Estimating Costs for Precommercial Silvicultural Treatments in the Northeast

by Arlyn W. Perkey

In 1982, Burl S. Ashley authored "TSI Cost Computations, Guidelines," which replaced "Guidelines for TSI Cost Computations," 1975. The following tables and formulas are an update of the 1982 tables using current wage rates and herbicide costs. Equations were developed that approximate the contents of the 1982 Cost Per Square Foot of Basal Area Tables. These equations provide the user with the option of obtaining a more specific answer for a given set of labor, herbicide, and carrier costs. Some tables are printed to provide the user with the flexibility of applying the information when a calculator is not readily available. The tables also display the cost estimates Per Diameter Inch, a means of applying the information for those who are less familiar with basal area.

Since it is now much more common to use water soluble herbicides in silvicultural treatments, the method of applying these costs has been adjusted to provide the flexibility of having water as a carrier at no cost. Also, non-petroleum based carriers are now available, and they provide a viable option to fuel oil that was frequently used as a carrier in 1982. Non-petroleum based carriers are generally regarded as more environmentally friendly.

What has not changed is that these costs are based on the same wide range of averages that Burl Ashley used in 1982. His basis was data gathered in the field during actual timber stand improvement operations and the average of various research results. The method of application was principally the axe and hand sprayer. The costs involve all time expended to carry out the operation beginning with the departure from the farmstead and ending at the time of return to that point. Most of the estimates are based on relatively inexperienced personnel performing the procedures. Planned operations conducted by trained and experienced workers would require less time.

A hand ax and hand sprayer are inexpensive, readily-available tools landowners can easily operate to accomplish silvicultural treatments.

The amount of herbicide used in a silvicultural treatment should be the amount shown on the label. Being too conservative and using less may result in poor results that require additional, costly treatment. Using too much herbicide can increase the risk of damaging or killing untargeted trees through root grafts or movement in the soil. Herbicides vary regarding their persistence, movement in the soil, and movement through root grafts. **Read and follow the label carefully.**

Deadening wild grapevines is sometimes a greater challenge than killing undesirable trees. Time and cost figures for deadening a vine less than four inches in diameter is about the same as for killing a 4-inch tree. It is appropriate to use the diameter inch cost computation method to determine grapevine deadening costs. To do this, each vine smaller than four inches should be tallied as four inches; larger ones should be tallied according to their actual diameter. When estimating tree-deadening costs with the basal area method, a separate diameter inch grapevine tally should be considered. The point sample center can be used as a 1/10-acre plot center.

USE OF TABLES I-VIII OR RELATED EQUATIONS TO ESTIMATE TREATMENT COSTS

To estimate the cost of doing precommercial silvicultural practices using herbicides, you need the following information:

- Price of herbicide per gallon
- Cost of carrier per gallon
- Appropriate quantity of carrier to mix with herbicide
- Hourly wage rate of applicator
- Size of the trees to be deadened

Combine that price, quantity, and size information with the following coefficients for trees of various size classes.

D.B.H. (inches)	X	Y
2	0.015	0.82
4	0.017	0.3875
6	0.017	0.2475
8	0.017	0.1775
10	0.017	0.1375
12	0.017	0.1075
14	0.017	0.0875
16	0.017	0.07
18	0.017	0.06
20	0.016	0.0575

The cost of equipment, herbicide, and carrier is relatively small compared to the cost of labor required to deliver the product to the tree.

Use the following equations to calculate the cost of deadening trees per square foot of basal area.

