-	-	-	-	-	-	-	-	+
Rumex maritimus	2	+	+	-	3	3	+	-	-	-
Salsola kali	-	-	-	-	-	-	-	-	-	+
Solidago gigantea	-	-	-	-	-	-	-	-	-	+
Solidago missouriensis	-	-	-	-	-	-	-	-	-	+
Solidago mollis	-	-	-	-	-	-	-	-	-	+
Sonchus asper	-	-	-	-	-	+	-	-	-	-
Tanacetum vulgare	-	+	-	-	-	-	-	-	-	-
Verbena bracteata	-	-	-	-	-	-	-	-	-	+
Verbena hastata	-	-	-	-	-	-	-	-	-	+
Veronica catenata	-	+	-	-	-	-	-	-	-	-
Xanthium strumarium	-	-	-	-	-	-	-	-	-	+

TABLE 11

Presence (% Coverage) of Species in the Thicket Community Type

Location number	16	8	17	2	14	13	12	9	Present
Bare ground	23	25	12	10	38	25	28	32	-
Litter	75	38	75	74	43	27	43	45	-
TREE SPP.									
Populus deltoides	+	+	+	+	+	+	+	+	-
Salix amygdaloides	+	+	+	+	+	+	+	+	-
Salix fluviatilis	+	+	+	+	+	+	+	+	-
SHRUB AND VINE SPP.									
Artemisia frigida	-	-	-	-	-	-	-	-	+
Artemisia ludoviciana	-	3	-	+	-	-	+	-	-
GRASS SPP.									
Agropyron repens	2	5	-	-	8	2	8	-	-
Agropyron smithii	-	-	+	3	2	-	2	-	-
Agropyron trachycaulum	-	-	-	-	-	-	-	-	+
Agrostis diegoensis	-	-	-	-	-	-	-	-	+
Andropogon hallii	-	-	-	-	+	-	-	-	-
Bromus inermis	-	-	-	-	+	-	-	-	-
Calamovilfa longifolia	-	-	-	-	-	2	+	-	-
Carex brevior	-	2	+	+	-	8	-	-	-
Carex lanuginosa	-	-	-	-	-	-	-	+	-
Distichlis stricta	-	-	-	-	-	-	+	-	-
Echinochloa crusgalli	-	+	-	+	+	-	-	-	-
Elymus canadensis	+	2	-	+	3	+	10	3	-
Hordeum jubatum	-	-	-	+	+	-	-	-	-
Juncus balticus	-	-	-	-	-	-	-	-	+
Muhlenbergia racemosa	-	5	2	3	-	5	2	-	-
Phalaris arundinacea	-	-	-	-	-	-	+	-	-
Poa spp.	-	-	2	-	-	-	-	-	-
Poa palustris	-	-	-	-	-	-	-	-	+
Poa pratensis	-	-	-	-	-	-	-	-	+
Poa reflexa	-	-	-	-	-	-	-	-	+
Polypogon monospeliensis	+	-	-	-	-	-	-	-	-
Scirpus americanus	-	-	-	-	-	-	-	-	+
Scirpus validus	-	-	-	-	-	-	-	-	+
Setaria viridis	+	-	-	-	-	-	-	-	-
Sporobolus cryptandrus	-	-	-	-	-	-	2	15	-
FORB SPP.									
Ambrosia psilostachya	-	+	-	-	2	+	2	-	-
Asclepias verticillata	-	-	-	-	-	+	-	2	-
Aster oblongifolius	-	-	-	2	-	-	-	-	-
Aster pansus	+	-	-	-	-	-	-	-	-

TABLE 11--Continued

Location number	16	8	17	2	14	13	12	9	Present
Chenopodium album	-	+	-	-	-	-	-	-	-
Chenopodium leptophyllum	-	-	-	-	+	-	-	-	-
Cirsium arvense	-	+	-	-	-	3	+	-	-
Conyza canadensis	-	-	-	-	-	3	-	-	-
Cycloloma atriplicifolium	-	-	-	-	+	-	-	-	-
Equisetum arvense	-	+	+	+	-	+	-	-	-
Equisetum laevigatum	-	-	-	-	-	-	+	-	-
Euphorbia glyptosperma	+	3	-	-	-	-	3	-	-
Galium triflorum	-	-	-	-	-	-	-	-	+
Glycyrrhiza lepidota	-	-	-	-	+	3	-	-	-
Gnaphalium palustre	-	10	-	-	-	-	-	-	-
Helianthus petiolaris	-	-	-	2	+	-	-	-	-
Melilotus alba	-	3	-	-	-	13	-	+	-
Melilotus officinalis	-	2	+	-	2	3	-	3	-
Oenothera albicaulis	-	-	-	-	+	-	-	-	-
Plantago major	-	-	-	-	-	-	-	-	+
Plantago patagonica	-	-	-	-	-	-	-	+	-
Polygonum lapathifolium	-	+	-	-	2	-	-	-	-
Potentilla anserina	-	-	-	-	-	+	-	-	-
Potentilla paradoxa	-	-	+	+	-	2	-	-	-
Rorippa sinuata	-	+	-	-	-	-	-	-	-
Rumex maritimus	-	-	-	-	-	2	-	-	-
Salsola kali	-	-	-	-	+	-	+	-	-
Sisymbrium loeselii	-	-	-	+	-	-	-	-	-
Solidago gigantea	-	-	3	-	-	-	-	-	-
Solidago occidentalis	-	+	7	-	-	-	+	-	-
Sonchus asper	+	-	+	-	-	-	-	-	-
Tanacetum vulgare	-	-	-	-	-	-	-	-	+
Taraxacum laevigatum	-	-	+	-	-	-	-	-	-
Tradescantia occidentalis	-	-	-	-	-	-	-	-	+
Verbena bracteata	-	-	-	7	-	-	-	-	-
Veronica americana	-	2	-	-	-	-	-	-	-

TABLE 12

Presence (% Coverage) of Species in the Young Cottonwood Community Type

Location number	9	14	16	8	18	2	12	13	6	Present
Bare ground	2	2	-	-	13	2	3	20	3	-
Litter	82	62	57	74	67	77	69	57	58	-
TREE SPP.										
Elaeagnus angustifolia	-	+	-	-	+	-	+	-	-	-
Fraxinus pennsylvanica	-	-	-	-	+	+	-	+	-	-
Juniperus scopulorum	-	-	-	+	-	-	-	-	-	-
Populus deltoides	60	60	65	60	75	75	45	75	75	-
Salix amygdaloides	-	+	+	-	+	-	+	+	+	-
SHRUB SPP.										
Amelanchier alnifolia	-	+	-	-	+	-	-	-	-	-
Artemisia ludoviciana	-	+	-	+	-	-	-	+	+	-
Cornus stolonifera	-	+	-	+	-	-	-	-	-	-
Parthenocissus quinquefolia	-	+	2	+	-	-	+	+	-	-
Rhus trilobata	+	-	-	-	-	-	-	-	-	-
Ribes aureum	+	+	-	+	-	+	-	-	-	-
Ribes setosum	-	-	-	-	-	-	-	-	-	+
Rosa woodsii	+	+	+	+	+	-	+	+	-	-
Shepherdia argentea	-	+	-	-	-	-	-	-	-	-
Symphoricarpos occidentalis	+	+	+	-	-	-	+	+	-	-
Toxicodendron rydbergii	-	+	2	+	-	+	-	+	+	-
Vitis riparia	-	-	+	-	+	-	2	-	-	-
GRASS SPP.										
Agropyron repens	+	22	8	-	5	-	7	3	3	-
Agropyron smithii	-	-	3	-	-	-	2	-	-	-
Agrostis alba	-	-	-	-	-	-	-	-	-	+
Bromus inermis	8	-	8	2	+	-	-	+	-	-
Calamovilfa longifolia	-	-	-	-	-	2	-	-	2	-
Carex brevior	-	-	-	-	3	-	-	-	-	-
Carex lanuginosa	-	-	-	-	-	-	10	-	-	-
Elymus canadensis	8	7	5	5	2	7	5	12	12	-
Elymus junceus	-	-	-	-	-	-	-	-	-	+
Elymus virginicus	-	-	-	-	-	-	-	-	-	+
Muhlenbergia racemosa	+	5	15	13	+	13	+	8	13	-
Poa spp.	-	-	-	2	-	-	-	-	2	-
Poa palustris	-	-	-	-	-	-	-	-	-	+
Poa pratensis	-	-	-	-	-	-	-	-	-	+
Polypogon monospeliensis	-	-	-	-	-	-	-	-	-	+
Setaria viridis	-	-	-	-	-	-	-	-	-	+

