A Dynamical Model of Church Growth and Global Revival

John Hayward
University of Glamorgan

Presented at:

Annual Meeting for the Scientific Study of Religion
Houston, Texas, USA
18-21 October 2000

Technical Report UG-M-00-4
(revised October 2001)

A revised version of this paper will be appearing in the Reviews of Religious Research in 2002

Division of Mathematics & Statistics
University of Glamorgan
Pontypridd, CF37 1DL
Wales, UK
(+44) 1443 482258
jhayward@glam.ac.uk
http://www.church-growth-modelling.org.uk/

Abstract

The world-wide Christian church has grown substantially since its beginnings in the first century AD. Such growth has come through conversion into the church from the unbelieving population in which individual church congregations are immersed. In addition it is also fuelled from the children of existing members being brought up and remaining in the faith. However growth is offset by deaths, and the reversion of some church members back to the unbelieving community. This paper sets up a dynamical model of such church growth, based on the methods of systems dynamics, capable of giving qualitative analysis and quantitative simulations of growth. The model is an extended version of a mathematical model of church growth, published by the author, and is presented in the easier-to-understand format of systems dynamics.

The model investigates the claim that conversion growth is driven by a sub-class of church members called enthusiasts. These enthusiasts make contact with unbelievers which in turn leads to the conversion of some of those unbelievers to the church. These new converts also become enthusiasts. A further claim is that enthusiasts only retain their conversion potential for a fixed length of time after which they become inactive church members playing no further part in recruitment. The model is also applied to the growth of movements within the Christian church, such as Pentecostalism, which change the nature of the church over time. In this case the enthusiasts are the proponents of a new brand of Christianity and the "unbelievers" are the Christians who have yet to adopt it.

The effect of enthusiasts on the growth of the church, or movements within it, can be quite dramatic, following a similar pattern to that of an epidemic. Although substantial growth is possible it eventually "burns" itself out due to a lack of enthusiasts. This behaviour is similar to the patterns of growth seen in revivals, or religious awakenings of the past. The key parameter of growth, which represents contact between an enthusiast and unbelievers is investigated in the light of the internet and email. Such global means of communication speed up the transfer of information, enabling enthusiasts to exert a wider influence on the world church. Thus revival, which has tended to be a localised phenomena now has the potential to proceed rapidly on a global scale. The prospect for the future growth of the church is discussed and the results applied to such recent phenomena as the Toronto Blessing, and the South American revivals.

1 Introduction

There is no doubt that the Christian church has grown substantially since its birth. It started with a few hundred people in and around Judea, and after 2000 years has exceeded 1000 million people, some 28% of the world population (Brierley 1999a Table 1.2.1, figure 1.3.2). Often this type of growth is described as "exponential". But what is exponential growth?

True exponential growth assumes the population, in this case the church numbers, increases at the same rate each year. Consider the following situation. A church has a guest service where everybody in the church is asked to bring one new person. If all those people come and stay then clearly the church doubles! Now say that the church had started with 100 people and has one such guest service each year. After the first year it becomes 200. After the second year it becomes 400 if all the new converts do the same. In subsequent years it becomes 800, 1600, 3200 etc. This is exponentially growth. The rate, "multiply by 2", is the same each year, the growth becomes explosive.

What has been constructed here is a model, in this case the exponential model. It can be described by an equation (appendix part1), and the resulting behaviour described by a formula (appendix part1). This is one of the simplest models of population growth that can be constructed. In this case it is a very simple, and unrealistic, model of church growth.

Until recently church growth studies have been confined to qualitative aspects of growth, and the factors that help or hinder it, or to statistical analyses. (See Hayward 1999 for a brief discussion, and Inskeep 1993 for a more in-depth history of church growth). Very little modelling has taken place. Stark (1996 p.7) produced an arithmetic model, similar to the above exponential one, for growth in the early church, based on similar ideas in Stark and Bainbridge (1985, Ch 16). Iannaccone et al (1995) produced a model of church growth along economic lines, however none of these sought to derive the dynamics of the growth from the underlying causes.

In a true dynamic model assumptions are used to construct the model which in turn leads to growth or decline. In the case of the exponential model the assumption is that every person brings someone new to the church in a set period of time and keeps doing so over similar periods of time. This leads to a growth rate that is constant per person, i.e. the rate is proportional to the number in the church. The exponential solution (appendix part1) is the inevitable result of the original, highly idealistic, assumption. Such models can always be expressed precisely using mathematics. The accuracy of the result only depends on the accuracy of the assumptions!

In 1999 the present author presented a more sophisticated model of church growth, which assumed that only some of the church were involved in the conversion process (called enthusiasts or active believers), and their enthusiasm or conversion potential only lasted for a limited period of time. The result was behaviour similar to an epidemic, where growth could be explosive but always eventually burned out. Again the advantage of using such a mathematical model was that the consequence of making these assumptions could be worked through precisely. If the resulting behaviour was not seen in church growth then clearly other factors must be at work. Indeed it is easy to see factor that are missing by asking questions of the above scenario. "What if only some new converts bring in others?" "What if some of the people fall away, or their children do not go on to be believers?" Tackling such questions is one of the advantages of mathematical modelling.

However the mathematical approach also had a distinct disadvantage in that many of the people interested in church growth, and the results of the work, could not understand the technical mathematics used in the paper. In order to widen access to the dynamic modelling of church growth a different approach is needed. Systems dynamics, or systems thinking, is one such alternative approach. It was originally developed by JW Forrester (Forrester 1961) and has been successfully used in such diverse fields as business modelling, ecology, organisational strategy, psychology and sociology (see Ford 1999, Goodman 1989, Sterman 2000 and the Systems Dynamic Society website). Such systems dynamics models are capable of simulation with specialist software. The present author has re-presented and extended the original mathematical model in systems dynamics format (Hayward 2000 a,b).

The purpose of this paper is two-fold:

- To convince church growth practitioners and sociologists of religion that a systems approach to modelling church growth is worth considering;

- To make clear the consequences of the assumption that churches grow through enthusiasts, who are a subset of the church, and whose enthusiasm doesn't last indefinitely.

As such a number of models will be developed. In each model it will possible to:

- State the assumptions underlying the model
- Establish the consequences of these assumptions
- Establish principles of growth
- Identify the parameters in the model and determine their effect

Each model will be presented using the causal loop diagrams of systems thinking, the qualitative part of systems dynamics. For reference the actual systems dynamics models are given in the appendix along with the underlying mathematical equations.

2 Systems Thinking

Systems thinking reduces the dynamics of a problem to the relationship between cause and effect, between conditions and actions. It is especially useful when the actions in turn feed back and affect the conditions. Consider the case of exponential church growth discussed in the introduction. The *conditions* are the number of people in the church called *believers*. The *actions* are that each person brings someone into the church, which will be called the *conversions*. This can be represented by a causal arrow (figure 1).

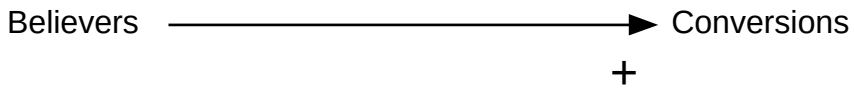


Fig. 1 Causal relationship between the number of believers and the number of conversions

Thus believers "cause" conversions to occur. This is not a theological, or a sociological, explanation of conversion. It may be that the believer has brought the person to a service where some truth, when heard, results in the conversion. It maybe that the believer has told the unbeliever that such services exist or they have been a "good advert" for the beliefs of the church. These points are discussed in Hayward 1999.

The *plus* sign indicates that an *increase* in the number of believers gives an *increase* in the number of conversions, because each believer is bringing someone new at the same rate.

Of course the conversions now result in an increase in the number of believers. Thus there is a link back from "conversions" to "believers". In this case the link is a flow as the people converted flow into "believers". This is represented by a thicker line. Putting the two connections together gives the causal loop diagram for conversion (figure 2).

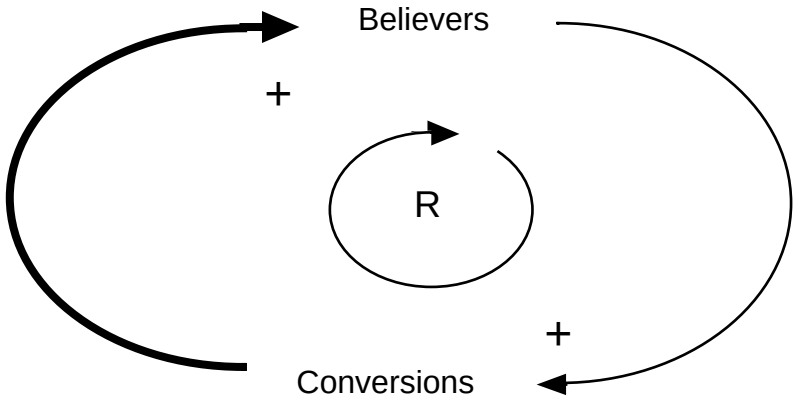


Fig. 2. Causal loop diagram for the conversion process - positive feedback

This link is also *positive* as an *increase* in the number of conversions gives a *faster* increase in the number of believers. This results in a reinforcing loop, also called a positive feedback loop, represented by the "R". The more believers there are in the church the more conversions occur, resulting in yet more believers and conversions etc. This type of analysis is called systems thinking. The systems dynamics model is given in the appendix, part 1.

The resulting solution and simulation shows that growth is exponential (figure 3):

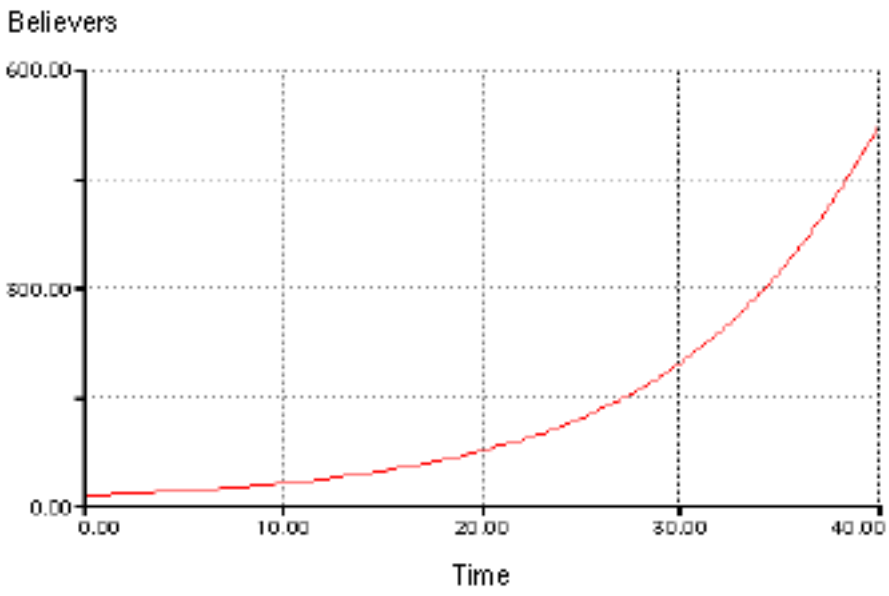


Fig. 3. Exponential growth - result of positive feedback

The assumption that each person makes converts at a constant rate has resulted in exponential growth. This is the consequence of the model. If the rate at which people make converts is increased then the exponential growth gets steeper. This conversion rate is a parameter of the model.

In practice exponential growth cannot occur indefinitely as the population is finite, thus the assumption must be modified. This will furnish a simple model of the dynamics of conversion.

3 Model of Conversion Growth

3.1 Model Construction

The fundamental assumption is that converts result through contact between believers and unbelievers. "Believers" refers to those in the church, and "unbelievers" are those outside it. The population is split into these two categories of people.

It is further assumed that believers do not target unbelievers, nor do they shun them, so that their likelihood of contact with a person is independent of whether they are a believer or not. This is often referred to as homogeneous mixing and is assumed extensively in the theory of the spread of disease. It means that being a church member does not stop a person having a mixture of contacts throughout society. (See Hayward 1999 for a fuller discussion of homogeneous mixing in church growth).

Thus for a conversion to occur, not only must the believer make a contact with another person, the person must be an unbeliever. If people can only hold down a fixed number of relationships in a given time that probability will go down as the number of unbelievers gets less. Indeed the probability is the proportion of unbelievers in society:

$$\text{Probability of finding unbeliever} = \frac{\text{Unbelievers}}{\text{Unbelievers} + \text{Believers}} \qquad \text{(equation 1)}$$

Thus a causal loop diagram can now be constructed for the situation (figure 4). The full systems dynamics model with equations appears in the appendix, part 2.

