



μ μ

&

&

μμ



μ

Bioengineering Techniques for Streambank Restoration

A Review of Central European Practices

Martin Donat

■



μ

- μ
- μ (μ) μ . μ . μ
- (. . μ , μ) , μ μ μ . μ
- μ μ μ μ μ : μ .
1. μ μ μ .
2. μ μ μ .
3. μ μ μ .
4. μ μ μ .
5. μ μ μ .

μ



μ :

1.

.

2.

μ .

3.

μ .



μ :

1.

μ

μ

,

.

2.

μ

,

μ

3.

μ

μ

.

4.

.

μ



μ

μ :

1.

.

2.

μ

.



μ

:

1.

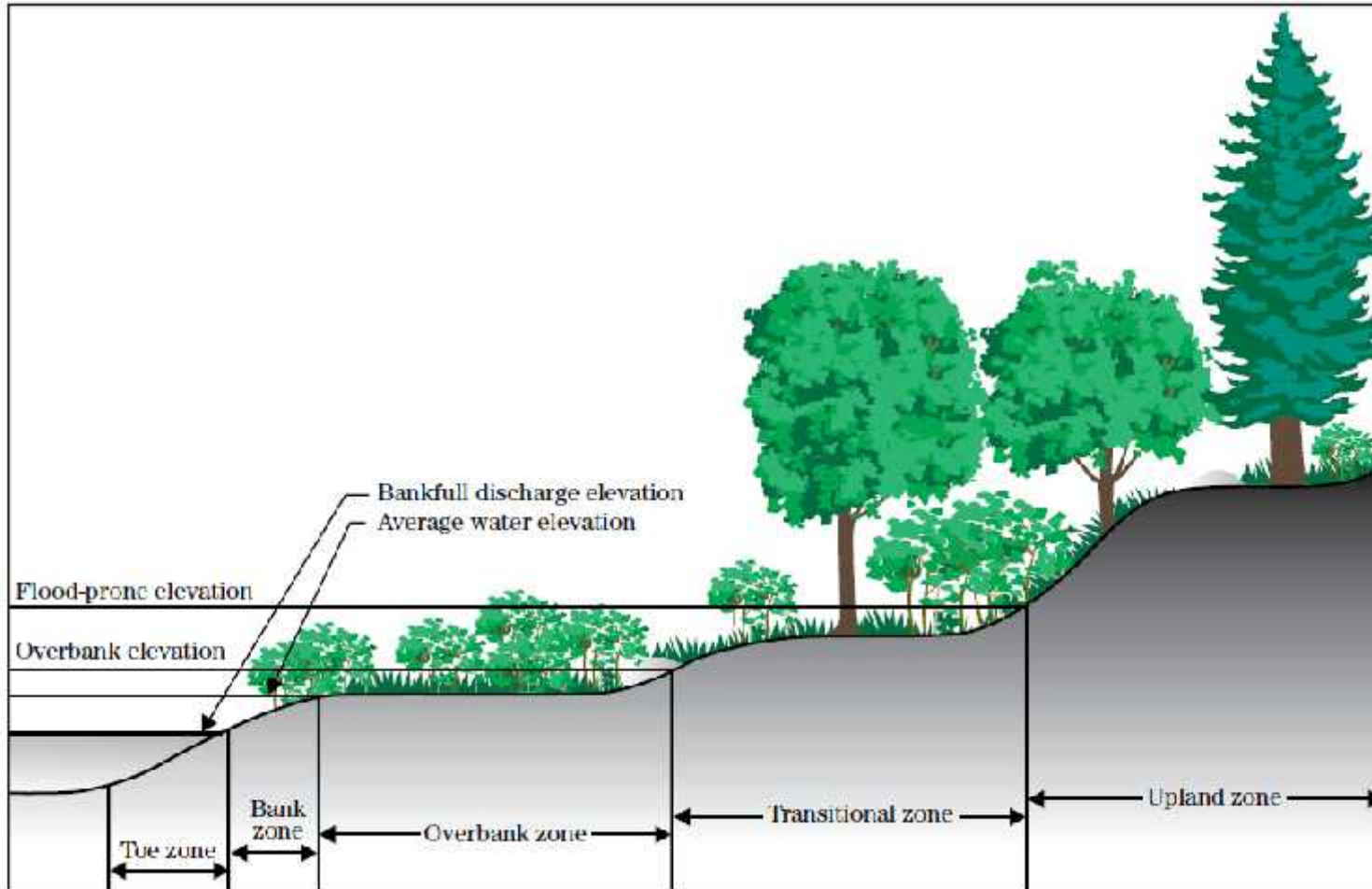
μ μ

.

2.

.

