

MANAGEMENT PLAN FOR A REMNANT HERD OF FERAL HORSES ON CUMBERLAND ISLAND

by

Bryan K. Burkingstock
Jason E. Long
Linda M. Vallance

FRS 473
Fall 1994

Committee Members:
Dr. Walter L. Cook, Jr.
Dr. Todd C. Rasmussen
Dr. Robert J. Warren

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ACKNOWLEDGEMENTS

We thank Jennifer Bjork, Resource Management Specialist at Cumberland Island National Seashore (CINS), for making this project possible. Her close coordination with us, along with help from the National Park Service (NPS), provided us with trips to the island and a place to stay during our visits. Dr. Robert J. Warren especially was helpful in initializing contact with CINS, as well as supplying us with most of the literature necessary to familiarize ourselves with feral horse management. We thank Dr. Todd Rasmussen and Leslie Crawford for their assistance in collecting hydrological data. Dr. Walter L. Cook, a committee member, was available when we needed advice, and lent us supplies for our field work. Mike Moore, curator of the UGA Herbarium, helped us identify important plant species. We also thank Dr. Karl V. Miller and Dr. Lawrence A. Morris for helping us weekly throughout this study as our advisors.

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INTRODUCTION

Feral horse¹ damage to native flora and fauna on Cumberland Island National Seashore (CINS) is well-documented (Hillestad et al. 1975, Bratton 1985, Turner 1986). The National Park Service (NPS) management policy permits control or eradication of this exotic species as it affects the environment. The 1971 Wild Free-Roaming Horse and Burro Act specifically does not protect feral horses on national parks, refuges, nor military installations (Public Laws 86-234 and 92-195).

Public opinion plays a vital role in management decisions as these horses are a major attraction in a park held in public trust (Absher and Bratton 1986). Romantic notions of free-roaming, wild horses and opposition to shooting or poisoning for population control make compliance with NPS policy difficult. An Adopt-a-Horse program was discarded as a way to reduce the horse herd because of its expense (Goodloe 1991). Fertility control is accepted widely as a non-lethal method for regulating feral horse populations. Scientists currently are investigating immunocontraception for the island's feral horses (Bratton and Finley 1986).

CINS wants to reduce the feral horse population as low as possible without significantly reducing current visitor sightings to avoid public discontent. At least 66% of CINS visitors must see the remnant herd per visit (Absher and Bratton 1986). The following is a management plan for maintaining visitor viewing of a reduced horse population.

OBJECTIVES

No single landowner exists because CINS is managed by the NPS. Rolland Swain, the Park Superintendent, is responsible for implementing NPS policy. Jennifer Bjork, Resource Management Specialist, was our contact and client for this project as she is in charge of developing a feral horse management plan

¹Appendix A lists the scientific names of animal and bird species in the text.

for 4 eastern U.S. barrier islands, including Cumberland Island. Her specific objective for feral horses on CINS is to maintain or increase current visitor viewing success (approximately 66%) of a planned remnant herd of 40 feral horses within the island's public land. The cost of this project must not exceed \$10,000 annually.

SITE HISTORY

Prior to the 16th century, the Timucuan Indians occupied Cumberland Island as their sacred hunting ground. In 1566, the Governor of Florida built a fort on the island. The Spanish then brought several hundred cattle, hogs, and horses to Cumberland. The English took control of the territory in 1736 and developed Cumberland Island, building Fort St. Andrews and Fort Prince William (Hillestad et al. 1975).

General Nathanael Greene, a Revolutionary War hero, bought land on Cumberland Island in 1783. In 1785, he wrote of a feral horse population of at least 200 individuals. His widow, Catherine Greene, constructed Dungeness, a 4-story tabby house (Natl. Park Serv. 1991a). The structure's name was adopted from a hunting camp set up by General Ogelthorpe in the same area (Natl. Park Serv. 1991b). The island's economy was on the rise.

Several plantations were formed from 1786 to 1880. Live oak² timber was used for building ships. Many agricultural crops were grown, primarily sea island cotton. Citrus fruits, corn, sweet potatoes, and sugar cane also were harvested. Cattle, hogs, and horses were used in animal husbandry. The Civil War damaged much of the island, and the economy never recovered (Hillestad et al. 1975).

Thomas Carnegie, brother and partner of Andrew Carnegie, bought Dungeness and Stafford plantations in 1881. His family introduced several horse breeds to the population to improve the feral stock, including the Tennessee Walker, Quarter horse, Paso Fino, and Arabian (Goodloe 1991).

²Appendix B lists the scientific names of plant species in the text.

Fig. 1. Location of Cumberland Island in relation to Georgia's coast.

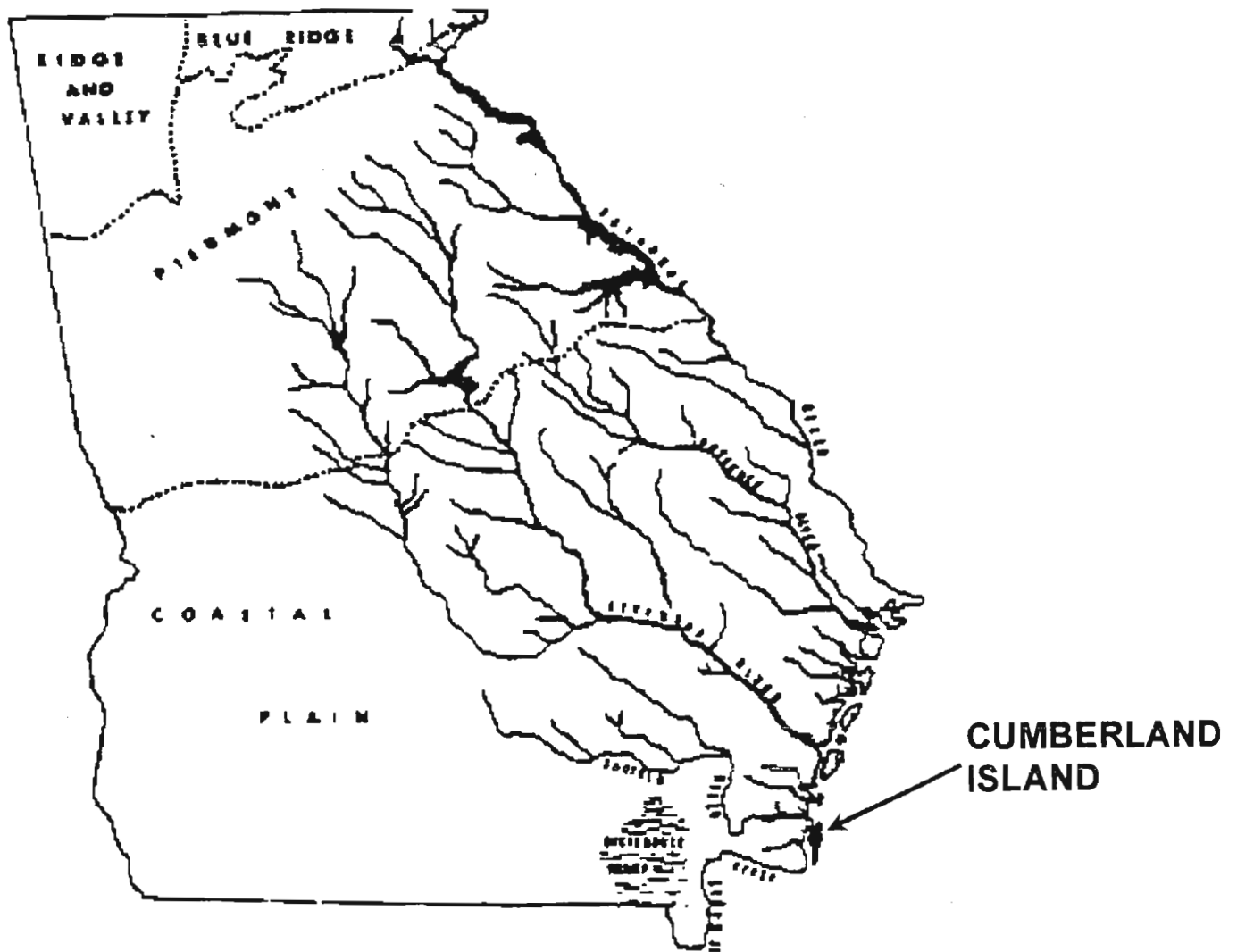
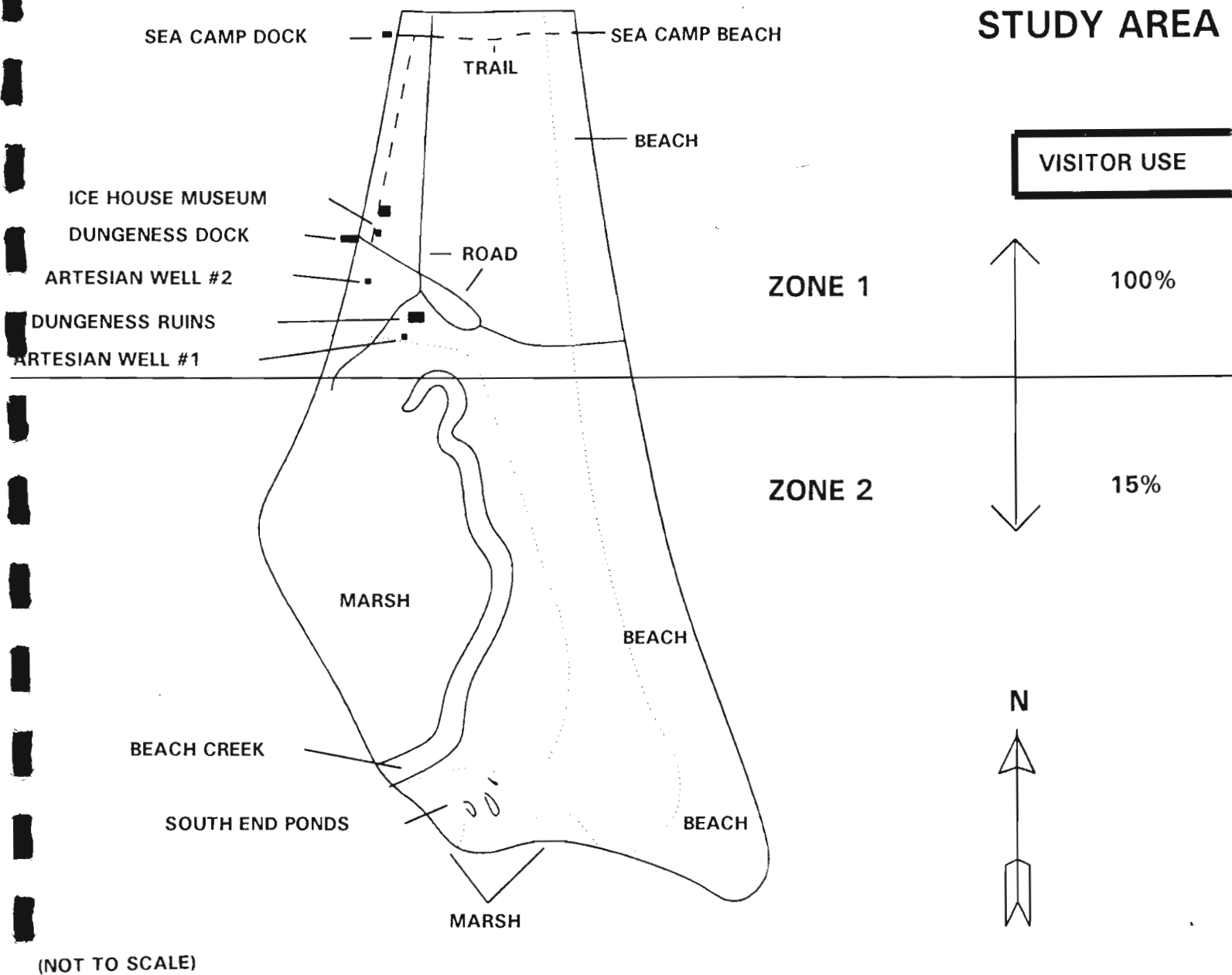


Fig. 3. Study area zones for managing a remnant herd of feral horses on Cumberland Island.



Vegetation

Environmental stresses, such as nutrient deficiencies, flood, and drought control the various plant types on Cumberland Island. Hillestad et al. (1975) recognized 22 specific plant communities. We grouped similar communities into 6 general vegetation categories:

Foredune.--This habitat consists of the primary dunes adjacent to the beach. Sea oats and seashore paspalum dominate the area, while salt-meadow cordgrass and beech hogwort are common locally. These plant species serve to stabilize the dunes, which continually are eroded by wind and waves (Lenarz 1983). The foredunes are damaged often by humans straying from designated trails, as well as browsing and trampling by deer and horses (Bratton 1985).

Interdune meadow.--This area separates the foredunes from the landward dunes. Centipede grass, salt-marsh fimbristylis, and wax myrtle dominate this dense shrub habitat (Lenarz 1983). Sedges, bluestem, and coastal love grass are common locally, as well as live oaks and pines (Ragsdale and Sollie, unpubl. data).

