

## A PLANT COMMUNITY ANALYSIS OF COLLINS GULF

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### ABSTRACT

Nine plant community types were identified in the southern portion of Collins Gulf located on the west-facing escarpment of the Cumberland Plateau: a hemlock, a red maple, a chestnut oak, a mixed hickory-sugar maple, a sweet pignut hickory, an oak-hickory, and three mixed mesophytic community types. The number of canopy species ranged from a low of 10 in the red maple community to a high of 24 in the oak-hickory community. The red maple community also had the lowest number (21), and the oak-hickory community also had the highest number of species (43) in the shrub layer. When the communities were compared with each other and with the communities previously recognized in adjacent Savage Gulf using polar ordination analysis of the overstory the communities of the neighboring gorges clustered around an axis roughly determined by the Savage Gulf hemlock chestnut oak communities at one end and the Collins Gulf sweet pignut hickory community at the other. Of the 24 communities, only the Collins Gulf red maple and the Savage Gulf sugar maple communities ordinated far from this axis.

### INTRODUCTION

Collins Gulf, north opening with steep rugged east- and west-facing slopes, is one of three large gulfs in Savage Gulf State Natural Area in Grundy County, Tennessee. Marketable timber, limited to trees 16 inches in diameter or larger, was last harvested in the gulf in 1972 (personal communication, Franklin W. Smith, logging manager, Huber Corporation).

The objectives of the research were to identify the plant community types within the southern portion of Collins Gulf, to compile lists of species along with their associated importance values for the overstory and shrub layer of each community type, and to compare the community types with each other and with community types previously recognized by Sherman (1978) in adjacent Savage Gulf.

Savage Gulf, west-opening with steep rugged north- and

south-facing slopes, contains one of the few stands of virgin forest remaining in the southeastern United States although the lower reaches of the gulf forest were last harvested in 1973 (Sherman, 1978). Collins Gulf and Savage Gulf converge where Savage Creek joins the Collins River.

### METHODS

Community boundaries were determined by observing changes in the overstory and understory composition. The point centered quarter method was used to sample the overstory of each community. Identification of the taxa was based on Radford et al. (1981).

A four meter by four meter square in the southeastern quarter of each sampling point was used to sample the shrub layer. Woody vegetation one foot in height or taller and less than 3.9 inches in diameter at breast height was identified, counted, and stem diameter four inches above the ground determined. Diameters were measured in inches and basal areas were calculated in square feet.

The sampling data was used to compute the relative frequency, relative density, relative dominance and importance value (IV 300) of each species in the overstory and shrub layer of each community. The communities recognized were compared with each other and with the communities previously recognized in Savage Gulf using polar ordination analysis of the overstory. Polar ordination reduces the sampling data to a simple graphical form which illustrates each community as a point in space. The distance between the points represents the degree of dissimilarity between the communities. Using overstory importance values the community types at Savage Gulf (Sherman 1978) were included in the ordination data set.

### RESULTS AND DISCUSSION

Ten forest stands representing nine community types were recognized in the southern portion of Collins Gulf.

#### *The Hemlock Community*

The hemlock community, the least disturbed and most stable



Table 3. Shrub Layer Importance Values for Collins Gulf Communities.