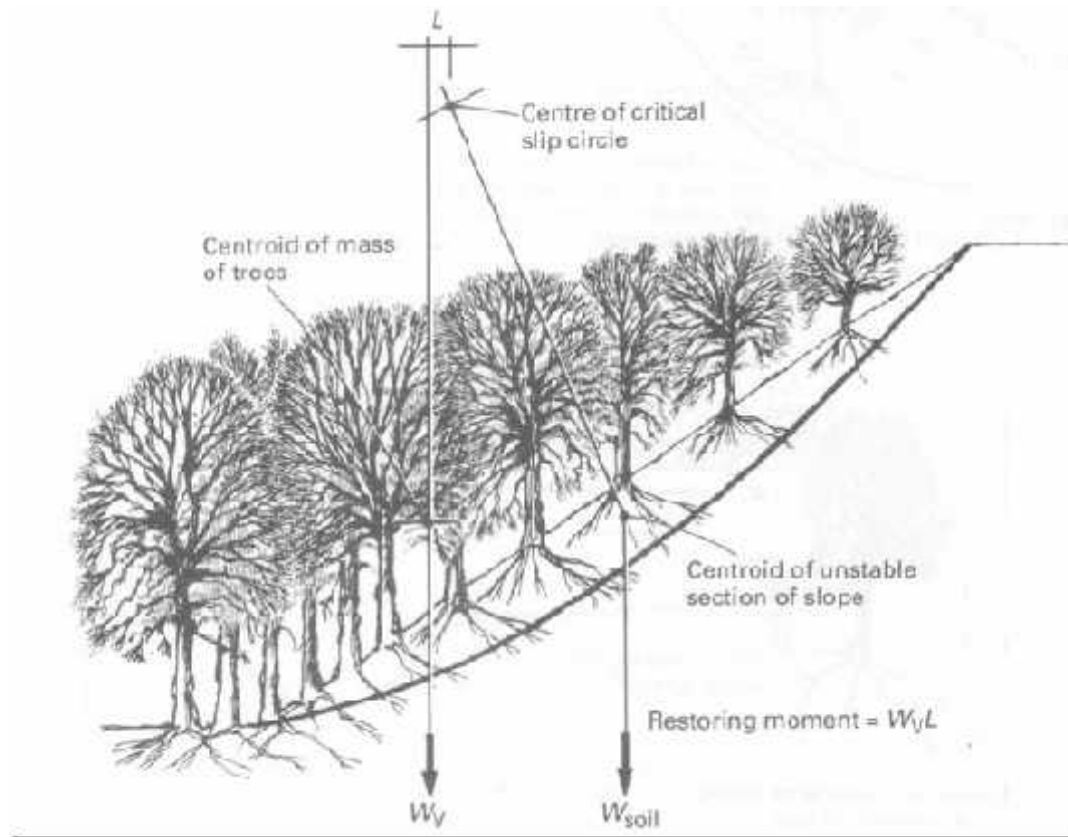
■



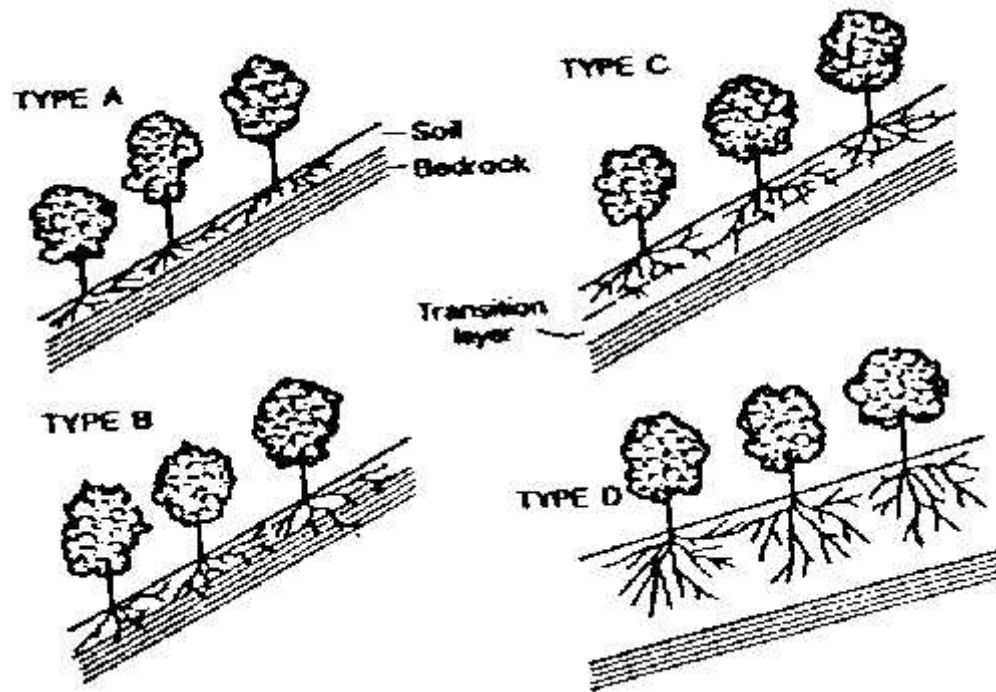


1. $\mu (\mu$
2. $\mu \mu$).
3. μ
4. $\mu (\mu$).

1. μ
2. $(\mu$).
3. $($
4. $\mu \mu \mu$).
5. μ



μ





μ A:
μ

μ

μ μ

μ

. μ ,

μ

.



μ B:
μ

μ

μ

,

μ

μ

μ

.



μ C:
μ

μ
μ
μ

, μ

μ .

μ μ μ

.



μ D:
μ

μ

«

»

.

μ

()

μ

μ

μ

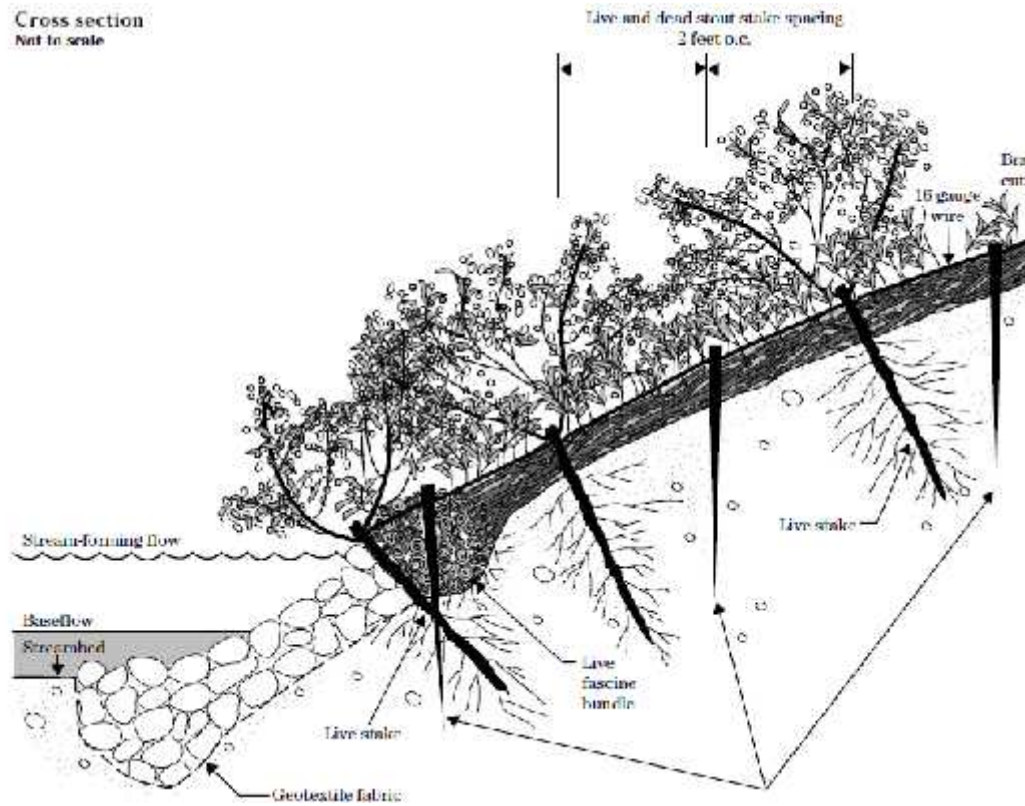
μ
μ

	/		/
<i>Salix glabra</i>	2.4	<i>Anus viridis</i>	1.5
<i>Viburnum lantana</i>	2.3	<i>Fraxinus excelsior</i>	1.5
<i>Erica carnea</i>	2.0	<i>Acer pseudoplatanus</i>	1.1
<i>Salix eleagnos</i>	1.8	<i>Populus tremula</i>	1.1
<i>Salix nigricans</i>	1.8	<i>Salix alba</i>	0.5
<i>Salix purpurea</i>	1.5	<i>Populus nigra</i>	0.4
<i>Equisetum arvense</i>	5.5	<i>Festuca ovina</i>	1.1
<i>Rumex scutatus</i>	5.0	<i>Carex flacca</i>	0.6
<i>Petasites paradoxus</i>	1.4	<i>Calamagrostis epig.</i>	0.5



μ

Cross section
Not to scale



1. μ
- 2.
- 3.
- 4.
- 1.
- 2.
- 3.