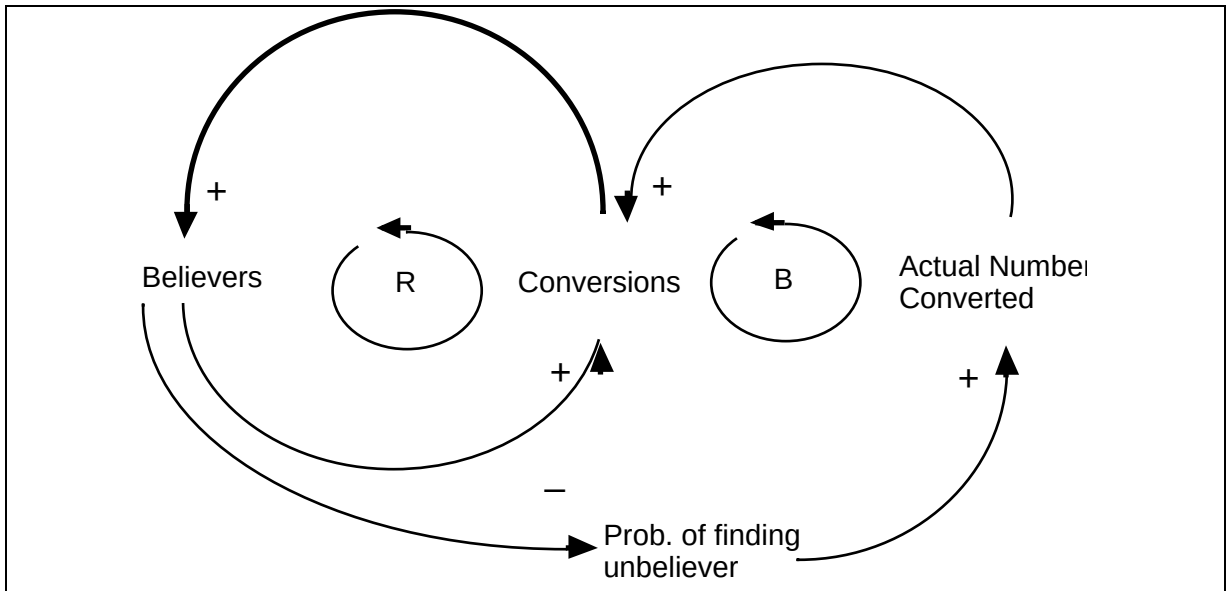


Fig. 4 Causal loops for the conversion process in a population of fixed size

The original reinforcing loop giving the exponential growth is still present, however there is now an additional process. As believers *increase* the probability of finding an unbeliever gets *smaller*. This is a negative link. The decrease in this probability reduces the number of actual conversions per person in a given time period and hence the total number of conversions into believers. Tracing all these causal links from "believers" through the probability back to "believers" shows a net negative effect due to the one negative link. Thus this additional process is a balancing loop, or negative feedback, (indicated by the “B”) slowing down the increase in believers as the church grows.

3.2 Model Simulation

The model can be simulated using appropriate software[1]. This paper uses software called Stella[2]. For a simulation to take place values need to be provided for the number of believers and unbelievers at the beginning of the time period. The time period of the simulation also needs to be set.

Any parameters in the model also need setting. In this model there is only one parameter: the potential number of people a believer is responsible for converting in a given time period, or conversion potential. (For all the simulations in this paper time periods are in years.) The conversion potential is only the same as the actual number converted if all the rest of the population are unbelievers.

If the church is small its growth is initially exponential, due to the reinforcing loop, but slows down as it gets bigger due to the balancing loop becoming more important. Essentially as the pool of unbelievers gets less believers spend more and more time with each other and the conversions start to dwindle. Thus the actual number converted per year by each believer gets less as their effort is “wasted” on the growing number of unbelievers. This type of curve (curve 2 in figure 5) is called the S-shaped or logistic curve. Notice that all of society gets converted.

[1] This is the equivalent of solving the mathematical differential equations that took place in Hayward 1999.
[2] Stella is manufactured by High Performance Systems.

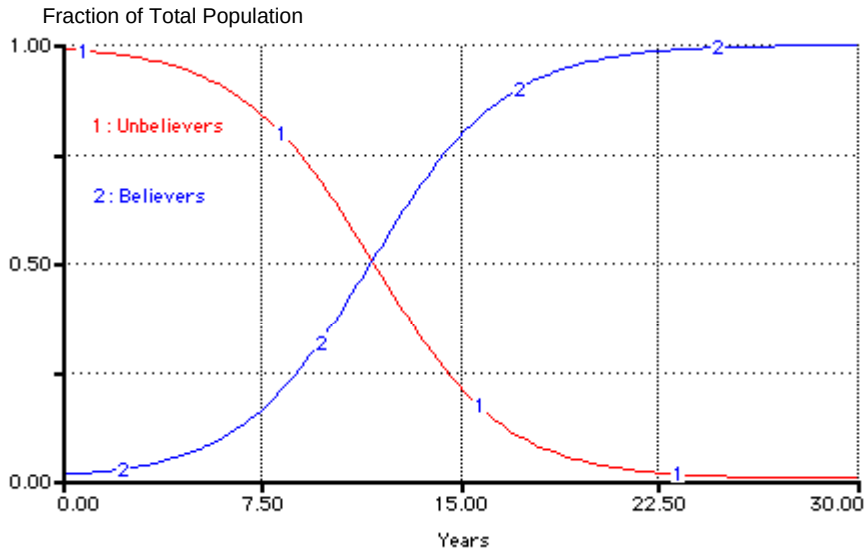


Fig. 5. S-shaped growth of the church, represented by believers

A plot of the number of conversions shows that it peaks when the two categories are equal in size (figure 6):

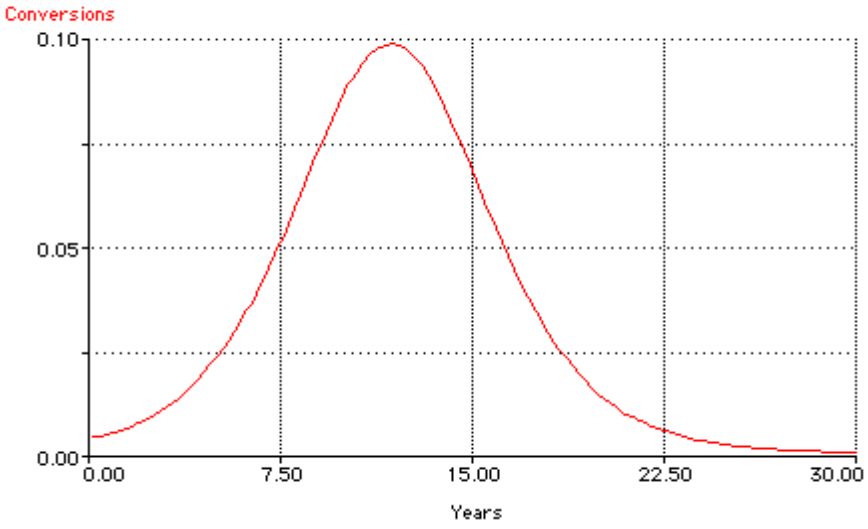


Fig. 6. Percentage converted per year in the conversion model

3.3 Model Conclusions

Assumptions and their Consequences:

If there are no losses from the church, if birth and deaths can be ignored (or even if the birth rate is equal to the death rate in the population), and if all believers are involved in making contacts at the same rate through their lifetime, then all the population ultimately gets converted.

Parameters:

There is one parameter. This is the number of people in a given unit of time one believer is responsible for bringing into the church assuming the whole population are unbelievers. This is called potential number converted per believer per unit of time, or conversion potential. (The actual number of converts per person depends on the proportion of unbelievers in society.)

Principles Established:

1. *The whole population gets converted whatever the conversion rate*. If the conversion rate is lower it just takes longer to convert the whole population. The complete conversion of society is a result of the assumptions not any particular values for the rates. If in practice the whole of society does not get converted then some of the assumptions must be changed.

2. *The bulk of the conversions occur in the middle period of the growth, with early growth being slow*. Early on in the growth there are few contacts, a thus few conversions, because the percentage of unbelievers is so small. Because growth is the main factor through which new churches and revivals in existing ones are first noticed it can mean that such a work can be underway some time before it comes to the attention of the population at large. This was true of the early Christian church which remained small for the first 200 years. E.g. only 1% of the city of Rome was Christian in about 250 AD. Yet by 300 AD the church was so widespread further persecution by the still Pagan state became impossible (Stark 1996). Similarly, in Egypt, estimates of the size of the Christian church based on inscriptions of Christian names shows similar slow then rapid growth (Bagnall 1982).

   This similar slow start can also be seen in the charismatic renewal in the USA and UK through the 1970's which had not been really noticed except by those who were directly involved. However in the early eighties there was rapid growth in the number of independent charismatic fellowships - most of whom had been operating at a smaller level since the early days of the renewal. It was only after they had increased substantially that they drew widespread attention to themselves.

   The S-shaped growth is typical of the type of growth seen in religious revivals. A point comes when the growth of the church explodes because there are so many enthusiasts whose contacts are resulting in the conversion of unbelievers, many of whom also become enthusiasts. Such behaviour can be seen in the Welsh revival of 1904, where 100,000 people were converted in just over a year. Likewise the current revival in South America is seeing explosive growth. Nevertheless no revival, however powerful, has ever resulted in the conversion of a whole population. Thus some changes to the model are required.

Limitations of the Model:

Requires all believers to be recruiters throughout their lives. The model will not apply with anything less than this. It is also limited to time scales short enough that births, deaths and reversion can be safely ignored, up to about 15 years.

4 Limited Enthusiasm

4.1 Model Construction

The consequences of the model of conversion growth do not reflect reality - churches do not grow to take over all of society. Thus the assumptions need to be changed. The fundamental thesis of Hayward 1999 was that only a subset of believers are ever responsible for the conversion growth of the church[3]. Many believers, although playing an active part in church life, play no part in recruitment to its ranks. Recruitment is in the hands of a normally much smaller group of enthusiasts, also called active believers because they alone are active in the conversion of others.

It was further assumed in Hayward 1999 that active believers cease to be active after a length of time. Their enthusiasm is limited in duration, after which they become inactive believers, although still members of the church. It is recognised that new converts are often the most active in the conversion of others (Stark and Bainbridge p.363). However this enthusiastic phase rarely lasts for a number of reasons:

1. The active believers have been recruiting through their network of friends and relatives which is now exhausted. There are three scenarios:
   - The people in this network have become believers themselves;
   - People in this network have become immune to any further pressure to join the church;
   - The active believers have ceased to have meaningful contact with unbelievers. Many new converts find after a year or so that they have a new set of friends in the church and their old unbelieving set

[3] The limited enthusiasm model of church growth was called the simple church growth model in Hayward 1999.

have drifted away. Often the new convert does this subconsciously because being part of the church means taking on a new set of values leaving them uncomfortable with the values of their old friends. In strict churches they may even be encouraged to distance themselves from the world, inadvertently losing their recruitment potential.

2. Churches do not just recruit or evangelise. After a while new converts find other work to do within the church and spend less time on recruitment activities.

3. In periods of intense growth the pastoral demands of dealing with new converts prevent ministers from spending as much time on evangelism as they might like and thus their recruitment potential drops.

4. Often believers run out of enthusiasm for recruitment and settle into a more subdued version of belief where the zeal to see new converts has declined to the point of inactivity. Again there are a number of scenarios behind this:
   - The believer has forgotten why they converted from unbelief to belief. They now have no desire to see others converted;
   - Often the believers gain status within the church and loses the real reasons why they joined in the first place. Any enthusiasm they now have is centred on their own advancement within the church;
   - In non-strict churches the lifestyle is so close to the world that the new convert quickly sees little point in attempting to win people to the church. Believers are so similar to unbelievers that they have little to offer and so stop seeking converts;
   - The believers may find the church so enjoyable that their enthusiasm is for their own experience of it rather than to see others converted;
   - It may be that the church has not lived up to expectation and the believer has lost enthusiasm for anything to do with the beliefs. Instead they have settled into a nominal church life.

Many of these reasons are summed up in Wesley's Law of the decline of pure religion. "Taking up the religion has produced benefits which makes missionary zeal too costly to engage in" (Kelley 1986).

Thus there are now three categories of people in the population. Unbelievers, active believers (called enthusiasts) and inactive believers. As an extension to Hayward 1999 it will also be assumed that not all the new converts become active believers. Some start inactive straight away and remain so. There are a number of reasons for this:

1. They may be naturally shy and unwilling to engage in any form of recruitment;

2. They may be a social isolate and have virtually no network of friends to influence;

3. They may be a secondary convert, the spouse or child of a primary convert, who has "converted" for social reasons. It was common practice in the early church for the pagan husbands of Christian women to "convert" to the church (Stark p. 111-115). Often such secondary converts have little real enthusiasm for the actual faith;

4. It is possible for people to be converted to the ethos of the church - its services, customs, and morality - without ever being converted to the truth of the faith. As such they may have little desire to see others converted. Their "conversion" has been a purely social phenomena rather than one of deep conviction. Nevertheless they are part of the church, albeit an inactive believer.

