sent one fifth the total. If numbers of individuals were
needed, one could count the numbers of individuals in the
five squares and multiply by 20.

The quadrat was laid over the turfgrass plot equidistant
from each edge of the plot which measured 1.21 meters
square. The percent cover was determined in each of the
sampling squares by estimating the amount of cover of live
grass in increments of 12.5% for each species. Therefore,
a representative value for each species in each plot was
obtained by totaling the percentage of cover in each of the
five sampling squares of each quadrant.

Results and Discussion

Data collected in March 1991 on four turfgrass after
an eight month period of establishment showed that St.
Augustine cv. FX-10 demonstrated the highest percent
coverage and Buffalo grass cv. 'Prairie' the lowest. Table 1
represents the mean percentage cover 8 months after
planting of the four turfgrass treatments under two 20
minute irrigation events per week. Evaluation of the data
by the analysis of variance, with the level of type I error
set at α=0.05, were found to be highly significant where
F_{5,64}=84.954, p<0.0001.

These data represents base line data for a much more
involved split-split plot experiment involving the four
turfgrass treatments vs. irrigation treatments. I hope that
this information will not be available to those in the hort-
icultural industry who may be skeptical about the FX-10
and to provide more information about possible problems
with Buffalo grass cv. Prairie in southern Florida on sand
soils. The influences that can be made from this experi-
ment are limited indeed, but recent discussions with sod
growers who have had extensive weed invasion of buf-
falograss growing sites corroborate these results.

<table>
<thead>
<tr>
<th>N of Cases</th>
<th>Cultivars</th>
<th>Mean percentage of cover (± Standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>St. Augustine cv. FX-10</td>
<td>95.8 ± 1.7</td>
</tr>
<tr>
<td>20</td>
<td>Bahia cv. 'Argentine'</td>
<td>82.1 ± 5.0</td>
</tr>
<tr>
<td>20</td>
<td>Bahia cv. RCP-2</td>
<td>31.6 ± 6.4</td>
</tr>
<tr>
<td>20</td>
<td>Buffalo cv. 'Prairie'</td>
<td>19.6 ± 5.2</td>
</tr>
</tbody>
</table>

Additional index words. ozone depletion, shade tolerance, St.
Augustine grass, Stenotaphrum secundatum, trees, urban en-
vironment.

Abstract. Earth's ozone layer is being destroyed, thus an in-
creasing UV hazard gives people a legitimate complaint,
"Why can't we sit and play in the grass, while enjoying the
health benefits of tree shade?" The problem of growing grass
in the shade will increase as people plant more trees, and as
older landscape canopies mature. St. Augustine grass, and to
a lesser extent zoysia grass and centipede grass, tolerate par-
tial tree shade, thus are more suitable for urban areas. The
gometry and orientation of trees and buildings will most
easily help homeowners and landscapers estimate the sever-
ity of shade. We explain a simple single-lens reflex (SLR)
camera assay. The difficult region for growing Florida grasses
appears to be where the SLR camera requires between 2 and
3 aperture stops or f-values to compensate for reduced illumi-
nation, compared with the open, unshaded environment.

There are considerable differences among cultivars, with Bit-
terblue, Delmar, Jade, and Seville more shade tolerant than
Floratam. Even so, proper management has a large potential
benefit. Careful pruning, increased mowing height, reduced
fertilization, and reduced irrigation are often effective in sus-
taining turf among trees. Integrated designs which consider
the need of people for both trees and turf are a rational
approach to a healthy landscape.

Trees in the landscape can reduce the need for turf
irrigation and protect us from excess heat and UV radia-
tion. Turfgrass works with trees to provide safe and sani-
tary play areas, and vantages to observe the diversity of
organisms at the interface of pseudo-prairie and urban
forest. Together, turf and trees provide the "sense of
place" which is important emotionally. Human beings, es-
specially their young, prefer park-like habitats, such as
savanna and open forest scenes (Balling and Falk, 1982).