μ : μ μ
· μ μ
μ · μ
μ · μ
μ : μ

μ . μ

-) μ (,) .
- μ : μ
- 1. ..
- 2. .
- 3. μ .
- 4. .
- 5. .
- 6. μ μ (μ) .
- 7. μ μ μ (μ) μ (. . , μ 5-30 .) .

μ . μ

μ	μ	μ	:
(. μ >5 mm)		μ	
()		, , μ μ	
(. μ 2-5 mm)		, μ μ	
μ (. μ 0.5-1 mm)			
μ (. μ 0.08-0.5 mm)		μ (μ)	

μ	μ	μ	:
μ		μ μ	
		,	
μ (,)		μ , (μ μ)	

(Fascines)

(μ).

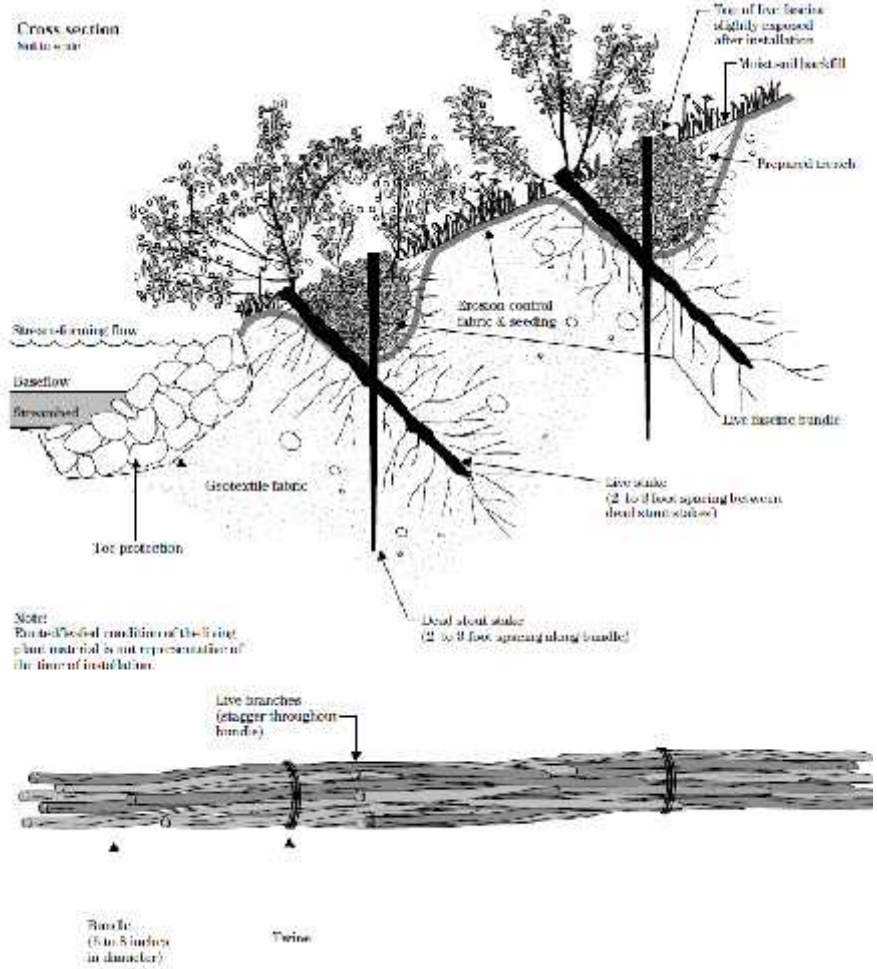
- μ (Fascines) μ
(: 0.3-0.5 μ: : 0.3-0.5 μ).
5 , μ μ 1 cm μ .
- μ μ (. μ 1/2 m
3/4 m, μ).
Hoffmann), μ (
- μ Käbel). (
- μ . μ μ μ
- ○ μ μ μ .

(Fascines)

(μ).

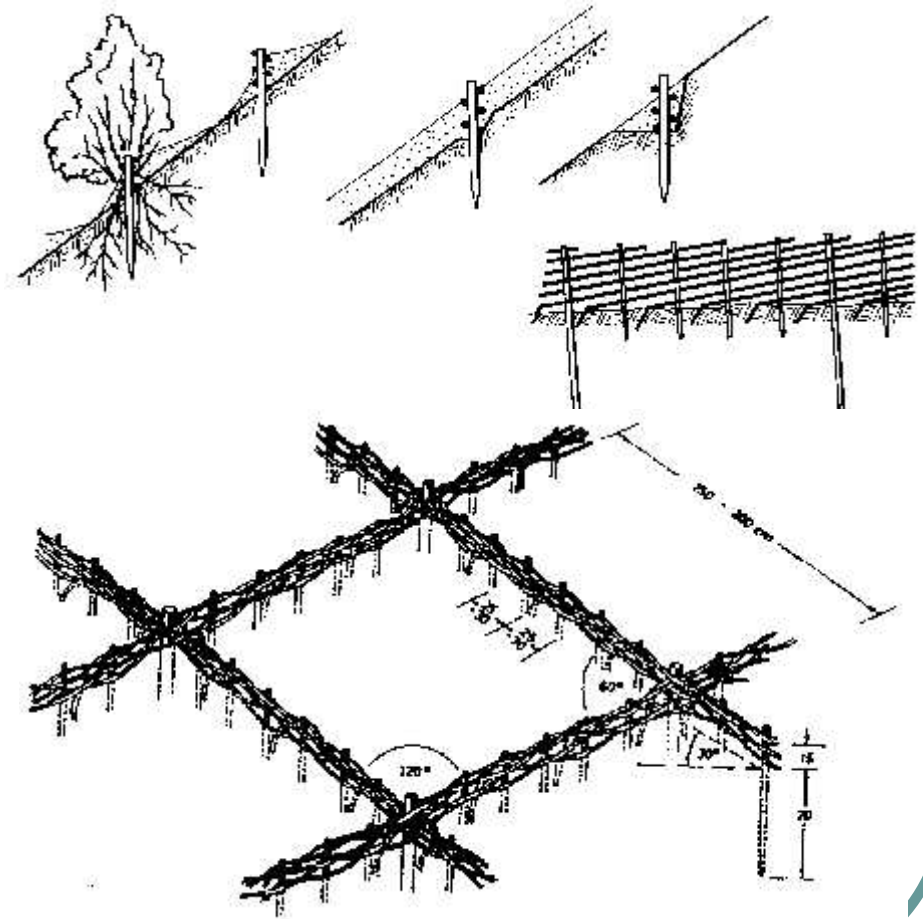
1. μ : .
2. μ .
3. μ .
4. .
5. Klimax.

