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# Oak Savanna Restoration: A Case Study

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## Abstract

A degraded oak savanna in southwestern Wisconsin is being restored using intensive cutting of undesirable shrubs—buckthorn (*Rhamnus cathartica*), prickly ash (*Zanthoxylum americanum*), honeysuckle (*Lonicera* spp.)—and selective removal of trees that are crowding the open-grown bur (*Quercus macrocarpa*) and white (*Q. alba*) oaks. Land use records and historic aerial photographs have been used to guide the restoration process. Slippery elm (*Ulmus rubra*), black walnut (*Juglans nigra*), black cherry (*Prunus serotina*), and black oak (*Q. velutina*) are being removed by cutting and burning or by converting to lumber or firewood. Hundreds of aspen (*Populus tremuloides* and *P. grandidentata*) have been killed by girdling with subsequent cutting and burning. Management involves controlled burns and extensive weed control. Removal of invasive shrubs and trees has exposed the groundlayer to higher light intensities and stimulated the growth of savanna forbs and grasses. A number of typical herbaceous savanna species have reappeared after clearing or have been successfully introduced from local sources. However, control of brambles (*Rubus* spp.) and regrowth of buckthorn and honeysuckle remain principal problems. One savanna species endangered in Wisconsin—purple milkweed (*Asclepias purpurascens*)—was first seen in the savanna after a single controlled burn, and appears to be spreading. The redheaded woodpecker (*Melanerpes erythrocephalus*), a typical savanna bird, was first seen after shrub and canopy clearing in the savanna. Tree removal is a slow and expensive operation, and strategies for preventing damage to the groundlayer during tree removal had to be devised. About 70 acres (28 hectares) of savanna have been restored during nine years.

**Keywords:** oak, savanna, *Quercus macrocarpa*, *Quercus alba*, *Asclepias purpurascens*, invasive plant removal, *Melanerpes erythrocephalus*

## Introduction

The oak savanna ecosystem was once a major vegetation type in the midwestern United States, but is now exceedingly rare (Nuzzo 1986). Definitions of oak savanna vary, but generally focus on the extent of tree canopy coverage (for instance, 10–50% tree cover) or the presence of open-grown oaks (oaks with large horizontal branches) (Leach and Givnish 1996). The groundlayer plant composition of oak savannas seems to be unique, with a number of species that can probably be called “savanna specialists” (Packard 1988, Leach and Givnish 1999).

Pleasant Valley Conservancy, a 140-acre natural area, is in the Driftless Area of southwestern Wisconsin (T7N, R6W, Section 5). In this region, the landscape is controlled to a great extent by the underlying rock formations. This is the “Hill and Valley Region” of the state—a scenic landscape where steep hills are separated by narrow valleys. At Pleasant Valley Conservancy there is a 200-foot change in elevation from the hilltop ridge to the wetland in the valley. The soils of the ridge-top and steep slope are thin and of low fertility. Only a small amount of the property in bottomland is suitable for cultivation, although historically all the property was pastured extensively.

Surveyors’ notes indicate that the area was oak savanna. For the area including Section 5, the witness trees used by the surveyor were ten white oak (*Quercus alba*) specimens with diameters from 13 to 20 inches, three bur oaks (*Q. macrocarpa*) with diameters from 10–12 inches, and one black oak (*Q. velutina*) of 22 inches diameter. The surveyor reported: “Land hilly, broken & poor, third rate. I think timbered with white, black & bur oak.” The designation “third rate” indicates that the forest was not dense, but rather open, with relatively few trees. (The surveyor’s notes are available at <http://digicoll.library.wisc.edu/SurveyNotes/SurveyInfo.html>)

The earliest air photo—from 1937—shows a landscape on the ridge top and south-facing slope with widely spaced trees characteristic of a savanna. (This photo, taken by the U.S. Soil Conservation Service, is available from the U.S. National Archives and Record Center.) The map of the Wisconsin Land Economic Survey, done for this area in 1939, also confirms the savanna-like nature of the landscape. Recent tree surveys confirm that the dominant vegetation before settlement was oak savanna, with areas of dry prairie on the steepest south-facing slopes and wet to mesic prairie in the bottomlands. One of the oldest bur oaks on the property fell in 1997 and was later found to be 200 years old by counting its tree rings. Many oaks on the property are more than 150 years old.