The habitat preference for mixed communities of trees
and understory has been viewed as a "hard-wired" trait,
which is supported consistently by observations on peoples
from around the world (Falk, personal communication).
People have more than the desire for green spaces: They
specifically demand park-like settings of trees and turf.

Landscape designers and managers in Florida re-
peatedly report a problem of growing grass underneath
trees. The purposes of this paper are to understand the shade environment and management of Florida turfgrasses.

Grasses Differ in Shade Adaptation

One of the desires of homeowners and plant breeders is that a type of turfgrass be developed specifically to grow well in the shade. This basis for this hope lies in long-recognized differences among species and cultivars. Enlow and Stokes (1929) pointed out, “Bermuda will not grow as well in the shade as St. Augustine...” Research has scarcely advanced beyond that statement, and the search for shade tolerant grass has also been fraught with several difficulties, including the lack of a general understanding of what is meant by shade. In a later section we will present a practical approach to the description of shade.

Warm-season C4 grasses are believed to have naturally lower tolerance to shaded environments than cool-season C3 grasses. Cool-season plants become “light-saturated” (peak their growth) at moderate light intensities, while warm-season plants are not light-saturated at the highest natural sun intensities (Larcher, 1980). It seems intuitive, though demonstrated in only a few cases (Böhning and Burnside, 1956), that warm-season plants should also have higher “compensation” (break-even, or no growth) light intensities than cool-season plants. The compensation light intensity of C4 plants is high, 1 to 3 klux (Larcher, 1980), and required radiation levels to sustain plant growth should be expected to be 1 to 3 times the compensation light intensity (Svenson, personal communication), which would amount to about 5% of natural sunlight.

As an example, bermudagrass stands have a high compensation light intensity, about 9 klux (Alexander and McCloud, 1962). This high level, approximately 7% of the illumination of full sunlight, would not allow for net growth, but would be the radiation level at which carbon lost through respiration and carbon gained through photosynthesis would be equal to each other. Any mowing, insect stress, or traffic damage would have to be accommodated by a higher level of radiation.

The presumed differences in shade tolerance between C3 and C4 grasses, in their normal habitats, are confounded by differences in temperature and the density of shade under temperate versus subtropical trees. In any case, shade adaptation is a fundamental challenge for different kinds of turf in the urban environment, and different levels of shade adaptation exist among species and cultivars important in Florida.

Research on screening grasses for adaptation to shaded environments has often been inconclusive. Bahiagrass and bermudagrass are widely recognized for their failure to persist in moderately shaded areas, despite an unverified report of tolerance by ‘No-Mow’ bermudagrass (McBee and Holt, 1966). The poor shade performance of bermudagrass is thus consistent with the concept of high compensation light intensity. Centipedegrass is reported to have medium shade tolerance, while zoysiagrass has good shade tolerance (Beard, 1973). Zoysiagrass cultivars may vary, as ‘Meyer’ is reportedly poor in shade adaptation (McBee and Holt, 1966) while ‘Emerald’ shows little reduction in clippings production at 37% of natural radiation (Barrios et al. 1986). Although St. Augustinegrass is reported to have excellent shade tolerance (Beard, 1973), the cultivar ‘Floratam’ is intolerant of shade (Almodares et al., 1978), which is consistent with the observations of Florida landscapers. Among four grasses, Floratam showed the most reduction in clippings production at 37% of full sunlight (Barrios et al. 1986).

In a comparison of St. Augustinegrass and bermudagrass grown on 30% sunlight, Winstead and Ward (1974) concluded,

“No definite conclusions could be drawn from these experiments as to why a particular grass may be shade tolerant. . . . No reliable indicator was found . . . which could be used in screening turfgrasses for shade tolerance.”