Taxa	Community									
	He	RM	COE	COW	Hi-SM	Hi	O-H	MMTu	MMHe	MMBe
<i>Tsuga canadensis</i>	58	20	10	1			1	5	18	9
<i>Liriodendron tulipifera</i>		7			4	8	5	16	3	5
<i>Tilia heterophylla</i>			4		5	1	11	12	8	7
<i>Fagus grandifolia</i>	9	5		1	6	2	6	4	14	19
<i>Acer saccharum</i>	4		12	8	57	35	16	44	18	20
<i>Acer rubrum</i>	3	111	32	17	4	1	6	1	8	6
<i>Acer pensylvanicum</i>	41	8								
<i>Fraxinus americana</i>			1	10	14	6	6	6	1	10
<i>Quercus prinus</i>		6	17	41	21		1			
<i>Quercus rubra</i>		2	5	7	2	9	8	3	2	1
<i>Quercus alba</i>				1		4	6			10
<i>Quercus muehlenbergii</i>						5	2		4	
<i>Carya ovalis</i>				2	5	21	1	1	3	1
<i>Carya ovata</i>	8	3	7	19	13	5	2	1	7	7
<i>Garya glabra</i>			5	5	1	2	1	1	6	6
<i>Carya cordiformis</i>			1	1	1	3	5	9	9	4
<i>Carya tomentosa</i>			5						1	1
<i>Betula lutea</i>		48							6	
<i>Cornus florida</i>	4	10	31	25	20	21	30	27	15	11
<i>Cercis canadensis</i>			10	10	8	17	13	9	3	14
<i>Aesculus octandra</i>			2		2	2	1	15	3	6
<i>Prunus serotina</i>			2	7	1	3	1	4	1	2
<i>Oxydendrum arboreum</i>		10	15	1			1			
<i>Nyssa sylvatica</i>		15				1		2	1	
<i>Ulmus rubra</i>	7		2	7	4	10	10	11		9
<i>Ulmus alata</i>				4	1	9	3	2		5
<i>Magnolia acuminata</i>	6					4	1		1	2
<i>Magnolia tripetala</i>	15	2							5	
<i>Sassafras albidum</i>		24	6	4			2			
<i>Ostrya virginiana</i>					9	23	17	3	1	8
<i>Carpinus caroliniana</i>	6				3	6	33	18	14	9
<i>Ilex opaca</i>	3						1	1		2
<i>Robinia pseudo-acacia</i>			3	2	1	1	1			
<i>Liquidambar styraciflua</i>		3					1		1	1
<i>Juniperus virginiana</i>				1						
<i>Morus rubra</i>										1
<i>Castanea dentata</i>		2								
<i>Hammamelis virginiana</i>	3		4	4	1	3	7	3	18	7
<i>Asimina triloba</i>					3		7	11	3	5
<i>Rhododendron maximum</i>	32	9	1						22	19
<i>Rhododendron nudiflorum</i>				5						
<i>Kalmia latifolia</i>			16	4						
<i>Calycanthus florida</i>			3	2	14	1	18	24	27	27
<i>Rhus radicans</i>	7		45	10	13	46	33	17	18	20
<i>Smilax species</i>	24	2	8	26	21	22	16	16	14	10
<i>Parthenocissus quinquefolia</i>	13		5	6	22	16	7	14	10	10
<i>Crataegus species</i>				4		1				1
<i>Aralia spinosa</i>		6								
<i>Vitis species</i>	5	4	6	4	3	2	5	1	6	3
<i>Rubus species</i>	3		12	5		1	1	1	1	1
<i>Hydrangea arborescens</i>			14	1	18	3	7	8	7	8
<i>Euonymus americanus</i>	12		4	1	5	1	1	4	12	6
<i>Viburnum acerifolium</i>	23	3	11	17	4				5	4
<i>Viburnum prunifolium</i>				1		3	1			
<i>Arundinaria gigantea</i>				6		1	2	1		1
<i>Anisostichus capreolata</i>	3		1	1	7	3	4	6	6	1
<i>Vaccinium species</i>	3		4	12						
<i>Lonicera japonica</i>							1			
Unidentified								1		1

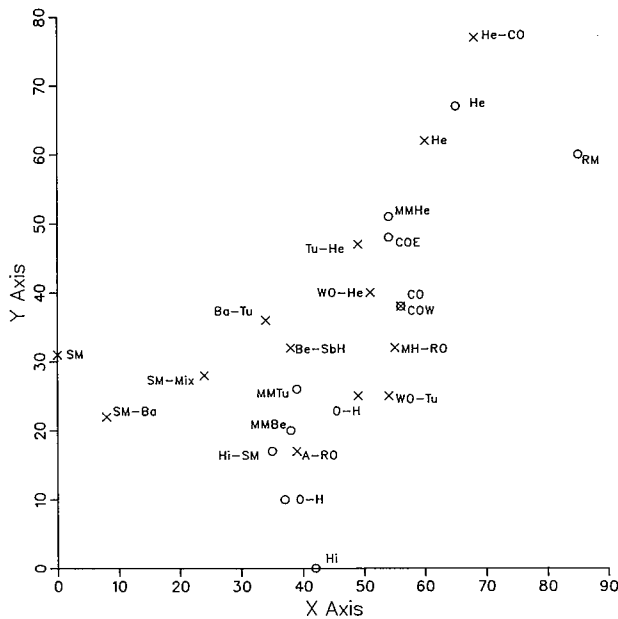


Figure 1. Polar Ordination of the Communities of Collins Gulf and Savage Gulf  
(See Table 4 for coding of community types)

