

GHOST

OF TSUSHIMA

Procedural Grass



Concept art



Concept art



Concept art



Dense foliage

Many types of plants

Grass card method



+ Texture

Cheap

Overdraw

Low density feeling

Meh graphics



1M grass blades

83k rendered

2.5 ms (PS4)







Render Tile = 512 x 512

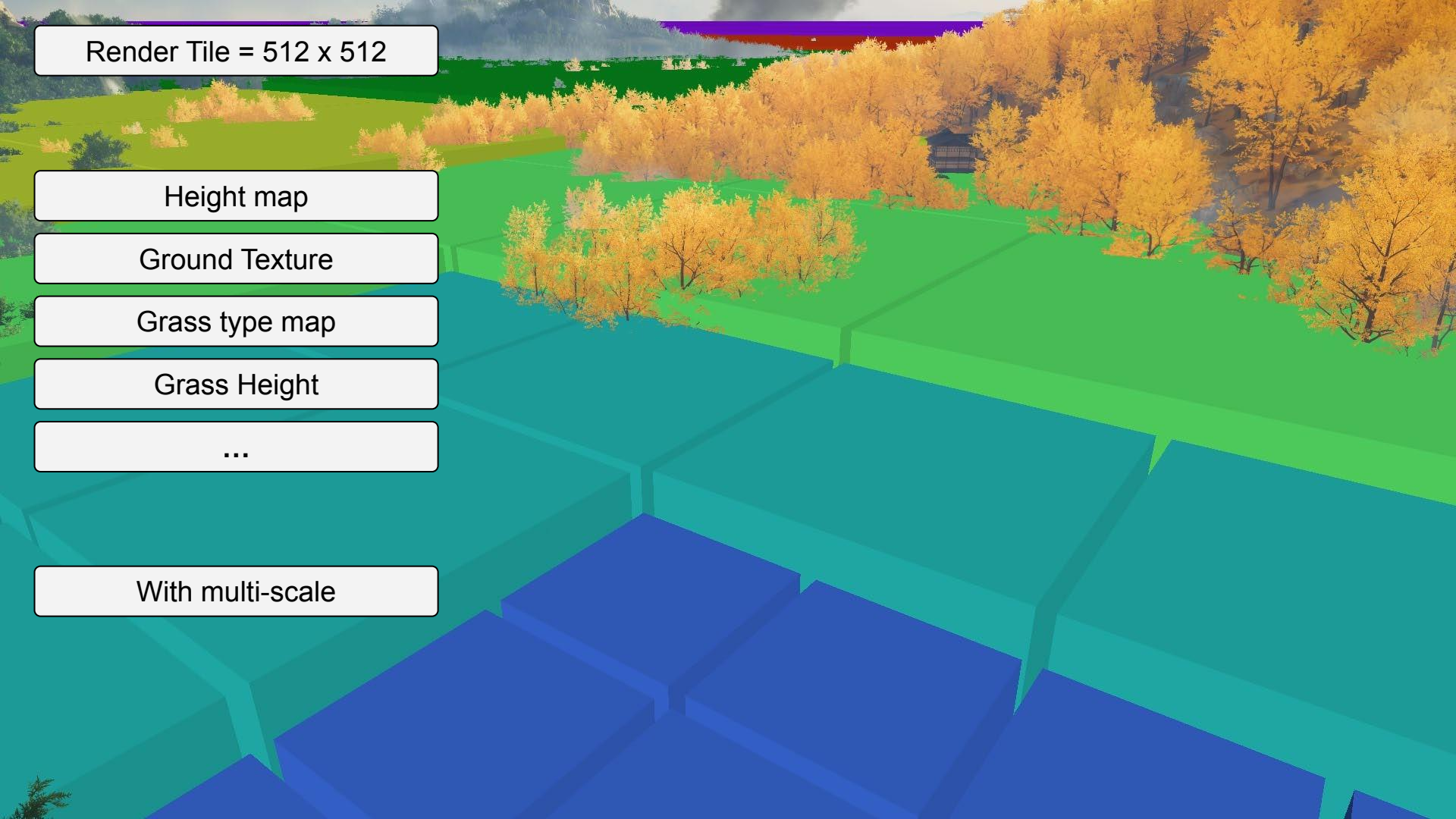
Height map

Ground Texture

Grass type map

Grass Height

...



