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IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF CALIFORNIA

EARTH ISLAND INSTITUTE, a non-profit)
organization,)

Plaintiff,)

vs.)

KATHLEEN MORSE, in her official capacity)
as Forest Supervisor for Lassen National)
Forest, RANDY MOORE, in his official)
capacity as Regional Forester for Region 5 of)
the United States Forest Service, , and the)
UNITED STATES FOREST SERVICE,)

Defendants.)
)
)
)
)

Case No.: 2:08-cv-01897-JAM-JFM

**DECLARATION OF DR. GUY PINJUV
IN SUPPORT OF PLAINTIFF'S
MOTION FOR SUMMARY
JUDGMENT**

Hearing: April 8, 2009 at 9:00 a.m.
Courtroom: 6

1 I, GUY PINJUV, Ph.D., hereby declare as follows:
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4 **Qualifications**
5

6 1. My name is Guy L. Pinjuv. I am a forest scientist with more than 11 years of research
7 experience with both private and governmental organizations in the United States and New
8 Zealand. I have a B.A. in Physics and a B.S. in Forestry Timber Resource Management from the
9 University of Montana, a M.S. in Forestry from Northern Arizona University, and a Ph.D. in
10 Hybrid Forest Growth Modelling from the University of Canterbury in New Zealand. I am
11 currently a Post-Doctoral Research Fellow at the Department of Forest Ecosystems and Society
12 with Oregon State University and am studying landscape scale vegetative responses to climate
13 change. I have published papers in Forest Ecology and Management, Forest Products, Forest
14 Service General Technical Reports, have completed studies on fire reduction and ecological
15 restoration treatments that have been presented to the United States Congress, and have
16 published a book on hybrid physiological forest growth modelling. I have been a private forest
17 consultant for government, and non-profit organizations in New Zealand, Northern California,
18 Northern Arizona, Oregon, Washington, and New Hampshire, and have done contracted research
19 funded by NASA.

20 2. I have experience with indices related to biological overcrowding. My published book
21 and PhD thesis, “Hybrid Forest Modelling, Integrating Physiological and Statistical Approaches
22 to Predict Stand-Level Growth of Pinus radiata D. Don in Canterbury New Zealand” is research
23 on forest growth modelling systems that predict growth using both physiological principles of
24 tree growth and statistical models of historical growth measurements. This research includes
25 modelling forest canopy structure, root zone water balance as predictors of tree growth, and uses
26 an index based on the law of self thinning to predict future mortality of trees.

27 **Information Reviewed**
28

1 3. I reviewed the following documents related to the Champs Project, Located in the Lassen
2 National Forest, Eagle Lake Ranger District. The Champs Decision Notice and Finding of No
3 Significant Impact (hereafter “DN”), the Champs Environmental Assessment (hereafter
4 “EA”),the Champs Silvicultural Report (hereafter “Silvicultural Report”), The Forest Vegetation
5 Simulator output prepared for the Champs project and the 2004 Letter from the Region 5
6 Regional Forester regarding Stand Density. I also reviewed related scientific literature. A list of
7 scientific references is included at the end of this report. In my review, I also drew on my own
8 professional judgement and experience.

9 4. The Purpose of this report is to help explain technical terms, including the concepts of
10 Stand Density Index (SDI), Limiting Stand Density Index, Maximum Stand Density Index (SDI-
11 Max), and explain to the Court how the use of an erroneous SDI-Max value, when
12 recommendations regarding the intensity of thinning rely on the forest stands being reduced to a
13 certain percentage of SDI-Max, can corrupt the scientific accuracy of the Forest Service’s project
14 documents and decision.