Thus the flow between the 3 categories is:

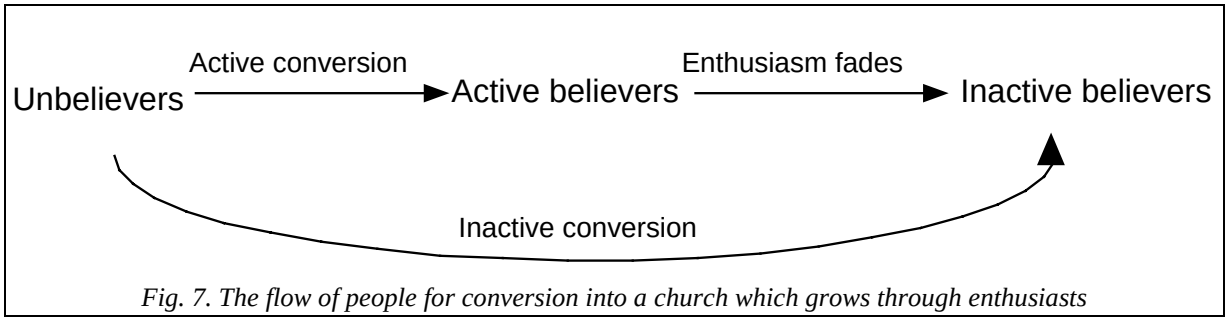


Fig. 7. The flow of people for conversion into a church which grows through enthusiasts

In terms of causal loops the active believers are still subject to the reinforcing loop of the conversion process and the balancing loop as the probability of contact with an unbeliever goes down, as outlined in figure 4. (In figure 4 replace "believers" with "active believers".) However there is now an additional balancing loop as the active believers lose their enthusiasm and "flow" to the inactive believer category.

Because the enthusiastic phase lasts for the same length of time for each active believer (taken as an average figure), the drain from the this category is proportional to the number of active believers. This assumes they were all converted at uniformly different times. E.g. if the enthusiastic phase is one year and there are 12 such active believers then in one month one will be lost. If there are 24 active believers then in one month two will be lost.

Thus the number of active believers positively affects the number of people who lose their enthusiasm in a given time. However these losses also affect the number of active believers negatively as people flow out of this category. This gives the additional balancing loop to figure 4[4]:

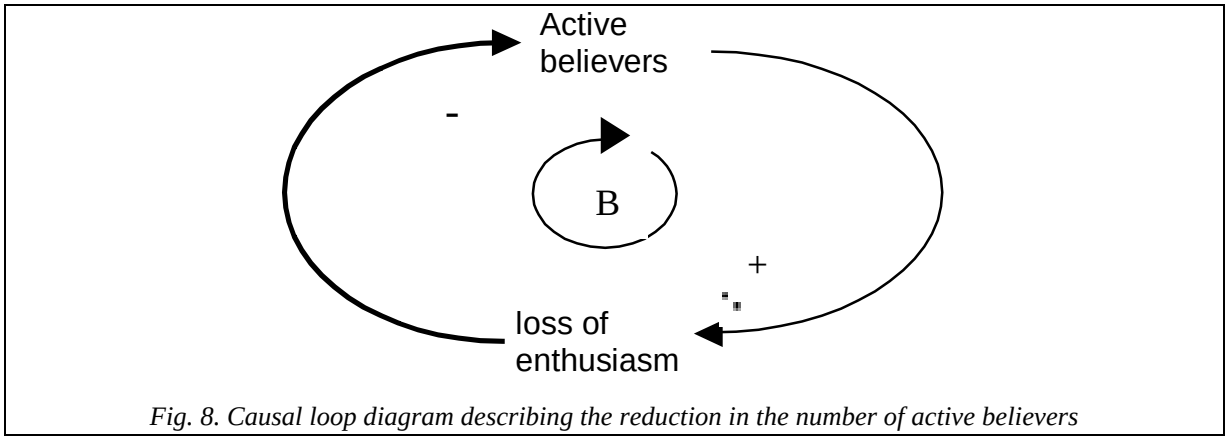


Fig. 8. Causal loop diagram describing the reduction in the number of active believers

If there more active believers then more of them lose their enthusiasm. The loss of enthusiasts is a percentage loss. In turn the loss of enthusiasm drains the active believers, causing their numbers to decline. As it is a percentage loss it continues until no active believers are left. Thus the initial growth in active believers, due to conversion, is eventually drained away until they become zero. This happens before all the population is converted. Thus the growth of the church has been restricted by the limited enthusiastic period of the enthusiasts.

4.2 Model Simulation

A typical simulation of the limited enthusiasm model is given in figure 9. Clearly the numbers in the total church, eventually reflected by just the number of inactives, is limited and the church has failed to convert the whole population. This was the result discovered by Kermack and McKendrick (1927) where they showed that even in an epidemic the infection didn't spread through the whole population. It burned itself out due to a lack of infected people who had less and less contact with those susceptible to the disease and more with those already immune[5]. In the church growth case the growth has run out due to a lack of enthusiasts caused by their limited enthusiastic period..

Likening the spread of social phenomena to that of an infection is not new. The conversion model of section 3 was discussed by Coleman (1964) and similar models are used for the diffusion of innovations throughout society (Kumar and Kumar 1992). Batholomew (1983) used a stochastic model for the spread of a rumour with equations similar to the epidemic model. Recently Gladwell (2000) has argued for a range of phenomena such as fashion and crime spreading like an epidemic. He identified three sorts of enthusiasts: those with many contacts, those who gather and pass on information, and those who are salesmen. In the limited enthusiasm model the behaviour of all these enthusiasts is averaged in the category called active believers.

[4] The systems dynamics model, and equations, appear in the appendix, part 3.

[5] The spread of infection and disease is modelled mathematically by Anderson and May (1987) and Bailey (1975).

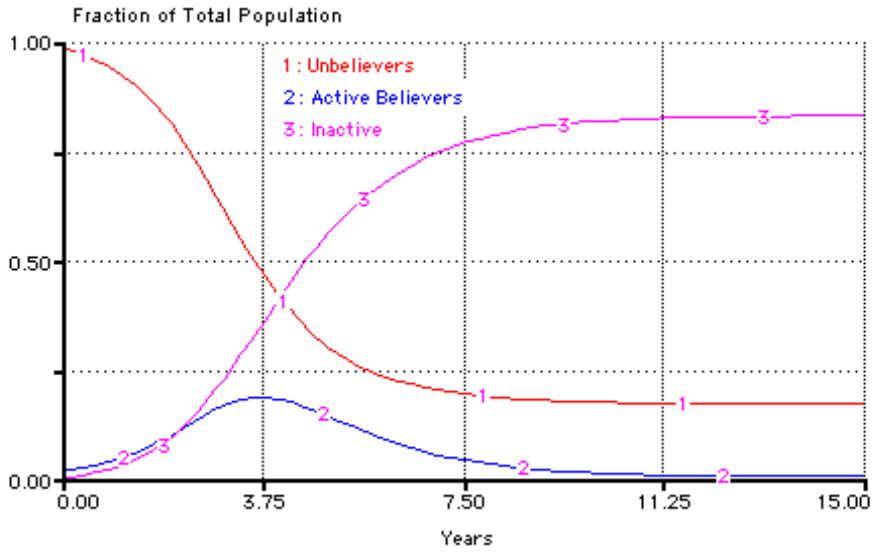


Fig. 9. Limited enthusiasm with no births, deaths or reversion. Enthusiastic phase is 1 year and the potential number converted per believer is 2

4.3 Threshold of Revival-Type Growth

In this model the church can only grow, or standstill. This is also true with the spread of a disease. However the spread of a disease becomes an epidemic if the number of infectives increases for a time. In this case the disease spreads rapidly. The condition for this to occur is when the number susceptible to the disease exceeds a threshold based on the likelihood of infection.

A similar result holds in the limited enthusiasm model. If the number, or percentage, of unbelievers exceeds a threshold determined by the conversion potential then the ensuing growth is rapid following the pattern of figure 9. If the initial number of unbelievers, is under this threshold no such rapid, or revival-type, growth occurs. The exact relationship was shown in Hayward 1999 to be:

$$\text{Initial number of Unbelievers} \geq \text{Threshold} = \frac{1}{\text{Conversion potential}} \qquad \text{(Equation 2)}$$

Essentially if the number of unbelievers multiplied by the potential number converted per active believer is bigger than 1 then revival type growth will occur.

This can be simulated for the model by varying the conversion potential and comparing results (figures 10 and 11). In this simulation the unbelievers were initially 50% of the whole population giving a threshold for revival-type growth of 0.5. Thus a conversion potential of 2 converts per active believer during their enthusiastic phase will be on the threshold exactly[6]. Anything above this will see the number of enthusiasts increase for a period (figure 11) and thus produce rapid growth in the total church (figure 10). Increasing the conversion potential to 2.25 and then 2.5 has lowered the threshold in each case and increased the growth in enthusiasts and the resulting effect on the final size of the church[7].

[6] Of course this is the *potential* number only. The actual number converted during the enthusiastic phase is only 1 because half of the enthusiasts' contacts are with believers who are already converted.

[7] Increasing the conversion potential, by increasing the number of contacts, for example, is enough to "tip" the growth into epidemic behaviour. It is for this reason that Gladwell (2000) calls his book "The Tipping Point". He argues that the presence of enthusiasts with a very high number of contacts tips the balance. In the Limited Enthusiasm model such people would give an increase in the conversion potential as they are "averaged" in with the other enthusiasts.

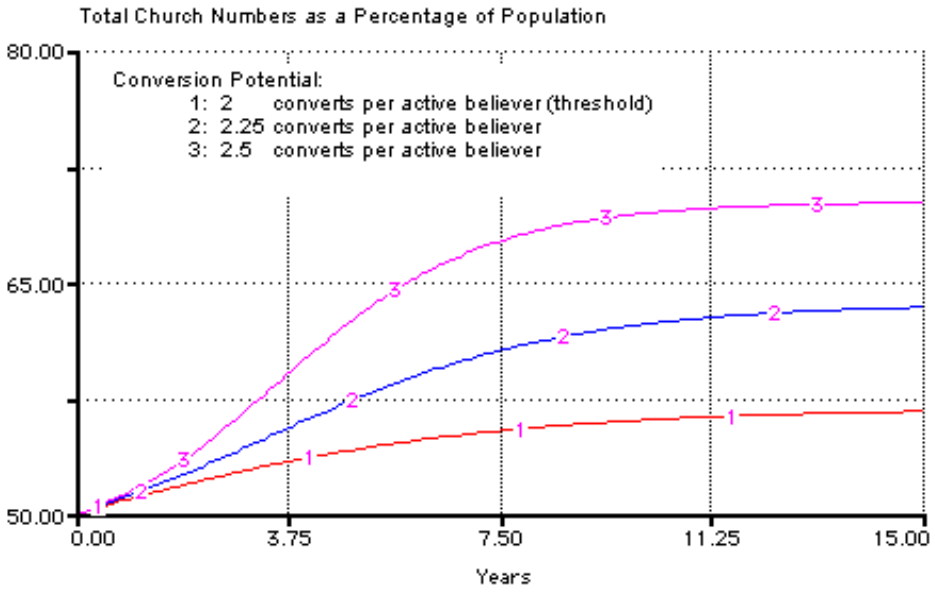


Fig 10. Effect on total church of increasing the conversion potential in the Limited Enthusiasm model. Church initially 50% of society, duration of enthusiastic phase = 0.5, all converts become enthusiasts

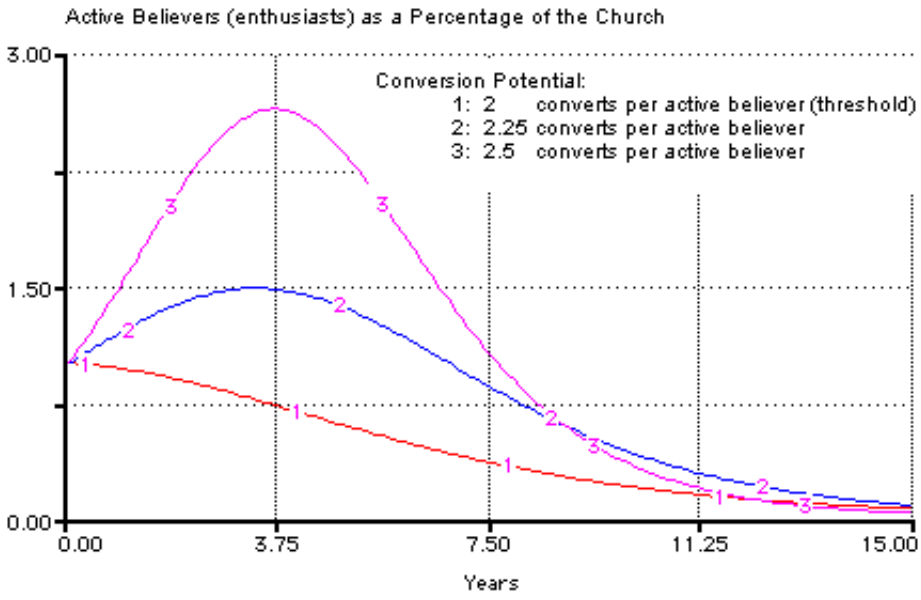


Fig 11. Effect on number of enthusiasts of increasing the conversion potential in the Limited Enthusiasm model. (Parameters are the same as figure 10)

The number of enthusiasts present initially has no influence on the threshold of revival-type growth. It is purely the number of unbelievers, i.e. the potential converts, and the conversion potential, that determines this type of growth. Thus revival-type growth will occur even with a very small number of enthusiasts as long as the potential number converted by them times the fraction of unbelievers in society is bigger than 1. Simulations show that with a smaller number of enthusiasts at the beginning the revival-type growth takes longer to get going (figure12). However the effect on the final church percentage is marginal. With 5% of the church initially active the church ends up at 82% of the population, whereas with 0.2% initially active the church becomes 79%. So, even though the former situation has a higher peak in the number of enthusiasts (figure 12) than the latter situation of 0.2% initially enthusiastic, the total number of conversions is more or less the same. For the higher initial values of enthusiasts the revival growth burns out quicker. For the lower ones it lasts longer with a lower peak.