Equation 1:

G = H+QC

Where

G = total cost of mixing one gallon of herbicide
H = cost of the herbicide per gallon
Q = quantity of water, vegetable oil, fuel oil or other carrier in gallons to be mixed with 1 gallon of herbicide
C = cost of the carrier per gallon (may be zero)

Equation 2:

M = G/(1 + Q)

Where

M = cost per gallon of herbicide mixture, ready to apply
G = total cost of mixing 1 gallon of herbicide
Q = number of gallons of carrier to mix with 1 gallon of herbicide

Equation 3:

T = WY+MX

Where

T = total cost of the application work per square foot of basal area for a given size class
W = hourly wage rate of applicator ($/hr.)
M = cost per gallon of the herbicide mixture, ready to apply
Y = time required to treat 1 square foot of basal area of trees in a given diameter class
X = quantity of herbicide mixture required to treat 1 square foot of basal area of trees in a given diameter class

USING THE EQUATIONS AND CONVERTING COSTS FROM SQUARE FOOT OF BASAL AREA TO DIAMETER INCH

The cost of herbicide (H) is $60/gallon. It is mixed with 1 gallon of water as a carrier (at no cost). The hourly wage rate of the applicator is $10/hour. The size of the trees to be deadened is 10 inches dbh. What is the cost of deadening these trees per square foot of basal area? What is the cost of deadening them per diameter inch?

From Equation 1:

G = H+QC
G = $60+1(0) = $60

From Equation 2:

M = G/(1+Q)
M = $60/(1+1) = $30

From Equation 3:

T = WY+MX
T = $10(.1375)+$30(.017) = $ 1.89 per square foot of basal area

To answer the second question, information in the following table is used to convert costs from square foot of basal area to diameter inch.

Diameter	Basal Area	Trees/1 square foot	Dia. In./sq.ft.
2	.022	45.45	90.9
4	.087	11.49	46.0
6	.196	5.10	30.6
8	.349	2.87	23.0
10	.545	1.83	18.3
12	.785	1.27	15.2
14	1.069	.94	13.2
16	1.396	.72	11.5
18	1.767	.57	10.3
20	2.181	.46	9.2

The trees to be deadened are 10 inches in diameter. Therefore,

$1.89/sq. ft. divided by 18.3 diameter inches/sq.ft. = $0.103 per diameter inch.

Tables I, III, V, and VII are based on calculations made from the above equations. Tables II, IV, VI, and VIII are derived by converting cost per square foot of basal area to cost per diameter inch as shown above.

After the herbicide is mixed with a carrier, it should be placed in a sturdy container and labeled to avoid confusion.

TABLE I

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $20.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	6.86	8.50	10.14	11.78	13.42
4	3.44	4.22	4.99	5.77	6.54
6	2.32	2.82	3.31	3.81	4.30
8	1.76	2.12	2.47	2.83	3.18
10	1.44	1.72	1.99	2.27	2.54
12	1.20	1.42	1.63	1.85	2.06
14	1.04	1.22	1.39	1.57	1.74
16	0.90	1.04	1.18	1.32	1.46
18	0.82	0.94	1.06	1.18	1.30
20	0.78	0.90	1.01	1.13	1.24

TABLE II

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $20.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.075	0.094	0.112	0.130	0.148
4	0.075	0.092	0.108	0.125	0.142
6	0.076	0.092	0.108	0.124	0.141
8	0.077	0.092	0.107	0.123	0.138
10	0.079	0.094	0.109	0.124	0.139
12	0.079	0.093	0.107	0.121	0.136
14	0.079	0.092	0.105	0.119	0.132
16	0.078	0.090	0.103	0.115	0.127
18	0.080	0.091	0.103	0.115	0.126
20	0.085	0.097	0.110	0.122	0.135

TABLE III

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $30.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	7.01	8.65	10.29	11.93	13.57
4	3.61	4.39	5.16	5.94	6.71
6	2.49	2.99	3.48	3.98	4.47
8	1.93	2.29	2.64	3.00	3.35
10	1.61	1.89	2.16	2.44	2.71
12	1.37	1.59	1.80	2.02	2.23
14	1.21	1.39	1.56	1.74	1.91
16	1.07	1.21	1.35	1.49	1.63
18	0.99	1.11	1.23	1.35	1.47
20	0.94	1.06	1.17	1.29	1.40