The property was in general agricultural use from the 1880s through the 1950s with about 15 acres in cropland (now planted to prairie) and the rest in pasture, woodland, or wetland. Savanna areas that had probably been lightly pastured retained many remnant forbs and grasses in suppressed condition, with a number of characteristic savanna species. Today, about 30% of the property is prairie, 40% oak savanna, and 40% oak woods. Extensive restoration work began in 1997, and has involved clearing of invasive shrubs and trees, controlled burns, extensive weeding, and planting with seeds collected from remnants on the property or nearby.

## Overall Approach to Savanna Restoration

The long-term goal of the restoration process is an unimpaired functioning ecosystem in which viable populations of native species are maintained (McShea and Healy 2002). This includes not only oaks, but associated tree species, as well as an understory of native herbaceous savanna plants with occasional native shrubs. Also, a range of ages in the oaks is desirable, thus ensuring continued integrity of the savanna ecosystem.

Two types of oak savannas are present at Pleasant Valley Conservancy, one dominated by white oak and the other by bur oak. In general, the bur oak savannas are on the ridge tops (dolomite bedrock) and the white oak savannas are on the slopes (sandstone bedrock), although there is some intermixture. In both savannas, black oak, shagbark hickory (*Carya ovata*), and black cherry (*Prunus serotina*) are significant but minor components. Basswood (*Tilia americana*) and hackberry (*Celtis occidentalis*) are also occasionally present. Several native shrubs that would have been components of the original savanna are also present: hazelnut (*Corylus americana*), choke cherry (*Prunus virginiana*), nannyberry (*Viburnum lentago*), elderberry (*Sambucus canadensis*), and Juneberry (*Amelanchier arborea*). Although these shrubs are relatively fire-sensitive, they generally have the ability to resprout quickly, and in the original savanna would probably have remained as minor components, depending on the fire-return interval.

When restoration began, both savanna types contained large, typical open-grown oaks, but were heavily degraded. The understory contained dense stands of invasive shrubs, primarily honeysuckle (*Lonicera* spp.), buckthorn (*Rhamnus cathartica*), and prickly ash (*Xanthoxylum americanum*). (Although prickly ash is native, it is quite fire-sensitive and would not have been present in the original savanna.) Black walnut (*Juglans nigra*) and slippery elm (*Ulmus rubra*)—two fire-sensitive tree species that would not have been part of the original savanna—had also invaded, and in some areas were present in large populations.

A decision was made to remove all black walnut and slippery elm and to remove any black oak or shagbark hickory trees that were crowding open-grown bur or white oaks. Black cherry, basswood, and hackberry are not as invasive as walnut and elm and were only removed when they were crowding open-grown oaks or were present in larger numbers.

## Brush Removal

Much of the initial restoration work involved brush removal. All cut stumps were treated with herbicide, generally glyphosate (20% active ingredient in water), to prevent resprouts. Herbicide used in this manner is effective at any time of year (Brock 2004). Brush removal was most efficient when part of tree removal activities on the same site. The cut brush provides an excellent base for the burn pile that is an essential part of the tree removal process.

Although cutting followed by herbicide treatment eliminated shrubs, there was always a seedbank in the soil. Despite annual burns, new seedlings of invasive shrubs continued to appear. This problem was worse with buckthorn and honeysuckle than it was with prickly ash. Honeysuckle plants generally flower and set seed in their second year, so it was essential to remove any new honeysuckle plants arising from the seedbank. New buckthorn plants do not flower and set seed until they are older, so that it takes some years after buckthorn are removed before new growth begins to again contribute to the seedbank.

With annual burns, competition from native herbaceous species should perhaps eventually eradicate these invasive shrubs. The principal effect of fire is to top-kill shrubs because the roots are not killed. After a burn, the aboveground plant parts may be dead, but in the next growing season new shoots quickly arise from the living roots. Another season of fire will kill these new shoots, but even after years of consecutive fire, invasive shrubs may remain a problem. To help suppress new woody growth, establishment of native herbaceous savanna vegetation to compete with the invasive shrubs was done.

Because buckthorn is allelopathic (Seltzner and Eddy 2003), it may be several years after a heavy buckthorn infestation has been removed before native species will become established. Several of our savanna areas were essentially “buckthorn deserts” in the first two years after eradication, despite extensive seeding with native species, but a good groundcover was eventually established.