TABLE 12--Continued

Location number	9	14	16	8	18	2	12	13	6	Present
FORB SPP.										
Ambrosia psilostachya	-	-	-	-	-	-	-	-	2	-
Asclepias speciosa	-	-	-	-	-	-	-	-	-	+
Asclepias verticillata	-	+	-	+	-	-	-	+	-	-
Aster pansus	-	-	-	-	-	-	-	-	-	+
Chrysopsis villosa	-	-	-	-	-	-	-	-	-	+
Cirsium arvense	-	-	+	3	-	-	-	-	-	-
Clematis ligusticifolia	-	-	-	-	-	-	-	-	-	+
Conyza canadensis	-	-	-	-	-	-	-	-	-	+
Equisetum arvense	-	-	-	-	-	-	-	-	2	-
Equisetum laevigatum	-	-	-	-	-	-	+	-	-	-
Euphorbia esula	-	+	-	-	-	-	-	+	-	-
Glycyrrhiza lepidota	+	2	2	3	3	+	3	+	2	-
Grindelia squarrosa	-	+	-	+	-	-	-	-	-	-
Helianthus petiolaris	-	-	-	-	-	-	-	-	-	+
Lactuca pulchella	-	-	-	-	-	-	-	-	-	+
Medicago lupulina	-	-	-	-	-	-	-	-	-	+
Melilotus alba	-	+	-	-	7	-	+	-	-	-
Melilotus officinalis	-	-	-	-	+	-	-	-	-	-
Plantago major	-	-	-	-	-	-	-	-	-	+
Solidago gigantea	-	-	-	-	-	-	-	-	3	-
Thalictrum venulosum	-	-	-	-	-	-	-	-	-	+
Verbascum thapsus	-	-	-	-	-	-	-	-	-	+
Viola canadensis	-	-	-	+	-	-	-	-	-	-

TABLE 13

Presence (% Coverage) of Species in the Mature Cottonwood Community Type

Location number	1	2	14	12	16	11	Present
Bare ground	-	-	-	3	-	2	-
Litter	47	60	63	85	67	45	-
TREE SPP.							
Acer negundo	-	-	-	-	-	+	-
Elaeagnus angustifolia	+	-	+	-	-	+	-
Fraxinus pennsylvanica	+	+	+	+	+	+	-
Juniperus scopulorum	+	+	+	+	-	+	-
Populus deltoides	45	50	25	50	40	30	-
Salix amygdaloides	-	-	-	+	-	-	-
SHRUB AND VINE SPP.							
Artemisia ludoviciana	+	+	+	-	+	-	-
Cornus stolonifera	-	-	+	-	+	-	-
Parthenocissus quinquefolia	2	+	+	2	2	+	-
Rhus trilobata	-	5	-	-	-	-	-
Ribes aureum	-	1	1	+	-	+	-
Ribes setosum	-	-	-	-	-	-	+
Rosa woodsii	19	5	14	7	4	20	-
Shepherdia argentea	-	-	-	-	+	+	-
Symphoricarpos occidentalis	7	3	5	2	4	16	-
Toxicodendron rydbergii	20	15	7	3	10	25	-
Vitis riparia	13	+	-	-	8	+	-
GRASS SPP.							
Agropyron repens	-	-	-	-	3	-	-
Agropyron smithii	-	3	3	-	-	+	-
Agropyron trachycaulum	-	-	-	-	-	-	+
Bromus inermis	-	2	-	2	-	10	-
Elymus canadensis	8	7	13	3	3	2	-
Muhlenbergia racemosa	5	3	13	2	5	2	-
Poa spp.	2	10	-	-	+	11	-
Poa palustris	-	-	-	-	-	-	+
Poa pratensis	-	-	-	-	-	-	+
Setaria viridis	-	-	-	-	+	-	-
Stipa comata	-	-	-	-	-	-	+
FORB SPP.							
Abronia fragrans	-	-	-	-	-	-	+
Asclepias verticillata	+	+	-	-	+	-	-
Asparagus officinalis	-	-	-	-	-	+	-

TABLE 13 --Continued

Location number	1	2	14	12	16	11	Present
Aster oblongifolius	-	-	-	-	-	-	+
Cirsium arvense	-	-	-	-	-	+	-
Euphorbia esula	-	-	-	-	-	-	+
Euphorbia glyptosperma	-	-	-	-	-	-	+
Glycyrrhiza lepidota	2	+	+	-	1	-	-
Lygodesmia juncea	-	-	-	-	-	-	+
Lysimachia ciliatum	-	-	-	-	-	-	+
Melilotus officinalis	-	-	-	-	-	3	-
Ratibida columnifera	-	-	-	-	-	+	-
Smilax herbacea	-	-	-	-	-	-	+
Solanum nigrum	-	-	-	-	-	-	+
Solidago gigantea	-	-	-	+	-	+	-
Thalictrum venulosum	-	-	-	-	-	-	+
Tragopogon dubius	-	-	-	+	-	-	-

TABLE 14

Presence (% Coverage) of Species in the Shrub Community Type

Location number	14	6	2	1	17	16	14	11	9	Present
Bare ground	-	-	-	-	-	-	-	-	-	-
Litter	69	82	84	64	84	89	95	82	80	-
TREE SPP.										
Fraxinus pennsylvanica	+	-	+	+	+	-	+	-	-	-
SHRUB AND VINE SPP.										
Artemisia frigida	-	-	-	-	-	-	-	-	-	+
Artemisia ludoviciana	-	-	+	-	-	-	-	-	1	-
Coryphantha viviparia	-	-	-	-	-	-	-	-	-	+
Opuntia fragilis	-	-	-	-	-	-	-	-	-	+
Parthenocissus quinquefolia	-	-	1	+	-	+	-	+	-	-
Rhus trilobata	+	-	-	-	-	-	4	3	-	-
Ribes aureum	+	+	-	+	-	+	+	-	1	-
Ribes setosum	-	+	-	-	+	-	-	-	-	-
Rosa woodsii	12	11	20	20	17	14	14	10	4	-
Symphoricarpos occidentalis	10	9	13	6	6	3	8	14	7	-
Toxicodendron rydbergii	10	2	-	8	1	+	+	-	5	-
Vitis riparia	-	-	-	-	-	-	-	-	-	+
(Dead shrubs)	-[3]	-	40	20	30	-	-	25	30	-
GRASS SPP.										
Agropyron repens	2	-	-	-	-	+	-	2	-	-
Agropyron smithii	12	+	-	5	-	-	+	5	3	-
Bromus inermis	-	-	-	-	+	-	-	-	-	-
Calamovilfa longifolia	-	-	-	-	-	-	-	-	-	+
Elymus canadensis	5	+	3	+	2	3	-	2	+	-
Muhlenbergia racemosa	+	2	3	17	5	2	2	5	3	-
Poa spp.	-	8	+	3	3	-	-	-	7	-
Poa palustris	-	-	-	-	-	-	-	-	-	+
Poa pratensis	-	-	-	-	-	-	-	-	-	+
Setaria viridis	-	-	-	-	-	-	+	-	-	-
FORB SPP.										
Achillea millefolium	-	-	-	+	-	-	-	-	-	-
Ambrosia psilostachya	-	-	7	-	-	-	-	-	-	-
Asclepias speciosa	+	-	+	-	-	-	+	2	-	-
Asclepias verticillata	-	3	-	-	-	-	-	-	-	-
Asparagus officinalis	-	-	+	-	+	+	-	-	-	-
Aster ericoides	-	-	-	-	-	-	-	-	-	+
Aster pansus	-	-	-	+	-	-	-	-	-	-

[3] No data for dead shrubs for the transects with dashes.

TABLE 14--Continued

Location number	14	6	2	1	17	16	14	11	9	Present
Cirsium arvense	2	-	+	+	2	-	-	-	-	-
Conyza canadensis	-	-	-	-	-	-	-	-	-	+
Euphorbia esula	-	-	-	-	-	-	3	-	-	-
Glycyrrhiza lepidota	-	-	-	-	+	5	-	-	-	-
Helianthus petiolaris	-	-	-	-	-	-	-	+	-	-
Melilotus officinalis	-	-	-	-	-	-	+	-	-	-
Physalis heterophylla	-	-	-	-	2	-	-	-	-	-
Polygonum aviculare	-	-	+	-	-	-	-	-	-	-
Ratibida columnifera	-	-	-	-	-	-	-	-	-	+
Sisymbrium loeselii	-	-	+	-	-	-	-	-	+	-
Smilacina stellata	-	-	-	-	-	-	-	+	-	-
Solidago gigantea	-	-	-	3	2	2	-	-	-	-
Viola canadensis	-	-	2	-	-	-	-	-	-	-