1. μ : .
2. μ .
3. μ .
4. μ .

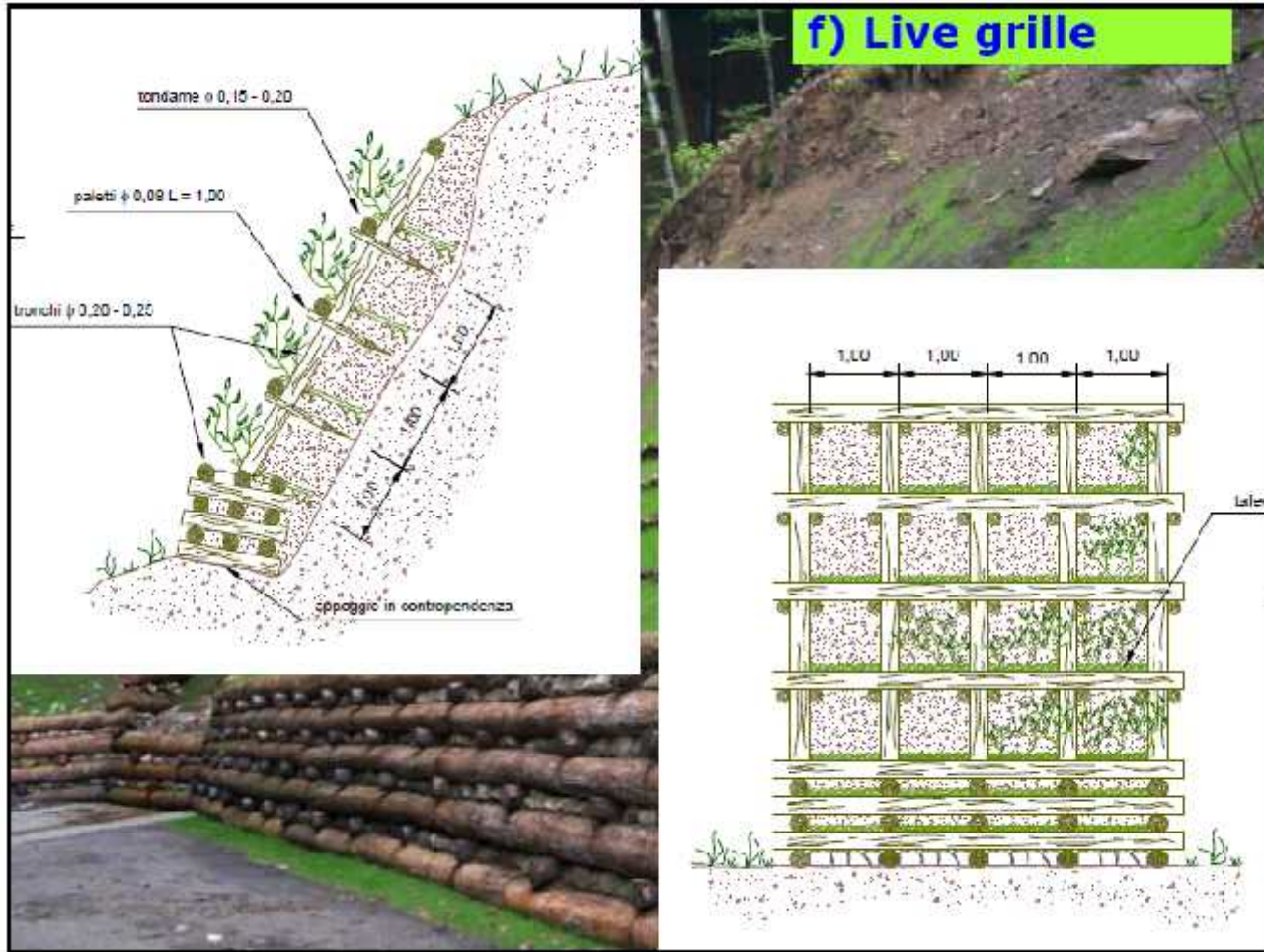


μ (Wattle fences)

1. μ : μ
2. μ . ' μ
Klimax.
3. μ μ .
1. μ :
2. .
3. μ μ (
4. μ μ) .
5. μ μ .



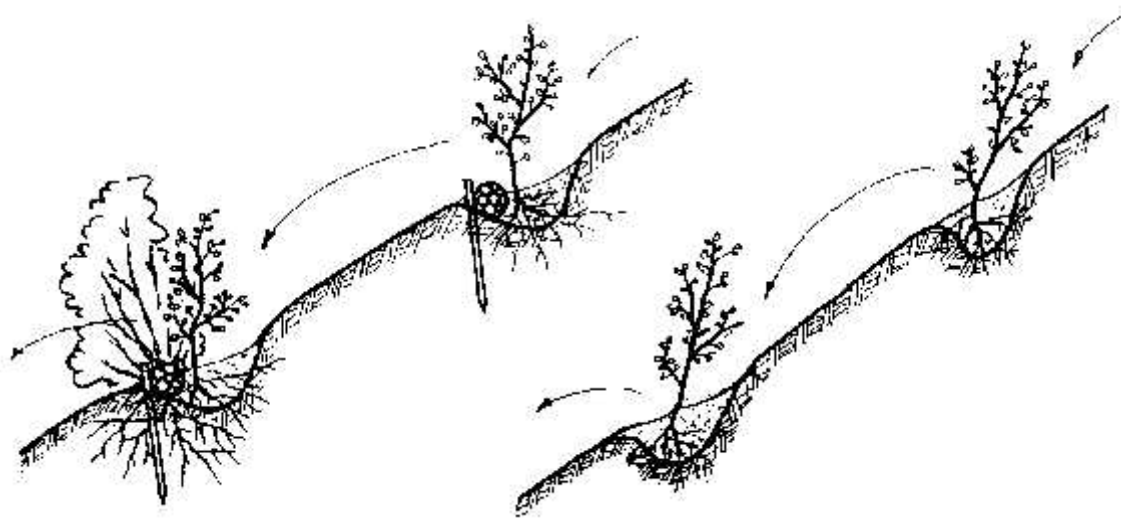
μ (Live slope gratings)