## Tree Removal

The goal of savanna restoration is to create an open tree canopy (10–50% cover). In our case, tree removal was not done to generate trees for market, but to restore the land to its former state. Although it may be possible to have some economic return from the cut trees, this should only be done if it can be ensured that damage to the habitat will not occur. Loggers operate with a different rationale than restoration ecologists. Slash that a logger might leave is often not compatible with the restoration process and logging trucks and skidders may damage fragile topsoil layers.

Removal of woody plants is best done in the winter, preferably when there is snow on the ground. Selection of personnel is important. The workers should be able to identify the various tree species in winter and should be careful when felling trees so as not to damage nearby trees that are to remain. Although wheeled vehicles are essential for the



removal of tree trunks, they should only be permitted when the ground is frozen solid (preferably with some snow cover). If the cut trees were not removed, the logs were cut in lengths short enough for a person to toss them on a fire. We prefer to have a manager on site when trees are being cut. This person can be treating cut stumps with herbicide or tending a burn pile while at the same time monitoring the tree-cutting personnel. Once a tree is cut it is gone forever!

Tree removal is a slow and expensive operation. For example, it took six people one week or 240 hours to clear a 2.1-acre savanna at our site. This is over 114 hours/acre, a not insignificant expense. The actual cost will depend upon the labor costs in the area under restoration. If the average hourly cost for labor is \$25, the total cost for this 2.1 acre parcel would be \$6,000, or about \$2,860 per acre. The cost per acre on a larger parcel could conceivably be less. Also, clearing on a level site should be faster than on a slope. Most of the trees cut were black walnuts or slippery elms. In addition there was a lot of honeysuckle and prickly ash on this site that was also removed at the same time. Twenty of the walnuts were large enough to be saw logs. Since these were on relatively level ground, and there was good snow cover, they were accessible and could be moved to the town road using a skidder installed on the back of a tractor. These logs were donated to a nonprofit group and were hauled to a nearby mill for sawing into lumber. Most of the smaller cut logs were donated to neighbors, who cut them up and removed them for firewood. Again, it is important to monitor those removing firewood to ensure that they are not damaging the soil surface.

## Use of Fire

Fire plays an important role in the maintenance of the oak savanna ecosystem (Curtis 1959, Dey 2002). Fire near our property was used frequently even after European settlement, according to William Aeschlimann, a nearby retired dairy farmer, who told us that the hills in our area were burned every spring. Historic photographs show that the south and west slopes of these hills were open (Jones and others 1936). At the time our restoration work began, our hillside had become mostly closed, either with red cedar or with invasive shrubs and trees.

Farming stopped at Pleasant Valley Conservancy about 1955 and subsequent air photos show the savanna areas gradually filling in with trees. By 1997, when we began restoration, the south-facing slope was almost completely wooded, except for a few isolated areas where some common prairie grasses and forbs still existed in scattered amounts. The lower slope had very few open-grown oaks, but the upper slope had trees typical of a savanna. Once the undesirable woody vegetation was removed, fire was introduced. In the first years, burns were very spotty, but over-seeding and annual burning brought back prairie and savanna vegetation capable of carrying a fire. Since year four, greater than 90% of the south-facing slope has burned with each spring burn. The savanna burns have been less complete but are usually greater than 50%, in some areas greater than 90%. (Burn success depends

greatly on the weather, which in our area varies considerably from year to year.)

We have burned our oak savannas in both spring and fall, but the fall is often the best time. A lot depends upon rainfall and temperature, and since the leaf litter is the major fuel, on leaf fall. In our area, bur oaks begin to lose their leaves in mid-October and by the end of the month, or in early November, most of the leaves are on the ground. Leaves remain longer on white oaks, and some leaves stay on the tree through the winter. To do a fall burn in our white oak savanna areas, we wait until most of the white oak leaves are down, which is usually mid-November. The savanna fire is a low-intensity fire that moves slowly through the leaf litter.