TABLE 15

Presence (% Coverage) of Species in the Grassland Community Type

Location number	6	17	2	1	1	9	14	11	16	Present
Bare ground	7	-	-	-	-	5	-	-	12	-
Litter	67	45	82	45	38	40	53	45	38	-
SHRUB AND VINE SPP.										
Artemisia cana	2	-	2	-	4	+	1	2	+	-
Artemisia dracunculus	-	-	-	-	-	-	2	-	1	-
Artemisia frigida	-	-	+	-	-	-	-	-	-	-
Artemisia ludoviciana	3	+	+	3	10	+	+	-	-	-
Coryphantha vivipara	+	-	-	-	-	-	-	-	-	-
Opuntia fragilis	-	-	-	-	-	-	-	-	+	-
Parthenocissus quinquefolia	-	-	-	-	-	-	-	-	-	+
Rosa woodsii	+	+	-	+	-	2	+	+	-	-
Symphoricarpos occidentalis	+	+	-	1	-	+	1	+	+	-
Toxicodendron rydbergii	-	-	+	-	-	-	-	-	-	-
GRASS SPP.										
Agropyron cristatum	-	-	-	-	-	-	-	-	-	+
Agropyron repens	-	3	-	-	2	-	+	-	-	-
Agropyron smithii	10	3	10	20	20	7	45	35	+	-
Bouteloua gracilis	-	-	-	-	-	-	-	-	-	+
Bromus inermis	+	5	-	+	8	-	2	+	+	-
Bromus japonicus	+	-	-	-	-	-	-	-	-	-
Calamovilfa longifolia	2	15	+	28	10	12	+	-	30	-
Carex brevior	-	-	-	-	-	2	-	-	-	-
Echinochloa crusgalli	-	-	-	-	-	-	+	-	-	-
Elymus canadensis	-	+	+	+	5	13	+	-	+	-
Muhlenbergia racemosa	-	15	+	-	+	8	-	-	2	-
Panicum capillare	-	-	-	-	+	-	-	-	5	-
Poa spp.	+	10	+	-	-	8	-	18	-	-
Poa palustris	-	-	-	-	-	-	-	-	-	+
Poa pratensis	-	-	-	-	-	-	-	-	-	+
Setaria viridis	+	-	-	-	-	-	+	-	2	-
Spartina gracilis	-	-	+	-	-	+	-	-	-	-
Sporobolus cryptandrus	+	-	-	-	-	-	-	-	-	-
Stipa comata	+	-	-	-	-	-	-	-	+	-
Stipa viridula	5	-	7	2	-	-	-	-	-	-
Vulpia octoflora	+	-	-	-	-	-	-	-	-	-
FORB SPP.										
Achillea millefolium	+	-	+	-	-	-	-	-	-	-
Amaranthus powellii	-	-	-	-	-	-	-	-	-	+
Ambrosia psilostachya	-	-	-	+	-	-	-	-	-	-
Arabis holboellii	-	-	-	-	-	-	-	-	-	+
Asclepias speciosa	-	+	-	-	-	+	-	-	+	-

TABLE 15--Continued

Location number	6	17	2	1	1	9	14	11	16	Present
Aster oblongifolius	-	-	-	+	-	-	-	-	-	-
Aster pansus	-	-	-	-	-	-	-	-	-	+
Chenopodium album	+	2	-	-	-	-	-	-	-	-
Chenopodium leptophyllum	+	-	-	-	-	+	-	-	-	-
Conyza canadensis	-	-	-	-	-	-	-	2	-	-
Euphorbia esula	-	-	-	-	7	-	+	-	12	-
Glycyrrhiza lepidota	-	-	-	-	+	5	+	+	-	-
Grindelia squarrosa	-	+	-	-	-	-	-	-	-	-
Helianthus petiolaris	-	-	-	-	-	-	+	-	-	-
Heterotheca villosa	+	-	-	-	-	-	-	-	-	-
Iva axillaris	-	-	-	-	-	-	-	-	-	+
Kochia scoparia	-	-	+	-	-	-	-	-	-	-
Lactuca pulchella	-	-	-	-	-	-	-	-	-	2
Lappula echinata	+	-	-	-	-	-	-	-	-	-
Lappula redowskii	+	-	-	-	-	-	-	-	-	-
Lepidium densiflorum	+	-	-	-	-	-	-	-	-	-
Linum perenne	-	-	-	-	-	-	-	-	-	+
Medicago sativa	-	2	-	-	-	-	+	-	-	-
Melilotus alba	-	-	-	-	-	+	-	-	-	-
Melilotus officinalis	+	+	-	-	-	+	-	-	-	-
Mentzelia nuda	+	-	-	-	-	-	-	-	-	-
Nepeta cataria	-	-	-	-	-	-	-	-	-	+
Oenothera biennis	+	-	-	-	-	-	-	-	-	-
Physalis heterophylla	-	-	-	-	-	-	-	-	-	+
Polygonum aviculare	-	-	-	-	+	-	-	-	-	-
Psoralea argophylla	-	-	-	-	-	-	-	-	-	+
Ratibida columnifera	+	-	-	-	-	-	-	-	-	-
Rumex maritimus	-	-	-	-	-	-	-	-	-	+
Salsola kali	7	-	-	+	-	-	-	-	-	-
Sisymbrium altissimum	-	-	-	-	-	-	-	-	-	+
Sisymbrium loeselii	+	-	-	+	+	-	-	-	-	-
Smilacina stellata	+	-	+	-	-	-	-	-	-	-
Solanum rostratum	-	+	-	-	-	-	-	-	-	-
Solidago gigantea	-	-	-	-	+	-	-	-	-	-
Solidago mollis	-	-	2	-	-	-	-	-	-	-
Thlaspi arvense	+	-	-	-	-	-	-	-	-	-
Tradescantia occidentalis	+	-	-	-	-	-	-	-	-	-
Tragopogon dubius	-	-	-	-	-	-	-	-	-	+
Veronica americana	-	-	-	-	-	-	-	-	-	+

TABLE 16

Presence (% Coverage) of Species in the Green Ash Community Type

Location number	4	5	15	3	3	10	7	Present
Bare ground	-	-	10	-	2	27	17	-
Litter	53	58	55	84	28	47	27	-
TREE SPP.								
Elaeagnus angustifolia	-	-	+	-	-	-	-	-
Fraxinus pennsylvanica	20	20	70	80	65	75	75	-
Juniperus scopulorum	+	+	+	-	+	+	+	-
Populus deltoides	+	+	+	-	-	-	+	-
Salix amygdaloides	-	-	-	-	-	-	-	+
Salix fluviatilis	-	-	-	-	-	-	-	+
Ulmus americana	+	+	+	-	+	+	+	-
SHRUB AND VINE SPP.								
Acer negundo	-	-	+	+	-	-	-	-
Amelanchier alnifolia	-	+	+	-	-	-	-	-
Artemisia ludoviciana	+	+	-	-	-	-	-	-
Cornus stolonifera	-	-	+	-	-	+	-	-
Cotoneaster sp.	-	-	+	-	-	-	+	-
Parthenocissus quinquefolia	2	7	3	-	-	2	+	-
Prunus virginiana	1	1	-	-	-	-	-	-
Rhus trilobata	+	1	-	-	-	-	-	-
Ribes aureum	1	-	-	-	-	-	+	-
Ribes setosum	2	1	+	-	+	+	1	-
Rosa woodsii	5	11	+	-	-	-	6	-
Shepherdia argentea	-	+	+	-	-	-	-	-
Symphoricarpos occidentalis	28	16	+	-	1	-	6	-
Toxicodendron rydbergii	3	2	+	-	-	+	-	-
Vitis riparia	2	-	-	-	-	-	-	-
GRASS SPP.								
Agropyron repens	3	-	10	-	-	3	10	-
Agropyron smithii	-	7	-	-	-	2	-	-
Agrostis alba	5	-	-	-	-	+	-	-
Bromus inermis	5	-	+	12	69	-	-	-
Bromus japonicus	-	-	1	-	-	-	-	-
Carex brevior	-	-	-	-	-	-	-	+
Carex lanuginosa	3	-	-	-	-	-	-	-
Elymus canadensis	7	3	8	+	+	5	15	-
Muhlenbergia racemosa	+	2	-	-	-	5	2	-
Poa spp.	+	17	5	-	2	-	18	-
Poa palustris	-	-	+	-	-	-	-	-
Stipa viridula	-	2	-	-	-	-	-	-

TABLE 16--Continued

Location number	4	5	15	3	3	10	7	Present
FORB SPP.								
Achillea millefolium	-	-	-	-	+	-	-	-
Asclepias verticillata	-	-	-	-	-	-	-	+
Asparagus officinalis	-	-	-	-	-	+	+	-
Aster pansus	-	-	-	-	-	3	-	-
Chenopodium album	-	-	+	5	-	-	-	-
Cirsium arvense	3	-	-	+	+	-	-	-
Convolvulus sepium	-	+	-	-	-	+	+	-
Euphorbia esula	+	-	-	-	-	2	-	-
Galium triflorum	-	-	-	-	-	-	-	+
Glycyrrhiza lepidota	3	-	-	-	-	+	-	-
Helianthus petiolaris	-	-	-	+	-	-	-	-
Lactuca serriola	-	-	-	-	-	-	-	+
Lappula redowskii	-	-	-	-	-	+	-	-
Medicago lupulina	3	3	5	-	+	-	2	-
Medicago sativa	-	-	-	+	-	-	-	-
Melilotus alba	3	-	+	-	-	-	-	-
Melilotus officinalis	+	-	-	-	-	-	-	-
Mentha arvensis	-	-	-	-	-	-	+	-
Oenothera albicaulis	-	-	-	-	-	2	-	+
Plantago major	-	-	-	-	-	-	-	+
Rorippa sinuata	2	+	-	-	-	2	-	-
Smilacina stellata	-	+	-	-	-	-	-	-
Solidago gigantea	-	-	+	-	-	-	-	-
Taraxacum laevigatum	-	-	+	+	-	-	10	-
Thalictrum venulosum	+	-	-	+	+	-	+	-
Tragopogon dubius	+	-	-	-	-	-	-	-
Verbascum thapsus	-	-	-	-	-	+	-	-
Viola canadensis	2	-	2	-	-	2	-	-