An interpretation of shade screening methods was derived from a study of six St. Augustinegrass cultivars grown at as low as 42% of sunlight (Peacock and Dudeck 1981):

“No one [morphological or physiological] parameter apparently can be used to identify a best cultivar for use in shaded environments, rather growth and persistence over time under field conditions still remains [sic] the best criteria for acceptable turf in shaded conditions.”

Floratam actually yielded higher clippings dry weight at 42% light intensity than at full sunlight (Peacock and Dudeck, 1981). Similarly, Barrios et al. (1986) showed that at 37% sunlight Floratam produced more clippings than other grasses. While this may seem contradictory with the idea of shade intolerance, it probably reflects the extreme tendency of Floratam to grow tall and upright (etiolation) in the shade, as well as illustrates the difficulty of finding quantitative measures of shade tolerance. While some progress has been made in developing cool-season grasses with shade tolerance (e.g., Wood, 1969), progress among warm-season grasses has apparently been limited.

In addition to the need to emphasize the subjective concept of persistence, warm-season grasses have the experimental challenge of stolon encroachment, which makes long-term replicated cultivar comparisons more expensive to maintain, and more demanding of space. Field approaches to study the relative adaptation of grasses to the shade environment include artificial shade cloth evaluation (Fig. 1) and natural tree shade evaluation (Fig. 2).

A comparison of the long-term persistence of seven St. Augustinegrasses was made from 1988 to 1991 at Jedlo Ranch, R & D Sod Farms, Okeechobee County, Florida. There were two replications (complete blocks), and plots were sufficiently large to observe changes in grass and other factors which affected turfgrass quality. A native hammock of mixed live oak and sabal palm provided 20.8% of natural photosynthetic energy (Table 1). A natural linear gallery among the trees was rogued out, and the resulting shade environment allowed a little direct sunlight in the late afternoon. Turfgrass quality was observed on several dates and the last two dates were combined as repeated measures (Table 2). Four cultivars provided better (P < 0.05) turfgrass quality than Floratam. The “shade-adapted” cultivars (Delmar, Seville, Jade, and Bitterblue) were the same cultivars generally recognized as shade tolerant in the commercial trade.
Fig. 1. Artificial shade tolerance evaluation of St. Augustinegrass cultivars at the University of Florida’s Fort Lauderdale Research and Education Center, Davie, Florida. Shade cloth (27% relative illuminance) covers fully sodded plots representing 25 cultivars.

**What is Shade?**

When we speak of “light” and “shade”, we must remember that plants use only a small portion of solar irradiance, and the quality and quantity available vary dynamically throughout the day, throughout the season, and throughout the lawn. Different regions of the world receive different external (direct and diffuse) radiation levels, because of varying cloudiness, latitude, and altitude. External radiation interacts with trees and buildings to present a mix of filtered or transmitted sunlight, sun flecks, diffuse light reflected from the sky and objects, and full direct sunlight which is interrupted for periods of the day. For the county agent making a recommendation over the telephone, it is difficult to estimate whether the client’s shade is too dense for turfgrass, or whether cultural and cultivar modifications might provide some measure of success.

Table 1. Representative light attenuations underneath Florida tree canopies.

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Photometric illumination density</th>
<th>Photosynthetic photon flux density</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midday measurement converted relative to adjacent full direct sunlight:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black olive #1</td>
<td>1.0</td>
<td>0.9</td>
<td>Closed canopy; little view of sky; no survival after 6 months of six St. Augustinegrass cultivars established as sod</td>
</tr>
<tr>
<td>Valencia orange</td>
<td>1.8</td>
<td>1.7</td>
<td>Low canopy, to within 1 m of ground; no survival of St. Augustinegrass</td>
</tr>
<tr>
<td>Mango</td>
<td>2.8</td>
<td>2.9</td>
<td>Isolated tree, low crown; no turfgrass</td>
</tr>
<tr>
<td>Laurel oak</td>
<td>3.1</td>
<td>2.7</td>
<td>Tall, closed canopy; no survival of St. Augustinegrass, despite excellent stands elsewhere</td>
</tr>
<tr>
<td>Black olive #2</td>
<td>6.2</td>
<td>5.3</td>
<td>Single tree, 3m (10 ft) to base of 12 m diam. crown; solid stand of St. Augustinegrass up to the trunk</td>
</tr>
<tr>
<td>Tamarind</td>
<td>9.8</td>
<td>7.7</td>
<td>Small single tree, low crown, solid stand of St. Augustinegrass</td>
</tr>
<tr>
<td>Diffuse reflected skylight</td>
<td>9.5</td>
<td>11.6</td>
<td>Sun was blocked out</td>
</tr>
</tbody>
</table>

