

# Recommendations for N, P, K and Mg for Golf Course and Athletic Field Fertilization Based on Mehlich III Extractant<sup>1</sup>

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Golf courses and athletic fields typically see intensive use and require specifically-designed fertilization management programs depending on the turfgrass being grown, the season of the year, and their location within the state. Because of the diversity among turfgrass species, cultivars, soil types, climatic patterns, the intensity of utilization, and the physiological attitudes of turfgrass managers, interpretative soil test information and subsequent recommendations have not been heavily utilized in the past. But due to economic and environmental reasons, recently more attention has been directed to best management practices for turfgrass management. These best management practices involve the use of soil test information in the formulation of turfgrass fertilization programs. Therefore, the following fertilization recommendations for nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg) were developed based on the best current soil and turfgrass nutrition research information available.

Because the Extension Soil Testing Laboratory does not analyze for nitrogen, N fertilization recommendations were based on the turfgrass nutritional requirements. It is recognized that the level of required N will vary based on an array of factors, not the least of them being intensity of play and the turfgrass cultivar being used. Therefore, these N recommendations should serve as guidelines to be adjusted based on the turfgrass manager's experience.

Due to potential negative environmental impacts from over-fertilization, phosphorus fertilization should be based on soil test recommendations. It is typical for mature golf course greens to test high in Mehlich III extractable P; in which case, P fertilization on bermudagrass greens is not recommended. Research has shown that cool-season (overseeded) grasses respond more to P fertilization than warm-season grasses, so if overseeding is part of an annual maintenance program it is best to apply P to the cool-season turfgrass when soil tests indicate that P is required.

Potassium is highly mobile in most turfgrass soils; therefore, it is common to observe low Mehlich III exchangeable K levels in Florida's sandy soils. As a consequence, many turfgrass managers routinely apply K not based on soil test recommendations. Research has shown that there is a critical minimum Mehlich III soil test level at which a response to K fertilization will be obtained. Therefore, quality turfgrass can be maintained based on soil test recommendations. Deposition of clippings and water and stress management also influence the turfgrass requirement for K fertilization and should be factored into the overall K fertilization program.

Mehlich III exchangeable Mg level has been shown to directly influence turfgrass growth. When the Mehlich III soil test Mg level drops below 20 ppm, a response to Mg

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fertilization is anticipated. Research has also shown that there is no magic Ca:Mg ratio for turfgrass growth—it is not the Ca:Mg ratio that influences growth, but the level of extractable Mg. Apply Mg as either dolomitic lime when the soil pH is low and liming is required, or as magnesium sulfate when the pH is in the desired range.

The recommendations in Tables 1, 2, 3, 4, and 5 are based on Mehlich III extractable levels of P, K, and Mg. These recommendations are for bermudagrass and overseed cool-season grasses.

Table 1. N, P, K, and Mg recommendations for golf course turfgrasses: golf greens

Grass Type (Location)	Target pH	N <sup>N</sup>	P <sub>2</sub> O <sub>5</sub> <sup>P</sup>			K <sub>2</sub> O <sup>K</sup>			Mg <sup>Mg</sup>	
			L	M	H	L	M	H	<20 mg/kg	
lb/1000 sq ft/yr										
Bermuda										
North <sup>x</sup>	6.5	8.0	0.2	0.1	0		4.5	3	0	2
South	6.5	12.0	0.4	0.2	0		6	4	0	2
Cool-Season Turfgrass										
North	6.5	4.0	0.5	0.2	0		1	0.5	0	1
South	6.5	3.0	0.4	0.2	0		1	0.5	0	1

<sup>N</sup>Notes:

1. Don't apply more than 1.0 lb soluble N/1000 sq ft/application. Higher rates of N/1000 sq ft/application may be applied depending on the slow-release N composition of the mixture, but no more than 3 lb N/1000 sq ft should be applied in any one application, regardless of the fertilizer N source being applied.
2. These N rates are for the growing season of the turfgrass being presently grown. If you are overseeding with a cool-season turfgrass, combine the warm and cool-season N fertilization rates to obtain the total annual N fertilization rate. An 8-month warm-season growth period was assumed for North Florida and a 10-month warm-season growth period was assumed for South Florida. If you are not overseeding, these N rates may need to be increased slightly; however, N fertilization during dormancy is not recommended.
3. These N rates are for the most commonly-used putting green turfgrass (Tifdwarf) under normal growing conditions. If turfgrass is under stressed conditions (heavy play or low mowing heights) or one of the ultradwarf bermudagrasses is being used, N fertilization rates may need to be increased during the warm-season growing period.
4. When applying a soluble source of N, irrigate with approximately 0.25 inches of irrigation after application to enhance fertilizer use efficiency and reduce potential salt burn.
5. In most cases when the soil pH exceeds 6.0, a foliar application of Fe and/or Mn at 1/8 lb per 1000 sq ft can be used in place of N for temporary color improvement.
6. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>P</sup>Notes:

1. It is typical to obtain a greater response to P fertilization during the cool-season growth period than the warm-season growth period; therefore, higher P rate is recommended during the cool season than the warm season.
2. In most coated sand greens, P is not mobile and does not leach, but in uncoated sand greens P may leach. Therefore, limit your P fertilizer applications to greens whose soils tests indicate a need for P fertilization. When the soil test indicates a need for P fertilization, do not apply more than 0.25 lb of P<sub>2</sub>O<sub>5</sub>/1000 sq ft per application to established turfgrass. During the turf establishment period (turf that is less than 1 year old) and if the soil test indicates a low level of P, a one-time application of up to 1.0 lb P<sub>2</sub>O<sub>5</sub>/1000 sq ft may be applied.
3. Note these are recommended annual rates of P application. If the recommended rates are very low, a single annual application of a P fertilizer may serve the P needs of the turfgrass. If you overseed, and a low rate of P is recommended based on a soil test, you may elect to apply the total annual rate of P to the cool-season turfgrass.
4. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>K</sup>Notes:

1. Potassium (K) fertilization is typically linked to N fertilization. In general, the higher the rate of N fertilization, the higher the rate of K fertilization. Research has suggested that in unstressed bermudagrass a N:K fertilization ratio of 1.5 to 1.0 is sufficient to maintain healthy turfgrass. Although not proven, many turfgrass managers elect to increase the N:K ratio to a 1:1 when the turfgrass is stressed by heavy play or low mowing heights. Potassium is not considered to be an element of impairment; therefore, it is not environmentally unsafe to apply additional K, but use of excessive amounts may cause salinity problems, increase fertilization costs, and deplete a natural resource.
2. In most green situations, K is highly mobile and a single soil test K level may not totally represent the K fertilization requirement of the green. Maintenance of long term soil test records should aid the turfgrass manager in the K fertilization program that best fits the specific turfgrass management situation.
3. In situations where high rates of K are being utilized and the soil Mg status is near or below 20 ppm, additional attention should be directed toward the Mg fertilization requirement of the turfgrass.
4. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>Mg</sup>Notes:

If Mg is recommended and the soil pH exceeds the target pH, apply a Mg source fertilizer material rather than dolomitic lime. Application of dolomitic lime to a high pH soil will increase the soil pH and limit the availability of essential micronutrients.

<sup>x</sup>The arbitrary dividing line between north and south Florida is a straight east-west line from coast to coast through Orlando.