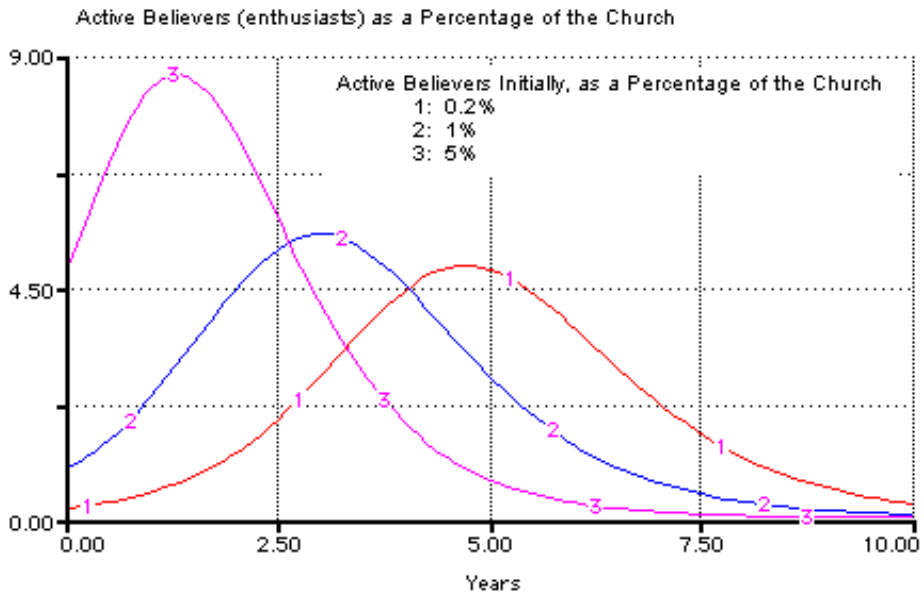


Fig. 12. Effect on number of enthusiasts of varying the initial number of enthusiasts in the Limited Enthusiasm model. (Conversion potential of 3 with other parameters the same as figure 10)

4.4 Model Conclusions

Assumptions and their Consequences:

If there are no losses from the church, if birth and deaths can be ignored, if only a subcategory of believers - the enthusiasts or active believers - are responsible for the conversions, and if their enthusiastic phase is limited then not all the population gets converted and the church eventually runs out of enthusiasts.

Parameters:

The potential number of people converted by one active believer during their enthusiastic phase - the conversion potential;
The duration of the enthusiastic phase;
The fraction who become active believers on conversion rather than inactive.

Simulations show that growth is more sensitive to the number converted per person than it is to the actual number of enthusiasts (Hayward 1999).

The fraction who become enthusiasts on conversion affects the size of the revival-type growth.

Principles Established:

1. *The number of unbelievers must exceed a threshold for revival-type growth to occur*. This threshold depends on the conversion potential only. Thus increasing the potential number converted will lower this threshold, making revival-type growth possible. The length of the enthusiastic phase does not affect the threshold or the size of the growth, only how long it takes for growth to occur.

2. *The threshold of revival-type growth does not depend on the number of enthusiasts*. However small the number of enthusiasts the growth will occur eventually, it just takes longer to do so.

3. *The peak in the number of enthusiasts occurs before the growth in the church has even reached the half-way point*. Thus most of the growth comes after the number of enthusiasts has started declining (see figure 9). Thus measures of church growth alone may mask the fact that the means of the growth is already waning. A knowledge of the number of enthusiasts may give advance warning that action is needed to stem future decline.

Limitations of the Model

Only applies on time scales short enough that births, deaths and reversion can be safely ignored, up to about 15 years.

5 Applications of Limited Enthusiasm Model to Revival

5.1 General Considerations

The sudden growth behaviour of the limited enthusiasm model is typical of times of religious revival both at the local level, and at a national or international level. Examples of such local growth in the Christian church are well documented: New England in the 1730's (Edwards 1965); Hebridean Islands Scotland (1949) (Edwards 1990); Nagaland North East India 1976 (Orr 2000) and more recently Pensecola Florida from 1995 onwards. Examples of such national growth include the First Great Awakening 18th century USA and UK (Edwards 1990), and the Second Great Awakening Early 19th century USA. Much faster revivals occurred in the USA (1857-8) and then Wales, Scotland and Northern Ireland in 1859, and also Wales in 1904-5[8]. A much longer revival in the twentieth century has been the growth of Pentecostalism especially in South and Latin America.

Many of the past revivals were local to one country. Occasionally they crossed to other countries after a length of time, however few were truly international in scale as contacts between people were restricted to personal contact. However, increasingly through the 20th century, contacts are made through other means, such as: media, internet and email. These may be enough to drop the threshold and enable revival-type growth to occur. This is now discussed for three current phenomena which have the nature of revivals within the Christian church: the Alpha Course, Vineyard Church and the Toronto Blessing.

5.2 Alpha Course

The Alpha course is a world-wide phenomena within the Christian church, currently operating in over a hundred countries. The intention of the course is to teach the basics of the Christian faith to unchurched people in a series of ten meetings and a weekend using videos and books. The course originated in Holy Trinity Brompton Church London, a parish church of the Church of England, who produce the videos and books that resource the course. Although originating within a specific denomination it is used by churches of many denominations including a number within the Roman Catholic church. Theologically it is evangelical and charismatic yet it is endorsed by church leaders who would not normally fit into these categories. Although aimed at unchurched people it also acts as a "refresher" course for existing Christians and is a significant vehicle for spreading charismatic renewal.

It is impossible to estimate accurately how many people have been through an Alpha course. Alpha's own estimates are that 1.5 million people had attended a course world-wide by 1998.[9] However the number of courses operating is better known. It started with one course in the late 1980's in Holy Trinity Brompton. By 1994 this had become 4 courses operating in different centres. A year later, after making the course national in the UK, there were 200 courses operating, rising to 750 the year after. So far in 2001 there are over 15,000 courses operating around the world, most in English speaking countries.[10] As such it is a significant revival-type movement within the Christian church, yet only recently has received much media attention outside of the church itself.[11] Thus it is possible to be reasonably confident the course has not grown through secular media exposure. Indeed it is not clear *how* so many churches came to know about the course so quickly. Its initial exposure probably came through adverts in the growing Christian magazine market, the large number of Christian conference/holiday weeks in the UK, and personal contacts between clergy.

The main mechanism of growth within each course is that the people in the church who run the course invite friends and relatives onto the course. Some courses are advertised locally but anecdotal evidence suggests this brings little in the way of recruitment to the course. Although the Christian teaching comes from the video presentation, the course is intensely relational. The evening starts with a meal with much opportunity for conversation. The invited people have an easy opportunity to widen their circle of friends, which will now include more Christian people. After the video, people are split into small groups and the video content is discussed. There is

[8] Hayward 1999, and 2000a applied the model to data from the 1904 Welsh revival. If all new converts were enthusiasts then potential number converted per active believer was about 2.02 with the duration of the enthusiastic phase about 1 week. If only 10% of new converts became enthusiasts this changed to 18.3 and 1 month respectively.

[9] As quoted on the Alpha USA Web Site, http://www.alphana.org/

[10] For example the USA has 2360 courses, Australia has 1590 courses and Canada has 1325 courses. However some non-English speaking countries have significant numbers: Germany has 280; Netherlands 410 and Norway 350. (Figures based on those published in Alpha News No 24, 2001.)

[11] For example Time magazine recently ran an article on the course (Time 1999). Most media attention has been confined to the UK, in the religious slots of television and newspapers.

no attempt to coerce people to believe what they have been taught, but to find out what they think of it and compare it with their current beliefs. It is part of the ethos of the course that people's own views are respected and not belittled in any way. Those who become converted are encouraged to help on the next course and invite their non-church friends.

In terms of the model presented in this paper the enthusiasts are those that run and help on the Alpha course.[12] The unbelievers are the unchurched people who, if converted, become enthusiasts themselves helping on the next course inviting their friends. The success of the course is twofold:

Firstly, the potential number converted is higher as Alpha is a more intelligible meeting to invite non-church friends to, compared to a Sunday service. As such there is a greater possibility of believers being converted or at least being retained by the church even if only part of a fringe. Thus even if a believer invites the same number of people to Alpha as they do to Sunday services, their conversion potential is higher, and the threshold of revival type growth is lower.

Secondly, the initial number of potential unbelievers is higher. One feature which sets the Alpha course apart from other church based courses is that it is beneficial to both believers and unbelievers alike. Most other courses are aimed exclusively at either one or other categories, either purely renewal meetings or purely evangelistic ones. Those aimed at renewing, or teaching, believers are not conducted in a way that are meaningful to an unbeliever, so few unchurched people get invited to such meetings. There were many such renewal meetings in the charismatic movement of the seventies and eighties but they burned themselves out as their potential pool of recruits did not include many unbelievers. The other sort of meetings, aimed purely at evangelising unbelievers, fail to attract or hold believers, who receive little benefit from it themselves. As such the meetings can run out of believers to help and recruit before enough unbelievers have been converted. Even worse, the new converts often take no further interest in the course, thus failing to tap their contacts with unbelievers.

By contrast a typical Alpha course starts with nearly all believers, injecting them with new enthusiasm for the faith. Many of these stay for the second and later courses, enthusiastically bringing their unbelieving friends along, yet still receiving benefit from the course themselves. Any converts resulting from the second course remain with subsequent courses, because of the benefits obtained, as well as bringing their unconverted friends. Indeed the course can become the "spiritual home" for new converts for some length of time. Thus the pool of potential converts is much larger than the more specialist courses, enough to push the growth over the threshold of revival-type growth. The ability of the course to "infect" existing believers, while being meaningful to unbelievers, could be the key to its success.

Enthusiasm cannot last indefinitely as people run out of non-church friends to invite, or they can only take helping on so many Alpha courses before repetition and exhaustion make them change their commitments.[13] According to the model the numbers attending the Alpha course will peak at some point and start to decline. The course will not be maintained indefinitely and will burn out for a lack of enthusiasts. Thus Alpha would find it helpful to keep a record of the number of leaders and helpers on the courses, both nationally and locally, to look for their decline as an early sign of the course burning itself out. Alternative ways of "re-infecting" existing Alpha helpers to make them more effective could substantially improve its future prospects.

In order to sustain growth on the course either the threshold needs to be reduced - enthusiasts to have a higher conversion potential - or the number of unbelievers that could be reached must be larger. The decision by Independent Television to broadcast the Alpha course on national television in the UK in the fall of 2001 (Alpha News 2001) might well open up a much larger pool of untapped unbelievers taking their numbers well over the current threshold of revival-type growth. If these broadcasts also infect believers with enthusiasm to participate in Alpha the growth of the course later in 2001 might well be explosive.

[12] It could also be argued that the "enthusiasts" are the Christians who influence other churches to run the course. However most people who start a course in their church will have been on a course in an existing "Alpha" church first, if only to get the feel of the course. Thus the stated interpretation of the model holds.

[13] The Alpha course is a large commitment for those who help: one meeting a week; prayer meetings; training evenings and a weekend. Some churches run the course three times a year, the recommended number. This can leave little time for any other activities in church.

5.3 Vineyard Christian Fellowship[14]

The Vineyard Christian Fellowship is one of the new paradigm churches that has grown from small beginnings 25 years ago to have a significant world-wide impact. The church was founded by Ken Gullikson between 1974 and 1977 as a more charismatic offshoot of Calvary Chapels, and thus it has its origins in the Californian Jesus movement of the late sixties and seventies. However it only achieved its international reputation and growth when leadership passed to John Wimber in 1982 after he had brought his own Anaheim congregation into the Vineyard. His church had started as an offshoot of an evangelical Quaker church in 1977, and had also belonged to Calvary Chapels before becoming "Vineyard".

Although John Wimber brought a wealth of evangelistic and church growth experience to the church,[15] Vineyard became best known for its worship culture. Worship, the Vineyard way, was predominantly musical and informal. They produced easy to sing songs in popular West-Coast style[16] enabling people to "express their heart" directly to God. Formal liturgy was effectively abandoned, as was the mixture of hymns and prayers favoured by less liturgical churches. Instead the worship became a blended series of songs where people could sing for anything from 20 to 40 minutes uninterrupted by words from the front. This worship style was used in many conferences produced by the Vineyard movement, which started in the 1980's. Although the conference topics included signs and wonders, healing and prophecy, it was the worship style that drew widespread attention to Vineyard. This "concert" style of worship has been one of the largest changes in evangelical worship culture across the denominations in the last twenty years (Miller 1997, 1998). Many evangelical churches now have a worship band very much along the lines of a contemporary rock group leading their services.

This style of worship, pioneered at the Vineyard conferences, produced a demand for tapes, and later CD's, of the music. The first two tapes were produced in 1981, even before Wimber's Anaheim congregation became "Vineyard", and sold 150,000 without any formal distribution. However tapes were sold at conferences and demand was such that they were eventually distributed by mail order and through EMI. By 1997 the production of worship music was handled by a special group employing 58 people. Currently the Vineyard catalogue has over 50 titles even with much of the earlier work no longer available. Vineyard songs are included in most modern collections of Christian songs world-wide.