Render Tile = 512 x 512

Height map

Ground Texture

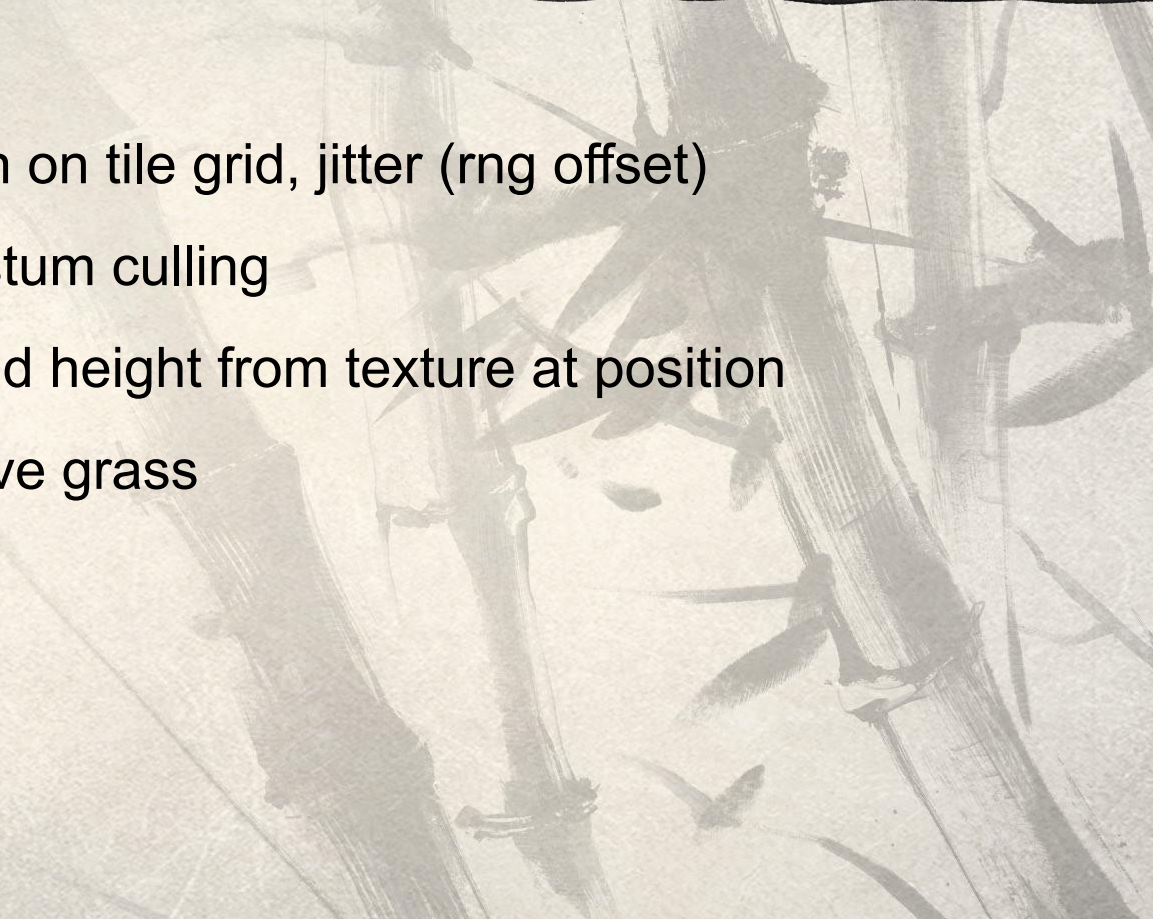
Grass type map

Grass Height

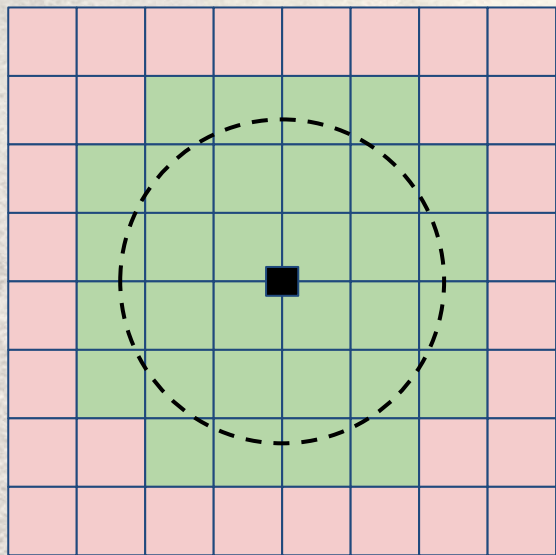
...

With multi-scale

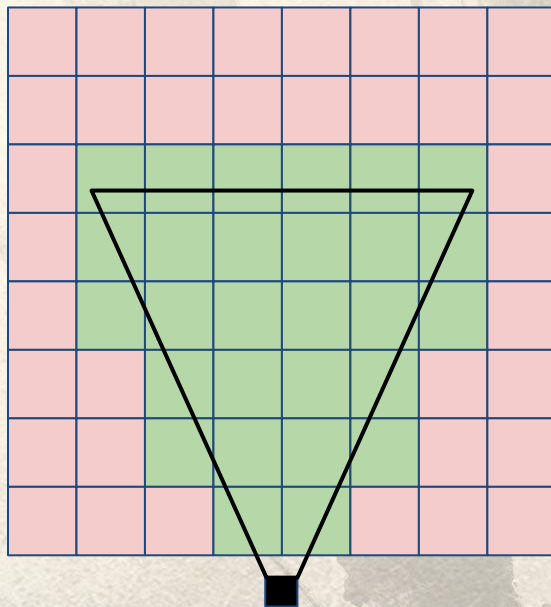
Placing a Grass Blade

- 1 - Turn lane ID into position on tile grid, jitter (rng offset)
 - 2 - Distance culling and frustum culling
 - 3 - Determine grass type and height from texture at position
 - 4 - Drop lanes that don't have grass
 - 5 - Occlusion culling
- 
- A close-up, artistic rendering of several tall, thin grass blades. The blades are rendered with a soft, painterly style, showing detailed textures of the grass blades and their shadows. The background is a light, hazy green, suggesting a field of grass.