TABLE 17

Presence (% Coverage) of Species in the Willow-Shrub, Peach-Leaved Willow and Marsh Community Types

Community type	Willow-Shrub			Peach-leaved willow	Marsh
Location number	1	10	14	14	
Bare gound	-	33	-	-	-
Litter	38	50	45	43	-
TREE SPP.					
Elaeagnus angustifolia	-	-	+	-	-
Fraxinus pennsylvanica	-	-	+	+	-
Salix amygdaloides	20	15	25	60	-
SHRUB AND VINE SPP.					
Artemisia ludoviciana	2	-	-	-	-
Cornus stolonifera	-	1	1	28	-
Parthenocissus quinquefolia	2	-	+	-	-
Prunus virginiana	+	-	-	-	-
Ribes setosum	+	-	-	-	-
Rosa woodsii	6	21	7	9	-
Salix fluviatilis	-	-	+	-	-
Symphoricarpos occidentalis	9	2	8	1	-
Toxicodendron rydbergii	3	2	+	+	-
Vitis riparia	+	2	+	+	-
GRASS SPP.					
Agropyron repens	8	-	-	-	-
Agrostis alba	5	-	-	-	+
Beckmannia syzigachne	-	-	-	-	+
Bromus inermis	5	2	28	23	-
Carex lanuginosa	-	-	-	23	-
Echinochloa crusgalli	-	-	-	-	+
Eleocharis palustris	-	-	-	-	+
Elymus canadensis	2	5	2	-	-
Muhlenbergia racemosa	5	5	-	-	+
Panicum capillare	-	-	-	-	+
Phalaris arundinacea	-	-	-	2	-
Poa palustris	3	-	3	3	+
Scirpus americanus	-	-	-	-	+
Scirpus validus	-	-	-	-	+
FORB SPP.					
Arctium lappa	-	-	7	-	-
Asclepias speciosa	-	-	-	+	-
Asclepias verticillata	+	-	-	-	-
Asparagus officinalis	-	-	-	2	-

TABLE 17--Continued

Community type	Willow-Shrub			Peach-leaved Willow	Marsh
Location number	1	10	14	14	
Aster pansus	-	2	+	+	+
Cirsium arvense	-	-	12	2	+
Convolvulus sepium	-	+	2	-	-
Conyza canadensis	-	-	-	-	+
Equisetum laevigatum	-	-	-	-	+
Galium triflorum	-	-	+	-	+
Glycyrrhiza lepidota	12	+	-	2	-
Helianthus petiolaris	-	-	-	-	+
Iva axillaris	-	-	-	-	+
Medicago sativa	5	-	-	-	-
Melilotus officinalis	2	-	-	-	-
Mentha arvensis	-	-	-	-	+
Plantago major	-	-	-	-	+
Polygonum coccineum	-	-	-	-	+
Potentilla paradoxa	-	-	-	-	+
Sagittaria cuneata	-	-	-	-	+
Smilacina stellata	-	-	-	+	-
Solidago mollis	-	-	-	-	+
Solidago occidentalis	8	-	-	-	-
Sonchus asper	-	-	-	-	+
Trifolium fragiferum	-	-	-	-	+
Viola canadensis	-	-	2	-	-

TABLE 18

Density (number/10 m^2) of Trees, by Diameter Class[1], in the Seedling and Thicket Community Types

Community type		Seedling									Thicket							
Location number[2]		16	9	12	13	8	17	2	6	14	16	8	17	2	14	13	12	9
Original plot size		1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	12	18	18	18	18	18	18	18
Species	Dia.Class(cm)																	
Pode[3]	0-0.5	573	520	533	807	207	153	673	207	660	-	-	-	-	-	-	-	-
	0.5-1	-	-	-	-	-	-	-	-	-	58	14	89	33	38	18	3	77
	1-2	-	-	-	-	-	-	-	-	-	15	3	2	2	17	6	1	13
	2-3	-	-	-	-	-	-	-	-	-	6	3	-	1	-	2	-	5
	3-4	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	3
	4-5	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	5-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Saam	0-0.5	20	10	40	60	-	20	-	-	-	-	-	-	-	-	-	-	-
	0.5-1	-	-	-	-	-	-	-	-	-	84	-	1	1	1	6	2	1
	1-2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-
	2-3	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	1
	3-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	4-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Safl	0-0.5	190	70	210	30	90	10	10	10	170	-	-	-	-	-	-	-	-
	0.5-1	-	-	-	-	-	-	-	-	-	7	90	15	156	93	86	92	46
	1-2	-	-	-	-	-	-	-	-	-	1	12	50	64	12	24	9	2
	2-3	-	-	-	-	-	-	-	-	-	-	2	26	3	-	2	-	2
	3-4	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-

[1] Diameter classes from 0 cm to 6 cm are basal diameters and diameters 6+ are diameters at breast height.
[2] Locations are identified in Table 5.
[3] Species are *Acer negundo* (Acne), *Elaeagnus angustifolia* (Elan), *Fraxinus pennsylvanica* (Frpe), *Juniperus scopulorum* (Jusc), *Populus deltoides* (Pode), *Salix amygdaloides* (Saam), *Salix fluviatilis* (Safl) and *Ulmus americana* (Ulam).

TABLE 19

Density (number/1000 m^2) of Trees, by Diameter Class, in the Young Cottonwood and Mature Cottonwood Community Types

Community type		Young cottonwood									Mature cottonwood					
Location number		9	14	16	8	18	2	12	13	6	2	2	14	12	16	11
Original plot size		108	75	75	120	75	92	75	84	75	1200	360	1200	1200	1200	1200
Species	Dia.Class(cm)															
Acne	4-5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	6-10	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
Elan	0.5-1	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
	1-2	-	27	-	-	-	-	-	-	-	-	-	-	-	-	1
	2-3	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-
Frpe	0-0.5	-	-	-	-	-	-	-	-	-	17	-	-	-	-	50
	1-2	-	13	-	-	-	459	-	-	-	2	7	-	-	1	-
	2-3	-	-	-	-	-	-	-	5	-	2	-	-	-	-	-
	6-10	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-
	20-30	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Jusc	1-2	-	-	-	3	-	-	-	-	-	-	4	-	-	-	-
	6-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
	10-20	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	20-30	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Pode	6-10	175	-	13	49	-	108	319	120	80	-	-	-	-	-	-
	10-20	-	53	106	100	133	87	160	101	53	-	8	-	-	1	-
	20-30	40	120	27	19	-	21	-	20	106	1	-	2	1	3	-
	30-40	-	-	-	-	-	-	-	-	-	1	-	7	9	6	2
	40-50	-	-	-	-	-	-	-	-	-	8	12	8	7	11	-
	50-60	-	-	-	-	-	-	-	-	-	3	3	2	3	3	2
	60-70	-	-	-	-	-	-	-	-	-	1	-	-	-	2	2
Saam	0.5-1	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-
	1-2	-	-	-	-	-	-	-	5	-	-	-	-	-	2	1
	2-3	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
	4-5	-	-	-	12	-	-	-	-	-	-	-	-	2	1	-
	5-6	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	6-10	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-

TABLE 20

Density (number/10 m^2) of Trees, by Diameter Class, in the Shrub Community Type

Community Type		Shrub								
Location number		14	6	2	1	17	16	14	11	9
Original plot size		15	15	15	14	14	14	30	30	30
Species	Dia.Class(cm)									
Frpe	0-0.5	5	-	1	-	-	-	28	-	-
	0.5-1	-	-	-	-	1	-	8	-	-
	1-2	-	-	-	1	1	-	-	-	-
	2-3	-	-	-	2	-	-	-	-	-
	4-5	1	-	-	1	-	-	-	-	-
	6-10	-	-	-	1	-	-	-	-	-

TABLE 21

Density (number/1000 m^2) of Trees, by Diameter Class, in the Green Ash, Willow-Shrub and Peach-Leaved Willow Community Types

Community type		Green ash							Willow-shrub			Peach-leaved willow
Location number		4	5	15	3	3	10	7	1	10	14	14
Original plot size		360	160	360	240	240	360	284	110	60	220	120
Species	Dia.Class(cm)											
Acne	0-0.5	-	-	3	-	-	-	-	-	-	-	-
	6-10	-	-	11	-	-	-	-	-	-	-	-
Elan	0-0.5	-	-	3	-	-	-	-	-	-	-	-
	0.5-1	-	-	-	-	-	-	-	-	-	9	-
	3-4	-	-	-	-	-	-	-	-	-	5	-
Frpe	0-0.5	218	3093	118	206	1289	120	11	3590	170	104	75
	0.5-1	-	25	-	-	-	3	-	18	-	36	-
	1-2	-	-	-	-	-	20	7	27	-	18	-
	2-3	-	-	-	-	-	25	18	-	-	-	-
	3-4	-	6	-	-	-	14	32	-	-	-	-
	5-6	-	12	-	-	-	11	25	-	-	-	-
	6-10	14	32	8	38	8	17	91	-	-	-	-
	10-20	14	95	101	76	105	3	53	-	-	-	-
	20-30	3	6	3	34	42	-	-	-	-	-	-
	30-40	-	-	-	21	-	-	-	-	-	-	-
Jusc	0-0.5	-	1	1	-	-	-	3	-	-	-	-
	6-10	4	-	-	-	-	-	0.4	-	-	-	-
	10-20	-	-	-	-	-	-	0.4	-	-	-	-
Pode	6-10	+	+	+	-	-	-	+	-	-	-	-