Salt marsh.--This habitat, located on the western side of the island, comprises about 37% of Cumberland. These areas are nearly monospecific, with smooth cordgrass as the dominant vegetation. However, differences in height and density of this species give the salt marsh structural diversity. The tidal creek borders and interior portions of the marsh support the tallest, densest grass while the shortest grass generally is found closer to the grasslands (Lenarz 1983).

Grassland.--This habitat surrounds the salt marshes, but also includes large areas on the south end of the island subject to tidal fluctuations. Species commonly found in this area include seashore dropseed, salt grass, and salt-marsh fimbristylis (Lenarz 1983).

Upland forest.--Oak-palmetto, open woodland-oak, and open woodland-oak-pine communities are included in this category. A live oak canopy and dense saw palmetto understory make up the oak-palmetto forest. The open woodland-oak forest also contains a live oak canopy; however, grape

vines, herbs, and hardwood seedlings dominate the sparse understory. The understory of the open woodland-oak-pine community is similar to that of the open-woodland forest, but loblolly and slash pine occur along with the live oak in the canopy.

Lawn areas.--This category accounts for 2.6% of our study area, comprising the smallest habitat type. Three distinct lawn areas are located in Zone 1: Beach Field, Dungeness Ruins, and Dungeness Dock (Fig. 4). The Beach Field and Dungeness Ruins areas are roughly 16 ac. each, while the Dungeness Dock lawn covers 8 ac. We subdivided Dungeness Ruins' into the Servants' Quarters, the Cottage Area, and the Lower Garden.

We determined the plant species composition and abundance of each lawn area using the point intercept-step point survey method (U.S. Fish & Wildl. Serv. 1981). This technique involves pacing along 2 random transects in each area, recording the plant species found at the foot's tip. We then determined percent plant species occurrence from our actual data. Centipede and Bermuda grasses dominate most of this habitat, comprising 46% and 13% of the total vegetation respectively (Table 1). Frost-weed and sandspur are common locally. Many shrub and tree species, including Southern magnolia and cabbage palm, also are scattered within and border each lawn area.

Freshwater Sources for Wildlife

Location.--The distribution of fresh water is limited to the extreme north and south ends of the study area. Two artesian wells, tapped by the Carnegies, are located in Zone 1 near Dungeness Ruins. Artesian Well #1 is located behind Dungeness Ruins below a 7-ft. high concrete wall. Artesian Well #2 is located near a private residence and the historic Duck Pond, which currently is dry. Zone 2 consists of 3 ponds on the west side of Cumberland called the South End Ponds (Fig. 5). A dense live oak/palmetto forest surrounds these ponds. The artesian wells in Zone 1 are approximately 2 mi. north of the South End Ponds in Zone 2.

We noted the presence of sloughs and tidal pools along the eastern side of the island. We considered these temporary water sources unimportant

Fig. 4. Location of lawn areas within our study area.

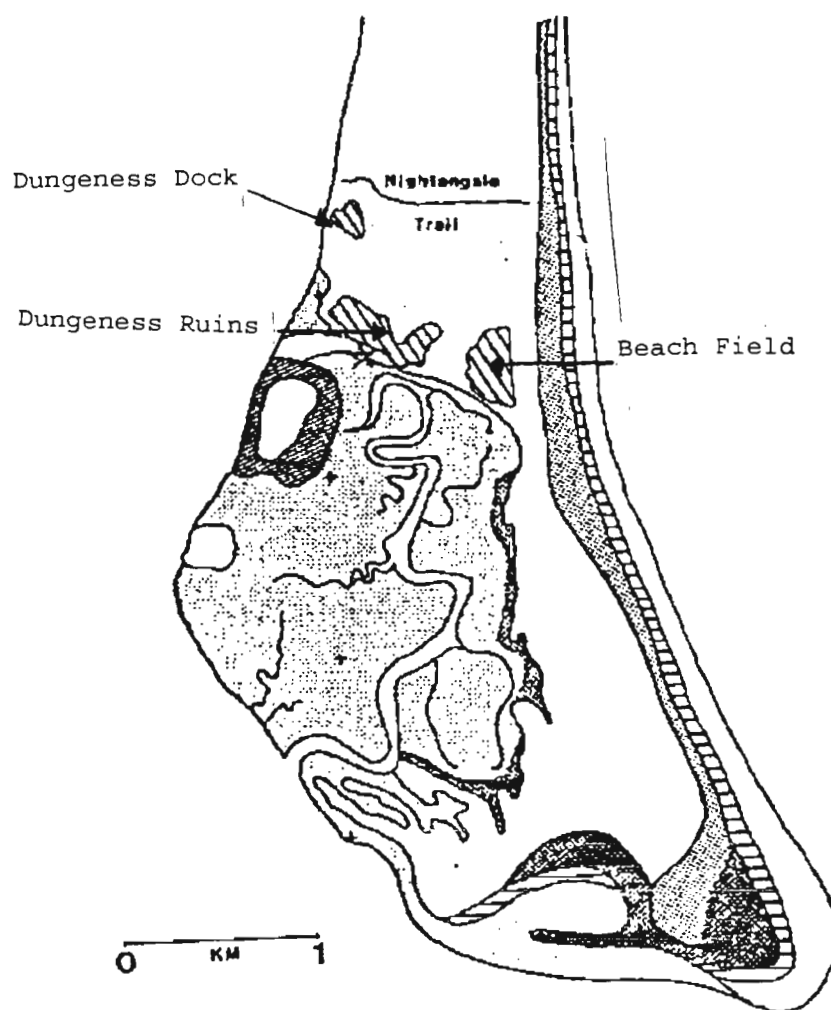


Table 1. Plant species abundance on Zone 1 lawn areas.^a

Location ^b	Centipede	<u>Grasses</u>		Coffee Weed	Sand Spur	Frost- Weed	Other Plants ^c
		Bermuda	Bahia				
Beach Field	121 (21)	124 (22)	9 (2)	20 (4)	91 (16)	124 (22)	49 (9)
Dungeness Ruins							
-Servants' Qtrs.	149 (73)	7 (3)	0 (0)	0 (0)	28 (14)	2 (1)	17 (8)
-Cottage Area	501 (47)	147 (14)	72 (7)	16 (2)	58 (5)	21 (2)	226 (21)
Dungeness Dock	265 (67)	17 (4)	19 (5)	14 (4)	11 (3)	17 (4)	43 (11)
Total	1036 (46)	295 (13)	100 (5)	50 (2)	189 (9)	164 (7)	335 (15)

^a Percentage shown in parenthesis.

^b Does not include bare ground estimates.

^c Consist of false garlic, poor-joe, sawbrier, sedge, and bristly paspalum.

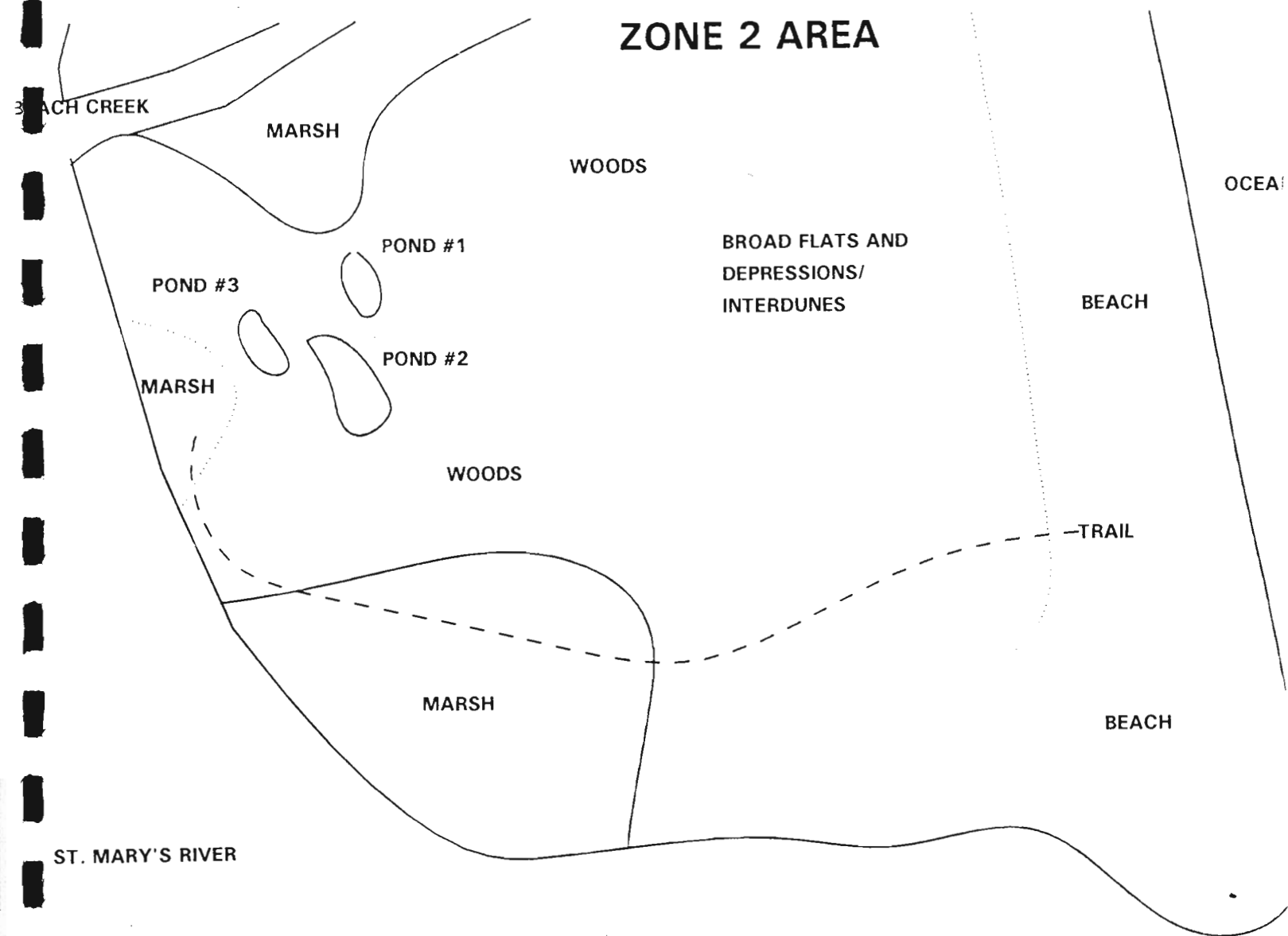
Fig. 5. Location of South End Ponds in Zone 2.

N



(NOT TO SCALE)

ZONE 2 AREA



because their existence is based on the return frequency of rain storms. Therefore, we restricted our efforts to areas of permanent fresh water.

Quantity.--Due to saltwater intrusions and tidal fluctuations, freshwater ponds and marshes are a limiting factor for wildlife, comprising only 8% of the island. Many ponds are shallow and seasonal. The island's northern portions, including the Wilderness Area and private property, contain the most fresh water. Sources of drinkable water for wildlife are limited in our study area.

We determined the amount of permanent freshwater in Zone 1 by measuring water flow of the 2 artesian wells. We timed how quickly Artesian Well #1's water exited the wall and filled a 1-L bottle. To ensure flow rate accuracy, we repeated this measurement 4 times. The water filled the bottle in an average of 4 sec. We then used conversion factors to determine a flow rate of 5706 gal./day⁴.

The water from Artesian Well #2 flows into the bottom of a 6.5 x 4.5-ft. concrete trough and out a groove on 1 side. We determined this discharge rate differently than that of Artesian Well #1 because the water flowed into a pool rather than out a specific point. After plugging the groove with mud, we measured the size of the pool and timed how quickly the water level rose 1.5 in. Rising this distance in 16 min., the water filled a volume of 6318 in³. With this information, we calculated a discharge rate of 2462 gal./day for Artesian Well #2⁵.

The South End Ponds in Zone 2 do not have flow rates like the artesian wells in Zone 1. We estimated volume by acreage and depth. The total open water area for the 3 ponds is 4.5 ac. (Hillestad et al. 1975). We observed that Pond #2 is about twice the size of the other 2 ponds. Therefore, we assume that Pond #2 extends approximately 2.25 ac. Based on visual observation, this pond is about 3 ft. deep during October 1994, containing

⁴Appendix D shows flow rate calculations for Artesian Well #1.

⁵Appendix E shows flow rate calculations for Artesian Well #2.

approximately 2199874 gal. of water⁶.

Quality.--Total dissolved solids (TDS) is an important indicator of water quality as it controls species composition and abundance of aquatic biota and irrigated plants (Maidment 1993). The quality of the permanent water sources varies from fresh (TDS<1000 ppm) to briny (TDS>35000 ppm). We measured TDS of each water source, including tap water for comparison, with an Oakton hand-held conductivity meter. The 2 artesian wells and South End Pond #2 are the only freshwater sources in our study area (Table 2). Tap water has the lowest TDS while Pond #2 has the highest salinity of the fresh water sources.

HORSE REQUIREMENTS

Food

Food requirements depend on age and condition of the horse. Bradley (1981) found a positive correlation between horse age and food consumption. Intake is highest for pregnant mares during the first 3 months of lactation as they eat about 2% of their body weight. Half of this intake (1% body weight) is required for maintenance of males and non-pregnant females. Average dry matter intake is 10 lbs./day, based on an average body weight of 1000 lbs. Weaned foals require more crude protein (15%) than adults (8%) (Cunha 1980).