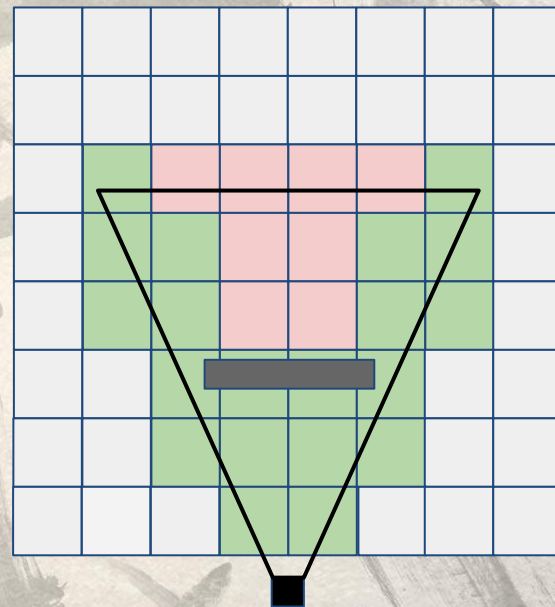
Distance Culling

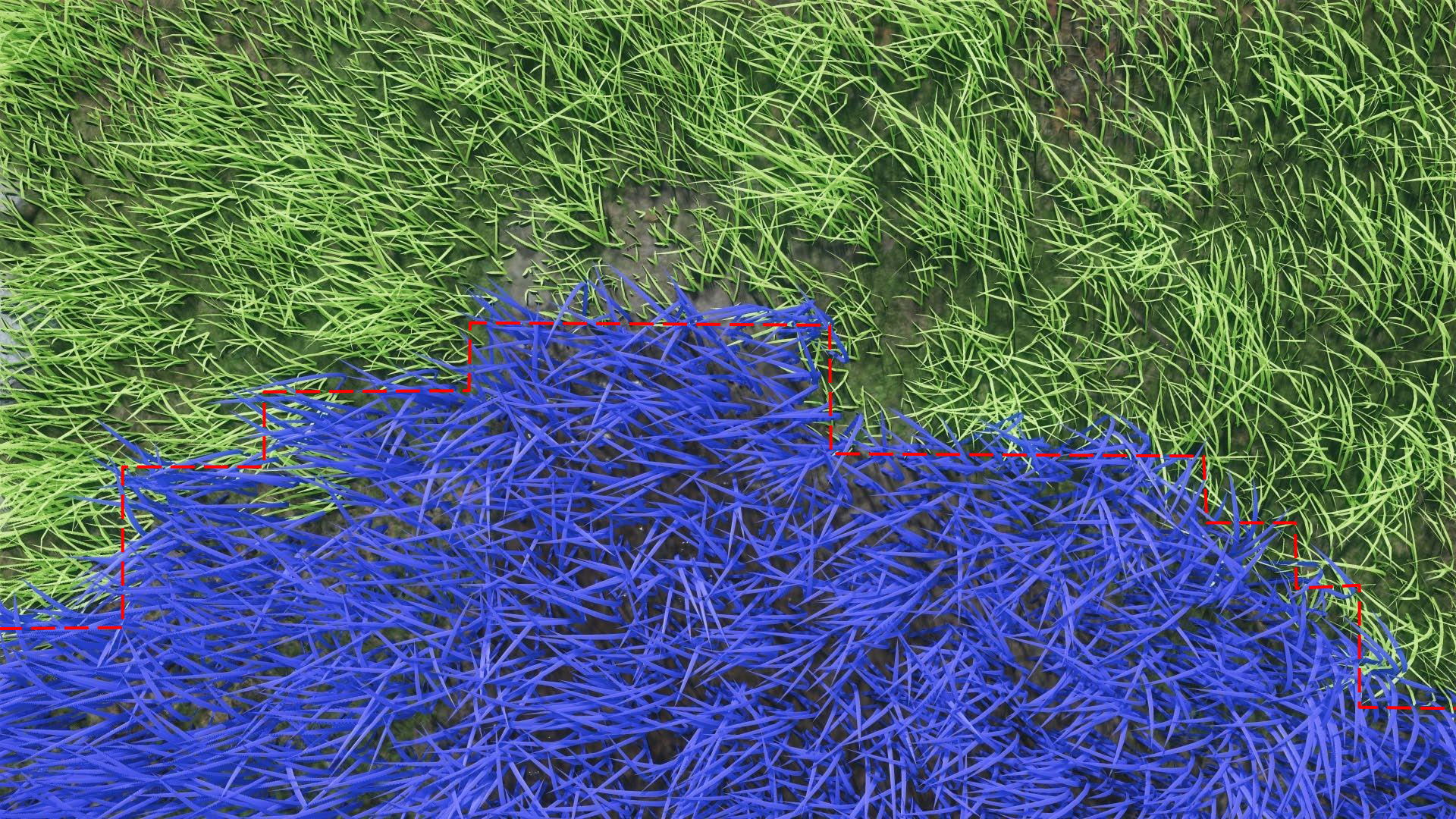


Frustum Culling



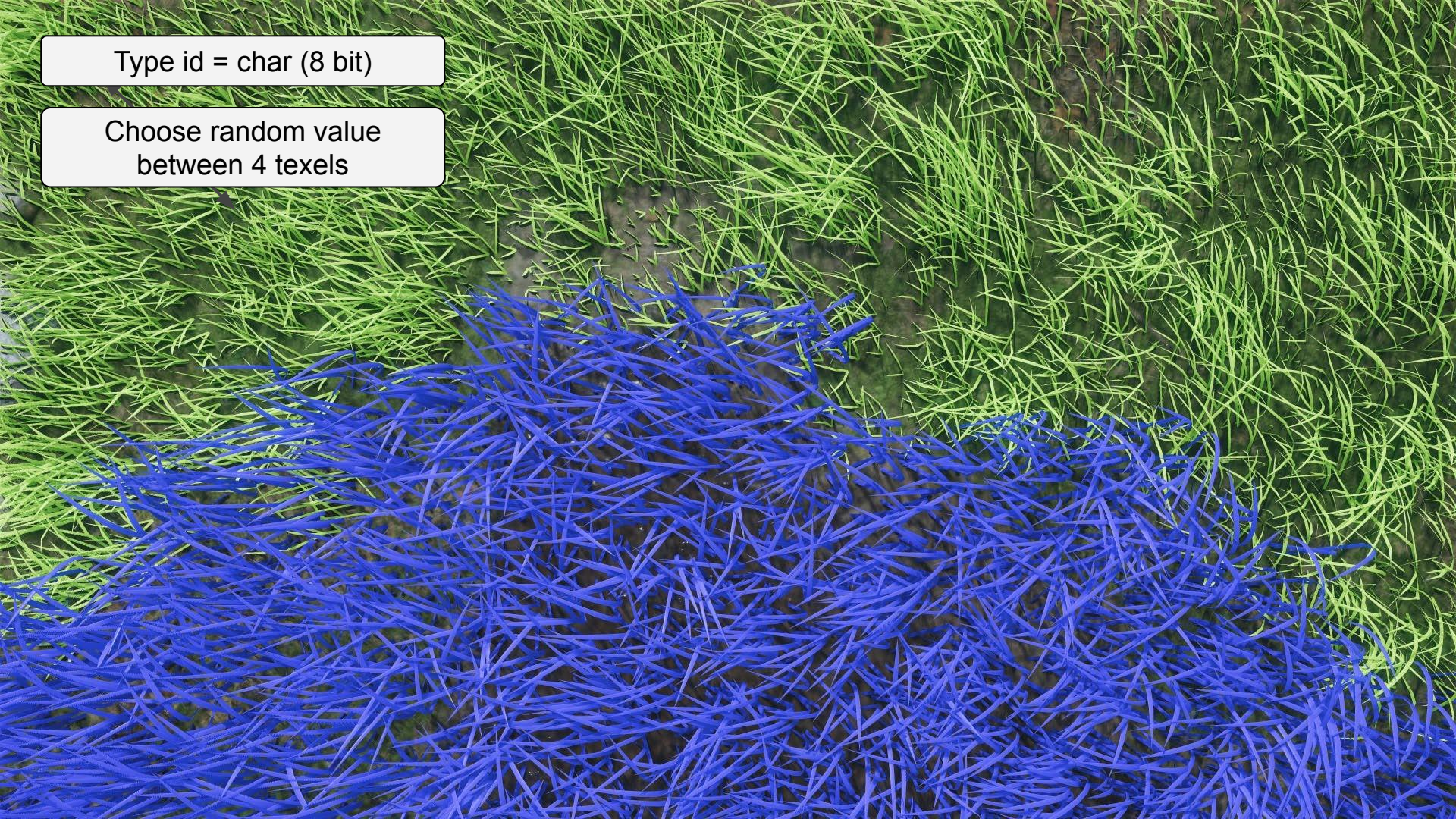
Occlusion Culling





Type id = char (8 bit)

Choose random value
between 4 texels



- Position (vec3)
- Facing (vec2)
- Per-blade Hash
- (Wind strength at position)