TABLE 21 --Continued

Community type		Green ash							Willow-shrub			Peach-leaved willow
Location number		4	5	15	3	3	10	7	1	10	14	14
Original plot size		360	160	360	240	240	360	284	110	60	220	120
Species	Dia.Class(cm)											
Saam	0.5-1	-	-	-	-	-	-	-	-	136	36	-
	1-2	-	-	-	-	-	-	-	-	425	126	-
	2-3	-	-	-	-	-	-	-	18	323	90	-
	3-4	-	-	-	-	-	-	-	45	221	63	-
	4-5	-	-	-	-	-	-	-	27	34	18	-
	5-6	-	-	-	-	-	-	-	36	17	18	-
	6-10	-	-	-	-	-	-	-	189	51	9	8
	10-20	-	-	-	-	-	-	-	117	102	-	-
	20-30	-	-	-	-	-	-	-	-	-	-	42
	30-40	-	-	-	-	-	-	-	-	-	-	16
Safl	0.5-1	-	-	-	-	-	-	-	-	-	36	-
	1-2	-	-	-	-	-	-	-	-	-	32	-
Olam	0-0.5	109	6	11	-	1285	–	4	-	-	-	-
	20-30	-	-	22	-	4	+	-	-	-	-	-

TABLE 22

Density (number/100 m^2) of Shrubs, by Canopy Diameter Class[1], in the Young Cottonwood and Mature Cottonwood Community Types

Community type		Young cottonwood									Mature cottonwood					
Location number[2]		9	14	16	8	18	2	12	13	6	1	2	14	12	16	11
Original plot size		120	90	120	60	28	37	160	46	120	15	15	30	15	15	20
Species	Size Class(dm)															
Amal[3]	0-1	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-
Cost	0-1	-	37	-	14	-	-	-	39	-	-	-	3	-	+	-
	1-2	-	2	-	-	-	-	-	8	-	-	-	-	-	-	-
	2-3	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
	3-4	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
	5-6	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
Rhtr	0-1	-	-	-	-	-	-	-	-	-	-	60	-	-	-	-
	1-2	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-
	2-3	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-
	3-4	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-
	4-5	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-
	5-6	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-
Riau	0-1	1	4	-	10	-	97	-	-	-	-	207	12	7	-	10
	1-2	-	-	-	-	-	-	-	-	-	-	20	9	-	-	10
	2-3	-	-	-	-	-	-	-	-	-	-	7	6	-	-	-
	3-4	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-

[1]Canopy diameter is the average of the widest crown measure and the crown measure perpendicular to it at its midpoint.

[2]Locations are identified in Table 5.

[3]Species are *Amelanchier alnifolia* (Amal), *Artemisia cana* (Arca), *Artemisia dracunculus* (Ardr), *Artemisia ludoviciana* (Arlu), *Cornus stolonifera* (Cost), *Cotoneaster* sp. (Co sp), *Prunus virginiana* (Prvi), *Rhus trilobata* (Rhtr), *Ribes aureum* (Riau), *Ribes setosum* (Rise), *Rosa woodsii* (Rowo), *Shepherdia argentea* (Shar) and *Symphoricarpos occidentalis* (Syoc).

TABLE 22--Continued

Community type		Young cottonwood									Mature cottonwood					
Location number		9	14	16	8	18	2	12	13	6	1	2	14	12	16	11
Original plot size		120	90	120	60	28	37	160	46	120	15	15	30	15	15	20
Species	Size Class(dm)															
Rowo	0-1	+	10	5	+	4	-	39	-	-	113	200	30	127	20	145
	1-2	-	8	-	-	4	-	2	2	-	227	80	40	87	60	100
	2-3	-	-	-	-	-	-	-	-	-	180	47	47	40	20	35
	3-4	-	-	-	-	-	-	-	-	-	40	13	43	27	20	40
	4-5	-	-	-	-	-	-	-	-	-	13	-	-	7	-	15
	5-6	-	-	-	-	-	-	-	-	-	-	-	13	-	-	10
	6-7	-	-	-	-	-	-	-	-	-	-	-	3	-	-	5
	7-8	-	-	-	-	-	-	-	-	-	-	-	7	-	-	5
	9-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Shar	0-1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Syoc	0-1	3	4	+	217	218	-	11	102	-	400	874	286	374	634	980
	1-2	1	1	-	27	28	-	-	41	-	234	47	67	60	153	465
	2-3	-	-	-	-	-	-	-	4	-	20	-	47	-	7	80
	3-4	-	-	-	-	-	-	-	-	-	7	-	10	-	-	15

TABLE 23

Density (number/100 m^2) of Shrubs, by Canopy Diameter Class, in the Shrub and Grassland Community Types.

Community type		Shrub									Grassland								
Location number		14	6	2	1	17	16	14	11	9	6	17	2	1	1	9	14	11	16
Original plot size		15	15	15	15	15	15	30	30	30	120	120	120	120	120	120	50	120	35
Species	Size Class(dm)																		
Arca	0-1	-	-	-	-	-	-	-	-	-	6	-	-	-	67	+	-	14	83
	1-2	-	-	-	-	-	-	-	-	-	6	-	-	-	47	-	2	2	6
	2-3	-	-	-	-	-	-	-	-	-	6	-	-	-	39	-	2	9	-
	3-4	-	-	-	-	-	-	-	-	-	-	-	7	-	8	-	2	4	-
	4-5	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	6	-
	5-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
	6-7	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-
	7-8	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-	-
Ardr	0-1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	15
	1-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	15
	2-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	3
	3-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
	4-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Rhtr	0-1	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-
	1-2	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-
	2-3	-	-	-	-	-	-	6	9	-	-	-	-	-	-	-	-	-	-
	3-4	-	-	-	-	-	-	9	6	-	-	-	-	-	-	-	-	-	-
Riau	0-1	27	47	-	7	-	-	7	-	-	-	-	-	-	-	-	-	-	-
	1-2	13	20	-	13	-	13	-	-	7	-	-	-	-	-	-	-	-	-
	2-3	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rise	0-1	-	20	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
	1-2	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 23--Continued

Community type		Shrub									Grassland								
Location number		14	6	2	1	17	16	14	11	9	6	17	2	1	1	9	14	11	16
Original plot size		15	15	15	15	15	15	30	30	30	120	120	120	120	120	120	50	120	35
Species	Size Class (dm)																		
Rowo	0-1	400	454	280	67	340	293	160	123	210	28	+	-	+	-	30	+	2	-
	1-2	354	293	200	153	347	93	213	103	77	15	-	-	-	-	23	-	-	-
	2-3	73	87	107	187	153	153	67	63	27	-	-	-	-	-	19	-	-	-
	3-4	13	7	73	40	20	13	50	20	3	-	-	-	-	-	5	-	-	-
	4-5	-	-	20	27	7	7	6	3	3	-	-	-	-	-	-	-	-	-
	5-6	-	-	-	-	-	7	3	3	-	-	-	-	-	-	-	-	-	-
	6-7	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
Shar	0-1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syoc	0-1	2828	2428	1067	880	1834	534	793	1272	586	+	7	-	53	-	61	76	7	69
	1-2	227	260	460	133	153	53	190	240	220	-	-	-	29	-	17	26	4	9
	2-3	-	-	20	46	-	13	37	43	33	-	-	-	4	-	-	2	-	-
	3-4	-	-	-	-	-	-	10	20	-	-	-	-	-	-	-	-	-	-
	4-5	-	-	133	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
	5-6	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-

TABLE 24

Density (number/100 m^2) of Shrubs, by Canopy Diameter Class, in the Green Ash Willow-Shrub and Peach-Leaved Willow Community Types

Community type		Green ash							Willow-shrub			Peach-leaved willow
Location number		4	5	15	3	3	10	7	1	10	14	14
Original plot size		15	15	39	120	70	15	17	15	15	15	15
Species	Size Class(dm)											
Amal	0-1	-	-	8	-	-	-	-	-	-	-	-
	1-2	-	7	-	-	-	-	-	-	-	-	-
Gost	0-1	-	-	20	-	-	+	-	-	7	40	-
	1-2	-	-	-	-	-	-	-	-	14	7	54
	2-3	-	-	-	-	-	-	-	-	-	14	40
	3-4	-	-	-	-	-	-	-	-	7	-	33
	6-7	-	-	-	-	-	-	-	-	-	-	20
	7-8	-	-	-	-	-	-	-	-	-	-	27
Co sp.	0-1	-	-	15	-	-	-	+	-	-	-	-
	1-2	-	-	2	-	-	-	-	-	-	-	-
Prvi	0-1	7	-	-	-	-	-	-	+	-	-	-
	1-2	7	7	-	-	-	-	-	-	-	-	-
	2-3	7	13	-	-	-	-	-	-	-	-	-
Rhtr	0-1	+	-	-	-	-	-	-	-	-	-	-
	1-2	-	7	-	-	-	-	-	-	-	-	-
	2-3	-	7	-	-	-	-	-	-	-	-	-
Riau	0-1	-	7	-	-	-	+	-	-	-	-	-
	1-2	-	7	-	-	-	-	-	-	-	-	-
	4-5	-	7	-	-	-	-	-	-	-	-	-