Horses generally prefer nutritionally superior forages over those of poor quality (Ball et al. 1991). However, food intake within a habitat is a function of relative abundance as well as preference. Horses may not eat highly-preferred foods the most if less-palatable food is more available (Table 3). For example, horses consume moderately-preferred smooth cordgrass in the expansive salt marsh more than highly-preferred Bermuda grass in the smaller lawn areas.

⁶Appendix F shows volume calculations for South End Pond #2.

Table 2. Total dissolved solids (TDS) of water sources within our study area.

Water Source	Part per million (mg/L)
Atlantic Ocean	53,130
Beach Creek	35,600
South End Pond #1	27,600
South End Pond #3	14,700
-----	-----
Fresh water	<1,000
-----	-----
South End Pond #2	925
Artesian Well #2	501
Artesian Well #1	500
Tap water	483
-----	-----

Table 3. Comparison of horse use to preference of Cumberland Island habitats^a.

Habitat	Horse ranking ^b	
	Use	Preference
Salt marsh	* * * * *	* * *
Grassland	* * * *	* * * *
Interdune meadow	* * *	* *
Lawn area	* *	* * * * *
Foredune	*	*

^aAccording to Lenarz (1983)

^bRankings are as follows: ***** highest
 ***** high
 *** moderate
 ** low
 * lowest

Water

Depending on the heat, work, and type of feed consumed, horses drink from 2-12 gal. of fresh water daily (Bradley 1981). For example, the water requirements for a horse increase 15-20% with a rise in temperature from 55°F to 77°F (Cunha 1980).

We defined horse limits of TDS based on Cunha's (1980) livestock guidelines. TDS of 7000-10000 ppm should be avoided because it presents health risks when used by pregnant or lactating cows, horses, sheep, the young of these species, or for any animals exposed to heavy heat stress or water loss. We assume that water sources with a relatively low sodium content (TDS<7000 ppm) attract the most horses.

Movements

Hall (1991) determined the annual movement rate and home range for Cumberland Island feral horses. Daily movement rates range from 1.5-2.7 mi./day with no significant seasonal variation. The average annual home range size is 139±34 ac. Significantly smaller home ranges appeared in the winter when compared to spring. Factors influencing movement patterns include parasite abundance and the availability of preferred forage (Hall 1991). Feral horses must travel while feeding to meet daily nutrient requirements, but dispersal is relatively low as horses are not territorial (Berger 1986). Therefore, horses may move less in areas of abundant preferred forage.

ALTERNATIVES

We developed criteria to quantitatively evaluate and compare our alternatives based on the effectiveness of visibility parameters and a benefit-cost ratio. The capability of a resource to attract horses, the openness of an area frequented by horses, and the percentage of horse time spent grazing and/or drinking are factors of viewing effectiveness. We determined approximate costs for a final index (benefit-cost ratio) for each

alternative. The best alternative for maximizing visitor viewing of a remnant horse herd lies within our budget, effectively attracts horses to highly-visited, open areas, and is economically efficient.

Estimated costs were determined from man-hrs. and wages. We contacted sources related to each action considered for the approximate man-hrs. needed to complete each project. The NPS plans to use its maintenance personnel to perform all necessary actions. Therefore, we multiplied man-hr. estimates by 1994 NPS technician wages to determine labor costs per acre. We assumed that the NPS has access to all standard equipment (ie., bush-hog, chainsaw, tractor) needed for each alternative. We obtained estimates, excluding sales tax, for any special equipment needed (ie., boom-truck, fertilizer, seed). We suggest transporting equipment from the mainland to the island on the garbage ferry to eliminate transportation costs.

We measured viewing effectiveness as the product of daily carrying capacity, visibility, and the percentage of time the horses inhabit each area. Carrying capacity includes the number of horses supported per resource evaluated (ie., lawn area and/or freshwater source). We used dry matter yield and a horse digestibility coefficient to determine the number of horses each lawn area can support (H. Huesner, pers. commun.). Similarly, we used fresh water quantity and quality to determine the carrying capacity of each water source. We assume those alternatives with relatively high carrying capacities as the most attractive to horses.

The visibility, or openness of an area, was measured by sight line surveys in each area. First, we established a base point to represent a typical visitor viewpoint. We then measured the approximate distance, in feet, from the base point to the edge of the nearest vegetation that obscures the view into the area. We also measured potential increases in visibility as a result of clearing plants. To determine the potential increase in visibility from clearing, we added the length of the encroaching vegetation, along the sight line, to the original base point length. The resulting visibility included this sum as well as the distance into the lawn area beyond

the vegetation. Higher length estimates represent better visibility.

The viewing effectiveness of an area depends on the carrying capacity and visibility of an area. However, these factors are unimportant if the horses typically do not spend time in the area. Therefore, we used Lenarz's (1983) observations of percent time that Cumberland's feral horses spent in different habitats as a factor in the effectiveness of horse viewing. We divided the estimated 8% time spent grazing by the total lawn acres, thereby weighing time spent in larger areas more than in smaller lawns. Similarly, we distributed the 5% time used for drinking among the water sources considered in each alternative.

We calculated the final index of each alternative by dividing the total viewing effectiveness (ie., carrying capacity x visibility x percent time) by the estimated cost. This index incorporates all of our criteria to give a benefit-cost ratio. The alternative with the highest final index represents the most visitor viewing of horses for the least amount of money.

1. No Action

We determined the current effectiveness of each resource in attracting horses based on carrying capacity, sight line length, and the percentage of time the horses generally spend in each area. We considered this alternative as costing nothing as the NPS presently does not manage the lawn areas nor the water sources for wildlife. However, we assigned a \$0.01 cost to prevent an undefined final index (Table 4).

Beach Field.--This area, partially used as a dumping ground for NPS trash, has the greatest carrying capacity⁷ in terms of available forage and acreage. Data from our point intercept-step point survey reveals relatively abundant Bermuda grass, a highly-preferred forage. Frost-weed is as abundant as Bermuda grass. Centipede grass ranked second in abundance. Feral horses spend relatively high amounts of time feeding in this area. However,

⁷Appendix G shows carrying capacity calculations for Zone 1 lawn areas.

TABLE 4. Evaluation of Cumberland Island's current resources for viewing a remnant horse herd on Cumberland Island.

LAWN AREA (TOTAL AC.)	ESTIMATED COST (\$) (no tax)	VIEWING EFFECTIVENESS					FINAL INDEX (TOTAL EFFECTIVENESS)/ COST
		CARRYING CAPACITY (# HORSES/RESOURCE)	VISIBILITY		TOTAL (PRODUCT)		
			(FT.)	TIME (%)			
BEACH FIELD (16.0 AC.)	0.01	3.4	0	3.2	0	0	
DUNGENESS RUINS (16.0 AC.)							
SERVANTS' QUARTERS (1.1 AC.)	0.01	0.1	100	0.2	2	200	
LOWER GARDEN (0.0 AC.)	0.01	0.0	0	0.0	0	0	
COTTAGE AREA (14.9 AC.)	0.01	1.8	710	3.0	3834	383400	
DUNGENESS DOCK (8.0 AC.)	0.01	0.8	46	1.6	59	5888	
ARTESIAN WELL #1	0.01	40	0	2.5	0	0	
ARTESIAN WELL #2	0.01	40	0	2.5	0	0	
TOTAL (Excluding artesian wells)	0.05	6.1	856	8	3895	389488	

NOTE: Artesian wells were excluded in the total to prevent overestimation of carrying capacity.

encroaching vegetation greatly limits visibility of the horses. Therefore, the Beach Field currently is ineffective for visitor viewing.

Dungeness Ruins.--We recognized 3 separate parts of this lawn area:

Servant's Quarters.--This area encompasses 1.1 ac., consisting mainly of centipede grass and sandspurs (73% and 16%, respectively). Despite high visibility, the carrying capacity and percentage of time spent here are low. Therefore, the overall chance of seeing horses is relatively low.

Lower Garden.--The Lower Garden currently is void of forage for horses. This 0.5-ac. area was once a well-landscaped garden, including an lawns of centipede grass and an irrigation system (Zeichwer 1988). Current vegetation includes dense cabbage palm, hackberry, wax myrtle, wild grape vines and saw palmetto in the understory. This area currently cannot support horses it is void of suitable forage. Thick vegetation inhibits sight into this area.

Cottage Area.--This largest lawn completely encircles Dungeness Ruins. Containing 14.9 ac., visibility is greatest in this area. Despite the low number of horses supported here, the large acreage results in a relatively high time percentage and currently is the best site for viewing horses (Bratton and Finley 1986).

Dungeness Dock.--Sixty-seven percent of this lawn is centipede grass. Many visitors travel through this area when they exit the ferry. However, visibility of the horses is limited by a dense hedgerow. Furthermore, fewer horses spend their time here, giving a lower total effectiveness. Aside from the Cottage Area, the Dungeness Dock lawn is the next best area for viewing horses.

Water sources.--Based on our measurements of water quantity and quality, we determined which water sources in our study area currently are capable and suitable for horses to drink. We assume a population of 40 horses, the maximum daily drinking rate of 12 gal./horse, and a salinity tolerance of <7000 ppm. We then assessed the current visibility of each suitable water source.

Artesian wells.--Based on flow rates, Artesian Well #1 supports 475 horses and Artesian Well #2 supports 205 horses⁸. The TDS of each artesian well easily falls within the range of suitable drinking quality.

Although these wells provide for the horses' needs, the surrounding vegetation limits visibility. Visitors probably do not notice Artesian Well #1 as it is located below a 7-ft.-high wall, primarily surrounded by switchcane and wax myrtle. However, this well may be more visible than Artesian Well #2 because it is closest to the visitors' tour route. Artesian Well #2 is off-limits to visitors as 2 "keep out" signs next to a private residence warn people away. In addition to these signs, the dense oak-palmetto forest surrounding this well inhibits the viewing of horses drinking.

These wells, caused by a high piezometric surface, are the only sources of fresh water for horse to drink in Zone 1. The piezometric surface for a confined aquifer is the surface representative of the level to which water will rise in a well screened to that aquifer (Fetter 1994). Currently, the piezometric surface is higher than the ground surface, causing water to flow from the wells. If this level falls below the ground surface, fresh water would be eliminated in Zone 1.

Prior to 1880, the artesian pressure in Cumberland's wells caused water to rise to an elevation of about 65 ft. above sea level (Warren 1944). The current reduction in piezometric head is due to the heavy use of the water supplies by the nearby cities of St. Marys, Brunswick, and Fernandina for municipal water supplies and industries (especially paper mills) located in and around these cities (Hillestad et al. 1975). The pumping of this aquifer formed a cone of depression, which lowered the piezometric surface to slightly above ground level. The artesian wells will persist if pumping rates do not increase. The possibility of losing the fresh water in Zone 1 is important because the piezometric head dropped to ground level in the past century.

⁸Appendix H shows carrying capacity calculations for artesian wells in Zone 1.

South End Ponds.--Based on our TDS readings, South End Pond #2 is the only acceptable freshwater source in Zone 2. We predict that horses exclusively would use this water if the piezometric surface dropped and the artesian wells in Zone 1 dried. The current volume of water in this pond can support the target population of 40 horses for 4583 days⁹. Unlike the artesian wells, this water source does not replenish itself until a rainfall event.

Few people, if any, travel to Pond #2 as it is inaccessible. Those visitors that hike about 1 mi. to the end of the trail probably cannot see the ponds because of the surrounding dense forest. We assume horses prefer drinking from the artesian wells more than from the South End Ponds.

2. Add a third water source

One alternative to increase horse visibility is to add a third freshwater source in a highly visible area where most people visit. We concentrated our efforts in Zone 1 because all Cumberland Island visitors walk through the Sea Camp and Dungeness Dock areas (Absher and Bratton 1986).

The Sea Camp Dock, located in the northern-most part of our study area, is surrounded by a dense live oak/palmetto forest. No open areas exist for the installation of a third water source. However, visitors immediately see a large lawn as they exit Dungeness Dock. People often visit the museum or walk the road to the Dungeness ruins, which both border the lawn. Many visitors that exit the ferry at Sea Camp Dock pass the lawn area on their way to the museum as well.

We suggest placing the third water source relatively far from the artesian wells for better distribution of fresh water in Zone 1. By scattering the wells around more lawn areas, more horses may prefer Zone 1 over Zone 2, thereby presenting themselves to more visitors. The installation area should be accessible to tap water, if needed.

Because of the location and visibility of this lawn area, we would put a third water source in the field at Dungeness Dock. This water source should

⁹Appendix I shows the carrying capacity calculations for South End Pond #2.

ensure a reliable source of water for the horses to drink in Zone 1 if the piezometric surface of the wells dropped. We assume a decrease in time spent at each artesian well because horses would distribute drinking time among more water sources¹⁰. Table 5 compares 2 methods for providing this fresh water:

Drill a new well.--The installation cost of a mud-drilled well, using a stainless steel pipe to a depth of 700 ft., is \$15,000-\$20000. This estimate, obtained from the Middle Georgia Well Drillers, excludes the cost of a water test (M. Hubner, pers. commun.). In addition to exceeding our budget, installing an artesian well that may go dry risks the elimination of future water sources in Zone 1. Therefore, drilling a new well is infeasible.