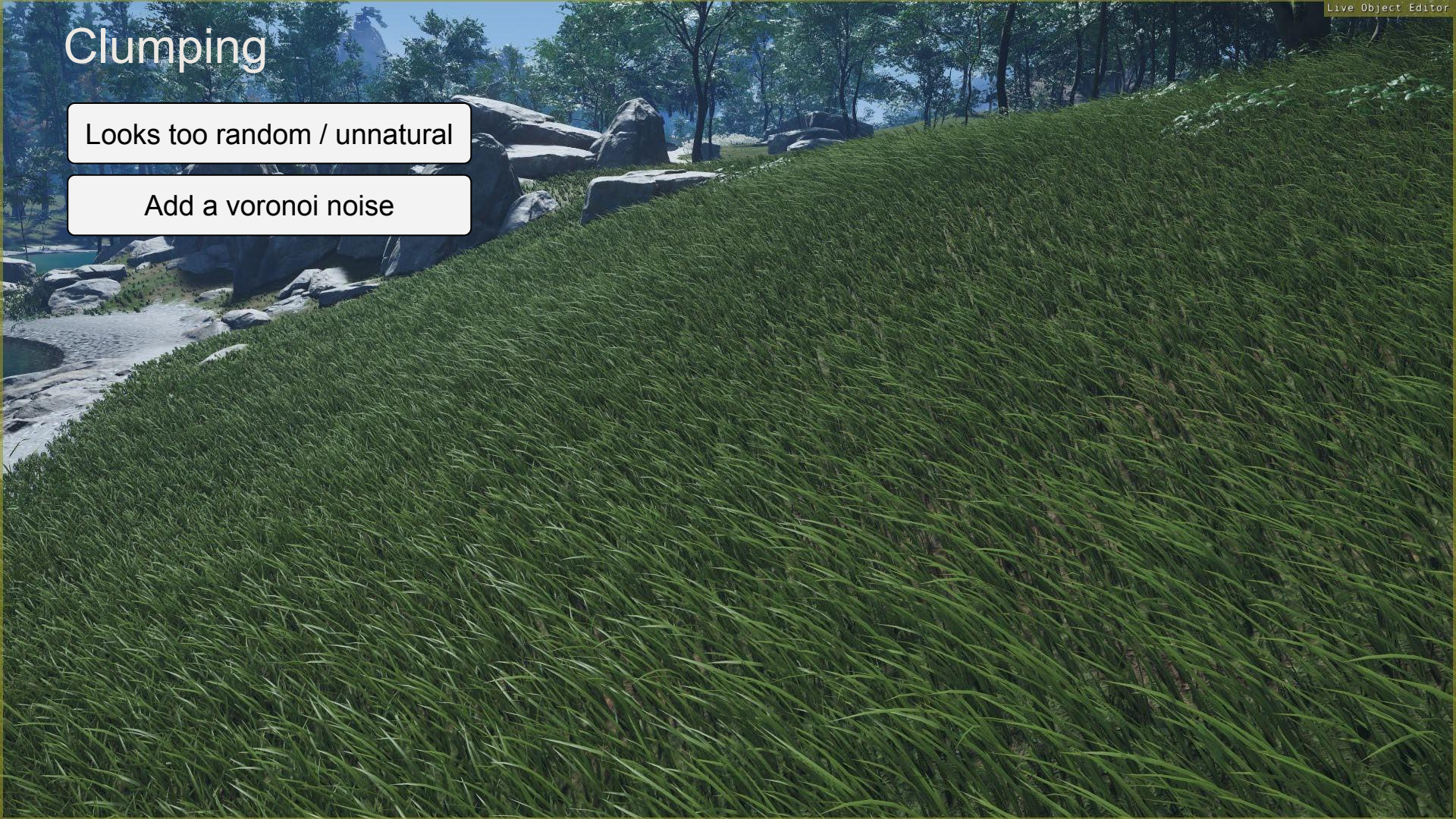
Artist control

- Clump facing (2 floats)
- Clump color
- Grass Type
- Height
- Width
- Tilt
- Bend
- Side Curve

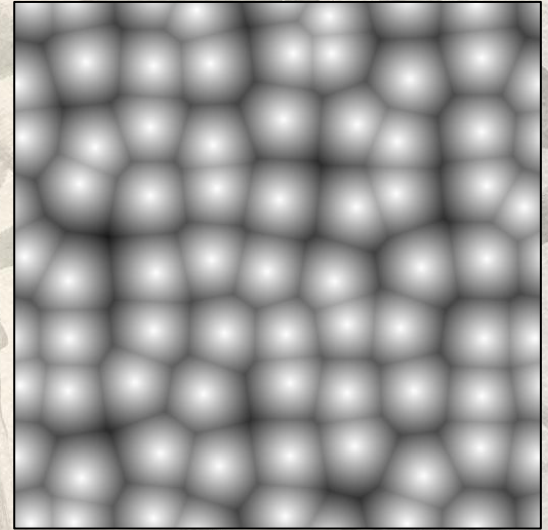
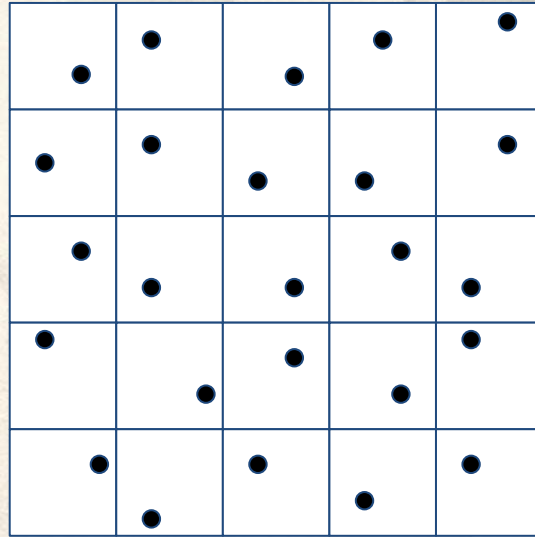
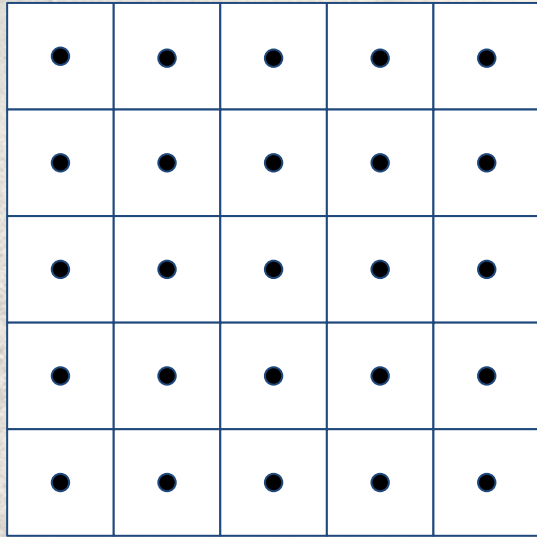
Clumping