TABLE 24 --Continued

Community type		Green ash							Willow-shrub			Peach-leaved willow
Location number		4	5	15	3	3	10	7	1	10	14	14
Original plot size		15	15	39	120	70	15	17	15	15	15	15
Species	Size Class (dm)											
Rise	0-1	20	34	10	-	+	7	34	+	-	-	-
	1-2	67	34	-	-	-	7	30	-	-	-	-
	2-3	13	13	-	-	-	-	-	-	-	-	-
	3-4	-	-	3	-	-	-	6	-	-	-	-
Rowo	0-1	-	27	-	-	-	80	77	13	101	-	7
	1-2	40	1487	3	-	-	114	142	80	174	27	40
	2-3	20	67	-	-	-	73	34	60	228	54	47
	3-4	20	40	-	-	-	34	-	13	60	47	27
	4-5	7	7	-	-	-	-	-	13	27	20	34
	5-6	-	-	-	-	-	-	6	-	13	7	7
	6-7	-	-	-	-	-	7	-	-	-	-	7
	7-8	-	-	-	-	-	-	-	-	-	-	7
Syoc	0-1	194	667	20	-	94	570	153	1005	101	47	7
	1-2	844	523	18	-	25	536	165	161	54	114	20
	2-3	214	94	-	-	3	87	59	80	27	80	13
	3-4	20	7	-	-	-	13	-	7	-	20	-

TABLE 25

Constants[1] and Estimates of Relative Error[2] for Regressions Relating Logarithm Plant Weights to Their Logarithm Diameters

Diameter basis	Species	Constants + error	Leaf	Wood 0-.5 cm	Wood 5+ cm	Wood 0-1 cm	Wood 1-10 cm	Wood 10+ cm	Roots 1cm+
Crown canopy	Rowo[3]	b	1.46	1.44	1.59	-	-	-	-
		m	0.23	0.30	0.47	-	-	-	-
		r	0.93	0.92	0.86	-	-	-	-
		E	1.73	1.73	2.07	-	-	-	-
Crown canopy	Syoc	b	1.48	1.59	1.93	-	-	-	-
		m	0.18	0.31	-0.09	-	-	-	-
		r	0.94	0.98	0.95	-	-	-	-
		E	1.37	1.20	1.30	-	-	-	-
Crown canopy	Arca	b	1.80	2.31	3.21	-	-	-	-
		m	0.46	0.43	-0.02	-	-	-	-
		r	0.98	0.95	0.97	-	-	-	-
		E	1.33	1.63	1.69	-	-	-	-
Trunk base	Safl	b	2.136	-	-	2.43	3.35	-	-
		m	0.982	-	-	0.89	1.06	-	-
		r	0.99	-	-	0.97	0.92	-	-
		E	1.39	-	-	2.69	1.56	-	-
Trunk base	Saam	b	2.09	-	-	2.22	2.98	-	-
		m	0.93	-	-	1.08	0.91	-	-
		r	0.98	-	-	0.97	0.92	-	-
		E	2.46	-	-	2.99	1.75	-	-
Trunk base	Pode	b	2.53	-	-	2.38	2.85	-	2.33
		m	0.76	-	-	0.88	0.87	-	0.62
		r	0.99	-	-	0.98	0.99	-	0.99
		E	1.87	-	-	2.33	1.09	-	1.11
DBH	Pode	b	1.533	-	-	1.93	1.87	2.83	2.45
		m	-1.29	-	-	-1.78	-0.85	-1.67	1.14
		r	0.97	-	-	0.99	0.99	0.99	0.99
		E	1.27	-	-	1.24	1.18	1.18	1.41

[1] m = slope of the regression line. b = y intercept of regression line.

[2] r = correlation coefficient. E = estimate of relative error for a logarithmic regression. An E of 2 indicates that the predicted value lies between one half and twice the true value.

[3] Plant species are Rosa woodsii (Rowo), Symphoricarpos occidentalis (Syoc), Artemisia cana (Arca), Salix fluviatilis (Safl), Salix amygdaloides (Saam) and Populus deltoides (Pode).

TABLE 26

Bulk Density (g/m^2) of Soils from Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	0.80	1.05	1.25	1.25	1.23
	SE	0.80	1.05	1.25	1.25	1.23
	TH	1.20	1.89	1.24	1.23	1.07
	YC	1.08	1.31	0.99	1.19	1.26
	MC	0.97	1.31	1.21	1.10	1.12
	SH	0.95	1.55	1.28	0.97	1.02
	GR	0.90	1.10	1.19	1.15	1.05
10-30 cm	SA	1.42	0.95	0.98	1.04	1.15
	SE	1.42	0.95	0.98	1.04	1.15
	TH	0.79	1.37	1.04	1.18	1.19
	YC	1.09	1.12	1.02	1.19	1.15
	MC	1.28	0.99	0.99	1.04	1.06
	SH	1.31	0.93	1.34	1.19	1.07
	GR	1.00	1.23	1.29	1.45	1.11
30-150 cm	SA	0.87	0.78	1.23	1.11	1.20
	SE	0.87	0.78	1.23	1.11	1.20
	TH	0.71	1.11	1.08	1.04	0.92
	YC	1.06	0.68	1.16	1.12	0.90
	MC	1.09	0.99	1.06	1.06	0.98
	SH	1.10	1.14	0.99	1.13	1.16
	GR	0.84	1.20	1.15	1.19	1.23

[1]Bulk densities were estimated by weighing dried samples from five pooled cores and dividing by the volume of the coring tube segment. Weights of soils (gm/m^2) in each horizon are calculated by multiplying by the volume of the horizon for 0-10 cm = 100,000; for 20-30 cm = 200,000; for 30-15 cm = 1,200,000.

[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

[3]Locations are identified in Table 5.

TABLE 27

Elemental Contents (%) of Riparian Plants of the Lower Yellowstone River[1]

Species[2]	Part[3]	Number[4]	N X±SD[5]	P X±SD	K X±SD	Na X±SD	Ash X±SD
Pode	lf	5	1.64±0.19	0.20±0.04	1.32±0.03	0.03±0.01	9±1
	0-1	5	0.42±0.11	0.08±0.00	0.46±0.08	0.03±0.01	5±1
	1-10	4	0.31±0.10	0.05±0.01	0.30±0.12	0.04±0.02	4±2
	10+	4	0.07±0.02	0.01±0.01	0.18±0.04	0.06±0.05	3±1
Safl	lf	5	2.16±0.39	0.28±0.03	1.24±0.28	0.05±0.03	8±1
	0-1	5	0.65±0.29	0.08±0.03	0.58±0.31	0.03±0.01	3±1
	1-10	3	0.34±0.17	0.04±0.00	0.20±0.00	0.02±0.00	2±1
Rowo	lf	5	1.63±0.20	0.25±0.06	0.35±0.06	0.02±0.00	6±1
	0-0.5	5	0.55±0.11	0.07±0.03	0.14±0.04	0.02±0.00	3±0
	0.5+	5	0.32±0.07	0.04±0.00	0.07±0.01	0.01±0.00	2±1
Syoc	lf	5	1.65±0.18	0.23±0.08	1.70±0.20	0.02±0.00	7±1
	0-0.5	5	0.48±0.06	0.05±0.01	0.89±0.11	0.02±0.00	4±0
	0.5+	4	0.35±0.08	0.04±0.01	0.70±0.11	0.01±0.00	3±0
Arca	lf	5	1.84±0.38	0.25±0.04	1.64±0.13	0.02±0.00	7±1
	0-0.5	5	0.84±0.96	0.09±0.02	1.05±0.41	0.03±0.01	5±1
	0.5+	4	0.53±0.08	0.05±0.01	0.47±0.18	0.02±0.00	3±1

[1] Methods used for determining elemental contents are described in Bremner (1965, N), Olsen and Dean (1965, P) and Pratt (1965, K and Na).

[2] Species studied were Populus deltoides (Pode), Salix fluviatilis (Safl), Rosa woodsii (Rowo), Symphoricarpos occidentalis (Syoc), Artemisia cana (Arca), Toxicodendron rydbergii (Tory), vine and Artemisia ludoviciana (Arlu).

[3] Plant parts analyzed were leaves (lf) and twigs of the dimensions specified: 0-0.5 cm, 0.5+ cm, 0-1 cm, 1-10 cm, and over 10 cm.

[4] The number of transects examined.

[5] Mean ± standard deviation.