*Simultaneous radiation measurements made under full direct sun in the summer averaged 2138 μmol s⁻¹ m⁻² ± 61 SD (photosynthetic photon flux density = quantum flux density); 120.1 klux ± 3.6 SD (illuminance); and 1068 W m⁻² ± 47 SD (total irradiance). Measurements were made using a LI-COR Quantum Sensor (Model LI-190SA), Photometric Sensor (Model LI-210SA), and DataLogger (Model LI-1000) (LI-COR, Inc. Lincoln, NE 68504).

The complications of light quality and quantity are fascinating to study. For about $20,000 one can obtain a sophisticated radiometer that would tell which precision the quality and quantity of irradiance at a spot within a lawn, yet this would not assist with the immediate problem. The simple concept which we rely on, relative illumination, is the percent light intensity relative to adjacent full direct sunlight, measured at a given location and time. A demon-
Table 2. Turfgrass quality of seven St. Augustinegrass cultivars in a mixed live oak and sabal palm hammock, R & D Sod Farms, Okeechobee County, Florida. Means of two replications.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Origin</th>
<th>Turfgrass quality*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delmar</td>
<td>O M Scott &amp; Sons</td>
<td>6.8 a</td>
</tr>
<tr>
<td>Seville</td>
<td>O M Scott &amp; Sons</td>
<td>6.0 ab</td>
</tr>
<tr>
<td>Jade</td>
<td>O M Scott &amp; Sons</td>
<td>5.3 abc</td>
</tr>
<tr>
<td>Bitterblue</td>
<td>Trade type, 1950's sod producers</td>
<td>4.3 bcd</td>
</tr>
<tr>
<td>Raleigh</td>
<td>North Carolina State University</td>
<td>4.0 cde</td>
</tr>
<tr>
<td>Floratam</td>
<td>University of Florida</td>
<td>2.8 de</td>
</tr>
<tr>
<td>Floralawn</td>
<td>University of Florida</td>
<td>2.3 e</td>
</tr>
</tbody>
</table>

Statistics:

<table>
<thead>
<tr>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.26</td>
<td>0.0061</td>
</tr>
</tbody>
</table>

*Means of November 1989 and January 1991 quality ratings, 10 = best, 1 = worst, 7 = acceptable.

What we hope will at least temporarily relieve the concerns of physiological ecologists.

Midday radiation was observed under several species of Florida trees (Table 1) and converted to a percentage of full direct sun (including diffuse skylight) recorded adjacent at the same time. No turfgrass survived under closed tree canopies offering 1 to 3% relative illuminance (Table 1). Solid stands of St. Augustinegrass persisted underneath single trees which offered 6 to 10% relative illuminance. The main difference between the two situations was that single trees allowed a view of the sky, which was eliminated by closed canopies. Diffuse skylight must thus have been the main midday source of light in the single-tree situation, but this would have been supplemented by direct, angular sunlight penetrating below the canopy in morning and afternoon, which was not measured. Measurements which are integrated throughout the day should be more realistic, but difficult to obtain for practical use. An analog approach is to measure radiation during overcast conditions, and to compare the values inside the canopy with those outside. Overcast measurements should integrate the type of exposure that would occur throughout the sun's passage across the sky. By this method, a realistic value for the turf-incompatible closed canopy of black olive trees was 5.7%. While photosynthetic photon flux is a truer measure of the irradiance used by the plant, and photometric illuminance is biased in measuring tree shade, the results (Table 1) are close enough for practical discussion.