Looks too random / unnatural

Add a voronoi noise



Clump Texture



Clumping

Change height



Clumping

Direction per clump



Clumping

add offset



Clumping

direction out of clump



Clumping

all together

New

Old



High LOD
15 vertices



Low LOD
7 vertices

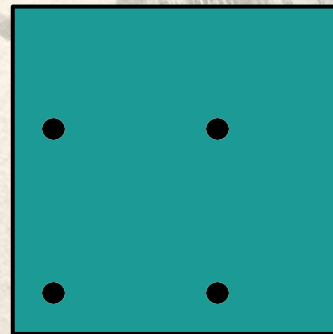
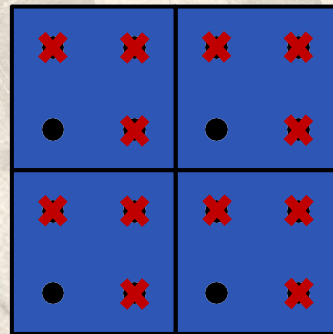


can choose the distribution of vertices

Transition Low => high

Linear interpolation of geometry

remove blade before transition



High LOD
15 vertices



Low LOD
7 vertices



When grass is short

Much denser

Low LOD is weird ... that's all

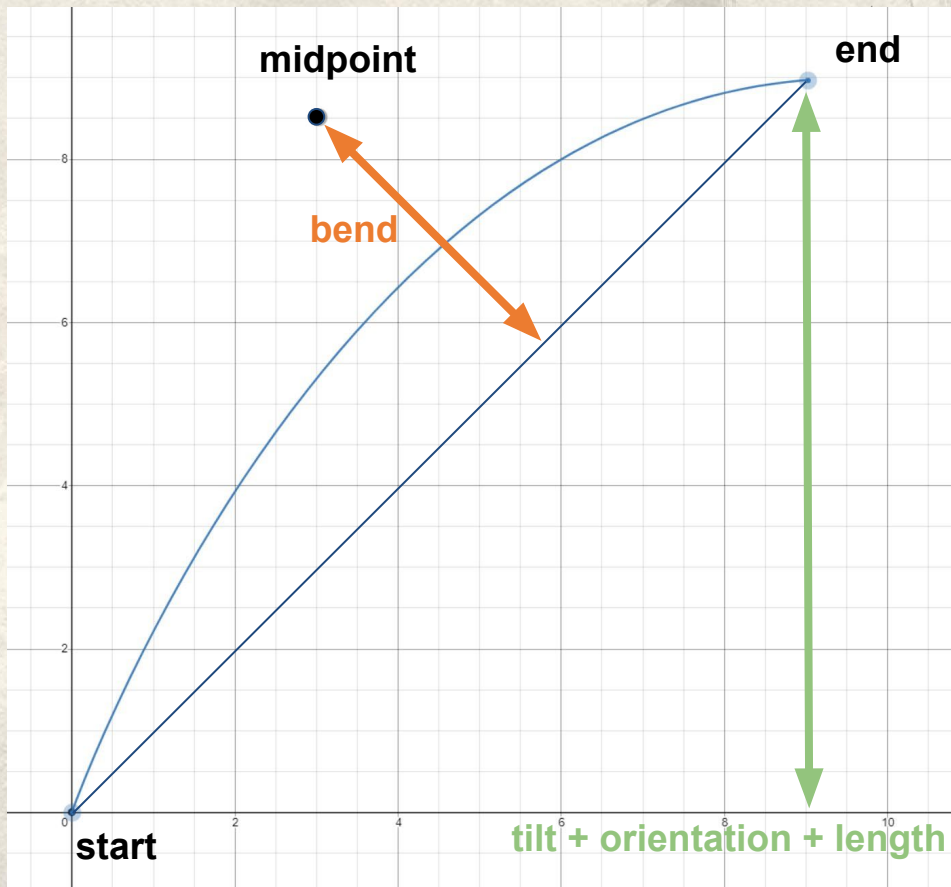
Cubic Bezier curve

- Easy position + normal evaluation
- Control point changes blade shape

Blade Generation

- Evaluate Bezier curve
- Get normal orthogonal to facing
- Step vertex in width direction
- Evaluate Bezier derivative curve