Note: O's represent Collins Gulf communities  
X's represent Savage Gulf communities

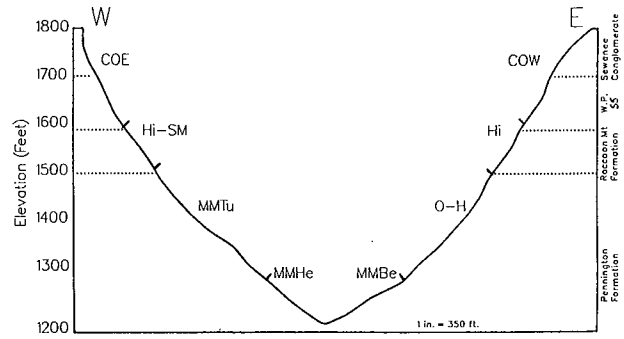


Figure 2. Profile of the Central Gorge Area of Collins Gulf and Approximate Locations of Community Types on Gorge Slopes

Red-berried elder has been reported in only three other gorges of the Cumberland Plateau in Tennessee, a gorge near Wartburg, a gorge in Fall Creek Falls State Park, and Savage Gulf (Robertson 1969; Wofford et al. 1979).

The hemlock community was similar to the virgin hemlock community of Savage Gulf. Both occurred in the narrow portions of the gorges, had similar importance values calculated for hemlock, and occupied the same general area on the polar ordination graph (Figure 1).

#### The Red Maple Community

The red maple community occurred juxtaposed to the hemlock community in the narrow southernmost section of the gorge. A very disturbed area, indicated by the large number of trees per acre and the small average overstory tree basal area, it was the smallest community and occupied approximately ten acres of east- and west-facing slopes. That the area was part of the adjacent hemlock community prior to logging was evidenced by the presence of several large hemlock stumps. Red maple (*Acer rubrum*) had an importance value of 96; yellow birch and tulip poplar were important overstory associates.

The shrub layer was dominated by red maple. Yellow birch, sassafras (*Sassafras albidum*), and hemlock were important shrub layer associates. The high shrub basal area figure was due to the large number of transgressives in the shrub layer as opposed to smaller species such as greenbrier (*Smilax* spp.) and poison ivy (*Rhus radicans*) which dominated the shrub layers of many of the other less disturbed community types.

The uniqueness of the red maple community was expressed

by its isolation on the polar ordination graph. The high importance value of red maple in the shrub layer indicated that the community was reproducing a red maple community type; but hemlock's importance value of 20 in the shrub layer despite its absence from the overstory indicated that this species was beginning to reclaim a share of the canopy.

#### The East-facing Chestnut Oak Community

The east-facing chestnut oak community was located on the uppermost east-facing slope positions (Figure 2). Chestnut oak (*Quercus prinus*) had an importance value of 138; red maple and sourwood (*Oxydendrum arboreum*) were important associates.

Analysis of the shrub layer indicated that the community was reproducing the existing type. The shrub layer included, in order of highest importance value, poison ivy, red maple, flowering dogwood (*Cornus florida*), and chestnut oak.

#### The West-facing Chestnut Oak Community

The west-facing chestnut oak community occurred on the uppermost west-facing slope positions. This community was dominated by chestnut oak (importance value 110) with Virginia pine (*Pinus virginiana*), pignut hickory, and northern red oak (*Quercus rubra*) and white oak (*Q. alba*) as important associates.

The shrub layer included, in order of highest importance value, chestnut oak, greenbrier, and flowering dogwood.

