



TERRAIN SHADER DOCUMENTATION

AUGUST 2014

Ever since the very first public build of rFactor 2 had been released, a lot of modders have struggled to get the most out of materials that use the Blended Grass Infield shader and its variants.

And quite understandably so: the limitation of only being able to blend between two textures not only meant that an almost exponential amount of materials were required to blend between several terrain types, which all had to be processed during game play leading to a small but potentially noticeable performance drop.

Modders also had to switch between these materials manually, which frequently resulted into visible seams unless the modder knew exactly what he was doing. The fact that the live result cannot be viewed inside the modelling tools only increased that risk of seams.

And last but definitely not least, the visual transition between the two blend maps was a linear blend – something that defies the laws of physics as a substance can never be a grass blade and a sand pebble at the same time, for example.

Now it's time to deal with these limitations ...

New Shader Description

The main goal was to make the new shader as versatile as possible, whilst removing the old limitations and without introducing (m)any new limitations. Ideally, the new terrain shader would have been an evolution of the existing Blended Grass Infield shader family, in order to keep maximum backward compatibility for any existing content that had already been published. Unfortunately, there is simply no way to deal with the old shader's limitations whilst preserving the assets. Instead, the decision was made to go back to the drawing board and start from scratch. So here's what the new "Multi layer grass / dirt" shader looks like ...

Stage	Type	UV	Description
T1.RGB	Diffuse Map	1	First diffuse map (clean grass)
T1.A	Specular Mask	1	Greyscale specular map for the first diffuse map
T2.RGB	Diffuse Map	2	Second diffuse map (rough grass, weeds, ...)
T2.A	Specular Mask	2	Greyscale specular map for the second diffuse map
T3.RGB	Diffuse Map	3	Third diffuse map (dirt, sand, ...)
T3.A	Specular Mask	3	Greyscale specular map for the third diffuse map
T4.RGB	Pattern Map	4	Noise map to break up repetitive tiling patterns
T4.A	Pattern Map	4	Alternate noise map (e.g. mowed grass lines)
T5.RGB	Normal Map	1	T1/T2 Shared Normal Map
T5.A	Mix Map		T1/T2-dominant Mix Map
T6.RGB	Normal Map	3	T3 Normal Map
T6.A	Mix Map		T3-dominant Mix Map

First of all, we wanted to be able to blend more than two textures within the same material. So the new shader offers three sets of diffuse maps including greyscale specular masks for all three, stored in each diffuse map's Alpha Channel. Each of the diffuse maps and their respective specular mask can use their own dedicated UV mapping channel. Because the specular masks are greyscale, they are multiplied with a lighter version of the respective diffuse map, and the pattern map for extra variation.

The look of the gradual, fading linear interpolation blend between the textures has been enhanced by the use of two so-called Mix Maps, stored in the normal maps' Alpha Channels. These are important enough to deserve its own section later on.

Vertex Colours are used to blend between the various maps. Blending from T1 to T2 is controlled by Vertex Colour Green; Vertex Colour Red defines the blend from T2 to T3. In situations where both the green and red Vertex Colour components are equal to 1.0 (255), T3 will always take precedence over T2.

The logic behind this choice of red and green Vertex Colours is really quite simple: green is the only colour you could possibly associate with grass, and was therefore the logical choice to blend between two grass textures; while red is the hottest colour of the three (R, G, B), and blends in the hotter/drier surface type (dirt) – an easy rule of thumb ...

This change frees up the Vertex Alpha property which was previously used to blend textures in the old shader family. At the same time we're now using the Vertex Colours, which in the past contained vertex-based terrain Ambient Occlusion information, typically in the form of a Radiosity pass. However, since most kinds of Ambient Occlusion including Radiosity are limited to greyscale, it is much more efficient to store that data in Vertex Alpha. The procedure of rendering and storing the data from a Radiosity pass into Vertex Alpha is identical to storing it in the three Vertex Colours.

A very old trick to break up repetitive tiling patterns on larger surfaces such as terrain pieces, is to use a (greyscale) 'noise' texture on a much larger mapping scale. We've kept that feature from the old shader and further expanded upon it, by introducing a second greyscale texture in the pattern map's Alpha Channel. The blue Vertex Colour component blends between these two pattern maps, using a standard, fading linear interpolation, without making use of a Mix Map.