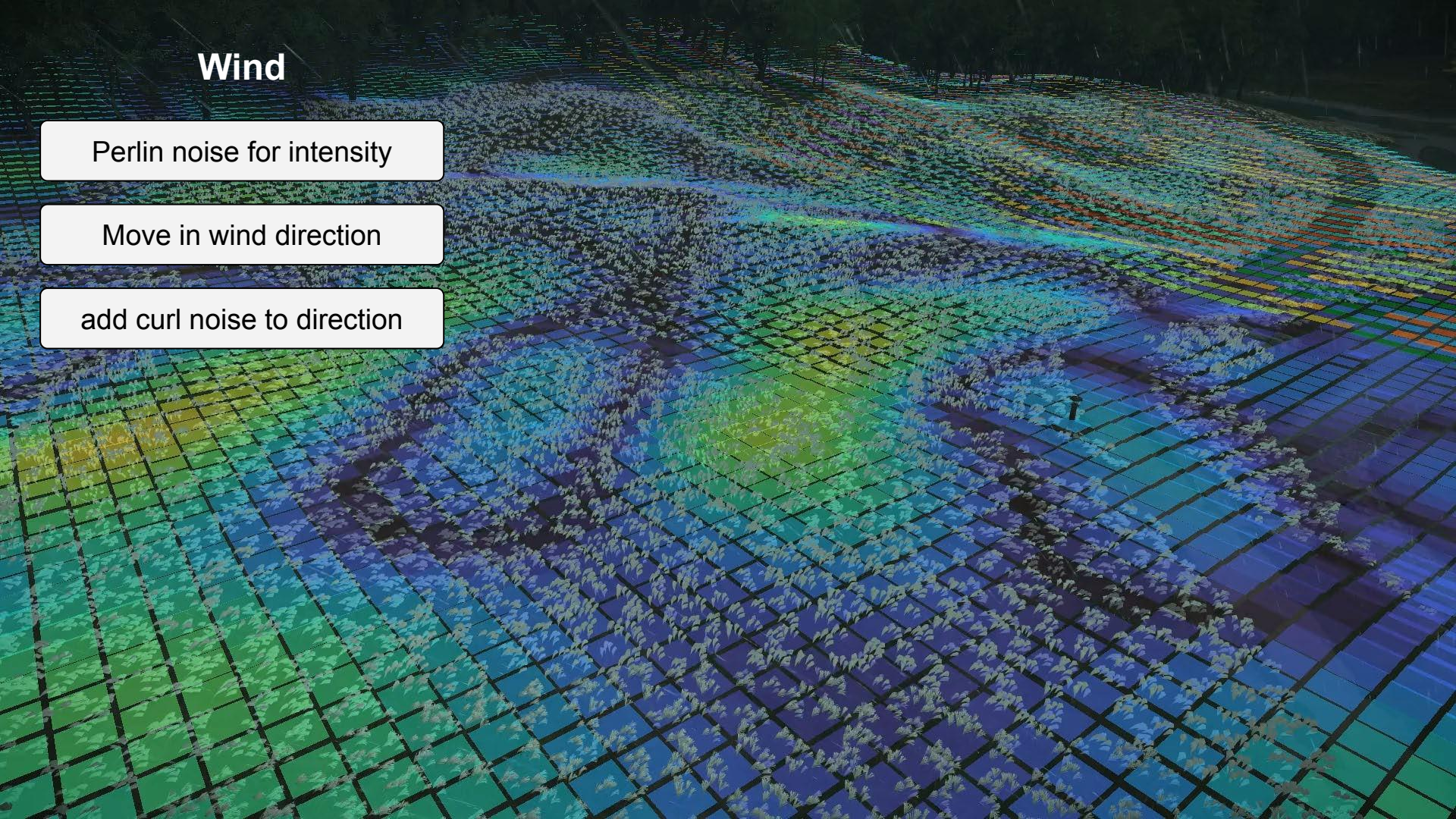


Wind

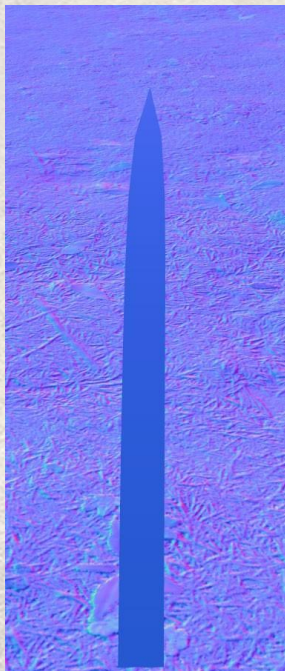
Perlin noise for intensity

Move in wind direction

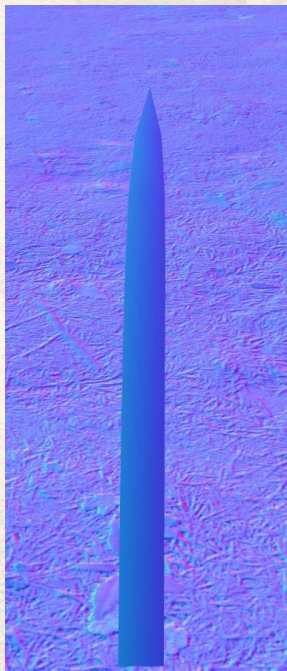
add curl noise to direction



Flat normals



Rounded normals



Can deduce rounded normal

Controlled by "Side Curve" ?

Facing bias

seems empty

orthogonal blades are thin



Facing bias

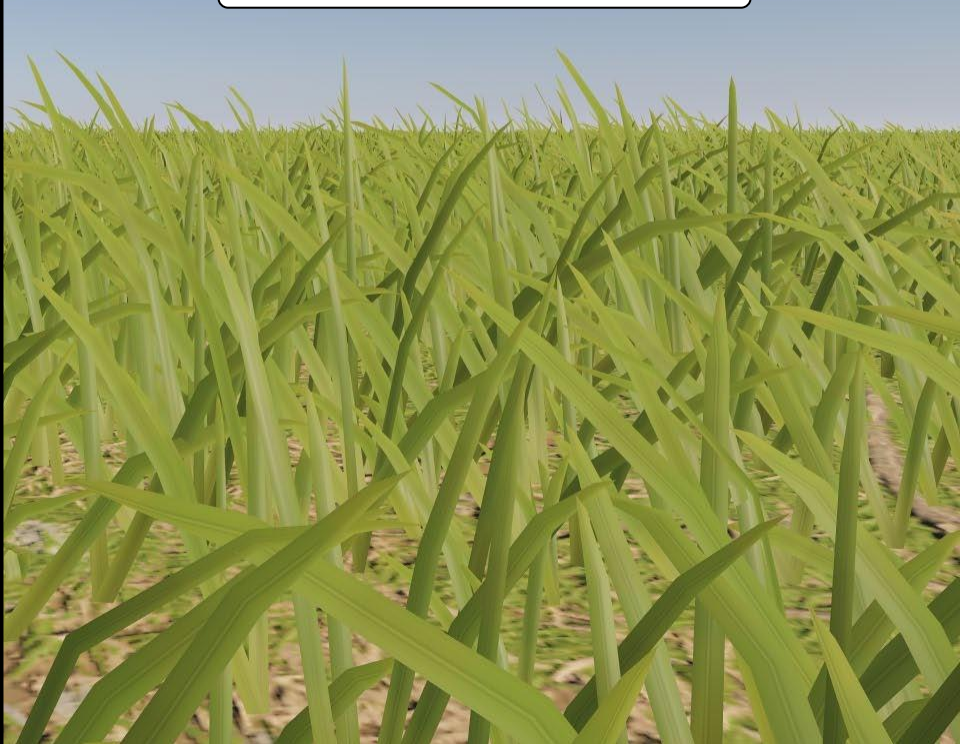
seems empty

orthogonal blades are thin



Add shift in view space

like billboard ?