As a new church Vineyard has seen phenomenal growth from the first congregation started by John Wimber in 1977. That congregation started with around 50 people, grew to 200 in the same year and to 2000 by 1983. Currently it is about 5000 mark. However it is the growth in the number of Vineyard congregations that has seen revival-type growth. The handful of congregations in California in the early 1980's became 200 throughout the USA by 1986. With a vigorous church planting campaign its figure has risen to over 400 by the late 1990's, with over a hundred in other countries. In addition to this growth there are an unknown, but probably large, number of Christians in other denominations who also have a Vineyard ethos, or sympathies.

What has influenced the recruitment to Vineyard? In a studies on recruitment Perrin and Mauss (1991), and Perrin et al (1997), showed that over half of the Vineyard's recruits had "shopped around" in previous conservative churches, suggesting they were looking for a more fulfilling religious experience. In the light of the above it is proposed that this experience is largely influenced by the worship of Vineyard. In this case the enthusiasts are the Christians who have benefited from the church, especially its worship style. Many of these may not be in a Vineyard church but have the tapes and have been to conferences The "unbelievers" are the Christians looking for something more fulfilling in church worship. The potential number converted is enhanced by the way the worship music is promoted, the conferences, their inclusion in other churches song books, and especially the passing around of tapes and CD's. Although Vineyard sees many true conversions among non-Christians, and has other means that influence people (notably its acts of charity), the influence of its worship style may well have been enough to tip the conversion potential over the threshold and thus see the revival-type growth. This could not have taken place without the media of tapes and CD's thus making it a late 20th century phenomena

At present the Vineyard Music Group has cut back production of its main series of worship. If worship is a significant means of the spread of Vineyard then this could indicate a drop in the number of enthusiasts. According

[14] Historical material for this section are taking from Issues of Voice of the Vineyard, Spring 1997, Fall 1997, Winter 1998 and Jackson (1999).

[15] Wimber was appointed founding director of the Department of Church Growth at the Fuller Institute of Church Growth and Evangelism in 1974. He taught many courses at Fuller into the eighties including one on signs and wonders in church growth, started in 1982, which had a significant impact on the wider church.

[16] The author visited the Anaheim congregation in 1995. Members described their worship service as the worship equivalent of a "Grateful Dead" concert!

to the model this will be followed by a slowing down of the growth of the movement. However this slow down may not be noticeable for some time. If this is the case the church will need to find other means to influence people to sustain its growth and should do so now before its attendance figures show signs of decline, even though that decline may be some years away.

5.4 The Toronto Blessing[17]

The "Toronto Blessing" is a name given to a world-wide phenomena that is associated with its starting place: the Toronto Airport Church.[18] The phenomena, which includes fainting, shaking and extremes of emotion, started in series of meetings at that church in January 1994. Although such phenomena had been in seen in a number of Christian churches over previous years, and was seen in the ministries of people who had an influence on the Toronto church, these meetings were set apart by the intensity of the phenomena and the fact that the church decided to carry on the meetings indefinitely. Throughout the next few months the Vineyard and Charismatic "grapevines" buzzed with the news of events at Toronto and the church saw a steady stream of visitors from Canada, the USA and abroad. Similar phenomena were seen on a smaller scale in a number of other churches. At this point news of the phenomena appeared to be only travelling by word of mouth, presumably including phone calls.

In May of 1994 one British visitor to Toronto brought the phenomena to a prominent London Anglican church[19] which brought immediate Christian and secular media attention in the UK and subsequently in the USA. Indeed the secular media in the UK, who coined the expression "Toronto Blessing", initially appeared more sympathetic than the main-stream Christian church (Poloma 1997). After this date the spread of the phenomena became much faster, and many churches, charismatic and otherwise, came under its influence. In time other centres of similar revival phenomena appeared, such as Pensecola in Florida and Sunderland in the UK, however there are many others. Although actual attendance data is patchy, it is from the increasing appearance of these centres that the extent of the phenomena can be judged. It would appear that the media interest fuelled its spread.

However 1994 also saw vast strides in the spread of internet and email usage. Improvements were being made in web browsers almost monthly and the technology was moving from being university-based to personal and commercial uses. At the end of 1993 the internet barely existed with 623 web sites. However by the end of 1994 there were 10,000 sites, with 100,000 a year later.[20] The churches which were central to the phenomena quickly acquired websites, indeed they were among the first churches to do so. People could then read daily accounts from the places where these events were occurring without them being "slanted" by the secular and mainstream Christian media.[21] An early website defending the Toronto Blessing, at the Champaign Vineyard Illinois, was receiving 800-1000 hits per day during 1994 (Jackson 1999:287).

The growth of the internet also spawned the growth of email usage, which became an additional way of spreading information concerning the Toronto blessing. The "New Wine" discussion list, dedicated to news on the blessing, was set up that year and others distributed email newsletters of its progress. The accounts were not academic treatise but testimonies of personal experience, encouraging other to seek the same, and thus spreading interest in the phenomena. Prior to this date the use of such technology would have reached few outside the academic community.

Although the primary means of spread of the Toronto blessing has been personal contact, these contacts have undoubtedly been enhanced by the use of the internet and email. This may well have been enough to increase the conversion potential and thus lower the threshold of revival-type growth to enable this substantial growth to occur. In addition, the fact that the technology involved is instantaneous, and world-wide, has enabled the phenomena to become truly global rapidly. In fact the same phenomena had been widespread in Argentina prior to 1994, but never influenced the world because the enthusiasts' contacts were confined to personal ones alone. Only

[17] Historical material for this section is taken from History of the Awakening 1992-1995 website, Dixon (1994) and Jackson (1999).

[18] The church was a Vineyard church until the end of 1995 when it left that movement and dropped the word Vineyard from its title.

[19] Holy Trinity Brompton, the home of the Alpha course and a church with significant Vineyard sympathies. There is much scope for work on the relationship between the three potential revival movements.

[20] Data quoted from "Hobbes' Internet Timeline" website: http://www.zakon.org/robert/internet/timeline/. There are currently around 30 million websites.

[21] The Toronto church, along with many others, shunned media attention and would not allow cameras or recording devices into its meetings.

when they influenced the people of the Toronto church, in a country where the new technology was emerging, was there the possibility of a rapid influence on an international scale.

6 Effect of Births, Deaths and Reversion on Church Growth

6.1 General Limited Enthusiasm Model

The model outlined in the last section is only valid in the short-term. To extend it over many generations the losses due to reversion, people leaving the church, and deaths need to be included. To balance the deaths births will also need to be modelled. This model is given in detail in Hayward 2000a and 2000b.

6.2 Reversion - Model Extension

In the case of reversion it is assumed that people stay in church for an average length of time. As such this means that a fixed *proportion* of the church reverts to the world at any time. Thus the inactive believer category is drained back into the unbelievers category. This can be modelled a bit more realistically if the those who lose the faith spend some time in a "hardened" category when they return to the world, before becoming open to re-conversion. Thus the flow of people becomes:

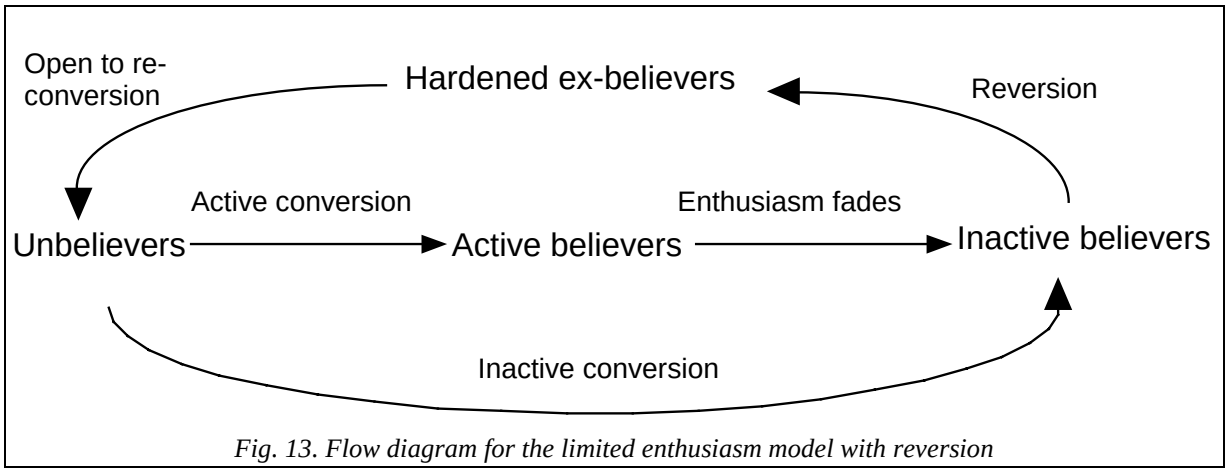


Fig. 13. Flow diagram for the limited enthusiasm model with reversion

It is now possible for inactive believers to become active again due to them falling away and being re-converted. With the active believers now subject to an additional reinforcing loop through this recycling of people it no longer targets to zero, as in the previous model, but to a non-zero value. Thus the whole system can stabilise to a steady state with all four categories of people non-zero. Thus the number of enthusiasts can always be present in the church.

6.3 Births and Deaths - Model Extension

Including births and deaths can have a similar effect to reversion[22]. Consider the simplest case where births and deaths are equal[23]. The church loses people through deaths, but gains people through births, the children born into the church going on to be believers. This latter process is called biological growth. If all the children who are born to believers become believers through their upbringing in the church, then the inclusion of births and deaths make no difference to the outcome of the system. Even when believers die they are replaced by the same number of believers through their children[24]. However if a fraction of believer's children leave the church then they are effectively born as unbelievers and open to conversion. Thus dead believers are "re-cycled" as new unbelievers through the children of other people. Thus the effect of losing children to the faith is the same as losing adults through reversion.

[22] The systems dynamics model, and equations, appear in the appendix, part 4.

[23] The case where they are not equal is considered in Hayward (2000a)

[24] Few churches would count the children of believers straight away. Not until teenage years, or perhaps earlier in the Roman Catholic church, will they be added to the membership role of the church through some rite such as confirmation or baptism. Thus the effect on actual membership will be delayed. Nevertheless the process by which they have joined the church is substantially different from conversion through contact with an active believer. The faith has taken hold gradually through their childhood years.

Mathematically it can be shown that this biological growth model, with equal births and deaths, where a fraction of children do not automatically become believers without conversion, is equivalent to the reversion model. Thus again the numbers of the different categories of people can stabilise out to fixed values.

6.4 Model Simulation

To show how this "re-cycling" of people back into unbelievers gives a steady state with enthusiasts still present, a simulation is run with children giving up the faith before incorporation into the church. Given that there is no reversion of adults, it is assumed that all the children of inactive believers are lost to the unbelieving world, but that all the children of the active believers become enthusiasts themselves. The results are compared with all the children retained in figures 14 and 15.

Firstly, once the revival-type growth has taken place, there is a marked decrease in the final size of the church when children are lost (figure 14). Nevertheless the church does survive, albeit at lower numbers. The number of enthusiasts no longer declines to zero (figure 15).

Secondly the numbers also oscillate about the final steady state before settling down. In this simulation, with the revival lasting for less than a hundred years, the numbers still haven't stabilised in 300 years. These are generational effects as the pool of unbelievers keeps getting replenished, taking it over the threshold of revival-type growth and then being depleted again.

The frequency of the oscillations is shortened if the duration of the enthusiastic phase is shortened, or if the conversion potential is increased. In the latter case the amplitude of the oscillations increases making it even longer to settle down after an initial revival.

Thirdly, note that the increase in church numbers for the first 75 years is almost the same for both cases (figure 14). The effect of losing children only shows up in the long term. Thus for the first two generations the success of the church masks the underlying problem of losses. By the time there is an obvious decline it is too late remedy the situation. If improvements are made in child retention after say 100 years the church will still not recover to the level it could have made unless it also improves its conversion potential.

Interestingly the number of enthusiasts during the growth phase is higher in the case when children are not retained (figure 15). This is the re-cycling effect. Thus the church may actually appear more exciting with many conversions taking place. However, numerically speaking, it would have been better if it had retained its children rather than lose them and see some converted later.

Including adult reversion into the model produces similar effects to figures 14 and 15.