Table 2. N, P, K, and Mg recommendations for golf course turfgrasses: tees

Grass Type (Location)	Target pH	N <sup>N</sup>	P <sub>2</sub> O <sub>5</sub> <sup>P</sup>				K <sub>2</sub> O <sup>K</sup>				Mg <sup>Mg</sup> <20 mg/kg	
			L	M	H		L	M	H			
lb/1000 sq ft/yr												
Bermuda												
North <sup>x</sup>	6.5	6.0		0.2	0.1	0		3	2	0		2
South	6.5	8.0		0.3	0.1	0		4	3	0		2
Cool-Season Turfgrass												
North	6.5	3.0		0.5	0.2	0		1	0.5	0		1
South	6.5	2.0		0.4	0.2	0		0.5	0.2	0		1
<sup>N</sup> Notes:												
<ol style="list-style-type: none"> <li>1. Don't apply more than 1.0 lb soluble N/1000 sq ft/application. Higher rates of N/1000 sq ft/application may be applied depending on the slow-release N composition of the mixture, but no more than 3 lb N/1000 sq ft should be applied in any one application, regardless of the fertilizer N source being applied.</li> <li>2. These N rates are for the growing season of the turfgrass being presently grown. If you are overseeding with a cool-season turfgrass, combine the warm and cool-season N fertilization rates to obtain the total annual N fertilization rate. An 8-month warm-season growth period was assumed for North Florida and a 10-month warm-season growth period was assumed for South Florida. If you are not overseeding, these N rates may need to be increased slightly; however, N fertilization during dormancy is not recommended.</li> <li>3. When applying a soluble source of N, irrigate with approximately 0.25 inches of irrigation after application to enhance fertilizer use efficiency and reduce potential salt burn.</li> <li>4. In most cases when the soil pH exceeds 6.0, a foliar application of Fe and/or Mn at 1/8 lb per 1000 sq ft can be used in place of N for temporary color improvement.</li> <li>5. For additional information, refer to SL21, SL181 and/or CIR1262 at <a href="http://edis.ifas.ufl.edu">http://edis.ifas.ufl.edu</a> and/or contact your local county Extension agent.</li> </ol>												
<sup>P</sup> Notes:												
<ol style="list-style-type: none"> <li>1. Note these are recommended annual rates of P application. If the recommended rates are very low, a single annual application of a P fertilizer may serve the P needs of the turfgrass. If you overseed, and a low rate of P is recommended based on a soil test, you may elect to apply the total annual rate of P to the cool-season turfgrass.</li> <li>2. Because P has environmental risks, apply P only when recommended by a soil test. When the soil test indicates a need for P fertilization do not apply more than 0.25 lb of P<sub>2</sub>O<sub>5</sub>/1000 sq ft per application to established turfgrass. During the turf establishment period (turf that is less than 1 year old) and if the soil test indicates a low level of P, a one-time application of up to 1.0 lbs P<sub>2</sub>O<sub>5</sub>/1000 sq ft may be applied.</li> <li>3. For additional information, refer to SL21, SL181 and/or CIR1262 at <a href="http://edis.ifas.ufl.edu">http://edis.ifas.ufl.edu</a> and/or contact your local county Extension agent.</li> </ol>												
<sup>K</sup> Notes:												
<ol style="list-style-type: none"> <li>1. Potassium (K) fertilization is typically linked to N fertilization. In general, the higher the rate of N fertilization, the higher the rate of K fertilization. Research has suggested that in unstressed bermudagrass a N:K fertilization ratio of 1.5 to 1.0 is sufficient to maintain healthy turfgrass. Although not proven, many turfgrass managers elect to increase the N:K ratio to a 1:1 when the turfgrass is stressed by heavy play or low mowing heights. Potassium is not considered to be an element of impairment; therefore, it is not environmentally unsafe to apply additional K, but use of excessive amounts may cause salinity problems, increase fertilization costs, and deplete a natural resource.</li> <li>2. In situations where high rates of K are being utilized and the soil Mg status is near or below 20 ppm, additional attention should be directed toward the Mg fertilization requirement of the turfgrass.</li> <li>3. For additional information, refer to SL21, SL181 and/or CIR1262 at <a href="http://edis.ifas.ufl.edu">http://edis.ifas.ufl.edu</a> and/or contact your local county Extension agent.</li> </ol>												
<sup>Mg</sup> Notes:												
If Mg is recommended and the soil pH exceeds the target pH, apply a Mg source fertilizer material rather than dolomitic lime. Application of dolomitic lime to a high pH soil will increase the soil pH and limit the availability of essential micronutrients.												
<sup>x</sup> The arbitrary dividing line between north and south Florida is a straight east-west line from coast to coast through Orlando.												