Install a stock tank.--We considered a standard 400-gal., pressure-fed stock tank for a third water source. This concrete tank, which contains 80 ft. of 0.5-in. reinforcing rod, is fitted with a liquid-flow float valve (Fig. 6). This type of valve limits water loss to horse drinking and evaporation and ensures a continuous supply of water for the entire horse herd to use. J. W. Buffington's (pers. commun.) estimate of the total installation cost, including parts, equipment, and labor, is relatively low¹¹. Potential maintenance costs range from \$0.23-\$1430 for a broken PVC elbow to complete reinstallation of the stock tank.

Placing the tank in the ground with only 1.5 ft. showing preserves the aesthetic integrity of the Carnegie era. The risk of freezing water would be low because of the ground's insulation. The soil around the tank would remain dry, minimizing the formation of mud holes. Older horses and weanlings often hesitate to drink in areas of deep mud (Cunha 1980).

We would use tap water in this tank to ensure clean, fresh water, even if the artesian wells stopped flowing (Fig. 7). Fewer undesirable minerals, such as sulfur and calcium, exist in tap water as it is pumped from an aquifer and filtered. Horses probably would prefer this cleaner, fresher water over

¹⁰Appendix J shows the evaluation of current and potential freshwater sources in our study area.

¹¹Appendix K itemizes the cost of installing a stock tank in Dungeness Dock lawn area.

TABLE 5. Comparison of methods for adding a third water source for viewing a remnant horse herd on Cumberland Island.

WATER SOURCE METHOD	ESTIMATED COST (\$ (no tax)	VIEWING EFFECTIVENESS				FINAL INDEX (TOTAL EFFECTIVENESS)/ COST
		CARRYING CAPACITY (# HORSES/RESOURCE)	VISIBILITY		TOTAL (PRODUCT)	
			(FT.)	TIME (%)		
INSTALL 400-GAL. STOCK TANK	1422	40	256	1.67	17100	12
DRILL A NEW WELL	20000	40	256	1.67	17100	0

Fig. 6. Suggested 400-gal. stock tank for third water source in Dungeness

Dock lawn area.

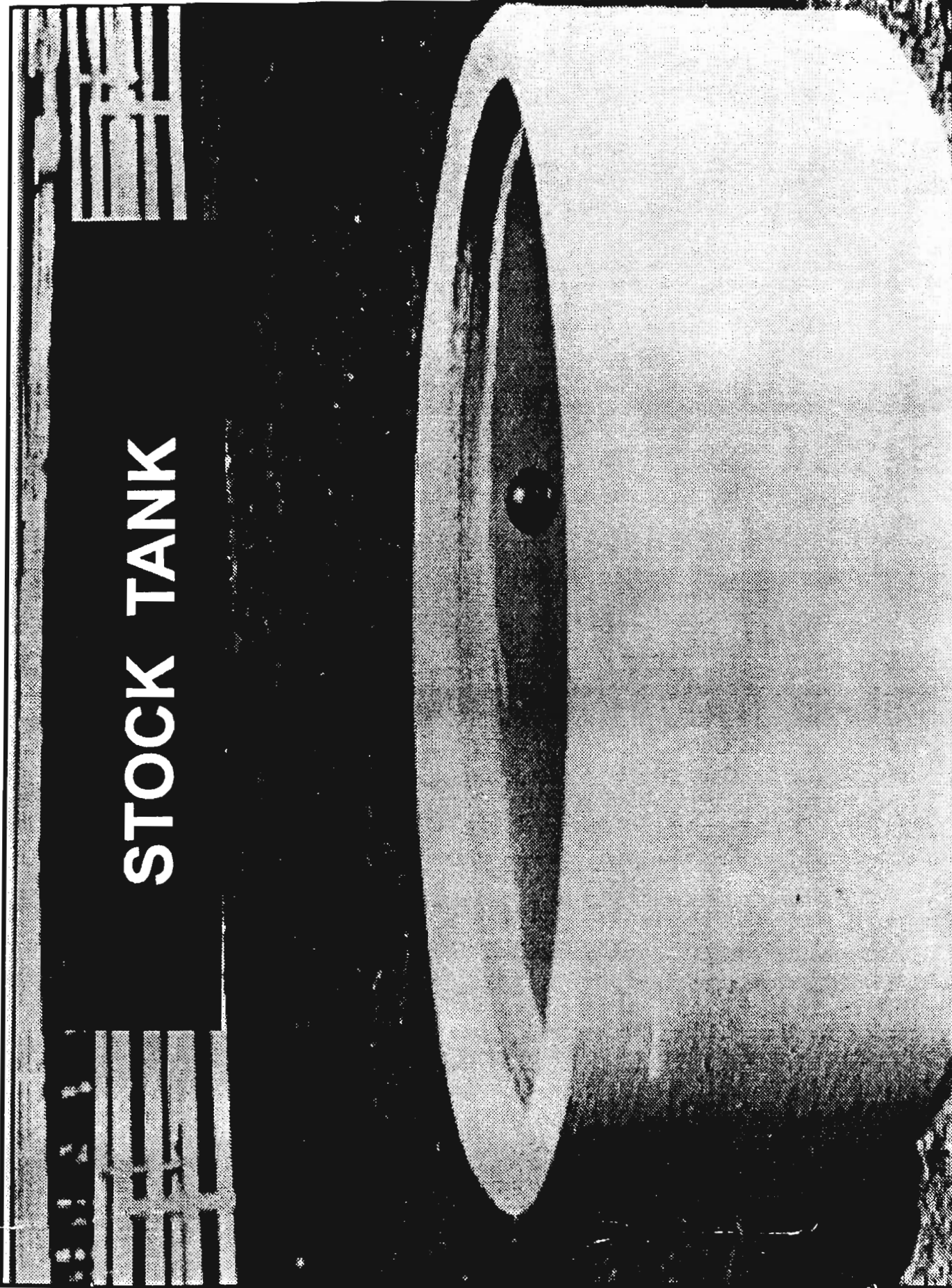
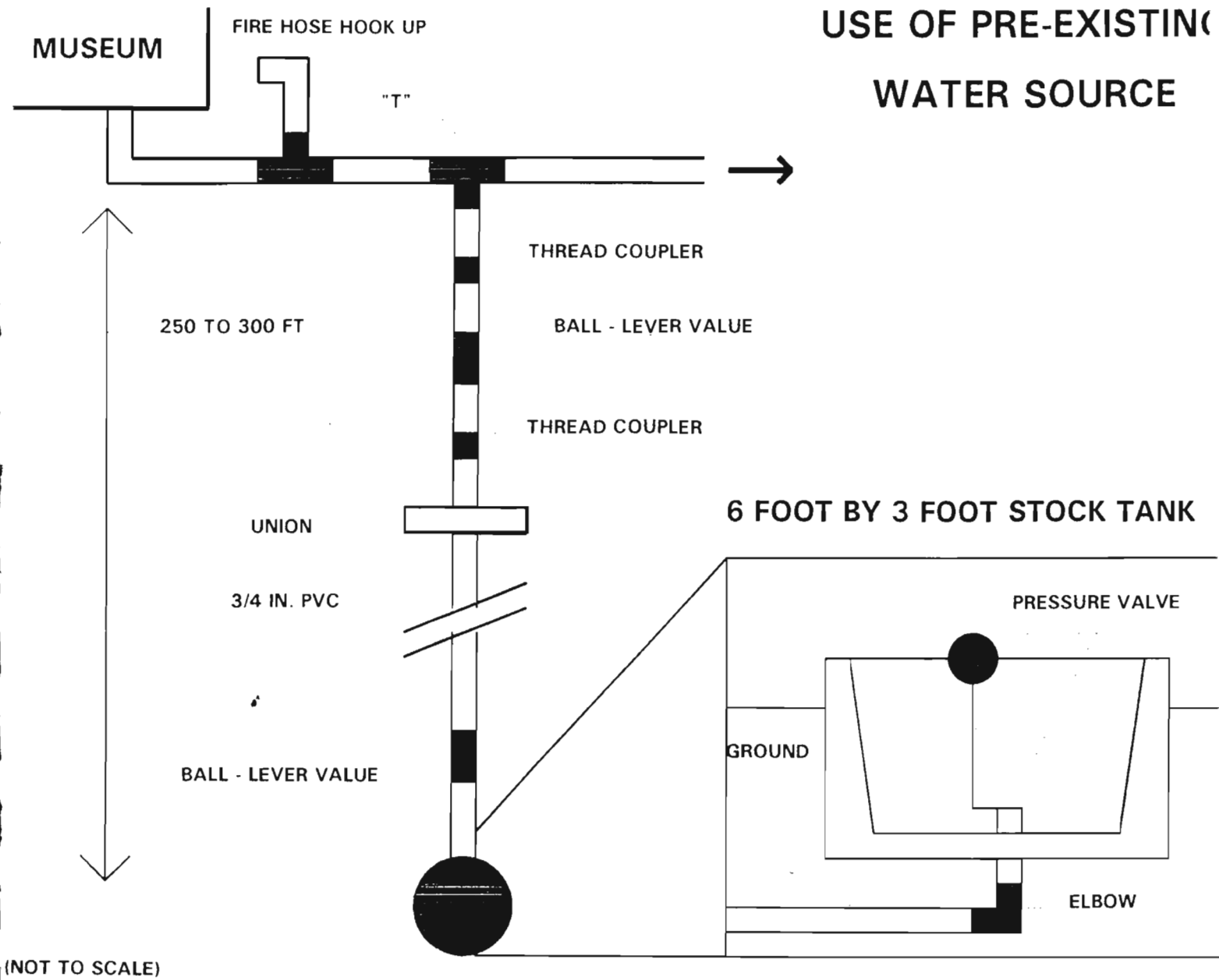


Fig. 7. Suggested use of tap water for stock tank installation.



the artesian wells or South End Ponds. Therefore, a stock tank may attract the horses to Zone 1 for increased visitor viewing.

3. Clear encroaching vegetation

We defined encroaching vegetation as shrubs and trees that obscure the view of the lawn areas and water sources. Clearing shrubs and trees <10-in. diameter breast height (dbh) and pruning trees with dbh $\geq$ 10-in. would increase visitor viewing of the horses grazing and drinking while maintaining the historical aesthetics of large trees. We conducted a track count survey around each artesian well to determine which species may lose habitat and cover from clearing. Using a rake and trowel, we smoothed 3 ft. of mud around each well's perimeter to give each species the chance for all limbs to step within the survey area. We returned to each well 24 hrs. later to record track data.

We identified each track according to Murie (1982). The survey revealed horse, white-tailed deer, raccoon, and nine-banded armadillo use (Table 6). Visual observation also showed wild turkeys, Southern leopard frogs, mud snakes, and various songbirds using the wells. We then calculated the maximum number of individuals visiting the well by dividing the number of tracks counted by the number of feet per species (ie., paws, hooves). Abundance may be positively skewed towards smaller animals due to higher track densities (ie., more steps per area). We assume that tracks of the same species positioned differently on $\geq$ 1 side of each well indicate >1 individual of that species.

We decided to leave buffers around these artesian wells as we do not know the potential impacts on wildlife. Therefore, we limited clearing recommendations to 2.7 ac. near the lawn areas. According to Bass Landscaping Inc., 4 people are needed for approximately 2 wks. to clear all lawn areas. The initial cost of clearing is \$4160. Maintenance costs range from \$35-\$70 for annual mowing and pruning every 5 years¹². We assume the vegetation that

¹²Appendix L itemizes the total cost of clearing encroaching vegetation in all lawn areas.

Table 6. Track count survey around 2 artesian wells in Zone 1.

Aquifer	Species	# Tracks	Max. #	All tracks coming from
			individuals	same side of well?
1 ^a	Raccoon	66	16	No
	Horse	25	6	No
	Deer	4	1	No

2 ^b	Horse	14	3	No
	Armadillo	3	1	Yes

^aFree-flowing, behind Dungeness Ruins in the Lower Garden

^bImpounded, Dungeness Ruins near the Servants' Quarters

grows back after clearing will not differ significantly from the current species composition and abundance. A positive correlation exists between the increase in area as a result of clearing and the increase in carrying capacity (Table 7). We compared the effectiveness and final indices of clearing each lawn area (Table 8).

Beach Field.--Along the road from the Servants' Quarters to the beach, a 0.9-ac. area of thick brush obscures the view of this open field. We suggest clearing the young live oaks and small cabbage palms, dog-fennel, thoroughwort, and grape vines while pruning Southern red-cedars (Fig. 8). Clearing this area may increase the quantity of Bermuda and centipede grasses, thus increasing carrying capacity. Visibility would increase slightly.

Dungeness Ruins.--We evaluated the effects of clearing each section of this lawn area:

Servants' Quarters.-- Approximately 0.8 ac. of trees and shrubs impedes viewing distance in this area. We suggest pruning Southern red-cedar, red bay, and hackberry limbs as well as cutting and mowing saw palmetto and acacia. This clearing excludes the vegetation around Artesian Well #2. The new vegetation that grows back would not increase carrying capacity. However, visibility would increase significantly from 100 ft. before clearing to 615 ft. after clearing (Fig. 9).