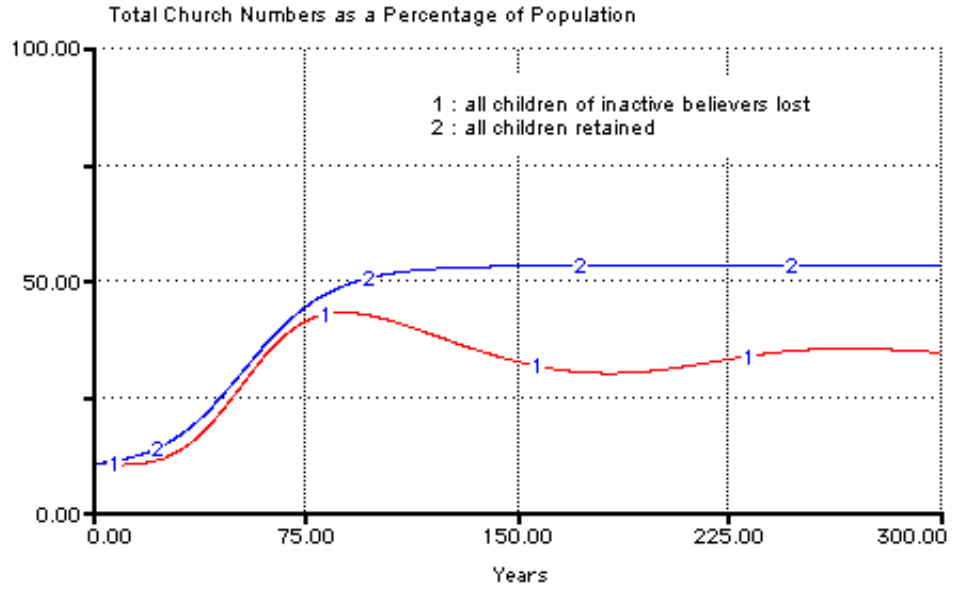


Fig. 14. Effect on total church of losing children in the General Limited Enthusiasm model. Church initially 10% of society, duration of enthusiastic phase = 5, all converts become enthusiasts, conversion potential =1.5

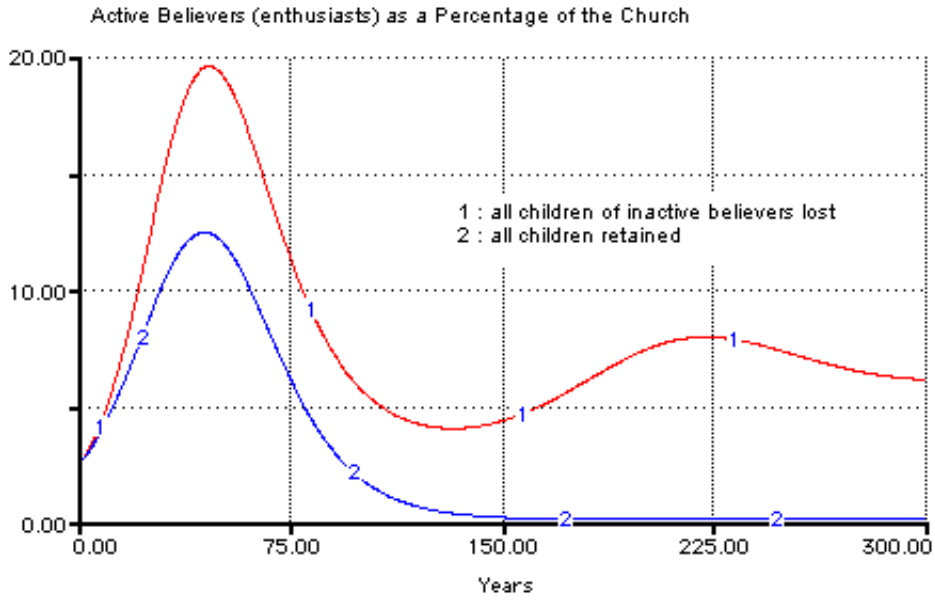


Fig. 15. Effect on number of enthusiasts of losing children in the General Limited Enthusiasm model. (Parameters are the same as figure 14)

6.5 Threshold of Extinction

Unlike the model of section 4 the church in this model can decline as well as grow. As well as the threshold of revival-type growth in the short term (section 4.3) there is now a threshold of extinction in the long term. This depends on all the parameters, reversion rate, loss of children, duration of enthusiastic phase and conversion potential in a quite complex formula. However it is changing the conversion potential that makes the biggest

impact. If it is too low compared to the losses the church will decline to extinction. Above a critical value the church will grow and may exhibit revival type growth at some phase of its growth.

Figure 16 shows the effect of increasing the conversion potential, from 2 converts per active believer up to 3, given the church initially occupies 10% of the population. Such an apparently small change has a far more significant impact than changing the reversion rate or the child loss rates. Thus if a church which had been growing loses its evangelistic impact among its enthusiasts then it can quickly move into a mode where extinction is inevitable, even though it is a few hundred years away. It may also find that improving its loss rates does not remedy the situation, there is not enough leverage unless it can keep nearly all its adults and children. The problem lies with its low conversion rate.

Figure 17 shows the percentage of enthusiasts in the church in the three scenarios. Comparing the case of the highest growth (curve 3), with the one that is borderline (curve 2), shows a far higher percentage of enthusiasts in the early phase. However from 75 years to 200 years it is *lower*. Such a church (curve 3) might think it is less successful than the church in curve 2 because there are proportionally less enthusiasts. At the congregational level it may just feel less enthusiastic. However this is a purely generational effect. It already has higher numbers, so there are still more enthusiasts and as some of the lost children get converted and made enthusiasts the percentage of enthusiasts is restored.

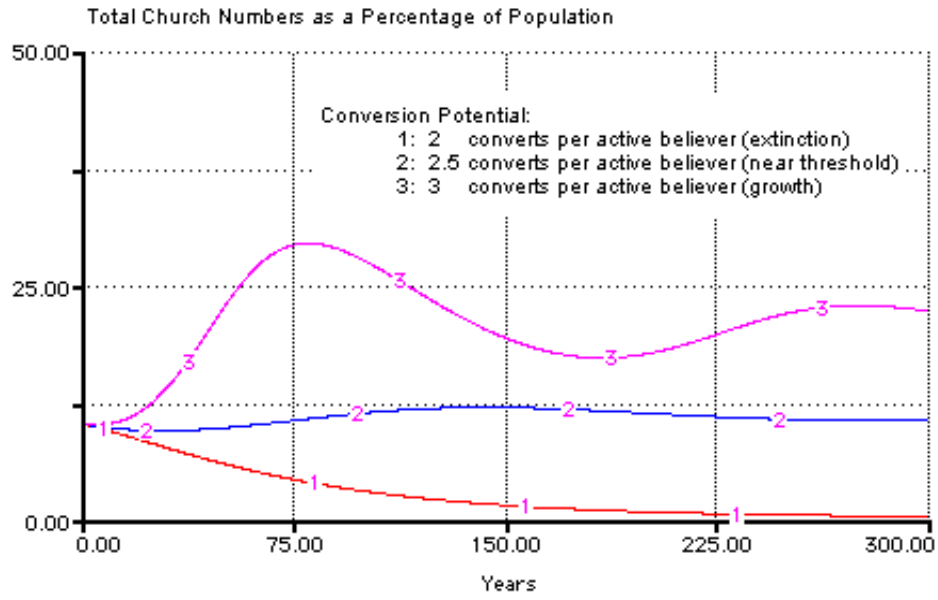


Fig. 16. Effect on total church of increasing the conversion potential in the General Limited Enthusiasm model.

Church initially 10% of society, duration of enthusiastic phase = 5 years,50% of all converts become enthusiasts, 50% of children of inactive believers retained, 75% of children of active believers retained of whom 50% become enthusiasts themselves. Reversion = 1% and softening = 1%

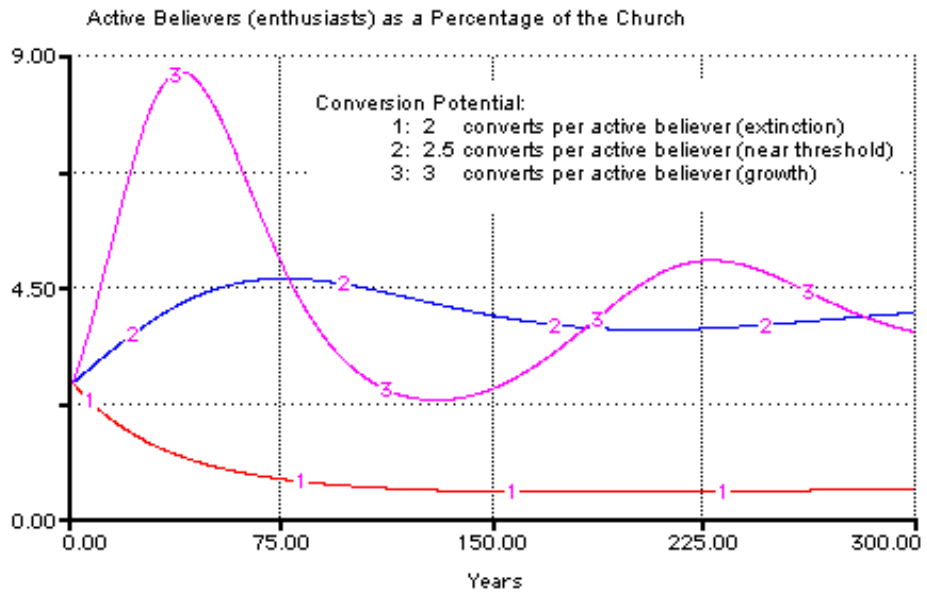


Fig. 17. Effect on number of enthusiasts of increasing the conversion potential in the General Limited Enthusiasm model. (Parameters are the same as figure 16)

6.6 Twentieth Century Church Growth and Decline

It is not easy to simulate actual church situations. Such a task would require accurate attendance numbers, reversion numbers and ideally the number of enthusiasts over a time range. However, given that estimates can be made for the losses it is possible to use the model to estimate the conversion potential and the duration of the enthusiastic phase by matching the church numbers in 1900 and 2000. This is attempted for the UK as typical of Western European situations and a typical South American situation.

At the beginning of the 1900's the church in the UK accounted for about half the population. However enthusiasm was noticeably running out, especially with a tide of disbelief and liberalism within the church's own ranks. A simulation of the subsequent decline appears in figure 18, where the conversion potential (2.4 converted per active believer) and the duration of enthusiastic phase (4 years) were estimated from the model. Other parameters were estimated by recent data or local anecdotal evidence.

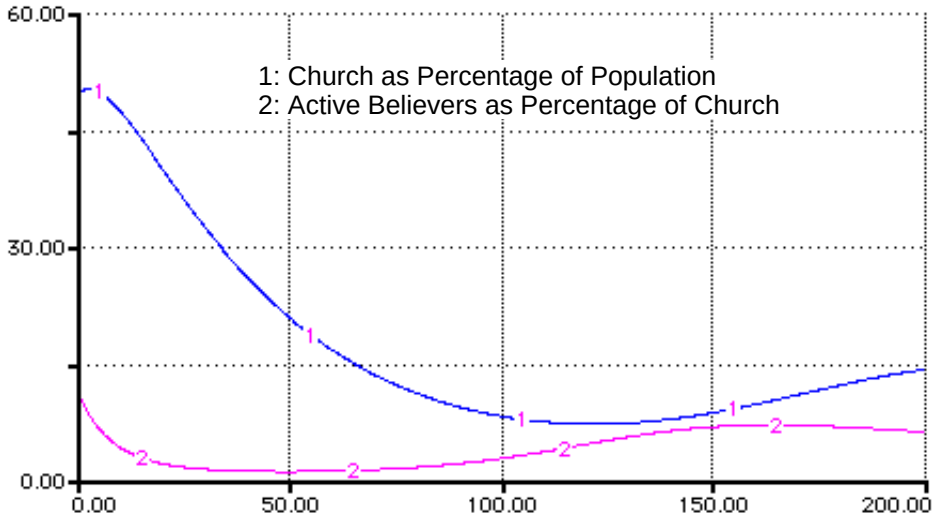


Fig. 18. Typical church decline in UK from 1900.

conversion potential = 2.4, duration of enthusiastic phase = 4 years, reversion rate = 1.6%, softening rate = 50%, converts who are enthusiastic = 50%, inactive's children lost = 0.75, enthusiasts children lost = 0, enthusiasts children who become enthusiastic 50%

Note that the number of enthusiasts in this model was rising for the last 50 years of the 20th century. In reality there has been a rise in the most enthusiastic part of the church, the evangelical and charismatic parts. These are the section of the church that recruit the most. If this model is close to the truth then the church will begin to start growing again in about 30 years due to the increasing number of enthusiasts. This growth is without any change in the value of the parameters and is a generational effect, rather than a true revival, and is due to child losses and reversion achieving their true level. There is a long-term damped oscillation to a fixed value. Eventually it could recover from its current low of 8% to about 14% of the total population at the end of the 21st century.

What can be done within the church to improve the growth by changes made now? Changing the softening rate has little effect. However if reversion is switched off the final value of 14% becomes 16%. It becomes 18% if all the children are retained and 20% if both effects are combined. Clearly tackling loses makes some significant improvements.

The dramatic effects come from improving the recruitment to the church. If the conversion potential goes from 2.4 to 3 in the year 2000, the percentage in the year 2060 becomes 30%. Indeed the same improvement can be made by making 60% of the new converts enthusiasts rather than just 50%.

Also of significance is the lag between the total number in the church and the number of enthusiasts. The number of enthusiasts starts to wane long before the church does. If the number of enthusiasts could be measured then early warnings of problems within the church could be given.

By contrast the Protestant Christian church in South America has seen explosive growth especially during the 1970's and 1980's (Brierley 1999b). This has been largely the result of the activity of Pentecostal churches which display a high degree of enthusiasm. A typical simulation is given in figure 19, which has been adjusted to fit typical South American church membership data. Other parameters are kept the same as in the UK case.