Table 3. N, P, K, and Mg recommendations for golf course turfgrasses: fairways

Grass Type (Location)	Target pH	N <sup>N</sup>			P <sub>2</sub> O <sub>5</sub> <sup>P</sup>			K <sub>2</sub> O <sup>K</sup>			Mg <sup>Mg</sup>
		L	M	H	L	M	H	L	M	H	<20 mg/kg
		lb/1000 sq ft/yr									
Bermuda											
North <sup>x</sup>	6.5	4.0	0.2	0.1	0	1	0.5	0	1	1	
South	6.5	5.0	0.2	0.1	0	1.2	0.6	0	1	1	
Cool-Season Turfgrass											
North	6.5	2.0	0.2	0.1	0	0.5	0.2	0	0.5	0.5	
South	6.5	1.0	0.1	0.1	0	0.2	0.1	0	0.5	0.5	

<sup>N</sup>Notes:

1. Don't apply more than 1.0 lb soluble N/1000 sq ft/application. Higher rates of N/1000 sq ft/application may be applied depending on the slow-release N composition of the mixture, but no more than 3 lb N/1000 sq ft should be applied in any one application, regardless of the fertilizer N source being applied.
2. These N rates are for the growing season of the turfgrass being presently grown. If you are overseeding with a cool-season turfgrass, combine the warm- and cool-season N fertilization rates to obtain the total annual N fertilization rate. An 8-month warm-season growth period was assumed for North Florida and a 10-month warm-season growth period was assumed for South Florida. If you are not overseeding, these N rates may need to be increased slightly; however, N fertilization during dormancy is not recommended.
3. When applying a soluble source of N, irrigate with approximately 0.25 inches of irrigation after application to enhance fertilizer use efficiency and reduce potential salt burn.
4. In most cases when the soil pH exceeds 6.0, a foliar application of Fe and/or Mn at 1/8 lb per 1000 sq ft can be used in place of N for temporary color improvement.
5. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>P</sup>Notes:

1. Note these are recommended annual rates of P application. If the recommended rates are very low, a single annual application of a P fertilizer may serve the P needs of the turfgrass. If you overseed, and a low rate of P is recommended based on a soil test, you may elect to apply the total annual rate of P to the cool-season turfgrass.
2. Because P has environmental risks, apply P only when recommended by a soil test. When the soil test indicates a need for P fertilization do not apply more than 0.25 lb of P<sub>2</sub>O<sub>5</sub>/1000 sq ft per application to established turfgrass. During the turf establishment period (turf that is less than 1 year old) and if the soil test indicates a low level of P, a one-time application of up to 1.0 lb P<sub>2</sub>O<sub>5</sub>/1000 sq ft may be applied.
3. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>K</sup>Notes:

1. Potassium (K) fertilization is typically linked to N fertilization. In general, the higher the rate of N fertilization, the higher the rate of K fertilization. Research has suggested that in unstressed bermudagrass a N:K fertilization ratio of 1.5 to 1.0 is sufficient to maintain healthy turfgrass. Although not proven, many turfgrass managers elect to increase the N:K ratio to a 1:1 when the turfgrass is stressed by heavy play or low mowing heights. Potassium is not considered to be an element of impairment; therefore, it is not environmentally unsafe to apply additional K, but use of excessive amounts may cause salinity problems, increase fertilization costs, and deplete a natural resource.
2. In situations where high rates of K are being utilized and the soil Mg status is near or below 20 ppm, additional attention should be directed toward the Mg fertilization requirement of the turfgrass.
3. For additional information, refer to SL-21, SL-181 and/or CIR-1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>Mg</sup>Notes:

If Mg is recommended and the soil pH exceeds the target pH, apply a Mg source fertilizer material rather than dolomitic lime. Application of dolomitic lime to a high pH soil will increase the soil pH and limit the availability of essential micronutrients.

<sup>x</sup>The arbitrary dividing line between north and south Florida is a straight east-west line from coast to coast through Orlando.