These empirical measurements of light under canopies can be compared with limited experimental work. Turfgrass shade tolerance research has often employed artificial black cloth, which casts a neutral shade. (The relative illuminance under black shade can be known, even though external radiation is not always reported.) While St. Augustinegrass cultivars have acceptable quality at 42% relative illuminance (Peacock and Dudeck, 1981), bermudagrass quality is unacceptable between 35% and 25% of relative illuminance, depending on cultivar (McBee and Holt, 1966). It is plausible that the critical range of warm-season grass varies somewhere between 10 and 40% of relative illuminance, with sensitive species such as bermudagrass failing to persist at the high end, and St. Augustinegrass failing to persist at the low end. Interestingly, the 9.8% relative illuminance from the sky (no sun, Table 1) is in the range of acceptable limits for St. Augustinegrass, and this seems reasonable considering that the species can survive on the north side of tall buildings.

**Low-Tech Approaches**

For fast and inexpensive shade measurement, one can use a neutral reference card such as the gray backing of a legal pad and a single-lens-reflex (SLR) camera with semi-automatic control. (A hand-held light meter also works). For the reasons discussed, an overcast day should provide a more realistic value.

First measure the unshaded environment 20 or 30 meters away from the trees. Do this by manually setting the SLR camera exposure time to an initial value (e.g., 1/30th of a second), point the camera at the gray reference card, placed horizontally, and record the aperture or "f-number" (e.g., f = 11). (Presumably, the ASA value has been left on some intermediate value, such as ASA 64). Try not to bring the camera or yourself so close to the gray card as to shadow it. Perform the same procedure in the shade environment, and record the aperture (e.g. f = 4). If either value is at the edge of the range of apertures, e.g. f = 2.5 to f = 22, depending on the camera, then the initial exposure time must be readjusted so that both f-values are safely within range, and you will have to go back to the unshaded environment and repeat the procedure.

The differences in the number of full stops between f-values (e.g., f = 11 and f = 4) would differ by 3 full F-stops indicates the decreasing illumination, in successive powers of 2. A difference of 1 F-stop (50% light intensity) would be light shade; 2 F-stops (25% light intensity) would be moderate shade; 3 full F-stops would indicate 12.5% light intensity, or severe shade.

While measurement of light may provide information as to the suitability for turfgrass, another low-tech approach is to describe the geometry of the shade, specifically the proximity to trees and buildings (Table 3). As was shown previously, filtered light from closed canopies of several common Florida tree species appears empirically to be too dense to support turfgrass. Except from thin canopies (e.g., jacaranda and slash pine) and those which defoliate seasonally (gumbo-limbo), turf survival requires at least partial canopies. Tree limbs must generally be sufficiently high to allow interception of light reflected from the sky or direct morning and afternoon sun, and this is one of the factors under management control, by means of careful pruning.

**The Shade Environment**

While we frequently refer to shade as being a problem, reduced light level is compounded by more deadly problems. Some of these problems might be related to lack of shade "conditioning" of new sod. Infestations of tropical sod webworm (Herpetogramma phaeopteralis Guenee), other lawn caterpillars, and Pythium root rot are often observed within the first 2 to 4 weeks after sodding in a shade habitat. In the sun environment, adult moths lay their eggs at night, but congregate most densely near perimeter shrubs, where the greatest damage is observed. In shaded environments, moths are observed at all hours of the day,
Table 3. Levels and characteristics of shade environments affecting Florida turfgrass.