14 **Stand Density Index and -3/2 Power Law of Self Thinning**

15 5. (Reineke 1933) described Stand Density Index (SDI) as “a measurement of relative
16 density in single-species, even-aged forest stands”. The main purpose of this index is to allow
17 comparisons of stands of different densities (trees per acre) and different ages within the same
18 region. Reineke (1933) developed the index of SDI by examining size-density data for 14 forest
19 types – pure and mixed composition, natural stands and plantations – and concluded that when
20 the logarithm (log) of quadratic mean diameter was plotted against the log of stem density (trees
21 per acre), the maximum values formed a slope that was consistent among species (equation 1).
22 Although the slope appeared to be constant, the intercept varied among species, indicating that
23 different maximum values existed for different species. When the intercept is located such that
24 all size-density points fall below the curve, the curve represents the maximum size-density
25 relationship for the species or forest type (Shaw, 2006).

25 Equation 1:

$$26 \log N = -1.605\log D + k$$

27
28

1 Where: N = number of trees per acre, D = diameter at breast height, and k = constant varying
2 with species

3
4 6. For any stand, relative density (or the density of trees in one stand as it relates to another
5 in terms of total available resources used) could be described in two ways. In the first, the
6 maximum size-density curve represents 100% density and other size-density combinations are
7 expressed as a percentage of the maximum. Because the maximum varied by species, Reineke
8 suggested an alternative in which all size-density combinations were referenced in terms of
9 equivalence to the number of 10-inch stems per acre. In practice, both methods are useful – in
10 the former case, the density of a stand can be assessed in terms of the maximum possible for its
11 type, and in the latter, the density of stands of differing composition may be compared to a
12 common reference (Shaw, 2006). Reineke’s SDI is the latter case, which is calculated directly
13 using (equation 2).

14 Equation 2:

$$SDI = TPA(Dq/10)^{1.605}$$

15
16
17 Where: TPA is the number of trees per acre, and Dq is quadratic mean diameter (in inches) of the
18 tree bole measured at 4.5 feet.

19
20 7. This size density relationship developed by Reineke (1933), was related to later research
21 used by Japanese scientists who experimentally explored size density relationships across many
22 species and life forms and developed the -3/2 self thinning law (equation 3) (Yoda *et al.* 1963).
23 This rule is very similar to that used by Reineke (1933) but it relates mass to density rather than
24 stem diameter to density, and is really a more robust and powerful way of expressing biological
25 carrying capacity of a given system.

26 Equations 3 & 4:

$$W = C \cdot N^{\left(\frac{-3}{2}\right)}$$

1 Or

$$2 \log W = -\left(\frac{3}{2}\right) \cdot \log N + \log C$$

3
4 Where: W = plant weight in kg, N = plant density (stems/ha), C= constant

5
6 This law states that the slope of the relationship between log(stocking) and the log(stem mass) is
7 linearly related and has a slope of -3/2. This law is based on the geometrical overcrowding of
8 growing space and describes mortality caused by competition for space and resources.

9 **Stand Density Index, Practical Example**

10
11 8. Another way of describing SDI is that it is a number telling us how close to the maximum
12 carrying capacity of a given system we are for a certain species. So the question is how many
13 individuals can get the resources needed for survival? A simplified example of a closed system
14 that might help conceptualize the meanings of SDI, SDI-Max, and limited-SDI is to imagine an
15 animal cage with a fixed daily supply of food and water. The cage might be able to support many
16 “healthy” baby rats on the daily food supply and space for growth. As the rats grow into
17 adolescence and each individual requires more food as their metabolisms increase, there will
18 only be enough food to support the same number of “weak” adolescent rats (the number of weak
19 rats supported would be akin to a “limited-SDI”, or a level where the individuals are weakened).
20 Now if you let all of these rats grow into maturity with the same daily intake of food, something
21 will have to give in this closed system and some of these unhealthy adolescent individuals will
22 not make it to maturity, likely dying of malnutrition. A certain number of the rats will live into
23 maturity growing into adults. The idea of SDI-Max is akin to the carrying capacity for that cage
24 of adult rats. How many individuals of a given size (regardless of their health) can be supported?
25 As they grow in body mass, rats will surely die as there will not be enough food for them all. The
26 idea of SDI then tells us how close to the maximum, and the limited level we are for a given
27 species.