μ (Groove or rut structures)

1. μ : μ (μ)
2. μ Klimax.
3. μ
4. μ

1. μ : μ
2. μ
3. μ μ



(Cordon)

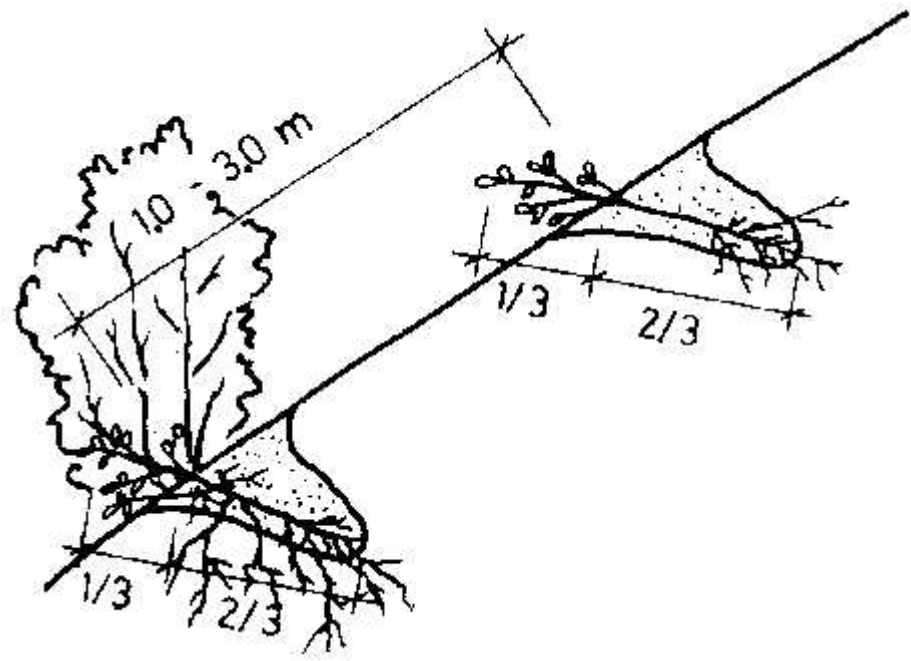
- μ 0.5-1.5,
 μ μ μ μ
- μ 10 μ μ
- μ 2 μ 3 cm) μ (μ
- μ μ μ μ

1. μ μ μ μ μ
 2. μ μ μ μ μ
 3. μ μ μ μ μ
 4. μ μ μ μ μ
 5. μ μ μ μ μ
-
1. μ μ μ μ μ
 2. μ μ μ μ μ
 3. μ μ μ μ μ

μ

(Hedge layers)

- 1. μ :
- 2. Klimax.
- 3. μ μ
- 1. μ :
- 2. μ
- 3. μ μ (μ μ)



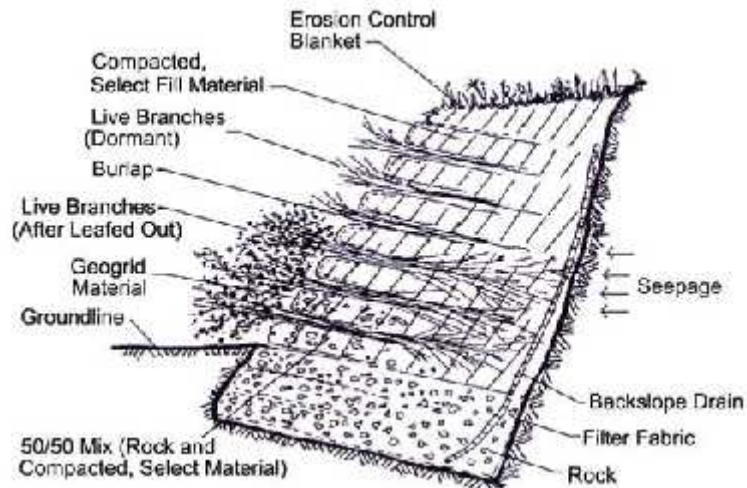
(Brush layers)

μ μ μ

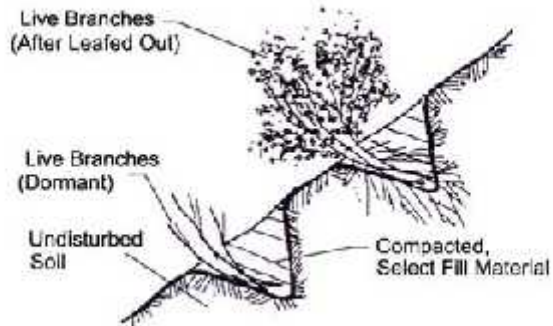
- 0.5-2 m. μ
- μ μ μ (10) μ
0.25 m () μ
 μ μ μ μ μ
- μ μ μ μ μ μ μ
- μ μ μ μ μ μ μ 15
- 90 μ μ μ μ μ μ μ 1.5
m (μ μ μ μ μ μ μ)
- :
0.25 m μ , μ , μ ,

μ μ μ

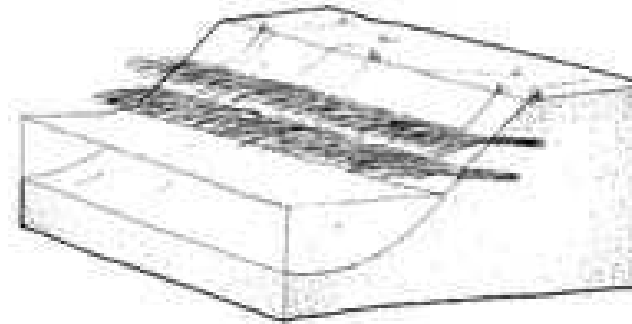
(Brush layers)



LAYERS OF LIVE BRUSH BETWEEN LIFTS OF TOPSOIL SECTION VIEW



CUT SLOPE BRUSH LAYER INSTALLATION SECTION VIEW



μ

μ

.

1.

μ :

μ

.

2.

μ .

3.

μ

μ

μ

.

4.

μ

.

5.

μ

6.

μ

μ

μ

μ

.

μ

7.

μ

μ

.

μ :

1.

μ

μ

.

2.

μ

3.

μ μ

(

μ

,

,

.)

.

4.

μ μ

μ

μ

.

5.