TABLE 27--Continued

Species	Part	Number	N $\bar{X}$±SD	P $\bar{X}$±SD	K $\bar{X}$±SD	Na $\bar{X}$±SD	Ash $\bar{X}$±SD
			Elements				
Tory		4	1.19±0.22				
Vine		2	0.60±0.14				
Arlu		5	1.42±0.50				
Grass	SE[6]	3	0.99±0.35	0.25±0.02	1.91±1.10	0.08±0.02	13±1
	TH	5	0.98±0.05	0.17±0.03	1.05±0.55	0.01±0	7±2
	YC	5	1.00±0.03	0.17±0.03	0.91±0.41	0.01±0	8±1
	MC	3	1.00±0.09	0.14±0.05	0.61±0.06	0.01±0	7±2
	SH	4	1.00±0.01	0.12±0.04	0.62±0.30	0.01±0	7±1
	GR	5	0.98±0.06	0.10±0.05	0.49±0.25	0.01±0	7±2
Forb	SE	3[7]	1.08±0.25	0.30±0.06	0.58±0.06	0.13±0.07	11±2
	TH	3	2.01±0.65	0.23±0.00	0.81±0.03	0.06±0.04	15±3
	YC	4	1.38±0.33	0.19±0.05	0.45±0.08	0.25±0.01	7±1
	MC	1	0.64	0.05	0.50	0.04	5
	SH	4	1.82±0.52	0.31±0.08	0.68±0.41	0.04±0.02	11±3
	GR	3	2.01±1.33	0.13±0.13	1.09±1.49	0.02±0.01	11±11
Litter	SA	2	0.49±0	0.04±0.01	0.11±0.04	0.09±0.06	15±10
	SE	5	0.91±0.41	0.10±0.04	0.34±0.18	0.10±0.12	19±12
	TH	5	0.78±0.18	0.08±0.02	0.23±0.05	0.02±0	14±2
	YC	5	0.63±0.17	0.07±0.02	0.20±0.02	0.02±0	16±5
	MC	4	0.67±0.10	0.07±0.01	0.25±0.03	0.02±0	20±8
	SH	5	0.55±0.11	0.05±0.01	0.27±0.09	0.02±0	12±4
	GR	5	0.94±0.15	0.07±0.01	0.20±0.04	0.01±0	13±2

[6] Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).

[7] For nitrogen, the number of samples tested is two in the seedling and grassland community types.

TABLE 28

Organic Matter Contents (%) of Soils from Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	<0.1	<0.1	0.2	<0.1	<0.1
	SE	0.3	0.4	1.2	1.2	1.4
	TH	1.0	<0.1	1.6	1.2	1.5
	YC	1.2	0.7	2.3	0.8	0.3
	MC	6.0	3.5	1.8	2.2	4.3
	SH	4.6	1.0	1.2	2.2	3.8
	GR	3.1	1.5	2.0	3.3	4.4
10-30 cm	SA	<0.1	<0.1	<0.1	1.0	0.5
	SE	<0.1	1.1	1.2	1.3	1.6
	TH	1.2	0.2	1.4	1.5	1.6
	YC	1.9	1.0	1.6	1.0	0.6
	MC	2.0	1.7	2.1	1.0	2.0
	SH	2.2	1.4	1.9	2.2	2.9
	GR	2.2	1.7	1.4	1.8	2.8
30-150 cm	SA	<0.1	0.6	<0.1	0.1	<0.1
	SE	<0.1	1.1	<0.1	0.2	0.2
	TH	0.6	0.3	0.8	0.2	0.6
	YC	0.9	1.5	1.1	1.6	1.0
	MC	-	1.5	1.5	0.9	1.2
	SH	1.5	1.2	1.5	0.8	1.2
	GR	1.0	0.5	0.8	0.9	1.0

[1]Organic matter contents were colorimetrically determined after dichromate oxidation (Sims and Haby 1970).
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).
[3]Locations are identified in Table 5.

TABLE 29

Kjeldahl Nitrogen Contents (%) of Soils from Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	.002	.002	.030	.010	.012
	SE	.019	.023	.012	.028	.039
	TH	.050	.014	.063	.022	.064
	YC	.051	.034	.089	.029	.023
	MC	.253	.114	.062	.073	.169
	SH	.149	.035	.069	.101	.167
	GR	.138	.062	.074	.107	.202
10-30 cm	SA	.007	.012	.005	.043	.028
	SE	.006	.034	.036	.040	.047
	TH	.045	.009	.049	.048	.062
	YC	.068	.036	.071	.037	.020
	MC	.084	.062	.083	.052	.069
	SH	.103	.072	.057	.097	.126
	GR	.104	.055	.075	.080	.163
30-150 cm	SA	.009	.020	.012	.017	.012
	SE	.002	.036	.026	.013	.008
	TH	.028	.014	.028	.014	.025
	YC	.040	.055	.039	.053	.046
	MC	-	.053	.053	.044	.033
	SH	.056	.043	.061	.019	.043
	GR	.034	.018	.023	.032	.039

[1]The method is described in Bremner (1965).
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).
[3]Locations are identified in Table 5.

TABLE 30

Total Phosphorus Content (%) of Soils in Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	.057	.046	.059	.056	.052
	SE	.052	.065	.032	.064	.062
	TH	.065	.045	.073	.048	.068
	YC	.071	-	.075	.059	.058
	MC	.090	.085	.073	.064	.074
	SH	.080	.055	.073	.074	.083
	GR	.083	.065	.073	.072	.088
10-30 cm	SA	.037	.045	.035	.072	.060
	SE	.053	.071	.071	.070	.068
	TH	.071	.052	.067	.066	.072
	YC	.076	.055	.063	.061	.052
	MC	.076	.076	.063	.060	.064
	SH	.071	.065	.063	.073	.074
	GR	.080	.065	.065	.071	.072
30-150 cm	SA	.050	.046	.041	.048	.046
	SE	.046	.069	.033	.054	.048
	TH	.061	.055	.062	.048	.062
	YC	.071	.073	.066	.068	.058
	MC	.065	.071	.068	.064	.064
	SH	.069	.073	.072	.048	.062
	GR	.063	.059	.060	.064	.064

[1]The method is described in Olsen and Dean (1965).
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).
[3]Locations are identified in Table 5.

TABLE 31

Bicarbonate Extractable Phosphorus Contents (%) of Soils in Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	.013	.004	.011	.003	.008
	SE	.009	.006	.0004	.001	.007
	TH	.015	.005	.020	.003	.011
	YC	.015	-	.020	.001	.008
	MC	.038	.012	.018	.007	.021
	SH	.031	.0004	.016	.010	.019
	GR	.029	.006	.013	.011	.025
10-30 cm	SA	.005	.005	.006	.001	.006
	SE	.017	.016	.009	.001	.007
	TH	.017	.006	.008	.005	.009
	YC	.020	.008	.010	.003	.002
	MC	.017	.023	.006	.001	.012
	SH	.020	.001	.006	.015	.013
	GR	.025	.008	.008	.011	.015
30-150 cm	SA	.010	.004	.008	.00003	.002
	SE	.005	.023	.004	.001	.002
	TH	.008	.004	.006	.004	.003
	YC	.015	.020	.012	.007	.001
	MC	.012	.007	.001	.007	.003
	SH	.014	.009	.015	.001	.001
	GR	.015	.010	.010	.007	.003

[1]The method is described in Pratt (1965).
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).
[3]Locations are identified in Table 5.

TABLE 32

Ammonium Acetate Extractable Potassium Content (%) of Soils from Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	.001	.002	.008	.004	.003
	SE	.005	.008	.002	.009	.006
	TH	.015	.004	.021	.010	.028
	YC	.014	-	.022	.012	.012
	MC	.054	.031	.021	.024	.044
	SH	.032	.011	.014	.022	.032
	GR	.036	.016	.029	.029	.051
10-30 cm	SA	.002	.001	.001	.008	.006
	SE	.003	.010	.009	.010	.009
	TH	.010	.005	.012	.013	.016
	YC	.018	.010	.024	.012	.009
	MC	.026	.022	.018	.019	.026
	SH	.020	.015	.015	.027	.031
	GR	.028	.018	.016	.024	.039
30-150 cm	SA	.002	.004	.002	.003	.004
	SE	.002	.004	.001	.004	.004
	TH	.007	.005	.007	.004	.006
	YC	.011	.016	.010	.021	.011
	MC	.010	.021	.021	.014	.014
	SH	.016	.012	.019	.006	.012
	GR	.014	.007	.009	.010	.013

[1]The method is described in Pratt (1965).
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).
[3]Locations are identified in Table 5.

TABLE 33

Ammonium Acetate Extractable Sodium Content (meq/100g) of Soils from Three Horizons in Seven Community Types[1]

Soil horizon	Community type[2]	Location[3] K	L	M	N	O
0-10 cm	SA	.1	.01	.3	.4	.2
	SE	.3	.3	.2	.3	.5
	TH	.1	.01	.9	.1	.3
	YC	.2	-	.3	.01	.1
	MC	.3	.4	.5	.01	.3
	SH	.1	.2	.1	.1	.3
	GR	.2	.1	.3	.1	.3
10-30 cm	SA	.1	.01	.1	.2	.3
	SE	.1	.2	.5	.3	.4
	TH	.3	.01	1.2	.7	.9
	YC	.4	.1	.5	.3	.2
	MC	.3	.3	.3	.2	.5
	SH	.2	.01	.2	.2	2.0
	GR	.3	.1	.3	.3	1.4
30-150 cm	SA	.1	.1	.2	.3	.2
	SE	.01	.4	.1	.3	.3
	TH	.6	.03	1.0	.4	.8
	YC	1.1	.6	1.7	1.5	.4
	MC	.4	2.2	2.2	.4	2.2
	SH	1.4	.7	.7	.3	4.1
	GR	.4	.1	.3	1.2	2.2

[1]The method is described in Pratt (1965).
[2]Community types are sandbar (SA), seedling (SE), thicket (TH), young cottonwood (YC), mature cottonwood (MC), shrub (SH) and grassland (GR).
[3]Locations are identified in Table 5.