28 9. The maximum and limited level of SDI is also a species dependant index. For example,
the same cage and food supply will surely support different numbers of baby, adolescent, and
adults of a different species (say one with a much smaller average body mass and metabolism).

1 Now consider mice eating the same supply of rat food in the same cage. Self thinning of the
2 population will occur as the population grows, but at much higher relative numbers as the mice
3 consume much less food and water than do rats. There will initially be many more baby mice,
4 and as they grow their numbers will thin as there is not enough food to support them. This self
5 thinning will occur at different rates with mice than would occur with rats. And in the end, the
6 cage will support many more adult mice than it will adult rats. So each forest species will be
7 similar to this example (though slightly more complicated), each species will have its own
8 corresponding SDI-Max, limited-SDI, and SDI for a certain piece of forest land, where the land
9 represents the resources available for growth, and in our example is analogous to the animals
10 food, water, and cage size.

11 **Misuse of SDI-Max as a Cutting Limit in the Champs Project**

12
13 10. The concept of SDI-Max is based on the same biological principal as the $-3/2$ power law
14 (Equation #4 above). SDI-Max is the maximum biological growing limit and cannot be
15 exceeded. While, as discussed previously, SDI-Max values can and do vary between species it is
16 inaccurate and incorrect to ever describe stand conditions as being over 100% of SDI-Max.

17 11. There is a significant body of scientific literature that sets the SDI-Max value for
18 ponderosa pine in northern California (Forest Service Region 5) at 571 (Oliver and Uzoh 1997,
19 Dixon 1992, and Dixon 1994). Thus, in order to be scientifically accurate, any thinning
20 prescription proposed in Region 5, which uses SDI as a target for timber removal, should use
21 SDI-Max values consistent with current literature.

22 12. For the Champs project area, which is located in Region 5, the Forest Service utilized an
23 erroneous value for SDI-Max as a target for the proposed thinning prescriptions. The
24 Silvicultural Report, on page 14, inaccurately characterizes SDI-Max stated in Oliver (1995) as
25 having a value of 365. The Silvicultural Report states, "*Pines have a suggested maximum SDI of*
26 *365 (Oliver 1995) and because this is the most limiting species within the stands this will be the*
27 *maximum SDI used for all stands even though other species can persist at higher densities*".

28 However, Oliver (1995) actually states that the SDI-Max used at that time for ponderosa pine in
Region 5 was 500, not 365. Forest stands can and do reach SDI-Max (Oliver 1995, Oliver and

1 Uzoh 1997). As cited above, more recent scientific literature, available at the time the Forest
2 Service prepared their analysis, sets SDI-Max for ponderosa pine at 571.

3 13. Oliver (1995) does state “the *limiting* SDI for ponderosa pine stands in northern
4 California as defined by Dendroctonus bark beetles is 365”. This “limiting-SDI” refers to a level
5 of stand density where some of the less vigorous ponderosa pines in that region could be
6 weakened by competition and could succumb to bark beetle attacks as the stand increases in
7 density toward SDI-Max. Limiting SDI is not the same concept as SDI-Max (see Practical
8 Example). This point is crucial to understanding the relevance of the error made by the Forest
9 Service because the 2004 Letter (referenced on pg. 14 of the Silvicultural Report) which is
10 directing the Forest Service’s actions here requires thinning prescriptions to reduce a forest stand
11 to a percent of SDI-Max, and not to a percentage of Limiting SDI.

12 14. In addition, as previously discussed, SDI-Max values are species specific and thus cannot
13 be applied to other species. The Silvicultural Report, on page 14 inaccurately characterizes SDI-
14 Max recommended in Oliver (1995) as 365, and incorrectly applies this number to both
15 ponderosa pine and white fir. There is no rationale consistent with the concepts of SDI and SDI-
16 Max which allows assignment of an SDI-Max to a forest stand of mixed species based on the
17 species within that stand which has the lowest value for SDI-Max (Shaw 2006). While the
18 Champs area is mostly pine, many of the stands are partially, or predominantly, white fir. White
19 fir has an SDI-Max value of 800 (Oliver and Uzoh 1997, Zhang et al. 2007).