μ

μ

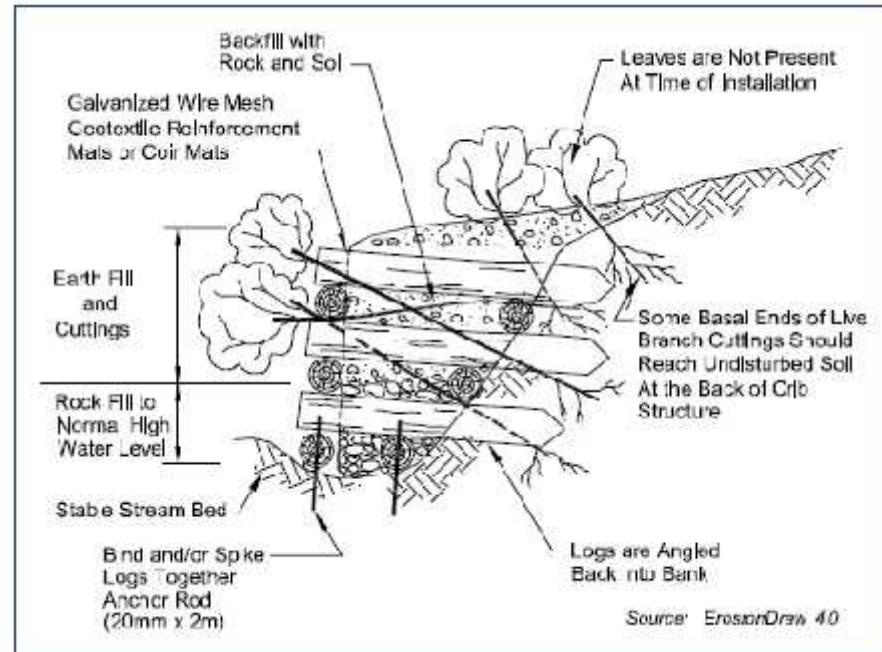
.

6.

.

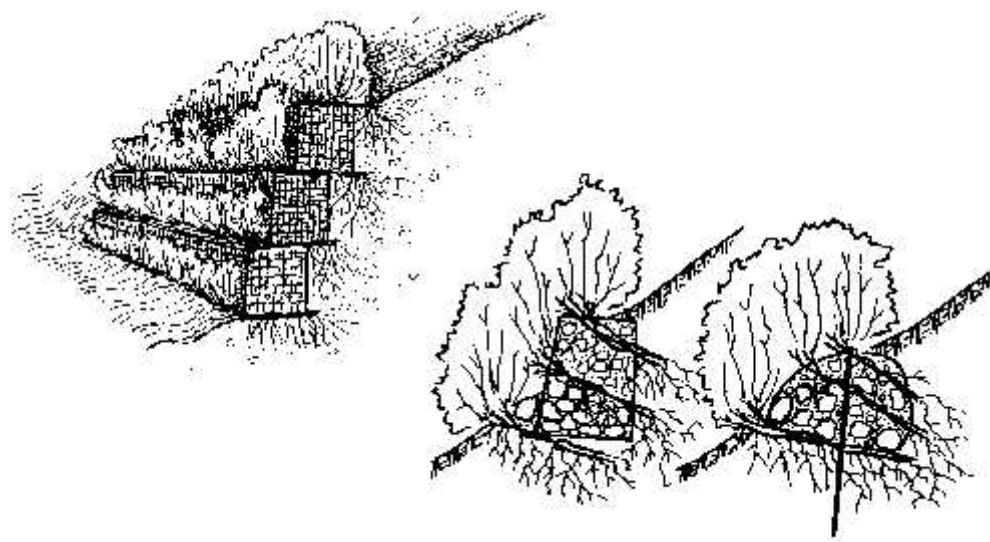
(Crib wall)

1. μ μ μ :
2. μ μ μ (μ μ μ)
3. μ μ μ μ μ)
4. μ :
1. μ μ μ)
2. μ :
3. μ μ μ
4. μ :



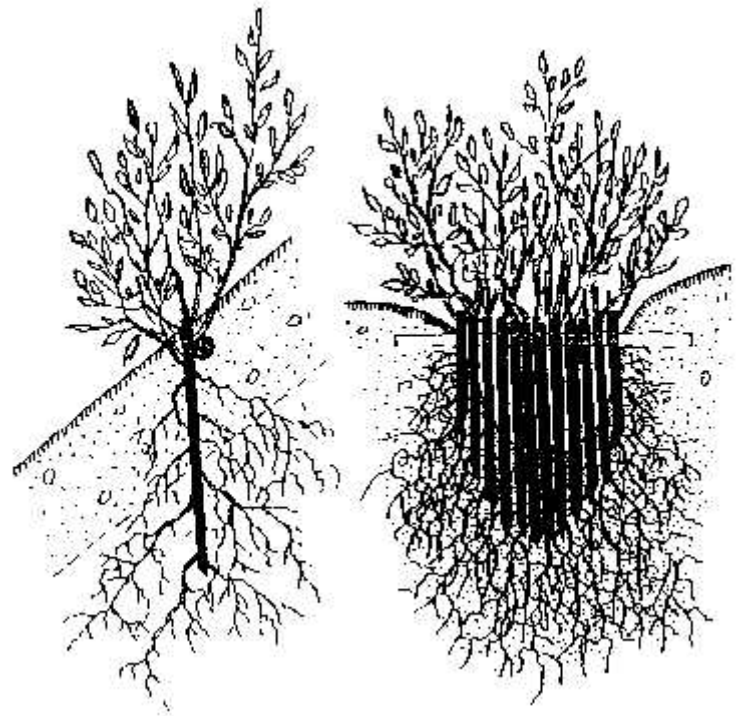
μ μ (Vegetated gabions)

- μ μ μ (gabions) μ μ
- μ μ μ , μ μ
- μ μ μ μ μ μ μ μ
- μ μ μ μ μ μ μ μ



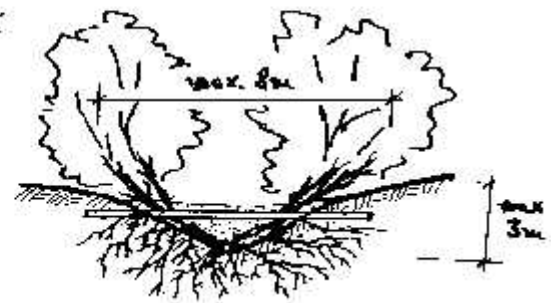
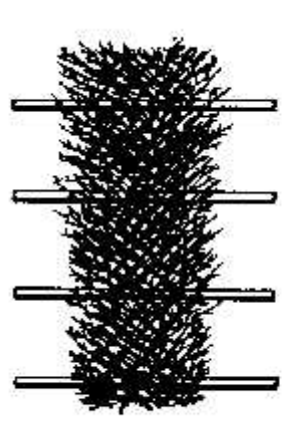
μ (Vegetated palisades)

- μ μ)
- μ μ (
- μ μ , μ , μ μ).
- μ :
- μ ,
- μ .
- μ μ :
- (2-4 m). μ (6 m) μ
- μ μ (μ ,
- μ μ .