Noise Problem

glossy / specular material

normal variation

lot of aliasing when far



Noise Problem

glossy / specular material

normal variation

lot of aliasing when far



Update with distance

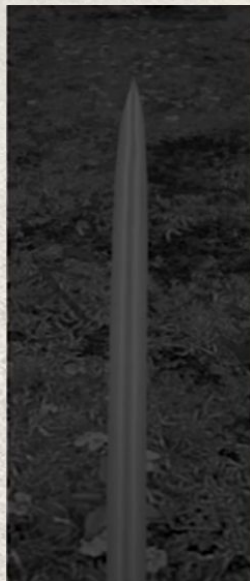
lerp normal to global normal

reduce gloss



Colors

gloss



1D texture

vein



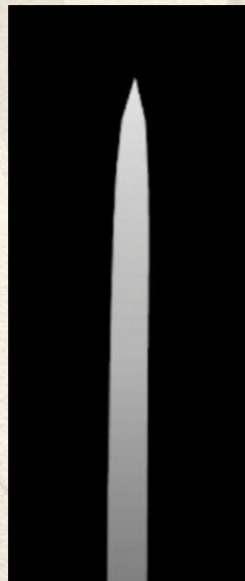
1D texture

diffuse



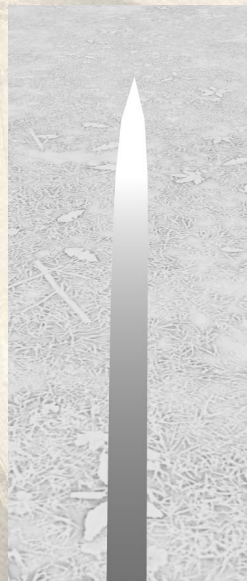
2D texture

translucency



constant

**ambient
occlusion**



constant



final





Artists can place assets to add diversity

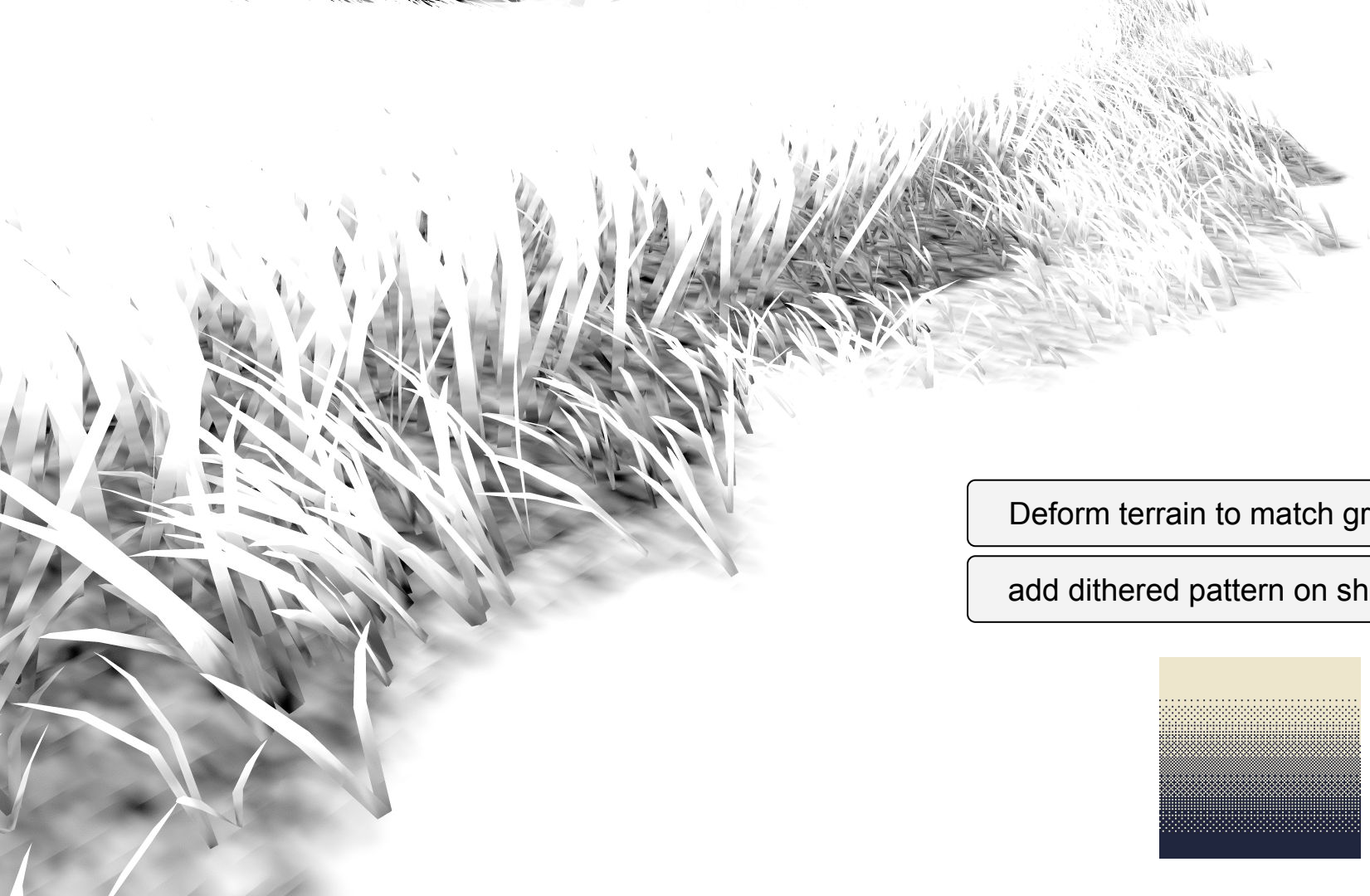