TABLE IV

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $30.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.077	0.095	0.113	0.131	0.149
4	0.078	0.095	0.112	0.129	0.146
6	0.081	0.098	0.114	0.130	0.146
8	0.084	0.099	0.115	0.130	0.146
10	0.088	0.103	0.118	0.133	0.148
12	0.090	0.104	0.118	0.133	0.147
14	0.092	0.105	0.118	0.131	0.145
16	0.093	0.105	0.117	0.130	0.142
18	0.096	0.108	0.119	0.131	0.143
20	0.102	0.115	0.127	0.140	0.152

TABLE V

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $40.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	7.16	8.80	10.44	12.08	13.72
4	3.78	4.56	5.33	6.11	6.88
6	2.66	3.16	3.65	4.15	4.64
8	2.10	2.46	2.81	3.17	3.52
10	1.78	2.06	2.33	2.61	2.88
12	1.54	1.76	1.97	2.19	2.40
14	1.38	1.56	1.73	1.91	2.08
16	1.24	1.38	1.52	1.66	1.80
18	1.16	1.28	1.40	1.52	1.64
20	1.10	1.22	1.33	1.45	1.56

TABLE VI

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $40.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.079	0.097	0.115	0.133	0.151
4	0.082	0.099	0.116	0.133	0.150
6	0.087	0.103	0.119	0.135	0.152
8	0.091	0.107	0.122	0.138	0.153
10	0.097	0.112	0.127	0.142	0.157
12	0.101	0.115	0.130	0.144	0.158
14	0.105	0.118	0.131	0.144	0.158
16	0.108	0.120	0.132	0.144	0.157
18	0.113	0.124	0.136	0.148	0.159
20	0.120	0.132	0.145	0.157	0.170

TABLE VII

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
(Herbicide and Carrier Cost: $50.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	7.31	8.95	10.59	12.23	13.87
4	3.95	4.73	5.50	6.28	7.05
6	2.83	3.33	3.82	4.32	4.81
8	2.27	2.63	2.98	3.34	3.69
10	1.95	2.23	2.50	2.78	3.05
12	1.71	1.93	2.14	2.36	2.57
14	1.55	1.73	1.90	2.08	2.25
16	1.41	1.55	1.69	1.83	1.97
18	1.33	1.45	1.57	1.69	1.81
20	1.26	1.38	1.49	1.61	1.72

TABLE VIII

ESTIMATED TOTAL COST PER SQUARE FOOT OF BASAL AREA
DIAMETER INCH
(Herbicide and Carrier Cost: $50.00 per gallon)

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.080	0.098	0.117	0.135	0.153
4	0.086	0.103	0.120	0.136	0.153
6	0.092	0.109	0.125	0.141	0.157
8	0.099	0.114	0.130	0.145	0.160
10	0.107	0.122	0.137	0.152	0.167
12	0.113	0.127	0.141	0.155	0.169
14	0.117	0.131	0.144	0.157	0.170
16	0.123	0.135	0.147	0.159	0.171
18	0.129	0.141	0.152	0.164	0.176
20	0.137	0.149	0.162	0.174	0.187

EXAMPLE PROBLEM 1

Purpose: This problem is designed to help you use Equations 1 and 2 to determine the cost of herbicide mixture, and (given inventory information in diameter inches) use the appropriate table to estimate the cost of doing a silvicultural treatment.

Use the preceding equations and tables to estimate the cost of releasing 20 crop trees per acre on a 15 acre project using the inventory of trees to be deadened from 1/10th acre plots. The cost of labor is $8.00 per hour and the cost of the herbicide is $60/gallon, and it is to be mixed with water at a ratio of 1 to 1. One gallon of water is mixed with one gallon of herbicide.

Inventory information:

DBH	Dia. In./acre	Cost/dia. inch	Cost/acre
4	80		
6	240		
8	320		
10	200		
Total	840		

SOLUTION:

Use Equations 1 and 2 to determine the cost of the herbicide mixture ready to apply.