Savanna burns are much more difficult to do than prairie burns because there is a lot more preparation necessary before a burn can begin and mop-up after the burn takes a lot more time. Once a prairie is burned, it takes very little time to ensure that the fire is out and it is safe to leave. A savanna almost always has standing dead trees that can easily catch fire. A standing dead tree can act as a chimney, carrying the fire from the ground into the upper parts of the tree. Such a "smoker" cannot be left to burn, even if there is nothing around to catch fire, because changes in wind may blow sparks into distant parts. (We leave our dead trees standing as habitat for wildlife.)

The best way to deal with a standing dead tree is to prevent it from catching fire in the first place. This means making a wide leaf- and stick-free zone around each tree. We first cut any vegetation next to each trunk with a gasoline-powered brush cutter, using a plastic blade (Stihl, Polycut) to prevent damage to the trunk. Next we use a gasoline-operated leaf blower that creates a vegetation- and leaf-free zone. In addition to dead trees, we also remove flammable materials around the relatively fire-sensitive white oaks. The purpose is to lessen the chance of fire scarring, which could eventually leave the tree susceptible to disease. It may take a whole day to "fire-proof" all trees on our ridge-top savanna.

Savannas often have a lot of dead branches or even whole logs on the ground. These logs can block the progress of fire. If the fire does not carry well through the unit, because of dead logs or other reasons, it is essential to walk into the unburned area with a drip torch and restart the fire (a technique called "stripping"). Often one has to strip the burn unit extensively, walking back and forth with the drip torch, igniting the unit over and over again. Again, this is in contrast to a prairie burn, where once the black lines are set and the head fire is started, it is usually possible to just stand back and watch.

## Bramble Control

A major problem in oak savanna restoration is the control of brambles, mainly black raspberry (*Rubus occidentalis*) and blackberry (*Rubus* spp.). Brambles are a minor component of the degraded savanna, but once the habitat is opened up and light reaches the forest floor, they can grow rampantly. Although our brambles are native, we still consider them undesirable because they tend to take over the savanna.



Brambles are biennials, but have a perennial root system. The bramble plant is top-killed by fire, but the roots send up new shoots the next growing season. Since flowers only develop on the second-year shoots, annual fire will keep brambles from setting seed, but we have not succeeded yet in eradicating brambles by annual burns.

One approach to bramble control is to cut the plants in mid-summer, at flowering time. At this time of year, most of the nutrients are in the stems, and if these are severed the roots will be starved. We have found this procedure to be helpful, although it does not completely eliminate the brambles.

Complete elimination of brambles from an area requires the use of herbicide. A successful approach is to cut every living bramble cane and treat the cut stem with 20% active ingredient glyphosate. Although laborious, this procedure is quite effective and can be done any time of the year, including winter. We have used this approach primarily on areas of high priority or high visibility. A second approach is basal bark treatment of bramble canes with triclopyr (Garlon 4®, 15% active ingredient in a hydrocarbon oil; Diluent Blue®). A sponge-type applicator can be used. In order to avoid damage to other plants from the volatile triclopyr, this technique should only be done in the winter. To achieve eradication, every cane must be treated.

A third approach that is effective after a controlled burn is an early spring treatment with fosamine (Krenite®, 1.2% active ingredient aqueous). In our area, by mid-May, bramble plants have formed rosettes of leaves adjacent to the fire-killed stems. These rosettes are killed quickly by the herbicide and disappear within a week or so. If sprayed carefully, damage to nearby desirable plants can be avoided. (The manufacturer's literature on Krenite® implies that the herbicide should be used only on fully grown plants in the late summer or early fall. However, we have found that small plants in early spring are very sensitive and die quickly.) Since brambles grow very rapidly in the early spring, the habitat must be carefully monitored and treatment carried out as soon as the rosettes have four or five leaves.

Brambles always has an extensive seedbank, so that effective bramble control requires reseeding with herbaceous savanna species, since competition from other plants is an important factor in keeping brambles from becoming reestablished.

## Handweeding

An essential part of savanna restoration is careful handweeding of areas in the years immediately following clearing. Opening up an area to increased sunlight is virtually a guarantee that invasive plants will flourish. Many of these are the same plants encountered during prairie restoration, such as sweet clover (*Melilotus* spp.), wild parsnip (*Pastinaca sativa*), mullein (*Verbascum thapsus*), and bull thistle (*Cirsium vulgare*). Although generally present in smaller numbers in savannas than in restored prairies, they still must be dealt with. Careful surveys at least weekly (preferably more often)

during the growing season are necessary to discover and cut and or pull these weeds.