Many applications



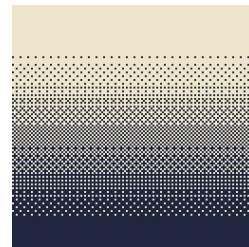
Far => replaced by texture

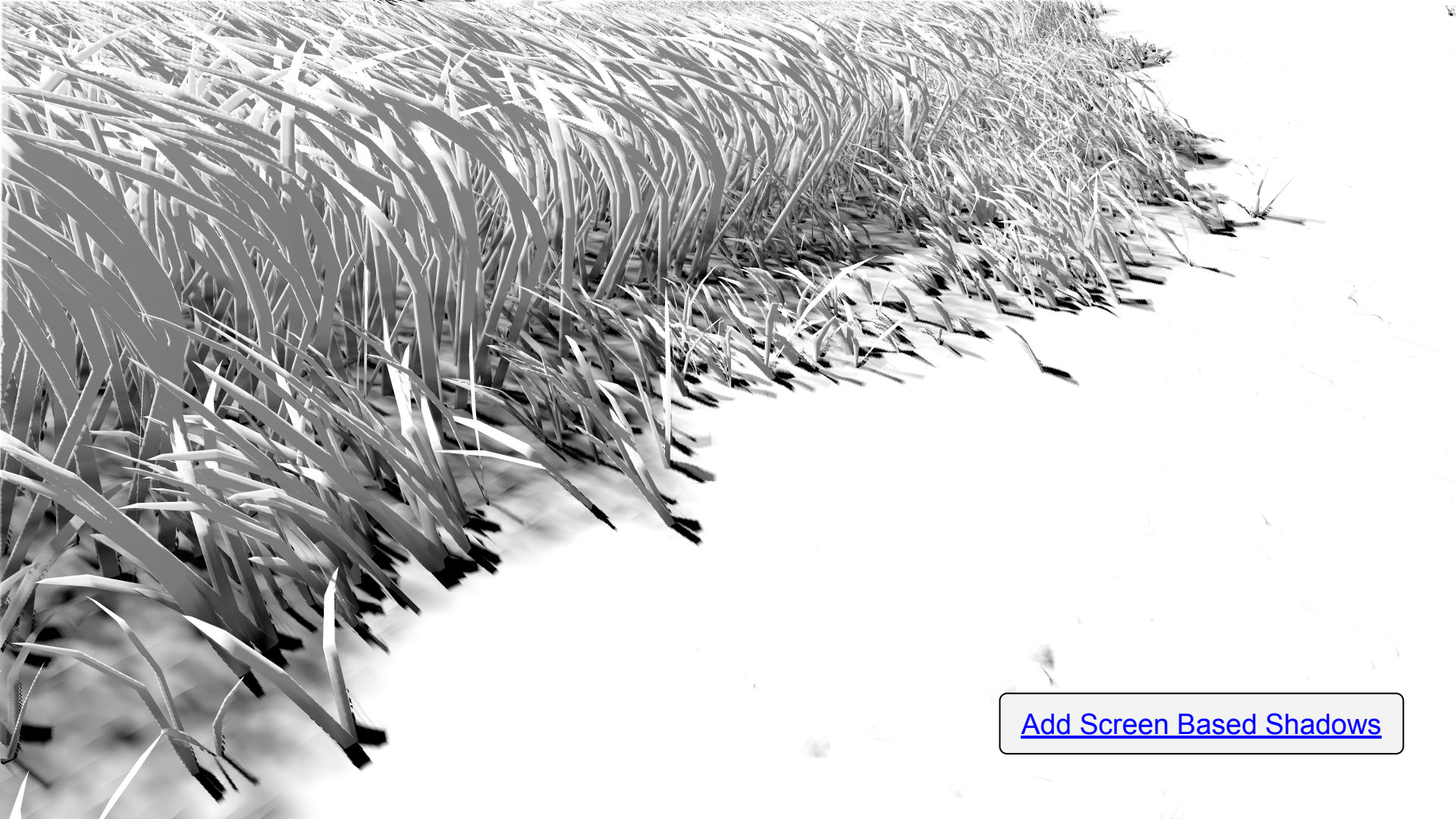




Deform terrain to match grass height

add dithered pattern on shadow map

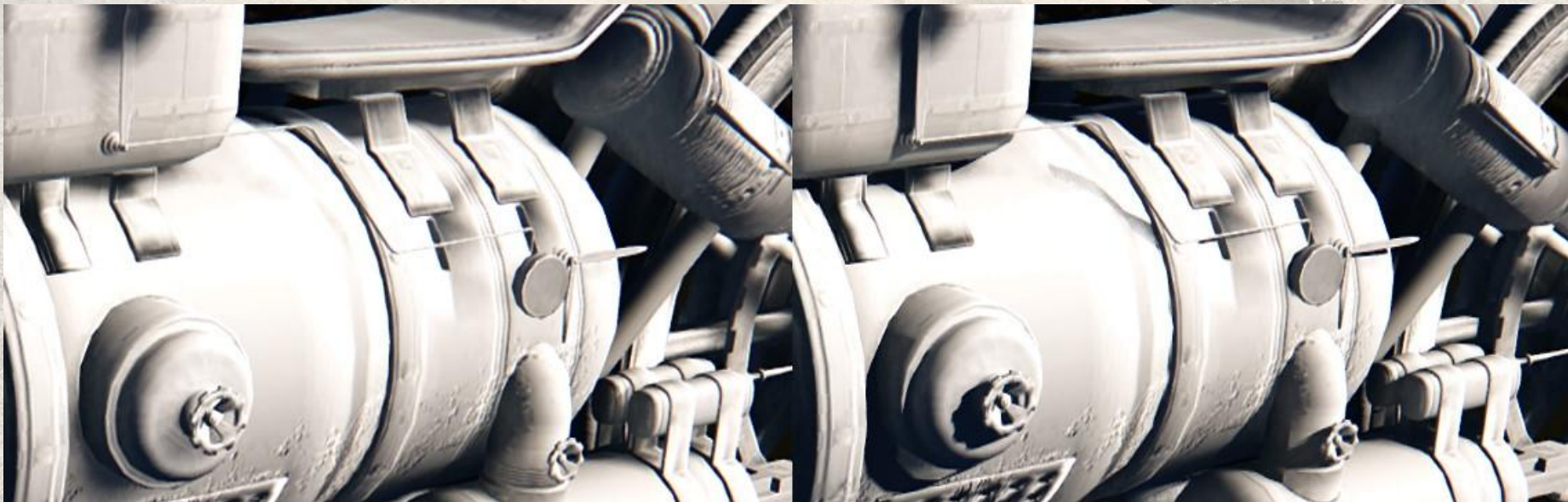




[Add Screen Based Shadows](#)

Shadow Map

+ Screen Space Shadow



Add fine details to shadow + Cheap

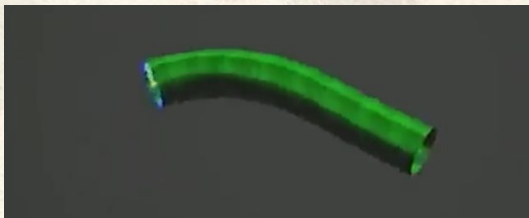
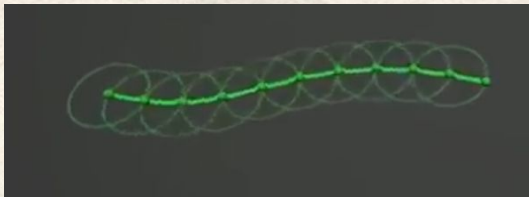




Conflict between terrain and assets



Limited with foliage type



Flexible particle system

Grass, Tentacles, Destructible Terrain, Fog, etc.