With all the vertex properties explained, here's a table as an overview of what they control:

Vertex Property	Minimum Value	Maximum Value
Alpha	Black Shading	White Shading
Blue	Noise Pattern	Noise+Mowing Alt Pattern
Green	Clean Grass	Rough Grass
Red	Clean/Rough Grass	Dirt

Or for the more mathematical minds:

Vertex Property	0% (0 or 0.0)	100% (255 or 100.0)
Alpha	Full vertex shading	No vertex shading
Blue	T4.RGB	T4.A
Green	T1	T2
Red	T1 or T2 according to Green	T3

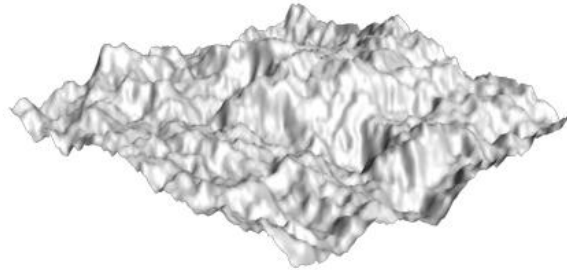
And finally, since organic terrain usually consists of more than just grass, we added an additional normal map slot. So now there are two normal maps: one linked to both T1 and T2 (grass), and one linked to T3 (dirt). This extra normal map adds the ability to use a unique normal map for a special surface material, such as sand, dirt with pebbles, or even gravel). They are blended in exactly the same fashion as the diffuse and specular maps.

Since we are now blending patches of textures rather than full texture maps, the terrain mesh density does need increasing, with a slightly more Quad mesh approach close to the race surface for higher blending precision.

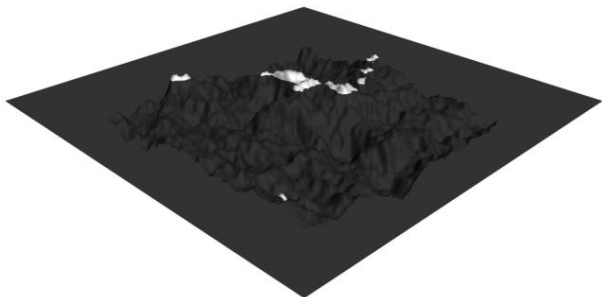
Please check Appendix II for an overview of the various texture maps.

Enhancing linear interpolation using a Mix Map

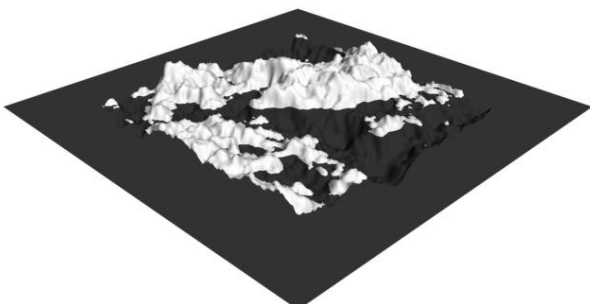
A Mix Map is essentially a tileable greyscale Height Map from which portions are selected/discarded by using a threshold value. In order to grasp how this threshold operation, imagine that the 2D height map represents a mountain range, with the lightest values being the mountain tops, and blacks being valleys¹, which gets flooded:



Then imagine a floating horizontal plane representing (1.0 - water level). As the water level drops, more and more mountain tops will appear dry. When the water level reaches 0.0, the entire area will be visible. In the images below, the resulting 2D view on the right hand side show the Top view of the mountain range after a Boolean operation as it would be processed by the shader after the threshold operation, with the water level being controlled by either vertex colour component red or green. The hard edges caused by the Boolean-like threshold operation are filtered before the actual blending.



MixMap - 0.20



MixMap - 0.50



¹ Please note that the mountain range in this example is NOT tileable ...

Both Mix Maps (T5.A and T6.A) are merged using hardwired UV mapping scalars to generate a larger internal Mix Map with reduced repetitive tiling patterns. For the merged grass Mix Map, T6.A is used as a stretched low frequency map (+/- 10% of Ch UV1), with half of T5.A mixed in at a much higher frequency (+/- 120% of UV Ch3). The opposite applies to the dirt Mix Map, with T6.A serving as the high frequency component (+/- 110% of UV Ch3), mixed with a stretched T5.A (+/- 30% of UV Ch1).

Again, please see Appendix II for an overview of the Mix Maps and all other texture maps ...