From Equation 1:

G = H+QC
G = $60+1(0)

From Equation 2:

M = G/(1+Q)
M = $60/(1+1) = $30

From Table IV, $30/gallon herbicide and carrier cost table, obtain the cost per diameter inch for each respective diameter class. Multiply the diameter inches per acre to be treated times the cost per diameter inch to obtain the estimated cost of releasing the 20 crop trees per acre.

DBH	Dia. In./acre	Cost/dia. inch	Cost/acre
4	80	.078	6.24
6	240	.081	19.44
8	320	.084	26.88
10	200	.088	17.60
Total	840		$70.16

Since the project area is 15 acres:

15 acres ($70.16/acre) = $1,052.40

EXAMPLE PROBLEM 2

Purpose: This problem is designed to help you use Equations 1 and 2 to determine the cost of herbicide mixture, and (given inventory information in square feet of basal area) use Equation 3 to estimate the cost of doing a silvicultural treatment. This procedure is needed when labor and herbicide mixture costs do not coincide with parameters in a table.

Using the equations that preceded the Tables I-VIII, estimate the cost of doing the following silvicultural work. How much will it cost to do 15 acres of site preparation for natural regeneration work using herbicides to deaden interfering trees? Treated trees will be injected with herbicide using a hatchet and squirt bottle. The cost of the herbicide is $56 per gallon. Reading the label reveals the herbicide is water soluble and for this type of application it should be a 50 percent solution (mix one gallon of herbicide with one gallon of water). Your labor cost is $8.00 per hour. You have inventoried the work area, and estimated the square foot of basal area per acre to be deadened by diameter class as follows (two left columns).

DBH	Basal area/acre	Cost/sq. ft. of BA	Cost/acre
2	.5		
4	1		
6	2		
8	2.5		
10	3		
12	10		
14	14		
Total	33		

SOLUTION:

Use Equations 1-3 to calculate the cost per square foot of basal area by diameter class and the cost per acre.

From Equation 1:

G = H+QC
G = $56+1(0)

From Equation 2:

M = G/(1+Q)
M = $56/(1+1) = $28

From Equation 3:

T = WY+MX

Using X and Y values (from Table on page 17) for trees in the respective diameter classes, calculate the cost for each class:

For 10-inch dbh trees,
T = $8(.1375) + $28(.017) = $1.58
Cost/acre = 3.0 sq.ft./ac($1.58/sq.ft.) = $4.74

Following is the completed table for the diameter classes in this treatment area.

DBH	Basal area/acre	Cost/sq. ft. of BA	Cost/acre
2	.5	6.98	3.49
4	1	3.58	3.58
6	2	2.46	4.92
8	2.5	1.90	4.75
10	3	1.58	4.74
12	10	1.34	13.40
14	14	1.18	16.52
Total	33		$51.40

Since the proposed work area is 15 acres, the estimated cost of this treatment is:

15 acres ($51.40/acre) = $771

Note: When herbicides are used to do silvicultural treatments, the root systems as well as the stem are killed. Depending on the herbicide being used, nearby trees, especially of the same species, may also be affected through root grafts. When this is undesirable, managers may need a means to do treatments that does not involve the use of herbicides. Tables IX and X or the following formula may be used to estimate the cost of doing treatments in young stands.

Cost per square foot of basal area by diameter class = Labor rate (Y)

Where Y has the following respective values by diameter class:

DBH	Y
2	.81
3	.55
4	.385
5	.315
6	.245
7	.205
8	.175
9	.15
10	.135

For example, if trees to be treated are 10 inches in diameter, and the labor rate is $10/hour, the estimated cost of doing the work is:

C = .135($10) = $1.35 per square foot of BA

TABLE IX

ESTIMATED THINNING COSTS FOR YOUNG STANDS
PER SQUARE FOOT OF BASAL AREA
NO HERBICIDE

DBH	HOURLY LABOR RATE				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	6.48	8.10	9.72	11.34	12.96
3	4.40	5.50	6.60	7.70	8.80
4	3.08	3.85	4.62	5.39	6.16
5	2.52	3.15	3.78	4.41	5.04
6	1.96	2.45	2.94	3.43	3.92
7	1.64	2.05	2.46	2.87	3.28
8	1.40	1.75	2.10	2.45	2.80
9	1.20	1.50	1.80	2.10	2.40
10	1.08	1.35	1.62	1.89	2.16

TABLE X

ESTIMATED THINNING COSTS FOR YOUNG STANDS
PER DIAMETER INCH
NO HERBICIDE

D.B.H.	Hourly Labor Rate				
(inches)	$8.00	$10.00	$12.00	$14.00	$16.00
2	0.071	0.089	0.107	0.125	0.143
3	0.096	0.120	0.143	0.167	0.191
4	0.101	0.126	0.151	0.176	0.201
5	0.110	0.137	0.164	0.192	0.219
6	0.107	0.134	0.161	0.187	0.214
7	0.108	0.135	0.162	0.189	0.216
8	0.106	0.133	0.159	0.186	0.212
9	0.104	0.130	0.157	0.183	0.209
10	0.105	0.131	0.157	0.183	0.210

EXAMPLE PROBLEM 3

Purpose: This problem is designed to build on what you learned in Example Problem 1 using diameter inches as the inventory parameter. It shows how to go from raw diameter-inch-inventory information to a completed cost estimate for a project.

The following tally sheet is from a one-tenth acre plot where crop trees, cut trees, and leave trees were inventoried. Normally, several plots like this would be measured to get an estimate of average

CROP TREE RELEASE TALLY SHEET

LANDOWNER: DATE: 8-22-00
STAND HISTORY: Abandoned pasture that reverted to forest
STAND NUMBER: 1 TYPE: cherry-maple AGE: 35-40 years
ACRES: 20 ~~BAF~~: 1/10 acre SITE: mesic
LANDOWNER OBJECTIVES: timber income, mast for wildlife, fall foliage

Species	DBH	Ht	Crop Tree			Other Tree	
			T,W, A,WQ	F T G	#/Ac	C,L	#/Ac
BC	16		T+W	2			
RM	10					C	
BC	12					C	
RM	6					C	
SM	8					L	
SM	10					L	
SM	8					L	
BC	8					C	
SM	8					C	
SM	10		T+A	0			
SM	6					C	
SM	10					C	
RM	6					C	
SM	8		T+A	0			
WA	6					C	
BC	4					C	
SM	6					C	
WA	6					C	
WA	8					C	
WA	8		T	0			
SM	6					L	
SM	6					L	

USDA Forest Service, NA-S&PF, Morgantown, WV
(January 1993)
(from Crop Tree Management In Eastern Hardwoods)

BC - black cherry
SM - sugar maple
RM - red maple
WA - white ash

Crop Tree Categories:
T - Timber
W - Wildlife
A - Aesthetic

Other Tree Categories:
C - Cut Tree
L - Leave Tree

DBH - Diameter Breast High
Ht - Height
FTG - Free To Grow Rating (0-4)

stand conditions. For the purpose of this learning exercise, use this one plot as though it represents the average condition in this stand.

Compare the cost of releasing crop trees in this 20 acre stand using a herbicide with the cost of doing the same treatment mechanically with chain saws.

For the herbicide treatment, the chemical costs $60 per gallon and is mixed at a 1:1 ratio with water as a carrier (no cost). The labor cost to do the work is $10.00 per hour.

For the mechanical treatment, the cost of a person with a chainsaw is $10.00 per hour.

The data on the foregoing tally sheet is for one-tenth of an acre. There are four crop trees on that plot, representing 40 crop trees per acre to be released. There are an additional five leave trees (L) per acre that are not being cut because they do not interfere with a crop tree. There are 13 trees that are to be either deadened with herbicide, or cut (C). These 13 trees represent 130 trees per acre to be treated.