Table 4. N, P, K, and Mg recommendations for golf course turfgrasses: roughs

Grass Type (Location)	Target pH	N <sup>N</sup>	P <sub>2</sub> O <sub>5</sub> <sup>P</sup>			K <sub>2</sub> O <sup>K</sup>			Mg <sup>Mg</sup>
			L	M	H	L	M	H	
lb/1000 sq ft/yr									
Bermuda									
North*	6.5	2	0.2	0.1	0	0.5	0.2	0	1
South	6.5	2.5	0.2	0.1	0	0.5	0.2	0	1

<sup>N</sup>Notes:

1. Don't apply more than 1.0 lb soluble N/1000 sq ft/application. Higher rates of N/1000 sq ft/application may be applied depending on the slow-release N composition of the mixture, but no more than 3 lb N/1000 sq ft should be applied in any one application, regardless of the fertilizer N source being applied.
2. When applying a soluble source of N, irrigate with approximately 0.25 inches of irrigation after application to enhance fertilizer use efficiency and reduce potential salt burn.
3. In most cases when the soil pH exceeds 6.0, a foliar application of Fe and/or Mn at 1/8 lb per 1000 sq ft can be used in place of N for temporary color improvement.
4. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>P</sup>Notes:

1. Because P has environmental risks, apply P only when recommended by a soil test. When the soil test indicates a need for P fertilization do not apply more than 0.25 lb of P<sub>2</sub>O<sub>5</sub>/1000 sq ft per application to established turfgrass. During the turf establishment period (turf that is less than 1 year old) and if the soil test indicates a low level of P, a one-time application of up to 1.0 lb P<sub>2</sub>O<sub>5</sub>/1000 sq ft may be applied.
2. For additional information, refer to SL21, SL181 and/or CIR1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>K</sup>Notes:

1. Potassium (K) fertilization is typically linked to N fertilization. In general, the higher the rate of N fertilization, the higher the rate of K fertilization. Research has suggested that in unstressed bermudagrass a N:K fertilization ratio of 1.5 to 1.0 is sufficient to maintain healthy turfgrass. Although not proven, many turfgrass managers elect to increase the N:K ratio to a 1:1 when the turfgrass is stressed by heavy play or low mowing heights. Potassium is not considered to be an element of impairment; therefore, it is not environmentally unsafe to apply additional K, but use of excessive amounts may cause salinity problems, increase fertilization costs, and deplete a natural resource.
2. In situations where high rates of K are being utilized and the soil Mg status is near or below 20 ppm, additional attention should be directed toward the Mg fertilization requirement of the turfgrass.
3. For additional information, refer to SL-21, SL-181 and/or CIR-1262 at <http://edis.ifas.ufl.edu> and/or contact your local county Extension agent.

<sup>Mg</sup>Notes:

If Mg is recommended and the soil pH exceeds the target pH, apply a Mg source fertilizer material rather than dolomitic lime. Application of dolomitic lime to a high pH soil will increase the soil pH and limit the availability of essential micronutrients.

\*The arbitrary dividing line between north and south Florida is a straight east-west line from coast to coast through Orlando.

Table 5. N, P, K, and Mg recommendations for athletic field turfgrasses<sup>T</sup>

Grass Type (Location)	Target pH	N <sup>N</sup>	P <sub>2</sub> O <sub>5</sub> <sup>P</sup>			K <sub>2</sub> O <sup>K</sup>			Mg <sup>Mg</sup>
			L	M	H	L	M	H	<20 mg/kg
lb/1000 sq ft/yr									
Bermuda									
North <sup>x</sup>	6.5	3.0	0.5	0.1	0	2	1	0	1
South	6.5	5.0	0.5	0.2	0	3	2	0	1
Cool-Season Turfgrass									
North	6.5	2.0	0.5	0.2	0	1	1	0	1
South	6.5	2.0	0.5	0.2	0	1	1	0	1

<sup>T</sup>Notes:

For more explanation of these recommendations, contact your county Extension agent. Publications related to turf fertilization include SL-21, SL-181 and CIR-1262 at <http://edis.ifas.ufl.edu>. These are available at <http://edis.ifas.ufl.edu> or by contacting your local county Extension agent.