Lower Garden.--Although this entire area was once the Carnegies' garden, we limited clearing to avoid impacting wildlife using Artesian Well #1. We suggest clearing a 0.5-ac. area close to a common visitor route, the Dungeness Trail. The clearing would extend from an iron fence, adjacent to the Cottage Area, west towards the intracoastal waterway (Fig. 10). We suggest eliminating cabbage palm, hackberry, wax myrtle, wild grape and saw palmetto. This clearing would result in the highest increase in visibility among these alternatives, increasing sight lines to approximately 2 mi. Assuming that Bermuda and centipede grow back, carrying capacity would increase slightly.

Table 7. Potential increase in carrying capacity for clearing encroaching vegetation in Zone 1 lawn areas^a.

<u>Location</u>	<u>Potential</u>	<u>Horses/ac.^b</u>	
		<u>Current</u>	<u>Increase</u>
Beach Field	3.50	3.40	0.10
Dungeness Ruins			
-Servants' Qtrs.	0.30	0.10	0.20
-Lower Garden	0.05	0.00	0.05
-Cottage Area	3.70	1.80	1.90
Dungeness Dock	1.60	0.80	0.80
Total	9.15	6.10	3.05

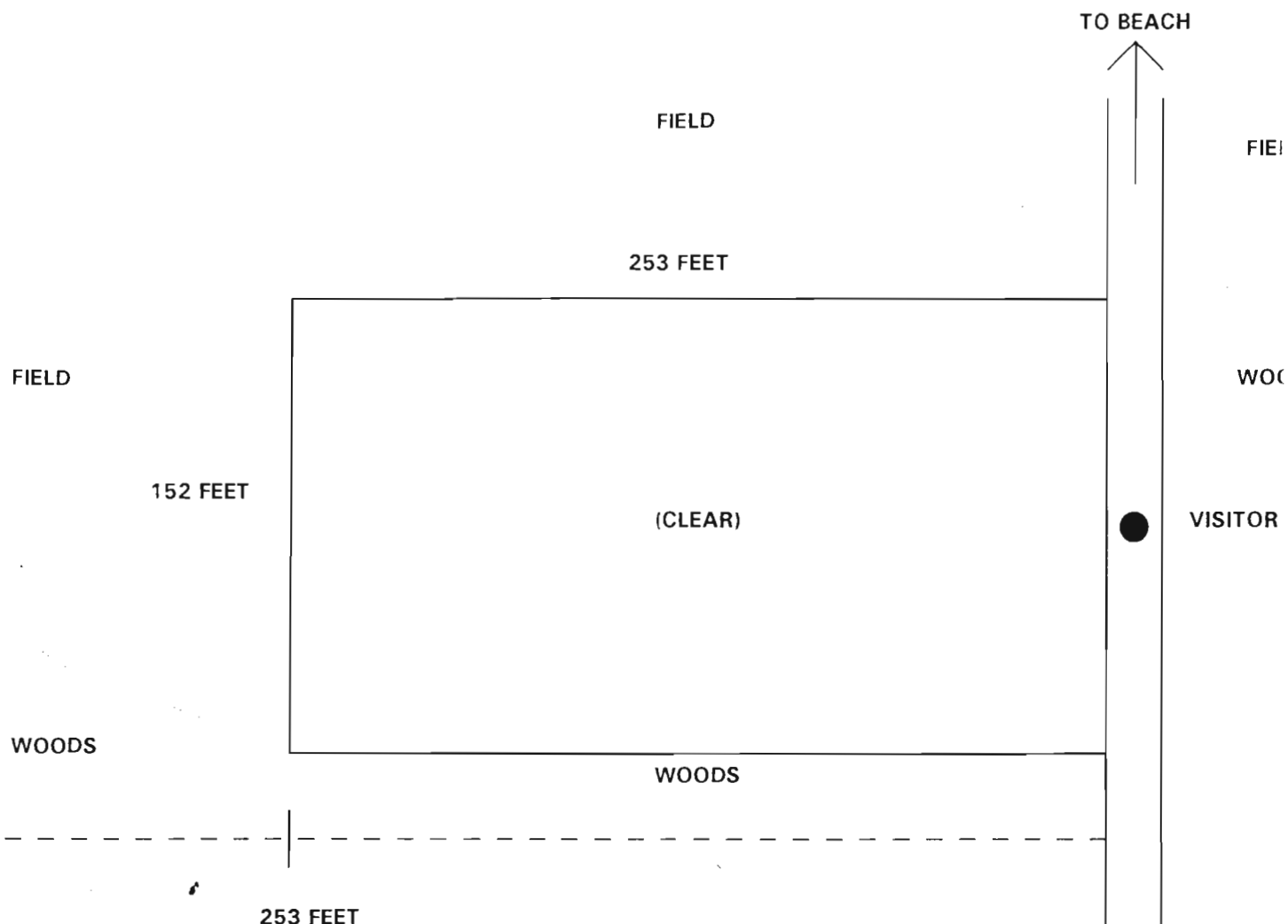
^a Calculations based on yearly average of cool- and warm-season grasses

^b For an average weight of 1000 lbs.

TABLE 8. Evaluation of clearing encroaching vegetation for viewing a remnant horse herd on Cumberland Island.

LAWN AREA TO BE CLEARED (TOTAL RESULTING AC.)	ESTIMATED COST (\$) (no tax)	VIEWING EFFECTIVENESS					FINAL INDEX (TOTAL EFFECTIVENESS)/ COST
		CARRYING CAPACITY (# HORSES/AREA)	VISIBILITY		TOTAL (PRODUCT)		
			(FT.)	TIME (%)			
BEACH FIELD (16.9 AC)	1387	3.5	412	3.4	4903	4	
DUNGNESS RUINS (17.7 AC.)							
SERVANTS' QUARTERS (1.9 AC.)	1233	0.3	615	0.4	74	0	
LOWER GARDEN (0.5 AC.)	770	0.05	10560	0.8	422	0	
COTTAGE AREA (15.3 AC.)	616	3.7	860	3.1	9864	16	
DUNGNESS DOCK (8.1 AC.)	154	1.6	496	1.6	1270	8	
TOTAL (42.7 AC.)	4160	9.15	12943	9.3	16533	28	

Fig. 8. Suggested area of Beach Field lawn for clearing encroaching vegetation.



N ← →

INITIAL VISIBILITY = 0 FEET
 RESULTING VISIBILITY = 412 FEET
 ACREAGE = 0.9 ACRES

(NOT TO SCALE)

Fig. 9. Suggested area of Servants' Quarters lawn for clearing encroaching vegetation.

DUNGENESS RUINS: SERVANT'S QUARTERS

INITIAL VISIBILITY = 100 FEET

RESULTING VISIBILITY = 615 FEET

ACREAGE = 0.8 ACRES

WOODS

215 FEET

615 FEET

FIELD

155 FEET

(CLEAR)

100 FEET

PRIVATE RESIDEN

RECREATION BUILDING

N

FIELD

(NOT TO SCALE)

VISITOR

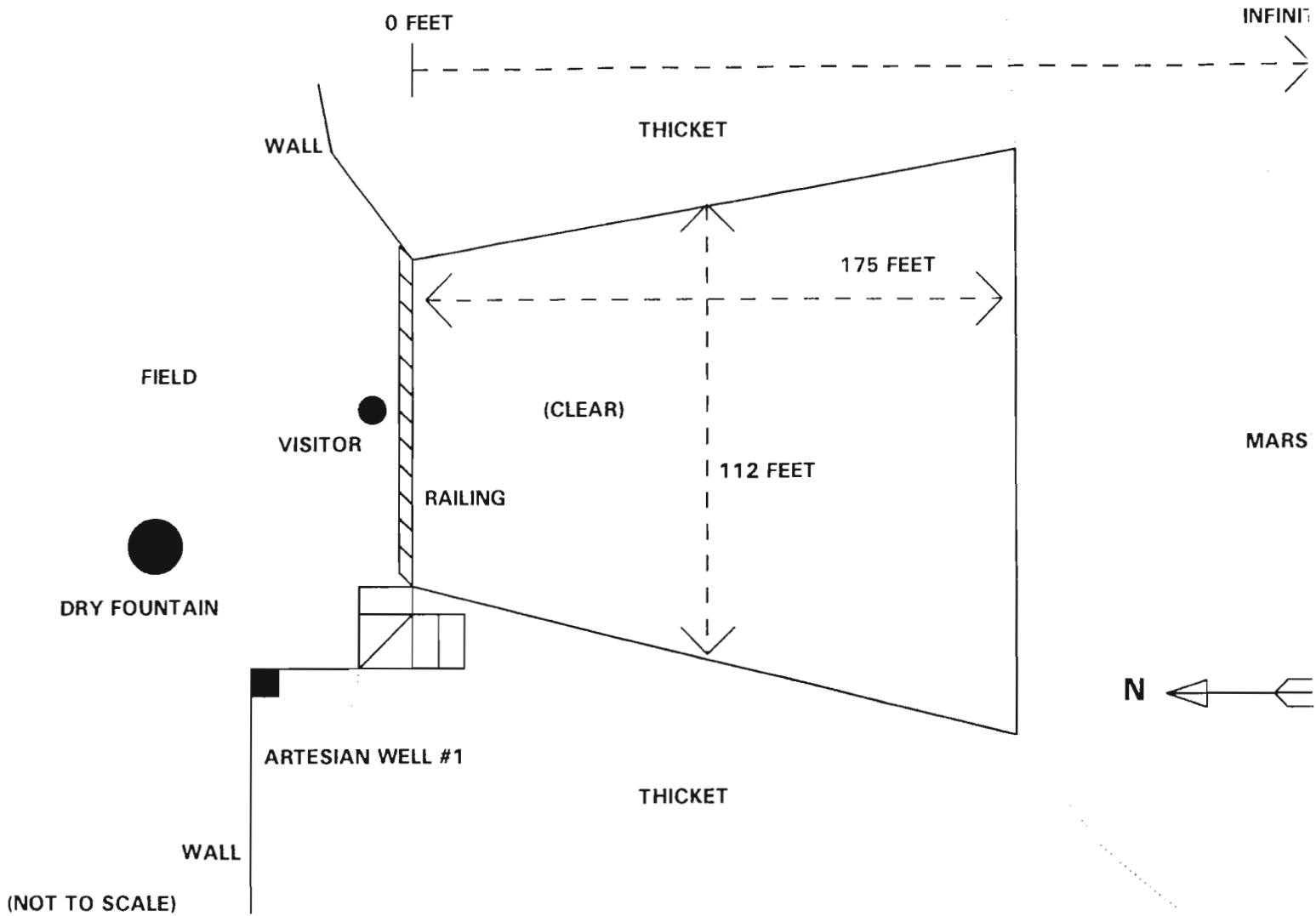
TO DUNGENESS RUINS

FIELD

Fig. 10. Suggested area of Lower Garden for clearing encroaching vegetation.

DUNGENESS RUINS: LOWER GARDEN

INITIAL VISIBILITY = 0 FEET
RESULTING VISIBILITY = INFINITY
ACREAGE = 0.5 ACRES



Cottage Area.--We recommend clearing a 0.4-ac. area along the perimeter of this lawn area (Fig. 11). Visibility would increase slightly by bush-hogging the encroaching acacia and shrub-like coffeeweed. Potential increase in carrying capacity is minimal.

Dungeness Dock.--The 443 x 4-ft. hedgerow in this area consists of tall trees, such as red bay, and shrub species, such saw palmetto (Fig. 12). Visitor viewing of the horses as they board and exit the ferry would increase significantly with clearing. However, changes in carrying capacity are minimal.

4. Establish preferred forage in existing lawn areas

We inferred that preferred forage in 40 ac. of highly-visited areas would attract and support more feral horses for the public to see. We considered all areas previously discussed in alternative #3 except the Lower Garden. We used several criteria to define preferred forage to concentrate improvements on particular plant species.

Because horses are grazers, we narrowed our research to grasses that grow close to the ground. We looked for a hardy, drought-resistant species with a high dry matter yield to increase horse density in commonly-visited areas. Nutritionally superior foods attract more horses than those of poor quality (Ball et al. 1991). Therefore, we assume that horses prefer highly-nutritional forages due to high palatability. To ensure year-round food production, we needed both warm- and cool-season grasses. The chosen species must be native or naturalized on Cumberland. A perennial grass already established on the lawn areas economically is best as reseeding maintenance is minimal; most perennials require reseeding every 7-10 yrs. while annuals require reseeding every year.

Based on these criteria, we considered centipede grass, bahia grass, and Bermuda grass for the warm season. We do not recommend centipede grass as it has lower protein and dry matter yield than bahia grass or Bermuda grass (Miller 1984). According to Heath et al. (1985), Bermuda grass is more palatable to horses than bahia grass. Crude protein content for Bermuda grass

Fig. 11. Suggested area of Cottage Area lawn for clearing encroaching vegetation.