## Savanna Remnants

We were fortunate at Pleasant Valley Conservancy that a number of characteristic savanna species had maintained populations throughout the years. Those found in our surveys the year after clearing are: doll's eyes (*Actaea alba*), red baneberry (*Actaea rubra*), white snakeroot (*Ageratina altissima*), tall agrimony (*Agrimonia gryposepala*), wood anemone (*Anemone quinquefolia*), tall anemone (*Anemone virginiana*), wild columbine (*Aquilegia canadensis*), sicklepod (*Arabis canadensis*), spikenard (*Aralia racemosa*), poke milkweed (*Asclepias exaltata*), purple milkweed (*Asclepias purpurascens*), beggar's ticks (*Bidens frondosus*), Pennsylvania sedge (*Carex pensylvanica*), broadleaf enchanter's nightshade (*Circaea lutetiana canadensis*), old-field thistle (*Cirsium discolor*), Virgin's-bower (*Clematis virginiana*), longbract frog orchid (*Coeloglossum viride*), honewort (*Cryptotaenia canadensis*), large yellow lady-slipper (*Cypripedium calceolus* var. *pubescens*), pointedleaved tick trefoil (*Desmodium glutinosum*), shooting star (*Dodecatheon meadii*), wild cucumber (*Echinocystis lobata*), bottlebrush grass (*Elymus hystrix*), silky wild rye (*Elymus villosus*), Virginia wild rye (*Elymus virginicus*), burnweed (*Erechtites hieracifolia*), fleabane (*Erigeron* spp.), tall boneset (*Eupatorium altissimum*), upland boneset (*Eupatorium sessilifolium*), wild strawberry (*Fragaria virginiana*), stiff bedstraw (*Galium tinctorium*), wild geranium (*Geranium maculatum*), white avens (*Geum canadense*), rattlesnake plantain (*Goodyera pubescens*), stickseed (*Hackelia virginiana*), woodland sunflowers (*Helianthus* spp.), dotted St. John's wort (*Hypericum punctatum*), wild lettuce (*Lactuca* spp.), wood nettle (*Laportea canadensis*), Indian tobacco (*Lobelia inflata*), great blue lobelia (*Lobelia siphilitica*), fringed loosestrife (*Lysimachia ciliata*), whorled loosestrife (*Lysimachia quadrifolia*), bergamot (*Monarda fistulosa*), hairy sweet cicely (*Osmorhiza claytoni*), smooth sweet cicely (*Osmorhiza longistylis*), lopseed (*Phryma leptostachya*), Mayapple (*Podophyllum peltatum*), Jacob's ladder (*Polemonium reptans*), smooth Solomon's seal (*Polygonatum biflorum*), oldfield cinquefoil (*Potentilla simplex*), lion's foot (*Prenanthes alba*), shinleaf (*Pyrola elliptica*), small-flowered buttercup (*Ranunculus abortivus*), early buttercup (*Ranunculus fascicularis*), black snakeroot (*Sanicula marilandica*), lanceleaf figwort (*Scrophularia lanceolata*), balsam ragwort (*Senecio pauperculus*), false Solomon's seal (*Smilacina racemosa*), starry false Solomon's seal (*Smilacina stellata*), Canada goldenrod (*Solidago canadense*), elmleaf goldenrod (*Solidago ulmifolia*), calico aster (*Symphyotrichum lateriflorum*), hairy white oldfield aster (*Symphyotrichum pilosum*), white arrowleaved aster (*Symphyotrichum urophyllum*), yellow pimpernel (*Taenidia integerrima*), germander (*Teucrium canadense*), tall meadowrue (*Thalictrum dasycarpum*), early meadowrue (*Thalictrum dioicum*), early horse gentian (*Triosteum perfoliatum*), large-flowered bellwort (*Uvularia grandiflora*), Culver's root (*Veronicastrum virginicum*), common blue violet (*Viola*



*sororia*), and golden Alexander (*Zizia aurea*). Some of the species were fairly restricted, while others were common. Even those of restricted distribution often had populations large enough so that seed could be collected for planting in other areas.

Several species of more-than-usual interest should be mentioned. Shooting star has developed in almost all of our cleared white oak savannas. Most plants of this species also flower and set seed. Presumably, this species had been growing vegetatively in the deep shade and proliferated in the increased light.