<sup>N</sup>Notes:

1. Don't apply more than 1.0 lb soluble N/1000 sq ft/application. Higher rates of N/1000 sq ft/application may be applied depending on the slow-release N composition of the mixture, but no more than 3 lb N/1000 sq ft should be applied in any one application, regardless of the fertilizer N source being applied.
2. These N rates are for the growing season of the turfgrass being presently grown. If you are overseeding with a cool-season turfgrass, combine the warm and cool-season N fertilization rates to obtain the total annual N fertilization rate. An 8-month warm-season growth period was assumed for North Florida and a 10-month warm-season growth period was assumed for South Florida. If you are not overseeding, these N rates may need to be increased slightly; however, N fertilization during dormancy is not recommended. These N rates are for athletic fields that are used no more than 6 to 8 times per year of actual games. Fields that are used more intensively for practices and games may require as much as 1 lb of N every 14 days during the active playing months to maintain the recuperative ability of the turfgrass. Nitrogen should always be applied on an environmentally sound basis, but N is essential for the health of the turfgrass and a proper N fertilization program based on the turfgrass tissue status should always be maintained in order to sustain the turfgrass in the long term.
3. Fertilization of localized wear areas is often more effective than fertilization of the entire playing surface. Supplemental fertilization of high traffic areas may speed the recovery of damaged turf due to increased top growth.
4. When applying a soluble source of N, irrigate with approximately 0.25 inches of irrigation after application to enhance fertilizer use efficiency and reduce potential salt burn.
5. In most cases when the soil pH exceeds 6.0, a foliar application of Fe and/or Mn at 1/8 lb per 1000 sq ft can be used in place of N for temporary color improvement.

<sup>P</sup>Notes:

1. It is typical to obtain a greater response to P fertilization during the cool-season growth period than the warm-season growth period; therefore, higher P rate is recommended during the cool season than the warm season.
2. Because P has environmental risks, apply P only when recommended by a soil test. When the soil test indicates a need for P fertilization do not apply more than 0.25 lb of P<sub>2</sub>O<sub>5</sub>/1000 sq ft per application to established turfgrass. During the turf establishment period (turf that is less than 1 year old) and if the soil test indicates a low level of P, a one-time application of up to 1.0 lb P<sub>2</sub>O<sub>5</sub>/1000 sq ft may be applied. Because P is essential relative to the recuperative ability of the turfgrass additional P fertilization may be required on fields that have been damaged by intensive play or utilization.
3. Note these are recommended annual rates of P application. If the recommended rates are very low, a single annual application of a P fertilizer may serve the P needs of the turfgrass. If you overseed, and a low rate of P is recommended based on a soil test, you may elect to apply the total annual rate of P to the cool-season turfgrass.

<sup>K</sup>Notes:

1. Potassium (K) fertilization is typically linked to N fertilization. In general, the higher the rate of N fertilization, the higher the rate of K fertilization. Research has suggested that in unstressed bermudagrass a N:K fertilization ratio of 1.5 to 1.0 is sufficient to maintain healthy turfgrass. Although not proven, many turfgrass managers elect to increase the N:K ratio to a 1:1 when the turfgrass is stressed by heavy play or low mowing heights. Potassium is not considered to be an element of impairment; therefore, it is not environmentally unsafe to apply additional K, but use of excessive amounts may cause salinity problems, increase fertilization costs, and deplete a natural resource. On intensively used and damaged fields additional potassium application will enhance the recuperative ability of the turfgrass.
2. In sandy soils, K is mobile and a single soil test K level may not totally represent the K fertilization requirement of the field. Maintenance of long-term soil test records should aid the turfgrass manager in the K fertilization program that best fits this turfgrass management situation.
3. In situations where high rates of K are being utilized and the soil Mg status is near or below 20 ppm, additional attention should be directed toward the Mg fertilization requirement of the turfgrass.

<sup>Mg</sup>Notes:

If Mg is recommended and the soil pH exceeds the target pH, apply a Mg source fertilizer material rather than dolomitic lime. Application of dolomitic lime to a high pH soil will increase the soil pH and limit the availability of essential micronutrients.

<sup>x</sup>The arbitrary dividing line between north and south Florida is a straight east-west line from coast to coast through Orlando.