μ (Branch layers)

- μ μ μ
- μ μ 2 m μ
- μ μ μ
- μ μ μ 8 m μ 3 m. μ μ



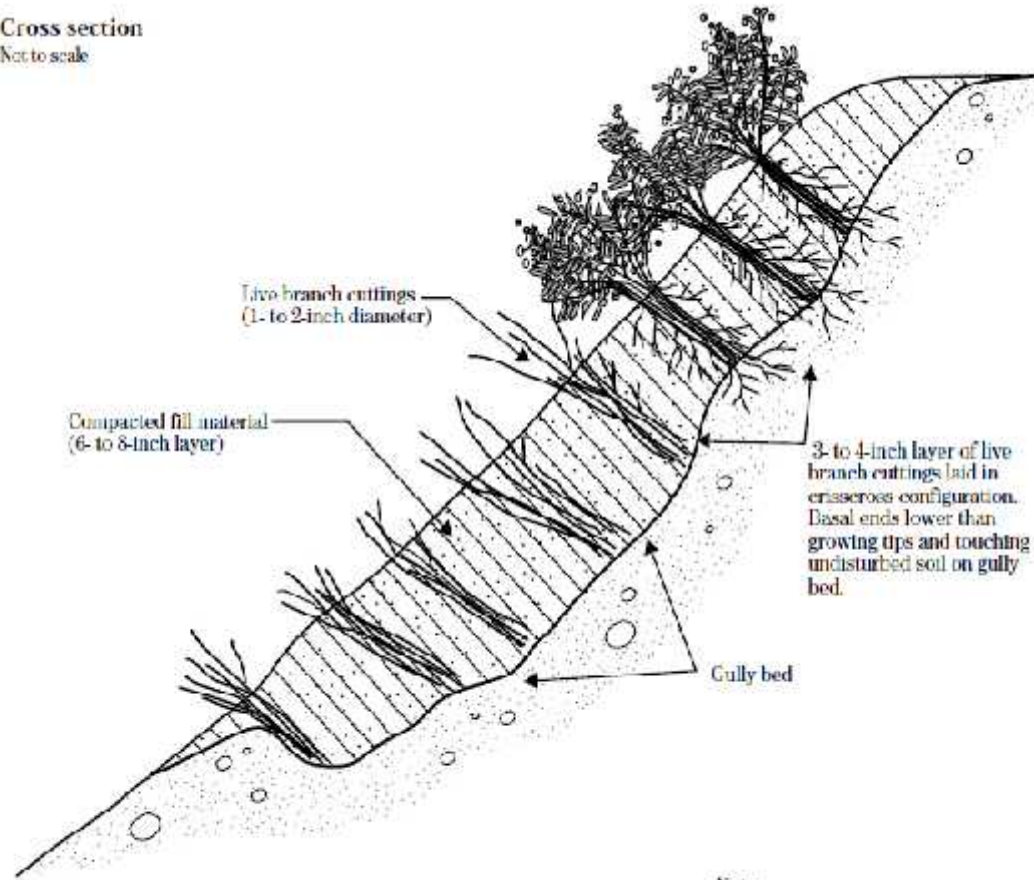
μ (Branch layers)

- 1.
- 2.
- 3.
- 4.

- 1.
- 2.

μ :
)
 μ
.
.
.
.
 μ :
 μ
 μ
 μ
 μ
(
 μ
 μ
)

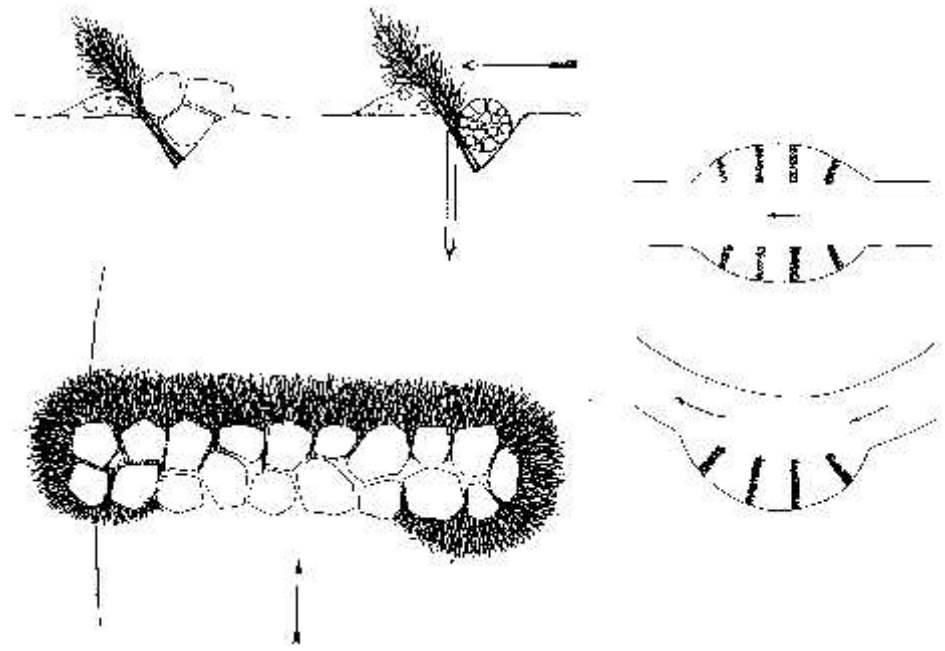
Cross section
Not to scale



Note:
Rooted/leafed condition of the living plant material is not representative of the time of installation.