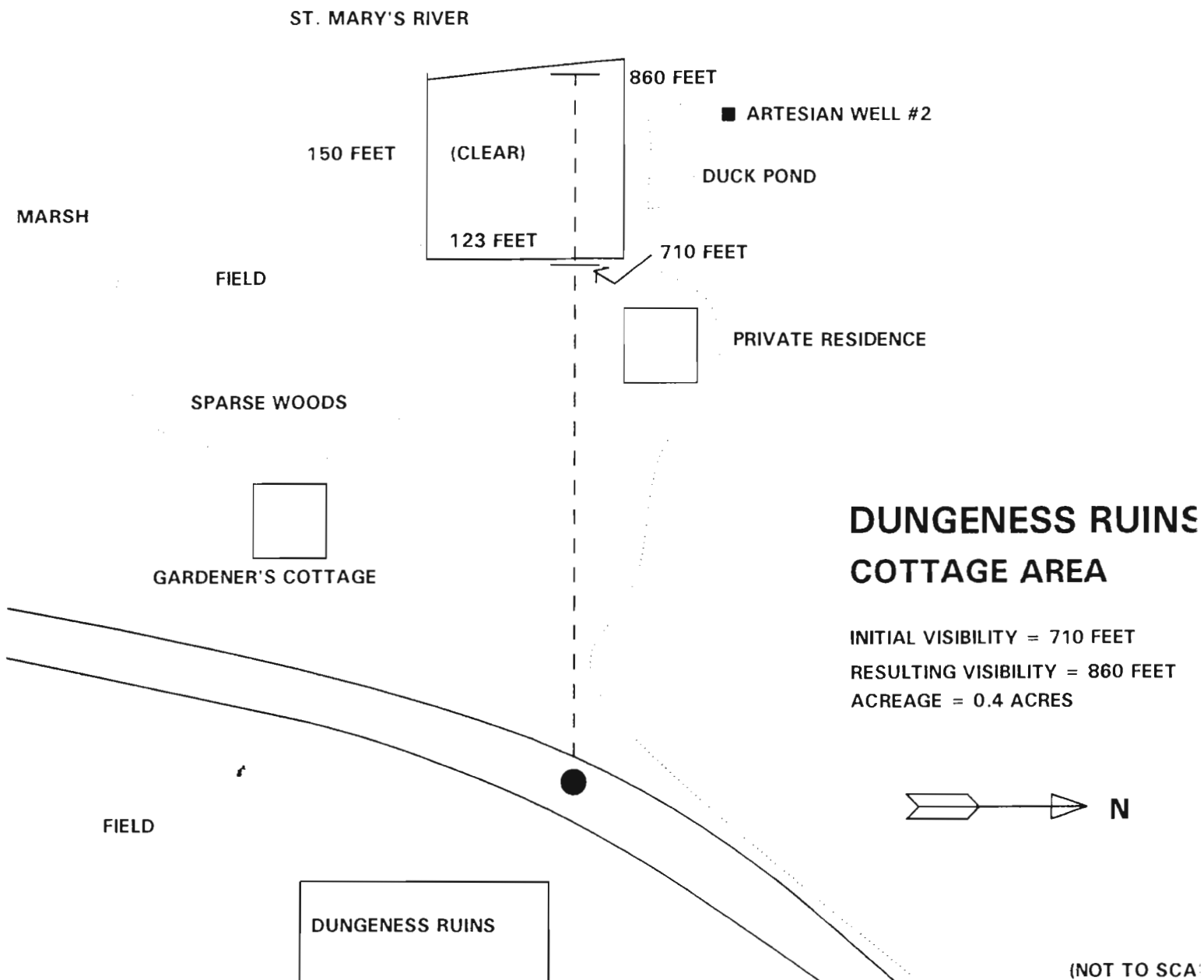
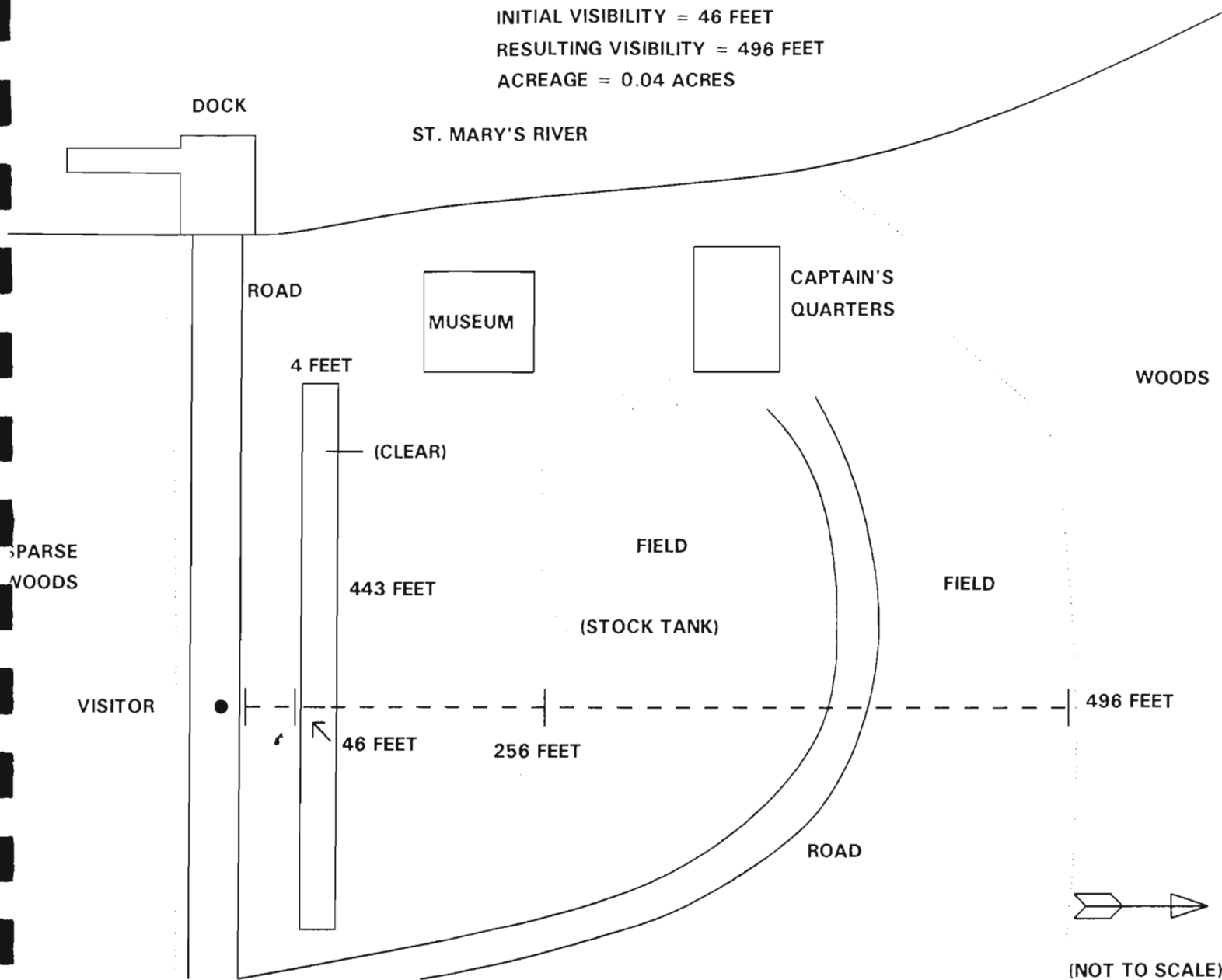


Fig. 12. Suggested area of Dungeness Dock lawn for clearing encroaching vegetation.



ranges from 9-11% of the dry matter yield. This species is well-adapted to drought with roots that may extend 78 in. deep (Ball et al. 1991). When fertilized, Bermuda grass produces about 9600 lbs./ac. from May-October (Heath et al. 1985). Therefore, we suggest improving the Bermuda grass currently in each lawn area.

We then chose a cool-season forage because Bermuda grass goes dormant in the winter. Ryegrass, an annual, is our only option as it is the only cool-season forage naturalized on Cumberland Island; no cool-season native grasses exist on the island. Occasionally, annual ryegrass performs like a perennial by reseeding itself. According to Miller (1984), this cool-season annual ranks high in germination and helps combat soil erosion. Crude protein ranges from 10-16%. Palatability often exceeds that of oats (Ball et al. 1991). When fertilized, ryegrass produces approximately 2500 lbs./ac. from November-May (Heath et al. 1985).

Establishing Bermuda grass and ryegrass requires the elimination of less-desirable species, such as centipede grass. This pest outcompetes all other lawn grasses, thriving on Cumberland's infertile soils; sod density is maintained with little or no fertilizer. Therefore, we concentrated on eliminating this species.

We compared the effectiveness of herbicides to fertilizer for controlling centipede grass. Herbicides temporarily denude all current forages and weeds in the lawn area, leaving the horses without food until the establishment of preferred forage. This action would encourage grazing in the salt marsh, an ecologically sensitive habitat. The public may disapprove of herbiciding the lawn areas due to potential environmental impacts and the negative connotation of pesticides.

Lance (1969) showed a decline in centipede grass productivity with over-fertilization. Fertilizing the lawn areas would significantly reduce this undesirable species while promoting Bermuda grass and ryegrass, which thrive on highly fertile soils. The public most likely would accept fertilizing over herbicide application because the horses would have a

continuous food supply. Therefore, we recommend broadcasting fertilizer to reduce centipede grass while promoting Bermuda and ryegrass to attract horses to lawn areas for public viewing.

D. Gunnels (pers. commun.) recommends a fertilizer formulation (N-P-K) of 200-0-100 for Bermuda grass and 150-0-50 for ryegrass. We suggest using two commercially available formulations, 34-0-0 and 15-0-25, to meet the requirements of both species. Commercial formulations generally are less expensive than special mixtures given minimal N-P-K excess. Bermuda grass requires 204 lbs./ac. of each formulation. Ryegrass needs 120 lbs./ac. of 34-0-0 and 60 lbs./ac. of 15-0-25¹³.

We would distribute fertilizer applications among the growing season for Bermuda grass and ryegrass. Fertilizer must be applied once every season for 5 yrs. to eliminate centipede grass (Lance 1969). The first fertilizer application would accompany the first Bermuda grass planting. Sowing seed would supplement existing Bermuda grass to ensure establishment. We recommend broadcasting seed at a rate of 5 lbs./ac. in early spring every 7-10 yrs. Ryegrass requires seeding every fall at a rate of 30 lbs./ac. (Ball et al. 1991).

According to Goldkist Farm and Garden Co., the total cost for establishing preferred forage is \$5180. Maintenance costs range from \$1072-5180 annually¹⁴. This cost ranges from fertile soils that only require ryegrass reseeding to relatively infertile soils that need fertilizing and reseeding of both species. Table 9 separately evaluates the effectiveness of establishing preferred forage in each lawn area. Carrying capacity would increase with forage establishment (Table 10). However, this alternative has a relatively low total effectiveness and final index.

¹³Appendix M shows fertilizer requirement calculation for Bermuda grass and ryegrass on Zone 1 lawn areas.

¹⁴Appendix N itemizes the cost of establishing and maintaining preferred forage on Zone 1 lawn areas.

TABLE 9. Evaluation of establishing preferred forage for viewing a remnant horse herd on Cumberland Island.

LAWN AREA FOR ESTABLISHING PREFERRED FORAGE (TOTAL AC.)	ESTIMATED COST (\$) (no tax)	VIEWING EFFECTIVENESS				FINAL INDEX (TOTAL EFFECTIVENESS)/ COST
		CARRYING CAPACITY (# HORSES/AREA)	VISIBILITY		TOTAL (PRODUCT)	
			(FT.)	TIME (%)		
BEACH FIELD (16.0 AC.)	2072	14.4	0	3.2	0	0
DUNGENESS RUINS (16.0 AC.)						
SERVANTS' QUARTERS (1.1 AC.)	143	0.9	100	0.2	18	0
COTTAGE AREA (14.9 AC.)	1929	13.3	710	3.0	28329	15
DUNGENESS DOCK (8.0 AC.)	1036	7.2	46	1.6	530	0
TOTAL (40 AC.)	5180	35.8	856	8	28877	15

NOTE: We excluded the Lower Garden because it is not an existing lawn area.

Table 10. Potential increase in carrying capacity for establishing preferred forage in Zone 1 lawn areas^a.

Location	Potential	Horses/ac. ^b	Increase
		Current	
Beach Field	14.4	3.4	11.0
Dungeness Ruins			
-Servant's Qtrs.	0.9	0.1	0.8
-Cottage Area	13.3	1.8	11.5
Dungeness Dock	7.2	0.8	6.4
Total	35.8	6.1	29.7

^a Calculations based on yearly average of cool- and warm-season grasses.

^b For an average body weight of 1000 lbs.

5. Best combination of alternatives

We combined all beneficial-cost alternatives (final index >1) to determine the highest horse visibility possible (Table 11). Although this alternative does not yield the best final index, it gives the highest total effectiveness as it increases horse viewing 2-11 times more than the other alternatives evaluated. Furthermore, the relatively high total cost remains well within our budget.

CONCLUSION

Management Recommendations

We compared all alternatives for increasing visitor viewing of a reduced horse population in terms of cost, effectiveness, and final index (Table 12). We weighed effectiveness over the final index given that the cost remained within our budget; viewing success is more important to the NPS than minimizing cost. Therefore, we recommend Alternative #5, the best combination.

Alternative #5 combines the most economical subalternatives for the highest viewing effectiveness. By managing specific areas under each alternative, we maximized viewing benefits per cost. This option allows the NPS to allocate the remaining funds to feral horse management. For example, the \$3940 left over in the budget may be used for other less beneficial subalternatives. The NPS may chose to clear encroaching vegetation near the Servants' Quarters or establish preferred forage in the Beach Field lawn, Dungeness Dock area, or the remaining Dungeness Ruins area. We also suggest the use of volunteers to decrease labor costs, increasing the funds available for improving visitor viewing of feral horses.