TABLE 34

Biomass (g/m^2) Present in the Sandbar and Seedling Community Types

Community type Location[1] Component	Sandbar K	 L	 M	 N	 O	Seedling K	 L	 M	 N	 O
Total Soil OM[2]	1412	5932	1917	3537	2685	1572	12853	5323	6870	8286
0-10 cm[3]	80	105	250	125	123	240	422	1500	1502	1721
10-30 cm	283	191	196	2082	1150	283	2098	2352	2707	3681
30-150 cm	1049	5636	1471	1330	1442	1049	10333	1471	2661	2884
Total Roots[4]	-	-	-	-	-	218	406	223	514	358
0-1 mm	-	-	-	-	-	90	278	95	386	230
1-10 mm	-	-	-	-	-	128	128	128	128	128
Total Litter	8	44	-	-	-	2	102	9	5	114
Total Herbs	-	-	-	-	-	+	23	3	20	19
Grass	-	-	-	-	-	+	13	+	4	8
Forb	-	-	-	-	-	-	10	3	16	11
Total Safl[5,6]	-	-	-	-	-	18	58	2	17	96
Leaves	-	-	-	-	-	9	29	1	8	48
0-1 cm	-	-	-	-	-	9	29	1	9	48
Total Pode	-	-	-	-	-	11	168	34	28	92
Leaves	-	-	-	-	-	5	84	17	14	46
0-1 cm	-	-	-	-	-	6	84	17	14	46

[1] Locations are identified in Table 5.

[2] Organic matter (OM) colorimetrically determined after dichromate oxidation (Sims and Haby 1970) included roots less than one centimeter in diameter.

[3] Soil horizons sampled included the depths 0-10 cm, 10-30 cm and 30-150 cm.

[4] Roots were separated into the diameter classes 0-1 mm, 1-10 mm and 10 mm+.

[5] Shrub wood was separated into the diameter classes 0-0.5 cm and 0.5 cm+; for tree or willow wood 0-1 cm, 1-10 cm and 10 cm+.

[6] Plant species are *Symphoricarpos occidentalis* (Syoc), *Rosa woodsii* (Rowo), *Artemisia cana* (Arca), *Toxicodendron rydbergii* (Tory), *Artemisia ludoviciana* (Arlu), *Salix fluviatilis* (Safl), *Salix amygdaloides* (Saam) and *Populus deltoides* (Pode).

TABLE 35

Biomass (g/m^2) Present in the Thicket and Young Cottonwood Community Types

Community type	Thicket					Young cottonwood				
Location / Component	K	L	M	N	O	K	L	M	N	O
Total Soil OM	8246	4748	15226	7524	12088	16962	15436	20864	24759	12580
0-10 cm	1197	188	1976	1476	1607	1298	918	2288	953	377
10-30 cm	1908	547	2923	3541	3821	4174	2246	3253	2383	1377
30-150 cm	5141	4013	10327	2507	6660	11490	12272	15323	21423	10826
Total Roots	1085	566	617	708	1380	6298	9531	13215	5673	6046
0-1 mm	786	249	254	392	1079	540	1003	977	1335	528
1-10 mm	296	296	296	296	296	558	558	558	558	558
10 mm+	3	21	67	20	5	5200	7970	11680	3780	4960
Aboveground Dead	499	532	144	445	315	1559	1779	2060	2287	639
Litter	499	532	144	445	315	612	514	1913	301	388
Dead trees	-	-	-	-	-	947	1265	147	1986	251
Total Herbs	34	17	4	55	57	21	16	8	48	45
Grass	34	15	4	33	17	14	4	8	42	38
Forb	-	2	+	22	40	7	12	+	6	7
Total Shrubs	-	-	-	-	-	3	11	-	12	2
Syoc leaves	-	-	-	-	-	+	4	-	4	-
0-0.5cm	-	-	-	-	-	+	5	-	5	-
0.5 cm+	-	-	-	-	-	+	2	-	2	-
Rowo leaves	-	-	-	-	-	1	+	-	+	1
0-0.5cm	-	-	-	-	-	1	+	-	+	1
0.5 cm+	-	-	-	-	-	1	-	-	+	+
Arlu	13	-	-	+	-	-	-	-	-	-

TABLE 35--Continued

Community type Location Component	Thicket K	L	M	N	O	Young cottonwood K	L	M	N	O
Total Willow	112	138	125	206	726	-	-	-	-	-
Saam leaves	+	+	1	+	+	-	-	-	-	-
0-1 cm	+	+	2	+	+	-	-	-	-	-
1 cm+	-	-	4	-	-	-	-	-	-	-
Safl leaves	40	47	29	59	197	-	-	-	-	-
0-1 cm	32	38	26	50	174	-	-	-	-	-
1 cm+	40	53	63	97	355	-	-	-	-	-
Total Pode	18	108	559	103	34	12421	15230	26965	8843	10122
leaves	5	30	141	34	10	679	437	891	394	628
0-1 cm	6	38	159	39	13	501	486	991	378	533
1-10 cm	7	39	259	30	11	3420	3477	6620	2675	3621
10 cm+	-	-	-	-	-	7821	10830	18463	5397	5340

TABLE 36

Biomass (g/m^2) Present in the Mature Cottonwood and Shrub Community Types

Community type	Mature cottonwood					Shrub				
Location	K	L	M	N	O	K	L	M	N	O
Component										
Total Soil OM	-	25804	25487	15890	23203	30020	20569	24493	18237	26749
0-10 cm	5804	4571	2184	2417	4817	4374	1547	1541	2128	3883
10-30 cm	5148	3354	4154	2077	4240	5759	2594	5078	5218	6228
30-150 cm	-	17879	19149	11396	14146	19887	16428	17874	10891	16638
Total Roots	5967	6758	12052	8757	8876	1320	1609	1436	1549	2023
0-1 mm	641	542	1036	1411	1010	565	854	681	794	1268
1-10 mm	946	946	946	946	946	755	755	755	755	755
10 mm+	4380	5270	10070	6400	6920	-	-	-	-	-
Aboveground Dead	987	2328	1232	1553	632	407	867	380	882	684
Litter	987	1074	795	1237	609	407	867	380	882	684
Dead trees	-	1254	437	316	23	-	-	-	-	-
Total Herbs	8	30	1	8	19	39	8	22	14	5
Grass	8	30	1	8	7	29	4	16	14	1
Forb	-	+	-	+	12	10	4	6	-	4

TABLE 36 --Continued

Community type / Location / Component	Mature cottonwood K	L	M	N	O	Shrub K	L	M	N	O
Total Shrubs	156	83	44	135	50	113	87	126	113	168
Syoc leaves	24	7	8	11	4	21	5	21	14	22
0-0.5 cm	34	10	11	15	5	29	7	27	18	30
0.5 cm+	16	5	4	7	2	14	3	10	7	14
Rowo leaves	20	15	5	25	10	12	18	18	19	25
0-0.5 cm	23	17	6	30	11	14	21	21	23	30
0.5 cm+	39	30	10	48	18	23	32	29	32	47
Tory	-	24	18	-	41	-	1	-	-	-
Arlu	-	+	-	-	-	-	-	-	-	-
Vines	-	29	-	2	4	-	1	-	1	-
Total Pode	15270	15792	27003	17270	20755	-	-	-	-	-
leaves	164	244	381	226	303	-	-	-	-	-
0-1 cm	276	354	571	350	450	-	-	-	-	-
1-10 cm	1790	2337	3754	2287	2962	-	-	-	-	-
10 cm+	13040	12857	22297	14407	17040	-	-	-	-	-

TABLE 37

Biomass (g/m^2) Present in the Grassland Community Type

Community type / Location / Component		Grassland K	L	M	N	O
Total Soil OM		17251	13034	17065	21902	25581
0-10 cm		2778	1648	2372	3787	4641
10-30 cm		4412	4181	3611	5214	6228
30-150 cm		10061	7205	11082	12901	14712
Total Roots		1858	1252	1529	1951	1939
0-1 mm		1369	763	1040	1462	1450
1-10 mm		489	489	489	489	489
Total Litter		185	455	152	506	385
Total Herbs		114	154	144	114	147
Grass		108	132	124	114	147
Forb		6	22	20	+	-
Total Shrubs		31	23	4	64	47
Syoc	leaves	+	1	1	1	-
	0-0.5 cm	+	2	1	2	-
	0.5 cm+	+	1	+	1	-
Arca	leaves	7	2	1	5	13
	0-0.5 cm	13	3	1	12	19
	0.5 cm+	11	3	+	13	11
Arlu		-	11	-	30	4