What the final result looks like

These ingame shots show the end result post-blending, with plenty of variety in the shape and density of the dirt patches:

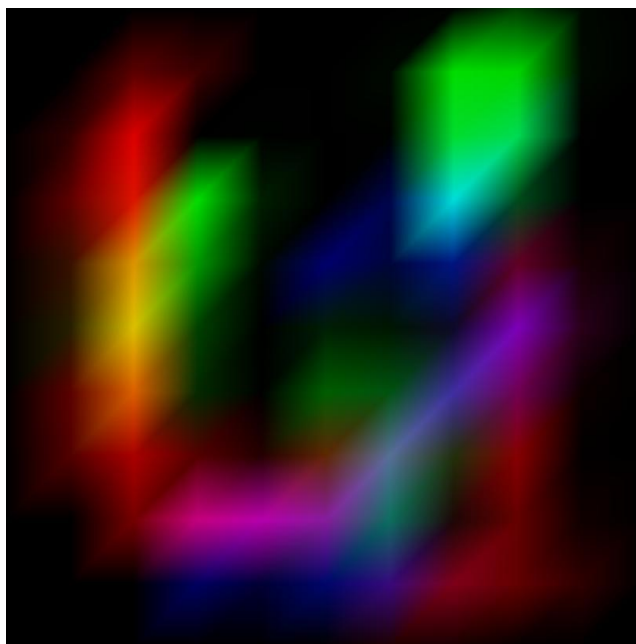




Using the shader

Standard workflow:

- First, set up a material according to the table on page 2;
- Select the object and assign the material;
- Edit > Object Properties, make sure Vertex Channel Display is set to Vertex Color and Shaded;
- Select all polygons that use the material's ID;
- *[Optional: Detach selection to Element;]*
- Add a UVW Map modifier and uniform map UV Channels 1, 2 and 3;
- Do the same for UV Channel 4 (pattern map), or Spline Map the terrain's mowing lines;
- **Set Vertex Colour of the element to (0, 0, 0) – Black, this sets the entire surface to T1;**
- Add a VertexPaint modifier, set the blend mode to ADD and pick (0, 255, 0) to paint in T2;
- Add a VertexPaint modifier, set the blend mode to ADD and pick (255, 0, 0) to paint in T3;
- The mesh with vertex colours will look similar to this piece of art:



- Perform a Radiosity² pass and bake vertex-based ambient occlusion to Vertex Alpha.

Useful advice:

- Use slightly different scalars for UV Channels 1, 2 and 3 to minimize repetition of the same diffuse patterns post-blending – prime numbers are excellent scaling factors for this reason;
- Rename each VertexPaint modifier in the stack for easier editing;
- If you have really large patches of dirt or gravel traps, consider cloning the material and adjust the material name prefix to match a different entry in the TDF file.

² See Appendix I ...

Appendix I – Radiosity: Vertex-based Ambient Occlusion

Radiosity is a very effective way to add vertex-based ambient occlusion to your terrain objects, and is a fairly easy step to perform near the end of the track creation process, when all key elements are in place. Applying some kind of ambient occlusion to the terrain will result in a much better sense of depth of the environment, both in cockpit and replay cameras.

Please read the “3ds Max - Radiosity” section on the excellent Polycount Wiki here:

http://wiki.polycount.com/wiki/Ambient_occlusion_vertex_color

Notes

- When using the new shader, bake the Radiosity to vertex alpha, rather than vertex illumination as described on the Polycount Wiki;
- When you assign the vertex alpha, they will overwrite any existing values by default. So manual vertex alpha painting should either be done after the Radiosity pass in a new VertexPaint layer on top of it (Multiply), or Radiosity should be assigned as a Multiply layer.
- Works best if all terrain pieces are attached and edge vertices are welded. Before attaching all terrain objects, assign a unique smoothing group to each of them, so you can quickly select and detach them again when you're happy with the results.
- Walls (concrete, armco, ...), structures (buildings, bridges, ...), tree walls, ... should be left visible; crowds, vehicles and other small TSOs should be hidden.
- Any triangles using a RealRoad material should be detached from the terrain objects (they don't belong in the terrain objects in the first place!) to prevent assigning vertex colours to them.

A higher 'Initial Quality' value will take (much) longer to process, but will result in a cleaner result. Typically, ISI tracks use 98.5 - 99.