<table>
<thead>
<tr>
<th>Shade Relative Level</th>
<th>Description</th>
<th>Suitability for Turfgrass</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 100%</td>
<td>Full sun plus sky, the habitat where most turf research is conducted</td>
<td>Good to excellent; pest, drought, and thatch problems worse due to rapid, sustained growth; high evaporative demand</td>
</tr>
<tr>
<td>II 55-99%</td>
<td>Near but outside the drip-line of a single tree or near a building; or if within the drip-line, tree is small, less than 3 m (10 ft) in crown diameter; less than 1 full stop, or aperture f-value adjustment, required for SLR camera, compared with full direct sunlight</td>
<td>Good to excellent; there may be reduced wind and evaporative demand; improved sprinkler uniformity; high humidity and high advective heat transfer from other objects; disease problems in sensitive grasses</td>
</tr>
<tr>
<td>III 25-50%</td>
<td>Turf within the drip-line of a single tree less than 6 m (20 ft) in crown diameter, and at least 3 m (10 ft) from the ground to the bottom of the canopy; or surrounded by trees or a building and trees; sky is somewhat visible in all directions, or nearly half the sky is visible in one direction; compensatory aperture f-value adjustment between 1 and 2</td>
<td>Fair to good for shade tolerant grasses; mowing height must be elevated and fertilization rate reduced; sun grasses such as bermudagrass may have serious problems at the shadiest end of this environment</td>
</tr>
<tr>
<td>IV 12-25%</td>
<td>Turfgrass surrounded by and under trees, or a building and trees; tree canopies often touch, but these are generally small trees or else there is still a good view of the southern horizon; compensatory aperture f-value adjustment between 2 and 3</td>
<td>Poor to fair, generally requires shade tolerant grasses; traffic can be quite damaging; with proper care, and continued tree pruning, this is a difficult but not insurmountable environment for turfgrass</td>
</tr>
<tr>
<td>V 1-12%</td>
<td>Turfgrass within a closed tree canopy, that is, where the tree crowns are mainly touching, or a tree canopy which overlaps the shade of a building; compensatory aperture f-value adjustment 3 or more</td>
<td>Poor; turf persistence a weak or temporary situation sometimes when the trees are of narrow crown or with delicate foliage (e.g., jacaranda, pines, or palms), which belong to level IV</td>
</tr>
</tbody>
</table>

most probably searching for sites on which to lay their eggs. Sod shipped in a healthy condition may harbor caterpillar eggs which were undetectable and escaped pesticidal treatment; areas neighboring the transplant environment may be sources of webworm inoculum.

Fungal diseases have long been recognized to be a serious problem in turfgrass shade adaptation. Beard (1965) reported three or four fungi greatly reduced cool-season turf performance in a shade study. In Florida warm-season grasses, the problem is most often alleged to be *Pythium*. Because of the windbreak effect of trees and nearby buildings, the shade environment tends to provide a higher relative humidity near the ground throughout the day. High humidity would be conducive to fungal development and growth. The combined presence of high humidity and increased succulence of turfgrass in the shade, along with webworm excreta and partially chewed and skeletonized foliage, should be a suitable habitat for several facultative pathogens.

Homeowners are often under the false impression that newly sodded lawns need more frequent irrigation than established lawns, and this is generally not the case. Efforts to irrigate a newly sodded lawn even once per day can be extremely damaging especially in shaded areas in the summer. In fact, the presence of shade directly reduces the transpiration of turfgrass (Feldhake et al., 1983), thus irrigation should generally be reduced. Nitrogen fertilization, which contributes to succulence and excessive vertical growth, should also be minimized.

Another secondary stress on shaded lawns is from mowing. Shade-grown turf tends to etiolate, especially if the cultivar has a normally erect habit, as is the case with Floratam. Bermudagrasses under artificially filtered red light show much lower quality, lower coverage, and excessive vertical growth compared with those under blue-green light (McBee, 1969), thus light quality may also be important in affecting growth habit. Shaded growing points ("tilers") are cut too close by mowers, and stolons needed for covering the ground are severed. As a result, shade grown turf can become an isolated stand of "broomstick-like" tillers, with bare ground between.