(Groynes)

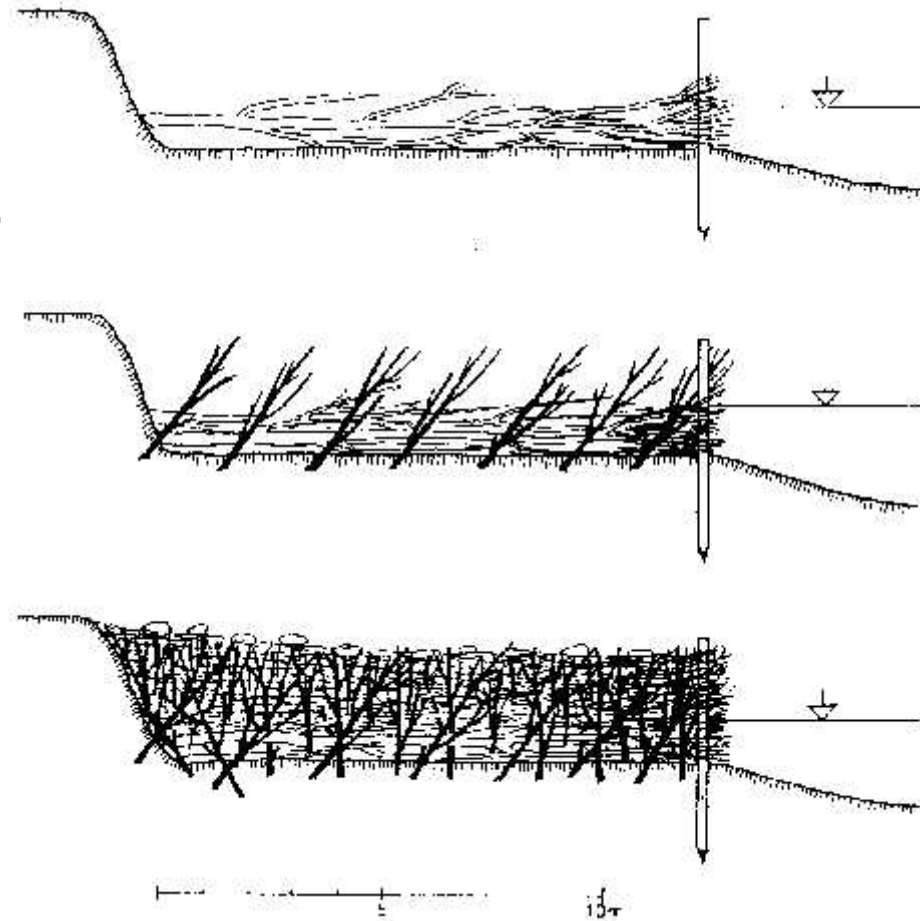
1. μ :
 2. μ , μ :
 3. μ , μ :
 4. μ .
 5. μ .
1. μ :
 2. μ , μ :
 3. 10 m. μ .
 4. μ , μ :
- (μ , μ) .



μ - μ μ μ

(Log brush barrier)

1. μ μ μ
 2. μ μ μ
 3. μ μ μ μ μ
 4. μ μ μ μ μ
 5. μ μ μ μ μ
-
1. μ μ μ
 2. μ μ μ
 3. μ μ μ μ μ
 4. μ μ μ μ μ
- 3m.

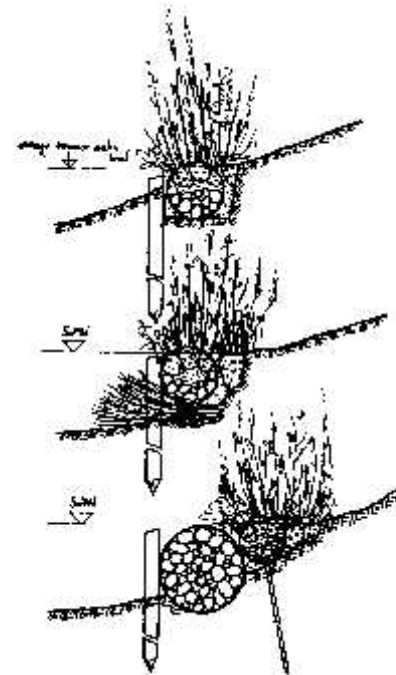
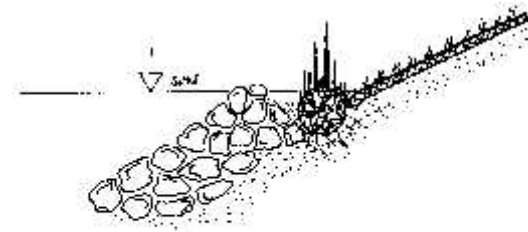


μ

(Reed roll, swamp sod rolls)

1. μ : μ μ
2. μ .
3. μ μ .
4. .

1. μ : ()
2. μ μ .



■





μ

,



μ

μ

(

),

μ



μ

.

,

μ



μ

.

μ

μ

μ

μ

:



(

μ

μ

)



)

(2-5



μ

.

-) μ :
- () , μ : , μ $\mu\mu$. μ , μ ,
- () μ : μ , μ . μ , μ ,
- () : , μ , μ .
- () $\mu\mu$. : μ , μ , μ (10-20 cm) .
- () μ : , μ , μ .
- () μ 2 μ : μ . μ μ μ μ μ μ .
-) μ (μ) : μ (μ) μ .

μ

- 1. μ is a measure of central tendency.
- 2. μ is a measure of dispersion.
- 3. μ is a measure of skewness.
- 4. μ is a measure of kurtosis.

2

- μ is a measure on \mathcal{A} with $\mu(\Omega) < \infty$.
Let $f: \Omega \rightarrow \mathbb{R}$ be a bounded measurable function.
Then $\int_{\Omega} f d\mu$ is the unique real number I such that
 $\int_{\Omega} f g d\mu = I \int_{\Omega} g d\mu$ for every bounded measurable function g .
- Let $f: \Omega \rightarrow \mathbb{R}$ be a measurable function.
Let μ be a measure on \mathcal{A} with $\mu(\Omega) < \infty$.
Then $\int_{\Omega} f d\mu$ is the unique real number I such that
 $\int_{\Omega} f g d\mu = I \int_{\Omega} g d\mu$ for every bounded measurable function g .

μ	1-5 hr/m ²
$\mu \quad \mu$	(?) μ
(μ):	
μ	0.5-1 hr/m
	1-3 hr/m
μ	0.75-1.5 hr/m
μ .	2-5 hr/m ²
μ :	
μ	1-3 hr/m
(Cordon)	3-4 hr/m

μ :	
μ	1-3 hr/m
$\mu \mu \mu$	0.75-2 hr/m
$\mu \mu \mu$	0.75-2.5 hr/m
μ :	0.05-0.1 hr/ μ μ
$\mu \mu$	5-7 m ² /hr
	2-4 m ² /hr
$\mu \mu$	(?) $\mu \mu$
μ	(?)
μ	(?) μ
μ	(?)

μ : μ μ ,	(?)
μ :	
	(?)
$\mu - \mu$ μ μ	(?) 25-50% μ
μ μ :	
μ μ μ ,	4-6 hr/m
μ	1-3 hr/m ²

• (μ 50%) 3μ , μ .

1. .
2. , μ .
3. (μ Klimax).
4. μ .
5. (μ).
6. (μ .
7. μ . μ .
8. .
9. μ (μ , μ μ).
10. μ μ .

• μ μ μ μ .