20 15. The Forest Service’s use of an erroneous SDI-Max is further evidenced by the
21 Silvicultural Report’s continued reference to current and future conditions being more than 100%
22 of SDI-Max. The Silvicultural Report describes the existing condition in the eastside mixed
23 conifer stands analyzed as being “139% of SDI-Max” (pg. 36) and the condition for eastside pine
24 after 20 years, if no thinning was done, as being 101% of SDI-Max (pg. 76), both of which, are
25 biologically unreasonable. Any prescription based on erroneously low estimates of SDI-Max will
26 remove more timber volume to attain targets that are based on leaving stands at some pre-
27 determined percentage of SDI-Max, or targeted SDI, than if the SDI-Max value were set
28 correctly at the higher level.

Necessary Prescriptions Using Correct SDI-Max

1 16. The thinning diameter limit of 20 inches is higher than is needed to meet the SDI target
2 recommended on page 17 of the Silviculturalist Report. The recommended thinning target
3 suggests reducing stand SDI to 35-50% of SDI- Max following thinning, such that they will not
4 exceed 60% of SDI-Max 20 years after thinning (EA, p. 10; Silvicultural Report, pp. 14, 17). If
5 the correct SDI-Max values are used that proportionally reflect a mixture of species contained in
6 the stands (571 for Ponderosa Pine (Oliver and Uzoh, 1997), and 800 for White fir (Zhang *et al.*
7 2007)), then the FVS output for all of the prescriptions would need to be re-run to assess if
8 prescriptions met the stated target in the EA and Silvicultural Report. If the proper, species
9 specific, literature recommended SDI-Max values are used in FVS model projections, a
10 prescription with a lower diameter limit than that recommended in the DN will meet the
11 criterion.

12 17. The target of 35-50% of SDI-Max would also be met for 100% of the stands in the
13 Champs project immediately after thinning to the 12” diameter limit used in the FVS outputs,
14 even if we accepted the Forest Service assumption that the SDI-Max for Ponderosa Pine (571)
15 should be applied to all species within the analysis. Also, even if the SDI-Max for Ponderosa
16 Pine was applied to all species, nearly all stands would not exceed 60% of SDI-Max at 20 years
17 after thinning (the only stand very nearly missing this target is stand 110011, with the highest
18 density, would have 60.4% of SDI-Max 20 years after thinning with a 12” diameter limit). Thus
19 it is likely that a thinning prescription diameter limit slightly higher than 12 inches will meet the
20 stated SDI target.

21 **Conclusions**

22 18. The Champs project thinning prescriptions recommended in the DN are based on the
23 application of SDI-Max values which are not consistent with current or referenced scientific
24 literature. Since the assessment of whether a given stand is currently, or will after logging, be 35-
25 50% of SDI-Max is intrinsically tied to the correct SDI-Max value, use of an erroneous value for
26 SDI-Max renders the Forest Service’s analysis scientifically inaccurate. Implementation of these
27 inaccurate prescriptions will result in the removal of larger volumes of timber than is necessary to
28

1 achieve the stated desired forest stand density and compliance with the 2004 Letter from the
2 Regional Forester.

3
4 I declare under penalty of perjury that the foregoing is true and correct to the best of my
5 knowledge.

6 DATED: January 27, 2009
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11 GUY L. PINJUV, Ph.D.
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1 CERTIFICATE OF SERVICE

2 I hereby certify that on January 30, 2009, I served a true and correct copy of Plaintiff's
3 Motion for Summary Judgment and Injunctive Relief with the Clerk of the Court using the
4 CM/ECF system, thus effecting service on upon all the parties and the following attorneys of
5 record:

6 Jared S. Pettinato
7 Jared.Pettinato@usdoj.gov

8
9 */s/ René Voss*
10 RENÉ P. VOSS