A turfgrass growing in a shade environment, close to its light compensation point, has reduced carbohydrates and increased nitrogen content. Excessive nitrogen fertilization is not only unnecessary, but stimulates additional, excessive etiolation and succulence, further contributing to disease and mowing problems. The combined stresses of leaf removal from mowing, insects, and traffic, which would be tolerated in the sun, may be enough to destroy the turf in the shade.

Direct effects of tree competition include competition for nutrients and water, thus turfgrass near or just outside the dripline may tend to be most droughty. Leaf litter adds to shade and potential disease problems in the shade environment, as well as sometimes being directly allelopathic. Mulching mowers can help reduce the mechanical smothering by tree leaves, but landscapes should be designed so that shrub beds or fern beds receive excess leaf litter, or else convenient compost facilities should be part of the landscape plan. Invasive tree roots often grow above the ground, adding to the difficulty of mowing the turf and the danger of walking. An extreme combination of such problems may be symptomatic of the wrong selection of tree species, such as certain species of *Ficus* and umbrella tree (*Brassaia actinophylla*), although some highly suitable trees such as live oak (*Quercus virginiana*) eventually can pose the same dilemmas.

Conclusions

While the preceding discussion makes the shade environment seem very complex, there are complicated interactions in the sun environment, as well. Factors influencing the sun environment include greater tendency to drought, chinch bugs and ectoparasitic nematode infestation, and thatch accumulation, and these have the benefit of careful scientific study. What is exceptional about the
shade environment is not that it is unknowable, but that it is not well known, as it does not fit well the layout of traditional field plots. The shade environment may be exceptional in turfgrass research, but is typical of places where grass is grown and where people often like to enjoy turf.

While research has far to go to give us practical answers, some general conclusions are warranted:

1. Turfgrasses can be grown in the shade environment, although bermudagrass, bahiagrass, and Floratam St. Augustinegrass should be avoided, and closed canopies are probably too restrictive for any turfgrass.

2. Relative illuminance is one simple way of describing shade.

3. As a working hypothesis, probably 10 to 40% of natural sunlight includes the critical range for growing warm-season grasses, with bahiagrass and bermudagrass failing to persist at the high end (20 to 40%) and St. Augustinegrass and zoysiagrass barely persisting at the low end (10 to 20%).

4. Secondary problems in the shade environment can be more damaging than reduced light level. Acute problems are caterpillars and fungal diseases, which occur typically a few weeks after sowing. Chronic secondary problems in the shade are traffic and improper mowing. Most secondary problems are compounded by excessive nitrogen fertilization and overwatering. Changes in maintenance habit and proper pruning of trees can have a decided effect in improving the ability of turfgrass to survive in the shade.

The challenge of growing grass in the shade will increase as people plant more trees, which landscape ordinances require, and as older landscape canopies mature. People will increasingly demand safe and sanitary play areas of turfgrass, surrounded by their urban forests. Earth's ozone layer is being destroyed, thus the UV hazard requires us to use more trees to reduce skin exposure. Integrated designs which consider the need by people for natural sunlight includes the critical rage for growing warm-season grasses, with bahiagrass and bermudagrass failing to persist at the high end (20 to 40%) and St. Augustinegrass and zoysiagrass barely persisting at the low end (10 to 20%).

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**WINTER OVERSEEDING TRIALS ON FAIRWAY AND PUTTING GREEN BERMUDAGRASSES**

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Additional index words. Agrostis palustris, chewings fescue, creeping bentgrass, Festuca rubra commutata, Lolium perenne, perennial ryegrass, Poa trivialis, rough bluegrass, turf, turfgrass.

**Abstract.** Differences between 38 cool-season turfgrasses overseeded on ‘Tifway II’ and ‘Tifgreen’ bermudagrasses, Cynodon spp., were noted under fairway and putting green conditions, respectively, throughout the 1990-1991 winter growing sea-

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