A conspicuous difference between the two chestnut oak communities was the high importance value of Virginia pine in the west-facing community. Portions of the west-facing slope were not bordered by prominent sandstone cliffs which allowed for a gradual transition between the west-facing chestnut oak

community and the level plateau surface community which consisted largely of Virginia pine. No Virginia pine occurred in the shrub quadrats which suggested that the invasion of Virginia pine into the community was a result of logging and that this species will not be an important associate in the future.

The west-facing chestnut oak community was similar to the virgin south-facing chestnut oak community of Savage Gulf. Both communities occupied the same coordinates on the polar ordination graph.

*The Mixed Hickory-Sugar Maple Community*

The mixed hickory-sugar maple community occurred on upper middle east-facing slope positions. Sweet pignut hickory (*Carya ovalis*) had the highest overstory importance value, 64, followed by sugar maple (*Acer saccharum*), chestnut oak, shagbark hickory (*Carya ovata*), and pignut hickory (*Carya glabra*). The high importance value calculated for chestnut oak was because the site environment was similar to that of the adjacent chestnut oak community.

The shrub layer was dominated by sugar maple. All the hickory species sampled in the overstory were sampled in the shrub layer and had a cumulative shrub layer importance value of 21 which indicated that the mixed hickory-sugar maple community was reproducing the existing community type. The high shrub layer importance value for chestnut oak indicated that parts of the upper slope positions of this community were in transition favoring a chestnut oak dominated community.

The central location of the mixed hickory-sugar maple community in the polar ordination indicated the more mesophytic character of this community compared to the west-facing sweet pignut hickory community.

*The Sweet Pignut Hickory Community*

The sweet pignut hickory community occurred on upper middle west-facing slope positions and was dominated by sweet pignut hickory (importance value 95). Shagbark hickory and white ash (*Fraxinus americana*) were important associates.

The shrub layer included, in order of highest importance value, poison ivy, sugar maple, and ironwood (*Carpinus caroliniana*). All the species sampled in the overstory were sampled in the shrub layer except black walnut (*Juglans nigra*) and chestnut oak.

Unlike the boundary between the east-facing chestnut oak and mixed hickory-sugar maple communities, the boundary between the west-facing chestnut oak and sweet pignut hickory communities was distinct. The presence of a shale lens between the resistant sandstone layers resulted in a bench with the chestnut oak above and the sweet pignut hickory below.

*The Oak-Hickory Community*

The oak-hickory community occurred on lower middle west-facing slope positions. The overstory was dominated by northern red oak (importance value 48) and white oak (importance value 41). Shagbark hickory, sweet pignut hickory, mockernut hickory (*Caryatomentosa*), and pignut hickory were sampled in the overstory and had a cumulative importance value of 48. Important associates included beech (*Fagus grandifolia*), sugar maple, and chinkapin oak (*Quercus muehlenbergii*).

The shrub layer included, in order of highest importance value, poison ivy, hop hornbeam (*Ostrya virginiana*), and flowering dogwood.

Its more central location on the polar ordination graph suggested the Savage Gulf mixed oak-hickory community had more mixed mesophytic characteristics than the Collins Gulf

Table 4. Coding for Communities

COLLINS GULF COMMUNITIES	
He	Hemlock
RM	Red Maple
COE	East-facing chestnut oak
COW	West-facing chestnut oak
Hi-SM	Mixed hickory-sugar maple
Hi	Sweet pignut hickory
O-H	Oak-hickory
MMTu	Tulip poplar-basswood mixed mesophytic
MMHe	Tulip poplar-hemlock mixed mesophytic
MMBe	Beech mixed mesophytic
SAVAGE GULF COMMUNITIES	
He	Hemlock (virgin)
He-CO	Hemlock-chestnut oak (virgin)
CO	Chestnut oak (virgin)
Ba-Tu	Basswood-tulip poplar-sugar maple (virgin)
Be-SbH	Beech-shagbark hickory (virgin)
Tu-He	Tulip poplar-hemlock (virgin)
WO-He	White oak-hemlock (virgin)
MH-RO	Mockernut hickory-northern red oak (virgin)
SM	Sugar maple
SM-Ba	Sugar maple-basswood
SM-Mix	Sugar maple-mixed hardwoods
WO-Tu	White oak-tulip poplar
A-RO	White ash-northern red oak
O-H	Mixed oak-hickory

oak-hickory community. In the Savage Gulf mixed oak-hickory community chestnut oak and black locust had the highest importance values and the northern red and white oaks did not have significantly higher importance values than the hickory species (Sherman 1978).