Appendix II – Texture Maps Overview



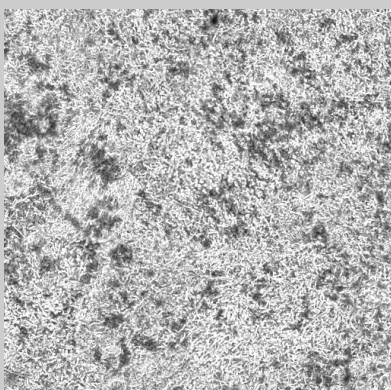
1st Diffuse Map (T1 RGB – Clean Grass)
UV Channel 1 – Default



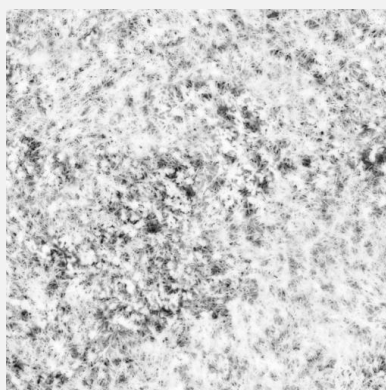
2nd Diffuse Map (T2 RGB – Rough Grass)
UV Channel 2 – Vertex Color Green



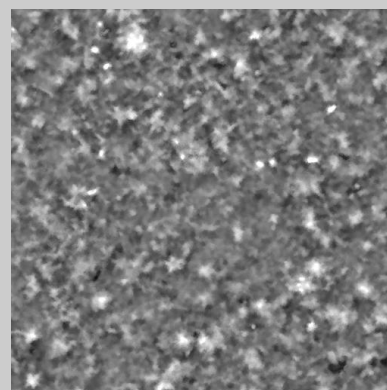
3rd Diffuse Map (T3 RGB – Dirt)
UV Channel 3 – Vertex Color Red



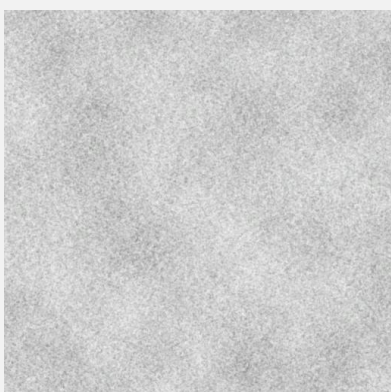
1st Specular Mask (T1 Alpha)
Follows Diffuse Map



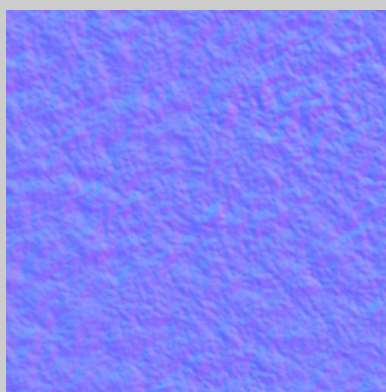
2nd Specular Mask (T2 Alpha)
Follows Diffuse Map



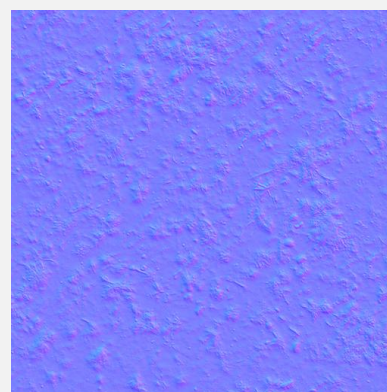
3rd Specular Mask (T3 Alpha)
Follows Diffuse Map



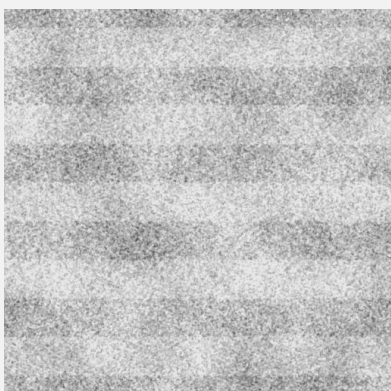
1st Pattern Map (T4 RGB)
UV Channel 4 – Default



1st Normal Map (T5 RGB)
UV Channel 1 – Follows Grass (T1 and T2)



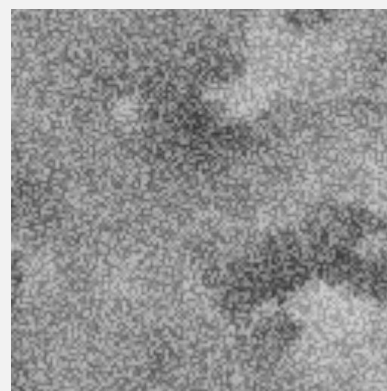
2nd Normal Map (T6 RGB)
UV Channel 3 – Follows Dirt (T3)



2nd Pattern Map (T4 Alpha)
UV Channel 4 – Vertex Color Blue



1st Mix Map (T5 Alpha)
UV Channels 1 (dominant) and 3



2nd Mix Map (T6 Alpha)
UV Channels 1 and 3 (dominant)