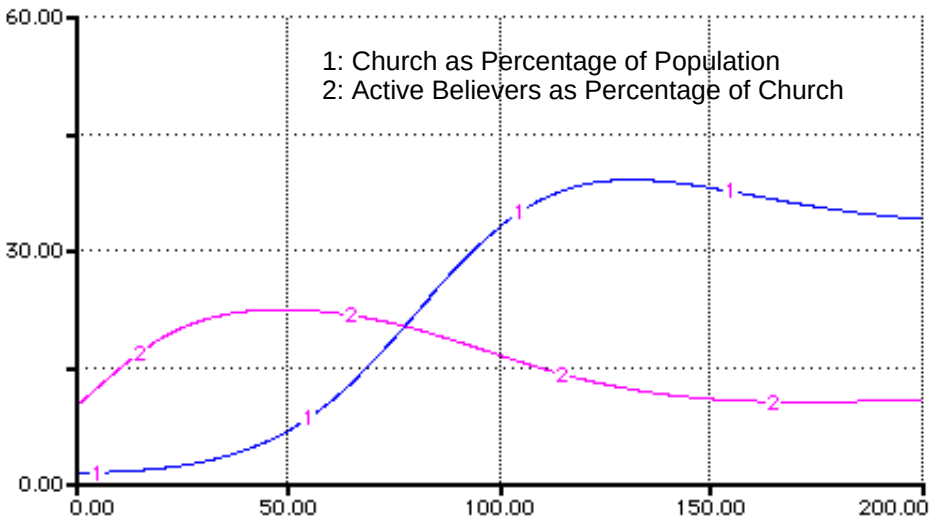


Fig. 19. Typical church growth in South America 1900-2100

conversion potential = 3.3, duration of enthusiastic phase = 10 years, other parameter are the same as figure 19

Clearly the percentage of enthusiasts is now past its peak leading to a levelling off and slight decline for the total church in the next 50 years. If this situation is true then the South American churches should be seeing a rise in the level of nominalism in the church. If so tackling this nominalism could prevent the church's future decline. If the church wants to see growth beyond these projected levels it must improve its conversion rate. It cannot expect to see the whole of the population converted on its current levels of conversion.

6.6 Model Conclusion

Assumptions and their Consequences:

If the only people who can be made enthusiastic, and hence recruiters, are new converts, then the church and the number of enthusiasts can sustain themselves, but are unable to convert the whole population. The number of enthusiasts does not become zero because the pool of unbelievers is being replenished by ex-church members and their children who are open to re-conversion

Parameters:

The potential number of people converted by one active believer during their enthusiastic phase - the conversion potential;
The duration of the enthusiastic phase;
The fraction who become active believers on conversion rather than inactive;
The fraction of children of inactive believers who leave the church;
The fraction of children of active believers who leave the church;
The fraction of children of active believers who, having been kept in the church, become enthusiasts themselves;
The rate at which adults leave the church and become hardened to conversion - the reversion rate;
The rate at which hardened people become open to re-conversion - the softening rate.

Simulations show that the growth is more sensitive to the number converted per person than it is to the various loss rates.

Principles Established:

1. *The conversion potential must exceed a threshold for the church to survive*. This threshold depends on all the parameters. Increasing the duration of the enthusiastic phase will have a small effect on increasing the threshold. Decreasing the proportion of converts who become enthusiastic has the biggest effect on raising the threshold. The other parameters have only a minor effect.

This principle is best expressed by saying that the number of *enthusiasts* that each enthusiast makes must be at least 1 plus a factor determined by the losses, birth rate and duration of enthusiastic phase.

2. *There is still a threshold of revival-type growth.* Again the unbelievers must be larger than a threshold, and it is independent of the number of enthusiasts. As before this depends on the conversion potential. If it occurs over an extended period then the threshold depends on the duration of the enthusiastic phase, death rate and fractions as well. The reversion rate does not affect the likelihood of revival type growth, only alter the final size of the church.

3. *Losses from the church do not reveal their true impact on church numbers for many years.* It may be two or more generations for reversion and child losses to seriously impact the church. Thus a church that has been recruiting well may already be storing up problems in later generations without realising it. The seeds of decline are sown long before that decline is seen.

4. *It is more beneficial for the long term growth of the church to retain children and adult believers than to attempt to reconvert them later*. By the time that these losses show in the church's total numbers the conversion potential needs to be increased substantially in order to recover the situation.

Limitations of the Model

The model will not apply if existing inactive believers can be made active again

7 Conclusion

This paper had two aims:

- To convince church growth practitioners and sociologists of religion that a systems approach to modelling church growth is worth considering;
- To make clear the consequences of the assumption that churches grow through enthusiasts, who are a subset of the church, and whose enthusiasm doesn't last indefinitely.

In each of the three models assumptions were stated and the dynamical consequences investigated. Thus it was clear that if all in the church recruited indefinitely through contact, the whole population became converted. However if that enthusiasm was limited in time and to certain people, or if there were losses of children or adults from the church, then the conversion of the whole population was not possible. Thus one advantage of the method is that the validity of the assumptions can be measured by the resulting effects on the growth of the church.

A second advantage of this method is that alterations to the assumptions can be made easily. Consider the assumption in 3.1 concerning homogeneous mixing. If it were believed that believers didn't mix evenly through the population but spend more time with other believers, or alternatively deliberately sought out unbelievers, then a modification to the probability in equation 1 is all that would be required. The model can then be analysed and results produced for each changed assumption in order to explore the consequences of the actions.

A third advantage is that additional categories of people can be built into the model. If for instance active believers dropped to a lower level of activity - semi-active believers - before becoming inactive, this extra category can be easily incorporated into the model. The procedure was seen as the model progressed from the unlimited enthusiasm model, through the limited enthusiasm model into the general model.

A fourth advantage, not explored in this paper, is the ability to model stocks (variables) that are not easily quantifiable. For example it would be possible to have a stock representing the tension between a church and the surrounding society and model its evolution as the church grew and perhaps became more accommodating to that society. This in turn could be fed back into modifications of the conversion potential.

The systems dynamics method is easy to learn with a minimum of mathematical knowledge. The System Dynamics website contains links to numerous introductions to the subject. There is also an introduction on the author's Church Growth Modelling website.

As for the model itself it is seen that the assumption that church growth is driven by enthusiasts who eventually lose their conversion potential can give growth similar to that of an epidemic. Such behaviour is seen in the vari-

ous revivals that have taken place throughout the history of the church. The fact that the enthusiastic phase is limited prevents the whole population from being converted, as does the presence of any losses from the church.

The key parameters are the conversion potential, and the proportion of converts who become enthusiasts. They control the threshold of revival-type growth and have the strongest influence on the threshold of extinction. As such any improvement in the contact rates, assuming such contacts lead to conversion, can tip a church from extinction to growth and from moderate growth to revival-type growth. It is thus possible in age where interpersonal communications are increasing through email, internet and other media that revival movements, especially those on a global scale, become more frequent. It does not take a large change in these parameters to tip into revival-type growth, thus the onset of such global revivals may not be easily predictable.

8 Further work

With a modelling methodology in place it is now possible to examine the effects of additional processes on the growth of the church. The following is not exhaustive but represents some possible extensions to the model:

1. A process by which inactive believers can become enthusiasts again without having to fall away from the church. This process is often referred to as renewal. Historically revivals have started because people within the church have had their faith and zeal renewed and then become active in evangelism and witness;

2. The media may have a role in making converts or enthusiasts directly. In countries where the Christian church is illegal the church relies on converts through radio broadcasts;

3. As a church increases it may become a threat to society, resulting in persecution;

4. There may come a point where a church is such a large part of society that it becomes socially acceptable to join. Persecution ceases and a greater proportion of inactive believers are recruited leading to a dilution in the evangelism of the church;

5. All societies are composed of different churches and religious groups. As well as competing for converts from society there is also transfer growth as people switch their church allegiance. Such transfers form a significant part of the growth of conservative churches (Perrin et al 1997);

The accuracy of the models presented here and any future models, need to be tested by data which measures the number of enthusiasts within churches and their level of enthusiasm in terms of their recruitment potential.

It is hoped that these issues will be examined in future publications.

References

Academic and Historical

Anderson R.M. and May R.M. (1987), *Infectious Diseases in Humans: Dynamics and Control*, OUP.

Bagnall R.S. (1982), "Religious Conversion and Onomastic Change in Early Egypt", *Bull. of the American Soc. of Papyrologists*, 19, pp.105-124.

Bailey N.T.J. (1975), *The Mathematical Theory of Infectious Diseases and its Applications*, Griffen, London.

Bartholomew D.J. (1983), *Stochastic Models for Social Processes*, Third Edition, Wiley, New York.

Brierley P. (1999a), *Religious Trends Number 2*, Christian Research.

Brierley P. (1999b), *World Churches Handbook*, Christian Research.

Coleman J.S. (1964), *Introduction to Mathematical Sociology*, The Free Press of Glencoe, New York.

Edwards J. (1965), *Jonathan Edwards on Revival*, Banner of Truth, Edinburgh (reprinted). Contains: *A Narrative of Surprising Conversions(1736)* & *An Account of the Revival of Religion in Northampton 1740-1742(1743)*.

Ford A. (1999), *Modeling the Environment: An Introduction Systems Dynamics Models of Environmental Systems*, Island Press.

Forrester J.W. (1961), *Industrial Dynamics*, Pegasus Communications inc. (reprinted).

Gladwell M. (2000), *The Tipping Point*, Little Brown and Company.

Goodman M.R. (1989), *Study Notes in System Dynamics*, Pegasus Communications, Mass.

Hayward J. (1999), "Mathematical Modeling of Church Growth", *Journal of Mathematical Sociology*, 23(4), pp. 255-292.

Hayward J. (2000a), "Modelling Church Growth - A Systems Approach," *Technical Report* - Part 1 UG-M-00-1, Part 2 UG-M-00-2, Part 3 UG-M-00-3, available from author or downloaded from the church growth modelling website.

Hayward J. (2000b), "The Growth and Decline of Religious and Subcultural Groups," *Sustainability in the Third Millennium - Proc. of the Systems Dynamics Society Annual Conference 2000*.

Iannaccone L.R., Olsen P. and Stark R. (1995), "Religious Resources and Church Growth", *Social Forces*, 74(2), pp. 705-731.

Inskeep K.W. (1993), "A short history of church growth research", in *Church and Denominational Growth*, Edited by D.A. Roozen and C.K. Hadaway (1993) pp. 135-148.

Kelley D. (1986), *Why Conservative Churches are Growing*, Mercer University Press.

Kermack W.O. and McKendrick A.G. (1927), "A Contribution to the Mathematical Theory of Epidemics," *Proc. Royal Society*, A115, pp.700-721.

Kumar V. and Kumar U. (1992), "Innovation Diffusion: Some New Technological Substitution Models," *Journal of Mathematical Sociology*, 17(2-3), pp. 175-194.

Miller D.E. (1997). *Reinventing American Protestantism: Christianity in the New Millennium*. University of California Press

Miller, D.E. (1998). "Postdenominational Christianity in the Twenty-First Century." *Annals of the American Academy of Political and Social Science*. 558: 196-210.

Perrin R.D., Kennedy P. and Miller D.E. (1997), "Examining the Sources of Conservative Church Growth: Where are the New Evangelical Movements Getting their Numbers?," *J. Scientific Study of Religion*, 1997, 36 (1): 17-80.

Perrin R.D. and Mauss A.L. (1991), Saints and Seekers: Sources of Recruitment to the Vineyard Christian Fellowship, *Reviews of Religious Research*, 33, pp.97-111.

Poloma, M.M. 1997. "The Toronto Blessing: Charisma, Institutionalization, and Revival." *Journal for the Scientific Study of Religion*, 36(2), pp.257-271.

Stark R. (1996), *The Rise of Christianity*, Princeton University Press.

Stark R. and Bainbridge W.S. (1987), *The Future of Religion*, Rutgers, University of California Press.

Sterman J.D. (2000), *Business Dynamics: Systems Thinking and Modeling for a Complex World*, Pegasus Communications, Mass.

Contemporary Christian Resources

Alpha News No. 24, published by Holy Trinity Brompton, London, 2001.

Dixon P. (1994), *Signs of Revival*, Kingsway Publications, UK.

Edwards B.H. (1990), *Revival*, Evangelical Press, Durham UK.

Jackson W. (1999). *The Quest for the Radical Middle: A History of the Vineyard*. Cape Town, South Africa: Vineyard International Publishing.

Orr E. (2000*), The Outpouring of the Spirit in Revival and Awakening and its Issue in Church Growth*, British Church Growth Association (reprinted).

Voice of the Vineyard: Spring 1997, Fall 1997, Winter 1998, published by Association of Vineyard Churches.