*The Tulip Poplar-Basswood Mixed Mesophytic Community*

The tulip poplar-basswood mixed mesophytic community occupied a large portion of the lower middle east-facing slopes. Tulip poplar had the highest importance value, 60, followed by basswood (*Tilia heterophylla*), sugar maple, and white ash. This was the only community in which bitternut hickory (*Carya cordiformis*) had a higher importance value than the other hickory species present.

Only three species sampled in the overstory were not sampled in the shrub layer: cucumber magnolia (*Magnolia acuminata*), mockernut hickory, and tree of heaven (*Ailanthus altissima*). Sampled in the shrub layer in order of highest importance value were sugar maple, flowering dogwood, and spice bush (*Calycan-*

*thus florida*). Tulip poplar and basswood, the dominant overstory species, had shrub layer importance values of 16 and 12 respectively. Bitternut hickory had a significantly higher shrub layer importance value compared to the other hickory species.

Polar ordination indicated that the tulip poplar–basswood community was more similar to the beech mixed mesophytic community than it was to the adjacent tulip poplar–hemlock mixed mesophytic community. No community similar to tulip poplar–basswood was documented at Savage Gulf (Sherman 1978).

#### *The Tulip Poplar–Hemlock Mixed Mesophytic Community*

This community occurred on the lowest positions of the east-facing slopes. Tulip poplar had the highest importance value, 54, closely followed by hemlock, 50. Beech and red maple were important associates. Several large hemlock stumps indicated that hemlock had the highest importance value prior to logging.

The shrub layer included, in order of highest importance value, spicebush, rosebay, and hemlock. That this community was in succession toward a hemlock–tulip poplar mixed mesophytic community type can be concluded from the much higher shrub layer importance value of hemlock than tulip poplar.

The Savage Gulf virgin tulip poplar–hemlock community also occupied the deepest, most shaded slope positions in the central gorge, but tulip poplar had a much higher overstory importance value, 61, than hemlock, 36. The relative density values for the sapling layer were listed as 12.12 for hemlock and only 0.74 for tulip poplar (Sherman 1978). It can be concluded from this data that this community was also in succession toward a hemlock–tulip poplar community type.

#### *The Beech–Mixed Mesophytic Community*

This community occurred on the lowest west-facing slope positions. Beech had the highest importance value, 65, followed by tulip poplar and sugar maple. Northern red oak, chinkapin oak, and white oak were important associates and had a cumulative importance value of 51. Five hickory species were sampled in the overstory and had a cumulative importance value of 30. The community became gradually restricted to the stream side at the northern end of the study area where the lower slopes had greater isolation and were occupied by the oak–hickory community.

The shrub layer included, in order of highest importance value, spicebush, sugar maple, poison ivy, beech, and rosebay. The high shrub layer importance value for beech and the fact that all the species sampled in the overstory were sampled in the shrub layer except chinkapin oak, butternut (*Juglans cinerea*), and serviceberry (*Amelanchier arborea*) indicated that the community was reproducing the existing community type.

#### CONCLUSIONS

Ten forest stands representing nine community types were recognized in the study area. Each community was reproducing

the existing community type except the red maple and tulip poplar–hemlock mixed mesophytic which were in succession, respectively, toward hemlock and hemlock mixed mesophytic communities.

No environmental interpretation of the X and Y axes of Figure 1 has been attempted since the virgin communities occur at one end of the array and the secondary communities presumably occur on the same site environments as (now removed) virgin stands.

Sherman (1978), reported that significant changes in forest composition resulted shortly after selective logging occurred. Whether or not disturbances cause extensive permanent changes in forest composition has long been argued. Although long term effects which result from medium intensity short duration disturbances cannot be accurately assessed in such small isolated communities, the data of this study supports the hypotheses that complex mature ecosystems are resistant to limited disturbance and that selective logging does not cause extensive permanent changes in forest woody plant composition.

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