Further Studies

We considered many alternatives to maintain the viewing success of a reduced horse population on Cumberland Island. Our time constraints only allowed evaluation of relatively few options. The NPS may consider

TABLE 11. Evaluation of alternatives for viewing a remnant horse herd on Cumberland Island.

COMPONENT ALTERNATIVES OF BEST COMBINATION	ESTIMATED COST (\$) (no tax)	VIEWING EFFECTIVENESS				FINAL INDEX (TOTAL EFFECTIVENESS)/ COST
		CARRYING CAPACITY (# HORSES/AREA)	VISIBILITY		TOTAL (PRODUCT)	
			(FT.)	TIME (%)		
A. NO ACTION DUNGENSESS RUINS SERVANT'S QTRS. (1.1 AC)	0.01	0.1	100	0.2	2	200
B. ADD A STOCK TANK DUNGENSESS DOCK (8.0 AC.)	1422	40	256	1.67	17100	12
C. CLEAR ENCROACHING VEGETATION BEACH FIELD (16.9 AC)	1387	3.5	412	3.4	4903	4
DUNGENSESS RUINS LOWER GARDEN (0.5 AC)	770	0.05	10560	0.8	422	0.55
COTTAGE AREA (15.3 AC)	616	3.7	860	3.1	9864	16
D. ESTABLISH PREFERRED FORAGE DUNGENSESS RUINS COTTAGE AREA (14.9 AC)	2111	13.3	710	3	28329	15
COMBINATION OF C. AND D. IN COTTAGE AREA (15.3 AC)	2743	13.7	860	3.1	36524	13
TOTAL (41.8 AC.)	6306	17.35	12188	9.17	41851	217

Table 12. Evaluation of alternatives for viewing a remnant horse herd on Cumberland Island.

ALTERNATIVES	ESTIMATED COST (\$) (NO TAX)	CARRYING CAPACITY (# HORSES/RESOURCE)	VIEWING EFFECTIVENESS		TOTAL (PRODUCT)	FINAL INDEX TOTAL EFFECTIVENESS INDEX
			VISIBILITY (FT.)	TIME (%)		
1) NO ACTION						
BEACH FIELD (16 AC)	0.01	3.4	0	3.2	0	0
DUNGENESS RUINS						
SERVANTS' QTRS. (1.1 AC)	0.01	0.1	100	0.20	2	200
LOWER GARDEN (0.0 AC)	0.01	0	0	0	0	0
COTTAGE AREA (14.9 AC)	0.01	1.8	710	3	3834	383400
DUNGENESS DOCK (8.0 AC)	0.01	0.8	46	1.6	59	5888
ARTESIAN WELL #1	0.01	40	0	2.5	0	0
ARTESIAN WELL #2	0.01	40	0	2.5	0	0
Total (excluding artesian wells)	0.05	6.1	856	8	3895	389488
2) ADD 3RD WATER SOURCE						
STOCK TANK	1422	40	256	1.67	17101	12
DRILL	20000	40	256	1.67	17101	0
3) CLEAR ENCROACHING VEGETATION						
BEACH FIELD (16.9 AC)	1387	3.5	412	3.4	4903	4
DUNGENESS RUINS						
SERVANTS' QTRS. (1.9 AC)	1233	0.3	615	0.40	74	0
LOWER GARDEN (0.5 AC)	770	0.05	10560	0.8	422	0
COTTAGE AREA (15.3 AC)	616	3.7	860	3.1	9864	16
DUNGENESS DOCK (8.1 AC)	154	1.6	496	1.6	1270	8
Total	4160	9.15	12943	9.3	16533	28
4) ESTABLISH PREFERRED FORAGE						
BEACH FIELD (16 AC)	2072	14.4	0	3.2	0	0
DUNGENESS RUINS						
SERVANTS' QTRS. (1.1 AC)	143	0.9	100	0.2	18	0
COTTAGE AREA (14.9 AC)	1929	13.3	710	3	28329	15
DUNGENESS DOCK (8.0 AC)	1036	7.2	46	1.6	530	0
Total	5180	35.8	856	8	28877	15
5) BEST COMBINATION						
A) NO ACTION						
DUNGENESS RUINS						
SERVANTS' QTRS. (1.1 AC)	0.01	0.1	100	0.20	2	200
B) ADD 3RD WATER SOURCE						
STOCK TANK	1422	0	256	1.67	0	0
C) CLEAR ENCROACHING VEGETATION						
BEACH FIELD (16.9 AC)	1387	3.5	412	3.4	4903	4
DUNGENESS RUINS						
LOWER GARDEN (0.5 AC)	770	0.05	10560	0.8	422	0
COTTAGE AREA (15.3 AC)	616	3.7	860	3.1	---	---
D) ESTABLISH PREFERRED FORAGE						
DUNGENESS RUINS						
COTTAGE AREA (14.9 AC)	2111.00	13.30	---	---	---	---
COMBINATION OF C. AND D.						
IN COTTAGE AREA (15.3)	2743	13.7	860	3.1	36524	13
Total	6306.01	17.35	12188.00	9.17	41851	217

NOTE: In the no action alternative, artesian wells were not added

fencing and burning vegetation (ie., clearing, increase forage availability) to keep horses within visitor routes and out of environmentally-sensitive habitats, such as the salt marsh and dunes.

Despite the alternative considered, we suggest using our index for evaluating viewing effectiveness and benefit-cost ratios. This method facilitates the comparison of qualitative improvements by using easily-measured criteria. However, the reliability of this index rests upon the accuracy of criteria measurements. Forage-specific digestibility coefficients would improve carrying capacity estimates. Observations of horse time spent in individual lawn areas (vs. feeding and drinking) may strengthen the percentage time criteria to increase the dependability of our results. Most importantly, we recommend assessing potential impacts on native flora and fauna before implementing this management plan.

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APPENDICES

Appendix A. Scientific names of animal and bird species in text.

<u>Common name</u>	<u>Scientific name</u>
Cow (domestic) ^a	<u>Bos taurus</u>
Hog (feral) ^b	<u>Sus scrofa</u>
Horse (feral) ^a	<u>Equus caballus</u>
Mud snake ^c	<u>Farancia abacura</u>
Nine-banded armadillo ^b	<u>Dasypus novemcinctus</u>
Raccoon ^b	<u>Procyon lotor</u>
Sheep (domestic) ^d	<u>Ovis aries</u>
Southern leopard frog ^b	<u>Rana utricularia</u>
White-tailed deer ^b	<u>Odocoileus virginianus</u>
Wild turkey ^b	<u>Meleagris gallopavo</u>

^aScientific name according to Burt and Grossenheider (1980).

^bScientific name according to Hillestad et al. (1975).

^cScientific name according to Conant and Collins (1991).

^dScientific name according to Berger (1986).

Appendix B. Scientific names of plant species in the text.

<u>Common name</u>	<u>Scientific name</u>
Acacia ^a	<u>Acacia</u> sp.
Bahia grass ^a	<u>Paspalum</u> <u>notatum</u>
Beech hogwort ^a	<u>Croton</u> <u>punctatus</u>
Bermuda grass ^a	<u>Cynodon</u> <u>dactylon</u>
Bluestem ^a	<u>Andropogon</u> sp.
Bristly paspalum ^a	<u>Paspalum</u> <u>setaceum</u>
Cabbage palm ^a	<u>Sabal</u> <u>palmetto</u>
Centipede grass ^a	<u>Eremochloa</u> <u>ophiuroides</u>
Coastal love grass	<u>Eragrostis</u> <u>refracta</u>
Coffeeweed ^b	<u>Cassia</u> <u>obtusifolia</u>
Corn ^b	<u>Zea</u> <u>mays</u>
Dog-fennel ^a	<u>Eupatorium</u> spp.
False garlic ^b	<u>Allium</u> <u>bivale</u>
Frost-weed ^a	<u>Helianthemum</u> <u>corymbosum</u>
Grape vines ^a	<u>Vitis</u> spp.
Hackberry ^a	<u>Celtis</u> <u>laevigata</u>
Live oak ^a	<u>Quercus</u> <u>virginiana</u>
Loblolly pine ^a	<u>Pinus</u> <u>taeda</u>
Oats ^b	<u>Avena</u> <u>sativa</u>
Poor-joe ^a	<u>Diodia</u> <u>teres</u>
Red bay ^a	<u>Persea</u> <u>borbonia</u>
Ryegrass ^a	<u>Lolium</u> <u>multiflorum</u>
Salt grass ^a	<u>Distichlis</u> <u>spicata</u>
Salt-marsh fimbristylis ^a	<u>Fimbristylis</u> <u>spadicea</u>
Salt-meadow cordgrass ^a	<u>Spartina</u> <u>patens</u>
Sandspur ^a	<u>Cenchrus</u> <u>tribuloides</u>
Saw palmetto ^a	<u>Serenoa</u> <u>repens</u>
Sawbrier ^a	<u>Smilax</u> <u>glauca</u>

Appendix B. Continued.

Sea island cotton ^b	<u>Gossypium</u> sp.
Sea-oats ^a	<u>Uniola paniculata</u>
Seashore dropseed ^a	<u>Sporobolus virginicus</u>
Seashore paspalum ^a	<u>Paspalum vaginatum</u>
Sedge ^a	<u>Carex</u> spp.
Slash pine ^a	<u>Pinus elliottii</u>
Smooth cordgrass ^a	<u>Spartina alterniflora</u>
Southern magnolia ^a	<u>Magnolia grandiflora</u>
Southern red-cedar ^a	<u>Juniperus silicicola</u>
Sugar cane ^c	<u>Saccharum</u> sp.
Sweet potato ^c	<u>Ipomoea</u> sp.
Switchcane ^b	<u>Arundinaria gigantea</u>
Thoroughwort ^a	<u>Eupatorium aromaticum</u>
Tung-oil tree ^a	<u>Aleurites fordii</u>
Wax myrtle ^b	<u>Myrica cerifera</u>

^aScientific name according to Hillestad et al. (1975).

^bScientific name according to Radford et al. (1969).

^cScientific name according to Martin et al. (1961).

Appendix C. Soil test results for Bermuda grass on Zone 1 lawn areas.

SOIL ANALYSIS RESULTS

NAME: LUNG, JASON E

SOIL TESTING LABORATORY
COOPERATIVE EXTENSION SERVICE
THE UNIVERSITY OF GEORGIA

COUNTY EXTENSION DIRECTOR
CLARKE COUNTY
2152 W. BROAD ST.
ATHENS, GA

DATE: 10/07/94

30600

SAMPLE IDENTIFICATION															

LAB : SAMPLE :															
NUMBER : NUMBER :															
47680 : 1 : COASTAL BERMUDA															
: : PASTURE															
: : MANGANESE SOIL TEST LEVEL IS 14 LBS/ACRE. SEE COMMENT 998.															

47680 : 1 : HYBRID BERMUDAS -															
: : PASTURE															
: : MANGANESE SOIL TEST LEVEL IS 14 LBS/ACRE. SEE COMMENT 998.															

RECOMMENDATIONS															

LIME : LBS PER ACRE : SEE COMMENTS															
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Appendix D. Flow rate calculations for Artesian Well #1.

Field measurement:

Water filled 1-L bottle in approximately 4 sec.

Calculations:

$$\text{Per min.: } \frac{1\text{L}}{4 \text{ sec.}} * \frac{1 \text{ gal.}}{3.7854 \text{ L}} * \frac{60 \text{ sec.}}{1 \text{ min.}} = 3.96 \text{ gal./min.}$$

$$\text{Per day: } \frac{3.96 \text{ gal.}}{1 \text{ min.}} * \frac{60 \text{ min.}}{1 \text{ hr.}} * \frac{24 \text{ hrs.}}{1 \text{ day}} = 5706 \text{ gal./day}$$

Appendix E. Flow rate calculations for Artesian Well #2.

Field measurements:

Size of trough: 54 in. x 78 in. x 1.5 in. = 6318 in³.

Water rose 1.5 in. in 16 min.

Calculations:

$$\text{Per min.: } \frac{6318 \text{ in}^3}{16 \text{ min.}} * \frac{16.39 \text{ cm}^3}{1 \text{ in}^3} * \frac{2.6417 \times 10^{-4} \text{ gal.}}{1 \text{ cm}^3} = 1.71 \text{ gal./min.}$$

$$\text{Per day: } \frac{1.71 \text{ gal.}}{1 \text{ min.}} * \frac{60 \text{ min.}}{1 \text{ hr.}} * \frac{24 \text{ hr.}}{1 \text{ day}} = 2462 \text{ gal./day}$$

Appendix F. Volume calculations for South End Pond #2.

Field observations:

$$\frac{2.25 \text{ ac. (area)}}{1} * \frac{43560 \text{ ft}^2}{1 \text{ ac.}} * \frac{3 \text{ ft. (depth)}}{1} = 294030 \text{ ft}^3.$$

Calculations:

$$\frac{294030 \text{ ft}^3}{1} * \frac{1728 \text{ in}^3}{1 \text{ ft}^3} * \frac{16.39 \text{ cm}^3}{1 \text{ in}^3} * \frac{2.6417 \times 10^{-4} \text{ gal.}}{1 \text{ cm}^3} = 2199874 \text{ gal.}$$

Appendix G. Carrying capacity calculations of Zone 1.