Web Sites

Alpha USA Web Site, http://www.alphana.org/

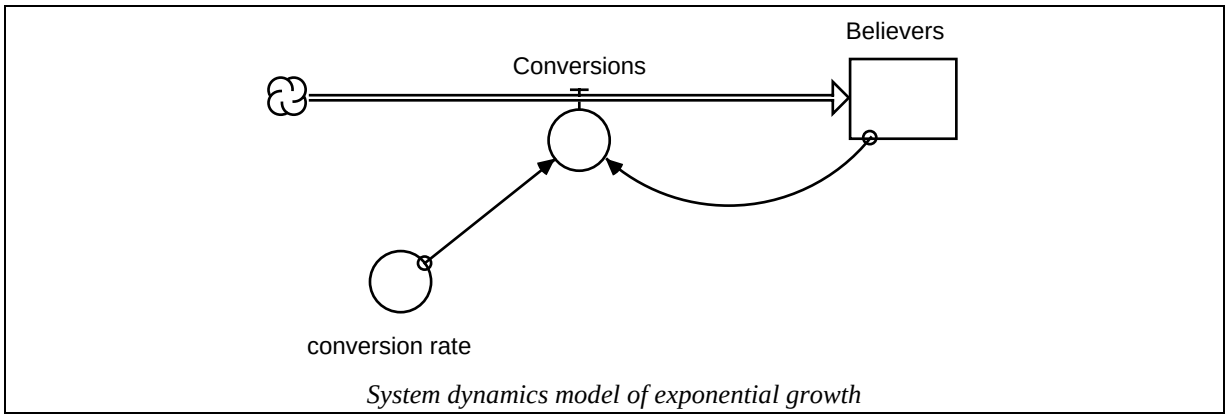
Church Growth Modelling, http://www.church-growth-modelling.org.uk/

Hobbes' Internet Timeline, Robert Zakon, http://www.zakon.org/robert/internet/timeline/.

History of the Awakening 1992-1995, Richard Riss, http://www.grmi.org/renewal/Richard_Riss/history/

Appendix

Part 1 - Exponential Model



System dynamics model of exponential growth

The box, *Believers*, represents the number of believers. It is called a stock. The double line to the left represents a flow into believers controlled by the *Conversions*, the number of conversions per unit time. *Conversions* depends the conversion rate (the number of conversion per unit time per person) and the number of believers by the formula:

$$\text{Conversions} = \text{conversion rate} \times \text{Believers}$$

The mathematical equation for exponential growth is:

$$\frac{dB}{dt} = c_r B$$

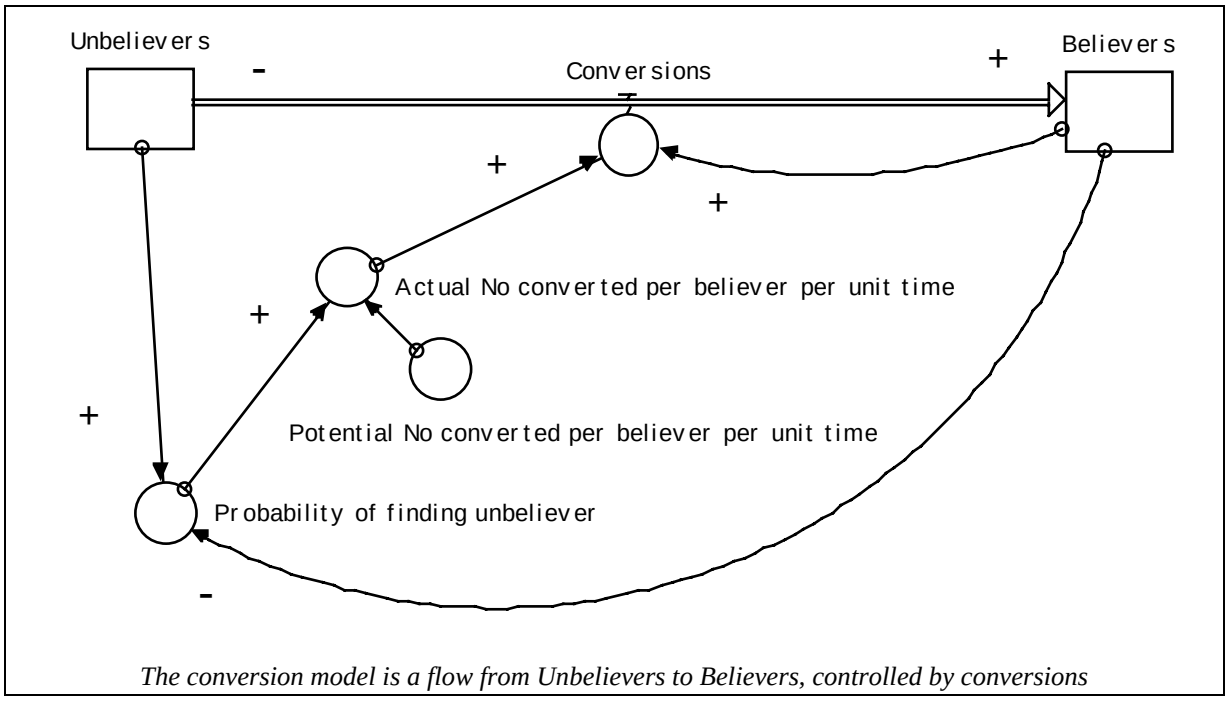
where the right hand side is Conversions. The solution of the equation is

$$B = B_0 \, e^{c_r t}$$

where:

c_r = conversion rate
B = Number of believers

Part 2 - Conversion Model



The conversion model is a flow from Unbelievers to Believers, controlled by conversions

The potential number converted per believer unit time is the conversion potential.

The equations are:

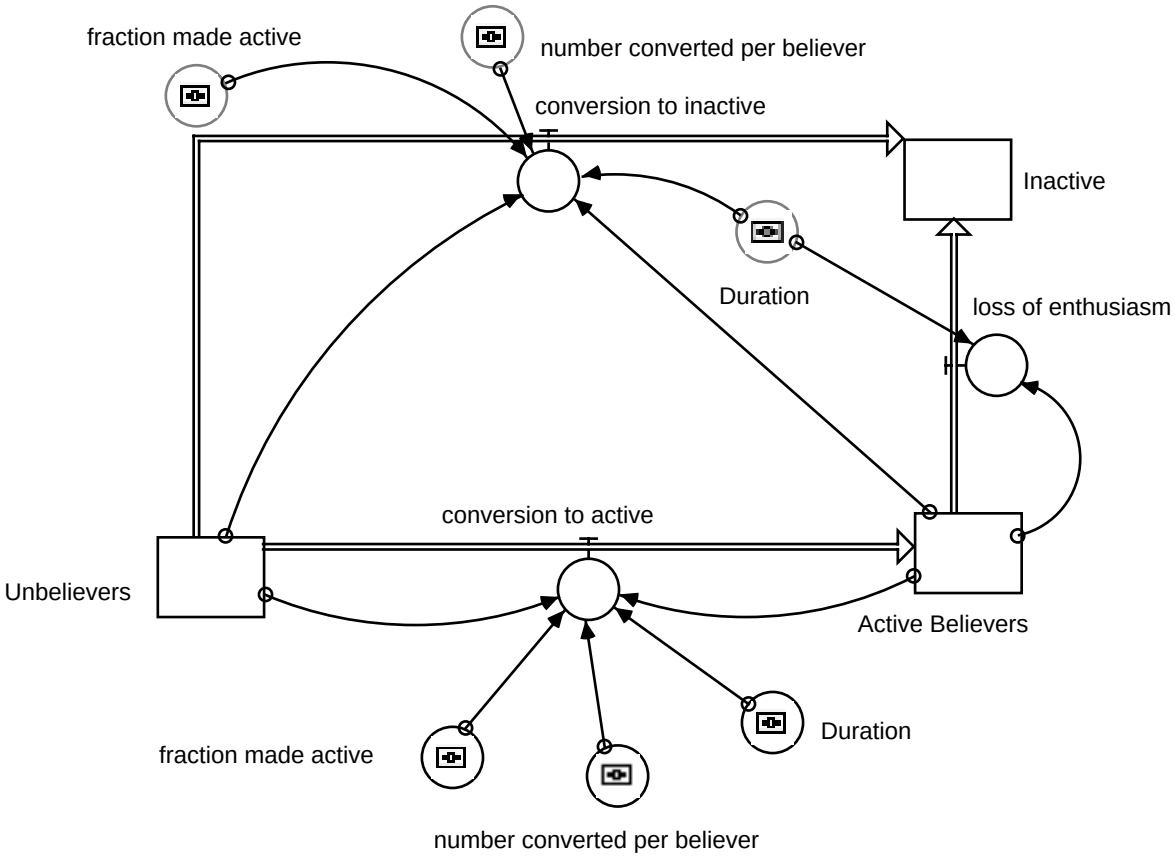
$$\frac{dU}{dt} = -\frac{c_p UB}{N}$$

$$\frac{dB}{dt} = \frac{c_p UB}{N}$$

where:

U = Number of unbelievers
N = Total population = $U + B$
c_p = conversion potential

Part 3 - Limited Enthusiasm Model



Limited enthusiasm model. Some new converts become enthusiasts, active in recruitment, for a limited time

The number converted per believer = conversion potential

The equations are:

$$\frac{dU}{dt} = -\frac{c_p UA}{N}$$

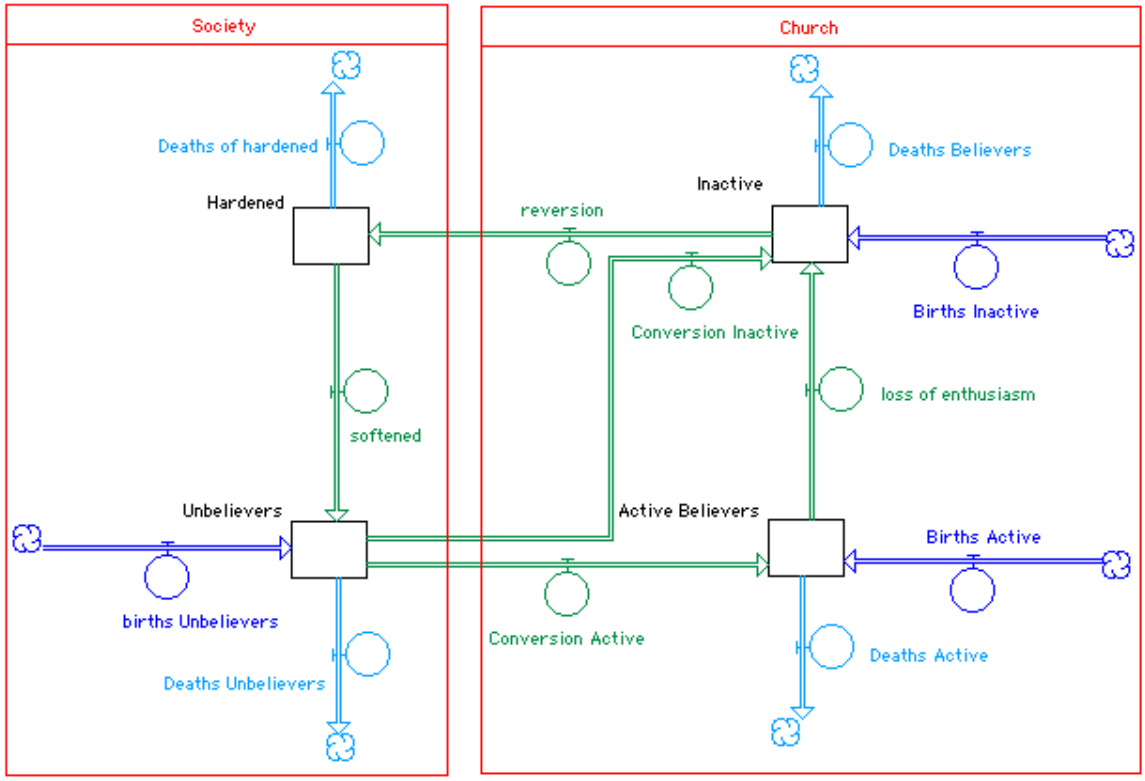
$$\frac{dA}{dt} = \frac{f_a c_p UA}{D_e N} - \frac{A}{D_e}$$

$$\frac{dI}{dt} = \frac{(1-f_a)c_p UA}{D_e N} + \frac{A}{D_e}$$

where

A = Number of active believers or enthusiasts
I = Number of inactive believers
f_a = Fraction made active at conversion
D_e = Duration of enthusiastic phase

Part 4 - General Limited Enthusiasm Model



The general limited enthusiasm model, with links suppressed

The equations are:

$$\frac{dU}{dt} = -\frac{c_p UA}{D_e N} + \frac{H}{D_h} + bU + bH + f_{iu} bI + f_{au} bA - d_e U$$

$$\frac{dA}{dt} = \frac{f_a c_p UA}{D_e N} - \frac{A}{D_e} + b(1 - f_{au}) f_{aa} A - d_e A$$

$$\frac{dI}{dt} = \frac{(1 - f_a) c_p UA}{D_e N} + \frac{A}{D_e} + b(1 - f_{au})(1 - f_{aa}) A + b(1 - f_{iu}) I - \frac{I}{D_i} - d_e I$$

$$\frac{dH}{dt} = \frac{I}{D_i} - \frac{H}{D_h} - d_e H$$

where:

H = Number hardened to conversion
D_h = Duration of hardening phase
D_i = Duration of inactive phase, i.e. length of time spent in church inactive before reverting
f_{au} = Fraction of children born to active believers who become unbelievers
f_{iu} = Fraction of children born to inactive believers who become unbelievers
f_{aa} = Fraction of children born to active believers who become believers and active