Purple milkweed is on the Wisconsin State Endangered list. This handsome plant—a characteristic savanna species—was presumably present in the savanna, but “hidden” among all the brush. Removing the brush and burning brought it out. We initially saw it in 1998 in one of our white oak savanna areas and as further areas were cleared, it was found elsewhere. It is never common, and some plants do not flower, making them particularly hard to find. Using permanent markers, plants have been followed for a number of years. Some years a plant does not appear, but then shows up again the following year. Flowers occur some years, but the following year only vegetative plants are present. Only in three years (2001, 2004, and 2005) have we seen seedpods form. Seeds have been collected whenever possible, and seedlings have been reared the same year as collection and set out the following year. Some of these plants have survived in the wild and a few have grown to substantial size and flowered.

Poke milkweed has also developed in our restored savannas. Although restricted in distribution, it is more prevalent than purple milkweed. Its flowering is never consistent, but we have had more success with seed set with this species than with purple milkweed.

Upland boneset is listed as Threatened in Wisconsin. So far, we have found it growing in only one small area of one of our bur oak savannas. It generally flowers and sets seeds, but, thus far, we have been unsuccessful in attempting to raise plants.

## Introduction of Savanna Species by Seed

An important part of oak savanna restoration is the introduction of savanna forbs and grasses that would originally have been present but had disappeared after years of neglect. All of our introductions have been with seed collected from elsewhere on the property or from other Dane County sites within less than 20 miles of the Conservancy.

We preferably plant seed after controlled burning, either in the fall of the year it is collected or, at latest, the next spring, depending on when the burn was carried out. Burning creates open and bare areas where seeds can take root. We based the seeding rates on information from the 1988 publication by Henderson. (Although this publication focuses on prairie restoration, many savanna species are included, especially those targeted for mesic prairies.)

## Successful Introductions

We have had excellent success with the establishment of various savanna grasses in newly cleared areas, especially bottlebrush grass, silky rye, woodland rye (*Elymus riparius*), and woodland brome (*Bromus pubescens*). The first two were already present in remnants on the property, and the others came from nearby roadsides. These cool-season (C3) grasses begin to develop earlier in the year than the C4 prairie grasses, and are usually in full flower by mid-July. We collected seed and hand-planted them on other savanna areas as they were restored. We have continued to spread these grasses and they are now widespread on the Conservancy. Because they are moderately cool-season grasses, they get a head start over brambles and invasive shrub resprouts, thus helping us to keep these latter plants in check. They also help to carry fire during savanna burns.

Early horse gentian is another savanna plant that has been quite successful at Pleasant Valley Conservancy. Originally it was present in a few areas, from which seed were collected for planting elsewhere. This plant is now widespread in the Conservancy.

In addition to the savanna species that were present at the time restoration began, we have also had considerable success in introducing new species that are characteristic of the oak savanna habitat. All of these species have been collected from nearby locations, primarily roadsides. A number of species were collected from the about 2,500 feet of roadside on Dane County Highway F, which is owned by Pleasant Valley Conservancy. This roadside is actually a high-quality remnant. Most of the golden Alexanders, arrow-leaved aster, smooth aster (*Aster laevis*), and Culver's root came from there. Woodland rye and woodland brome came from a roadside about a mile away. Giant yellow hyssop (*Agastache nepetoides*)—a state Threatened species—and woodland Joe-pye-weed (*Eupatorium purpureum*), both of which are now well established at Pleasant Valley Conservancy, came from Dane County sites about 20 miles away. The giant yellow hyssop has thrived and is now quite common in all of our savanna areas. Another savanna species, large-flowered yellow false foxglove (*Aureolaria grandiflora*) has also been introduced. This plant grows hemiparasitically on oaks, and was planted under the drip line of large oak trees. After several years with no plants visible, we now have a number of locations where plants of this species are growing and flowering.

Lists of species typical of oak savannas have been published (Bray 1960, Leach and Ross 1995, Bader 2001). The publication by Cochrane and Iltis (2000) is an excellent resource for assessing the significance of a particular species in a remnant.

A more detailed presentation of the restoration activities at Pleasant Valley Conservancy can be found at our web site: <http://www.savannaoak.org>.



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