Step 1: Ac. of Available Forage in each area

% Abundance of individual grass * Ac. = ac. of forage/grass species

of grasses * (ac. of forage/grass species) =
total ac. of forage

Step 2: Dry Matter Yield per Grass Species^a

Daily

Requirements -> 10% of average 1000 lbs. horse = 10 lbs./horse/day

- Using digestibility coefficient of 30%^b

Bahia

$$\frac{6137 \text{ kg./ha.}}{150 \text{ days}} * \frac{2.205 \text{ lbs.}}{2.471 \text{ ac.}} = \frac{36.51 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{36.51 \text{ lbs./ac.}}{\text{day}} * 0.3 = \frac{10.95 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{10.95 \text{ lbs./ac./day}}{10 \text{ lbs./horse/day}} = 1.0 \text{ horses/ac.}$$

Bermuda grass

$$\frac{9600 \text{ kg./ha.}}{180 \text{ days}} * \frac{2.205 \text{ lbs.}}{2.471 \text{ ac.}} = \frac{47.59 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{47.59 \text{ lbs./ac.}}{\text{day}} * 0.3 = \frac{14.28 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{14.28 \text{ lbs./ac./day}}{10 \text{ lbs./horse/day}} = 1.4 \text{ horses/ac.}$$

Centipede^c

$$\frac{2545 \text{ kg./ha.}}{120 \text{ days}} * \frac{2.205 \text{ lbs.}}{2.471 \text{ ac.}} = \frac{18.93 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{18.93 \text{ lbs./ac.}}{\text{day}} * 0.3 = \frac{5.68 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{5.68 \text{ lbs./ac./day}}{10 \text{ lbs./horse/day}} = 0.5 \text{ horses/ac.}$$

Appendix G. Continued.

Ryegrass

$$\frac{2800 \text{ kg./ha.}}{180 \text{ days}} * \frac{2.205 \text{ lbs.}}{2.471 \text{ ac.}} = \frac{13.88 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{13.88 \text{ lbs./ac.}}{\text{day}} * 0.3 = \frac{4.16 \text{ lbs./ac.}}{\text{day}}$$

$$\frac{4.16 \text{ lbs./ac./day}}{10 \text{ lbs./horse/day}} = 0.4 \text{ horses/ac.}$$

Step 3: Current Carrying Capacity

$$\text{ac. of forage/grass species} * \text{horses/ac.}^d = \text{horses/grass species}$$

$$\frac{\# \text{ of warm and cool season forages}^e * (\text{horses/grass species})}{2^f}$$

^a Taken from Heath et al. 1985.

^b H. Heusner pers. commun.

^c Based on 75% dry matter yield of Carpet grass (T. Johnson pers. commun.).

^d Determined by each grass species.

^e Includes bahia, Bermuda, centipede, and ryegrass.

^f Used to give a yearly average.

Appendix H. Carrying capacity calculations for artesian wells in Zone 1.

Assumptions:

1 horse drinks 12 gal./day

TDS<7000 ppm

Calculations:

$$\text{Artesian Well \#1: } \frac{5706 \text{ gal.}}{1 \text{ day}} * \frac{1 \text{ horse}}{12 \text{ gal./day}} = 475 \text{ horses daily}$$

$$\text{Artesian Well \#2: } \frac{2462 \text{ gal.}}{1 \text{ day}} * \frac{1 \text{ horse}}{12 \text{ gal./day}} = 205 \text{ horses daily}$$

Appendix I. Carrying capacity calculations for South End Ponds #2 in Zone 2.

Assumptions:

1 horse drinks 12 gal./day

TDS<7000 ppm

Horse water consumption is the only factor in volume change

Calculations:

$$\text{Individual horse: } \frac{2199874 \text{ gal.}}{1} * \frac{1 \text{ horse}}{12 \text{ gal./day}} = 183322 \text{ horse-days}^a$$

$$\text{Targeted population: } \frac{183322 \text{ horse-days}}{40 \text{ horses}} = 4583 \text{ days}$$

^aThis pond can support 183322 horses for 1 day or 1 horse for 183322 days.

Appendix J. Evaluation of current and potential freshwater sources in our study area.

Assumptions:

- Horses spend approximately 5% of their time drinking water (Lenarz 1983).
- The time % will either be used for the stock tank or the new well.
- .01 is used instead of .00 for cost in order to ensure that the final index is not defined.
- The final index above 1 is significant.

EXISTING PERMANENT WATER SOURCES (NO ACTION)

	ESTIMATED COST (\$) (NO TAX)	MAXIMUM # HORSES SUPPORTED	VISIBILITY		FINAL INDEX
			(FEET)	% TIME	(HORSE*TIME*FEET)/COST
ZONE 1					
ARTESIAN WELL #1	0.01	475	0	2.5	0
ARTESIAN WELL #2	0.01	205	0	2.5	0
ZONE 2					
SOUTH END POND #2	0.01	183322	0	5	0

EXISTING PERMANENT WATER SOURCES PLUS 2 ALTERNATIVES

	ESTIMATED COST (\$) (NO TAX)	MAXIMUM # HORSES SUPPORTED	VISIBILITY		FINAL INDEX
			(FEET)	% TIME	(HORSE*TIME*FEET)/COST
ZONE 1					
ARTESIAN WELL #1	0.01	475	0	1.67	0
ARTESIAN WELL #2	0.01	205	0	1.67	0
STOCK TANK	1422	> or equal to 40	256	1.67	12
NEW WELL	20000	> or equal to 40	256	1.67	0.9
ZONE 2					
SOUTH END POND #2	0.01	183322	0	5	0

IF THE PIEZOMETRIC SURFACE DROPS BELOW GROUND LEVEL

	ESTIMATED COST (\$) (NO TAX)	MAXIMUM # HORSES SUPPORTED	VISIBILITY		FINAL INDEX
			(FEET)	% TIME	(HORSE*TIME*FEET)/COST
ZONE 1					
STOCK TANK	1422	40	256	5	36
ZONE 2					
SOUTH END POND #2	0.01	183322	0	5	0

Appendix K. Cost itemization of installing a stock tank in Dungeness Dock lawn area.

STOCK TANK

Labor: 8 hrs. @ \$13/hr. for NPS technician = \$104.00

Parts: (estimates according to Ace Hardware, Athens, Ga.)

Trough = \$325.00
- 400-gal. (6 x 3 ft.)
- 4500 lbs. (round concrete)
- liquid-flow float valve
- obtained from B & F Concrete Products, Inc. (Gillsville, Ga.)

3/4-in. PVC = \$50.70
- 30 10-ft. sections @ \$1.69 each

3/4-in. PVC Coupler = 0.92
- 4 couplers @ \$0.23 each

3/4-in. PVC Elbow = \$0.69
- 3 elbows @ \$0.23 each

T-Connection = \$0.50
- 1-3/4 in. or 3/4-3/4 in.

3/4-in. Thread Sleeves = \$1.60
- 4 sleeves @ \$0.40 each

Unions = \$4.80
- 2 unions @ \$2.40 each

Ball Lever Valves = \$12.00
- 2 ball lever valves @ \$6.00 each

Flu-tile = \$21.00
- 2 flu-tiles @ \$10.50 each

Cleaner = \$2.29
- 1 cleaner @ \$2.29

CPVC Glue = \$2.99
- 1 can @ \$2.99

EQUIPMENT

Labor: 16 hrs. @ \$13/hr. for NPS technician = \$208.00
- 2 hrs. with Backhoe
- 2 hrs. with Ditch Witch
- 12 hrs. with Boom Truck

Parts: (necessary equipment)

Backhoe = \$5.00
- gas

Ditch Witch and trailer (Model 1020/Walk behind) = \$110
- \$110/day rental from Barron's Rental Center (706-543-3486)

Appendix K. Continued.

Boom truck = \$572.40
- \$330/day rental from Richbourg Sales & Rental (706-543-1328)
- 404 mi. from Gillsville to Cumberland Island @ \$0.30/mi.

TOTAL INSTALLATION COST = \$1421.89

Total Labor = 24 hrs.
Total Labor Cost = \$312.00
Total Equipment Cost = \$1109.89

Appendix L. Cost itemization of clearing encroaching vegetation in Zone 1 lawn areas.^a

A. Initial clearing

- 1994 NPS technician wage = \$13/hr.
- 4 NPS technicians are needed, therefore $4 * \$13/\text{hr.} = \$52/\text{hr.}$
- Estimated time to clear 2.7 acres = 2 wks.

With a 5 day wk. and 8 hrs./day,

$$5 \text{ days/wk.} * 2 \text{ wks.} = 10 \text{ days}$$

$$10 \text{ days} * 8 \text{ hrs./day} = 80 \text{ hrs.}$$

$$80 \text{ hrs.} * \$52/\text{hr.} = \$4160 / (\text{total } 2.7 \text{ ac.})$$

B. Maintenance cost

Assuming:

- Mowing takes 1 hr./ac. for 1 technician
- Cleared area is mowed every yr.

$$1 \text{ hr./ac.} * 2.7 \text{ ac.} = 2.7 \text{ hrs.}$$

$$2.7 \text{ hrs.} * \$13/\text{hr.} = \$35$$

- Pruning takes 1 hr./ac. for 1 technician
- Cleared area is pruned every 5 yrs.

$$1 \text{ hr./ac.} * 2.7 \text{ ac.} = 2.7 \text{ hrs.}$$

$$2.7 \text{ hrs.} * \$13/\text{hr.} = \$35$$

Total annual cost ranges between \$35 to \$70.

^a Initial clearing estimates given by Bass Landscaping, Inc.

Appendix M. Fertilizer requirement calculations for Bermuda grass and ryegrass on Zone 1 lawn areas.

Bermuda grass requires both at a 2-0-1^a ratio:

$$34-0-0 + 15-0-25 = 49-0-25$$

$$\frac{200 \text{ lbs./ac.}^b}{0.49} = 408 \text{ lbs./ac. of equal amounts}$$

$$\text{therefore, } 1/2 * (408 \text{ lbs./ac.}) = 204 \text{ lbs./ac.}$$

- 34-0-0 at 204 lbs./ac.

- 15-0-25 at 204 lbs./ac.

Ryegrass needs both at 3-0-1^a ratio:

$$2 * (34-0-0) + 1 * (15-0-25) = 83-0-25$$

$$\frac{150 \text{ lbs./ac.}^b}{0.83} = 180 \text{ lbs./ac.}$$

$$\text{therefore, } 2/3 * (180 \text{ lbs./ac.}) = 120 \text{ lbs./ac}$$

- 34-0-0 at 120 lbs./ac.

$$\text{also, } 1/3 * (180 \text{ lbs./ac.}) = 60 \text{ lbs./ac.}$$

- 15-0-25 at 60 lbs./ac.

^a From Cooperative Extension Service recommendations.

^b Using suggested nitrogen levels to determine amount.

Appendix N. Total cost of establishing and maintaining preferred forage on Zone 1 lawn areas^a.

A. Initial cost

Fertilizer (N-P-K)

- 34-0-0 \$6.85/50 lbs.

- 15-0-25 \$8.75/50 lbs.

Bermuda grass recommendations:

- 34-0-0 at 204 lbs./ac.

204 lbs./ac. * \$6.85/50 lbs. = \$27.95/ac.

- 15-0-25 at 204 lbs./ac.

204 lbs./ac. * \$8.75/50 lbs. = \$35.70/ac.

Cost = \$27.95/ac. + \$35.70/ac. = \$63.66/ac.

Ryegrass recommendations:

- 34-0-0 at 120 lbs./ac.

120 lbs./ac. * \$6.85/50 lbs. = \$16.44/ac.

- 15-0-25 at 60 lbs./ac.

60 lbs./ac * \$8.75/50 lbs. = \$10.50/ac.

Cost = 16.44/ac. + \$10.50/ac. = \$26.94/ac.

Seed

Bermuda grass = \$250/50 lbs.

- 5 lbs./ac. * \$250/50 lbs. = \$25/ac.

Ryegrass = \$23/50 lbs.

- 30 lbs./ac. * \$23/50 lbs. = \$13.80/ac.

Cost = \$25/ac. + \$13.80/ac. = \$38.88/ac.

Appendix N. Continued.

Labor

Assume sowing seed and spreading fertilizer takes

- 1 hr./ac.

- 1 NPS technician (\$13/hr.)

Cost = 1 hr./ac. * \$13/hr. = \$13/ac.

Total Cost = \$63.66 + \$26.94 + \$38.88/ac. = \$129.48/ac.

- \$129.48/ac. * 40 ac. = \$5180

B. Maintenance cost

Assume 1hr./ac. for NPS technician (\$13/hr.)

- 1hr./ac. * \$13/hr. = \$13/ac.

Assume fertilizer is leached out of the soil each year

- Bermuda and ryegrass

\$63.66/ac. + \$26.94/ac. = \$90.6/ac.

Reseeding ryegrass annually

- \$13.80/ac.

Reseeding Bermuda once every 10 years

- \$25/ac

Total maintenance cost could range from

\$13/ac * \$13.80/ac. = \$1072 to

re-establishment (initial cost) = \$5180

^a In 1994 \$ and excludes sales tax.