The following table shows the distribution of the treated trees by diameter class as it was summarized from the tally sheet and converted to a per acre basis.

DBH	Trees/acre	Dia. In./acre	Cost/dia. inch	Cost/acre
4	10	40		
6	60	360		
8	30	240		
10	20	200		
12	10	120		
Total	130	960		

The herbicide mixture is delivered into the hack made by a small hatchet on the sapling-size beech. A hatchet and commonly used herbicide is much safer for most applicators than a chainsaw.

Striped-maple that interferes with the establishment of regeneration can be treated with herbicide. Cutting this stem and not using herbicide would cause it to re-sprout and continue to inhibit the establishment of desirable tree species.

SOLUTION:

The following two tables list the cost of treatment by diameter class for each of the two methods. The number of trees per acre in each class is multiplied by the size of the tree to obtain the diameter inches per acre in each class. The diameter inches per acre is multiplied by the cost per diameter inch (obtained from Tables IV and X respectively), to obtain cost per acre by diameter class. The summation of the diameter class costs gives the total cost per acre.

COST PER ACRE BY DIAMETER CLASS FOR THE HERBICIDE METHOD

DBH	Trees/acre	Dia. In./acre	Cost/dia. inch	Cost/acre
4	10	40	.095	3.80
6	60	360	.098	35.28
8	30	240	.099	23.76
10	20	200	.103	20.60
12	10	120	.104	12.48
Total	130	960		$95.92

COST PER ACRE BY DIAMETER CLASS FOR THE MECHANICAL METHOD

DBH	Trees/acre	Dia. In./acre	Cost/dia. inch	Cost/acre
4	10	40	.126	5.04
6	60	360	.134	48.24
8	30	240	.133	31.92
10	20	200	.131	26.20
12	10	120	.131*	15.72
Total	130	960		$127.12

* cost per diameter inch was assumed to be the same as for the 10-inch class

Since this treatment area is 20 acres in size, the cost differential for these two methods on this project is as follows:

Herbicide method: $95.92 per acre (20 acres) = $1,918.40

Mechanical method: $127.12 per acre (20 acres) = $2,542.40

These cost revisions were possible with the assistance of the following individuals:

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Jim Kochenderfer, USDA Forest Service, Northeastern Research Station

The following formula and table can be used to estimate the cost of pruning pine to a respective height.

Cost per tree per pruned height class = Labor rate (Y)

Where Y has the following respective values by diameter class:

DBH	Y
6	.053
7	.06
8	.067
9	.073
10	.08
11	.093
12	.107
13	.12
14	.135
15	.16
16	.18
17	.20

For example, when the labor rate is $10/hour, the cost of pruning pine to a height of 17 feet is:

Cost of pruning pine per tree = $10 (.20) = $2.00

ESTIMATED COST PER TREE FOR PRUNING PINE

Pruned Height	Hourly Labor Rate				
(feet)	$8.00	$10.00	$12.00	$14.00	$16.00
6	0.42	0.53	0.64	0.74	0.85
7	0.48	0.60	0.72	0.84	0.96
8	0.54	0.67	0.80	0.94	1.07
9	0.58	0.73	0.88	1.02	1.17
10	0.64	0.80	0.96	1.12	1.28
11	0.74	0.93	1.12	1.30	1.49
12	0.86	1.07	1.28	1.50	1.71
13	0.96	1.20	1.44	1.68	1.92
14	1.08	1.35	1.62	1.89	2.16
15	1.28	1.60	1.92	2.24	2.56
16	1.44	1.80	2.16	2.52	2.88
17	1.60	2.00	2.40	2.80	3.20

Estimating the costs of doing silvicultural treatments is difficult because of the many variable factors that influence cost. The equations and tables presented provide a starting point. As experience in a local area is obtained, adjustments can be made to fit local conditions and crew experience.

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